Land Conservation Council Victoria

Mallee Study Area

Price $3.00

REPORT

on the

MALLEE STUDY AREA

Land Conservation Council, Victoria
Melbourne: June, 1974.

10605/73—PL

C O N T E N T S

FOREWORD

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

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

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

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

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

S.G.McL. DIMMICK
Chairman.

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

LAND CONSERVATION ACT 1970

EXTRACT

Public Land

Section 2.

(1) "Public land" means -

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

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

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

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

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

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

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

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

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

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

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

(a) publish a report of the investigation;

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

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

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

Notice to be given to Public Departments and Authorities in Certain Cases.

Section 10.

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

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

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

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

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

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

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

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

Section 11.

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

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

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.

The Council acknowledges the assistance of the following organizations, which prepared basic information for maps and chapters of this report: Departments of Agriculture, Crown Lands and Survey, and Mines, the Fisheries and Wildlife Division, and the National Parks Service of the Ministry for Conservation, the Forests Commission, Soil Conservation Authority, the State Rivers and Water Supply Commission, and the National Museum of Victoria.

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

The Australian Information Service, the Latrobe Library, M. Gottsch, and the government bodies listed above provided photographs for use in this report.

PART I INTRODUCTION

AIMS AND METHODS

This report presents all available information relevant to making decisions on the future use of public land in the study area. It describes important features of the environment, and particularly emphasizes the character and distribution of the plant communities and animals of the area. It also examines the forms of land use that will make demands on public land and attempts to assess their impact on the land. It does not contain land use recommendations for public land, but rather provides a factual basis on which those recommendations can be formulated.

Information obtained from published reports, Government departments, private organisations, and individuals, and from short-term surveys of the plants and mammals of the area, is included in this report. However, our knowledge of the environment and of the impacts of land use on the environment is still far from complete.

The four parts

Part One sets out the aims of the study and defines and briefly describes the study area. It gives a history of the region, including descriptions of the Aboriginal inhabitants. A locality plan is included.

Part Two describes the main features of the environment such as the geology, climate, water resources, soil, vegetation, and fauna. Maps showing the geology and rainfall of the study area are included. Thirteen distinct land systems are also described and mapped.

Part Three considers the main forms of land use that are likely to make demands on public land, and examines the present level of activity, the estimated demands, and the ability of the public and also private lands to meet these demands. Conservation and recreation are treated as important forms of land use. The hazards that occur in the region, such as salting, erosion, fire and pests are then described.

In Part Four the seven blocks into which the study area is divided - such subdivision being based on similarities of soils, climate, and vegetation - are described in more detail. The nature of the public land in each block and its potential for the various forms of land use is then assessed. A map showing the public land in the study area, and block

boundaries, is included.

Another map showing public land is included in a pocket at the back of this report for use in making submissions to the Council.

Metric units are used throughout and a table giving metric:imperial conversion factors is included at the back of the report as Appendix 1.

Appendix 2 contains extracts from the *Land Conservation Act*, 1970.

Appendix 3 gives the scientific names of the plants mentioned in the text.

Appendix 4 lists 40 species of plants that are rare or localized in the study area, with brief comments on each.

Appendices 5-9 contain detailed information on the mammals, birds, reptiles, and fish of the study area.

THE STUDY AREA

The Mallee study area lies in the north-western corner of Victoria and is bounded by the 26th parallel south (approximately), the Loddon River, and the State borders with South Australia and New South Wales (see locality plan facing page 4). The New South Wales - Victoria border follows the southern bank of the Murray River. The study area includes the counties of Millewa, Weeah, Karkarooc, and Tatchera.

The climate is semi-arid, and rainfall varies from 350 mm in the south to 250 mm in the north. Most of the rain falls during the mild winter months, while the summers are hot and dry. Frequent droughts are a feature of the environment. Apart from the Murray and Loddon Rivers, the area has no permanent natural supplies of surface water.

The area is a vast plain sloping gently down to the north-west from about 100 m at Beulah and Birchip to 50 m at Mildura and 35 m at Lake Cullulerraine. Low superficial land forms - ridges, dunes, and hummocks - are also present. The soils, which are sometimes saline, have developed on calcareous aeolian materials that vary from sands to clays. The region derives its name from the characteristic and widespread native vegetation of low, multi-stemmed eucalypts called mallees. Other plant communities are woodland, grassland, and saltbush.

Public land

The study area covers a total of 43,000 sq km, of which 14,430 sq km is public land. The bulk of this lies in the western part of the area, where the sandy nature of the soils has discouraged settlement. Substantial areas of public land along the Murray River have been reserved for the production of timber and fuelwood.

At present about 50% of the public land is leased for grazing. Timber is taken from forest and woodland areas, and beekeepers range over most of the area in winter and spring. Gypsum and common salt are extracted from shallow deposits at several places. Public land is used for recreation, chiefly near the main towns, in the two national parks, and in several reserved forests. There are wildlife reserves at Wathe, Annuello, and Lake Charm. Tourism plays an

important role in the economies of the Swan Hill and Mildura districts.

Most of the cleared land supports production of cereal crops, mainly wheat, in rotation with sheep grown for wool or meat. Irrigation areas along the Murray River produce vines and citrus, as well as pasture near Swan Hill and Kerang. Water supply to the dryland farms comes through a vast system of open earthen channels from storages in the Grampians or on the Goulburn River, or from the Murray River. West of Underbool, supplies are drawn from groundwater resources.

The settled parts of the Mallee are served by a good network of primary and secondary roads. Although bush tracks traverse much of the public land, large areas remain inaccessible. Rail transport has been particularly well developed to move the large quantities of wheat produced in the area.

An aerial view of Murrayville, a typical Mallee town.

Local government

The study area includes the Shires of Mildura, Karkarooc, Walpeup, and Swan Hill, large parts of the Shires of Birchip, Wycheproof, and Kerang, and small parts of the Shires of Kaniva, Lowan, Dimboola, and Gordon.

Population

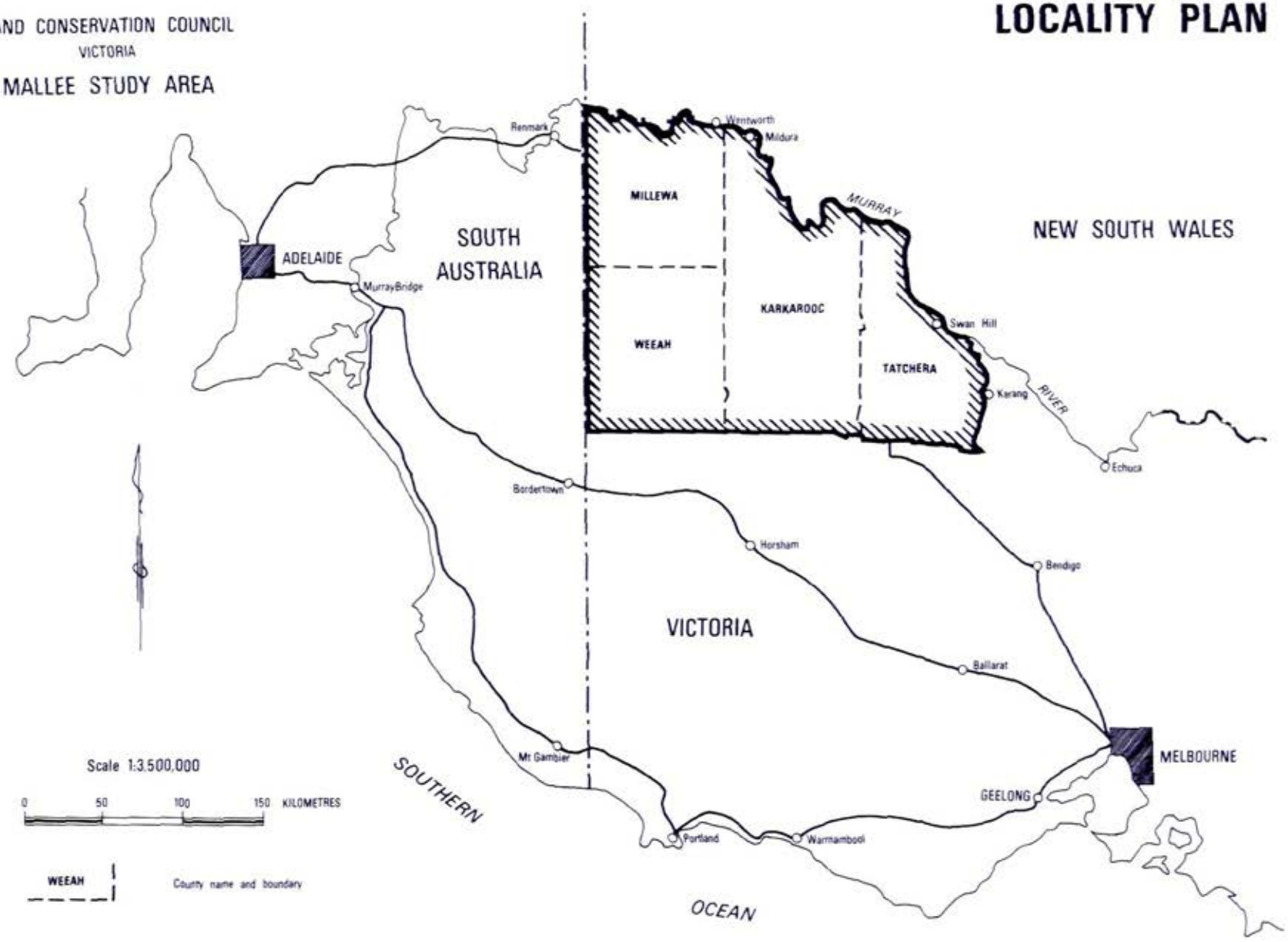
The population of the study area in 1971 was about 71,000, based on statistics for local government areas (where part of a shire lies outside the study area, an estimate has been made). The populations of Mildura, Swan Hill, and Kerang have been included in this total because of the closeness of these centres to the public lands, although technically they are not part of the study area. The population in 1966 was 72,400 - showing a fall of 1.7% over the 5-year period to 1971.

In 1971 the population of the city of Mildura was 13,190, and that of Swan Hill, 7,693, representing increases since 1966 of 0.7% and 2.2% respectively. The population of the Borough of Kerang was 4,120 in 1971, a fall of 1% since 1966. Concentrations occur in the irrigation

LAND CONSERVATION COUNCIL
VICTORIA

MALLEE STUDY AREA

LOCALITY PLAN



areas centred on the Murray River, particularly around Kerang, Swan Hill Nyah, Robinvale, and Mildura. The Sunraysia district, centred on Mildura and including adjacent irrigation areas in New South Wales, contains about 35,000 people.

The density of the population over the remainder of the study area is low. The largest towns outside the irrigation areas are Ouyen (1,562), Birchip (1,041), Sea Lake (971), and Hopetoun (923) (1971 statistics). The population of all these towns declined between 1966 and 1971.

Reference

Commonwealth Bureau of Census and Statistics. "Census 20 June 1971. Field Count Statement No 4 - Population: Local Government Areas and Towns, Victoria." (Government Printer:Canberra, 1972.)

HISTORY

The Aborigines

Although large numbers of Aborigines lived along the Murray and Loddon Rivers and around the lakes and streams of the northern Wimmera, very few lived in the central Mallee owing to the lack of food and water available there. The area was visited by groups seeking seasonal foods, and the few who settled there were probably renegades.

The name "mallee" comes from the Aboriginal word for the characteristic form of eucalypts that grow in the area.

The main tribes occupying the study area were the Wotjobalek in the south, the Ngintait on the Murray in the north-west and the Wemba Wemba in the east.

These people utilized many animals and plants for food - possums, bandicoots, emus, kangaroos, wild dogs, birds, fish, insects, bulbs, roots, tubers, and seeds.

In dry country, they obtained water from soaks by digging shallow wells. They covered these with sticks to reduce evaporation and protect the water from kangaroos and other animals. Water was also obtained by digging up the long horizontal roots of some mallees and breaking them into lengths to drain.

Natives moving between the Murray and the south traversed the central Mallee and knew and named all water-holes and soaks. Wirrengren Plain south of Underbool and Lake Coorong at Hopetoun were important meeting grounds to which the Aborigines travelled from long distances to meet and trade. Northern dwellers traded reeds, ochre, and mussel shells for stone axes and grinders brought by tribesmen from the south and west.

The simplicity of the material culture of the Aborigines belied their complex social organization, which involved leadership of the tribe, marriage and kinship rules, initiation rites, and religion. The Aborigines were intimately bound to their tribal lands by tradition and legends built around the deeds and spirits of their ancestors. Tribal life gave them social cohesion and security, and a harmonious adjustment to a difficult natural environment.

Aboriginal life began to decline in the 1840s after the white settlers arrived with their flocks and herds. Conflict

between the settlers and the Aborigines was inevitable, and over the following 30 years, after many violent clashes, the Aboriginal population was decimated and the tribes broke up. By the end of the century only a handful of full-blood Aborigines remained and their culture and way of life had vanished forever.

Relics of the Aboriginal era, such as old camp sites with ovens, shells, and fragments of worked stone, can still be found around the lakes and streams of the study area. Trees from which bark was taken for canoes, shields, or coolamons can be found along the Murray, and Aboriginal bones are sometimes exposed by wind erosion in sandy country near streams and lakes.

Exploration and settlement

In 1830 Captain William Charles Sturt skirted the Mallee on his voyage down the Murray from the Murrumbidgee Junction. Major Thomas Mitchell also navigated the Murray in 1836 on his journey of exploration to south-western Victoria, but he avoided the Mallee because of its hazards, and travelled instead over the northern and Wimmera plains.

The first attempt to penetrate the Mallee was made by Edward John Eyre, who discovered and named Lake Hindmarsh in 1838, before setting out for the Murray. However, he was forced to turn back to Lake Hindmarsh because of the lack of water and the difficult terrain.

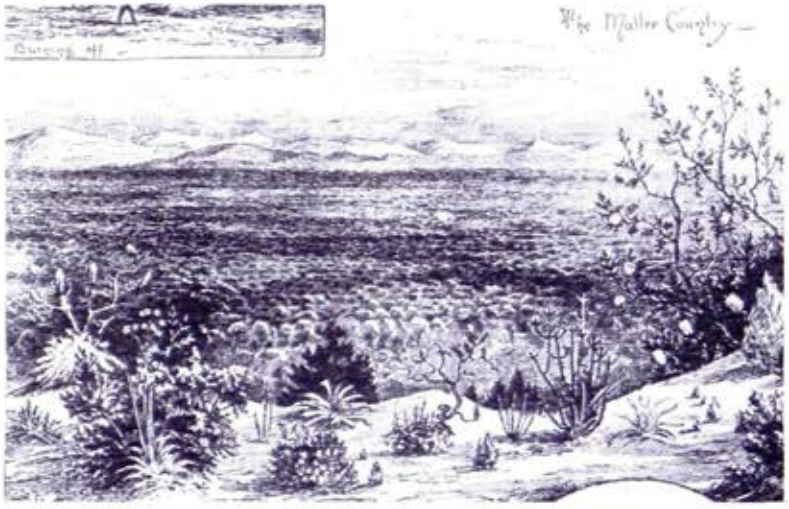
Squatters began moving into the Mallee in the mid 1840s after the better-watered country of the Wimmera and northern plains had been taken up. J.M. Clow occupied Pine Plains in 1847. The Murray frontage at Tyntynder near Swan Hill was occupied in 1846, and squatters reached Mildura that same year. Runs in the eastern Mallee (Lake Tyrrell and Lalbert runs) were taken up between 1845 and 1851.

The survey of the boundary between Victoria and South Australia north of the 36th parallel was commenced by E.R. White in 1849. After completing the survey, he made several hazardous journeys alone across the Mallee.

Natural history

Major Mitchell's account of his journey down the Murray contains some descript-

The first settler's home at Ouyen



An early artist's impression of the Mallee (1892)

ions of the country he passed. Frequent mention is made of the river flowing through extensive areas of reeds. He was also impressed by the many lakes and billabongs associated with the river. "The scenery of some lakes thus formed was very fine, especially when their rich verdure and lofty trees were contrasted with the scrub which covered the sand hills nearest the river." In other areas the sand hills carried pines, with a rich variety of flowering shrubs. Grassy plains lay between these hills. Mitchell reported having seen kangaroos, bandicoots, emus, and waterfowl, and the jerboa was first sighted near Swan Hill.

The accounts of the explorers and first settlers who penetrated the Mallee proper show that they found it an uninviting wilderness of dense scrub and porcupine grass, sandy and waterless. References are made to the lack of bird life and animal life.

In 1857 the Victorian Government instructed William Blandowski to proceed to the junction of the Murray and Darling Rivers, where he was to investigate the natural history of the area and collect specimens for the National Museum. The expedition set up camp at Mondellimin, close to where Mildura is now situated. With the help of local Aborigines he amassed a collection of many thousands of specimens. Unfortunately, the collection was not well labelled and annotated, and he took much of it out of the country. Nevertheless, a number of specimens were lodged in the National Museum, and Gerald Krefft, who assisted Blandowski, compiled several documents describing the expedition's findings. These documents and the remnants of the collection provide valuable information about a fauna that no longer exists intact.

Land Acts

Most of the early settlers grazed sheep on the native vegetation. Settlement was unauthorized at first and squatters occupied the land without legal tenure. However, in 1836 squatting was recognized and the Crown Lands Commissioner

was empowered to issue licences. In 1847 the British Parliament passed an Act giving squatters very favourable conditions of lease. However, as a result of disputes between the colonial government and the squatters over interpretations of the Act, no leases were issued in Victoria. Annual licences were issued instead.

To make provision for those who had not struck riches during the gold rushes of the 1850s, the new State of Victoria passed several Acts in 1860-62 designed to break up the large holdings of the squatters and encourage the selection of small holdings by ex-miners. Further Acts, the *Grant Acts*, were passed in 1865-69, and although these were successful elsewhere they had little effect on the Mallee.

During the late 1870s the Mallee was overrun by plagues of rabbits and wild dogs. Many holdings were abandoned. Wool production dropped from 5,000 bales in 1875 to only 900 in 1882. To meet this situation, the *Mallee Pastoral Leases Act* 1883 was enacted. This law, which embodied the first formal definition of the Mallee, referred to two separate areas, namely "Mallee country" and "Mallee border", with the latter being divided into "Mallee allotments".

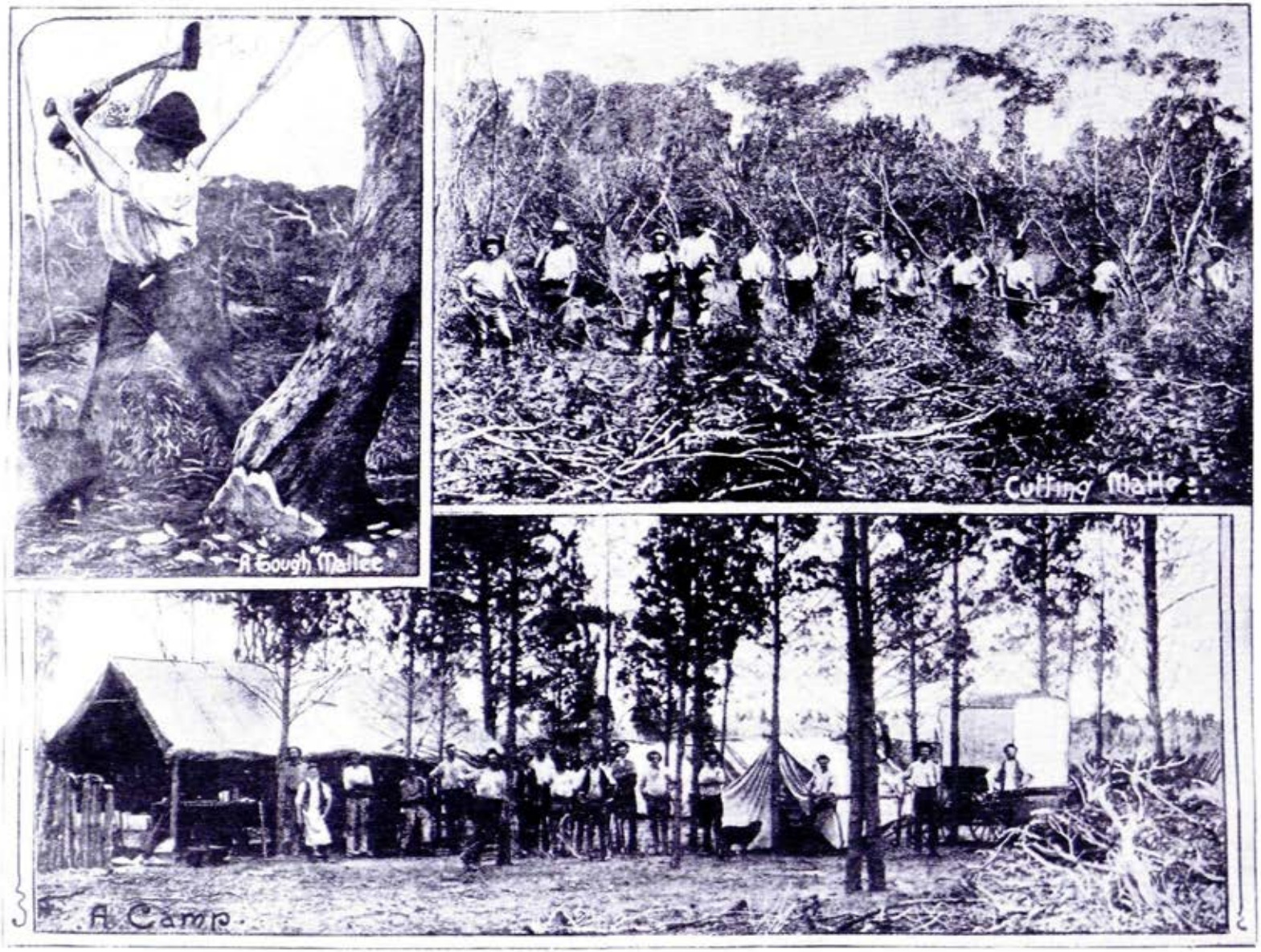
All land in both categories could be leased on attractive terms with the main one requiring only the destruction of vermin. The Act was most successful and much of the abandoned land was re-occupied.

In 1885 a rabbit- and dog-proof fence ("the dog fence") was built to stop rabbits moving into the Mallee. It ran from the South Australian border to Lake Hindmarsh and then to Swan Hill.

Cereal-growing

Cropping began around Swan Hill about 1870, but was not important until the 1890s, by which time the numbers of small freehold farms had increased. Many factors contributed to the start and ultimate success of cereal-growing in the Mallee. Prominent among these were the invention of the stump-jump plough and the stripper. Moreover, better methods of clearing mallee scrub were developed and strains of wheat (notably Federation) that were suited to dry country were introduced. Extension of the railway system, which provided cheap transport to markets, was also a significant factor. Crop yields increased with the application of superphosphate, which began on a large scale at about the turn of the century, and further increases were obtained soon afterwards with the introduction of bare fallowing to conserve moisture.

In this period of expansion of wheat-growing, Mr. E.H. Lascelles commenced a successful agricultural settlement around Hopetoun. While wheat-growing expanded, wool production nevertheless



Land development in the Mallee (1897)

remained an important industry. However, agricultural success led to agitation for selection, and the *Cuthbert Act* of 1895 permitted selection of 540 acres (215 ha). Further Acts in 1898 and 1899 also helped to foster settlement and, by 1907, 3¼ million acres (1.32 million ha) of Mallee country had been taken up. In 1911 a new *Land Act* introduced selection purchase leases, the maximum area of allotment in the Mallee being 1,600 acres (648 ha).

Closer settlement

After World War I, the Mallee was affected by the State-wide commitment to soldier settlement and closer settlement. Areas in the northern Mallee, along with the irrigation area at Red Cliffs, were settled by ex-servicemen between 1920 and 1924. The Millewa area west of Mildura was a closer-settlement area occupied by civilians and migrants in 1923.

Soon many of the dry-land settlements ran into difficulties because of the smallness of the holdings and the inexperience of the settlers in semi-arid conditions. Ultimately, the combined effects of declining soil fertility, droughts, serious erosion, and the economic depression of the 1930s caused great hardship, and many settlers were forced off their land.

In the 1940s, the value of a ley system of farming involving medics was proved and a new variety of wheat, Insignia, became available. The size of the individual holdings was now greater, as a result of the emigration of unsuccessful farmers from most of the Mallee. Reconstitution of allotments in the Millewa, Carwarp, and Annuello-Kooloonong areas under the provisions of the *Northwest Mallee Settlement Areas Act* 1946 also contributed to this trend. The period from 1945 to 1966 contained few years of below-average rainfall, and was a time of prosperity and consolidation for Mallee farmers.

Water

The interior of the Mallee has no natural supplies of fresh water apart from a few soaks. Indeed, the problem of obtaining water for human consumption and for stock dominated exploration and settlement of the area. The early settlers sought to conserve water by sinking dams in natural soaks or catchments. Catchments were prepared by removing the topsoil and ploughing drains to lead the run-off to "tanks" (dams) excavated in "good holding ground".

As settlement expanded, many public catchment tanks were constructed by the State Rivers and Water Supply Commission and local shires. A government program of boring to assess groundwater resources began in the 1890s and continued until 1930, when the boundary of the area in which usable groundwater occurs had been defined. This is the western

Tank-sinking with horse teams

Mallee, between Underbool and the South Australian border.

In areas where groundwater was not available and the porous nature of the soil precluded natural water catchments, "iron-clad catchments" were constructed. These were made of flat iron sheets laid on sloping ground, turned up and clipped together at the edges, to discharge water from rainfall into watertight covered storages.

During prolonged dry spells, water shortages occurred in the areas not served by bores, and water was brought to the settlers by train. Water trains were a feature of Mallee life until the channel system of water supply was installed.

Channel supplies

Recurring shortages of water in the Mallee led to the development of a water supply system in which water from storages in the wetter country to the south is delivered to the dry north through a network of channels. The first storage, Wartook in the Grampians, was completed in 1887, followed by Lake Lonsdale in 1902.

After the State Rivers and Water Supply Commission was formed in 1906, channel construction was pushed ahead until today 12 storages service 19,500 farms and 52 towns. Water is delivered a maximum distance of 480 km. The Millewa settlement and other farming areas near the Murray are supplied with water pumped from the river into earthen channels. After an inquiry, which was completed in 1967, the channels in the Millewa area are being replaced with pipes.

Irrigation

Irrigation schemes played an important part in the development of areas along the Murray. As early as 1884, more than 100 farmers were irrigating wheat farms around Swan Hill. However, the real impetus came in 1886, when George Chaffey came to Mildura to assess the potential of the area for irrigation.

The following year the Chaffey brothers and the Government signed an agreement for an irrigation settlement at Mildura.

In general terms the Chaffeys supplied capital, plant, and expertise and the Government made water and land available on attractive terms. Work commenced in 1888. The settlement began to encounter difficulties in 1892, and these culminated in a Royal Commission in 1896, which recommended a substantial loan in order to establish the scheme on a sound financial basis. After several more years of hardship, the area began to flourish and attracted more settlers. It is now a prosperous centre, producing vine and citrus products.

In its early years, the State Rivers and Water Supply Commission established the present system of farm water rights. As part of the closer-settlement movement, the Commission divided purchased properties and Crown lands into small units for extensive irrigation. From 1910 to 1930, large irrigation schemes were established at Merbein, Nyah West, and Red Cliffs. Robinvale was established for soldier settlers after World War II.

Transport

The earliest forms of transport in the Mallee were the horse and the bullock dray. Camels were also used. Movement was slow, as many sand-hills became impassable in summer and the flats were often waterlogged in winter. Because of the Mallee's large area and its distance from capital cities and ports, transport has played an important part in settlement and development.

Railways

Throughout much of northern Victoria, including the Mallee, settlement preceded railway construction by several years and farmers had to cart wheat long distances to the rail head. The Mallee Select Committee of the 1890s expressed the opinion that for successful settlement a suitable railway system was needed. Two key rules were formulated. One laid down that railways in a tentacle form are preferable to a network and the second declared that farmers must have railway access within a "fair day's journey", i.e. a maximum of 24 km. It was upon this basis that the parallel railway network has developed. The Mallee railways were built upon the estimate of revenue based on wheat traffic, and extensions could only be justified on a similar basis.

By the early 1880s the railheads were at Donald, Wycheproof, Boort, Kerang, and Dimboola. The proposed line to Adelaide was completed as far as Serviceton in 1887, and with gradual extensions year by year the lines had reached Birchip, Sea Lake, Quambatook, Swan Hill, Hopetoun, and Jeparit by 1895. For several years a suitable origin for the extension to Mildura was debated, but finally in 1899 it was decided to utilize the Birchip line. The connection to Mildura was opened in 1903.

Further extensions were made in subsequent years and the terminal points of

each line were completed as follows:

1914	Yaapeet
1920	Kulwin
1924	Robinvale
1925	Patchewollock
1926	Yungera

(but since partly closed)

Two lines, established after the others run to Murrayville and Morkalla. The Murrayville line runs from Ouyen and was the first line constructed in Victoria ahead of settlement. It was completed in 1912 and extended to Pinnaroo, S.A., in 1915. It connects with the line to Adelaide.

The Millewa line is the most recent and was completed to Meringur in 1925 and extended to Morkalla in 1931. Again, this more or less coincided with the closer settlement of Millewa, beginning in 1923.

A line running west from Nowingi (midway between Ouyen and Mildura) was built in 1928 and 1929 to serve a proposed settlement scheme in the Sunset Country. Thirty-five miles of line were to be built at first, with a later extension to Meribah, in South Australia. Lack of water prevented the settlement scheme from proceeding, and also stopped construction of the railway at the 24½-mile mark. A company operating a gypsum quarry took out a lease of the first 16 miles of the line in 1903, and this section is still in use. The tracks were removed from the remainder of the line during the 1940s.

River transport

Although Charles Sturt had shown in 1839 that the Murray was navigable, it was not until 1853 that the first riverboats steamed from Goolwa near the river mouth to Echuca. Within 10 years the river carried 17 steamers, and after another decade there were several hundred. Shipyards were set up to build the different types of steamers. Large boats more than 90 feet long transported wool, while small boats towing barges could operate on a low river. Some were hawkers' boats with one deck set up as a shop, and others were designed to serve the passenger trade. Most were side-wheelers.

The main commercial part of the river was from Goolwa to Echuca, although boats could navigate upstream as far as Albury. Normally they could operate for only 8 months of the year, as in summer the river carried insufficient water for navigation.

The boats carried a wide range of cargoes, the main ones being wool, wheat, flour, timber, and fruit.

The river trade reached its height in the years following the completion of the Echuca-Melbourne rail line. Ironically, the spread of the railways during the 1880s led to the decline of the

river trade, and in 1890 only 75 boats were cleared at Echuca. A few trading steamers struggled on until the 1930s and some boats survived in the timber trade until the 1950s. A few still ply the river for the tourist trade.

Local Government

The Shire of Swan Hill was created in 1871 and included all of the northern Mallee, while the Shire of Lowan (created 1875) covered the southern Mallee and much of the Wimmera. All the present-day shires, boroughs, and cities have been created by severance from the original shires, at the following times:

Kaniva	1891
Wycheproof	1894
Birchip	1895
Dimboola	1895
Karkarooc	1896
Walpeup	1911

The cities of Mildura and Swan Hill were created in 1934 and 1965 respectively.

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PART II

NATURE OF THE LAND

GEOLOGY

The Mallee study area lies within a large sedimentary basin, known as the Murray Basin, which evolved as the result of stretching of the earth's crust at the beginning of the Tertiary period. The sea eventually flooded the basin from the south, forming what is known as the Murravian Gulf, which at its maximum transgression covered parts of Victoria and South Australia and extended 150 km northwards into New South Wales. The basin filled with flat-lying sediments, which are almost completely covered by a veneer of Quaternary sediments.

The formations of Quaternary age, which are marked at the top by a soil and commonly at the base by a disconformity, are broadly subdivided into aeolian units (dune fields, sheets, lunettes, and source-bordering dunes) and alluvial units (channel, flood plain, and lacustrine deposits).

The Tertiary sediments of the basin include clay, silt, sand, gravel, marl, limestone, lignite, and glauconitic sediments. They generally thicken and dip gently towards a point immediately west of the north-western corner of Victoria. The main pre-Tertiary sediments consist of lower Permian fluvioglacials, granites of various ages, and metamorphosed sedimentary rocks of Cambrian to Lower Ordovician age. The different geological units have been described and placed into groups and formations, each identified by a place name relevant to the occurrence of the particular unit.

Map 3 shows the surface geology of the study area, and a cross-section.

Structure

Major faults are not a feature of the Murray Basin, and those that have been active are thought to coincide with older structures. One, the meridional Hindmarsh Fault, coincides with a basement greenstone belt. It was active throughout the Cainozoic era and facies changes occur across it. Another basement fault tends from the north-east to the south-west through Murrayville. Movement along this fault during the Upper Cainozoic has given rise to a monoclinal structure in the Tertiary sediments there.

The Leaghur Fault is oriented north-south and runs through Leaghur south-west of Kerang. Movement along the fault during post-Lower Pliocene times

has disrupted both basement rocks and basin sediments. The western block has moved upwards relative to the eastern block, resulting in deposition of Upper Cainozoic fluvial sediments to the east of the fault line but not to the west, where the Parilla Sand is exposed.

Apart from these notable examples there has been little disruption of the Cainozioc sediments, and as a result they are flat-lying.

Pre-Tertiary Basement Rocks

These rocks occur at the surface in one locality only within the study area, as a small granite outcrop near Lake Boga. Elsewhere pre-Tertiary basement rocks are buried beneath Cainozoic sediments, which generally thicken from approximately 200 m in the south-east to approximately 600 m in the north-west. The oldest basement rocks consist of folded Cambrian metasediments intruded by granite. Rock types include shale, slate, phyllite, and sericite schist.

Drilling indicates that Lower Permian glacial marine sediments (tillite, sandstone, silty clay, and siltstone) overlie the Cambrian metasediments in some places.

Lower Cretaceous sediments, consisting of sandstone and interbedded siltstone and mudstone up to 300 m thick, occur in the far north-west of the study area. These sediments are known as the Millewa Group and lie unconformably on the Lower Permian sediments.

Tertiary Sediments

Renmark Group

This group consists of a series of sands and carbonaceous sediments, which form the lower part of the Tertiary sequence and which were deposited in a non-marine environment, probably in lakes, streams, and marshes. They overlie Cambrian rocks and their granitic intrusives, although in some small areas they overlie Lower Cretaceous or Lower Permian sediments. The group is almost continuous throughout the region, although it does not outcrop in the study area. It reaches a thickness of more than 300 m to the west of Mildura.

Murray Group

This group consists of fossiliferous marine sediments, and includes all Tertiary marine sediments younger than the Renmark Group. It contains a number of formations that reflect the different environments for deposition afforded by the rapid transgression of the Murravian Gulf followed by a prolonged, gradual withdrawal of the sea.

The oldest unit of the Murray Group in the Ettrick Marl. It is found only in the western part of the area, and is a rapid marine transgressive deposit. The formation consists predominantly of

marl, with occasional thin beds of marly limestone and calcareous clays. It rests disconformably on the Renmark Group. To the east and north, the Ettrick Marl grades laterally into the Geera Clay. This is an olive to dark grey clay or silt that contains a few fossils, and appears to have been deposited in a shallow marine and lagoonal situation to which muds were added. It is distributed over a broad arc through Birchip and Nyah into New South Wales. Its boundary with the Renmark Group is similar to that of the Ettrick Marl.

During the mid-Tertiary era, when the marine transgression had reached its maximum, continuous beds of pure to marly limestone and marl were deposited in the western part of the area. The formation, which is known as the Duddo Limestone, is rich in fossils, is highly permeable and porous, and is a high yielding aquifer.

The nature of the eastern boundary of the limestone varies. The limestone grades eastwards, with some intertonguing, into the marly, silty, and fossiliferous Winnambool Formation, but to the south of Patchewollock the limestone pinches out rapidly to the east along a north--south line. This sharp facies change is accounted for by Cainozoic movement on the Hindmarsh Fault.

Northward, towards the New South Wales--Victoria border, the Duddo Limestone thins out, suggesting that it does not persist far into New South Wales. The eastern boundary of the limestone is probably near Carwarp on the Murray River.

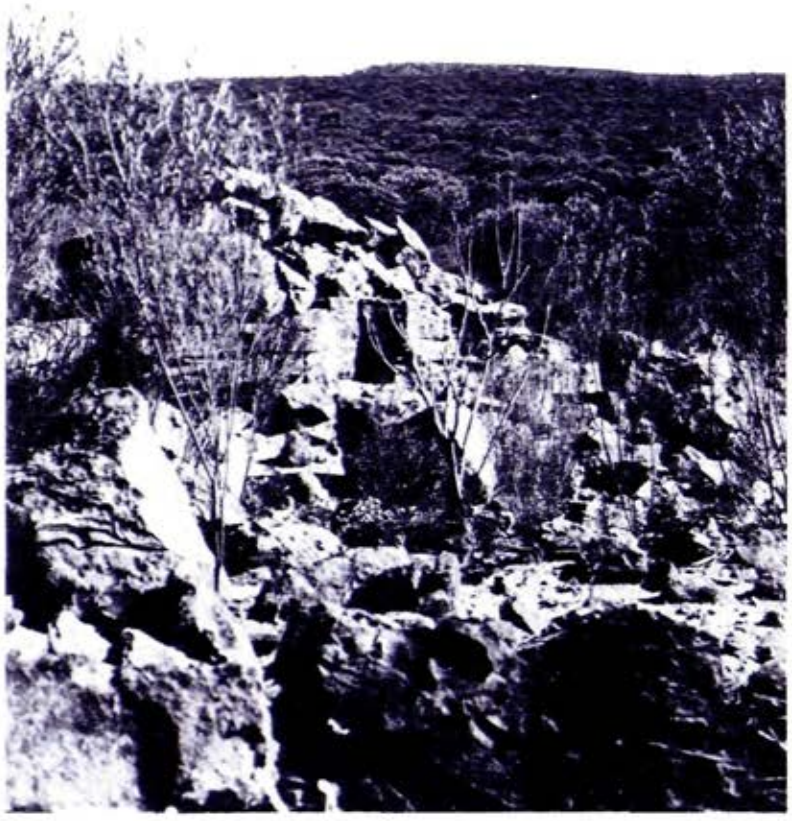
East of the Duddo Limestone are contemporaneous marine calcareous sediments, the Winnambool Formation, which probably extend in a broad arc from south of Hopetoun through Tempy and Piangil into New South Wales. The lithology is variable and ranges from a medium to light grey marly clay to marl, in which gastropod and pelecypod fossils are common. The environment of deposition was probably shallow, inshore waters. Towards the east the formation grades both laterally and vertically into the Geera Clay.

The Duddo Limestone and Winnambool Formation are conformably overlain by the Bookpurnong Beds. These are a series of dark glauconitic and calcareous or clayey silts, containing carbonate, which form a continuous unit over most of the Mallee region, except the eastern part. The beds were deposited in the inshore and coastal zones of the receding seas of the Murravian Gulf. They are about 3 m thick in the south, but increase in thickness markedly to the north; at Olney they are 65 m thick.

Parilla Sand

The Bookpurnong Beds are conformably overlain by the Parilla Sand, which extends as a continuous sheet throughout

the area. This latter formation was deposited when the sea of the Murravian Gulf receded after a brief advance. In the west it is overlain by a thin cover of Quaternary sediments, but there are prominent outcrops in the far east and the valley walls of the Murray River.



An outcrop of the Parilla Sand in the Big Desert

The Parilla Sand is a quartzose, poorly fossiliferous, well sorted silt to sand. It contains the stable minerals zircon, tourmaline, ilmenite, and rutile, either in dispersed or in concentrated form. Its upper surface is weathered to a lateritic profile where grains are cemented with kaolinite, limonite, and gibbsite. The laterite is a paleosol (ancient soil), the result of weathering during a former humid climate. Often the laterite is weathered, in turn, to a sandy soil, as occurs in the eastern outcrops.

The upper surface of the Parilla Sand is moulded into alternating ridges and valleys. The ridges are up to 70 m high and 3 km across, are sub-parallel, and trend NNW--SSE. It has been suggested that the ridges represent stranded coastal dunes. While there has been post-depositional stream dissection and partial infilling of the Parilla Sand, features suggesting stranded coastal dunes are reflected in the pattern of dissection. However, in the far eastern part of the study area the Cannie and Gredgwin Ridges are related to uplift immediately westward of the Leaghur Fault.

Most outcrops of the Parilla Sand are ridges, although there are outcrops in the Birchip district that have no topographic expression.

Sections of the Parilla Sand are revealed in quarries to the south-east and in cliffs along the Murray River in the north-west of the study area.

Quaternary Fluvial and Lacustrine Deposits

Wunghnu Group

This group, which consists of fluviatile and lacustrine sediments, predominates in the eastern part of the Murray Basin, where it occurs as a continuous unit throughout the flat Riverine Plain. In the study area its occurrence is restricted to the valleys of prior and existing streams, parts of the Swan Hill district, and around Birchip and Wycheproof.

In the Riverine Plain and outside the study area, the lower surface rests on the Renmark Group or on the Palaeozoic bedrock. It is probably of the same age as the marine sediments of the Murray Group occurring in the study area. However, only the upper part of the Wunghnu Group is represented in the study area.

Two formations within this group that outcrop in the study area are the Shepparton and Coonambidgal Formations. The Shepparton Formation includes the alluvial sediments of the Murray Basin which are older than the Coonambidgal Formation. This latter formation consists of the deposits of existing streams, or their recent ancestors.

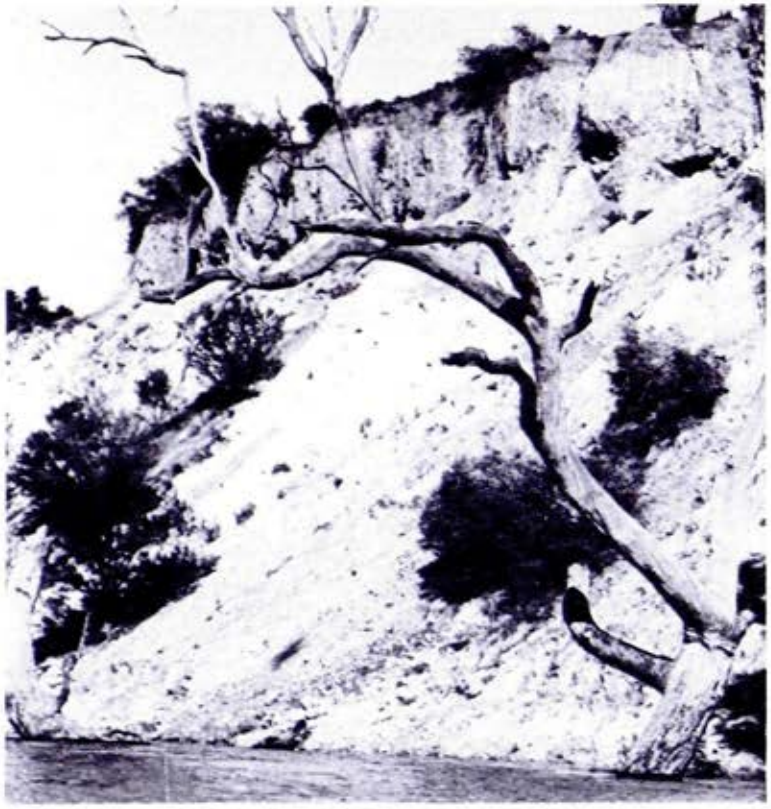
The Shepparton Formation is widespread in the Riverine Plain and rare in the east--west dune system, where it is always buried. It is characteristically covered by a thin layer of aeolian materials that has weathered to a heavy-textured calcareous duplex soil.

The Coonambidgal Formation is Upper Pleistocene to Recent in age and is usually associated with existing streams as terrace deposits. The degree of soil development is less than in the Shepparton Formation and its upper surface is often sculpted into a point bar or channel pattern. The Coonambidgal Formation is best known where it is associated with the Murray River drainage system. The lower terrace is well developed in the Hattah--Kulkyne area, and the upper terrace forms a vast plain in the far north-west of the State.

Blanchetown Clay and Bungunnia Limestone

These formations are Quaternary lacustrine deposits, and occur in close association in the north-west of the study area. They form a series of strips oriented NNW--SSE, in the same direction as the ridges of the Parilla Sand with which they alternate.

The Bungunnia Limestone consists of calcine dolomite, which contains ostracods and overlies the Blanchetown Clay. Its best outcrop is in the cliff of the Murray River at Boundary Point.



Blanchetown Clay and Chowilla Sand overlying the Parilla Sand in Murray River cliffs near Mildura

The Blanchetown Clay is exposed in most of the Murray River cliff sections, where it is represented by clay and sandy clay, which may be red or green, Occasionally a yellow fluvial sand, known as the Chowilla Sand, lies between the Blanchetown Clay and the Parilla Sand.

Yamba Formation

The Yamba Formation consists of Upper Quaternary gypseous deposits that occur in extensive playas, covered by a distinctive flora of salt-tolerant plants. Thin layers of gypsum occur immediately beneath the surface of playas and in transverse dunes of irregular distribution running north--south across the playas.

The gypsum is an evaporite deposit originating by precipitation from rising saline groundwaters.

Quaternary Aeolian Deposits

As shown on Map 3 aeolian deposits cover much of the study area. The most common unit is the Woorinen Formation.

Woorinen Formation

This consists of pale to dark reddish brown calcareous sandy clay and clayey sand in which at least five superimposed soils are present. The typical present-day Mallee soils have developed on this formation.

The upper surface of the Woorinen Formation has been moulded by the wind into several forms. Longitudinal east--west dune chains are widespread in the north and centre, but are less important in the south and east. In the Waitchie-Ultima district, the Woorinen Formation occurs in low elliptical to circular

Salt lakes fringed with glasswort west of Nowingi

hummocks, and near Brim it is a featureless sheet.

Throughout much of its distribution within the study area, the Woorinen Formation rests disconformably on the "lateritized" surface of the Parilla Sand. Here the topography is a composite of the closely spaced parallel east--west Woorinen Formation dune chains and the more irregularly spaced ridges of the buried Parilla Sand, which trend in a NNE--SSE direction.

Lowan Sand

The Lowan Sand consists of greyish yellow to brown, fine - to medium-grained siliceous sand. It is thought to have been formed by erosion of the Parilla Sand on which it lies. Within the study area it is represented by two huge "tongues", the Big Desert and the southern part of the Sunset country.

The dunes of the Lowan Sand lack the regular parallel pattern of the Woorinen Formation. Instead, a variety of dune types such as parabolic dune chains, densely packed low longitudinal dunes, and irregular dunes are present.

The instability of these dunes has prevented pronounced soil development, although in the swales there are signs of slight clay illuviation. Separating the dunes are swales and a few extensive sand plains.

Because of the irregular topography of the Lowan Sand, its thickness varies considerably from 1 m to probably 30 m beneath some of the largest dunes.

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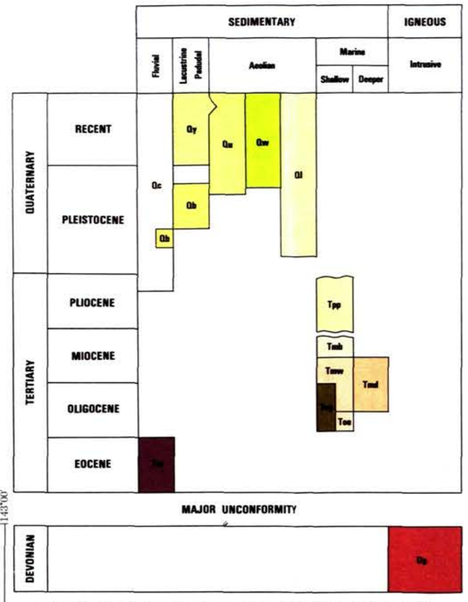
LAND CONSERVATION COUNCIL
VICTORIA

MALLEE STUDY AREA

GEOLOGY



WUNGHNU GROUP	Coonambidgal Formation and Shepparton Formation	Qc	*Clay, sand and sandy clay, slight soil development, also deposits of playas- often grey clay, in places buried beneath a thin layer of red sand or red-brown earth.*
	Yamba Formation	Qy	*Gypsum, evaporite deposits, macrocrystalline aeolian fine grained gypsum often as transverse dunes on floors of ancestral lakes.*
		Qa	*Lunette deposits; clay, silt, sand, gypseous clay and gypsrete. Includes several paleosols.*
	Woorinen Formation	Qw	*Sand, reddish, clayey. Includes paleosols with prominent calcite horizons. Parallel dunes orientated east-west.*
	Lowan Sand	Ql	*Sand, white to yellow, fine to medium grained. Sub-parabolic, parallel and irregular dune networks.*
	Bungunnia Limestone and Blanchetown Clay	Qb	*Dolomitic limestone, thin bedded dolomite containing ostracods Clay, sandy clay, silve to grey, fine bedded, containing ostracods, crustacean fragments.*
	Parilla Sand	Tpp	*Sand, sandstone and silt, white to yellow, cross bedding, lateritic weathering.*
MURRAY GROUP	Bookpurnong Beds	Tmb	*Calcareous clay and marl, grey, fossiliferous, sometimes glauconitic. Includes silt.*
	Dodda Limestone	Tmd	*Limestone, white, skeletal micrite to detrital micrite. Bryozoans major fossil group.*
	Winnambool Formation	Tmw	*Marly limestone, glauconitic silt and marl, grey, green, fossiliferous.*
	Ettrick Marl	Toe	*Marl, grey, fossiliferous and glauconitic, limonitic in places.*
	Geera Clay	Teg	*Clay, dark grey to black, rarely silt, sometimes glauconitic.*
RENMARK GROUP		Tor	*Siltstone, carbonaceous and dolomitic; lignite and sand, often pyritic and carbonaceous.*
	Lake Boga Granite	Dg	*Granite, felspar porphyry (composite intrusion).*
			Fault Inferred

1:500,000

MILES 16 12 8 4 0 16 MILES
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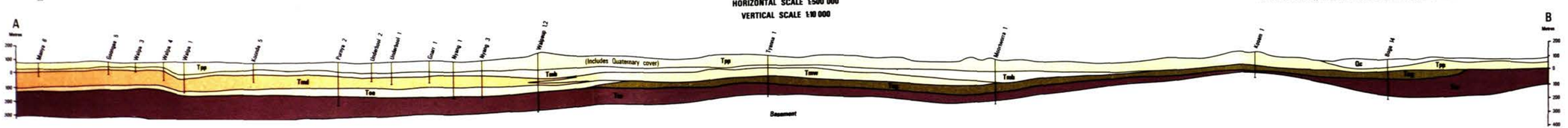
Some narrow stream frontages are not shown

CROSS SECTION

HORIZONTAL SCALE 1:500 000
VERTICAL SCALE 1:10 000



Prepared from maps supplied by the Geological Survey, Mines Department, Victoria.

MAP No 2

PHYSIOGRAPHY

The Mallee study area lies on a vast depositional plain on which sediments continue to be deposited and moulded. The plain slopes gradually to the north-west from elevations of about 100 m in the south to 50 m in the north. Relief is low throughout.

The study area has inherited features of the almost entirely buried topography of the Upper Cainozoic marine regressive sands and sandstones. NNW--SSE-trending ridges and valleys of these sands are still apparent, although now buried beneath thin Quaternary aeolian deposits that are represented by a variety of dune forms. Fluvial land forms, while extensive to the immediate east, are limited within the study area to the flood plains of the Murray, Loddon, and Avoca Rivers, and thin belts that are usually aligned NNW--SSE.

Eight land forms have been indentified in the study area and are described below.

Ridge

The ridges are usually 6--30 m high and 1--1.5 km across, with slopes between 1 and 3%. Their length varies from about 1 km to more than 50 km.

Ridges are most common in the central south of the study area, where they control the courses of Outlet and Yarriambiack Creeks. A major ridge extends from Galaquil in the south through Patchewollock to Meringur in the north, and Tyrrell Ridge runs from Watchupga in the south,along the western edge of Lake Tyrrell, to Robinvale. Five other roughly parallel ridges run between these, while smaller ones pass through Red Cliffs and Hattah.

In addition, two low broad ridges, known as the Gredgwin and Cannie Ridges, run between the Loddon and Avoca Rivers and from Cannie to Nyah West respectively.

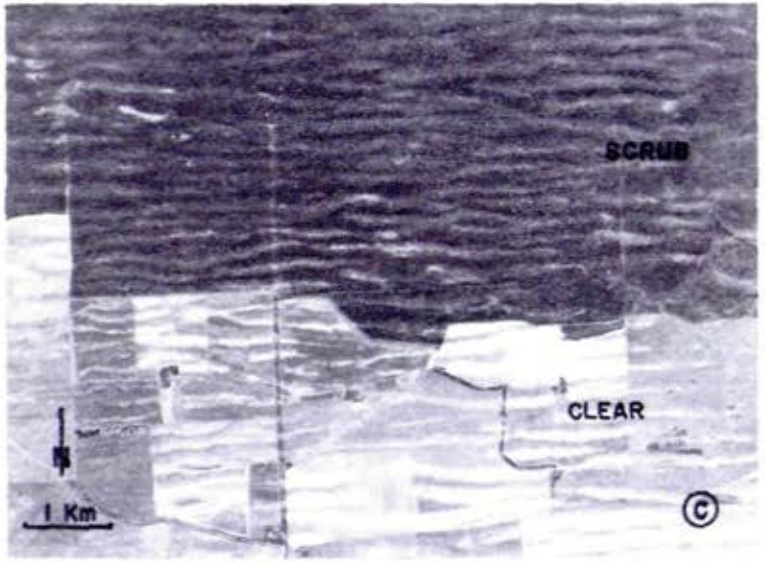
The ridges are composed of the Parilla Sand and are believed to represent dunes established at successive coastlines by the receding Murravian Gulf. They are frequently covered by the dunes of the Woorinen Formation and the jumbled dunes of the Lowan Sand.

The Cannie and Gredgwin Ridges are exceptions in that they were formed tectonically by uplift along the Leaghur Fault, and carry very few east--west dunes of the Woorinen Formation.

Dune

Dunes are strongly aligned east--west, and form a striking feature of the landscape. Most are 80--120 m wide, 3--10 m high, and 1--3 km long. In profile they are asymmetrical, with the south slope steeper than the north slope. They consist of the sands and clays of the Woorinen Formation.

Although these "tear-drop" shaped longitudinal dune chains almost certainly formed parallel to the dominant wind directions rather than transversely, they cannot be classed as typical longitudinal dunes like those in Central Australia. They were probably formed as a result of the winds shifting direction by more than 90°, westerlies largely influencing their formation.



Longitudinal (east--west) dunes of the "tear-drop" type north of Murrayville (vertical aerial photograph)

The dunes are relatively stable at present, although they were mobile during arid periods in the Pleistocene.

Irregular dune

These dunes are elongated, curve sharply, and include parabolic and subparabolic types. The average dimensions are greater than those of the east--west trending dunes, and impressive razor-backed prominences more than 30 m high are common.

Within the study area these dunes are confined to the Big Desert and the southern part of the Sunset Country. Their formation may be attributed to the copious quantities of Lowan Sand available.

Hummock

Hummocks are subcircular in plan and are only weakly elongated. They occur as individual mounds on plains or ridges. Their dimensions vary from about 30 to 1,200 m across and from about 1 to 7 m in height. Slopes are gentle, usually from 1 to 3%.

Hummocks are common in the Millewa, Central Mallee, Boigbeat, and Culgoa land systems. They are aeolian land forms,

but the conditions under which they were formed are not known.

Plain

Small plains are frequent throughout the aeolian landscapes of the Mallee, and consist mainly of heavy-textured material of the Woorinen Formation and Lowan Sand.

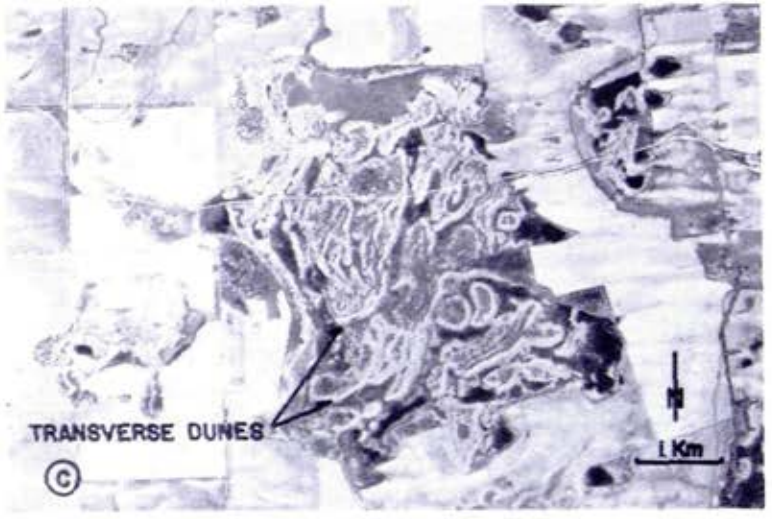
Alluvial plains of the Coonambidgal Formation occur along the streams that penetrate the Mallee, and reach their greatest extent on the Murray River in the Hattah--Kulkyne area, and around Ned's Corner. The plains are crossed by

Irregular dunes and intervening sandplains in the Big Desert (oblique aerial photograph)

Floodplain and terraces of the Murray River west of Mildura showing meanders, oxbow lakes, and scroll patterns (vertical aerial photograph)

numerous meanders, anabranches, and billabongs. Meander patterns are still discernible on the higher terrace near Ned's Corner.

Plains of older alluvium (the Shepparton Formation) occur on the south-eastern boundaries of the study area. They represent the northern edge of the Wimmera



Gypsum flats with numerous transverse dunes, near Chinkapook (vertical aerial photograph)

plains and western edge of the extensive Riverine Plains of northern Victoria and southern New South Wales. Some leveed stream traces can be recognized in this latter area, although in the study area the plains are covered by a layer of the Woorinen Formation materials.

Lunette

This is a crescent-shaped ridge found on the eastern shores of lakes or dry lakes. The horns of the crescent point westward. The dimensions of the lunette depend largely on the size of the associated lake. In the study area, heights vary from 1 to 22 km. Some lakes have more than one lunette on their eastern shores.

Lunettes are composed of layers which vary from sands to clays. Some layers are derived from the lake floors while others appear to have originated as regional dust deposits.

Salt lake--gypsum flat

These are low-lying areas, generally at altitudes of less than 70 m. They are widespread (Raak land system), with the largest areas at Lake Tyrrell and the Raak area west of Nowingi.

At Lake Tyrrell and associated lakes, the water table outcrops in winter, but the lakes become dry in summer. Occasionally, surface water reaches the lakes via Tyrrell and Lalbert Creeks, which are effluents of the Avoca River. Islands of powdered gypsum (transverse dunes) occur on the lake floors.

The Raak area is not a site of internal drainage, nor does groundwater outcrop there, but it may be an ancestral lake system now partly covered by aeolian sands. In the western part an extensive gypsum flat occurs, with numerous transverse dunes.

Transverse dune (copi island)

These are dunes or mounds on dry lakes, composed mainly of layers of copi (pow-

dered gypsum), gypsum, and sandy materials. Limestone is sometimes present. A typical "copi island" may have a surface layer of sand or loamy sand a few centimetres thick on the western face, and deeper towards the east. The second layer from the surface is white copi. The materials are derived mainly from the dry lake beds, with probable additions of regional dust.

Transverse dunes are usually less than 5 m high and about 100 m across. They can be subcircular, elongated, or irregular in plan, depending on whether the dune has been remoulded by wave action during the times when the lake held water, as for example at Lake Tyrrell.

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CLIMATE

The climate of north-western Victoria is semi-arid. Summers are hot and mainly dry while the winters are mild and usually moist. Thus the climate resembles the Mediterranean type, although it differs in that significant falls of summer rain sometimes occur. As the region is of uniformly low relief, no great variations in climate occur across it. Rather there is general gradation from south to north, with the north being drier and hotter.

Rainfall

The average annual rainfall decreases from 350 mm in the south to 250 mm in the north, and from field observations over a number of years, a difference in average annual rainfall of from 7 to 10% (approx. 25 mm) is significant for agriculture.

Isohyets are shown at 25 mm intervals on the land systems map (facing page 104) and have been drawn as "lines of best fit", based on data for the 30-year standard period (1931--1960) supplied by the Commonwealth Bureau of Meteorology.

The rainfall is not only low but also unreliable. At Ouyen, the yearly total has been from 108 to 680 mm, and the monthly totals also show wide variation. Percentage variability equals average deviation from mean annual rainfall, divided by mean annual rainfall, multiplied by 100. Its values here - 26% at Mildura, 23% at Swan Hill, and 21% at Wycheproof - provide another indication of the unreliability of the rainfall. These values also indicate that the variability increases from south to north.

The rainfall distribution throughout the year at selected stations is given in Table 1 and graphed in Figure 1. On average, the wettest months are from May to October. At Ouyen these six cooler months receive 60% of the yearly total. A minor peak in the rainfall curves occurs in February, and rains in this month are relatively heavy as shown by the rainfall per wet day, which at Rainbow, for example, is 9 mm compared with the yearly average of 4 mm.

Drought

Aridity imposes the most important restriction on land use in the Mallee. Even in years of average rainfall, dry spells during the growing season (April or May to October or November) limit

TABLE 1

DISTRIBUTION OF RAINFALL THROUGHOUT THE YEAR AT SELECTED STATIONS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mildura (1934-72)													
Av. rainfall (mm)	25	21	19	16	27	23	26	26	23	29	22	19	276
Av. number of wet days	4	2	4	5	8	8	10	10	8	6	6	5	76
Av. rainfall per wet day (mm)	6.4	10.5	4.8	3.2	3.4	2.9	2.6	2.6	2.9	4.8	3.7	3.8	36
Ouyen (1913-1972)													
Av. rainfall (mm)	20	25	21	22	32	30	30	33	32	35	26	24	330
Av. number of wet days	3	3	3	5	7	8	10	10	7	7	6	4	73
Av. rainfall per wet day (mm)	6	8.3	7	4.4	4.6	3.8	3	3.3	4.6	5	4.3	6	46
Rainbow (1901-1972)													
Av. rainfall (mm)	18	27	21	25	38	36	37	38	39	34	27	24	364
Av. number of wet days	4	3	3	6	9	10	12	12	9	8	6	4	86
Av. rainfall per wet day (mm)	4.5	9	7	4.1	4.2	3.6	3.1	3.2	4.3	4.3	4.5	6	43

yields of crops and pastures.

Droughts are relatively long dry periods permitting little or no harvest and very scant pasture growth. Although they are difficult to define statistically, six very severe droughts lasting longer than 12 months have occurred since reliable records have been kept (Foley 1957). These were in 1895--1902, 1913--15, 1918--20, 1925--30, 1942--45, and 1966--68 and had devastating effects on pastures, crops, soil stability, and water supply. Several dry months prevailed during the 1972 growing season also, resulting in yields well below average and severe erosion.

Recurrent drought must be regarded as a normal feature of the environment. During these periods plant growth is so poor that wind erosion causes widespread deterioration of the soils. The severities of the recognized droughts are compared in Table 2. In terms of the number of months when rainfall was less

TABLE 2

MONTHLY RAINFALL (mm) RECORDED AT OUYEN IN YEARS OF MAJOR DROUGHTS

Successive months of drought in specified drought periods indicated in italic type

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year	No. of months of drought*	
1913	0	13	79	33	34	0	0	13	59	*64*	*12*	*26*	333	3	
1914	*3*	*16*	*27*	*41*	*14*	*3*	*9*	*0*	*1*	*0*	*20*	*28*	162	12	20
1915	*16*	*0*	*0*	*9*	*34*	40	42	29	93	14	5	0	281	5	
1918	15	12	30	32	105	24	19	45	9	23	5	0	319	4	
1919	*0*	*59*	*16*	*10*	*48*	*23*	*12*	*9*	*14*	*5*	*16*	*55*	267	10	19
1920	*2*	*0*	*6*	*7*	*20*	28	43	79	81	81	21	25	393	5	
1926	3	0	8	49	74	19	34	35	*42*	*16*	*0*	*27*	307	4	
1927	*12*	*6*	*6*	*0*	*18*	*8*	*38*	*18*	*18*	*27*	*9*	*4*	164	11	
1928	*11*	*60*	*18*	*38*	*14*	*39*	*27*	*6*	*22*	*30*	*0*	*6*	271	10	36
1929	*3*	*24*	*3*	*22*	*9*	*23*	*9*	*18*	*11*	*4*	*20*	*70*	216	11	
1930	*0*	*1*	*13*	*5*	*67*	4	26	36	16	86	16	32	302	4	
1942	11	4	4	28	55	53	33	52	*19*	*53*	*28*	*6*	345	4	
1943	*11*	*9*	*3*	*16*	*5*	*22*	*26*	*40*	*22*	*27*	*20*	*27*	228	10	
1944	*10*	*5*	*4*	*12*	*45*	*1*	*17*	*4*	*10*	*26*	*22*	*28*	184	11	40
1945	*1*	*9*	*2*	*0*	*15*	*57*	*19*	*44*	*12*	*32*	*19*	*14*	224	10	
1946	*59*	*69*	*41*	*4*	26	32	33	30	13	12	30	14	363	5	
1966	11	31	27	9	18	5	31	*30*	*35*	*32*	*10*	*55*	294	5	
1967	*3*	*16*	*0*	*1*	*26*	*21*	*7*	*16*	*10*	*2*	*0*	*6*	108	12	21
1968	*42*	*12*	*12*	*49*	50	48	19	48	6	26	17	21	350	4	
1971	27	15	70	83	17	25	25	32	*17*	*14*	*56*	*16*	397	4	
1972	*49*	*48*	*0*	*24*	*42*	*3*	*10*	*37*	*16*	*11*	*26*	*2*	268	10	15
1973	*19*	*118*	*43*	*39*	48	67	51	71	34	114				1	
Means (60 yr)	20	25	21	23	32	31	30	33	33	35	26	24	333		
	Calculated Average Potential evapotranspiration (mm)														
	132	104	91	56	38	23	20	31	46	69	89	119	818		

* Number of months during specified period when rainfall was less than calculated potential evapotranspiration

TABLE 3

AVERAGE MAXIMUM AND MINIMUM TEMPERATURES (°C) RECORDED AT THREE STATIONS FOR THE FOUR SEASONS OF THE YEAR

Station	Summer (Dec. - Feb.)		Autumn (Mar. - May)		Winter (June - Aug.)		Spring (Sept. - Nov.)	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Mildura	32	16	24	10	16	5	25	11
Swan Hill	31	15	23	9	15	5	24	9
Birchip	30	13	23	9	15	4	23	8

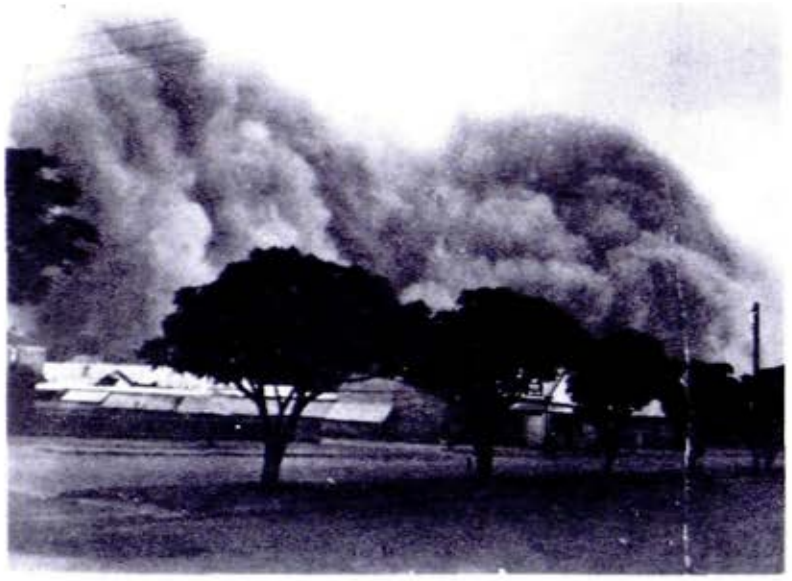
than the calculated average potential evapotranspiration, the worst droughts were those in 1925--30 (36 months) and 1942--45 (40 months).

Temperature

Data on temperature in Table 3 show that summers are hot and winters mild. Throughout the year, slightly higher temperatures prevail in the north than the south. Temperatures above 34°C are common during summer and most stations have recorded 46°C. Normally, several frosts occur during the cooler months (May to September).

Temperate-zone plants cease growth when temperatures fall below approximately 5°C and their optimum growth rate occurs at about 27°C. Table 3 shows that the average winter maximum temperature is about 16°C. This allows considerable

Bare ground on a grazing lease in the Millewa block during the 1966-68 drought



A dust storm in a Mallee town in the 1930s

growth of crops and pastures. Optimum temperatures for growth occur mainly in early autumn and late spring.

Evaporation

Average annual evaporation ranges from 1,300 mm in the south of the study area to just over 1,500 mm in the north. In winter, average monthly values are about 40--50 mm. Evaporation is usually greatest in January, when values range from 230 mm in the south to 250 mm in the north. (All values are for Australian Sunken Tank.)

Winds

Winds in the Mallee usually blow from the northern, western, or southern quarters. In summer the northerlies from the interior of the continent are hot and dry, while the west to south-westerly winds are cooler. In the winter there is no marked difference between the various windstreams.

Strong winds are an important factor in soil erosion in this region. Winds reach gale force on several days each year as a rule, and field observation suggests that most wind erosion occurs on these days. During dry periods, soil from bare fallows and overgrazed pastures may "blow", the finer particles being lifted into the air to form dust storms, while the heavier particles are driven along the surface to be deposited on fences and roads. This latter process is called "saltation". As gales come mainly from the west, south-west, or north-west, the general direction of soil drift is from the west. In recent years, dust storms have been fewer than in the earlier days of settlement owing to improved farming techniques, particularly in regard to fallows, and to less-frequent droughts.

Growing season

A study of the combined effects of rainfall and evapotranspiration gives a better understanding of the availability of moisture for plant growth than an

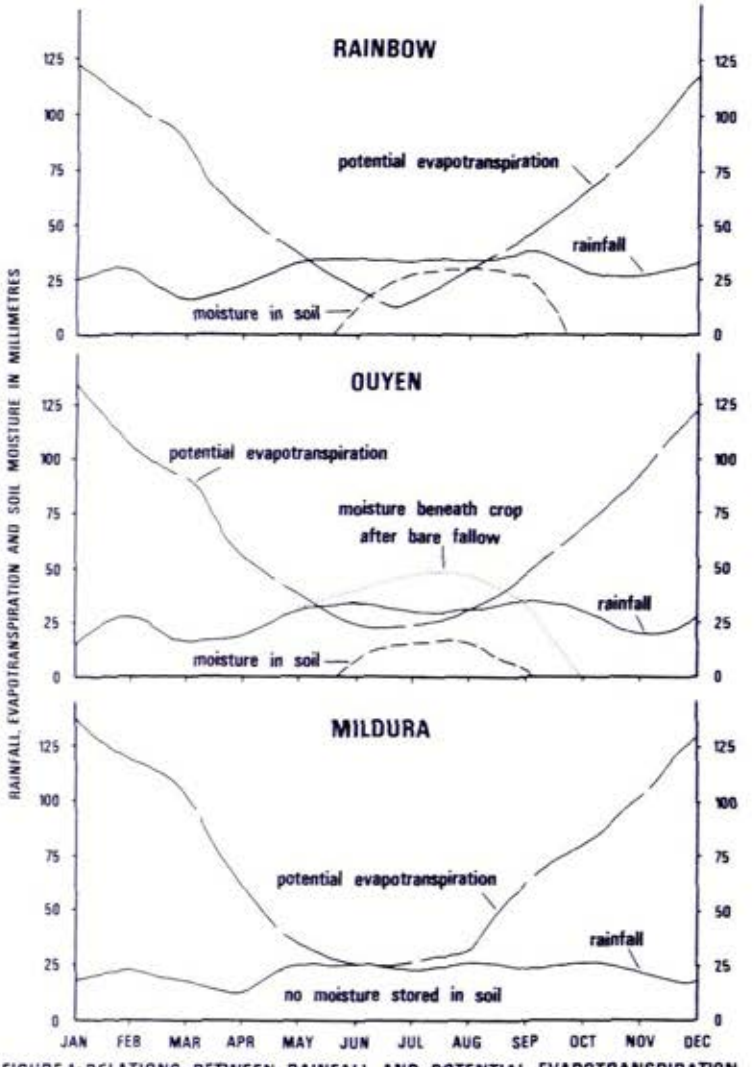


FIGURE 1: RELATIONS BETWEEN RAINFALL AND POTENTIAL EVAPOTRANSPIRATION

Taken from Gibbons and Downes (1963)

examination of rainfall records alone. Leeper (1950) proposed a formula for calculating monthly potential evapotranspiration from temperature records. This value, when compared with monthly rainfall, indicates whether the moisture received is sufficient for plant growth. Rainfall and evapotranspiration have thus been compared in Figure 1 for three stations representative of the south (Rainbow), centre (Ouyen), and north (Mildura), the graphs being based on average monthly records for the period 1911--40.

Figure 1 shows that the growing period is limited, on the average, to three winter months at Ouyen. The closeness of the two curves during the growing period indicates that the build-up of soil moisture is only slight (for example it is less than 5 m at Ouyen). These findings agree well with field observation.

The dotted-line graph for Ouyen indicates that crops on fallowed land are supplied with adequate moisture for some weeks longer than crops without fallow. However, crop yields are still limited by lack of moisture in late spring, and good rains are needed in October and November to produce heavy crops. Figure 1 also shows that, compared with Ouyen, Rainbow has a more favourable moisture supply during the growing period and Mildura a less favourable one. Because Figure 1 is based on average monthly data, it does not show the value of rain outside the growing period, particularly

for perennials, which can respond to autumn, spring, and summer rains.

The above calculations of growing seasons, having been derived from climatic averages for dense ground cover, may be quite inaccurate for the predominantly sparse and xeromorphic native trees and shrubs. These have deep root systems and probably maintain their green tissues over the long dry periods by tapping moisture which penetrates deeply after the rare prolonged rains.

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WATER RESOURCES

Surface Water

The Mallee lies on porous sediments in a semi-arid zone, and so it lacks a surface drainage system. Although eight streams (with catchments to the south and east) enter the study area, only three - the Murray, Avoca, and Loddon Rivers, maintain permanent flows. Gaugings for these streams are set out in Table 4. No reliable data are available for the minor streams, namely Outlet, Yarriambiack, Dunmunkle, Tyrrell, and Lalbert Creeks. These are effluent streams, which in wet years flow north into the dry country until they terminate in shallow depressions.

Seasonal conditions have a marked effect on the flow of the Murray. Since gaugings began at Swan Hill, the Murray has ceased to flow there for short periods in 1914, 1915 and 1923. Since the Hume Reservoir was constructed, the river has been kept flowing at all times, despite several severe droughts.

Water quality

Salinity in the Loddon Rivers averages

TABLE 4

Stream Gaugings

Stream	Station	Records	Annual discharge (Ml)		
			Maximum	Minimum	Mean
Avoca	Coonooer	1890--1970	396,944	3,272	76,204
Loddon	Appin South	1946--1970	307,632	5,261	92,011
Murray	Swan Hill	1909--1970	7,717,955	1,094,097	4,239,318

The Murray River near Mildura at a time of high winter flow

500-600 mg/l total dissolved solids (T.D.S.). Water from this river is sometimes diluted with higher-quality water before delivery to Kerang for domestic use. The Murray River contains 100--200 mg/l T.D.S. at Swan Hill and is slightly more saline at Mildura.

Salinity in the Avoca River varies greatly with stream flow. During dry periods the river may become quite saline (up to 5,000 mg/l T.D.S. in its lower reaches),while during floods water quality improves (200 mg/l T.D.S.). Average quality is about 2,000 mg/l T.D.S.

Groundwater

The search for groundwater in the Mallee began in the 1880s, and an official program of exploratory drilling continued during the period 1908--1915. The groundwater proved to be of good quality in the south-west, but mainly saline elsewhere.

The Murray Basin

The study area lies towards the centre of the Murray Basin, a sedimentary basin that acts as a closed groundwater basin.

Groundwater saturates the Tertiary and Quaternary sediments of the basin - from the surface near lakes and streams, or from a depth of about 50 m elsewhere, down to the pre-Tertiary basement. The groundwater has originated in two main ways - from rainwater seeping down through the sediments or from seawater trapped in them at the time of their deposition.

The main recharge area lies immediately to the north of the Dundas Highlands, south of the study area. Only a few, small, localized recharge areas occur within the study area. Since under natural conditions the aquifers and the associated less-permeable sediments have constant storage capacity, water entering the groundwater basin and moving north displaces an equal volume at discharge zones. Discharge occurs into the Murray River, particularly downstream from Loxton (South Australia), and into numerous salty lakes in the northern and eastern parts of the study area.

There are four main aquifers or aquifer systems in the study area. They are, from deepest to shallowest, the sands of the Renmark Group, the Duddo Limestone--Winnambool Formation, the Parilla Sand, and the Wunghnu Group (see chapter 4 and the cross-section on the geology map). Figures 2,3, and 4, give quality classes for groundwater.

Sands of the Renmark Group

This group is almost continuous throughout the study area, but as yet its groundwaters have not been fully explored. Discharges of up to 38 litres per second have been pumped from screened bores, and the salinity of the groundwater is invariably less than 12,000 mg/l T.D.S. The sands are 300--400 m from the surface.

Good-quality groundwater in the Carwarp--Yatpool area (south of Mildura) has been reported. Exploratory drilling in the late 1960s indicated that water with a salinity of 3,000--5,000 mg/l T.D.S. was present in Renmark Group sands in the Natya--Yungera area. The relatively low salinity of the groundwater in the Renmark Group aquifer system suggests that there has been circulation to flush out the saline connate water expected to remain after sedimentation.

Clearly, the sands of the Renmark Group offer potential for groundwater development in the Mallee.

Duddo Limestone--Winnambool Formation

The Duddo Limestone and the closely related but less permeable Winnambool Formation act as semiconfined to confined aquifers. The Duddo Limestone is the most productive source of groundwater in the Murray Basin, and provides water for town, industrial, irrigation and stock purposes in an area of about 5,800 sq km in South Australia and Victoria. Since the permeability and porosity of the Duddo Limestone are fairly high, it has excellent properties as an aquifer. Consequently no special technology is involved in tapping it and the bores do not require casing. The location of the limestone is well known, and it occurs in a continuous unit 45--120 m thick, at depths ranging from 70 to 130 m. Salinities are often less than 3,000 mg/l T.D.S.

Measurements show that in the Duddo Limestone the hydraulic gradient is towards the Murray River downstream from Loxton. In the Mallee the groundwater moves northwards beneath the Big Desert, and then to the north-west.

The difference in permeability between the Duddo Limestone and the Winnambool Formation is reflected in the salinities and yields of each. The low hydraulic gradient for the Winnambool Formation suggests that the groundwater is stagnant and the high salinity (which ranges from 5,000 to 35,000 mg/l T.D.S.) indicates that the groundwater contains a

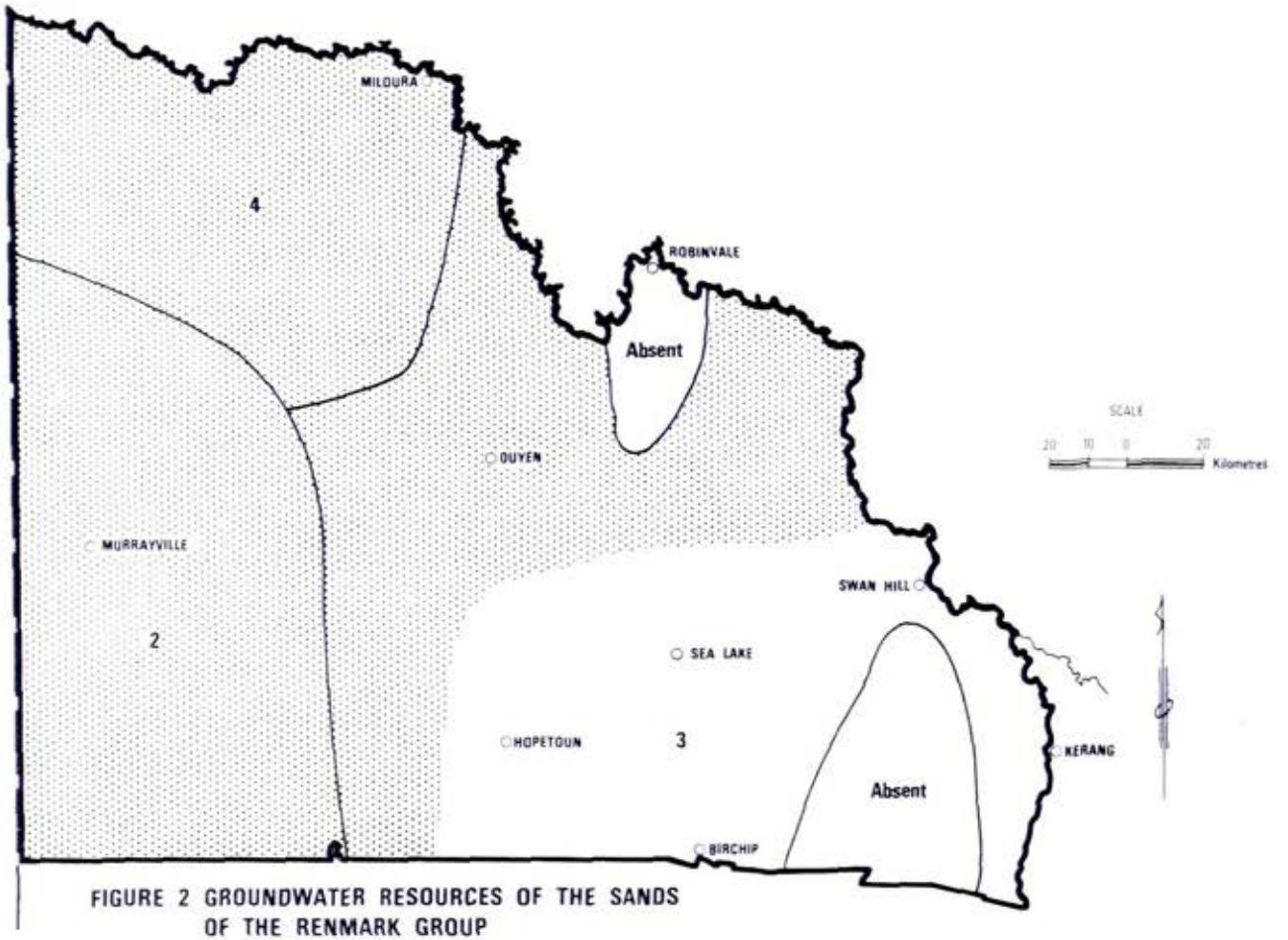

FIGURE 2 GROUNDWATER RESOURCES OF THE SANDS OF THE RENMARK GROUP

QUALITY CLASSES

	mg l T.D.S			mg l T.D.S	
1	<1 000	Commonly suitable for domestic and industrial uses and for livestock and irrigation	4	7 000 14 000	Suitable for sheep beef cattle will tolerate up to 10 000 mg l T.D.S
2	1 000 3 000	Suitable for all livestock some domestic and limited industrial uses and for irrigation under favourable conditions	5	>14 000	Unsuitable for livestock
3	3 000 7 000	Suitable for most livestock and very limited domestic and industrial use			Areas in which yields in excess of 12 61 s are available (Note inferred large yields not based on pumping tests but on thickness and texture of the aquifer)

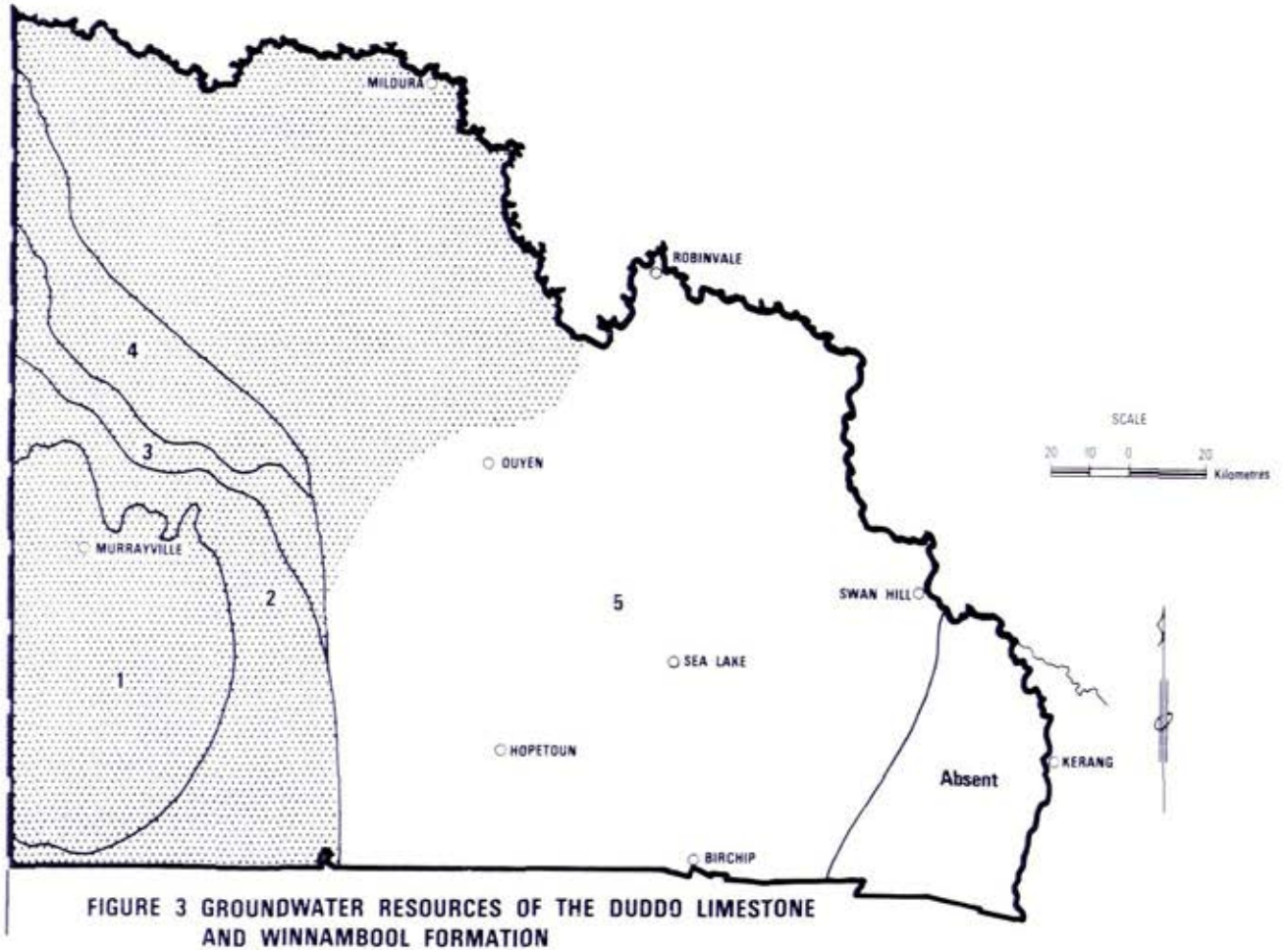

FIGURE 3 GROUNDWATER RESOURCES OF THE DUDDO LIMESTONE AND WINNAMBOOL FORMATION

QUALITY CLASSES

	mg/l T.D.S			mg/l T.D.S	
1	<1,000	Commonly suitable for domestic and industrial uses, and for livestock and irrigation	4	7,000-14,000	Suitable for sheep, beef cattle will tolerate up to 10,000 mg/l T.D.S.
2	1,000-3,000	Suitable for all livestock, some domestic and limited industrial uses, and for irrigation under favourable conditions	5	>14,000	Unsuitable for livestock
3	3,000-7,000	Suitable for most livestock and very limited domestic and industrial use			Areas in which **yields** in excess of 12 6l/s are available

"The Springs", on the Murrayville-Yanac Road is a freshwater spring fed from perched groundwater in the surrounding dunes

large proportion of trapped connate water. Discharges through a 15-cm bore are always less than 6.3 l/s for the Winnambool Formation, whereas discharge rates for the Duddo Limestone range from about 12.6 to 100 l/s.

The boundary between the groundwaters of different salinities is sharp 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, where the Fault is inactive, a broad salinity transition zone tends to the north-west.

The Parilla Sand

This unit acts as an unconfined aquifer throughout most of the Mallee. The watertable lies at depths of 0 to 45 m, sloping towards the Murray River and probably discharging groundwater into it.

The salinity of the groundwater varies greatly, but generally increases towards the north. Upward leakage from the deeper aquifers and influent seepage from streams and lakes account for local variations. The unconfined water in the Parilla Sand was once exploited by dug-wells, from which discharges of less than 1.25 l/s were obtained, but with the advent of drilling this aquifer has been neglected and water from the higher-yielding, deeper aquifers has been harvested instead.

The Wunghnu Group

Shallow aquifers occur in this group in the far eastern part 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 distributary pattern of the ancestral drainage systems, which emerge from the same valleys in the Great Dividing Range as are occupied by the existing streams.

A general increase in salinity of the Wunghnu Group groundwaters occurs

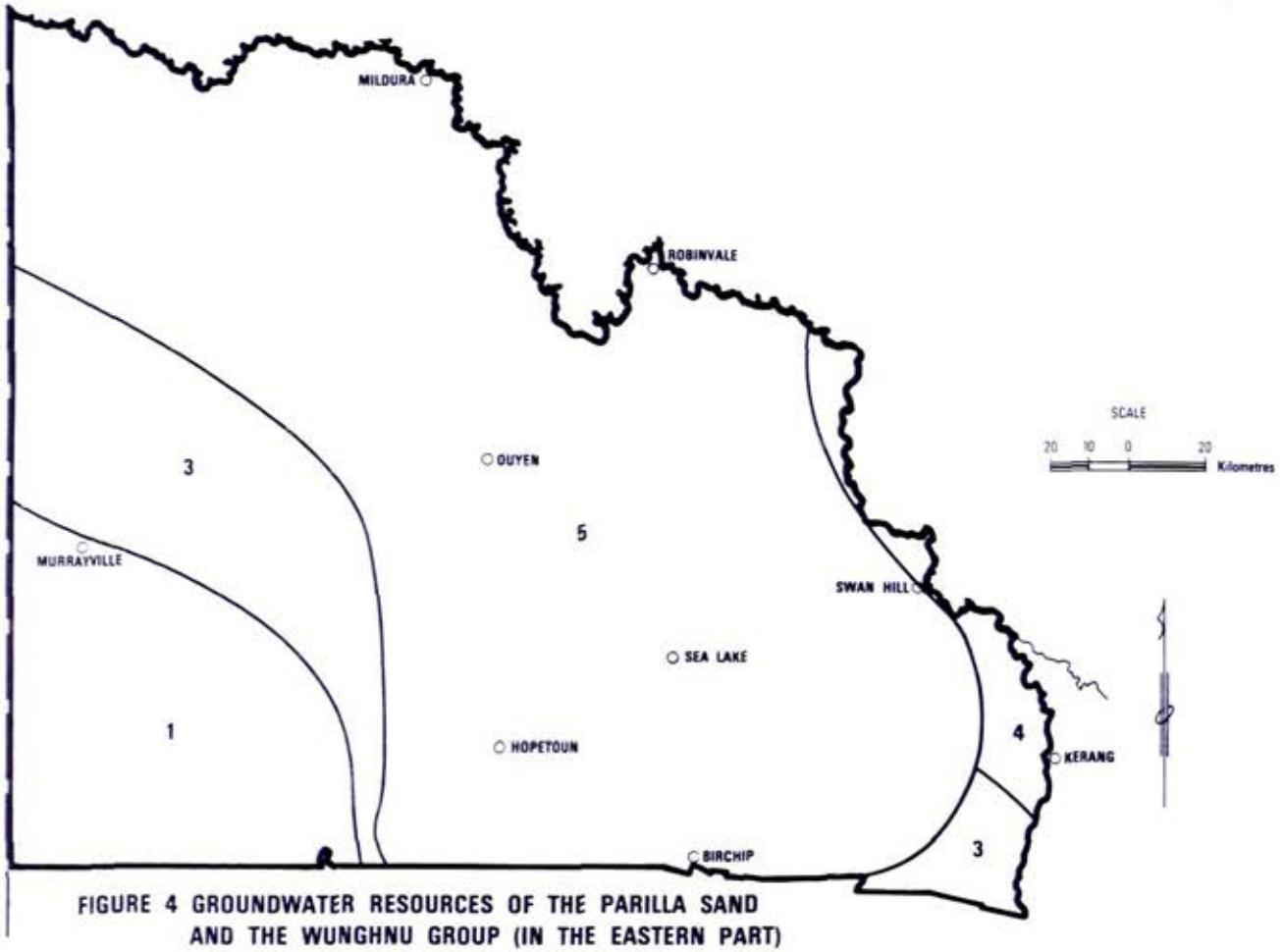

FIGURE 4 GROUNDWATER RESOURCES OF THE PARILLA SAND AND THE WUNGHNU GROUP (IN THE EASTERN PART)

QUALITY CLASSES

	mg/l T.D.S.			mg/l T.D.S.	
1	< 1,000	Commonly suitable for domestic and industrial uses, and for livestock and irrigation	4	7,000-14,000	Suitable for sheep; beef cattle will tolerate up to 10,000 mg/l T.D.S.
2	1,000-3,000	Suitable for all livestock, some domestic and limited industrial uses, and for irrigation under favourable conditions	5	> 14,000	Unsuitable for livestock
3	3,000-7,000	Suitable for most livestock and very limited domestic and industrial use			Areas in which yields in excess of 12.6 l/s are available

Developing a bore in the eastern Mallee by surging with compressed air

towards the centre of the Murray Basin, and this overrides the irregular and highly variable salinities within separate aquifers in any vertical section of the Group. While salinity can be very low close to the highlands, within the Mallee it always exceeds 7,000 mg/l and can reach 30,000 mg/l T.D.S. The highly saline waters in this group are considered to be connate waters and are associated with either deposition of salt from salt-water lakes, or post-depositional concentration, especially by evapotranspiration.

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SOILS

Detailed information about the soils of the area has been obtained from soil-type surveys, which (with one exception) are confined to irrigated districts along the Murray and Loddon Rivers, and may be found in several bulletins issued by the Victorian Department of Agriculture and the CSIRO Division of Soils (see references). Northcote (1960) has mapped the soils at a scale of 1:2,000,000, and Rowan and Downes (1963) have described and mapped the soils of most of the area on a regional scale.

Parent materials

The soil parent materials over most of the study area are the calcareous aeolian deposits of the Woorinen Formation. Sandy profiles occur on the dunes, which were formed chiefly by saltation, and textures become heavier downslope, with increasing proportions of clayey dust ("parna") in the parent materials. The upper one or two metres are characteristically layered, and the modern soil overlies remnants of two or more older soils. This layering is thought to be related to erosion during a series of arid periods of the Quaternary. Other common parent materials in the region are the Lowan Sands (of the Big Desert and Berrook areas) and alluvium (chiefly of clay texture) in the Coonambidgal Formation along the Murray River and the Shepparton Formation in the south-east.

The classification of soils set out in Table 5 is that of Rowan and Downes (1963), modified by the use of more descriptive terms for the local groups. In the terms of the great soil groups, several of the local groups are widely known as "solonised brown soils" or "Mallee soils", characterized by an abundance of limestone, marl, and soluble salts, and by weak leaching in a dry climate.

Soil features

The classification in Table 5 is based largely on soil texture, which has been found to influence greatly the availability of moisture and nutrients to crops and pastures.

Under the semi-arid climate, sandier soils have the more favourable moisture characteristics, although these are modified by current agricultural management techniques. Rainfall penetrates

* Stace et al(1968)

TABLE 5

SOILS OF THE STUDY AREA

Texture			
Surface	At Depth	Local Soil Group	Great Soil Group*
Sands	No change	Deep sands	-
	Sandy loam, sandy clay loam	Sandy calcareous soils - red, reddish yellow, white	Solonised brown soils
Sandy loams and sandy clay loams	Gradual change to sandy clay loam or sandy clay	Medium-textured calcareous gradational soils	Solonised brown soils
	Abrupt change to sandy clay loam or sandy clay	Medium-textured calcareous duplex soils	Solonetz
	Abrupt change to clay	Heavy-textured calcareous duplex soils	Red-brown earths
	Abrupt change at shallow depth to limestone	Shallow loamy soils on limestone	Solonised brown soils
Light clays	Little change	Brownish calcareous clays	Solonised brown soils
Clays	Little change	Grey cracking clays	Grey, brown and red clays
Variable	Variable	Saline soils	Solonchaks

sands deeply, thus restricting loss of moisture by evaporation. These soils lose less moisture by deep percolation than sandy soils in humid areas, particularly in the Woorinen Formation, where clays of low permeability occur at depth. The restricted drainage leads to reduced yields from the heavier soils as a result of the increase in salinity, particularly in the lower situations.

Under current management techniques, the relatively low available water capacities per unit depth in the sandier soils are significant, particularly with the use of shallow-rooted species and with the practice of fallowing aimed at increasing the storage of available water. Thus, for example, medics sometimes dry off on sands with abundant moisture beyond a depth of 40 cm. Unlike deep-rooted species such as lucerne, these annuals cannot exploit the moisture reserves. Again, in years of favourable rainfall, less available moisture is stored in the sandier soils within the rooting depth of cereals.

In general, the nutrient status increases with increasing clay content. All soils under agriculture require superphosphate but nitrogen deficiencies are most marked on the sandy soils. Trace elements, particularly copper and zinc, are applied to sands in cleared parts of the Big Desert.

Features of the soil groups are set out below. Profiles are alkaline except in many upper horizons of sandy texture, where the reaction tends to be neutral or weakly acidic. Surfaces are characteristically weak-structured but friable and thus are easily cultivated, albeit prone to wind erosion.

The soil groups

Deep sands of low fertility occupy the dunes and most of the plains in the Big Desert and Berrook land systems. Surfaces are pale brown and overlie off-white loose sand usually more than 1 m thick. More compact yellow sand occurs at depth.

Although the deep sands have relatively favourable moisture characteristics under the semi-arid climate, their fertility is too low for regular cropping. No satisfactory form of land use has been achieved with average management where these sands have been cleared. Consequently they have suffered severe wind erosion.

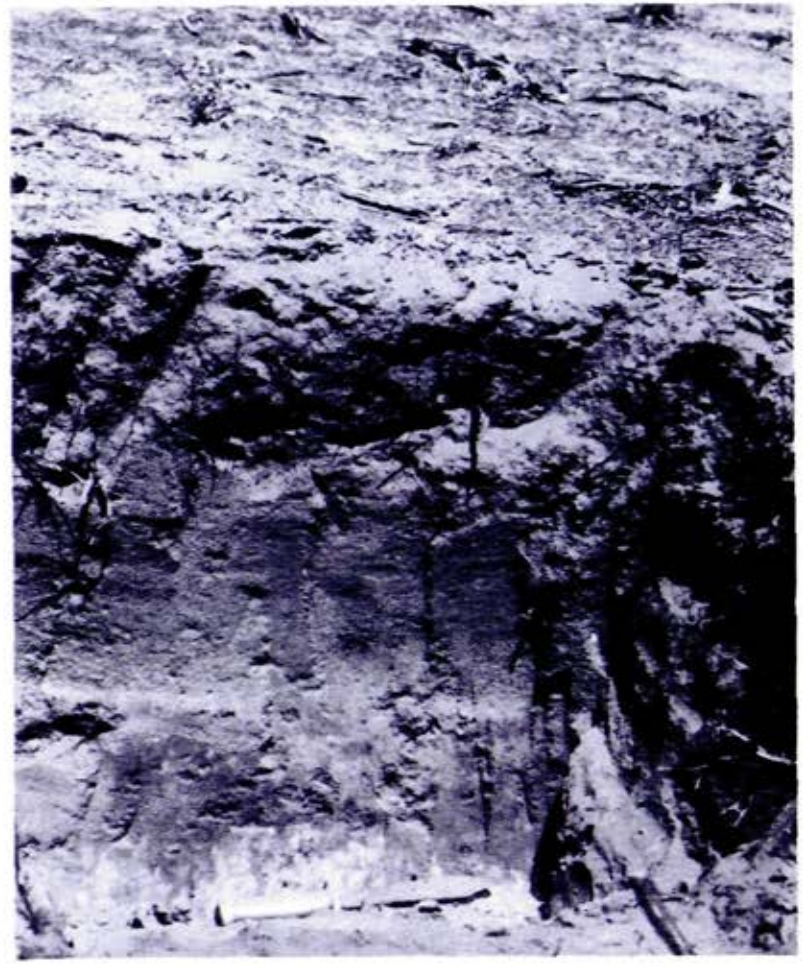
Sandy calcareous soils have upper horizons of sand, generally between 1 and 2 m thick, which overlie compact, calcareous sandy loam to sandy clay loam subsoils. Reddish yellow sands occur on most of the dunes in the agriculture areas (Central Mallee, Hopetoun, and Tempy land systems). White sands of low fertility with yellowish sandy loam horizons at depth are found in low sites in the Big Desert land system. Red sands predominate in the north and in

in the Millewa land system. Fertility increases from the white through the reddish yellow to the red sands, though even the latter have lower fertility than soils with heavier surface textures. As for the deep sands, the sandy calcareous soils have favourable moisture characteristics in this climate provided deep-rooted species are sown.

Medium-textured calcareous gradational soils predominate on interdune plains and on the lower slopes of ridges and hummocks. These are the most widespread soils in the region. Surfaces are red-brown, brown, or grey-brown sandy loams of variable lime content. Field texture increases gradually with depth. Subsoils are reddish yellow sandy clay loams to sandy clays with abundant lime as marl, angular stones, or nodules. These are relatively productive cropping soils having moderate fertility and moisture characteristics intermediate between those of the sands and the light clays.

Medium-textured calcareous duplex soils occur on the upper slopes of ridges and hummocks and to a lesser extent on interdune plains. The surface horizons are red-brown to yellowish brown sandy loams, often bleached above a sharp change, usually at about 30 cm, to sandy clay subsoils with abundant lime. Observations suggest that the agronomic features of these soils are similar to those of medium-textured calcareous gradational soils.

Heavy-textured calcareous duplex soils are restricted to broad plains and occasional lunettes. The surfaces are shallow (usually less than 14 cm) red-brown to yellowish brown sandy loams



Medium-textured calcareous duplex soil

Shallow loamy soil on limestone

giving way abruptly to clay subsoils. The surfaces are often eroded away to produce scalds. The subsoils are strongly structured blocky red clays, relatively low in lime.

The soils are of moderate fertility, but they have less favourable moisture characteristics than the medium-textured calcareous gradational and duplex soils.

The subsoils have a high salt content, and problems of dry land salting occur where the topsoils have been removed by the wind.

Shallow soils on limestone are found on plains and ridges, particularly in the western parts of the Central Mallee and Millewa land systems. Shallow discontinuous sandy loam surfaces overlie limestone in the form of massive sheet or large angular stones, so water-holding capacities are low. Colour and lime content of surfaces are variable. Fertility is moderate, and the erosion hazard is low because of the litter of stones.

Brownish calcareous clays occur most widely in the south-eastern parts of the region, on broad plains and ridges in the Culgoa and Hopetoun land systems.

The texture is clay throughout the profile except for shallow clay loam or light clay surfaces. Gilgais usually occur, and the colour of the upper horizons tends to be red-brown to brown on the puffs and grey-brown in the depressions. Lime is found throughout the profiles and surfaces are quite friable in spite of their heavy textures. These clays are fertile, but are only suited for cropping in the wetter parts of the study area because of their unfavourable moisture characteristics.

Grey cracking clays occupy flood plains along the Murray, Loddon, and Avoca Rivers and several creeks entering the area from the south. Coarse blocky structure predominates, but chemical features (including pH and content of lime and salts) are variable, and are probably related to variation in ages of alluvium and frequency of flooding. Although fertile, these heavy soils have poor moisture characteristics.

Saline soils occur naturally in several low basins, usually with copi and gypsum at depth. Soils saline to the surface usually support samphire, and are commonly dull red, finely textured, and weakly structured. Soils saline at shallow depth but not at the surface have sandy surfaces and support species such as bladder saltbush.

The incidence of saline soils has increased since settlement, as shown by the appearance of saltpans in low sites on farms in some localities. Affected soils are mainly medium-textured calcareous gradational soils and brownish calcareous clays.

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NATIVE VEGETATION

Native vegetation is important to land conservation for several broad reasons. Firstly, plants possess intrinsic interest and beauty apart from their great economic and scientific value. Secondly, vegetation is important for the conservation of most animals, as these depend directly or indirectly on plants for food, and often for shelter, protection, and nesting places. Thirdly, since the physical features of the site - climate, topography, and soils - largely determine the natural vegetation, the nature of the physical environment can often be judged by the type of vegetation present. Fourthly, plants are important in protecting soils from erosion by wind or water.

In this chapter, the nature of the flora of the Mallee is discussed and the vegetation is then classified into structural units to facilitate description. An account of rare, interesting, and endangered species is also given. Common names are generally used, the scientific names being given in Appendix 3. Nomenclature follows Willis (1962 and 1972). A list of vascular plant species has been compiled for the study area, but has not been included here because of its length.

The flora

The most widespread native vegetation in the study area is mallee scrub, in which the multi-stemmed eucalypts arising from lignotubers known as "mallee roots" dominate.

Mallee scrub occurs through much of the semi-arid south of the Australian continent, but in Victoria it is rare outside the study area. In the eastern half of this area and in parts of the west, the original scrub has been cleared for farms, but remnants along roads and in reserves preserve the special character of the countryside.

In a survey conducted for the Land Conservation Council, A.C. Beauglehole (1973) recorded 986 native and 274 introduced vascular species. Willis has estimated that the Mallee contains about 30 species of mosses and 20 species of fungi (mainly the drought-tolerant gasteromycetes).

Classification

Vegetation is usually classified into formations and associations. *Formations* refer to the structure of the vegetation

TABLE 6

STRUCTURAL CLASSIFICATION OF VEGETATION

This Report	Specht (1970)
Mallee	Open-scrub
Big mallee	Open-scrub
Hummock grass-mallee	Grassy-scrub
Scrub-mallee	Shrubby open-scrub
Saltbush-mallee	Shrubby open-scrub
Grassland	Grassland
Savannah	Grassy open-woodland
Woodland	Woodland and low woodland
Saltbush-woodland	Shrubby-woodland
Saltbush	Low shrubland
Heath	Open-heath
Mallee-heath	Tall open-shrubland

on a particular area, i.e. the height of the various layers of trees, shrubs, and herbs, the spacing of the plants, and the abundance of each species. *Associations* refer to constant groupings of species over large areas.

Because of the large area involved - and the difficulty in recognizing associations - formations or structural units provide the most suitable basis for classifying the Mallee vegetation. The 12 formations described by Rowan and Downes (1963) are used, the nomenclature generally following that of Beadle and Costin (1952). Table 6 compares the names of these 12 formations with those in a new scheme proposed by Specht (1970) for classifying structural units. However, the older, more descriptive terminology has been retained in this report, which defines and describes each formation and gives the names of the commonest plants found in each.

A typical stand of mallee

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Descriptions of Formations

Mallee

Mallee is the most widespread formation, and occurs on a wide variety of soils and land forms. It consists of a dense stand of small eucalypts generally 3-5 m high, each with many stems arising from a buried lignotuber. The crowns are umbrella-like, with sparse foliage. Several subforms, based on the size of the mallees and the nature and density of the associated shrubs and grasses, may be recognized within this formation.

The commonest *Eucalyptus* species are acorn (oil) mallee, dumosa mallee, yellow mallee, slender-leaf (hooked) mallee, white mallee, and red mallee. Mallee eucalypts often have variable forms, and many hybridize, making identification of individual species difficult.

Mallee usually occurs with scattered low acacias such as nealie, grey mulga, small cooba, and manna wattle, and other shrubs such as hopbush, daisy bush, desert cassia, quandong, and emu bushes. The conspicuous native poplar or bell fruit tree occurs occasionally. Most of the ground surface is bare, though thick layers of litter - bark, leaves, and twigs - may accumulate around the base of the mallee clumps. The low plants comprising the sparse ground cover include porcupine grass, velvet bush, guinea flower, twinleaf, and herbs and grasses.

Mallee stands typically contain several intermingling eucalypts, and discrete associations are difficult to recognize.

Large areas of relatively unaltered mallee remain in the study area, especially in the Sunset, Big Desert, and Annuello blocks.

Big mallee

This is a larger and more robust form of mallee, with the canopy about 7 m high. Generally only three or four relatively thick stems arise from each lignotuber, and are usually more than 9 cm across. Big mallee occurs on a broad range of soils and topographic situations in the dry north-west of the study area (Millewa land system). Elsewhere the formation occurs mainly in heavier soils in low situations.

The eucalypts listed under the mallee formation all occur as big mallee. In the south, bull mallee is numerically the dominant species in this formation. The understorey is sparse, with grasses and scattered low saltbush, bluebush, and twinleaf.

The Millewa block contains substantial areas of big mallee, though grazing has altered the ground flora in most stands.

Hummock grass-mallee

Hummock grass-mallee is a relatively open stand of low mallees over a promin-

ent understorey of porcupine grass. The formation occurs on sandy soils of low fertility, and is common on the crests of dunes in the Central Mallee land system and throughout the Berrook land system. Large areas of relatively unaltered hummock grass-mallee occur in the Sunset and Annuello blocks.

Several eucalypts commonly occur, with yellow mallee being prominent. Porcupine grass, a drought-tolerant plant, forms large clumps. In the absence of fire, these may grow into annular forms as the clumps expand and centres die. The grass is extremely prickly and difficult to traverse. In spring, each clump sends up dense, spike-like rods of flowers on tall stalks.

Hummock grass-mallee

Scrub-mallee

Scrub-mallee

Scrub-mallee consists of mallees with a dense lower stratum of shrubs. The formation is widespread on the poorer white sands in the north of the Big Desert and in the Berrook land system (Sunset block).

Yellow mallee is usually the prominent eucalypt species. The common scrub species are tea-tree, scrub pine, broombush, and broom heath-myrtle. Minor species include desert cassia, daisy bush, and ephemerals. Broombush is the dominant scrub species in some areas, particularly in the Central Mallee land system. It grows on reddish yellow calcareous sandy soils of the higher

Woodland of slender cypress pine and buloke at Pine Plains

positions, and on low sites in the Big Desert where the white sands overlie clays.

Saltbush-mallee

Saltbush-mallee contains mallees over an understorey of salt-tolerant shrubs. It occurs on plains in the Raak and Millewa land systems.

White mallee is the predominant eucalypt. In the Raak land system, bladder saltbush forms the shrub stratum on soils that are saline at depth, while glassworts occur where soils are saline to the surface. In the Millewa land system, saltbush and bluebush form the shrub stratum, usually in separate associations. Other plants that occur in the shrub layer are bassias, noon flower, sea heath, and various grasses and annuals.

Saltbush mallee was never very widespread. Since settlement, many of the mallees in the formation have died, and only a few stands remain.

Grassland

Grassland occurs throughout the study area, though it is most common in the drier north-west (Millewa land system), where it occurs on a wide range of soils. The dominant species are spear grass and wallaby grasses, with love grasses, windmill grasses, and sand brome. Ephemerals of the Cruciferae, Crassulaceae, and Compositae are very abundant during early spring. While large areas of grassland remain, the formation has been radically changed and extended by grazing and many weeds have become established.

Woodland

Woodland comprises open stands of trees usually 9--15 m in height and separated

by more than twice the diameter of the crowns. Two distinct types of woodland occur in the study area.

Woodlands of slender cypress pine and belar occur throughout the north of the study area. In the south, belar is replaced by buloke, and white cypress pine replaces slender cypress pine in the east. Other associated small trees, particularly in the north, are cattle bush, weeping pittosporum, sugarwood, weeooka, needlewoods, and quandongs. The woodlands usually occur with a ground cover of grasses and herbs.

While the area of these woodlands has been reduced by clearing, timbercutting, and fire, some good stands remain. These are found throughout the Millewa block, at Pine Plains, and in scattered reserves, the largest of which are at Timberoo and Yarrara.

Red gum and black box form a second woodland type, sometimes called "flood plain woodland", on alluvial soils near rivers, creeks, and lakes. Black box occurs on flood plains and along the infrequently flooded creeks, while red gum occupies wetter sites on the margins of lakes and along the Murray River. On very good sites, red gum may exceed 20 m in height and occurs in a forest rather than a woodland formation. Other common small trees are eumong, cooba, bramble wattle, and moonah, while the ground cover may include lignum, nitre-bush, and grasses.

This formation is well represented in the study area, although changed from its original condition by grazing and timbercutting.

Savannah

Savannah consists of grassland with very widely spaced trees and shrubs. It is found mainly in the Millewa land system on a wide range of soils and land forms. The grassland component is similar to the grassland formation described above, and the scattered trees and shrubs include those listed under woodland, plus mallee eucalypts.

Substantial areas of this formation occur in the Millewa block, although the

Black box woodlands in the Kulkyne forest

grassland has been altered from its original condition.

Saltbush-woodland

Saltbush-woodland consists of widely spaced trees with an understorey of salt-tolerant shrubs. The formation is not widespread. Belar occurs with bluebush and occasionally ruby saltbush on plains with heavy-textured calcareous duplex soils in the Millewa land system, and black box occurs with oldman saltbush on grey clays periodically flooded by the Murray River.

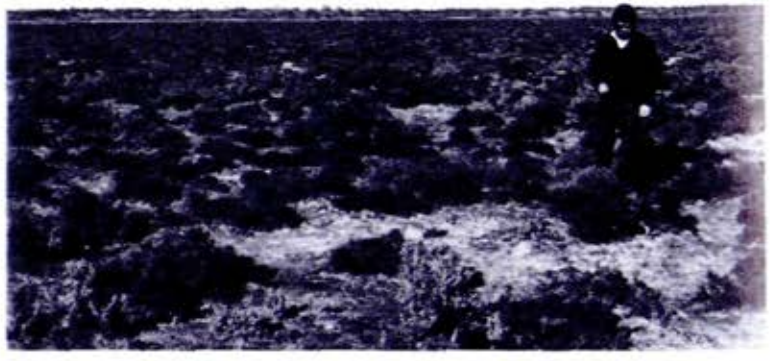
The original extent of this formation is not known, as heavy grazing may have eliminated the saltbush understorey from some areas. A few stands remain in the Millewa block and in the north-west of the Murray River block.

Saltbush

Saltbush consists of salt-tolerant shrubs about 1 m high. The formation occurs on the scattered areas of the Raak land system, and in the far north-west of the study area on the Ned's Corner land system. The soils contain relatively large amounts of soluble salts.

Glasswort is the dominant species where surfaces are saline in the Raak land system, while bladder saltbush occurs on the non-saline surfaces of Ned's

Saltbush - a stand of bladder saltbush and bluebush in the Millewa block



Saltbush - a stand dominated by glasswort at Rocket Lake

Corner land system. These areas also have stands of bluebush on heavy- or medium-textured calcareous duplex soils.

Other common plants are bassias and saltbushes, nitrebush, rounded noon flower, desert glasswort, and New Zealand spinach. Grasses and ephemerals are plentiful between the shrubs.

Large areas of this formation have been damaged by overgrazing. In the Raak land system the glasswort has survived grazing and additional salinity better than the saltbushes *(Atriplex)*, of which only a few good stands remain. Similarly, in the Ned's Corner land system only a few stands of saltbush and bluebush remain in good condition.

Heath

Heath consists of low shrubs with small hard leaves. In the Mallee this formation is of the open-heath type and is restricted to the deep white sands of dunes and plains in the Big Desert.

The diversity of species in this formation is greater than in any other, and many of them are not found further to the north of the study area. The genera present have affinities with the sandy coastal heaths of southern Victoria. The most common plants include desert banksia, scrub and dwarf she-oak, porcupine grass, broombush, several baeckias, correa, velvet bush, and holly grevillea. Other genera represented are *Aotus*,

Heath and mallee-heath in the Big Desert block

Acacia, *Pultenaea*, *Leucopogon*, *Boronia*, *Hakea*, *Olearia*, *Hibbertia*, *Leptospermum*, *Cassia* and *Lomandra*.

Mallee-heath

Mallee-heath consists of heath with scattered, widely spaced mallee eucalypts, the commonest being red, dumosa, slender leaf, and yellow mallees. Brown stringybark occurs on the crests of sand dunes at the northern limit of its distribution. The heath species resemble those given for the heath formation above. In the Big Desert the formation is interspersed with heath on all parts of the landscape. Extensive areas of heath and mallee-heath in good condition occur in the Big Desert block.

Aquatic plants

Aquatic plants form an important group that does not fit into the classification. They occur on wetlands associated with the Murray River, on the Avoca wetlands, in irrigation channels, and drainage areas. Some hardy plants are found around tanks and soaks in the dry country.

Common reed and spike rush occur on the margins of lakes and swamps. In shallow water, grasses, sedges, and cotula grow densely. Deeper water is colonized by rooted plants such as milfoil, pond weed, and eel weed, and by floating plants such as azolla and duckweed.

Significance of the flora

Many of the formations and associations of the study area are not found in other parts of Victoria, although they occur in the arid and semi-arid interior of the continent.

Formations of particular significance are saltbush (sometimes called "shrub steppe"), non-eucalypt woodlands, and the grasslands of the far north-west.

Families with numerous genera or species restricted to the Mallee include the Chenopodiaceae, Compositae, Cruciferae, Gramineae, and Myoporaceae. The commonest Mallee species are mentioned in the description of the formations and in the block descriptions.

The vegetation of the Big Desert differs significantly from that of the remainder of the study area. Many of the Chenopodiaceae are restricted to the northern sector, and several eucalypts (brown stringybark, yellow gum, black mallee box, and red mallee) and acacias (gold dust, mealy, myrtle, and three-nerve wattles) occur in the Big Desert but not further north. Also, many of the heath species in the Big Desert are not found in the north.

Factors influencing the vegetation

The semi-arid climate is the major influence on the vegetation, and most species show adaptations to the dry conditions. High soil salinities are also important in some areas. Many ephemerals appear in spring to take advantage of the short growing season.

Fire has always been an important factor. McArthur considers that the accumulation of litter beneath clumps of mallee and the growth of grass between clumps during wet years result in a high fire hazard every 10--15 years. Gardner states that mallee vegetation deteriorates after many years if it is not burnt. Shoot growth from buds on the mallee roots enable these eucalypts to re-establish rapidly after defoliation by fire or drought. Fire has long been recognized as playing an important role in the regeneration of heath formations.

The complete clearing by Man of more

than half the study area,and the grazing of livestock over much of the rest, has also had a major impact on the vegetation. Grazing has led, in many cases, to drastic changes in composition and structure, and in a few cases to soil erosion. It is likely that Man has altered the frequency and intensity of fires, causing further changes in vegetation. The removal of large quantities of logs, posts, and firewood from the red gum, black box, and pine stands has changed their character considerably.

The large number (274) of exotic species recorded in the Mallee indicates extensive invasion of the area by weeds. This has occurred wherever Man or grazing animals have disturbed the native vegetation.

Site factors

Rowan and Downes state that some communities appear on a wide range of soils and hence have limited value as soil indicators. The random and transient distribution of these communities suggests that the climate of recent geological times has not been sufficiently constant to allow any to become dominant on a certain narrow range of soils.

In the absence of a drainage system, topography is not a major factor, except as it influences the soils pattern. The variation in climate across the area has little effect, with the exception of grassland and heath, on the distribution of the dominant species of the structural units.

Rare or localized species

The study area contains a number of plant species that are rare in Victoria, and many of these are recorded from only one or two localities. Appendix 4, prepared by Mr. J.H. Willis, lists 40 such species, with brief notes on each.

The largest group among those listed consists of plants of the dry interior of the continent that have their southernmost occurrence in the Mallee study area - a few also have their most easterly occurrence there. Many of the occurrences are on freehold land. Five species are listed as probably extinct.

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FAUNA

Vertebrates

More than 400 native vertebrate animals have been recorded in the Mallee study area. Their distribution is influenced by a variety of environmental factors, such as the semi-arid conditions of the Big Desert and Sunset blocks and the relatively moist conditions that occur along the Murray River.

The large areas of public land in the Big Desert, Millewa, and Sunset blocks contain the largest assemblages in Victoria of animals that have adapted to arid conditions. More than 50 species of reptiles and more than 100 species of birds and more than 20 species of mammals have been recorded in these areas.

The diversity of mammals in the Sunset and Big Desert blocks has been seriously reduced over the last 120 years as a result of European settlement. However, about 10 native terrestrial mammals probably still occur in the region. Of these, the mouse dunnart, Mitchell's hopping mouse, the silky desert mouse, and the western pigmy possum are restricted to the Mallee vegetation of western Victoria.

In the Murray River block, birds are the best represented group and more than 200 species have been recorded. The woodlands along the river, as well as supporting water birds, maintain other birds that move out into the mallee areas when conditions are suitable. Of the other vertebrate groups, at least 3 reptiles, 5 amphibians, 2 mammals, and most of the 27 species of fish are found in or along the margins of the permanent waters of the Murray and its anabranches. About 8 species of reptiles, 2--4 amphibians, and 8 mammals inhabit the red gum--black box woodlands. The woodlands in the Kulkyne forest harbour the red kangaroo.

Though the remainder of the blocks contain relatively small amounts of public land, these areas are of considerable value as they provide shelter, protection, and nesting sites for birds as well as for other resident animals. The public lands in the Avoca block comprise one of the most important and best known areas for water birds in Victoria.

The major vertebrate group are described in general terms below. More detailed information on the species appears in Appendices 5--9.

Habitats

The vegetation formations described in the preceding chapter form the basis for the habitats described below, with the exception of the aquatic habitat.

The aquatic habitat in the Mallee study area consists of flowing rivers, still waters in deep and shallow billabongs, swamps used for evaporation of irrigation drainage waters, and the waters of lakes filled for irrigation purposes.

The red gum--black box woodland (floodplain woodland) habitat occurs along the Murray River and the other smaller streams in the south of the study area. It has several characteristics that are important for animals. Much of it is flooded at moderate river levels, providing large areas for waterfowl. Red gum provides the nesting requirements of species needing tall trees or hollows. The accumulation of litter provides habitat for small terrestrial animals, and the large litter (branches and logs) harbours reptiles and amphibians. The grassy and shrubby understoreys and the lignum swamps are also important.

The cypress pine--belar--buloke woodland habitat provides some tall trees, and usually has much log material in the litter suitable for use by reptiles. The numerous shrubs and low trees produce large quantities of seeds and fruits, which form part of the diet of many animals. As a result of grazing, however, the understorey has been altered from its original condition.

In the mallee and big mallee habitats, some of the larger trees contain nesting hollows and in summer the trees flower profusely, producing nectar. Ground cover in the former habitat is sparse. In the latter, the lower layers of shrubs and herbs produce seeds and succulent fruits, but grazing has reduced their density.

Mallee fowl and western grey kangaroos are often found among the porcupine grass in the hummock grass--mallee habitat, and many reptiles shelter beneath it. The grass produces large quantities of seeds.

The main characteristics of the scrub-mallee habitat are the shelter provided by the thick shrubs and mallees, and the hard fruits and seeds produced.

The dense layer of low shrubs, which is characteristic of the heath and mallee-heath habitat, produces a variety of fruits and seeds and thus provides food and shelter for small, ground-dwelling animals.

Heavy grazing pressure on the saltbush habitat since European settlement has altered its form and composition. The grasses growing between the shrubs are a source of food for western grey kangaroos. The composition of the grassland habitat has also changed due to grazing,

The dry heath and mallee heath habitats of the Big Desert block (left) contrast with the moister red gum woodlands of the Murray River block

and the elimination of many of the "soft grasses" suggests that the ability of this formation to support native animals has declined.

Savannah occurs where grasslands merge with woodland, and in the following discussion the animals in this habitat are considered to inhabit either grasslands or woodlands depending on whether they utilize the ground stratum or the tree stratum respectively.

Habitats of the blocks

The main habitats in the Big Desert block are scrub-mallee and heath and mallee-heath. A thin strip of red gum--black box woodlands, with some grasslands, follows the course of the Outlet Creek in the east of the block. Extensive pine--buloke woodlands occur in Pine Plains and at Timberoo. A few small flats in the north contain atypical habitats of tall vegetation - red gum, slender cypress pine, yellow gum, and big mallee. When full, Lake Albacutya is an important aquatic habitat.

In the Sunset block, mallee and hummock grass-mallee are the major habitats. Scattered areas of grassland and big mallee occur in the south and saltbush occurs in the north-east and on the southern edge.

The Millewa block contains diverse habitats, the major ones being grassland,

big mallee, and pine--belar woodland, and also saltbush and mallee.

The major habitats in the Murray River block are red--gum black box woodland and the aquatic habitat, with saltbush in the far north-west. Mallee and hummock grass-mallee are the major habitats in the Annuello block, which resembles the main part of the Sunset block.

Very little public land remains in the Tyrrell block. Small but important areas of black box woodlands occur on the frontage to Lalbert Creek, and small areas of mallee are scattered through the block. Lake Tyrrell and associated lakes hold water in winter only.

Most of the public land in the Avoca block consists of lakes, and so the aquatic habitat is the most common. Some areas of red gum--black box woodlands also occur.

Birds

More than 270 bird species have been recorded in the Mallee study area, and 212 species are known to have bred there. Appendix 7 lists common names, and also gives habitats, abundance, and breeding and feeding habits.

Because of the large number of species involved, this report does not discuss individual species. Instead it gives only general comments (based on data in Appendix 7) on geographic and ecologic distribution (including feeding and breeding niches) and abundance, especially for those birds occurring in the Big Desert, Sunset, and Murray River blocks.

Big Desert

Some 93 bird species occur in the scrub-mallee, heath, and mallee-heath communities of the block, and more than half of this number belong to four major groups - honeyeaters (16 species), parrots and cockatoos (13), birds of prey (9), and warblers (10). Some 31 species may be broadly categorized as medium to small insectivorous birds and include cuckoo-like birds, nightjars, swallows, cuckoo shrikes, thrushes, quail thrushes and babblers, chats, flycatchers, whistlers and shrike thrushes, fantails, shrike-tits, tree-creepers, silvereyes, and wood swallows. There are 14 miscellaneous species.

Eighty-three species recorded as occurring in the Big Desert block breed within the Mallee study area. At least 29 species use shrubs or low trees for nesting, 14 species use holes in trees, 29 species use tall trees, and 5 nest on or in the ground.

The mallee-fowl builds mounds in which the eggs are laid; incubation temperature is adjusted by removing or replacing litter over the eggs. Three species nest in tunnels in the ground or riverbanks, one builds nests on man-made

structures, and at least two species are parasitic on other nesting birds.

The avifauna of the scrub-mallee, heath, and mallee-heath communities consists primarily of species capable of feeding on the numerous terrestrial and flying insects inhabiting this area. A major part of the diet of 70 of the 93 species is made up of insects. Seventeen birds (mostly honeyeaters) include nectar, as well as insects, in their diets and

A mallee fowl working on her mound

The yellow-rumped pardalote nests in a tunnel excavated in sandy soil

another 19 consume quantities of seeds or fruits on both of these. About 12 predatory species in this area feed in varying degrees upon mammals, reptiles, and other birds.

An important characteristic of the avifauna in this area is its mobility. Movements of many of the bird species are governed by the availability of food, as this fluctuates with the season or weather, and may be either long term or short term. Thus species composition within any specific area is constantly changing, and this reflects adaptations that have evolved to allow maximum utilization of an area that at times cannot provide adequate food, water, shelter, and nesting sites for survival of all species.

Sunset block

The species composition of the birds recorded as inhabiting the mallee and hummock-grass habitats of this block resembles that of the birds inhabiting the communities of the Big Desert, although to date only 84 species have been recorded. At least 75 species inhabit the communities of both of these blocks.

Four major groups of birds occur in the Sunset area: honeyeaters (12 species), parrots and cockatoos (13), warblers (10), and the birds of prey (10). The remainder of the species have been placed in two broad categories. The first includes medium to small insectivorous birds (27 species), and the second category includes 12 miscellaneous species.

Seventy-seven species recorded in the vegetation types occurring in the Sunset block have also been recorded as breeding in the Mallee area. Of these, 16 species nest in hollow trees, which may indicate that many nest outside the Sunset block. Another 22 species nest in shrubs or low trees and 27 are listed as nesting on tree branches at varying heights. Six species nest either on the ground or in mounds, three others nest

in the ground, two are parasitic, and one nests under man-made structures or in caves.

Diets of birds occurring in the mallee and hummock grass-mallee communities are also similar to those of birds in the Big Desert block. For example, 60 species are insectivorous, 13 also feed on nectar, and 18 include seeds or fruit or both in their diets. The 10 birds of prey feed on various quantities of birds, mammals, and reptiles. Movements of birds within the Big Desert block are comparable to those of the birds inhabiting the Sunset block.

Murray River block

In all, 235 species have been recorded in this block. Of these, 109 species occur in the aquatic habitat, which is particularly important to 30 species of waders, 14 species of heron-like birds, 14 species of ducks and swans, 8 species of cranes and rails, 6 species of cormorants and pelicans, 5 species of gulls and terns, and 3 species of grebes. Many of the waders that occur here are intercontinental migrants, utilizing the wetlands along the Murray River as stopover areas.

Fifty-two of the aquatic species are recorded as breeding in the Mallee study area. Most nest either on the ground or in tree branches, but a few of the ducks use holes in trees and the grebes build floating nests. These birds gen-

A nankeen kestrel nesting in a chough's nest

erally feed on aquatic animals and some aquatic plants, although a variety of other food is sometimes taken. Some ducks graze on terrestrial herbage, and some ibises, plovers, and dotterels consume substantial quantities of terrestrial insects.

The floodplain woodlands of red gum and black box are of prime importance to the avifauna in the Mallee, as representatives from most major groups of Mallee birds are recorded as occurring in this habitat. Some 140 species are listed for this area and it is likely that more detailed observations would add substantially to this list.

This habitat is used by many species for most of the year, but some that normally inhabit other areas move to these woodlands for nesting purposes. Groups of birds that usually nest in branches of tall trees, such as birds of prey (15 species probably nest in the Mallee area), are particularly well represented in this woodland habitat. It is most important to the 16 species of parrots and cockatoos, which nest in the tree hollows.

The diet of the birds occurring in the floodplain woodland habitat varies, and many species probably spend much of their time foraging on other habitats. However, many insectivorous birds and the birds of prey obtain substantial quantities of food within this habitat, especially after periodic floodings when invertebrates are plentiful and herbaceous growth is stimulated. Many aquatic birds move to these flooded areas for foraging and breeding purposes.

A small amount of saltbush on public land in the north-west corner of the Murray River block contains a few species not normally found in the woodland and aquatic habitats; no species is exclusive to it.

Other blocks

Relatively small amounts of public land still remain in the Millewa, Annuello, Tyrrell, and Avoca blocks. The area in the Millewa block on the South Australian border has not been recently surveyed, but could be of importance to birds because it contains a variety of vegetation communities not well represented in any other land block. This area connects the wetter habitats bordering the Murray River with the drier areas of the Sunset country. The species composition of birds in the Annuello block is similar to that of the Sunset area.

The Tyrrell block contains only small scattered blocks of public land, but these have not been surveyed recently. The Avoca block contains one of the most important areas for waterbirds in Victoria. The shallow lakes fringed with red gum woodlands, which occur in the Kerang area, are of particular importance in years of moderate to high flooding. This area supports large breeding colonies of royal spoonbills and white and straw-necked ibises, and a breeding colony of gull-billed terns. All of the ducks listed as breeding in the Mallee region (Appendix 7) breed in the Kerang Lakes area during wet years. They include important game species. The black swan and various species of cormorants, grebes, and heron-like birds also breed in the area.

Discussion

The public lands remaining in the Big Desert and Sunset blocks still support an avifauna representative of that which formerly inhabited the Mallee study area

as a whole it is likely that extensive grazing by introduced herbivores has altered the original ground cover in some areas, but because of its low, thick, shrubby nature, the present vegetation still supports large numbers of birds adapted to feeding on insects, nectar and seeds and to constructing nests within the shrub layer. Honeyeaters, warblers (wrens, thornbills, and warblers), and some parrots are particular groups that require substantial areas of such vegetation for their survival. The birds of prey are usually wide-ranging and cover many types of habitat, and extensive hunting areas are important for maintaining their populations.

Most of the populations of the following 38 species depend on the habitats of the Mallee for survival, even though many hav wider distributions:

Mallee fowl
Major Mitchell
Regent parrot
Blue bonnet
Ringneck parrot
Mulga parrot
Spotted nightjar
White-backed swallow
Chestnut quail-thrush
Southern scrub robin
Chestnut-crowned babbler
Black-backed blue wren
Blue-and-white wren
Variegated wren
Mallee emu-wren
Red-tailed thornbill
Chestnut-rumped thornbill
Samphire thornbill
Red throat
Mallee heath-wren
Rufous field aren *
Straited grass wren
Crimson chat
Orange chat
Red-capped robin
Red-lored whistler
Gilbert whistler
Crested bell-bird
Wedgebill
Western whipbird
White-browed tree-creeper
Yellow-rumped pardalote
Yellow-fronted honeyeater
Purple-gaped honeyeater
Yellow-plumed honeyeater
Yellow-throated miner
Striped honeyeater
Dusky miner *

* The CSIRO Index does not recognize these birds as separate species.

The Victorian Mallee and the associated river habitats lie at the southern edge of the arid and semi-arid regions of Australia and provide refuge for many inland species in times of drought. The large remaining areas of mallee vegetation can support populations of nomadic birds seeking forage and shelter.

Although the floodplain woodlands of red gum and black box along the Murray River do not cover large areas, their contrib-

ution to the nesting, foraging, and sheltering of many bird species is very important. About three-quarters of all the birds recorded from the Mallee study area have been recorded as occurring in habitats contained within this block.

The sacred kingfisher is found near water and feeds on small lizards and fish and large insects

Mammals

The arrival of European settlers in the Mallee in the 1840s had a deleterious effect on native mammal populations. Since then, 45 species have been recorded as occurring in the area (Appendix 5) of which 38 are native mammals and 7 have been introduced.

Information from museum specimens and reports of the Blandowski expedition of 1857 indicate that the native mammal population originally consisted of at least 1 monotreme, 19 marsupials, 7 rodents, 9 bats, and 1 carnivore. Land use by the European settlers - clearing of native vegetation for farming, grazing of native vegetation by hooved animals, and competition and predation by exotic mammals - has probably resulted in the local extinction of 13 of these native and mainly ground-dwelling mammal species. Today, the area contains 2 monotreme species (it is likely that echidnas have only recently colonized it), possibly 10 marsupials, 3 rodents, 9 bats, and 1 carnivore. In addition, 7 exotic species are present, and many are now widespread.

The following discussion deals with the mammals occurring on the public lands within each land block of the study area. It is based on the literature, specimen collections, and field trips to the Big Desert and Sunset country by the Nation-

al Museum of Victoria and the Fisheries and Wildlife Division of Victoria respectively. Some additional notes were received from Mr. C. Crouch of Nhill and the Mammal Survey Group of Victoria. However, the information is not yet complete and future work in this region will undoubtedly modify and clarify many of the results presented here. More detailed information on the biology of the native mammals (excluding bats) that still occur in the Mallee study area is presented in Appendix 6.

Big Desert

The echidnas, mouse dunnart, western grey kangaroo, Mitchell's hopping mouse, and the silky desert mouse have recently been recorded in this area. These species occur generally throughout the public land in the block, although the two rodents usually occur in different habitats. While no specimens of the western pigmy possum have been taken since 1911, sightings have been recorded recently and it probably still occurs in dense stands of banksia and broombush throughout the area. Other species such as fat-tailed dunnarts, brush-tailed possums, and possibly feather-tailed gliders have habitat preferences that would restrict them to peripheral areas of the public lands. The fat-tailed dunnart and the brush-tailed possum probably also occur on farmland in the area.

The red-necked wallaby has been reported

The echidna appears to be widespread in the study area and may be a recent colonizer

from the southern fringes of the Big Desert (C. Crouch, personal communication). Although their specific habitat requirements have only been briefly documented, all the bats recorded from the Mallee (see Appendix 5) probably occur in this block.

There are no recent records of dingos in the study area; however, wild dogs are ocassionally trapped.

The silky desert mouse is found in the Big Desert block, where it feeds on fruits and seeds

Five exotic animals have been recorded in the Big Desert block. The rabbit is common locally, and foxes, feral cats, and hares are occasionally seen. The house mouse was trapped during the recent survey, but it was not as common as either the silky desert mouse or Mitchell's hopping mouse. Like the two native rodents, the house mouse exhibits large fluctuations in population numbers.

Sunset block

The native terrestrial mammals species now existing in the Sunset block are echidnas, mouse dunnarts, western grey kangaroos, red kangaroos, and (on the eastern edge) Mitchell's hopping mice. The largest Victorian red kangaroo populations occur on the gypsum plains in the east of this block, and in the adjacent Kulkyne forest. Mouse dunnarts are probably more abundant in the block than had previously been thought. There has been little documentation of the bats in this area, but all Mallee species probably occur here, although with specific variations in abundance and distribution. Rabbits, foxes, and cats are widely distributed and common, but the hare and house mouse are at present probably restricted to areas adjacent to farmlands.

Millewa block

Echidna, fat-tailed dunnarts, brush-tailed possums, western grey kangaroos, and red kangaroos have all been recorded on public land in this block, the latter species occurring in the north-west corner. As the area of public land is limited, most of the above species probably also occur in surrounding farmlands. Exotic species that have also been recorded are house mice, rabbits, hares, cats, and foxes.

Murray River block

This block now contains the greatest diversity of mammal species occurring in the Mallee study area. The river and associated lakes and billabongs support populations of platypus and eastern water rats, and the floodplain

still supports populations of echidna, yellow-footed antechinus, fat-tailed dunnarts, brush-tailed possums, feather-tailed gliders, and western grey kangaroos. Red kangaroos are common in the Kulkyne forest. Mitchell's hopping mouse still occurs in the sand ridge area of Hattah Lakes National Park. Because the many hollow limbs provide roosting sites, red gum woodland is an excellent habitat for bats. Pigs and goats, as well as the 5 exotic species mentioned above, are found in this block.

Annuello block

The species of mammals occurring in this block are probably the same as those occurring in the Sunset block because of the similarity of the vegetation on public land on both area. Echidnas, western grey kangaroos, and Mitchell's hopping mice have recently been recorded in this block.

Tyrrell and Avoca blocks

Little public land remains in these blocks and little is known of the mammal communities. The Avoca and Loddon River systems probably support populations of the eastern water rat and the platypus.

Discussion

Today only about 25 mammal species (i.e. approximately two-thirds of the number of a century ago) occur in the Mallee area, and some are very rare. These species are peculiar to this type of area and, because of their adaptation to arid conditions, are unique in Victoria. Judicious re-introduction of species that formerly occurred in the area and that are in danger of extinction elsewhere could help to ensure that those species survived.

Reptiles

Seventy-eight species of reptiles have been recorded in the Mallee area, and approximately half of these do not occur elsewhere in Victoria. This number of species is greater than that for any other area of comparable size in the State. Factors responsible for this multiplicity of diverse species are related to the ecological requirements of reptiles. In general, temperature is less important as a limiting factor for reptiles in the relatively hot Mallee region than in other parts of Victoria. Other factors influencing reptile distribution are food supply, reproduction, and predation. Specific food preferences for four groupings of reptiles are as follows:

(1) large reptiles (including goannas): small mammals, birds, other reptiles, frogs, and carrion

(2) large skinks and lizards (including stumpy tails and bearded dragons): berries, fruit, and arthropods

(3) small lizards and snakes: insects - although some species (Burton's legless lizard and bandy bandy) also eat small skinks

(4) tortoises: a varied diet of tadpoles, frogs, aquatic vegetation, and invertebrates

Reptiles are either oviparous or viviparous and both types occur in the study area. Oviparous reptiles require warm, dry, and safe sites for incubation of eggs. Because warmth and dryness are typical of the Eyrean zoogeographic subregion in which the Mallee study area falls, safety of nest sites is probably the most important factor limiting numbers.

A bearded dragon lays its soft-shelled eggs in a burrow in the soil

Major predators of reptiles include other reptiles, birds (birds of prey and kookaburras), and mammals (foxes and dunnarts).

A list of reptile species occurring in the area with summaries of available information is presented in Appendix 8. A general discussion of reptiles occurring within the major blocks follows. Information presented here has either been taken from the literature or supplied by the National Museum of Victoria. It is far from complete and in some cases, has not been substantiated by detailed field studies. Taxonomic reviews and future field trips will undoubtedly modify this record and add new species to the list.

Big Desert and Sunset blocks

More than 50 species of reptiles have been recorded in these areas. They belong to seven families (dragons, geckos, skinks, legless lizards, goannas, poisonous snakes, and blind snakes). It is undoubtedly the best single region for reptiles in Victoria.

The dragons (5 species) are heliothermic and are distributed widely throughout the area. Bearded, painted, and spinifex dragons prefer sandy substrates for burrowing, Cogger's dragon typically inhabits scrub areas, and the rare ear-

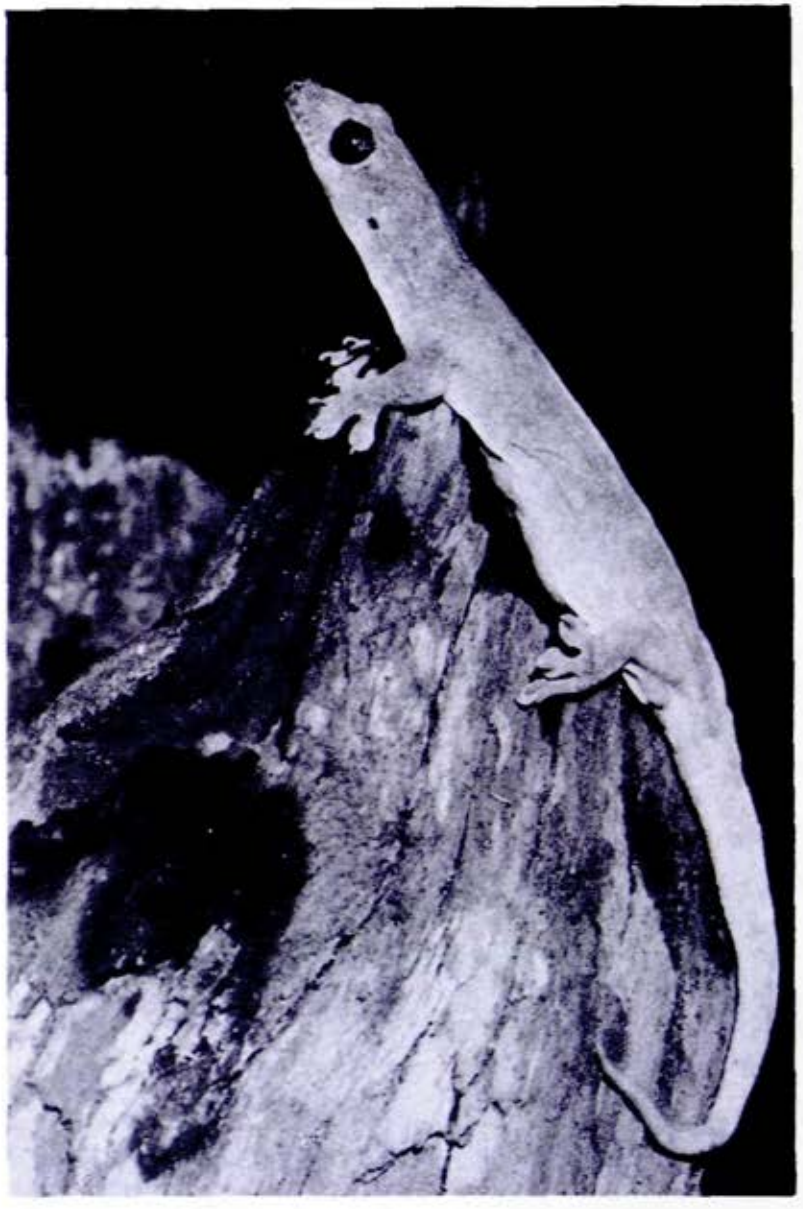
less dragon prefers rocky areas. The best-known, the bearded dragon, is often seen basking on the sides of fence posts and stumps.

All of the 9 species of geckos are primarily nocturnal and insectivorous, living on or close to the ground. In this area they occupy the same ecological niche as the diurnal insectivorous skinks, taking over the "night shift".

Legless lizards (5 species) are reptiles adapted to living in microhabitats such as porcupine grass, where legs would hinder rapid movement. With the possible exception of the fossorial pretty snake lizard, all are common and occur throughout the area.

Skinks are a very diverse group, ranging in size from the small fossorial Grey's skink to the large sluggish stumpy tail. They occur in most microhabitats, including sublitter, thick vegetation, and open terrain. About 20 species occur in these land blocks, making skinks the most diverse and common group in the region.

Goannas are represented by the sand goanna (which occurs throughout the sandy soil country) and by the tree goanna (which has been collected at Lake Albacutya). Both of these large lizards have been the target of unwarranted persecution. Their useful scavenging role generally reduces material conducive to blowfly breeding.



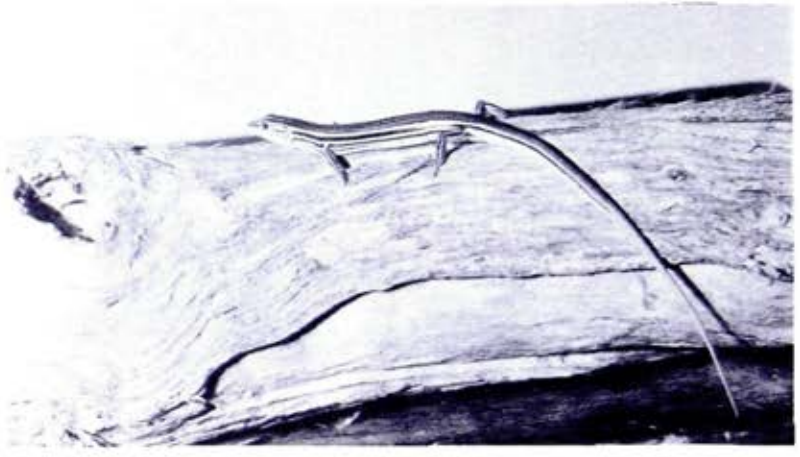
The variegated gecko, a nocturnal reptile, is rare in the study area

The area contains about 14 elapid or poisonous snakes - none are very common and most are relatively harmless. Most species are restricted to native scrubland but a few, such as the brown and curl snakes, occur on cultivated land. The brown snake has been particularly successful and is a valuable predator of rodents.

Blind snakes are widespread throughout the region, but are rarely encountered because of their fossorial habits. They are thigmotheric and spend most of their time beneath the ground feeding on subterranean insects. They are often found in termite colonies.

Murray River block

The Murray and Wimmera River systems have 12 associated reptile species that would otherwise not occur in the Mallee region. These species either depend directly on fresh surface water or occur in the large trees that border the streams and lakes.



The eastern coppertailed striped skink

Tortoises, which are aquatic, occur in the Mallee only in permanent lakes and river systems. One species (the snake-necked tortoise) extends into the Wimmera River system because it was formerly connected with the Murray River. Both these species, and the Murray River short-necked tortoise, are common throughout the Murray River system, while the broad-shelled tortoise is apparently restricted and rare in the study area, occurring in a section of the Murray River near its junction with the Darling.

Tiger and black snakes occur in areas with adequate moisture and hence in the Mallee are restricted to the Murray River corridor and Wimmera River. They feed primarily on frogs, but also take small mammals and birds. Quoy's water skink also extends into the Mallee only along the Murray River.

All of the species restricted to the Murray or Wimmera River corridors or both because of the presence of large trees are either arboreal or scansorial. The marbled gecko is nocturnal and forages on trunks of red gums and shelters under loose bark. The harmless and beneficial carpet snake was once common along the Murray River, but exploitation

by pet-traders has reduced its number in Victoria to very low levels.

Discussion

The Mallee study area, because of its typical Australian inland environment, is the only Victorian area in which many reptiles adapted to arid conditions occur in significant numbers. Of the 78 recorded species, about half are restricted to this area in Victoria and many others only occur elsewhere in marginal areas such as the Little Desert.

Porcupine grass is an important component of the dryland reptile habitats. Destruction of this and other ground vegetation by burning and grazing will adversely affect the reptile fauna.

Amphibians

Frogs are the only amphibians found in the Mallee. The distribution of frogs is closely related to the availability of moist breeding sites, because the life cycle of most frogs includes an unprotected (unshelled) egg and a free-swimming larval (tadpole) stage. Generally, wherever permanent or temporary water exists, frogs occur in abundance in one or more stages of their life cycle. Most frogs produce large numbers of eggs and tadpoles under optimum conditions, whenever opportunity arises.

Littlejohn (1966) reported the presence of 11 species of frogs, with one species

The common froglet is a wide-ranging species

having two call races, in an area in the north-west of Victoria. This area is slightly larger than the present Mallee study area, which contains only 9 of these 11 species.

Broadly speaking, the Victorian Mallee represents an overlap zone between the distribution of one species of desert-adapted frog of central Australia and the distribution of several species adapted to the cooler, more temperate regions of south-eastern Australia. Also present in the Mallee area are two groups, one of which could be described as river-adapted frogs, having distributions coinciding with the main rivers of the Mallee region, and the other, a group of frogs with wide-ranging distributions.

Neobatrachus centralis is the only frog species in the Mallee that has adapted to arid conditions. Its range extends from the south in Western Australia through the arid interior and into the western and central Victorian Mallee. A relatively brief tadpole stage enables it to make use of temporary ponds. The adults survive dry periods by burrowing into moist ground (usually in ponds that are drying out) and sealing the burrow off to conserve water.

Four species of frogs that have adapted to temperate conditions occur in the Mallee study area:

* Spotted marsh frog *(Limnodynastes tasmaniensis)*. The southern call race of this species extends into the south-eastern half of the Mallee. It comes into contact with the northern call race along the eastern boundary of the Mallee. More permanent waters are preferred for breeding.

* Bull frog *(Limnodynastes dumerili)*. This burrowing species inhabits all parts of the Mallee except the drier Sunset block, and uses both permanent and temporary waters for breeding.

* Spadefoot toad *(Neobatrachus pictus)*. This frog has similar habits to the closely related *N. centralis* in that it burrows and uses temporary ponds and claypans for breeding. It is probably present in all but the driest parts of the Mallee.

* *Ranidella parinsignifera*. This small frog makes use of temporary pools as well as the margins of more permanent waters for breeding. It ranges around the northern, southern, and eastern edges of the Mallee area.

Two species of frogs that prefer open permanent waters such as rivers for breeding are Peron's tree frog *(Litoria peroni)* and the barking frog *(Limnodynastes fletcheri)*. The former is restricted to the Murray River Valley and the Loddon and Avoca Rivers but has a more extensive distribution in eastern Victoria. The latter is restricted to the Murray River.

The following three species are 'wide-ranging' in their distribution.

* Spotted marsh frog *(Limnodynastes tasmaniensis)*. The northern call race of this species extends along the Murray River from eastern New South Wales to South Australia. It breeds in both temporary and permanent waters.

* The green and golden frog *(Litoria aurea)*. The species occurs mainly along the eastern and northern boundaries of the Mallee study area and prefers more permanent waters for breeding.

* The common froglet *(Ranidella signifera)*. This species ranges mainly along the southern and eastern bound-

aries of the Mallee area, with some extension along the northern edge. It makes use of pools for breeding.

Discussion

The importance of resident frog populations to the general ecology of an area can be substantial. Tadpoles feed voraciously on algae and phytoplankton and, because of their numbers, play an important role in food webs as primary consumers (herbivores).

As tadpoles mature, food preferences change and adult frogs feed primarily on terrestrial and aquatic insects. Although tadpole mortality is usually high, large numbers of frogs still emerge to exert considerable influence on local invertebrate populations.

Amphibians constitute a very important source of food for other animals. Both tadpoles and adult frogs are common prey for many waterbirds, freshwater fishes, tortoises, and swamp-dwelling snakes. Tadpoles may also provide food for aquatic carnivorous insects. Consequently, the amphibians constitute an important "middle section" in food webs of aquatic environments. They not only consume a variety of living material, but in turn provide an important food source for many other species, often of commercial, recreational, or culinary value.

The impact of farming on the distribution and abundance of frogs is uncertain. It seems likely that the distribution of most species, particularly *Limnodynastes tasmaniensis*, has been extended by the construction of channels and reservoirs associated with water supplies for stock.

The margins of streams with slow-flowing water and associated lush vegetation, or shallow weedy swamps, are particularly suitable for this group of animals.

Fishes

A total of 28 fish species have been recorded as occurring in the Mallee study area (Appendix 9), including seven introduced species. While large portions of the Mallee region are devoid of permanent water, there are four drainage areas that support fish populations - the North Loddon River, the Avoca River (including the Kerang Lakes), the Murray River, and the Wimmera River (Lake Albacutya).

For discussion purposes, the fishes in the study area have been divided into four categories, based partly on their value to Man and partly on their ecological significance. These are discussed below.

Native game species

These fishes have value in a commercial, recreational, or culinary sense, and are represented in the Mallee by seven species.

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

Freshwater catfish spawns in clear water from September to November. It makes a shallow depression in the substrate for egg-laying. Its food consists of invertebrates taken from the bottom of slowly flowing backwaters. It is an excellent table fish but is becoming scarce.

Murray cod and trout cod usually spawn on mud substrates in river channels. Spawning generally occurs after flooding (usually from September to November). Both species are carnivorous, feeding on other small fishes such as tench, goldfish, bony bream, gudgeons, and Australian smelt. They provide good angling and eating, but populations have decreased significantly in recent years - possibly as a result of the construction of dams, weirs, and locks on the Murray River. The trout cod is now very rare in the Mallee section of the River and may even be absent.

The range of Macquarie perch, an excellent sporting and table fish, has recently been drastically reduced and it is now very rare (if not absent) in the Mallee section of the Murray River. Golden perch spawns after floods, which usually occur during spring and summer. Its food consists mainly of crustaceans. It prefers warm sluggish muddy waters and will disappear where dams release cooler water and upset the normal flooding pattern. It has good sporting and eating qualities. Silver perch usually spawns after a rise in water level. Its omnivorous diet includes zooplankton, algae, and other aquatic vegetation. It is a good sporting and eating fish.

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

Introduced game species

These species have the same value as the native species but probably compete with them. Three occur in the Mallee.

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

Brown trout is not widespread in the Mallee study area, but has been reported

in the Waranga Western Channel, which flows through alienated land in the Tyrrell and Annuello blocks. It is an excellent sporting and eating fish.

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

Other introduced species

These are of little value to Man and are considered detrimental to populations of native species. Four species have become widespread in Mallee waters.

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

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

Forage fishes

These small species, usually native to Australia, are ecologically important as food for larger fishes and vertebrates. The fourteen species in the study area are the bony bream, Australian smelt, flat-headed galaxias, rainbow fish, Mitchellian freshwater hardyhead, Lake Eyre hardyhead, western chandra perch, southern pigmy perch, western carp gudgeon, flat-headed gudgeon, and purple-spotted gudgeon. The short-headed lamprey, a marine species, enters the fresh waters of the lower Murray River to spawn. The juvenile stages probably serve as food for some of the larger species.

The short-finned and long-finned eels have probably been introduced into Mallee waters from other parts of Australia, as eels are uncommon in streams north of the dividing range. Small eels may be eaten by other vertebrates.

Discussion

The Murray River and Avoca blocks contain most of the fishes recorded in the Mallee area. Introduced species such as redfin, carp, mosquito fish, and tench are well established, and have probably reduced native fish populations through competition and predation. The impact of the recently introduced European carp on fish populations in the Murray River system has yet to be adequately assessed. However, local reports indicate that it is rapidly becoming the predominant fish in the area. If this trend continues, it will certainly have a detrimental effect on local sport fisheries in the Mallee region. The regulation

of water flow (elimination of minor flooding etc.) in the main rivers probably favours the introduced species at the expense of the native populations.

Invertebrates

Invertebrates vastly outnumber the vertebrates in the study area in terms of both species and individuals. They include numerous types of insects and other arthropods and worms and molluscs. They occupy the lower levels of the food chain, and many higher animals, for example birds and reptiles, depend on them for food. Those invertebrates that function as decomposers also play a basic role in maintaining the energy flow within an ecosystem.

A scarab, Diaphonia mniszechi *(left), and* Stigmoderma yarralli, *a jewel beetle whose larvae are wood-borers*

Although the invertebrates are a vital part of any ecosystem, lack of information means that this report can do little more than draw attention to the group and mention a few species of special interest. The following sections deal firstly with the insects and then with all others.

Insects

The Mallee insect fauna contains many typical inland insects, which are to be found especially around dams and bores. It also has affinities with some Western Australian forms. In general, the orders Coleoptera (beetles and weevils), Blattodea (cockroaches), Hemiptera (bugs and scales), and Isoptera (termites) are well represented in the Mallee. Of the 94 genera of Scarabaeidae (Coleoptera) represented in Victoria, 60 occur in the study area.

Flower feeders - the types usually seen in mallee and big mallee - include many beetles, flies, and bees and wasps. The Sunset and Big Desert blocks are particularly rich in jewel beetles. The rare blue butterfly *(Candalides hyacinthinus simplex)* is commonly found on clumps of the large dodder-laurel.

In hummock grass-mallee, porcupine grass usually contains numbers of cockroaches, many of which are large and attractively marked. Spiders are also common. Amyc-

terine ground weevils are locally common and feed on the porcupine grass. The sedge *Gahnia lanigera* is often found in this formation, and is the food plant of a very rare skipper butterfly, *Motasingha atralba*, colonies of which exist at Hattah and in the Big Desert.

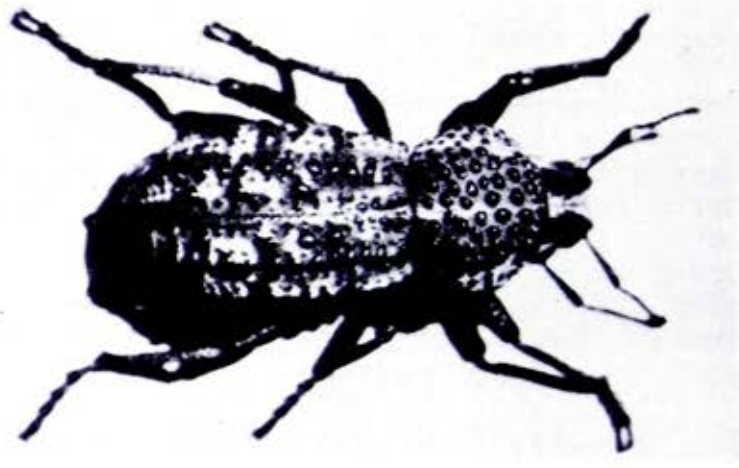
In aquatic habitats, the permanence and rate of flow of the water, and the amount of plant life, will influence the type of species found there. Waters that are flowing and contain abundant aerating plants will probably have extensive associations, including dragonflies, stoneflies, and caddisflies. Some bugs are associated with most swamps and some of the aquatic beetles also occur. Surprisingly large numbers of these beetles can be found after rain throughout the Mallee. The tiger beetle *(Cicindela saetigera)* occurs in Victoria only in saltpans in the Mallee.

In woodland habitats, the rare blue butterfly *Ogyris amaryllis meridionalis* is sometimes associated with buloke mistletoe and creeping mistletoe, both of which parasitize buloke. The butterfly larvae are attended by several species of ants, and pupae are found under the bark of the host trees. The wood white butterfly, *Delias aganippe*, also feeds on this mistletoe group. Several rare species of butterfly are restricted to habitats containing buloke.

Insects of the heath and mallee-heath habitat are usually prolific and clearly visible in spring, particularly where flowering shrubs such as tea tree or broombush grow. Flies, including many marchflies, and beetles, particularly species of the family Buprestidae, are found on the flowers, in association with wasps and bees, ants *(Camponotus* sp.) and a range of butterflies and moths. The extremely rare butterfly *Ogyris stanes* has recently been found in the Big Desert block and its life history traced to plants of the genus *Choretrum* (sour bushes). Many insects are attracted to the peaks of the dunes, and the day-flying moths of the family Castniidae are often seen over the dunes.

Other invertebrates

The terrestrial invertebrate fauna (other



A ground weevil, Celerorinus amycteroides, *which lives in porcupine grass tussocks in the Big Desert.*

than arthropods) of the Mallee is sparse and specialized due to the dry, sandy nature of most of the area. The aquatic invertebrate fauna is limited to areas of permanent water, which occur only infrequently away from the Murray River.

The following notes on the non-insect invertebrates were compiled by Dr. B. J. Smith of the National Museum of Victoria from the reference collections and associated records of the Museum. They are very incomplete, as no systematic study of invertebrates has ever been carried out in the area.

Several species of native land molluscs either are only found in this region of the State (being assocaited with a central Australian fauna) or are significant introduced species likely to be of economic importance.

Three species *Thermapupa adelaidae, Sinumelon fondinalis, and Australbinula bannertonensis,* the latter being first described from Bannerton - are confined to the Sunset Country and the drier areas close to the Murray River. Outside the State they range into south-western New South Wales and eastern and northern South Australia.

Two species, *Theba pisana* and *Cochlicella acuta,* have been recently introduced into the northern Victorian irrigation areas and have been recorded in the Murray valley area round Mildura and at Irymple. These species have been recorded before near the coast, both in Victoria and South Australia.

Aquatic invertebrates

Several species of aquatic molluscs are important in this area.

Two large gastropod species are confined to the Murray and some of its tributaries, but range in the Murray--Darling system from northern Victoria to southern Queensland. These are *Notopala hanleyi* and *Plotiopsis balonnensis.* The large freshwater mussel, *Velesunio ambiguus,* is very common in the Murray and many of the other streams, channels, and dams in the area. Of special interest is a freshwater snail, *Bulinus* sp., which is found in large numbers in many of the water tanks in the Sunset and the Big Desert blocks. These are probably of considerable importance as food for birds.

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LAND SYSTEMS

When dealing with very large areas of land such as the Mallee, mapping land forms, soils, or vegetation communities separately is impractical. However, as these are not random features it is possible to define larger mapping units, known as "land systems", in which a limited range of land forms and soils occur in characteristic patterns.

The land system method of describing and mapping land has an advantage in that each feature of the environment is considered in relation to others, not separately as in a soil or vegetation survey. Moreover, large areas can be described relatively simply. Some of the land systems encompass a significant range of climate, and subdivisions can be made by means of the average annual rainfall isohyets superimposed on the land systems map.

Salient features of the 13 land systems defined by Rowan and Downes (1963) in the study area are described below. Land systems containing large areas of public land are described more fully than those in which almost all the land has been cleared for agriculture.

Map 3 shows the distribution of the land systems, and the accompanying table (Table 7) summarizes their main features.

Central Mallee

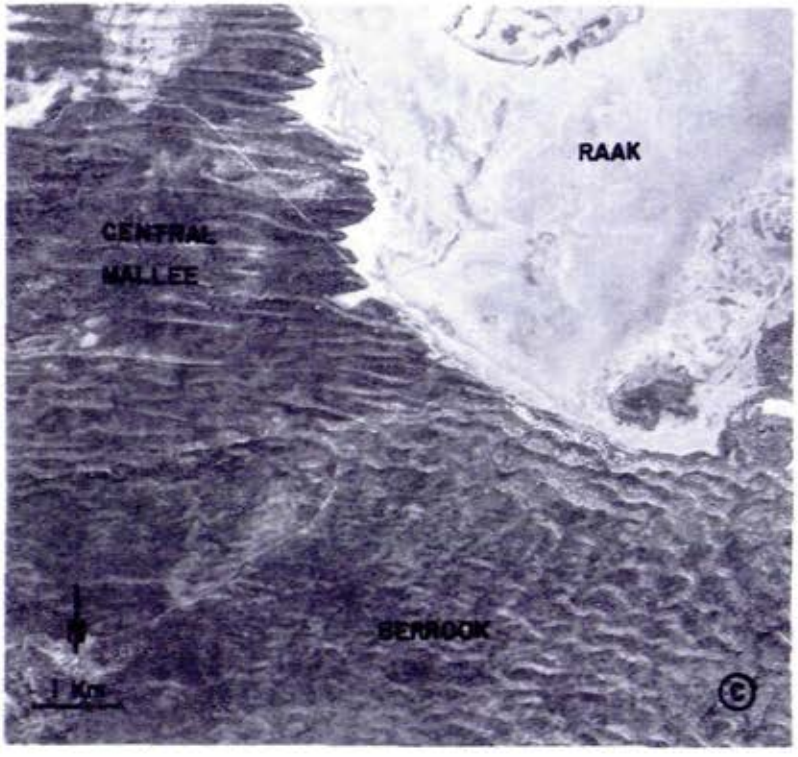
Soon after settlement, the Central Mallee land system, which covers one-third of the region, became one of the worst-eroded areas in Australia, and public enquiries were held into the wind erosion problem. Consequently this land system largely determined the popular concept of north-western Victoria as a whole.

The Central Mallee land system covers approximately 11,500 sq km of which large areas have been alienated and cleared for agriculture. Substantial areas remain under native vegetation in the Sunset block and south of Wemen. The materials laying at the surface in the land system have been named the Woorinen Formation (see Chapter 4) and consist of aeolian calcareous sands and clays, overlying Pleistocene limestone, clay, and sand, or the Parilla Sand.

East--west trending dunes dominate the landscape, and are more frequent here than in any other cleared parts of the region. They occupy some 30% of the

landscape, i.e. three or four occur in any north--south transect of 1 km, but their frequency varies from place to place. The basement on which the dunes rest is either level or undulating, consisting of plains, hummocks, and ridges trending NNW--SSE.

Soil textures range from sand to clay, with the sands occupying the higher positions, and sandy loams (medium-textured calcareous gradational and duplex soils) occurring on the flats. Brownish calcareous clays may be seen in the lowest positions.



Vertical aerial photograph of the junction of the Central Mallee, Berrook, and Raak land systems in the eastern part of the Sunset block

Mallee alternating with strips of hummock grass-mallee along the dune crests is by far the most widespread native vegetation. However, woodlands of cypress pine, belar, and buloke are scattered throughout on all landscape positions. Occasional stands of big mallee and grassland grow on heavy soils in the lowest sites and limited areas of scrub-mallee appear on reddish yellow dunes or on the steeper slopes of hummocks and ridges.

Although average rainfall varies from less than 280 mm in the north to 320 mm in the south, the gradation is not accompanied by significant changes in native vegetation or soils. However, agricultural production increases appreciably from north to south and reference should be made to the isohyets to subdivide the land system into units of comparable climate.

With its dense array of dunes, the Central Mallee land system has a high erosion hazard. The hazard is also severe on the sands of the upper slopes of hummocks and ridges. The eastern faces of these are areas of drift accumulation. Almost all the dunes on farms have had their A horizons either stripped or buried. Salting caused by seepage is a

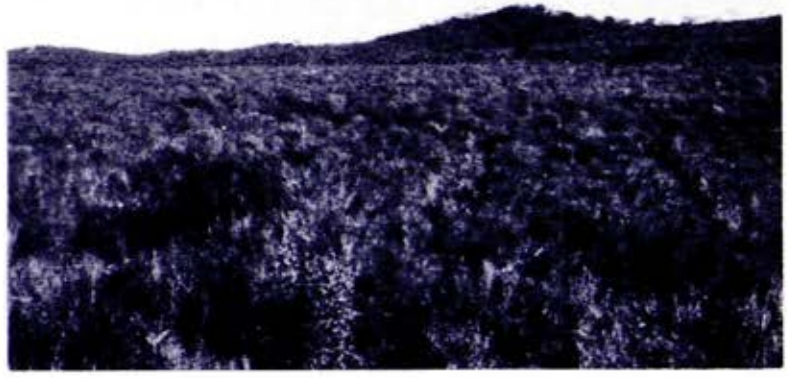
serious problem in the southern parts of the land system.

Big Desert

The Ouyen--Murrayville settlement gives way abruptly in the south to a vast area of uninhabited country known as the "Big Desert". However it is not a true desert as it is densely covered with scrub. The area is largely inaccessible, with the best track entering the scrub to the south of Murrayville and emerging north of Nhill, in the Wimmera.

The Big Desert covers 5,100 sq km and is the north-eastern extremity of a much larger area of infertile sands. These sands extend westwards into South Australia, where they form the "Ninety-mile Plain", and are also contiguous with those of the Little Desert in the Wimmera. Lawrence (1966) named them Lowan Sand, and supported the theory that they were produced by erosion of the underlying Parilla Sand.

In the Big Desert, wind has fashioned the landscape into a complex array of east--west trending dunes with impressive parabolic and irregular dunes, and intervening sandplains. On the land systems map facing page 104, areas of dense dunes with narrow sandplains occupying only 25% of the landscape have been mapped as BD1. Areas of large irregular dunes with larger sandplains occupying about 50% of the landscape have been mapped as BD2.



Heath on a sandplain in the Big Desert, with irregular dunes in the background

White deep sands predominate on all parts of the landscape with smaller areas of white sandy calcareous soils in the lowest sites. By comparison with other soils of the region, both types of sand have extremely low fertility. The pH of the surface horizons is approximately neutral. In occasional low sites strata of clay or sandy clay occur close to or at the surface.

Estimates of the rainfall, which averages about 325 mm per annum, apply only along the northern and eastern margins of the land system. In the isolated south-western parts the rainfall is higher, probably between 360 and 380 mm.

The native vegetation is mainly heath, mallee-heath, and scrub-mallee occurring throughout the landscape. Both the

heath and mallee-heath contain a wide variety of shrubs and do not occur north of approximately the 330 mm isohyet where scrub-mallee blankets the entire landscape. Further south the distribution of the three communities appears to be largely random with respect to topography and soils, except that heath is confined to the deep sands. Their random distribution may be largely the effect of scattered fires.

Together with the Berrook land system further to the north, the Big Desert land system has a higher erosion hazard than any other country in the region. The dunes and intervening sandplains are extremely unstable when cleared and the hazard on the latter, although lower, is nevertheless severe. At present the native vegetation provides complete protection from the wind except along the crests of the razor-backed dunes, where some sand movement occurs. When fires sweep through the scrub, not much erosion follows owing to the wind-breaking effect of the remaining stalks of the shrubs and mallees. Moreover, a resistant surface seal forms under the impact of raindrops, and mosses and lichens also help to bind the soil.

Around the margins of the land system the infertile white sands have been cleared in places, particularly where they occur on farms developed on pockets of more fertile country within the boundary of the land system. Even where stability has been maintained, productivity is low, but generally the cleared Big Desert sands have become unmanageable, with the dunes drifting and the lower sites supporting regenerating scrub or weeds.

Berrook

The Ouyen--Murrayville and Redcliffs--Morkalla settlements are separated by some 50 km of uncleared country known locally as the "Sunset Desert" or the "Sunset Country". The Berrook land system covers 3,000 sq km in the southern half of this area, and stretches over the South Australian border almost to the Murray River. With its deep, white infertile sands fashioned by the wind into irregular east--west dunes and intervening sand plains, it closely resembles the Big Desert land system. Although the soils differ to only a minor extent, the land forms, native vegetation, and climate are quite distinct.

In the Berrook land system the deep white sands occupy virtually the whole landscape except certain atypical areas. Most of the country contains dense jumbled dunes with narrow interdune corridors forming only about 20% of the landscape. Minor areas contain dense, relatively small dunes. The native vegetation consists of hummock grass-mallee and scrub-mallee in which tea tree is prominent. Mallee is confined to the lowest sites. Average annual rainfall ranges between 290 and 300 mm.

The problems of land development for agriculture are similar to those of the Big Desert land system, but they are accentuated by the drier climate and the less suitable arrangement of the jumbled dunes in which the proportion of reasonably sized sandplains is negligible. Removal of the native vegetation would undoubtedly lead to instability while knowledge of appropriate methods of managing these lands is limited.

Settlement has occurred within the boundary of this land system on a pocket of atypical country in and adjacent to the Parish of Berrook, where considerable areas of medium-texture calcareous gradational and duplex soils occur. Shallow loamy soils also occur on limestone.

Near the centre of the land system there are several large plains on which the native vegetation, soils, and topography differ markedly from the surrounding country. The three largest are known as the Birthday, Sunset, and Mopoke Plains. They support attractive grasslands, with scattered slender cypress pine, belar, and buloke woodlands or savannahs alternating with areas of big mallee and saltbush mallee in which the predominant shrub is bladder saltbush. The plains are leased for light grazing, as the grasslands afford low-cost feed. Stability has been well maintained except on the approaches to the occasional water-supply tanks, which are fed by surface run-off. The plains have considerable natural beauty.

Tempy and Hopetoun

In the central south of the study area two similar land systems have been almost completely cleared for agriculture. Their landscape consists of a regular series of large NNW--SSE trending ridges and a superimposed array of east--west trending sand dunes. Dense dunes comprise about 15% of the landscape in the Tempy land system, while in the Hopetoun land system they are less dense and occupy about 5%.

Sandy calcareous soils cover the dunes and ridge crests. Medium- and heavy-textured soils predominate elsewhere. In the Hopetoun land system, clay soils are particularly widespread.

Mallee is by far the most common native vegetation. It predominates on all sites except the crests of the dunes and the upper slopes of the steepest ridges. These support mainly hummock grass-mallee as well as scrub-mallee in which broom-bush is predominant. Scattered stands of slender cypress pine, belar, and buloke occur on all sites. Big Mallee and grassland appear to have been widespread on the heavy plains before settlement.

The average annual rainfall varies from 320 to 360 mm. Agronomically the Tempy land system has much in common with the southern parts of the Central Mallee land system because of the similar soils and rainfall. Most of the Hopetoun

land system is more moist and has a higher proportion of heavy soils.

The general erosion hazard is fairly severe in the Tempy land system and may be compared to that of the Central Mallee land system. The dense dunes on the ridges are particularly unstable, although the hazard is much less on the lower ridge slopes and on the inter-ridge plains. The Hopetoun land system, with fewer dunes, has a lower general erosion hazard. The seepage salting hazard is also severe, increasing in intensity towards the south.

Biogbeat and Culgoa

In the Biogbeat land system the landscape is dominated by hummocks usually 0.5--1 km across. The adjacent Culgoa land system has hummocks and ridges interspersed with extensive heavy plains. Both systems have been almost entirely cleared for agriculture, although a good stand of native vegetation remains at Yarrara.

Soils are of medium texture, with clay soils predominating on the plains.

Mallee is the most widespread remaining native vegetation, although woodlands of slender cypress pine, belar and buloke are common in scattered remnants in the northern parts of the land systems. Big mallee and grassland may have been widespread on the heavier plains in the south before settlement.

The general erosion hazard in these land systems is relatively low. They are productive cropping districts, except in the northern areas where rainfall is less than the annual average of 300--360 mm.

Millewa

The Millewa land system lies in the north-western part of the study area, stretching from the South Australian border to Mildura. It covers an area of 2,780 sq km and a large part of it has been cleared for agriculture. However, substantial areas of public land remain on the border and to the north of the Sturt Highway, with smaller areas near Mildura.

Most of the land system is undulating, owing to the presence of ridges, hummocks, and dunes, but some extensive heavy plains occur in the east. Dunes occupy about 15% of the landscape and thus are less frequent than in the Central Mallee land system. Medium-textured calcareous gradational soils occur on all sites except the dunes, where relatively fertile red, sandy calcareous soils predominate. Shallow soils on limestone are common towards the west.

The native vegetation is diverse, consisting of intermingling stands of grassland, savannah, slender cypress pine--belar woodland, and big mallee. Although each of these communities grows on a wide range of soils and in various

topographic situations, grassland is more common on the heavier soils in the lower sites, while woodlands occupy the dunes. The plains support grassland, big mallee, saltbush-mallee containing bladder saltbush and bluebush, and saltbush-woodland of belar and bluebush.

Annual rainfall is low, averaging only 250-265 mm, which is marginal for wheat-growing. The light and medium-textured soils are used for cropping, while the heavier soils support grazing.

The general erosion hazard is moderate to severe, although less than in the Central Mallee system, where there are more dunes.

The uncleared public land is used for low-intensity grazing and its stability has been fairly well maintained, except during droughts, when overgrazing has occurred. As a result, the stands of native perennial grasses have deteriorated.

Wycheproof

In north-western Victoria the dense array of undulating land forms - dunes, irregular dunes, ridges, and hummocks - diminishes towards the south-east, until in the Wycheproof land system the country consists entirely of plains. This is the start of the vast area of riverine plains in northern and north-western Victoria and adjacent parts of New South Wales. Although the plains are the result of stream deposition, in the Wycheproof land system the surface strata have originated as dust or "parna" that has covered the stream deposits.

Almost all of this land system has been alienated and cleared for agriculture. As it lies beyond the fringe of the Mallee vegetation, the native trees are buloke and yellow gum. These species also dominate in the east across the plains of northern Victoria and to the south in the Wimmera. The Wycheproof land system now contains only scattered trees, and it is not possible to assess their original density accurately. Yellow gum occurs in the northern parts of this system, marking the northernmost and driest extent of this species on rising ground in Victoria.

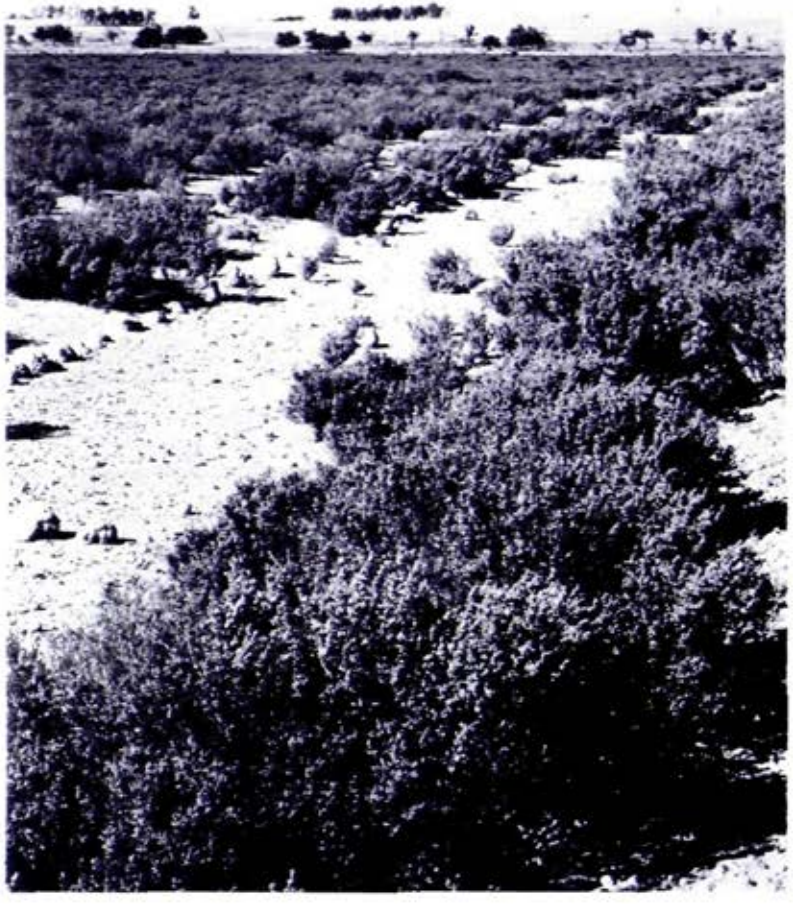
The predominant soils are light clays and, unlike those of equivalent texture elsewhere in the study area, are only weakly gilgaied and have mainly uniformly red-brown, lime-free surfaces, of approximately neutral pH. The rainfall averages almost 360 mm per annum. The erosion hazard is slight.

Grey heavy clays occur in shallow drainage lines, which trend in a general NNW direction. These soils are too heavy for cropping and are used for grazing.

Ned's Corner

The Ned's Corner land system, about 25% of which is public land, occupies a

plain of 700 sq km beside the Murray River in the far north-western corner of the State. It is an ancient river terrace above the present flood plain, but below the Millewa land system to the south. The plain carries a saltbush



Saltbush plains of the Ned's Corner land system, with the Millewa land system in the background

formation dominated by bladder saltbush and bluebush, which is unique in Victoria although widespread in the interior of the continent.

The bladder saltbush plains predominate in the central parts of the land system. The parent materials of the soils are mainly regional dust or "parna", which has frequently blanketed saline deposits. Heavy-textured calcareous duplex soils occupy the better-drained sites while in the slight depressions the soils have a similar texture profile but are darker brown and saline at a relatively shallow depth.

The bluebush plains, which are slightly more undulating than the saltbush plains, occur between the saltbush and the Millewa land system, occupying the western, southern, and eastern parts of the land system. The medium-textured calcareous duplex soils contain a greater proportion of coarse saltation material than those of the saltbush plains.

Overgrazing has often modified the native vegetation and appears to have led to the replacement of saltbush by bluebush in some places. In addition, new communities have probably developed, e.g. the stands of bamboo grass that occupy low sites and are flooded after heavy rains. The subordinate species beneath well-preserved stands of saltbush include glasswort and pigface, and these two unpalatable species have assumed dominance as a result of over-

grazing in certain areas. Annuals grow intermittently between the saltbush and bluebush shrubs, e.g. barley grass, camel grass, brome grasses, medic, and flatweed. These annuals are most dense beneath the bluebush.

The native vegetation has been grazed since the 1840s, when pastoral runs were established with headquarters along the Murray River. The annual rainfall averages only 250 mm and, although the soils are medium to heavy-textured, the native vegetation must be retained for soil stability in such a dry climate.

Because of frequent overgrazing, particularly during the droughts, the country is badly wind-scalded. Although the gradients are slight, the scalds may be rilled. Along the northern margins, which fall towards the Lindsay Island land system, deep gullies are common.

Tyrrell Creek

No streams rise in north-western Victoria because of the low rainfall and the porous nature of the soils on the rising ground. However, seven streams enter the region from the higher-rainfall country in the south. Six of these flow only in the wet years and owing to seepage and evaporation the waters penetrate only as far as the central parts of the region. Tyrrell Creek discharges into Lake Tyrrell, Lalbert Creek into Lake Timboram, and Yarriambiack Creek into a series of lakes to the north of Hopetoun. In very wet years Outlet Creek overflows from Lake Hindmarsh to Lake Albacutya, but it rarely penetrates as far as Lake Agnes. The Avoca River discharges into a series of lakes between Swan Hill and Kerang. The Loddon River, flowing through a complex of anabranches to the Murray, forms the eastern boundary of the study area.

The low-lying country bordering these streams, with the exception of the Loddon River, forms the Tyrrell Creek land system, with an aggregate area of about 2,100 sq km. A tongue of low-lying country around Birchip has been included. It is a northerly extension of the Avon River and rarely receives floodwaters. Isolated occurrences of the land system to the north of the creeks indicate that the streams have penetrated further north in the past, but their courses have been blocked by aeolian deposits.

While much of the land has been alienated, a substantial area of public land remains around Outlet Creek, with smaller areas on Lalbert Creek. Most of the lakes associated with the lower Avoca River are public land.

The native vegetation on the plains is quite distinct from that on the rising country through which the creeks flow. It consists largely of black box woodlands and grasslands, with smaller areas of redgum woodlands on the better-watered sites. The drainage pattern of

Black box, lignum, and sedges on a floodplain of the Tyrrell Creek land system

the floodwaters, rather than soils, influences the distribution of these communities. The woodlands fringe the creeks, and lakes, while grasslands predominate on the broader plains. The native vegetation on the lunettes is similar to that on the surrounding land systems. Although the area is now largely cleared, pine and buloke woodlands probably predominate among smaller patches of mallee.

Grey heavy clays usually occupy the more frequently flooded creek beds as well as most of the lake beds. At slightly higher levels the clays may be overlain by brown loam, especially on the flood plains of Tyrrell and Lalbert Creeks.

Annual rainfall decreases along each creek, from an average of approximately 350 mm in the south to between 300 and 330 mm in the north.

Along Outlet Creek the grey clays are frequently overlain by grey sands, varying in thickness from about 5 to 60 cm. These occur on several grassland plains in the Pine Plains area. Here grasslands alternate with woodlands of black box and red gum. About 44 sq km (25%) of the plains consist of the combination of grasslands and grey sands. These grasslands provide low-cost feed and although the sands are susceptible to wind erosion, stability has been reasonably well maintained except near the occasional watersupply tanks.

Around Birchip, the plains of the Tyrrell Creek land system , which consist of heavy-textured, calcareous duplex soils, are above present flood levels. Their native grasslands have been grazed for over 120 years, and overgrazing has led to the development of extensive scalds.

About 5% of the land system around Dattuck, Tiega, Yaapeet, Hopetoun, and Pine Plains consists of lunettes carrying various types of soils. On most of them cropping has been followed by serious wind and water erosion.

Lindsay Island

In north-western Victoria, the flood plain of the Murray River is of variable

width and is occasionally discontinuous, as for example where the river runs up against cliffs of the Central Mallee and Millewa land systems. This flood plain covers some 1,560 sq km and together with the flood plain of the Loddon River constitutes the Lindsay Island land system. Most of the plain is dry for the greater part of the year, and the whole is only rarely flooded.

The average annual rainfall decreases downstream, from 325 mm at Kerang to 250 mm towards the South Australian border. The soils, mainly grey heavy clays, are frequently overlain by 2.5--5 cm of grey sandy loam and occasionally by deeper grey and white sands.

Distribution of the native vegetation is governed more by the drainage pattern of floodwaters than by the soil pattern. Woodlands of red gum run along the banks of the more permanent creeks and around the lake shores and lignum scrub and reeds occur frequently on the lake and creek beds. However, black box woodland is the most widespread community and it occupies the plains furthest from the drainage lines. In the far north-west, scattered remnants of bladder saltbush and old-man saltbush suggest that saltbush woodland nay have formed the original community.

Since the 1840s the country has been used as a source of red gum and black box timber, and much of the land system has been reserved as public land for timber production. Parts of the land system are used for grazing, but the carrying capacity is low because of the paucity of edible shrubs and grasses. A small proportion is irrigated, mainly around Swan Hill, where dairying is the chief enterprise.

The erosion hazard within the land system is generally low, but can be severe on "spot" areas of atypical country such as the occasional hummocks and lunettes.

Tall red gum on a flooded site in the Lindsay Island land system

The lunettes occur to the east of several shallow lake beds. In the drier north-western parts of the land system they are badly eroded by both wind and water. In the south-east they carry crops and remain relatively productive. Reddish-yellow sandy hummocks occupy about 104 sq km in the Kulkyne--Hattah area. Their original vegetation of cypress pine and mallee has been heavily thinned or removed, and overgrazing in the past has resulted in moderate erosion. The present vegetation on stable areas is ham-and-eggs daisy.

Raak

This land system consists of depressions containing evaporite salts, mainly common salt and gypsum. The depressions carry scattered transverse dunes, and some have lunettes on their eastern margins. The system covers a total area of 1,630 sq km, of which a substantial proportion is still public land.

Saltpans occupy the lowest sites on the plains and occur most widely in the Lake Tyrrell district and the "Raak Plains" west of Nowingi. They support no vegetation, apart from algae that cover them intermittently. Salt is harvested from the pans at Lake Tyrrell, Pink Lakes, and several other lakes in the Swan Hill--Kerang area.

At slightly higher levels, or on the lowest sites where salt pans are absent, the salt and gypsum deposits underlie fine textured red soil, which has originated as regional dust, or "parna". This soil, which is widespread throughout the land system ranges from 25 mm to at least 60 cm in depth and is sufficiently saline at the surface to exclude vegetation other than samphire. The fact that salt has not been removed from these soils under the virgin, ungrazed stands of samphire indicates that there is little possibility of desalinating the land for agricultural or pastoral use. Despite the low carrying capacity, the land has been stocked. Grazing and trampling have caused degeneration of the samphire, and this appears to have been accompanied by a rise in surface salinity with consequent further degeneration of the stands.

Plains carrying bladder saltbush often occur at higher levels than the stands of samphire. They are most common north of the railway line between Danyo and Underbool. Their soils consist of sandy loams, which are non-saline at the surface and appear to have been deposited by wind over the salt and gypsum layers. Salt has not risen to the surface beneath the saltbush, largely because, unlike the fine materials beneath the samphire, the soils have a coarse texture. Downward leaching by rain has counteracted any rise of salt following evaporation at the surface.

The stands of bladder saltbush appear to provide good grazing, and feed is available not only from the perennial shrubs

but also from ephemeral grasses. In general, the stands are in good condition. However, where the saltbush has been eaten out, severe wind erosion has removed the sandy topsoils to variable depths. The exposed saline subsoils have been colonized by samphire.

In the Raak country another type of plain intermingles with the saltpans and the level areas supporting samphire and saltbush. The sand mantle over the copi on this plain is relatively deep, being rarely less than 60 cm. Within this mantle, reddish-yellow sandy calcareous soils have developed. The native vegetation is mainly grassland, with savannah containing pine, belar, buloke, sandalwood, and mallees fringing the margins of the plains. The erosion hazard is too severe for successful cropping and the country is lightly grazed.

The transverse dunes or "copi islands" consist of low mounds scattered on the plains in all parts of the land system. They are composed of layers of sand, copi, (white powdered gypsum), gypsum, and occasionally limestone. The uppermost layer is sand, which is relatively shallow on the western faces (generally less than 15 cm) but deeper on the eastern faces. This overlies copi. The most common native vegetation is bladder saltbush, big mallee, or a combination of the two (saltbush--mallee). Where the saltbush has been eaten out, erosion is severe, resulting in stripping of sand from the western face to expose

Looking across a gypsum flat carrying samphire to a transverse dune carrying bladder saltbush and white mallee - Raak land system

copi, and in deposition of sand on the eastern slopes. Although erosion is widespread, no attempts at reclamation have been observed.

Lunettes flank the eastern margins of many basins in the Lake Tyrrell and Ouyen districts. Although the native

vegetation on the lunettes has been largely removed, remnants of pine--belar--buloke woodlands, mallee and big mallee indicate that the original communities were diverse and more akin to those on adjacent land systems than to the flora of the basins. The large lunette immediately to the east of Lake Tyrrell is an exception, because here bluebush appears to have been the original dominant species.

References

Lawrence, C.R. Cainozoic stratigraphy and structure of the Mallee region, Victoria. *Proceedings of the Royal Society of Victoria*, 1966, 79, 517-553.

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TABLE 7

LAND SYSTEMS

Land System	Parent materials	Land forms	Rainfall (mm)	Vegetation	Dominant soils	Erosion hazard
CENTRAL MALLEE	Reddish aeolian clayey sand (Woorinen Formation)	Dense E--W dunes over plains, hummocks, and ridges	260--315	Hummock grass-mallee on dune crests, mallee elsewhere, with occasional woodland or grassland	Med. - textured calc. grad. soils; reddish-yellow sandy calc. soils	Severe on dunes, slight to moderate elsewhere
BIG DESERT*	White aeolian sand (Lowan Sand)	Dunes, irregular dunes, and sandplains	320--375	Heath, mallee-heath, and scrub-mallee	Deep sands; white sandy calc. soils	Very severe on dunes, severe on sandplains
BERROOK	Lowan Sand	Dunes, irregular dunes, and sandplains	275--300	Scrub-mallee and hummock grass-mallee on dunes, mallee on some sandplains	Deep sands	Very severe on dunes, severe on sandplains
TEMPY	Woorinen Formation	NNW--SSE ridges and plains; E--W dunes dense on ridges, less dense on plains	315--325	Mallee, with hummock grass- or scrub-mallee on dune crests, some woodlands - mostly cleared	Med. - textured calc. grad. soils; reddish-yellow sandy calcareous soils	Very severe on dunes and ridges, slight to moderate on lower sites
HOPETOUN	Woorinen Formation	As for Tempy, but dunes weakly developed and fewer	315--350	Mallee, hummock grass-mallee on dune crests, occasional woodlands - mostly cleared	Brownish calc. clays; medium-textured calc. grad. and duplex soils	Very severe on dunes, severe on ridges, slight to moderate on lower sites
BOIGBEAT	Woorinen Formation	Dense hummocks on plains	260--330	Mallee and woodland - mostly cleared	Med. - textured calc. grad. and duplex soils	Severe on hummocks, slight to moderate elsewhere
CULGOA	Woorinen Formation	Scattered hummocks on plains and ridges	325--375	Mallee and occasional woodland - mostly cleared	Brownish calc. clays; medium-textured calc. grad. and duplex soils	Severe on hummocks, slight on plains
MILLEWA	Woorinen Formation	Ridges, plains, hummocks, and dunes	240--270	Big mallee, grassland, saltbush-mallee, and woodland	Med. - textured calc. grad. soils; red sands	Severe on hummocks and dunes, slight to moderate elsewhere
WYCHEPROOF	Woorinen Formation	Plain, occasional drainage line	350--375	Woodland, savannah, and grassland - mostly cleared	Brownish calc. clays; Grey cracking clays	Slight
NED'S CORNER	Woorinen Formation over grey riverine clays	Plain	250	Saltbush	Heavy- and med.-textured calc. duplex soils	Moderate
TYRRELL CREEK	Clay alluvium (Coonambidgal Formation), overlain in some places by sand	Plain, occasional lunette	300--375	Woodland, savannah, and grassland	Grey cracking clays	Severe on lunettes, moderate to slight elsewhere
LINDSAY ISLAND	Coonambidgal Formation, covered by Woorinen Formation in some places	Plain, occasional hummocks, dunes, and lunettes	240--375	Woodland, scrub-mallee on some hummocks	Grey cracking clays	Severe on lunettes and hummocks, slight elsewhere
RAAK	Gypsum and salt deposits (Yamba Formation) often covered with sand	Plains, lunettes, transverse dunes	250--360	Saltbush, grassland, savannah, big mallee, saltbush--mallee	Saline soils	Moderate to severe

* BD1 - dense dunes, small sandplains BD2 - irregular dunes, large sandplains

LAND SYSTEMS AND RAINFALL

LAND CONSERVATION COUNCIL
VICTORIA
MALLEE STUDY AREA

1:500,000

LEGEND

- CM — CENTRAL MALLEE
- BD1 / BD2 — BIG DESERT
- BR — BERRIOOK
- T — TEMPY
- H — HOPETOUN
- Bg — BORGBEAT
- CO — COLIGOA
- M — MILLEWA
- W — WYCHEPROOF
- NC — NEDS CORNER
- TC — TYRRELL CREEK
- U — LINDSAY ISLAND
- R — RAAK

250 mm — AVERAGE ANNUAL ISOHYET

MILLIMETRES	INCHES (Approx)
250	10
275	11
300	12
325	13
350	14
375	15

Some narrow zonal transitions are not shown

Reproduced from - J.N. Rowan & R.G. Downes "A study of the land in North Western Victoria" (S.C.A. 1953), with some additions.

MAP No. 3

PART III

LAND USE

NATURE CONSERVATION

A number of uses of land require a high degree of nature conservation, that is, its plant and animal communities and its physical features (soils, land forms) need to be maintained in a natural condition. Such uses include reference, conservation of plant and animal species and associations, and recreation and education. These uses are often complementary.

Reference

The solution to problems arising from our use of a particular land type is often helped by reference to an undisturbed example of the land type, where the soils, vegetation, and fauna, and the processes linking them, can be studied under natural conditions. Knowledge of the basic relations operating within a land type has great value when studying problems such as falling productivity or soil instability. In the Mallee, the study of soil salting, resulting from farming in some dryland areas, is hindered by the lack of similar natural areas, with native vegetation and unaltered land forms.

Areas reserved for reference also make a valuable contribution to the conservation of plant and animal species and associations.

Reference areas must be carefully chosen and managed to permit natural processes to continue without disturbance. Entry to these areas is restricted and they should be protected by a buffer zone. Their selection is seldom hard in practice because few suitable areas remain.

Conservation of species

Each species of plant and animal makes a unique contribution to the richness and diversity of the human environment. Each is an essential part of Man's natural heritage and, to many people, there is a moral responsibility to ensure that none of them should knowingly be lost or endangered.

Chemists, geneticists, physiologists, and scientists in many other fields place a special value on each individual species for its potential to provide the means of solving a research problem, or to be used in future as the stock for breeding essential plants or animals.

Conservation of the existing plant and animal species and associations in their

natural habitats is thus an important land use. The survival of some species may require precautions because few individuals remain in existence. In other instances, particular species may be living in unusual habitats, or near the limits of their distributions, and it may be justifiable to devote the land expressly to their conservation.

The essential for conservation of plants and animals is to recognize the ecosystems they form (the interdependent complexes of soils, water, air, plants, and animals), and to conserve examples of each major one.

The range of different ecosystems in a region is reliably indicated by the vegetation. Plants express the various conditions of soil and climate, and they determine the types of food and shelter available for birds and animals. Conservation of a representative area of each distinct plant association or formation ensures the protection of the most different ecosystems of a region, and also most of the individual species. Numerous small occurrences of distinctive types of vegetation, land form, or natural habitat may comprise the remainder.

Lake Brockie, in the Hattah Lakes National Park

Recreation

Most Australians live in the artificial environments of the large cities and towns, and many find that their lives are enriched by renewed contact with the natural world. As discussed in Chapter 13, many forms of outdoor recreation require natural surroundings. Bird-watching, nature study, and bush-walking require conservation of the native plants and animals; for picnicking and driving the requirements are simply a background of trees or shrubs in the recreation areas. Large expanses of natural landscape are an essential part of the experience of solitude, which some people seek in their outdoor recreation.

Education

Education is another important use of land in a natural or near-natural condition. Forests, coastlines, rivers, and other natural landscapes have many

applications in education - from primary to post-graduate levels - giving students opportunities to see, interpret, collect, and monitor natural land forms and processes. The land requirements of education are less exacting than those for reference, but impact on the vegetation and soils is greater.

Small areas

Many small areas can contribute to nature conservation. They include narrow reserves along coasts, streams, and roads, and remnants of the native vegetation that have survived on areas originally set aside as gravel, water, cemetery,school and camping reserves. Where these small areas retain native vegetation, and are surrounded by cleared and developed land, they can make a major contribution to the regional character of the landscape.

In the study area, strips of native vegetation retained along the roads and railways are important for migratory and nomadic birds and for resident populations of small animals. These small areas are especially important in the south-eastern Mallee, where no large natural areas remain.

Commercial uses

Some commercial uses of land are achieved by conserving the natural ecosystems in varying degrees. The commercial product is obtained by harvesting a

A remnant of the native mallee on a small reserve

proportion of the population of a species or group of species at a controlled rate that the ecosystem can sustain,as in forests managed for sustained yield of timber and wetlands managed to produce game birds. The continued success of such uses depends on maintaining many of the natural features of the ecosystem. Land under such management can also be used for education, recreation, and scientific purposes, and it may form a

protective buffer around small areas devoted strictly to nature conservation.

Types of reserves

Many of the uses discussed above are complementary and this is reflected in the types of reserves into which natural land is placed. In reference areas, where the emphasis is on retention of natural conditions, conservation of species and water production are the only other compatible uses.

However, parks encompass a wider range of uses - conservation of plants, animals, and land forms, differing forms of recreation, education, and other uses such as the preservation of historical sites, and landscape preservation. There are different types of parks, and individual parks are zoned to prevent conflict between uses.

Some areas may have to be set aside especially for education, where extensive alterations to the environment for experimental purposes, not permitted in parks, can be carried out. In wildlife reserves, the conservation of species of animals - this mean conservation of their habitats - is the main use, and some recreational use is also permitted.

Viability

The viability and effectiveness of nature conservation reserves depend on a number of factors, including the size of the reserve, the type of community or ecosystem present, and the degree to which the area can be managed to control influences that tend to upset the natural balance.

Large compact reserves are best able to withstand intrusive factors. Generally, the conservation of birds and mammals will require areas larger than those for the maintenance of plants, insects, or amphibians. In the semi-arid Mallee environment, reserves must be large if animal populations are to survive droughts and fires.

RECREATION

Recreation is any activity freely undertaken for personal pleasure. Outdoor recreation, which includes a wide range of pursuits, forms an important use of public land. Indeed, as discussed in the preceding chapter, it is one of the major reasons for the retention of natural areas.

Although the Mallee contains vast areas of public land, it is remote from large centres of population and lacks well-known scenic attractions. While residents use the public land near the cities and towns, recreational pressure on the study area as a whole is low. From the scant information available it seems that most of the people who visit the remote areas are from the cities of southern Victoria.

The pattern of use is probably due to the low population of the study area, and the different recreational preferences of city and country dwellers. While the Mallee has no well-publicized tourist attractions - although Wyperfeld and Hattah Lakes National Parks are reasonably well known - there may be three reasons why city people visit the area. Firstly, it represents a unique environment within Victoria, and so would attract tourists looking for something different. Secondly, the Murray River and the two large river towns, Swan Hill and Mildura, offer much that interests city people. Thirdly, the Mallee is convenient to tourist routes linking Adelaide (and attractions such as the Barossa Valley and the Grampians) with Canberra, Sydney and Melbourne.

Thus while land near the cities and towns is used by local residents, few people visit the remote public lands. However, many people travel through the study area *en route* to the river towns or other destinations outside the study area.

This chapter described the recreational resources of the study area and their present use, and discusses the demands that could be placed on them in the future. Lack of statistics limits the accuracy of this account, although some are given.

Resources

In a general sense the Mallee as an entity is a recreational resource. The hot, dry climate, the undulating to flat land forms, the native vegetation, the

large wheat and sheep farms, and the irrigated vineyards and citrus orchards give the region a distinctive character that attract visitors.

Most of the public lands carry various forms of mallee scrub as well as heath in the Big Desert. While rarity lends interest to these landscapes in Victoria, they cannot be rated as attractive scenery, except from a few vantage points on high dunes. However, several areas with more attractive vegetation do exist, particularly grasslands, grassy woodlands, and pine--belar--buloke woodlands. These communities occur to the north and west of the Millewa settlement, at Pine Plains, and on the floodplains of the Murray River and minor creeks. The land to the north-west of the Millewa settlement has considerable potential for recreation, as it lies near the Sturt Highway, contains a range of vegetation types, including saltbush plains, and can be supplied with water from the nearby Murray River.

Am important feature of the public land is the occurrence of two very large blocks (Big Desert and Sunset) of relatively undeveloped land. The Big Desert in particular contains very large trackless areas - their recreational significance is their value as wilderness, where a hiker can walk for several days without seeing evidence of human activity. On the western side of the Murrayville--Yanac road an area of about 95,000 ha may be delineated that is more than 5 km from a road in any direction. On the eastern side about 263,000 ha lie more than 5 km from any road. In addition, some of the large sandhills give the area scenic grandeur. The Sunset block contains smaller but similarly remote areas. Isolated areas such as these are now quite rare in Victoria.

Diverse land forms and vegetation occur in the Sunset block. Unusual sandplains may be seen in the west, large grassy plains in the centre, and variably coloured saltpans interspersed with grassy plains in the east. Unlike the Big Desert, rough tracks provide access to most parts of the Sunset block.

Water

In the Mallee's semi-arid environment, water is a major attraction, and so the Murray River with its lakes and billabongs comprises an important recreational resource. In addition to the aquatic environment, the red gum forests and woodlands associated with the river are popular for recreation. Access is good, the tall red gums provide welcome relief from the low mallees, and wildlife abounds. The Murray has a long frontage of public land, most of which is used for several forms of recreation. The most important areas are the Kulkyne forest and the forests near Mildura, Robinvale, Narrung, Piambie, and Nyah.

A number of lakes, scattered through the dry centre of the study area, are all

used intensively by the local communities in summer. Many of the lakes are filled by the State Rivers and Water Supply Commission from the stock and domestic channel system. The major ones are Walpeup Lake, Green Lake, and Lake Lascelles. Lake Cullulerraine, many of the lakes in the Avoca wetlands and the saline evaporation basins receive water as part of the Water Commission's

An attractive grassy plain in the south of the Sunset block

The paddle steamer "Gem" at the entrance to the Swan Hill Pioneer Settlement

distribution system. Lake Albacutya, fed by Outlet Creek, is a popular recreation resort when it contains water.

Sandy undulating tracks in many parts of the study area are used occasionally for motor cycle and trail-driving events.

Wildlife in the region provides another important recreational resource. Ducks, snipe, and quail (Victoria's major game species) are common in some parts of the study area in good seasons. The streams and lakes support a popular freshwater fishery.

As pointed out in Chapters 9 and 10, the flora and fauna of the study area contain many species that are adapted to arid conditions and that are not found elsewhere in the State. The presence of these species - and also of the readily observed larger animals such as emus and kangaroos - gives the area special value for nature study.

The cities of Swan Hill and Mildura are probably the main attractions drawing visitors to the region for recreation. Mildura - with its sunny weather, organized sport, and natural features such as the Murray River, the red gum forests, and the vineyards and orchards - has a thriving tourist industry, while the main attraction at Swan Hill is the Pioneer Settlement, a re-creation of the early days of settlement in the Mallee and northern plains.

The public lands are not well distributed within the study area. No large areas of mallee scrub remain in the east and south-east, and visitors to the Pioneer Settlement cannot see any land in the vicinity clothed with the native mallee that confronted the pioneers.

Activities

The following paragraphs describe the recreational activities currently taking place in the Mallee and present statistics where available. The emphasis is on those activities that take place on public land, and it will be observed that many are closely associated, e.g. motoring, picnicking, and fishing.

Statistics

Several sources provide information on the number of visitors. Statistics relating to a specific activity, such as duck-shooting, are presented in the relevant sections following, while those relating to visitors to the region and covering several types of activities are given here.

Table 8 gives conservative estimates (expressed as visitor-days) of the number visiting the two National Parks in the study area over the last 6 years.

TABLE 8

NUMBER OF VISITOR-DAYS AT WYPERFELD AND HATTAH LAKES NATIONAL PARKS OVER THE 6-YEAR PERIOD 1967--73

Year	Wyperfeld	Hattah Lakes
1967-68	6,400	7,188
1968-69	8,601	8,134
1969-70	8,101	6,536
1970-71	9,360	12,019
1971-72	15,900	15,957
1972-73	19,697	16,224

Clearly, the number of people visiting the parks is growing rapidly. Increase in the numbers visiting Wyperfeld National Park since 1970-71 is particularly noteworthy. Visitor numbers at Hattah Lakes are influenced by the presence or absence of water in the lakes. The decline in numbers in 1969-70 was caused by the fact that the lakes were dry from 1967 to the spring of 1970.

Most visitors to Wyperfeld National Park camp there for at least one night after having travelled mainly from Melbourne and Adelaide. Single-day visitors usually come from the towns and farms within 150 km of the park.

An estimate made in 1970 of the number of visitors who stayed at Mildura for at least one night was 400,000, and numbers have been increasing since that time. Most visitors come from Melbourne or Adelaide. The number of people visiting the Swan Hill Pioneer Settlement has risen from 170,000 in 1969-70 to 300,000 in 1972-73. About 80% of them come from southern Victoria. The settlement is expanding and even more visitors can be expected in future years.

The impact that these city visitors make on the public lands is not clear. Most simply drive past public land without stopping because of the lack of developed stopping places. Visitors to the river towns have little impact on the public land of the Big Desert and Sunset blocks.

Pleasure driving/sightseeing

Visitors to the region (including those on bus tours) and also local townspeople

A black box tree in the Leaghur Forest Park from which Aborigines have removed bark

engage in this activity. They require visual diversity in the environment, with some features of particular interest such as wildlife, the river or a lake. The retention of strips of native vegetation on road reserves in cleared areas is important for pleasure driving. Bogging in mud or sand is a hazard.

Problems associated with motoring are the creation of too many tracks and disturbance of flora and soil when cars leave bush roads and drive across country.

Picnicking

This form of recreation requires pleasant surroundings, usually with some facilities such as fireplaces and tables. It often takes the form of day trips that involve 1--2 hours of travel each way and so pressure from this type of activity is greatest within 40--80 miles of population centres.

In general, the study area is well supplied with land resources for picnicking, except in the south east and near Swan Hill. However, fireplaces and tables have been installed in only a few places. Problems associated with picnicking are litter, high fire risk, and trampling of native vegetation.

Pleasure walking

This activity is often associated with the two mentioned above, and does not include long-distance hiking. Walkers want interesting landscapes and vegetation. In the Mallee, walking tracks are usually not required, but the exclusion of vehicles may often be desirable to preserve a natural atmosphere.

The study area includes many places suitable for walking. Problems are few

provided use is not so concentrated that trampling and soil erosion become evident.

Camping

Some campers need only a simple clearing in the bush near water, while others expect tables, fireplaces and toilets. Areas supplied with water are limited to the land along the Murray River, the Avoca wetlands and Wyperfeld National Park. Virtually no water is available throughout the remainder of the public land, with the exception of dams generally containing muddy water that is only suitable for stock. While the long frontage to the Murray River is available for camping, facilities such as tables and toilets are rare except in the Hattah Lakes National Park. Camping raises problems of disposal of litter, and a high fire risk is associated with this activity.

Bushwalking

Bushwalkers require large areas of natural country with some outstanding features, no roads or tracks, and little evidence of human activity. The areas most often used are Wyperfeld National Park, Hattah Lakes--Kulkyne forest, the Big Desert and the Sunset block. These are used by local and Melbourne-based clubs, although the present level of use is low. River and stream frontages, especially near towns, also provide opportunities.

Part of the large area of trackless country in the Big Desert

The Big Desert has some attractive features for bushwalkers and could become an important area if more value is placed on "wilderness" in future.

Lack of water is a problem for bushwalkers in most of the study area.

Nature study

Many areas in the Mallee are suitable for studying plants and animals in their natural surroundings. Nature walks, where visitors follow a track with prepared notes identifying the various features, have been constructed in the two National Parks. The more expert observer uses remote or undisturbed areas

The Australian painted snipe is a prized game bird

seeking unusual species, or studying a particular species or group in detail. The study area contains many popular bird-watching locations, the Avoca wetlands being particularly good for waterbirds.

Nature study requires the preservation of natural areas, which means the exclusion on motor vehicles,and in some cases provision of walking tracks and interpretive services. The number of people using any area should be regulated to prevent over-use.

Swimming/sunbathing

The hot summers in the study area make swimming a popular form of recreation. The Murray River is the most important venue for swimming, although the small lakes scattered through the central Mallee are also intensively used. Requirements include the provision of access to safe areas and care of beaches at swimming sites.

Power boating/skiing

These pursuits are conducted on both the Murray and in many of the lakes and irrigation and drainage basins in the study area. Most activity occurs close to cities and towns, and site requirements are a large area of water (free of snags) and boat-launching ramps. The main problems associated with this activity are noise, conflicts with swimming, disturbance of wildlife, pollution, and erosion of banks.

Hunting

Ducks are the major game species in the study area and the 60 or so permanent and ephemeral lakes and swamps are used by duck-hunters. It is estimated that the number of duck-hunters using the study area would be 8,000 in an average season, 20,000 in a good season, and 4,000 in a poor season. Of these hunters, 2,000--3,000 would live in the study area.

Most of the hunters use the Kerang lakes and marshes, while others go shooting on the Murray and at a few isolated lakes and swamps. Lake Albacutya is a popular area when it holds water.

The wetlands also harbour snipe and hence are important for this very challenging form of hunting; however, the number of snipe-hunters would not exceed 400.

The crops and pastures of the south-eastern Mallee support large populations of quail, and up to 5,000 quail-shooters use the region in a good season.

Rabbits, foxes, pigs and goats are also hunted in the study area.

The main requirements of the wetlands are an assured water supply and suitable vegetation to provide cover and nesting sites for game species.

Fishing

Fishing is a very popular form of recreation along the Murray River and in the Avoca wetlands. Up to 10,000 anglers use the area annually. Native fish populations appear to be declining owing to changes in the flow regime of the Murray River and the spread of the European carp. Fishermen mainly require access. Scattering of litter and possible damage caused by fires are the main problems associated with this activity.

Trail driving

This activity consists of driving cars and motor bikes over rough tracks through the bush. The requirements of the sport are tracks over varied terrain.

The Mallee is used for organized events and for pleasure riding by individuals or small groups.

The major event is the Sunraysia Desert Rally which has been run for the last 4 years over courses consisting of existing tracks in the eastern part of the Sunset block. Large parts of the circuits have been in public land. The rally is well known and 390 bikes and four-wheel vehicles took part in the 1973 event.

The Mallee Desert Rally was run around Lake Tyrrell for the first time in 1973. Eighty-five vehicles took part. This course includes very little public land.

In addition these organized events, bike and jeep riders use the area for pleasure riding. Most of this type of activity occurs near towns and main roads. The number of riders taking part in organized events is expected to increase more rapidly than the number of pleasure-drivers.

While the study area is favoured for this type of activity (due to its topography, sandiness and the large number of tracks) major hazards are involved. These include destruction of vegetation, soil erosion, and noise pollution. Where the vehicles are restricted to

existing tracks, as in the organized rallies, the hazards are minimized. However, pleasure-drivers, whether singly or in small groups, attempting to travel across country can cause serious damage.

Control of this type of activity presents a major problem.

Site capacity

The recreational capacity of an area is the maximum number of people (and boats and cars) that the area can absorb without suffering physical damage such as erosion, or without spoiling people's enjoyment through over-crowding. Large numbers of people and cars usually result in litter and trampled vegetation.

Most of the land in the study area is relatively fragile in that its soils are readily eroded and are protected only by sparse vegetation, which is slow to re-establish after damage. This means that in popular areas the activity of visitors must be regulated and special measures taken to prevent deterioration of the site.

Demand

The demand for outdoor recreation has increased markedly over the last decade. Many factors, some interdependent, are involved, although their exact influence is not clear. The major factors are discussed below.

Population

The size, density and distribution of the population influences the demand for land for recreation. As discussed in Chapter 2, the population of the region is low (about 71,000) with the main concentrations being around Mildura (35,000) and Swan Hill (8,000) (estimates from 1971 census). These are the only areas in which the population increased during the period 1966--1971. In the rural areas population decreased.

As the increases were of the order of 1--2% over the 5-year period, population growth in the area can be expected to generate a slow increase in the demand for outdoor recreation around the two city centres.

The growth of Melbourne (12% for the 5-year period 1966--1971 to a population of 2.5 million) and of other large southern cities will probably be more significant in generating increased demand for recreation in the study area as a whole.

Leisure

For most people leisure time follows a definite pattern - after school or work, at weekends, on school holidays, annual holidays, long-service leave and retirement. Leisure seems to be increasing, although the effect of second jobs on net leisure time is not clear. Introduction of the paid annual holiday,

long-service leave, and early retirement has led to an increased demand for outdoor recreation. Although this increase cannot be quantified, it is of special significance to the Mallee,as the area is remote from the capital cities and visits require at least 3 or 4 days. It would, therefore, be expected that the number of such visits may increase as people's leisure time becomes available in increasingly large blocks.

Income and transport

Overseas studies have shown that participation in outdoor recreation is directly related to disposable income. This is not surprising, as many recreational activities involve substantial costs for equipment, travel and accomodation. Incomes have been rising for many years and this trend is expected to continue.

All outdoor recreation involves travel, and the private car is the most common form of transport. With increasing affluence the proportion of the population owning cars is increasing - in Victoria in 1961 there was one car for every 4.6 people and in 1971 there was one car for every 3.4 people, despite the fact that about 34% of the population is younger than the legal driving age.

Car-ownership is of special significance for a remote area, such as the Mallee, where travelling is a major component of any outdoor recreation activity. Other vehicles such as trail bikes, four-wheel drives, and beach buggies, are also becoming more popular.

Other factors

The attractiveness of an area for recreation in comparison to alternative areas is important in determining what proportion of the total demand for recreation the area will receive. This involves personal preferences, the amount of publicity or promotion an area receives, distance, the condition of the roads, availability and quality of accomodation, and so on. Within Victoria the attractiveness of other areas such as the coast and the alpine country is rated highly in comparison with the Mallee. However, with the exception of Swan Hill and Mildura, the attractions of the Mallee have not been developed or promoted as yet. The extent to which this occurs in future will have a major influence on the nature and level of the demand for recreation in the area.

The development of recreation in the Mallee is hampered by the semi-arid conditions. Difficulties encountered in the area include lack of water, severe fire hazard at times, heat in summer and the risk of bogging in sand or mud on many of the tracks through public land.

Future demand

Accurate prediction is impossible owing to the number if variables involved. In

addition, changes in community attitudes to certain forms of recreation are quite unpredictable. The main conclusion that can be drawn is that most of the factors are working in favour of increasing the demand for outdoor recreation. In the study area the rate of increase may be relatively high, due to the generally low levels of activity at present.

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AGRICULTURE

Agriculture is the major form of land use in the study area - 30,000 of the 43,000 sq km are occupied for agricultural use and about half the public land is leased or licensed for grazing of livestock.

Most of the developed land is used for the production of cereal crops, mainly wheat, in rotation with volunteer or improved legume pastures for sheep grazing. Over the past 5 years, since the introduction of wheat delivery quotas in 1969, beef cattle and pig numbers have increased, but these are still small compared with sheep numbers (see Table 9).

Irrigation areas along the Murray River produce vines, citrus, and vegetables, and pasture for livestock enterprises (mainly near Swan Hill and Kerang).

Table 9 shows that most of the developed land - about 3 million ha - is devoted to dryland farming as compared with 70,000 ha under irrigation, the latter being almost exclusively confined to the counties of Karkarooc and Tatchera.

A figure for the average size of holdings cannot be derived accurately from Table 9 because of the different intensities of farming in dryland, irrigated pasture, and horticultural areas. However, information from other sources indicates the following breakdown of farm sizes:

	Land Holders	Av. size (ha)
Dryland	2,300	1,125
Horticulture	3,300	7
Irrigated pasture	300	160

Farm size varies widely in each case: 8% of dryland farms have areas of less than 400 ha and 9% greater than 2,000 ha.

Cereal Production

Cereal production is the main enterprise on the dryland farms in the study area. On average, over the 5-year period 1966--1971, 37% of the State's wheat (1.5 million tonnes), 31% of the barley (0.2 million tonnes), and 10% of the oats (0.1 million tonnes) has been grown in this area.

No single rotation is practised, but 80% of the wheat crop is grown on land

TABLE 9

AGRICULTURAL LAND USE IN THE FOUR MALLEE COUNTIES AS AT 31ST MARCH 1972

	Millewa	Weeah	Karkarooc	Tatchera	Total
Number of holdings	190	321	3,341	1,951	5,803
Total area occupied ('000 ha)	598	370	1,371	753	3,092
Crop	60	76	360	255	751
Fallow	30	46	222	157	455
Sown pasture	83	141	449	254	927
Balance of holdings (including native pasture)	424	108	339	86	957
Irrigation ('000 ha)					
Orchards	0.2		2	1	3.2
Vines	0.3		16.1	2.6	19
Irrigated pastures	0.6	0.7	1.8	44.6	47.7
Livestock ('000)					
Sheep	149	277	906	572	1,904
Beef cattle	6.5	5.1	33.9	55.7	101.2
Dairy cattle	0.5	0.5	3	20	24
Pigs	2.3	5.3	29.2	26	62.8

Note: County boundaries are shown on the Locality Plan facing page 4.

fallowed the previous spring, while most barley and oat crops are grown on stubble land following a wheat crop or on pasture land fallowed for only a short period. Legume pastures (medics and lucerne) for 1 or 2 years between cereal crops build up soil fertility. This method of stable cropping has been developed over the past 25 years.

The heavy soil types are more intensively cropped than the sandier soils.

Figure 5 shows the trends over the 5-year period 1966--71 in the acreages of each cereal, and total crop and fallow. Cereal acreages vary from year to year, but have averaged about 0.8 million ha in recent years. The trends in wheat

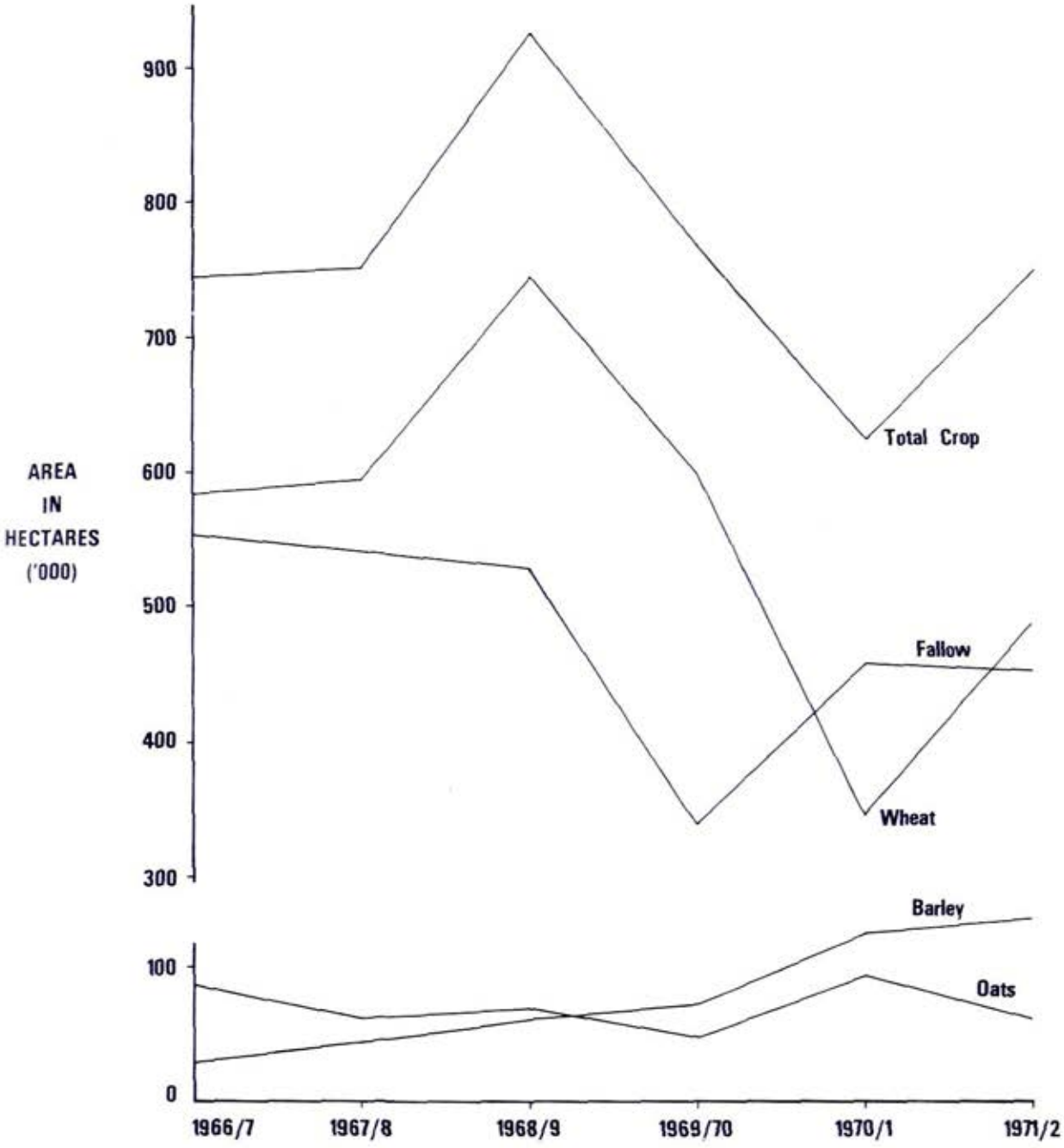


FIGURE 5 : TRENDS IN THE AREAS PLANTED WITH CEREALS

Wheat is by far the most important crop on the dryland farms of the study area.

acreages depict the fortunes of the wheat industry - increased sowings after the 1967 and 1972 droughts and small sowings in 1970 due to the full impact of the wheat delivery quotas. The barley acreage has increased over recent years.

Cereal production in a dryland environment depends largely on the rainfall in the growing season, but also on soil type, soil fertility, and management practices. In recent years the wheat yield for the study area has been 1.2 tonnes per ha, but this has varied from 1.5 tonnes per ha in the better seasons to less than 0.5 tonnes per ha in the dry seasons such as 1967 and the mid-1940s.

The average wheat yields decrease from south to north, being about 1.3, 1.1, and 0.9 tonnes per ha for the southern, central, and northern sections of the study area respectively. Individual farm yields can be 40% above their district average. Barley and oat yields tend to be 10--20% lower than those of wheat due to preferential cultural practices for the wheat crop.

Livestock Production

Livestock production is the most important enterprise after cereal-growing on the dryland areas, and is the main one on the irrigated pasture properties.

Sheep

Traditionally, sheep-grazing has been the main livestock enterprise on dryland and irrigated pasture farms. The total sheep population in March 1972 was 1.9 million (Figure 6), 80% of the adult flock being breeding ewes, mainly for prime lamb production. However, there is a tendency for sheep to be run for wool production in the drier, northern sections of the area.

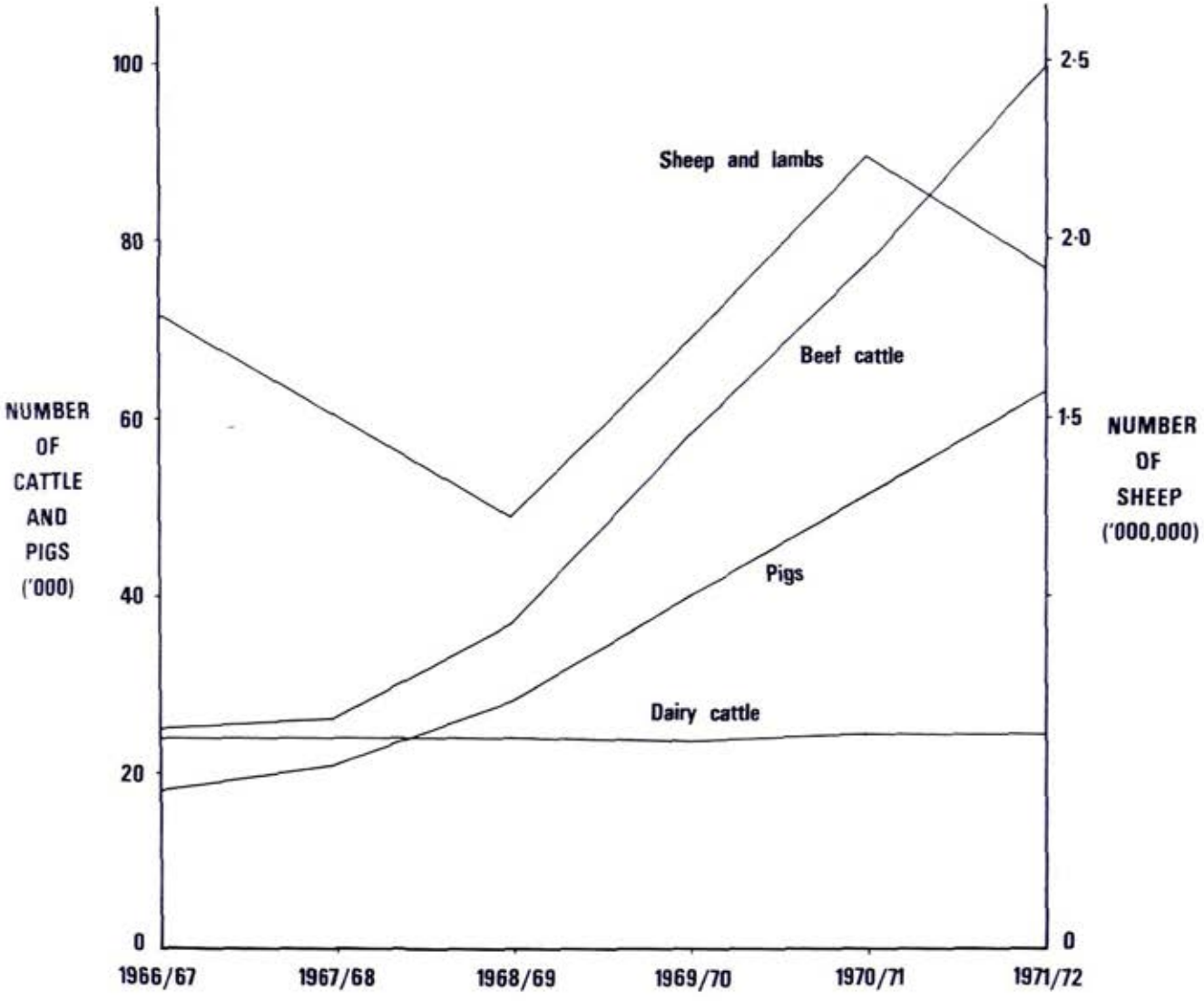


FIGURE 6 : TRENDS IN LIVESTOCK NUMBERS

About 85% of all sheep in the area are run on dryland pastures, the remaining 15% being carried on winter-irrigated pastures in the south-eastern section. Average stocking rate on dryland pasture is 1 sheep per ha, although this varies from 2 sheep per ha in the southern section to 1 sheep per 2.5 ha in Millewa County. Under existing grazing leases and licences, about 50,000 sheep and 3,000 cattle graze on 50,000 ha of public land, mainly in the Sunset, Millewa and Murray River blocks.

Annual wool production amounts to 23 million kg, and it is estimated that 1 million sheep and lambs and 30,000 cattle are slaughted each year for meat. However, total meat production figures are not available.

Beef cattle

Beef cattle numbers have increased fourfold since 1967, to a total of 101,000 in 1972. This is due to the increasing demand for beef, and was encouraged by the introduction of wheat delivery quotas, and low wool prices, in the period 1969--73. The major increase has been on the irrigated pasture farms, but increases of almost the same amount have been attained on dryland farms. In the latter case, supplementary feeding is used in the production of vealers.

Dairying is a minor industry in this area, although it is locally important on irrigated perennial pastures near Swan Hill. Other dairy farms are located on the Loddon River and at Mildura.

Pigs

Pig numbers have increased markedly since 1969. Many wheat--sheep properties started pig enterprises to offset the effect of wheat delivery quotas. Several large-scale piggeries have been built, and 10% of the Victorian pig population is now to be found in the Mallee.

Horticultural Production

The study area is one of the most important horticultural centres in the State. The main areas are on Mallee soils around Mildura, Robinvale, and Nyah--Woorinen. Many horticultural blocks lie between these districts, using water pumped by private diversions on the Murray River. Production figures (as a percentage of total production for Victoria) for some of the horticultural crops grown in these districts are as follows: grapes for drying 99%, plums 98%, melons 98%, table grapes 97%, wine grapes 85%, olives 74%, citrus 74%, nectarines 49%, pumpkins 48%, almonds 40%, lettuce 15%, apricots 15%, carrots 10%, and tomatoes 7%. In all 19,000 ha are devoted to vines and 12,900 ha to citrus.

Figure 7 shows that a slight upward trend in acreage of vines, orchards, and vegetables has occurred over the past 5 years, with the largest increase around

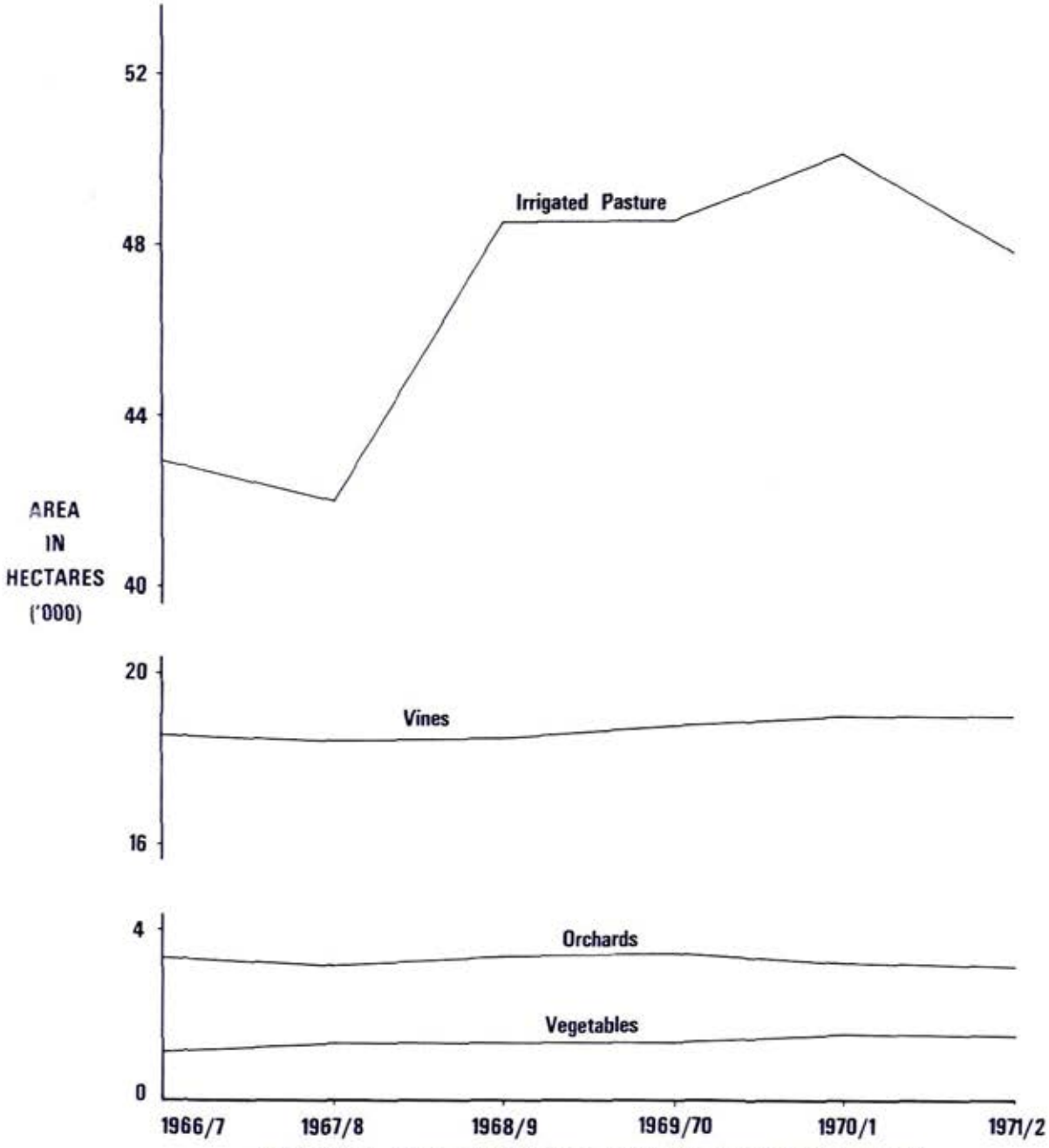


FIGURE 7 : TRENDS IN THE USE OF IRRIGATED LAND

Nangiloc, south of Mildura. Perhaps the biggest change has been replantings within the existing horticultural areas to new and better varieties of wine and table grapes, stone fruit, and new horticultural crops. The Commonwealth Bureau of Census and Statistics (1972) reports that 20% of the orchard area and 9% of vineyards contain young, non-bearing trees and vines respectively.

Future Potential of Private Land

The fortunes of agriculture have changed dramatically over the past 5 years - from surpluses and low prices for many products (such as cereal grains, wool, lamb and mutton, dairy products, and dried fruit) to the present situation of world shortages and near-record prices.

Irrigated grape vines

Future agricultural potential in the study area will therefore depend as much on the marketing prospects for the various crops and livestock products as on the physical potential of the land to produce them.

Uncleared land

There is a limited agricultural potential from uncleared land on the existing holdings. In 1971 only 7% (218,000 ha) of the area occupied was not under crop, fallow or pasture. Much of the uncleared land is reserved for shelterbelts or is unsuitable for development. Most are areas are in the northern section of the Annuello Block, and near the scrub line in the Sunset and Big Desert Blocks.

Cleared land

The greatest agricultural potential exists in the cleared freehold land. In 1971 only 55% of the pasture land was sown to improved pasture species and many of these pastures would have low densities of the improved species. Cereal and livestock production could be increased if more land was sown down to legume pastures of medics or lucerne or both. These pastures increase soil fertility for cereal cropping, suppress

many of the troublesome weeds, and provide more herbage, particularly on the sandier soils where other pasture species are limited by low levels of soil nitrogen.

Experiments at the Mallee Research Station, Walpeup, have shown that wheat crops after medic pastures have averaged 0.2 tonnes per ha better than adjacent crops after native pasture. Grain protein content also increased to 12% following medic pasture compared with 10% following native pasture. Increases in yield greater than that mentioned above have been achieved after lucerne pastures on sandy soil types where low soil nitrogen and skeleton weed suppress wheat yields on natural pasture land. The area sown to lucerne on sandy soils could easily be increased tenfold from the present 25,000 ha. Lucerne acreage has shown an upward trend from 11,000 ha in 1969.

Livestock production can also be increased in two ways: by increasing the acreage of more productive sown pastures, and by raising the average stocking rate. Both sheep and cattle can be successfully run on the dryland farms. Increased livestock numbers must be accompanied by better management skills and large fodder reserves to avoid overgrazing and soil erosion during the drier seasons. Experiments at the Mallee Research Station have shown that rates of 2½ ewes or 3¾ wethers per ha can be maintained on the better-quality medic pastures grown under Mallee conditions. Reports of the annual Mallee Soil Conservation competitions also indicate the level of crop and livestock production that can be achieved on farms in the study area.

In general, most farmers have adopted sound practices in their cropping programme (varities, use of fertilizers, fallowing, and sowing technique). Cereal and pasture yields can be increased on some farms by higher phosphate rates and on others by the application of gypsum to improve soil structure on the non-friable clay soils. However, there appears to be limited scope for new crops. Peas, lupins, safflower, and oilseed rape can be grown but low yields and other agronomic problems result in lower economic returns being obtained than with wheat or barley.

Irrigated land

Irrigation farming, which allows some flexibility in the types of crops that can be grown, requires an adequate water supply, suitable soil types and land layout for the crops being produced, sound irrigation techniques, and a good drainage system.

Increased production could be obtained from existing farms, possibly through more efficient water use, better farm management, and diversification into a wider range of crops and pastures. It could also be derived from new areas

being developed for irrigation. In the latter case, availability of water is a limiting factor as most of the available water rights within the area are being used at present. Land is not a limiting factor as suitable soils are available adjacent to the existing irrigation areas.

The permeability of the soil largely determines the crops that can be grown successfully under irrigation. In general, light-textured, permeable soils favour deep-rooting crops such as fruit trees and vegetables, but high water tables may develop with consequent danger of waterlogging and salinity in the root zone. The heavier-textured less-permeable soils tend to favour shallow-rooting plants such as the perennial and annual winter pasture species. They could also produce more summer crops such as sunflower, sorghum, maize, and soybean.

High water tables and increased soil salinity are the major threats to increased production through irrigation. These problems may be overcome by improved water management, better land layout, and suitable surface and underground drainage.

Agricultural Potential of Public Land

Physical and economic factors must be considered together in assessing the future capabilities of land for agriculture. The major physical factors influencing the agricultural potential are rainfall, soil type, location, topography, existing vegetation, and availability of water for irrigation. Economic factors are land clearing and development costs, possible levels of production or yield, costs of providing services, annual production costs, and market prospects for the various products.

Typical mallee wheat fields

As mentioned in Chapter 2, most of the public land (1.3 million ha) lies in the western part of the study area, where the sandy soils discouraged settlement in the past. Substantial areas of public land also exist along the Murray River and there are small areas throughout the more settled sections.

The main agricultural use for public land after clearing would be for cereal production in conjunction with grazing of sheep and/or cattle. Some areas adjacent to the Murray River and existing irrigation settlements would be suitable for irrigated crops and pasture and horticulture. However, suitable freehold land is available for any further expansion of irrigation areas. In some instances, because of special features such as more permeable soils, gentler slopes, or a high frost-free position, public land may be more suitable for irrigation than adjacent private land.

Some public land could be used to augment the size of adjacent holdings that are below the optimum area of 1,000--3,000 ha. The potential carrying capacity of improved pasture ranges from about 4 dry sheep equivalent per hectare in the south to about 1--2 per hectare in the north.

Soil type

Soil type is the key to agricultural potential. Sound agricultural practices have been developed for the medium-textured soils such as the sandy loams and sandy clay loams, which give good regular yields of cereal crops under most seasonal conditions. Soil fertility can be maintained by rotation with legume pastures.

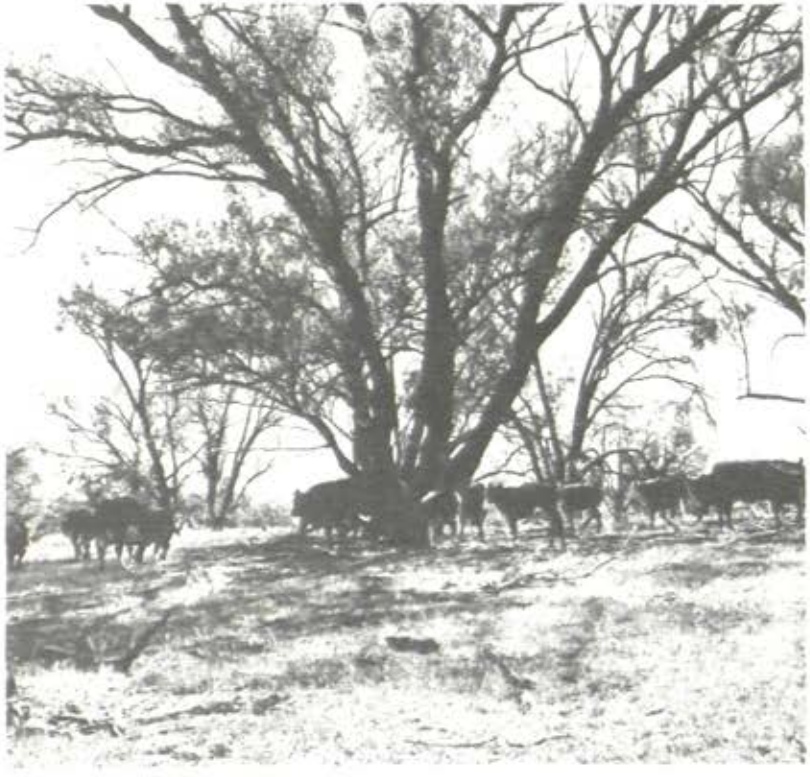
Although more prone to erosion, sandy soils with heavier-textured subsoils are suitable for agriculture. Production from these soils is lower, and less frequent cropping helps maintain soil fertility.

The deep sands have limited agricultural potential because of their low natural fertility, high soil erosion hazard, and the lack of suitable pasture species for this soil type under the low rainfall. (Lucerne- and phalaris-based pastures have been maintained on sands on the relatively wet south-west section of the study area.)

The clay soil types are suitable for agriculture, but cereal and pasture production is extremely variable, being high with above-average rainfall and very poor in dry years. Thus these soils have less potential in the drier northern areas.

The saline soils are not suitable for agriculture.

Assessments of the public land's capability for agricultural development are given in Part IV (Block Descriptions).



Cattle grazing under black box woodland in the Kulkyne forest

Grazing on Public Land

About 50,000 sheep and 3,000 cattle are grazed on 500,000 ha of public land held under leases or licences. These cover most of the public land in the Sunset, Millewa, and Murray River blocks, and many of the smaller parcels of public land throughout the study area. Cattle are usually grazed on land near the Murray River, and sheep elsewhere.

There are several types of tenure for grazing. On Crown lands, 21-year leases or annual licences are issued. Leases are generally issued for large areas and are restricted to the north-west of the study area. Stocking rates on these leases and licences are not controlled by the Crown.

Grazing in reserved forests, mainly on the Murray River at Nyah, Mildura, and Kulkyne, is controlled on an agistment basis, and elsewhere under annual licence. 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. Some control over stock numbers is also exercised in areas grazed under annual licence. In the Murray River Block, about 100 different owners graze 2,000 head of cattle on agistment, and 54 annual licences covering the use of 33,000 ha have been issued.

In the Sunset and Millewa blocks grazing is most intense on the grassland and savannah. Spear grass and exotic grasses are the major forage species, and scattered saltbushes, blue bush, and other edible shrubs are also important. The amount of forage available varies greatly with seasonal rainfall. Very little feed grows in the areas of dense mallee in the north of the Sunset block.

In the Murray River block dense swards of grass, mainly swamp couch, develop in

red gum 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 most valuable areas are at Boundary Bend, Nyah, and Nangiloc, and there are large areas of moderate value at Robinvale and Kulkyne and at Belcher, Lindsay, and Wallpolla Islands. Saltbush plains near Ned's Corner also have some value, but as this vegetation type does not require flooding it is more like the dryland areas than like the red gum--black box areas.

In general the public lands are grazed on a basis of low cost and low carrying capacity. The grasslands of the Millewa Block and the saltbush near Ned's Corner can carry one sheep to 2--4 ha. But land covered in dense mallee can carry only one sheep per 12--16 ha. Most grazing on this type of land is reserved for dry periods when food is scarce elsewhere.

Fencing and water supply are the main improvements made to the runs. Different areas derive water from the Murray River, the Millewa Waterworks District, South Australia, catchment tanks, or the groundwater. Fences divide each extensive run into a few large areas.

There are several hazards associated with grazing. The most important is overgrazing, which leads to degeneration of plant cover and to soil erosion. Another is browsing of seedlings, preventing the regeneration of slender cypress pine and saltpan vegetation. Lack of sufficient watering points, and inadequate subdivision into paddocks, makes proper management difficult. On many runs lessees and licencees are reluctant to spend large sums of money on improvements such as water supply and fencing because of their insecurity of tenure.

Apiculture

Apiculture is a small primary industry producing honey and beeswax. Honey is used mainly as a food for humans, but also as food for stock and in the preparation of some other products. Beeswax is used in a wide variety of industries, the most important consumers being polish and cosmetic manufacturers. Apiculture contributes to the welfare of some other primary industries, as many fruit, vegetable, and seed crops depend almost completely upon the honey bee for pollination.

The industry

The number of apiarists registered in Victoria in 1971/2 was 1,321. Many of these, however, have few hives and make an insignificant contribution to the industry, and about 300 apiarists produce 90% of the State's honey and beeswax.

The Victorian annual production of honey during the last 5 years has averaged 3.1 million kg and represents almost one-

fifth of total Australian production. A large proportion of Australian honey is exported to the United Kingdom, and in 1971/72 Victoria produced 2.17 million kg, more than half of which was exported. Beeswax is also exported, Japan and the United Kingdom being the main buyers. Of the 24,000 kg produced in Victoria in 1971/72,more than two-thirds was exported. The level of production fluctuates considerably due to climatic conditions. For example, honey production in 1968/69, following the 1966/68 drought, was only 1.6 million kg, compared with 4.45 kg in 1970/71.

World demand for honey has increased noticeably in recent times. One reason for this is that people in many countries now regard honey as a health food. Present prices are high - beekeepers are receiving 62¢ per kg for choice honey - and demand is expected to increase.

Maintaining hives

Although Australia contains some native bees, the species used in apiculture is the European honey bee, *Apis mellifera*.

In the natural state, bees collect and store sufficient nectar and pollen (the bee's sole source of protein) over the summer months to provide themselves with food for winter and for rearing young bees in spring. Thus, when a beekeeper manages bees for honey production, he never harvests all the honey the colony makes, but leaves a large quantity (up to 80 kg a year) for the prosperity of the colony. The beekeeper's crop is the honey which is surplus to the basic requirements of the hive.

The principal supply of nectar in Victoria comes from eucalypts and a few other native trees and shrubs.

The value of a particular eucalypt species to the apiarist depends on its flowering periods and its yield of nectar and pollen. Flowering periods vary, not only between species, but also within species from district to district, depending on local climatic conditions. Most eucalypts flower every second or third year.

Migratory beekeeping

Because of its dependence upon flowering eucalypts, beekeeping must be migratory. For maximum production of honey, hives are moved from district to district to coincide with peak nectar flows of various eucalypts over the summer months. Hives must be placed not only close to the nectar source, but also close to a reliable water source. An adequate source of pollen must be available, especially in autumn when bees are storing food for winter.

Apiculture in the Mallee

The Mallee is used by resident and migratory beekeepers for overwintering hives and honey production. The area is

particularly important for over-wintering as the mild climate and the availability of pollen, mainly from the ground flora, enable hives to be brought to full strength before moving to harvest the first nectar flows of spring. The importance of the Mallee for honey production has increased over the last 5 years as the area has become better known, and increased mechanization and mobility has enabled beekeepers to use the more remote areas. At present there are 92 permanent and 55 temporary apiary sites on public land in the study area.

The plant species important for over-wintering and honey production are shown in Table 10. The areas beekeepers most use at present are the red gum--black box woodlands along the Murray River, the mallee and heath on the fringes of public land in the Big Desert

TABLE 10

HONEY FLORA

Species	Flowering times	Honey produced per hive per usage (kg)	No. of times used since 1961	Pollen production
White mallee	Aug - Nov	40 - 55	4	None
Yellow mallee	Sept - Dec	40 - 55	3	Good
Grey (hristmas) mallee	Dec - Jan	27	2	Fair
Dumosa mallee	Feb - May	40	2	Good
Red mallee	Jan - Feb	27	3	Good
Acorn (oil) mallee	Jan - Mar	40 - 55	3	Fair
Red gum	Nov - Jan	55 - 80	4	Good
Black box	Jan - Feb	55 - 80	4	Fair
Tea-tree	Aug - Oct	27	9	None
Sugarwood	Nov	9 - 14	8-9	Good
Ham and egg daisy	Oct - Nov	9 - 14	3	Good
Desert banksia	Apr - Aug	14 - 18	8	Good

block, and the mallee in the Annuello block, and around Hattah in the east of the Sunset block. Country similar to that at Hattah extends throughout the Sunset block, and could be brought into production by beekeepers prepared to brave the sandy tracks and to carry water for their bees.

More information on the use of particular areas is given in the block descriptions.

Bee hives in white mallee

Other considerations

The most important factor limiting honey production in the Mallee is lack of access to vast areas of the Big Desert block and the Sunset block. Beekeepers believe that the Big Desert has great potential for overwintering and honey production, but lack of access at present limits them to the edges and the Murrayville--Yanac road.

Honey production is compatible with all forms of land use that retain the native vegetation, although the extent to which bees may compete with native insects, birds, and mammals for nectar is not known. Nectar and pollen can be harvested repeatedly from an area without any apparent ill-effects.

The greatest threat to beekeeping is the clearing of native vegetation,particularly the smaller, readily accessible reserves. The public lands are becoming more important as private property is progressively cleared, and as insecticide sprays are more widely used in agriculture.

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TIMBER PRODUCTION

The major forest resources of the study area are the red gum--black box stands along the Murray River and some minor streams, and cypress pine--belar--buloke stands scattered throughout.

The forest environment on the flood plain of the Murray River differs greatly from the large tracts of dry sandy land comprising most of the study area. They grey clay soils are often watered by floods, and water is probably available to plants in some locations from aquifers.

River red gum occupies the lower areas, which are watered most frequently. On the most favourable sites it grows in a tall forest formation and elsewhere in open woodlands. Of the 18,630 ha of red gum, about one-fifth is woodland.

Black box is closely associated with red gum, forming short forests and woodlands where waterings by flood and rain are insufficient for red gum. There are 52,650 ha of black box.

Slender cypress pine grows on sandy hummocks within the red gum and black box areas, often in association with belar and buloke. It is also found in small areas on the sandy loams of the Central Mallee and Millewa land systems. Cypress pine, belar, and buloke occupy 24,300 ha, of which two-thirds are open woodlands. In addition, cypress pine could be grown on extensive areas of clear land.

History of the forests

Since the region was first settled, the forests have supplied essential products for the development of local industries.

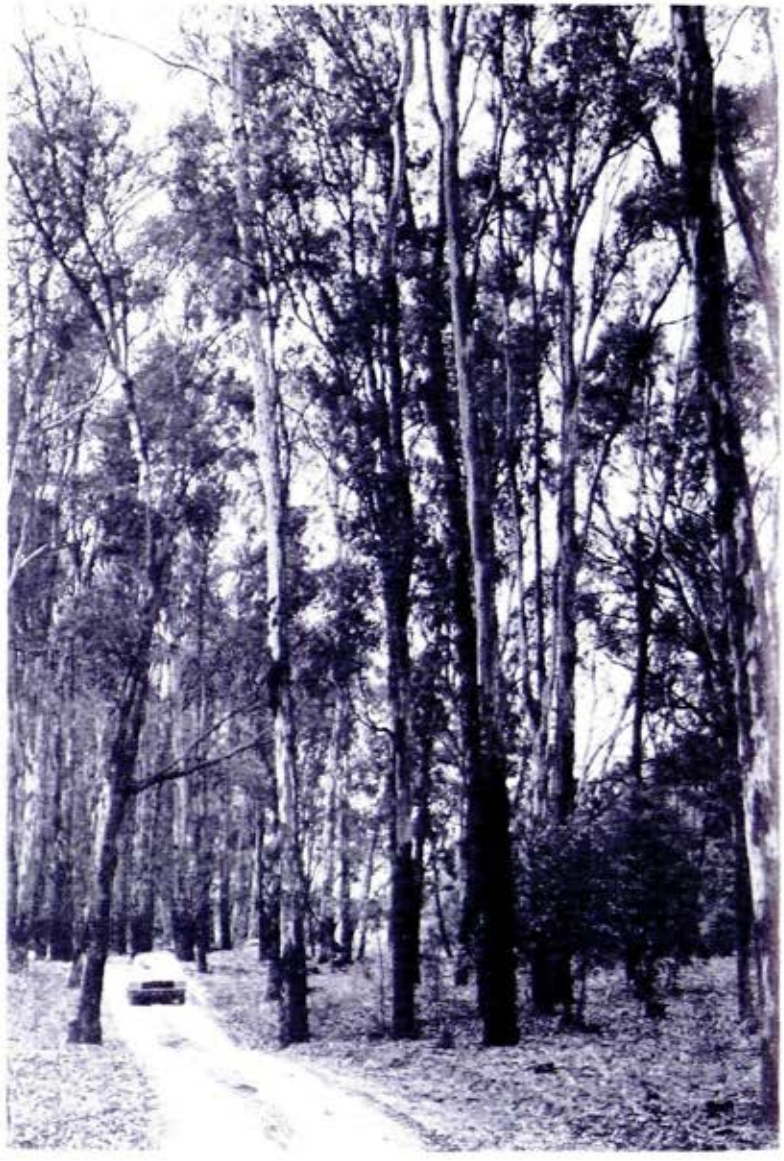
The first pastoral stations used the timbers for fences and buildings, and cattle grazed in the forests. Steamers on the river were fuelled with red gum and black box from the banks. Large quantities of fence posts and vine trellis timbers were required for the developing irrigation areas, and heavily timbered areas along the river were set aside as forest reserves to ensure supplies of these. Steam engines pumping irrigation water from the river used firewood from the forests. Indeed, the wood harvested from the forests in those days was about five times the present volume.

In the early days, sawmills at Mildura and Swan Hill produced timber from the red gum, and barges were used to bring logs to the mills and carry sawn timber to the irrigation settlements. Red gum sleepers were also hewn for the construction of the railways.

Many heavily timbered areas along the river have been reserved for timber production. During initial settlement of the southern and eastern Mallee, very few areas were reserved for timber, although in areas settled later well-stocked stands of cypress pine and belar were withheld from selection for timber production. The Yarrara and Timberoo reserves are the largest of these.

Wood was cut for the production of charcoal during the Second World War, and after the war the demand for posts and vine-trellis timbers for the new irrigation settlements rose sharply.

The native conifer , slender cypress pine, was of great interest to early foresters because it was capable of producing fine durable timber. Thinnings and harvesting operations in the Yarrara and Kulkyne forests during the 1920s were closely regulated, but the drought years of 1942--1945 seriously weakened the trees. Moreover, thousands of acres were attacked and killed by the cypress pine beetle *(Diadoxus erythrurus)*. Regeneration of the forests was unsuccessful because the seedlings were exposed to desiccation in dry years and



High-quality red gum forest on a frequently flooded site in the Piambie forest

extensive browsing as a result of the high population of rabbits.

Timber production

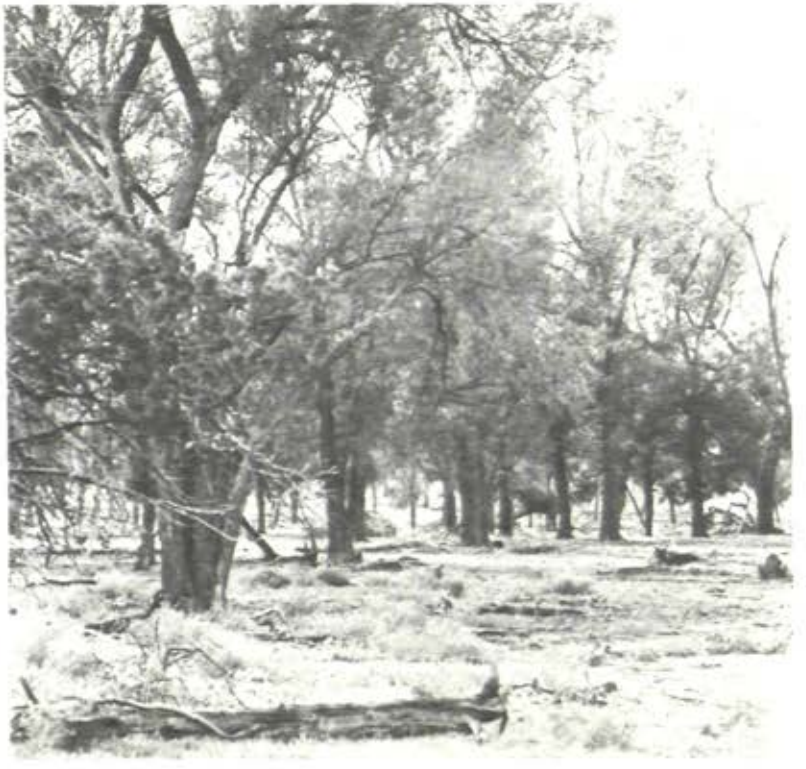
Supplies of various products from the forests are still in demand for local use, especially the strong durable red gum and black box timbers. Red gum grows to sizes suitable for sawlogs, sleepers, poles, and piles, while the smaller black box timbers are generally used for fences, vine trellises, and other farm structures.

Current levels of production from the forests could be maintained for many years. The volume harvested for sawlogs is subject to periodic review, and fellings of all other timbers are controlled by licences, which are supervised to ensure that the felled trees are completely utilized. Small quantities of timber are produced in the course of silvicultural operations.

The red gum forests supply two sawmills at Paringa (South Australia) and Nyah with about 1,000 cu. m of saw logs per year for construction timbers, framing, and fencing. Annual production of fence and trellis timbers from black box is currently limited to about 76,000 pieces per year, compared with several hundred thousand when the irrigation areas were being settled. Present output does not satisfy demand and, as little box timber remains on freehold land, the strong demand is expected to continue.

Important areas of red gum for timber production occur along the Murray River between Colignan and Karadoc, and young stands of great potential value lie upstream from Wemen. Stands on Lindsay and Wallpolla Island are also suitable for timber production.

In the managed red gum forests, groups of mature trees are removed to make substantial openings for new crops or seedlings as the young trees cannot thrive in soil depleted of moisture by large



Belar woodland in the Kulkyne forest

trees. Also, seedlings do not establish in soils carrying a strong cover of grasses and herbs. Flood waters receding from cleared areas create ideal conditions for germination.

Red gum seedlings need protection from rabbits, kangaroos, and sheep, and should be watered frequently. The young trees should also be well spaced by thinning the less thrifty stems at various stages during development. Thick groups of seddlings and scattered stands of saplings among the old red gums add diversity to the forests.

Durable poles and fence posts of slender cypress pine and belar have been produced in the past, but very little cutting is permitted in these forests at present.

Small amounts of several other forest products are taken from the study area. About 2,270 kg of eucalyptus oil per year is distilled from mallee eucalypts, and broombush is cut by one licensee for brushwood fencing.

Mallee roots were sold for domestic fuel when the wheat farms were being cleared, but none came from the forests. A small supply is still maintained as a result of clearing on freehold land. In earlier times dry firewood from box and belar forests was in strong demand as a domestic fuel, but these are not used to any extent at present.

As discussed in other chapters, grazing, honey production, and recreation are also important uses of forests in the study area.

WATER USE

Stock and Domestic Supplies

Water is supplied to most of the study area by the State Rivers and Water Supply Commission's Wimmera--Mallee Stock and Domestic System. This system, which services 28,500 sq km of farmland and 52 towns, draws water from storages to the south and east of the study area, and distributes it, either by gravity or with the aid of pumps for a few high areas, through a network of open earthen channels. The water is distributed in winter to minimize seepage and evaporation losses. The greatest distance water is conveyed from the headworks is 600 km.

Farm and town earthern storages are replenished once a year, those near the extremities of the distribution system receiving their supplies first and those near the headworks last. Most towns have an elevated reservoir into which water may be pumped from the earthern storages, thus enabling reticulation through the town by gravity. In addition to the towns served from storages, Mildura, Swan Hill, Robinvale, and some smaller towns are supplied by pumping from the Murray River.

The Wimmera--Mallee system delivers a total of about 136,000 Ml annually, and most of this comes from the Grampians storages; however, approximately one-quarter is supplied from the Loddon and Goulburn systems via the Waranga Western Channel extension. The total capacity of the headworks storages in the Wimmera --Grampians is 760,000 Ml. Reserves of this magnitude are necessary to ensure supplies during a prolonged drought. There are no catchments in the study area.

The Torrumbarry Weir, the Loddon River, and the Waranga Western Channel supply areas in the eastern Mallee near Boort and Kerang. In the north-western Mallee, the Cliffside pumping station pumps water from the Murray River to the eastern part of the Millewa settlement. The western part of the settlement also receives water from the Murray River via Lake Cullulleraine and several relift stations. Here the channels are being replaced by pipelines to reduce the volume and cost of the water that has to be pumped.

The area served by the stock and domestic systems has been fairly constant for

many years, although the area served by some systems has decreased due to the inclusion of farms in adjacent irrigation areas.

Groundwater

The distribution of useful groundwater was known before the channel system was constructed, and for this reason no channels were built in the western Mallee.

All stock and domestic water supplies for the settled areas west of Underbool are drawn from the groundwater. Although good-quality groundwater is available throughout most of the Big Desert, there are only a few bores, pumped by windmills, on the Murrayville--Yanac road.

A typical stock and domestic water supply channel

The aquifer tapped by these bores, the Duddo Limestone, lies at an average depth of about 100 m. It yields large quantities of good-quality groundwater that does not need screening. The groundwater rapidly becomes saline to the north and east of Underbool, giving rise to concern that high withdrawal rates could result in intrusion of saline water into the Duddo Limestone. However, careful monitoring of water quality has not yet revealed any increase in salinity and, at existing withdrawal rates, there appears to be no immediate propect of intrusion by saline water.

Irrigation

Government irrigation schemes cover about 62,000 ha in the study area, and private diverters irrigate another 16,000 ha. The Government schemes are located along the Loddon River (between Kerang and Swan Hill), at Nyah, at Robinvale, and in the Red Cliffs--Merbein district. The private diversion schemes are located on the Murray, Avoca, and Loddon Rivers, on Mosquito (an ana-branch of the Avoca River) and Lalbert Creeks, and on the lakes near Kerang. The Murray River is the ultimate source of supply for all the government schemes, except Boort, which is supplied from the Waranga--Goulburn and Loddon storages.

Irrigated lucerne pasture near Murrayville (left) and furrow irrigation of vines

The average volume of water delivered annually to the government schemes is 329,867 Ml. Most of the private diverters pump from the Murray, and on average use 131,019 Ml annually. Most of the land near Swan Hill and to the east is used for pasture enterprises, and the rest mainly supports horticulture.

Drainage

The groundwater lying at shallow depth beneath all the irrigation areas is highly saline. Soil salting has occurred when accessions from irrigation water, channel seepage, and natural sources have raised the water table and allowed transport of salty water to the surface. This upward movement of salt takes place most rapidly when not opposed by applications of sufficient irrigation water to leach the salt out of the root zone.

Only pockets of salting occur in the horticultural districts, as these are nearly all tile-drained. However, in the lands irrigated for pasture in the east of the study area, the Department of Agriculture has mapped a total of 5,820 ha of salted soils in the Swan Hill, Tresco, Fish Point, and Mystic Park areas. Salted soils also occur in the Boort, Kerang, and Third Lake areas, although the exact extent of their occurrence is not known.

Investigations aimed at the reclamation of land around Kerang, which has been affected by salt, and the control of salinity in the Murray River are in progress. Control measures are already in operation at Lake Tutchewop, into which saline water is diverted from Barr Creek, and at Lake Hawthorn, near Merbein, which receives saline water from tile-drains.

Windmill and tank on a Government bore near Walpeup

However, as a further control measure it has been proposed that low-lying areas be used as evaporation basins for the disposal of saline groundwater and drainage from irrigated lands. It has been suggested that Lakes Tyrrell, Wahpool, and Timboram be used as evaporation basins for saline drainage water from the Kerang region, thus diverting this water from the Murray River. Where a means of disposal is available, saline groundwater may also be pumped from the shallow aquifers in order to lower the water table.

The sites of evaporation basins that have been suggested for the Sunraysia district include one adjacent to Lake Hawthorn, a section of Kings Billabong, and part of the river flood-plain near Red Cliffs.

The establishment of evaporation basins, however, may result in rising water tables on adjacent land. Most of the sites for the proposed basins are on public land.

Groundwater

In the western Mallee, groundwater from about 50 bores is used for irrigation. The bores tap the Duddo Limestone, and yields range from 12 to 100 litres per second. The water is pumped by deep-well turbine pumps driven by diesel engines and then spread by flood or spray irrigation. In the 1971-72 season, 600 ha of pasture were irrigated in this way.

Capacity for expansion

There is virtually no "uncommitted" surface water available for further

development of government irrigation schemes.

In mid 1973, it was estimated that about 12,135 Ml, sufficient to irrigate 1,370 ha, could be allocated for Murray River private diversions down-stream of Nyah. Land availability is not a limiting factor.

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 back water up the River almost to Wentworth and inundate large areas of public and freehold land.

Due to technical and economic considerations, the scheme was shelved in 1970 in favour of the Dartmouth Dam on the Mitta Mitta River in north-eastern Victoria. When this is completed, additional water will be available for irrigation, but actual allocations have yet to be determined. Victoria's average annual allocation will be 493,390 Ml.

The South Australian Government still favours the construction of the Chowilla Dam, but there seems little chance of the project recommencing as originally proposed.

About 6,070 ha of land in the far north-west of the study area, which the Water Commission appropriated for the Chowilla project, is now leased for grazing.

Water Use and Wetlands

The extensive irrigation schemes developed in the study area, and headworks to provide stock and domestic supplies, have changed the nature of many of its streams and wetlands. While some of these changes have benefited native plants and animals, others have made the area less suitable and have favoured introduced species.

Changes made to streams are:

* Water is stored in dams at times of high flow and released at times of low natural flow - for example, in the Murray River.

* Stream flow has been diverted for irrigation and stock and domestic purposes - for example, in the Wimmera River--Outlet Creek system.

* Stream improvement, in which stumps, branches, and other obstructions are removed from stream beds and banks, has increased the rate of water flow.

Changes made to wetlands are:

* Incorporation of wetlands into the water distribution system has assured them of regular supplies of water - for example, the Reedy Lakes.

* Some lakes and swamps are now dry for long periods due to the diversion of water for other uses.

* Salinity due to inflow of saline groundwater has increased in lakes that are not flushed with fresh water- for example, Cullen's Lake.

* The area of some wetlands has increased where irrigation run-off accumulates.

Other beneficial results of water-works include the creation of extra habitat for fish and to a lesser extent for water-birds in the large storages. Stream improvement, while reducing the value of streams as wildlife habitat, may result in increased flow of water to wetlands down-stream. Irrigated pastures provide feeding areas for large numbers of birds such as ibis and mountain duck. Ibis play a significant role in controlling insect pests that infest pastures.

Prime wetland habitat

Although water storage and distrbution works (and drainage from irrigation areas) have reduced the area of habitat suitable for wildlife, the Water Commission has attempted to preserve wildlife habitat wherever practicable. It maintains close co-operation with the Fisheries and Wildlife Division and manages selected wetlands for wildlife. Water may be supplied to wetlands from the storages, if it is available and a means of supply can be arranged, and surplus water is supplied at a fraction of the district charge.

When the Dartmouth Dam is completed, an allocation of water may be made specifically for wildlife.

Murray River

The large dams constructed in the headwaters of this stream have enabled its flow to be intensively regulated for irrigation and domestic water supply. Consequently the annual flow pattern and water temperature pattern have been changed and the incidence of flooding has been reduced.

The reduced incidence of flooding has had ill-effects on many of the red gum

forests along the river. These forests require flooding in winter and spring to initiate regeneration and maintain vigorous growth. Similarly the flooding regime affects the regeneration and growth of many species of small aquatic plants, which are an important source of food for water-birds.

The filling of storages upstream has reduced the frequency of natural floods in winter and spring. In most years the Murray carries surplus flows in winter, although the river level is not high enough to flow naturally into the forests. Artificial forest watering by pumps and channels could utilize these surplus flows to simulate the natural flooding regime.

In some places saline drainage water from irrigated land is damaging the vegetation of the Murray River flood-plain.

Loddon River wetlands

These wetlands are important as fish and water-bird habitat and for the supply of water to nearby irrigated areas. Reedy Lakes, Racecourse Lake, and Kangaroo Lake are part of the water storage and distribution network, and now hold water for longer periods than before irrigation. By close liaison between the Water Commission and the Wildlife Division, Reedy Lake is managed to conserve water-birds. Many smaller lakes and swamps receive water only infrequently.

Avoca River wetlands

Koorangie Game Reserve, which consists of Lake Bael Bael and The Marsh, and the adjacent Second and Top Marshes (Bael Bael forest), comprise one of the most popular duck-hunting areas in the State. The Avoca River feeds these wetlands, which are often dry for long periods due to the erratic nature of its flows. Transit losses along the lower reaches are high, due to leakage into porous formations beneath the river bed, overflow to effluent streams, and spillage over the banks. Only 30% of the flow recorded at Coonooer (near Charlton) reaches Quambatook South, and 50% of the balance is lost before it reaches Lake Bael Bael.

Saline drainage water from irrigated land is killing the vegetation in some swamps. Lake Tutchewop is used as an evaporation basin for disposal of saline water, and although it still supports some wildlife, its future usefulness for this purpose is in doubt.

Hattah Lakes

These lakes are a series of depressions lying on the flood-plain of the Murray River about 70 km south of Mildura. They fill during times of high river flow, when water flows into them through Chalka Creek, an anabranch of the Murray. During this century the lakes have received water on average slightly more often than once every 2 years.

They are important for wildlife conservation and recreation, and stock and domestic supplies are pumped from Lake Hattah. In the last 2 years the higher parts of Chalka Creek have been deepened to permit more water to flow into the lakes system. Regulators have been installed to hold water there and prevent it flowing back to the river at times of low river flow. The present Murray flow pattern results in a satisfactory frequency of flooding for these lakes.

Outlet Creek

The Wimmera River flows from the highlands of Central Victoria into Lake Hindmarsh, on the boundary of the study area. In wet years, Outlet Creek carries overflow north to Lake Albacutya, which (when full) provides good habitat for water-birds and fish.

In most years the Wimmera River does not have sufficient flow to replace evaporation losses from Lake Hindmarsh, which has a surface area of 155 sq km. The effects of diversions from the Wimmera are difficult to assess, because the first of them date back to 1856. Records show that Lake HIndmarsh was full and overflowed in 1909, 1920, 1956, and 1974. Lake Albacutya last filled in 1956, and held water until about 1965.

The course of Outlet Creek continues north from Lake Albacutya, and the red gum and black box woodlands associated with it are an important feature of Wyperfeld National Park. The creek has not flowed through the Park since 1917, and many of the red gum trees it contains are now dying, probably due to the lack of flooding. Continued deterioration of this vegetation type would reduce the diversity and interest of the Park.

Plans for bringing water to Lake Albacutya and Wyperfeld National Park by pipe or channel have often been canvassed as the solution to the nature conservation and recreation problems caused by lack of water there.

Other wetlands

Lake Tyrrell is naturally saline and seldom holds much water. Silver gulls breed there on several islands each spring. Lake Lalbert, a shallow freshwater lake fed by Lalbert Creek, is often dry for long periods.

Green Lake, Walpeup Lake, and Lake Lascelles are used as outfalls, receiving excess water in the stock and domestic channel system which cannot be regulated. If adequate supplies are available in the headworks storages, water may be sold to the Committees of Management of the lakes. Tcham Lake near Birchip would normally be dry for long periods, but now acts as a regulating lake and is frequently filled. Although these lakes are used for recreational purposes, all attract water-birds. The dryness of the surrounding country increases their importance as water-bird habitat.

Lake Cullulleraine in the north of the study area is filled by pumping from the Murray as part of the Water Commissions' Millewa Settlement Supply Scheme. It covers a large area and is used for a variety of watersports. Near Mildura, Lake Hawthorn and other small lakes, depressions, and saltpans receive saline drainage water from irrigation areas. All have some value as habitat for water-birds, again enhanced by the dryness of the surrounding country.

Seepage from water supply channels sometimes fills nearby natural depressions. In the Wathe Wildlife Reserve these pools add significantly to the nature conservation value of the Reserves.

MINING AND QUARRYING

The known mineral resources of the study area are salt, gypsum, granite, calcrete, sandstone, and clay.

Salt

Common salt or halite is harvested annually from a number of salinas, which include Lake Tyrrell, Pink or Linga Lakes near Underbool, and Lake Kunat, Lake Kelly, Lake William, Little Lake, and McMullen's and Spencer's Lakes between Kerang and Swan Hill. All of these lakes are public land.

During winter these lakes are partially filled by rising groundwater rich in sodium chloride, which is precipitated as the water evaporates due to solar radiation during summer.

In some areas the floors of the salinas are unable to support harvesting machinery and this restricts the harvesting of salt. Production figures for salt are shown in Table 11.

Gypsum

The gypsum playas are also fed by rising groundwater, but here the water table, instead of outcropping, always lies about 1 metre below the surface. Water is drawn towards the surface by capillary action and in the process gypsum is precipitated by fractional crystallization. This process has built up deposits of gypsum about 1 metre thick (Yamba Formation).

Extensive deposits of gypsum of variable quality occur throughout north-western Victoria. They are mined by open-cut methods at Nypo and in the Raak Plains at Nowingi West and Hattah West, at Cowangie, and near Lake Hindmarsh. The gypsum mined from the Raak Plains is used exclusively for plaster manufac-

TABLE 11

PRODUCTION OF SALT AND GYPSUM (tonnes)

Year	Gypsum	Salt
1968	78,715	14,036
1969	43,377	27,076
1970	40,624	27,180
1971	39,357	39,191

ture, and is washed over a screen to remove the impurities before being transported from the area. Elsewhere, smaller deposits of less-pure gypsum are mined for agricultural purposes.

Most of the gypsum deposits are on public land. The thin shallow nature of the deposits means that extensive areas must be excavated to obtain the high annual production. In many places high water tables make reclamation difficult.

The production of gypsum has risen considerably in recent years, mainly in response to a continuing increase in demand by farmers, who now use it as a conditioner on solonised soils. However, Table 11 gives production figures for gypsum used for plaster manufacture only.

Granite

The one small outcrop of granite within the study area is on freehold land near Lake Boga, and represents the only indurated rock within the area. This granite is quarried and crushed and is an important source of aggregate.

Sandstone

Sandstone, consisting of the weathered zone of the Parilla Sand, is mined from numerous pits, 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.

Calcrete

Calcrete, a hard limestone formed by soil-development processes, occurs at several levels close to the surface in the Woorinen Formation. It is quarried from shallow pits, some of which are on public land, and is used as a base course for roads.

Clay

The Blanchetown Clay, which is suitable for making bricks, is mined at several pits near Mildura.

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A site on the Raak Plain from which gypsum has been extracted

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HAZARDS

Introduction

Anything that reduces the land's ability to sustain production of chosen commodities at satisfactory levels of quantity and quality - and that may also threaten the productivity of adjacent land - is regarded as a hazard. This chapter deals with the hazards of soil erosion, salting, fire, weeds, vermin, and insect pests.

At the time of European settlement, a balance existed between the soils, vegetation, climate, fauna, and Aborigines of the Mallee. The activities of the European settlers have resulted in major alterations to the environment, the main ones being removal of the native vegetation, cultivation of the soils, and the introduction of rabbits, stock, and exotic plants.

The region is now used for grazing and cropping, but has a low productivity compared with the remainder of the State, and erosion occurs as a result of farming. In addition, a series of soil salting problems has arisen due to the interactions between cultural practices (including irrigation), the natural salinity of the groundwater, and soil a high content of soluble salts. Grazing by domestic animals and rabbits, and infestation by weeds, have led to the deterioration of large areas of the public land as habitat for native plants and some small animals.

Soil Erosion

Changes in land forms and soils may occur as the result of normal geological processes. The present land forms and soils of the Mallee are largely the result of a series of arid periods alternating with moister periods during Pleistocene and Recent times. During the arid periods the surface materials, insufficiently protected by vegetation, were redistributed and moulded by the wind. During the intervening moist periods, colonizing vegetation brought stability to the landscape and soil development occurred. There have been at least four arid periods, the last one having been estimated as ending about 4,000 years ago. At the time of European settlement deep-rooted native vegetation provided a full protective cover for the soils, except on the crests of dunes of the Lowan Sand.

Vegetative cover is the key to soil stability - due to the semi-arid climate and the erosion-prone aeolian surfaces, a high wind-erosion hazard is present wherever the soil is exposed.

Land forms built up by saltation (bouncing of coarse particles) are the most susceptible to wind erosion. These are the longitudinal dunes and hummocks of the Woorinen Formation, and the longitudinal dunes, irregular dunes, and sandplains of the Lowan Sand. Broad plains in the Woorinen Formation and in the Wunghnu Group are fluviatile land forms, although the surface soils have formed on a veneer of dust. The erosion hazard on these plains is lower, although where heavy calcareous duplex soils occur, for example around Birchip and Mystic Park, the shallow loamy A horizons have been eroded by the wind.

A sandhill eroded by the wind at Pine Plains

Water erosion is not common, although it occurs on roads and undulating paddocks during thunderstorms. It is also significant in specialized situations such as the Murray River cliffs and undulating land forms from which the permeable upper horizons have previously been removed by the wind.

Erosion on public land

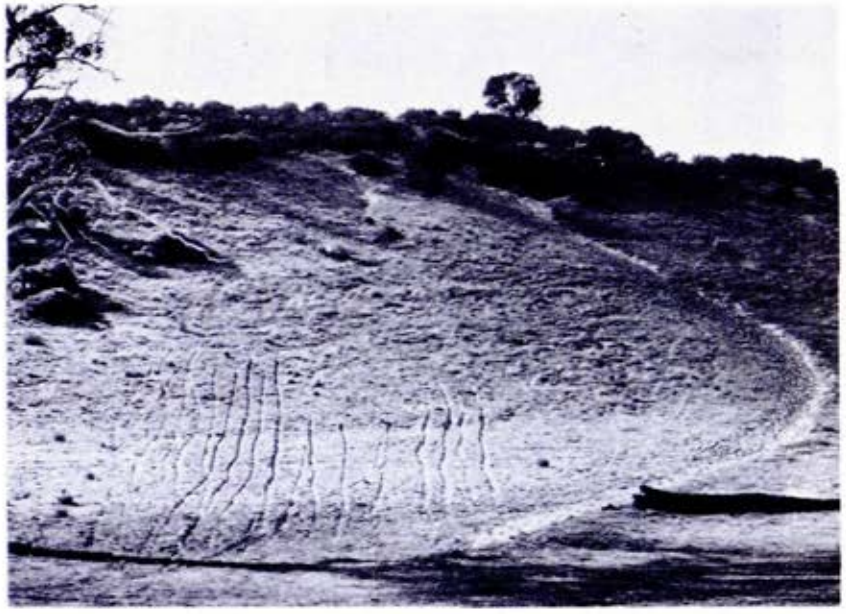
Most of the erosion on public land has occurred during droughts and has been mainly caused by overgrazing by domestic stock or rabbits. The most eroded areas are the duplex soils of the saltbush plains in the north-west, the dunes and hummocks of sand in the Kulkyne forest, scattered sand dunes in the eastern part of the Big Desert block, and lunettes throughout the area. Serious erosion also occurs on the grasslands held under grazing lease in the Millewa, Berrook, and Raak land systems. Most of the public land, especially the bulk of the Big Desert and Sunset blocks, is under native vegetation at present and is in a stable condition. However, where the mallee scrub is sparse, overgrazing leads to severe wind erosion, especially in times of drought. Vehicles moving off established tracks also damage the vegetation, which is slow to recover.

Eroding sandhills on public land can be revegetated by strict control of domestic grazing and a sustained rabbit control programme. In the Kulkyne forest, primary stabilization is being achieved by seeding with ryecorn after cultivating and fertilizing, and planting the treated areas with slender cypress pine. Success depends on effective protection of the crops and trees against grazing by rabbits, kangaroos, and emus.

Erosion on grazing leases

Wind erosion on public land occurs in sparsely timbered areas leased for grazing, such as the grasslands and savannahs of the Millewa land system to the north and west of the settlement, and the grassy plains in the Raak, Berrook, and Tyrrell Creek land systems. Grazing leases cover all public land in the Ned's Corner land system, which carries saltbush, and on very large areas of the Central Mallee land system, most of which is covered with dense mallee, in the Sunset block.

Before occupation, stability was maintained in the grasslands and savannahs by perennial grasses, chiefly *Stipa* spp. and *Danthonia* spp. Stands were lightly grazed by the native fauna because of limited permanent water supply. The introduction of livestock and watering points has increased grazing pressure, even though stocking rates are low (one sheep to 4 ha). This perennial grass cover has now degenerated.



Damage, caused by motor cyclists and pedestrians, to a sandhill in Wyperfeld National Park

When the soil surface is bared, as happens during recurrent droughts, physical degeneration of the soil occurs by sandblasting, resulting in less complete regeneration and vigour of perennials during subsequent favourable seasons. Scalds remain bare and tend to increase in area. Regrowth occurs on moderately eroded areas, but this has a higher complement of annual grasses and weeds, which do not provide permanent cover. To minimize further deterioration of this country, grazing pressure should be reduced during periods of stress, particularly long droughts.

A large scald in saltbush country in the north of the study area

Scalds are widespread in the saltbush country of the Ned's Corner land system. Here, overgrazing and drought have weakened or removed the vegetative cover on heavy-textured calcareous duplex soils. The wind has then stripped away the loamy A horizon, exposing the heavy subsoil. The subsoil clay forms a seal on wetting, due to its high content of soluble salts, and this prevents infiltration of water and penetration of plant roots. Thus many of the scalds, ranging up to 15 ha in extent, are completely bare.

The economics of reclamation are doubtful. A vegetative cover can be encouraged by breaking the surface seal and providing conditions suitable for plant growth, including planting of seed where necessary. This is best done by using a mouldboard plough or a disc pitter to cultivate in lines across the direction of the prevailing winds.

Erosion on farms

Settlement of the Mallee based on cultivation of wheat began in the wetter south in the 1880's on the heavy, relatively stable soils that predominate there. Settlers continued to clear much of the Mallee and reached the drier north by the 1920's, when the Millewa settlement was opened up.

Large areas of the Lowan Sands were not cleared because they are extremely erosion-prone, and are not highly productive. Areas of the Woorinen Formation also were not cleared. Many of these areas are now leased from the Crown in large holdings for grazing.

After removal of the scrub, the land was cropped intensively and exposed for lengthy periods by bare, finely worked fallows. Widespread wind erosion ensued, increasing in intensity towards the north with its drier climate and greater proportion of undulating, sandy land forms. The longitudinal dunes, formerly the most reliable sites for cropping, quickly lost their more fertile surface soil horizons. Several feet of loose sand were lost from many dunes, exposing compact horizons on which it

was difficult to establish vegetation. Much of the sand spread to the lower slopes of dunes and to adjacent swales, or formed banks of drift around obstructions such as fences or clumps of timber, and sometimes covered homesteads, roads, railways, and water supply channels.

Although less soil was lost from the loamy and clayey surfaces of the swales and broad plains, yields have dropped due to loss of the topsoil and the development of hard patches on which development of satisfactory tilth is a slow process.

Improved management practices

Because of improved management practices - such as the use of superphosphate on all soils and of nitrogenous fertilizers on sands - soil stability was gradually achieved on most farms during the run of drought-free years from the 1942--45 drought up to the mid-1960s. The use of tractors and other more efficient ploughing implements, the decline in the rabbit population (which began in the early 1950s as a result of myxomatosis), and introduction of livestock, particularly sheep, and of suitable pasture species to spell the land from cropping are other factors that contributed to soil stability. Long fallows are still prepared, about 9 months before sowing in late autumn, but are usually protected against drift by leaving rough surfaces and stubble mulching. The use of ryecorn and lucerne has helped to stabilize dunes.

Towards the end of the long run of good to average seasons from the late 1940s to the mid 1960s, erosion was virtually confined to poorly managed bare fallows on sandy rises. However, the droughts of 1966--68 and 1972 showed that the average standard of farm management, although curbing erosion in most years, does not do so during droughts when

Drift resulting from poor farming practices, west of Carwarp

rises and even flats are eroded severely. It is significant that conditions in 1966--68 and 1972 were less severe than in some of the earlier droughts, as shown in Chapter 6.

The erosion that occurs during droughts is caused by strong dry winds blowing over soils exposed by overgrazing and bare fallowing. While grazing improves soil fertility, especially when leguminous pastures are used, during droughts stock remove the protective cover of stubble, crop, or pasture and break down the coarse tilth prepared on bare fallows. Most farms carry inadequate conserved fodder to prevent stock roaming the paddocks during droughts.

Bare fallows are still prepared on most farms. Properties that did not erode significantly during recent droughts used stable techniques for preparing fallows, such as retention of dense stubble over the summer-autumn period or ploughing only after satisfactory autumn rains. While fallowing on medium - and heavy-textured soils certainly increases the amount of grain produced, trials in South Australia have shown that it is at best only marginally profitable to fallow sandhills, which are most erosion-prone sites.

Salting

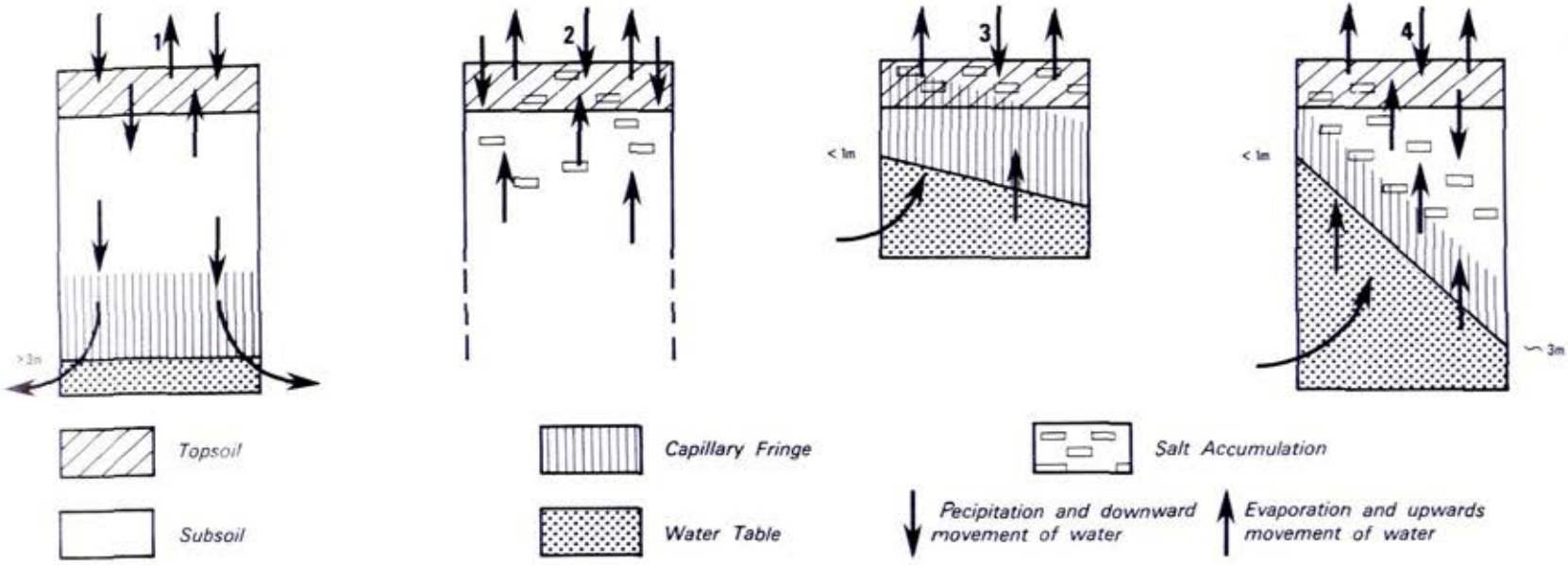
The concentration of salt in the soils of the Mallee has been occurring for thousands of years. It has become more widespread during the last 50 years because of hydrologic changes induced by Man. The Mallee is prone to salting because potential evaporation from the soil greatly exceeds rainfall, there is no surface drainage system for much of the region, and groundwater rises naturally to the surface there.

Salting is important because it reduces agricultural production by impeding plant germination and growth and even causing plant mortality. It results in great changes to native vegetation, and also leads to wind erosion of soils.

In this discussion a distinction is drawn between naturally-occurring salting and that induced by man. Possible remedies are discussed. The genetic classification of types of salting shown in Figure 8 is used throughout the discussion.

Natural salting

This may be either of the subpercolative or the epipercolative type (Figure 8). The former type is common in areas of low rainfall and high evapotranspiration. It occurs when salts are added to the soil in the rain or as dust and are deposited at shallow depths when the soil water is removed by evapotranspiration. Subpercolative salting is common in the clayey soils of the Woorinen Formation. The salt concentration usually reaches a maximum between depths of 1 and 2m, and remains high to at least



Type of moisture regime	1 Normal percolative	2 Subpercolative	3 Epipercolative	4 Amphipercolative
Precipitation/evaporation ratio	P>E most of the year	E>P except for very short periods	E>P most of the year	Variable with season
Topography	Flat or sloping low land	Mostly flat	Flat bottomland	Flat bottomland
Permeability of subsoil	Good to moderate	None : dry subsoil	Poor	Poor to fair
Water Table	Low	None : dry subsoil	Constantly high	Fluctuating with season
Moisture movement	Outflow of excess moisture	Evaporation of suspended water	Evaporation and ascending movement of imported water	Alternating downw. movement of imported water
Origin of salts	Weathered and air-borne sea salts leached through the soil profile	Imported by precipitation and released by weathering	Imported by inflowing water	Imported by inflowing water and by precipitation
Mode of accumulation	Adsorption of Na during possible leaching	At depth of wetting	At surface if water table at 1 m; in subsoil if deeper	In subsoil at balance between evaporation and leaching

FIGURE 8 MODES OF SALT ACCUMULATION IN SOILS
(after Yaalon, 1963)

3 m. For example, the salt concentration in virgin soils at Robinvale varies from 0.1% to 0.3%. Salting is rare in the more permeable Lowan Sand.

Epipercolative salting occurs where saline groundwater has recently risen to the surface. Saline groundwater close to the surface is concentrated by evapotranspiration. This type of salting is important in the north-western part of the study area, where the salinas and gypsum playas such as the Pink Lakes, Lake Tyrrell, the Raak Plains, and the Cowangie flats are fed by rising saline groundwaters. It is also of importance in the eastern part of the study area, where lakes in the north of the Avoca block have originated by highly saline groundwater rising to the surface. This groundwater contains 25,000--30,000 mg/l Total Dissolved Solids.

A saltpan formed at the base of a dune on a wheat farm south of Underbool

The groundwater flow system throughout this area has been considerably modified in recent times by irrigation, the use of lakes as surface water storages, and clearing of the native vegetation.

There is no practical way of reducing salting that occurs by natural processes. However, the gypsum and salt deposits that result are a valuable economic resource (see Cahpter 17).

Salting induced by Man

Salting on dryland farms has resulted from changed hydrological conditions following the removal of deep-rooted native vegetation and its replacement with fallows and shallow-rooted crops and pastures. These permit more water to infiltrate into the dunes, and this causes the salty groundwater to flow out beneath the swales. Evaporation concentrates the salts in soils at the base of the dunes, causing poor growth or death of crops and pastures. This type of salting is classified as amphipercolative. It may be insidious in that growth of crops and pastures may deteriorate before the saltpan stage, which is easily detectable, has been reached.

Aerial photographs taken in 1963 and 1964 showed that more than 900 saltpans, occupying a total area of 1,600 ha,

could be detected in swales between the longitudinal dunes of the Woorinen Formation, particularly in areas between the NNW--SSE ridges (see Chapter 5). Saltpans were more numerous and larger in the 1964 series of photographs than in the 1963 series. However, saltpans were rare in the dry north, and also in the south-east, where few dunes occur.

Some of the areas worst affected by this type of salting are those south-east of Lascelles, east of Rainbow, north of Danyo, and on the northern edge of the Big Desert.

Prevention of salting

To prevent amphipercolative salting and to reclaim salted sites, seepage from rises and evaporation from low flats must be minimized. On farms where saltpans are developing, it has been shown that lucerne can reduce the moisture content of soils on the dunes to wilting point to depths of at least 2.5 m over a period of years. Stands of lucerne are required to dry out the dunes, after which they could be cropped until excessive moisture built up again.

Land still carrying native vegetation on the northern margins of the Big Desert, in the Sunset block, and in the naturally saline Raak land system would become saline if cleared.

Further investigation into soils, groundwater, land forms, land use, climate, and the performances of various salt-tolerant crop and pasture species, which should be assessed under local conditions, is needed in order to fully elucidate the processes that lead to soil salting. The economics of alternative crop rotations and the affect of the retention of some native vegetation should also be investiagted. Unfortunately this work is hampered by the lack of suitable control areas carrying native vegetation, especially in the south where the incidence and spread of saltpans is greatest.

Seepage from channels

Seepage from the floors and walls of the channels carrying water to farms causes salting of adjacent low-lying land through processes similar to those that cause salting at the bases of cleared dunes. As a result saltpans are relatively common beside the main channels. This type of salting could be prevented by replacing the earthen channels, or at least those sections from which seepage is greatest, with pipes or concrete aqueducts.

Salting in irrigation areas

The major irrigation areas are in the Sunraysia district centred on Mildura, and at Robinvale, at Nyah West, and in the north of the Avoca block.

In these irrigation areas, water that is not used by plants moves down to the

Salting on irrigated pasture in the east of the study area

main water table. This annual accession of water to the water table builds up a "groundwater mound", which may intercept or come close to the ground surface. As the groundwater is saline, this causes salting - in the irrigation area, in the surrounding area, or in nearby streams.

In the Mildura settlement, salting due to rising water levels and mobilization of subpercolative soil salts had become a problem only 10 years after the commencement of irrigation. Excess irrigation water percolated down to form a groundwater mound perched on an impervious sediment, the Blanchetown Clay. In topographic depressions, mostly interdune swales but including terraces of the Murray River, the groundwater rises sufficiently close to the surface for capillary action to cause concentration of the salts within the root zone.

To overcome this problem, most of the irrigation districts are drained by a system of agricultural tile drains. When drainage is effective there is a reduction in the concentration of soluble salts in the soil.

However, disposal of the drainage water presents a further problem. At Mildura most of it is diverted to a lake, which acts as an evaporation basin, and saline water is released from the lake at times of high river flow. Alternative methods of disposal are to run the saline water either to inland evaporation basins or to storages from which it is released to the river at times of high flows. The Merbein, Red Cliffs, Robinvale, and Nyah West areas use combinations of these methods. At Tresco and Woorinen, two horticultural areas near Swan Hill, all drainage is disposed of to inland evaporation basins. Prolonged exposure to drainage water from irrigation areas is damaging red gum and black box stands in some small areas along the Murray and elsewhere.

Drainage water can only be used to advantage in a few areas, where the salinities of soils and water are low and the land is frequently flushed by flood waters from the river.

The Avoca block is an area where salting by rising groundwaters occurs naturally.

The application of irrigation water has aggravated the situation and now highly saline groundwater lies at depths of about 1.3 m over much of the northern part of the block. Salting here is a very serious problem because of its effects on the land and on the quality of water in the Murray River.

To remedy this situation the saline groundwater level could be lowered by installing sub-surface drains, by pumping from bores (where suitable aquifers exist), or both, and then releasing the water into the Murray River at times of high flow, or by transporting it to an inland evaporation basin such as Lake Tyrrell. However, this latter scheme could cause salting around that lake, especially in wet years, and also alongside any earthen channels used. The groundwater could also be piped to the sea or to evaporation basins within the irrigation districts. There is great scope for improving the present situation by achieving better management of the farms, particularly with respect to the use of irrigation water.

Another alternative would be to stop irrigating this area and convert it to dryland farming, and use the irrigation water on more suitable and productive areas.

Fire

Fires lit by Aborigines and lightning have occurred in the semi-arid regions of Australia for thousands of years. The Aborigines lit fires to induce fresh growth, which attracted kangaroos and other animals that were hunted for food.

The fuels in mallee vegetation consist of the litter of twigs, bark, and leaves beneath the mallee clumps, the porcupine grass between the clumps, and ephemeral grasses. The fuels accumulate slowly, and sufficient fuel to sustain severe fires builds up over 10--15 years. Most serious outbreaks of fire have occurred 1--2 years after heavy rains, when the dense growth of grasses produced by the rains has dried out. The grasses carry the fire between clumps of mallee and the highly inflammable porcupine grass.

The 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 from the mallees downwind, starting new fires. The fires consume the low vegetation and kill the aerial parts of the mallees.

In the Big Desert, the fuels differ from those of typical mallee areas. The heath, mallee-heath, and scrub-mallee formations form dense,continuous, and highly inflammable fuels, and fires burn fiercely in them, consuming the low vegetation. The effects of a fire that 15 years ago burned through more than 400,000 ha of the Big Desert are still visible from the air.

Fire has an important role in regenerating and maintaining the diversity of heath formations, such as those that occur in the Big Desert.

The forests and woodlands of red gum and black box that occur along the streams of the study area are less fire-resistant than the mallees. Red gum does not usually produce lignotubers. After defoliation by fire, the green crowns are re-established by epicormic shootsfrom dormant buds under the bark. Very hot fires damage or kill the trees.

The important fuels in red gum stands are dry grasses and branches, which are often moved about and heaped against the trees by floodwaters. Fires burn intensely in these accumulations of fuel and cause severe damage.

Cypress pine, belar, and buloke are easily killed by fire, and fires in

Litter fuels accumulating beneath mallee clumps (left) and burnt mallee near Hattah, 6 months after the fire

these types are especially serious as the species do not regenerate readily.

The hazard

Fires occurred before European settlement; they were a natural feature of the environment and often helped meet the requirements of the Aboriginal inahbitants. The area is now occupied by Europeans, who have built new resources such as farms and towns and who place different values on the natural resources of landscape, vegetation, fauna, and soils. Because wildfires can damage or destroy these resources and values, they are now regarded as serious hazards.

Since European settlement, the relation between fire and vegetation and wildlife has changed from that described above due to the greater frequency of fires now and the reduced area of natural habitat available. Under these changed conditions, wildfires may destroy all the vegetation on a reserve and seriously deplete wildlife populations.

Wildfires pose a threat to crops, livestock, and buildings on farms, and it is clear that measures must be taken to control fires on public land to prevent them spreading onto farms.

Fires in woodlands and forests of red gum and black box, and in cypress pine, belar, and buloke, result in loss of timber resources as well as wildlife habitat and scenic values.

Recovery of red mallee at Wathe, 10 years after a fire

The presence of sheep, cattle, or rabbits can have drastic effects on recovery of the land after fire. If these animals are present to graze regeneration and break up the soil surface, severe wind erosion may follow fires and the nature of the ground vegetation may be greatly altered.

Detection and suppression

Most fires in the study area are caused by people. Fires in the red gum areas are usually caused by careless use of camp fires. In the Sunset and Big Desert blocks, outbreaks are often lit deliberately, although lightning causes some fires in these areas. Fires are not frequent in the study area compared

with the number that occur in the dry forest vegetation elsewhere in Victoria.

Fire detection is difficult in the long irregular string of red gum stands along the Murray River and the huge expanses of the Big Desert and Sunset blocks. Roads and tracks deteriorate rapidly, especially in the sandy country, and fire crews often have to travel for many hours to reach fire outbreaks.

Mobile pumpers and long fire hoses are often used to obtain the large quantities of water needed to extinguish fires in the large timbers of the red gum stands. The most effective fire-fighting equipment in the mallee areas is the large bulldozer - the long distances to water supplies restrict the use of tankers.

Fire-fighting vehicles and equipment disrupt the vegetation and soils along the tracks and fire lines, and the effectiveness of mechanical fire-suppression measures must be weighed against their disadvantages.

The use of fuel-reduction burning to prevent spread of fires in mallee vegetation is feasible, but it would involve great expense. Fire prevention work has been undertaken in a strip along part of the southern boundary of the Big Desert to protect neighbouring land; but there is no prospect at present of providing this protection along the whole length of the boundary.

It is difficult to achieve affective patrols to prevent illegal lighting. There is little prospect of removing fuel in red gum areas by controlled burning.

Weeds and Vermin

An organism becomes a hazard when its activities run counter to those of Man, and conflict with many other species is inevitable because Man's interests and activities are so diverse. While pest plants and animals are best known for the losses they cause in agricultural land, they also have considerable impact on public land.

The presence of weeds on public land causes concern for several reasons. On recreation areas, they may be aesthetically displeasing, cause discomfort through the presence of prickles or thorns, or have poisonous properties. In nature conservation areas they compete with native plants and are aesthetically undesirable, and measures to control them may be incompatible with management goals. In some situations weeds on public land may spread to adjacent land.

Pest species of animals also present problems in the use and management of public land. For example, rabbits compete with native fauna and feed voraciously on the vegetation, thus leading to soil erosion and the elimination of some plant species. Control by poison-

ing may kill some native animals and this may conflict with some of the aims of management.

Three factors that should be taken into account when considering the future use of land badly infested with weeds and vermin are:

* whether they can be controlled
* whether the method of control is compatible with the use proposed for the area
* whether the proposed use will lead to the spread of weeds and vermin.

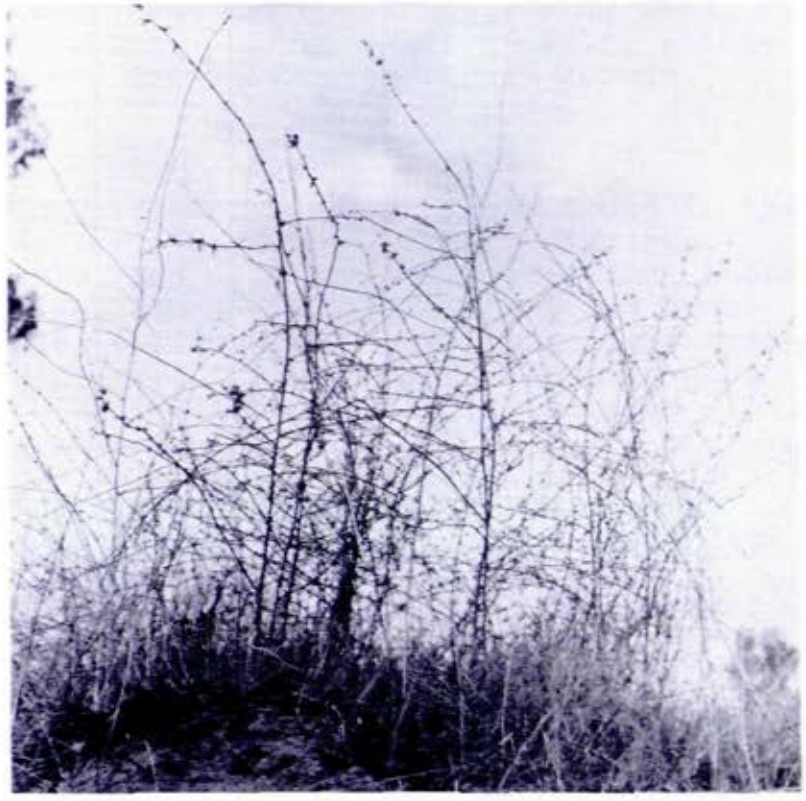
Most pest plants and animals are proclaimed noxious weeds or vermin, and their control is required by legislation. A major cost associated with vermin and noxious weeds on public land is the cost of control measures.

Weeds

The critical factors controlling the invasion of weeds onto undisturbed areas in the Mallee are availability of soil moisture and nitrogen. Summer-growing perennial and annual weeds are more frequent on sandy soils than on clays.

Table 12 records the occurrence of noxious weeds in the study area in 1970. The ratings are derived from records of the number of parishes within each block in which a particular weed occurs. Many of these weeds are normally found only in agricultural situations and on roadsides, but because large areas of public land are used for grazing, most of them occur on public land also.

Skeleton weed is the most widespread species, particularly on deep sands of low fertility, where it grows to the virtual exclusion of all other plants. It grows mainly on disturbed areas, but



Skeleton weed is a major noxious weed of farmland in the Mallee

TABLE 12

INCIDENCE OF NOXIOUS WEEDS

A - high B - medium C - low D - not recorded

Species	Annuello	Avoca	Big Desert	Millewa	Murray River	Sunset	Tyrrell
Amsinckia	B	A	B	C	B	B	A
Bathurst burr	A	A	A	A	A	A	A
Bindweed	B	B	C	C	B	C	C
Blackberry	C	B	D	C	C	D	C
Boneseed	C	B	B	C	B	C	B
Boxthorn	B	A	B	B	B	B	A
Buffalo burr	C	B	C	D	D	D	C
Californian burr	C	B	C	B	B	C	C
Caltrop	A	A	A	A	A	A	A
Camel thorn	D	C	D	D	C	D	D
Colocynth	D	D	D	C	D	D	D
Dodder	D	D	D	D	C	D	C
Drooping prickly pear	D	D	C	C	C	D	C
Erect prickly pear	C	D	B	B	B	B	B
Fennel	C	C	C	C	B	D	C
Five-spined saltbush	A	A	B	D	B	D	A
Flax-leaved broom	C	D	D	D	C	D	D
Hemlock	D	D	C	D	D	D	C
Hoary cress	D	B	B	C	C	C	B
Horehound	A	A	A	A	A	A	A
Ivy-leaf sida	D	B	D	D	D	D	C
Khaki weed	C	C	C	C	C	C	B
Musk weed	D	C	D	D	D	D	D
Noogoora burr	B	B	C	B	A	C	B
Nut-grass	D	C	C	C	C	D	C
One-leaf cape tulip	D	C	C	C	C	D	C
Onion weed	A	A	A	A	A	A	A
Pampas lily-of-the-valley	D	C	D	D	D	D	C
Paterson's curse	A	A	B	A	A	B	B
Perennial ragweed	D	B	C	D	C	D	C
Prairie ground cherry	D	C	C	D	D	D	C
Sand rocket	C	D	C	D	C	D	B
Skeleton weed	A	A	A	A	A	A	A
Soursob	B	A	A	B	B	B	A
Spiny burr-grass	A	C	B	B	A	B	B
Spiny emex	A	B	B	A	A	B	B
Spiny rush	B	B	C	B	B	C	B
Stinkwort	A	A	A	A	A	A	A
Sweet briar	D	C	D	D	C	D	D
Thistle - golden	D	D	D	C	C	D	D
hard head	B	B	C	B	B	C	B
saffron	B	A	A	A	A	A	A
slender	D	B	B	D	C	D	B
soldier	D	D	B	C	D	C	C
spear	A	A	A	A	A	A	A
spotted or variegated	B	A	B	B	B	C	B
star	D	B	B	B	C	C	B
stemless	A	A	A	A	A	A	A
Thorn apple	B	B	C	C	A	C	C
Tree of heaven	C	B	C	C	C	C	C
Two-leaf cape tulip	D	D	D	D	D	D	C
Wheel cactus	C	B	C	B	C	C	C
White horse nettle	D	C	B	C	C	C	C
Wild garlic	D	D	D	D	C	D	C
Wild mignonette	C	A	C	C	B	D	B

in uncleared areas has invaded lunettes and dunes where rabbits have prevented regeneration of native vegetation after fires.

Control of skeleton weed can be achieved by planting lucerne. Recently, biological control using rust fungus, mite, and midge has been tried. While these agents may prove successful, control of skeleton-weed may lead to invasion by other weeds, or to soil erosion.

Horehound is also widespread throughout the study area. It is a special problem in Hattah Lakes and Wyperfeld National Parks, particularly along Outlet Creek system in the latter.

Although not a noxious weed, heliotrope is a widespread summer-growing annual weed found on almost any cultivated land in the study area. It is of considerable concern to farmers because of its toxic properties but, apart from cultivation, no successful control method is available. Like many summer annuals, it germinates following each summer rain.

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 land in the study area, including roadsides, reserves, and land held under grazing leases or licence. Many are characterized by successive germinations and the ability to flower and fruit under adverse conditions.

Another group of annual weeds are the exotic species that have invaded the native vegetation in the partly cleared and grazed areas. Representative species are barley grass, *Bromus* spp., and the medics.

Some other weeds that are common in the study area are amsinckia, onion weed, Paterson's curse, spear thistle, stinkwort, and the Mediterranean turnip.

Vermin

The declared vermin animals found in the Mallee are rabbits, foxes, pigs run wild, and wild dogs. In addition, house mice, feral cats, kangaroos, and emus are considered to be pests in some circumstances. Dingoes and wild dogs were once important but are no longer a problem.

Rabbits are widespread in the study area, but may be absent from the undisturbed scrub in the west of the Big Desert and Sunset blocks. They do not require supplies of free water. On farms rabbits compete with stock for pasture and on public land they cause severe damage to the vegetation, depleting wildlife populations and initiating soil erosion. Methods used to eradicate rabbits when their numbers built up to plague proportions have included poison-

ing with 1080, infecting with myxoma virus, ripping warrens, and professional trapping and shooting. In the Kulkyne forest a 10-year programme of poisoning, myxoma, and ripping warrens has reduced the rabbit population to a very low level.

A rabbit warren at Pine Plains, showing the primary feeding area and loss of vegetation from the sandhills in the background

Feral cats are widespread in the study area, but are more common on farms than in scrub. These cats are opportunistic predators and scavengers, and their diet depends upon the availability of prey species. In undisturbed scrub, small native mammals form a great part of their diet, whereas rabbits and house mice are the main mammals they eat in farming areas.

Foxes are also widespread in the study area. They mainly live on rabbits, mice and carrion sheep, although most also eat herbage and some eat birds and insects. Native mammals are a minor source of food in the Mallee, in contrast to eastern Victoria.

Wild pigs are found mainly in the Murray River block. They are omnivorous, and can root up large areas while searching for food. Although feral house mice are present on all blocks, they are generally not regarded as pests and are an important food source for several other animal pests. Their presence may reduce predation by these animals on small native mammals.

Occasionally, when summer rainfall follows a mild winter and a food supply is available, the mouse population grows to plague proportions, and inflicts severe losses on farms and towns. The last plague was in 1969--70, and predation and poisoning failed to control it. Natural causes eventually reduced the numbers to normal levels.

Emus and kangaroos can create serious problems on farms by damaging fences and crops and eating fodder. On public land, the populations of these species sometimes reach high numbers and the onset of adverse conditions such as drought results in many deaths. Such populations on public land may have to be controlled to prevent invasion of farmlands and excessive grazing pressure on native vegetation.

European carp

European carp was introduced into the Murray River at Mildura in the early 1960s. It has spread rapidly and is now common throughout the lower reaches of the river. Carp has been formally declared a noxious fish. It is omnivorous and competes with native fishes for food. When feeding it stirs up the mud on the bottom of lakes and streams, and uproots aquatic vegetation. This changes the aquatic environment and makes it unsuitable for native fishes. European carp has greatly accelerated the decline in native fish populations. There is no method of control at present.

Insect pests

The common pasture pests - cockchafers and red-legged earth mites - are present on the dryland farms. Gum-leaf skeletonizer *Eraba lugens* and lerps may cause occasional damage in red gum stands. Many insects cause losses in the horticultural areas, and some fungi are also important there.

Australian plague locust

Australia contains more than 500 species of grass-hoppers and locusts. Most are harmless, although several species are agricultural pests that feed on a variety of cultivated plants and pastures.

The most important of these pests is the Australian plague locust *Chortoicetes terminifera* (Walk). This locust is found over large parts of the drier inland areas of Australia, and is of economic importance as a pest in Victoria in those years when flying swarms enter the State from the breeding grounds further north. The locust does breed to a small extent in north-western Victoria, but the numbers are usually too small to be significant. Noteworthy invasions by flying swarms occurred in the summers of the following years: 1869--73, 1875, 1934, 1946, 1950, 1953, and 1971--73. Open country with bare scalded areas, which are quite often on public land, are favoured egg-laying sites.

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PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

For each block (shown on Map No. 1) this part describes the characteristics and nature of the land, its capabilities for various uses, and the likely hazards and conflicts involved with such uses. It finally highlights those capabilities or other features that are of special significance.

A consistent format of headings and sub-headings has been used so that the reader can readily find specific information within one block and compare it with others. The discussion under most sections refers specifically to public land.

Capability

This term refers to the suitability of public land for various uses. Assessment is based on a number of considerations, including the inherent characteristics of the land, its proximity to centres of population, the relative scarcity of the land type, and the hazards associated with the various uses.

In most cases this report deals with capabilities in general terms, because the amount of information available varies from block to block, and because some values are difficult to quantify. In assessing capability, comparisons have been made with other blocks and with other parts of the State.

Capability for agriculture

In the Mallee the capability (potential productivity per unit area) of land for non-irrigated agriculture depends on soil type and rainfall. Using these criteria, the wheat-growing potential of the public land in each block has been assessed by comparing it with the agricultural land in the district, assuming an average level of management. The assessments refer to wheat-growing potential because it is estimated that on most farms 70--80 % of gross income is derived from cereal production, with 85% of this coming from wheat.

Although the Mallee produces about 40% of the State's wheat, yields in the region - 1.3 tonnes/ha in the south, 1.1 tonnes/ha in the centre, and 0.9 tonnes/ha in the north - are low compared with the State average of 1.45 tonnes/ha, and 1.7 tonnes/ha for

the Wimmera.

Thus on a State-wide basis, the productivity of the Mallee, and especially the central and northern Mallee, is low. In addition, recurring droughts, as well as reducing farmers' returns, lead to widespread erosion of soils on farms. These factors are also considered in assessing agricultural capabilities of the public lands of the study area.

1. MURRAY RIVER BLOCK

A. General

(1) Location and present tenure

This block contains the flood-plain of the Murray River downstream from Swan Hill. The block boundary lies within 3--5 km of the River, except in the Hattah--Kulkyne and Ned's Corner areas, where it is up to 15 km from the present course of the River.

Public land in the block covers a total of 120,700 ha; most of it is reserved forest, with about 24,000 ha of Crown land in the section west from Mildura, and 800 ha of National Park near Hattah. It consists of many relatively small areas strung out along the length of the River. The largest areas of public land are at Hattah--Kulkyne and on Wallpolla and Lindsay Islands.

(2) General description

The public lands of the block are confined to the flood-plains of the Murray River and most are in the Lindsay Island land system. The flood-plain is cut by many billabongs and anabranches. Woodlands and forests of red gum and black box are the most common vegetation types. West of Mildura the block includes an older terrace now carrying saltbush vegetation - this is in the Ned's Corner land system. Full descriptions are given in the Land Systems chapter.

Dense warrego grass beneath red gum saplings, Kulkyne forest

(3) Present use

The lands along the Murray River are used for recreation, timber production, nature conservation, and grazing. Swimming, boating, fishing, and pleasure driving are the main recreational activities, although camping and hunting are also important. Nature conservation and carefully controlled recreation are the main uses of the Hattah Lakes National Park.

The forests and woodlands of red gum and black box produce fencing and vine-trellis materials, and some logs and sleepers. Almost all the public lands carry cattle, which graze native vegetation, and sheep are also grazed in the far north-west.

B. Nature of the Land

(1) Climate

Average annual rainfall ranges from 325 mm at Swan Hill to less than 250 mm at the South Australian border. The rainfall is very variable.

(2) Geology and physiography

Plains and terraces of the clays, silts, and sands of the Coonambidgal Formation comprise the major component of this block. Oxbow lakes, anabranches, and scroll patterns provide minor relief on these predominantly flat land forms.

In a few areas, notably Hattah--Kulkyne, hummocks and dunes of the Woorinen Formation sands have been deposited over the fluvial clays. In the north-west, a layer of windblown dust overlies the vast upper terrace near Ned's Corner. Dunes and sheets of the Woorinen Formation sands and clays have been deposited on the edge of fluvial deposits, and in a few places extend to the river bank. The Lowan Sand abuts the fluvial deposits on the western edge of the Kulkyne forest.

Although storages upstream, and weirs and locks, permit intensive regulation of the River, it still floods at least the lower parts of this block about every 5--7 years, filling the lagoons and billabongs.

(3) Soils

Grey cracking clays are the dominant soil type. Heavy-textured calcareous duplex soils occur on the upper terrace near Ned's Corner (west of Mildura) and on occasional lunettes. Reddish yellow sandy loams occur on the hummocks in the Kulkyne forest.

(4) Vegetation

Forests and woodlands of red gum grow along the river and around the creeks and lakes. Associated species are willow acacia, eumong, and, on some sites, dense stands of warrego grass and swamp couch.

Portion of King's Billabong near Mildura

Higher, less frequently flooded sites carry large areas of black box woodlands. Common understorey species are moonah, small cooba, prickly bottle brush, lignum, and spear grass. Saltbush woodland - black box over old-man saltbush - occurs in scattered stands on rarely flooded land west of Mildura. Other plants found under black box (and on broad treeless plains common in the north-west of the block) include saltbushes, bassias, blown grass, leek lily, groundsel, blue rod, yellow poverty weed, and river bluebell. Slender cypress pine, belar, and buloke grow on sandhills in the Kulkyne forest, over small cooba and ham-and-eggs daisy. These and many of the black box stands were cut over during the early days of settlement, and are now very open.

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Eight kurrajong trees on the river bank in the Nyah forest have proably grown from seed carried by the river from the north-eastern highlands.

Dense lignum scrub occurs in low swampy areas, often with reeds and nitre bush. Other common plants of wet locations are common reed, spiny flat-sedge, water-wort, eelweed, river mint, small spike-rush, and cumbungi.

Woodlands of black box on a rarely flooded site

West of Mildura an extensive plain carries saltbush formation dominated by bladder saltbush and bluebush. Common plants in this formation include bassias, native goosefoot, rounded noon-flower, desert glasswort, grey glasswort, soft-horned saltbush, nitre bush, thorny saltbush, and New Zealand spinach. Of the now widespread introduced annual grasses, barley grass, camel grass, and brome grass are the most common. Native cane grass is common in shallow depressions.

(5) Fauna

The habitats of the Murray River block support diverse populations of vertebrates. Birds are the best-represented group, and more than 200 species utilize the habitats occurring in this area. The red gum and black box woodlands along the river are very important for maintaining avian populations in the Mallee, as many birds utilize both these habitats and the drier areas in the Sunset and Big Desert blocks. Many waterbirds and waders occur along the Murray and include several species that are rare in Victoria.

The other vertebrate groups are also well represented in this block. At least three reptiles, five amphibians, two mammals, and most of the Mallee fish species are found in (or along the margins of) the permanent waters of the Murray and its anabranches. The red gum and black box woodlands are inhabited by

about eight species of reptiles, two to four of amphibians, and eight of mammals. In Victoria, the red kangaroo is restricted to the woodlands of the Kulkyne forest, the adjacent eastern part of the Sunset block, and the saltbush plains of the far north-west.

C. Capabilities

(1) Nature conservation

The capability for nature conservation is high. This block contains a strip of well-watered land in a semi-arid climate, and contains a rich flora and fauna that differ markedly from those of surrounding dry country.

The major occurrences of red gum--black box woodlands in the study area are in this block. These vegetation types are not well represented in existing nature conservation reserves. The aquatic plants of the river, creeks, and lakes are not found in the dry country and are an important habitat component for the wildlife. The section of the block west of Mildura contains extensive stands of saltbush and bluebush and, although this association is widespread in Central Australia, this is the only large area of it in Victoria.

Appendix 4 lists 24 rare or localized plants that occur in this block - more than for any other block. Most occur in the section from the Kulkyne forest to the South Australian border. Many of

The barn owl nests in tree hollows, and inhabits the woodlands along the River

the plants are Central Australian species with distribution extending into the far north-west of Victoria.

This block contains very important habitats for birds and more than half the birds recorded in Victoria have been recorded here. The aquatic habitat is used by more than 100 species, of which almost one-third are waders, including some intercontinental migrants. Most of the bird groups that normally inhabit

the dry country have been recorded breeding, resting, or feeding in the woodlands associated with the river. The river habitats also act as a refuge for many birds of the dry country during droughts.

Other vertebrate groups are also well represented. The mammals, reptiles, and amphibians are each represented by about 10 species. Within this study area the habitats of this block are important for the red kangaroo, feather-tailed glider, platypus, eastern water rat, three species of tortoise, two skinks, and the brown snake. Most of the 27 fishes recorded from the Mallee occur in the permanent waters of the Murray River and its anabranches.

The woodlands and wetlands of Kings Billabong, 5 km south-east of Mildura, contain diverse flora and fauna, and are well known by naturalists.

Cliffs in the banks of the Murray River at Red Cliffs, Merbein, and Boundary Point (on the Victorian--South Australia border) are of geological interest. Aboriginal skeletons have been excavated from the land west of Mildura, and the block contains canoe trees, middens, and ovens.

The public land comprises many small areas, originally reserved for timber production, strung out along the River. The largest of them are the Kulkyne forest, Wallpolla Island, and Lindsay Island. The Kulkyne forest and adjacent Hattah Lakes National Park cover about 33,000 ha, and have more diversity than the other areas. In addition to the river environment they include 13 lakes, broad treeless plains, and sandhills and hummocks carrying slender cypress pine with some buloke and belar. Large areas of mallee lie to the west.

Wallpolla Island is contiguous with an area of saltbush, and covers 12,000 ha. Lindsay Island is also contiguous with saltbush on public land and with large areas of dry country in the Millewa block.

The condition and use of land in New

Open woodland of slender cypress pine on sandhills in the Kulkyne forest

South Wales directly across the Murray River from these public land areas affect their suitability for nature conservation (and also recreation). The tenure of the land across the River from the Kulkyne forest is mainly Western Lands Lease and State Forest, with two freehold blocks. Opposite Wallpolla Island, about half the land in Western Lands Lease and half is alienated. Most of the land opposite Lindsay Island is alienated. The utilization of trees is controlled on Western Lands Leases and State Forest but not on alienated land.

(2) Recreation

The capability for recreation is high. In the hot climate and waterless environment, the Murray River is used for swimming and boating and the tall forests and woodlands are used for camping picnicking, hunting, and pleasure driving. Sandy beaches close to the main towns receive the most use. Hunters and fishermen use all the public land frontage to the River. In addition to the areas close to towns, the Kulkyne forest and Hattah Lakes National Park are becoming popular, and the use of these areas should increase as they become better known and access to them is improved.

It has been proposed that an Aboriginal museum, depicting the life and culture of the Murray River Aborigines, be built on Bumbang Island at Robinvale as a tourist attraction.

A picnic spot in the Piambie forest

A shelter has been built in the Piambie forest on the site from which Major Thomas Mitchell sketched a lagoon, during his voyage down the Murray in 1836. The area is clearly recognizable from the sketch, and is known as Major Mitchell's Lagoon.

(3) Timber production

The capability for timber production is high when considered in relation to the study area, but is low to moderate on a State-wide basis. Red gum grows to large sizes suitable for sawlogs, sleepers, poles, and piles, and the smaller black box timbers are used for fence posts, vine trellises, and other farm structures.

Valuable red gum forests occur between Colignan and Kardadoc, and upstream from Wemen. Lindsay Island and Wallpolla Island are also suitable for timber production. Black box stands suitable for timber production are widely distributed.

(4) Agriculture

Because of their unfavourable moisture characteristics, the heavy clay soils of this block are not as productive for cropping, particularly in dry years, as the lighter soils on adjacent areas. Productivity decreases markedly towards the north-west, due to the lower rainfall. On a State-wide basis, capability for wheat-growing and dryland grazing is low. However, many areas have a moderate capability to produce irrigated pasture.

The block has a low capability for grazing stock on the native vegetation. Frequently-flooded areas on which swamp couch or warrego grass grow are the more productive sites. The saltbush plains at Ned's Corner have a low capability compared with well-watered sites near the River. On a State-wide basis, production from these areas is very small.

The block has a high capability for honey production. Red gum is one of the State's most important nectar-producing trees, and large numbers of hives are moved to the area when a good budding occurs. Usually some parts of the River are productive every year. Black box is also a valuable species.

(5) Minerals

No commercial resources of minerals are known to occur in this block.

(6) Utilities

A 220-kV transmission line (Kerang to Red Cliffs) runs in a 52-metre easement through the Kulkyne forest.

D. Hazards and Conflicts

The erosion hazard in this block is generally low to moderate, but is severe on isolated dunes and lunettes. Reclamation of eroded dunes in the Kulkyne forest has begun. Scalds are common in the saltbush areas west of Mildura.

Rabbits are a constant threat - numbers fluctuate widely, but are low at present. Wild pigs and goats are present in the Kulkyne forest, and cause some damage. Weeds and exotic plants are present throughout though none is is a serious problem at present. Fire is a hazard in the summer months - most fires in this block are lit by campers and fishermen.

Conflict occurs between grazing stock on native vegetation and nature conservation. The aim of nature conservation is to retain the full range of native animals and plants that occur naturally in an area. Stock graze the vegetation

selectively, choosing species that contain little fibre and lack a strong taste. These species tend to become rare and disappear, and are replaced by unpalatable and woody species, including exotics. The degree to which this happens depends on the grazing pressure, or stocking rate. Once degeneration of the natural vegetation has reached a certain stage, removal of stock will not result in return to the original climax condition. Instead, a disclimax, with exotic species dominant, establishes. If heavily over-grazed, the vegetation becomes so weakened that soil erosion occurs, with consequent deterioration of the soil resource.

In the Mallee, grazing has been partly responsible for preventing the regeneration of the cypress pine stands. In a few areas where grazing has been stopped and rabbits brought under control, some regeneration of pine has taken place.

Grazing conflicts directly with the conservation of native animals. Trampling and browsing by stock change the structure and nature of the low vegetation, thus altering the habitats of the ground-dwelling animals. In particular, trampling disrupts the breeding of animals that nest on the ground.

Stock also compete with native animals for food. Although in some cases stock and the native herbivores prefer different species of plants, in time of drought when food is scarce the two groups are thrown into direct competition.

It is clear that grazing conflicts seriously with nature conservation. However, in areas where nature conservation is not of prime importance, the impact of grazing can be reduced by careful management based on controlling stock numbers according to the condition of the vegetation. The location of watering points and subdivisional fencing is also important. Rabbit control is essential.

Grazing has some beneficial aspects. Watering points installed for stock also serve native animals and allow them to make better use of areas distant from natural water supplies. Stock can reduce the fire hazard on some public lands by removing a proportion of the grassy fuels.

Conflict between grazing and recreation exists where fences, gates, and signs discourage people from entering and travelling through public land, and where the presence of sheep or cattle detracts from the naturalness of an area. One the other hand, for some people the stock would add to the interest of an area.

E. Significance

The Murray River block has significance for nature conservation, recreation, and timber production.

2. MILLEWA BLOCK

A. General

(1) Location and present tenure

This block extends from Red Cliffs to the South Australian border, and lies between the very large area of the Sunset block and the flood-plains of the Murray River block.

The public land covers 93,200 ha (about 23% of the total area of the block). It consists of a large area on the South Australian border, an area adjacent to the irrigated lands at Red Cliffs and Mildura, and several smaller parcels. All of it is Crown land, except for about 2,600 ha of reserved forest at Yarrara.

(2) General description

Belar woodlands, grasslands and big mallee on undulating land forms - dunes, hummocks, and plains - are characteristic of this block. It also contains some salt and gypsum flats. Most of the public land is in the Millewa land system, and two areas in the west are in the Raak land system. These are described in the Land Systems chapter.

(3) Present use

Almost all the public land is held under lease or licence for sheep-grazing. Some of it, including most of the small areas south of Mildura, has been cleared for wheat-growing. Some parts of the public land west of Red Cliffs are used for disposal of saline drainage water, and for tipping rubbish. Calcrete (gravel) is also extracted from this area.

B. Nature of the Land

(1) Climate

Average annual rainfall ranges from 260 mm in the south to less than 250 mm in the north-west. The rainfall is highly variable.

(2) Geology and physiography

The Woorinen Formation lies at the surface over most of this block. In the centre and north it has been fashioned into hummocks, plains, and dunes, and in the south into dense longitudinal dunes. Two large areas of salinas and gypsum playas (Yamba Formation), containing

many transverse dunes of gypsum, lie in the west near the South Australian border.

(3) Soils

Medium-textured calcareous gradational soils, red sands, and shallow soils on limestone are the dominant soil types. Some brownish calcareous clays occur on broad plains, and saline soils occupy the gypsum and salt flats.

(4) Vegetation

Grasslands, savannahs, woodlands, and big mallee occur throughout most of the public land. In the grasslands the most common native species are spear grass and wallaby grasses. A number of introduced annuals - such as barley grass, camel grass, brome grasses, and medics - are now common as a result of grazing, and unpalatable species such as bassias have become widespread.

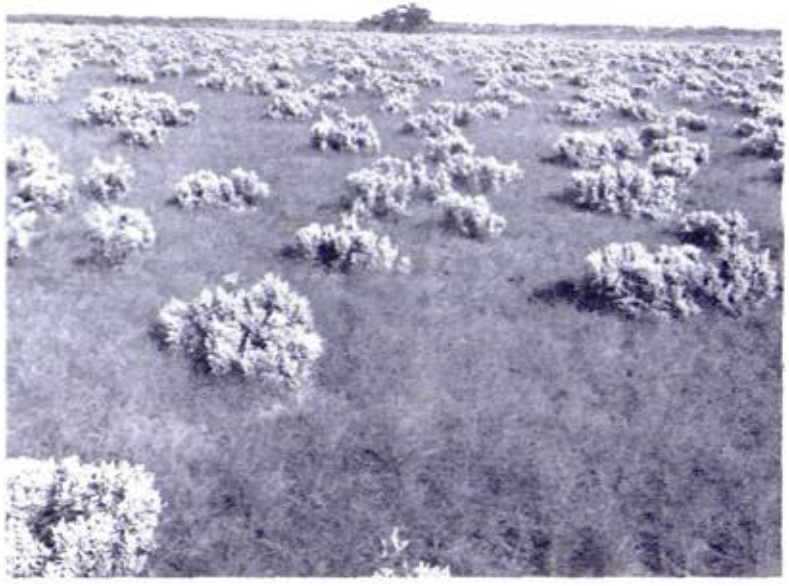
The savannahs consist of widely spaced clumps of big mallee and pine and belar over a layer of grasses. The eucalypts commonly found in the big mallee formations are dumosa, white, and acorn mallees. Belar and some slender cypress pine are the main woodland species. The following trees and tall shrubs occur throughout the block: weeping pittosporum, wait-a-while, umbrella wattle, small cooba, ballart, desert cassia, hop-bush, sugarwood, and cattle-bush. Common low shrubs and herbs include ruby saltbush, bassias, pale turpentine bush, frosted goosefoot, weeooka, cottony saltbush, and twinleaf.

Savannah - big mallee and grassland

The Yarrara forest contains woodlands of belar with a few small areas of big mallee. The former pine stands of this area were decimated by the 1942--45 drought and the subsequent beetle attack. The stands of belar and the pine remnants in this area are the most extensive in the north of the study area.

Saltbush mallee occurs in a few areas, notably west of Mildura. The public land west of Red Cliffs carries big mallee, grassland, and belar woodlands.

The two large areas of gypsum playas and salinas west of Morkalla carry saltbush,



An open stand of ruby saltbush

with mallee, saltbush-mallee, and grassland on copi rises. Saltpans and stands of samphire are rare in these areas. Bladder saltbush, bluebush, ruby saltbush, and bassias are the main saltbush species. Dumosa, acorn, and white mallees occur on the numerous transverse dunes. Native herbs found throughout include billy-buttons, dense crassula, and sand spurrey. Many introduced species are also present, including camel grass, barley grass, Arabian grass, and Indian hedge mustard.

(5) Fauna

Although this block has not been recently surveyed for animals, it is important because it contains large areas of plant communities - grasslands, big mallee, and belar woodlands - not well represented in other blocks. Along the South Australian border it forms a connection between the Murray River and the Sunset block, and this facilitates movement of birds (and possibly some of the larger mammals) between the Murray River and the drier inland areas.

Echidnas, fat-tailed dunnarts, brush-tailed possums, and western grey kangaroos have been recorded in this block, and a population of red kangaroos still exists in the north-western corner.

No detailed information is available on reptiles, but many of the species present in the Sunset block probably also inhabit the Millewa block.

Amphibians and fishes are poorly represented in this block - a few species may occur in the public lands near the Murray River and in farm dams throughout the area.

C. Capabilities

(1) Nature conservation

The capability for nature conservation in the western part of the block is high. Here the public land contains a

mosaic of vegetation types that does not occur elsewhere in the State. The belar woodlands, the grasslands and the saltbush are of particular interest. The belar woodlands in the Yarrara forest are an outstanding example of this vegetation type.

Although the fauna of the block is not well known, the public lands in the west would have moderate capability for fauna conservation because of the varied habitats present, and because this land links the wetter lands of the Murray River with the dry Sunset block. The population of red kangaroos in the north-west is important, as this species has a limited range in Victoria.

At its northern edge, the vegetation of this block has a long common boundary with the saltbush and red gum--black box woodlands of the Murray River block.

All land in South Australia adjacent to this block has been cleared for agriculture.

(2) *Recreation*

The capability for recreation is moderate, although use at present is very low. The public lands in the west of the block contain a variety of vegetation types, and the combination of grasslands, woodlands, and big mallee is visually attractive. Interesting saltbush plains lie within the block and just to the north. The Sturt Highway passes through this area, and a water supply for the northern part of the block could be drawn from the Murray River.

The large area of public land (10,250 ha) west of Red Cliffs has a moderate capability for recreation and education, as it contains grasslands, woodlands, and big mallee, and is close to the Sunraysia district, a major population centre.

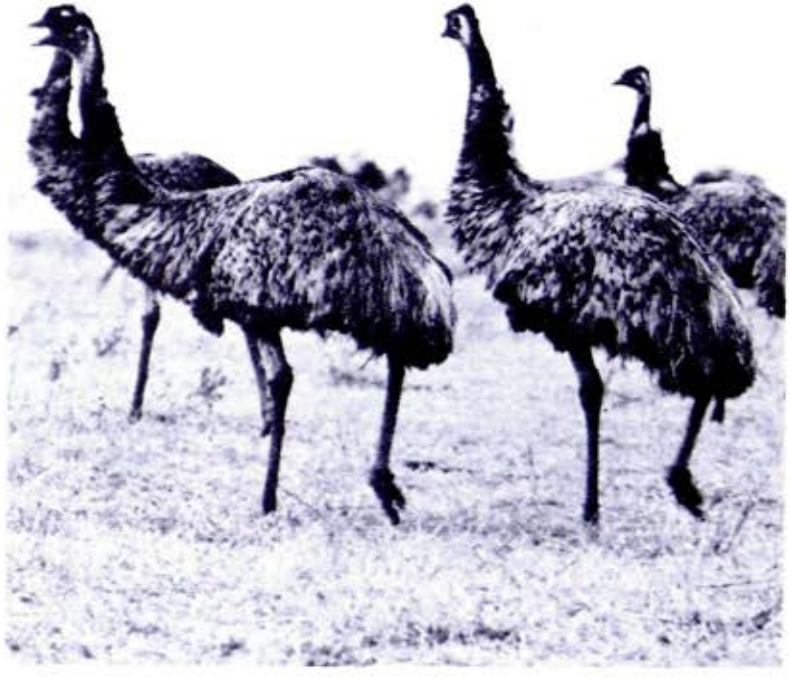
Belar woodland in the Yarrara forest

(3) Timber production

Capability is low. The stands of belar and the pine remnants are suitable for some uses, but little utilization takes place.

(4) Agriculture

The rainfall this block receives is marginal for wheat-growing, and varies considerably. The bulk of the public land, which lies in the west and north-west of the block, probably receives less rain than the settled areas, and for this reason, even though the soils are similar, it has a lower capability for agriculture. The productivity of the settled area (0.9 tonnes of wheat per ha) is low on a State-wide basis. In addition, the wind erosion hazard, especially on the dunes, is severe in this dry climate.



Emus inhabit most of the habitats of the study area

The saline soils are not suitable for agriculture.

The area has a low capability for grazing based on the native vegetation. The grasslands are the more productive areas. Grazing has lead to soil erosion and deterioration of pastures.

The block has a moderate capability for honey production based on mallees and sugarwood, although its remoteness results in a low level of use at present.

(5) Minerals

Shallow deposits of calcrete occur through the area. Those on the public land near Red Cliffs have been extensively utilized, and the demand exists for further utilization. Extensive deposits of gypsum occur near the South Australian border west and south-west of Morkalla, but are not utilized at present.

(6) Utilities

Pits from which calcrete (limestone gravel) have been removed are used as rubbish tips on the public land near Red Cliffs. Depressions and saltpans in this area are used as evaporation basins for saline drainage water from the adjacent irrigation districts.

The Army's Sunset Training Area includes the public land in the west of this block, and extends as far north as the Sturt Highway.

D. Hazards and Conflicts

Due to the dryness of the climate, a wind erosion hazard exists on all land in this block, and is most severe on the dunes. The native vegetation maintains stability on the public land except during droughts, when over-grazing occurs, resulting in erosion of dunes and flats with consequent degeneration of the grasslands.

Rabbits pose a constant threat, although numbers are reasonably low at present. There is a moderate fire hazard, particularly after wet seasons when the grasslands carry heavy accumulations of fuel.

Conflicts between grazing and nature conservation and recreation are discussed in the Murray River block (see page 181).

Conflict exists between nature conservation and recreation and the extraction of calcrete from shallow pits. These operations leave large areas of rubble on which few plants grow. Reclamation of these gravel pits, using well-known techniques, would reduce their impact on the environment.

There is some conflict between disposal of saline drainage water into depressions on public land, and nature conservation.

At the Cardross Lakes, west of Red Cliffs, stands of belar have been killed by drainage water. However, this method of disposal of the water may be preferable to the alternatives, and the dryland habitats have been replaced by shallow lakes, which have considerable value as habitat for waterbirds.

E. Significance

This block has significance for nature conservation and recreation.

3. SUNSET BLOCK

A. General

(1) Location and present tenure

The Sunset block stretches from the edges of the Murray River flood-plain near Hattah and Nowingi to the South Australian border. The Ouyen Highway forms the southern boundary.

Of the 661,700 ha of public land in the block, 645,200 ha form the one vast area known as the Sunset country. Numerous smaller areas lie near the southern boundary of the block. Almost all the public land is Crown land. In the east, the block includes 16,000 ha of the Hattah Lakes National Park and 3,300 ha of the Kulkyne reserved forest, and there are small areas of reserved forest near Wymlet and at Murrayville.

(2) General description

Dunes of the Central Mallee land system and irregular dunes of the Berrook land system predominate in this block. They carry mallee, hummock grass-mallee, and scrub-mallee. In the south and east, salt and gypsum flats of the Raak land system are bare or carry saltbush. Non-saline plains, transverse dunes, and lunettes associated with the flats carry grasslands, woodlands, and big mallee. In the central south of the block, plains carry grassland and big mallee.

(3) Present use

Grazing sheep, and to a lesser extent cattle, on native vegetation is the main form of land use in this block. Some areas of Crown land held under grazing lease or licence have been cleared for wheat-growing and grazing. The eastern

Salinas (salt lakes) on the Raak Plain (oblique aerial photograph)

section in the National Park is used for nature conservation and low-intensity recreation. The Pink Lakes, which lie north of Linga, are also used for low-intensity recreation. Salt is harvested from the Pink Lakes, another lake to the south-west, and from the south of the Raak Plain. Gypsum is mined from several leases on the Raak Plain, and the land north of Cowangie and north of Tutye. Eucalyptus oil is distilled from the leaves of mallee eucalypts in the south-west of the block. Part of the area is used for Army training.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from 300 mm in the south to less than 275 mm in the north. Rainfall is very variable.

(2) Geology and physiography

Dense longitudinal dunes of the Woorinen Formation cover most of this block. A long tongue of Lowan Sand, represented by irregular dunes, extends across the block in the south. There are three large areas of gypsum playas (Yamba Formation) and salinas, one in the north-east (the Raak Plain) and others in the south near Cowangie and north of Linga.

(3) Soils

The most common soils that have developed on the Woorinen Formation are medium-textured calcareous gradational soils in swales, alternating with reddish yellow sands on dunes. Deep sands occur on the Lowan Sand and saline soils on the salt and gypsum flats.

(4) Vegetation

Mallee formations cover most of this block. The major eucalypts are red, dumosa, slender-leaf, white, yellow, acorn, and grey mallees. Hummock grass-mallee occurs on the crests of dunes in the northern part of the block, and on sheets of deep sand in the south. Mallee occurs on the inter-dune flats in the north, with nealie, dwarf nealie, hakea wattle, hard-leaved wattle, cattle-bush, pimelea daisy bush, ballarts, common aotus, and guinea flower. The bell-fruit tree occurs occasionally.

In the south scrub-mallee is widespread, the major scrub species being mallee tea-tree, scrub pine, and broom-bush. The sparse ground flora includes porcupine grass, common aotus, pussy tails, and podolepis.

Grasslands of spear grass and wallaby grass are interspersed with stands of big mallee and some pine woodlands on plains - known as Sunset, Birthday, Mopoke, and Honeymoon Hut plains - in the central south of the block. Cattle-bush and weeping pittosporum also occur here.

On the Raak Plain, and north of Linga, bare saltpans are fringed with grey

glasswort, and higher areas carry saltbush containing bladder saltbush and bluebush. Associated salt-tolerant species include mat saltbush, bassia, bone-fruit, crested goosefoot, rounded noon-flower, barrier saltbush, and sea heath. Lunettes and non-saline sandy soils on plains between the salinas and the gypsum playas (which are widespread in and around the Raak Plains and the Pink Lakes) carry grasslands, woodlands, and scattered mallee. Belar and cattle-bush are the main woodland species.

Bladder saltbush on flats north of Cowangie, with big mallee on a transverse dune in the background

North of Cowangie the saltbush formation (containing bladder saltbush, bluebush, glasswort, and grasses) occurs on plains between transverse dunes that carry big mallee, often with a bladder saltbush understorey.

(5) Fauna

The habitats of the public lands support a number of animal species adapted to living under semi-arid conditions.

More than 80 species of birds have been recorded in the plant communities in the Sunset block. This undoubtedly is a conservative estimate. Four groups of birds (honeyeaters, parrots and cockatoos, birds of prey, and warblers) are particularly well represented.

Native terrestrial mammals still remaining in the block include echidnas, mouse dunnarts, western grey kangaroos, and Mitchell's hopping mice. The red kangaroo occurs on the Raak Plain. Other mammals present include bats and introduced species such as cats, rabbits, hares, and foxes.

Reptiles are well represented, with more than 50 species recorded from this and the Big Desert block. Families represented are dragons, geckos, skinks, legless lizards, goannas, poisonous snakes, and blind snakes.

Amphibians are poorly represented - with only the arid-adapted frog, *Neobatrachus*

The earless dragon

centralis, occurring over substantial areas.

C. Capabilities

(1) Nature conservation

The capability is high. Large areas of hummock grass-mallee, scrub-mallee, and mallee and small areas of cypress pine woodland remain in a relatively undisturbed condition. They are important for the conservation of the formations and associated plant species, and for the animals that live in them. Appendix 4 lists eight rare or localized plant species on this block.

Rocket Lake, a saltpan to the west of the Raak Plain, is a good example of the saltbush formation, dominated by grey glasswort, in an undisturbed condition. In the east the mallee of this block meets the flood-plain woodlands and lakes of the Kulkyne forest, which also have a high capability for nature conservation.

The capability for fauna conservation is high, and the area is particularly significant for the conservation of reptiles. The area encompassing this block, the Annuello block, and the Big Desert block contains more than 50 reptile species - more than any other comparable-sized area in Victoria - and the majority of these species occur in Victoria only in this region.

Birds are well represented, and the continued survival in Victoria of many of these species depends on the conservation of habitats such as occur in the Sunset, Annuello, and Big Desert blocks. Many of the birds in this area are nomadic. Relatively large areas are required to maintain populations of many of these species, particularly during times of fires or droughts. In seasons of abundant food this block is important as a breeding refuge, both for species adapted to arid conditions and for many other wide-ranging birds.

The many honeyeaters utilizing these habitats include striped and yellow-fronted honeyeaters and the dusky miner,

which occur only in this region in Victoria. Other species dependent on such habitats include mallee fowl, red-lored whistler, scarlet-chested parrot, western whipbird, chestnut-crowned babbler, chestnut quail-thrush, samphire thornbill, red-throat, field-wren, striated grass-wren, and mallee emu-wren.

The very rare western whipbird has been recorded at Manya, in the south-west of this block.

Significant mammals in this block include the mouse dunnart, Mitchell's hopping mouse, and western grey kangaroo. The largest Victorian red kangaroo populations occur on the gypsum plains in the east of this block, and in the adjacent Kulkyne forest.

The Parilla Sand outcrops at the Rockholes, in the south-western part of the block, and this site is of geological interest.

Mitchell's hopping mouse

The Pink Lakes in the south of the block are an unusual feature. They are a series of salinas that usually contain water only in the winter. The water has a pink hue, due to the presence of an alga of the genus *Dunella*.

All the land in South Australia adjacent to the border (the western boundary of this block) is held under freehold title or perpetual lease, and has been cleared and developed for agriculture.

(2) Recreation

The capability for most forms of recreation is low. Poor access, aridity, and lack of scenic features result in very low usage at present. However, the block has a moderate capability for hardy seekers of wilderness, for expert naturalists (especially ornithologists), and for organized trail-driving events.

The Pink Lakes

A small stand of slender cypress pine near the plains in the centre of the block

(3) Timber production

The only timber resources of the area are small scattered stands of slender cypress pine and the capability is very low. Eucalyptus oil is distilled from mallee eucalypts on two licensed areas totalling 5,600 ha in the south-west of the block. Annual production is about 2,300 kg. The capability for oil production is moderate.

Cattle grazing on a grassy plain in the centre of the block with dunes of the Lowan Sand in the background

(4) Agriculture

The deep sands of the Lowan Sands and the saline soils of the salinas and gypsum playas are not suitable for agriculture. The remaining land consists of a large area of the Central Mallee land system in the north of the block and smaller areas of the same land system in the south. The capability of these areas for wheat-growing is low.

In the north, the rainfall is marginal for wheat-growing and the soils include a high proportion of sandy types, which are not well suited to wheat-growing. Productivity would probably be less than in the adjacent Millewa settlement (0.9 tonnes per ha). In addition, the numerous dunes are extremely erosion-prone.

In the south, the capability is higher, due to increased rainfall and the presence of larger areas of loamy soils. However, the erosion hazard is still severe, and there is also a dryland salting hazard. Capability would be

less than in the adjacent settled areas to the south, (1.1 tonnes per ha), and is low on a State-wide basis.

The capability for grazing based on the native vegetation is low, even on the grassy plains in the centre and on the grasslands around salinas in the Raak land system. The capability of the dense mallee and hummock grass-mallee is very low.

The capability for honey production is moderate. Poor access and lack of water have prevented extensive use of this area, but if apiarists are prepared to cart water and brave the sandy tracks, production could reach high levels.

(5) Minerals

Salt and gypsum are taken from the public lands in this block.

Of the five current leases or licences for salt extraction, three are in the Pink Lakes, one is north of Tutye, and one is on the south of the Raak Plain. Production from the leases and licences varies greatly from year to year - the total production from this block over the last 5 years was 11,580 tonnes, most of it coming from the Pink Lakes.

Gypsum is mined from four areas in this block - north of Cowangie, north of Tutye and from two areas in the Raak Plain. Production of crystalline gypsum from these areas for 1972 was 240 tonnes, 490 tonnes, and 36,500 tonnes respectively. (Some of the gypsum produced from near Cowangie came from freehold land). No figures are available for the production of powdered (agricultural) gypsum.

(6) Utilities

A single-circuit 220-v transmission line (Horsham--Red Cliffs) runs through this block, parallel to and about 5 km west of the Calder Highway. It has a 37-metre easement. There are no plans for construction of major new lines in this block. In the event of solar energy being a viable means of generating electricity, this block could be considered for the siting of solar generating plants.

The Australian Army's Sunset Country Training Area, declared under the *Defence Act*, includes almost all the public land west of the Calder Highway. It also extends northwards along the South Australian border into the Millewa block. The area normally used is in the east of the block, where Citizen Military Forces carry out infantry minor tactics and firing of small-arms weapons on 8--10 week-ends each year. Light vehicles only are used, and these keep to existing tracks.

D. Hazards and Conflicts

The soil erosion hazard is severe throughout this block, and the maintenance of stability depends on keeping a

full vegetative cover. The main threat to stability at present comes from over-grazing by domestic stock on the many grazing leases and licences, especially on the grasslands and woodlands. Many parts of this block, particularly areas near natural saltpans, have a dryland salting hazard.

Removal of vegetative cover on these areas by rabbits is a threat, although rabbit numbers are low at the moment.

Fire is also a hazard, although aerial photographs show that many fires, probably originating from lightning, burn relatively small areas before being extinguished naturally.

The conflicts between grazing and nature conservation and recreation have been discussed in the Murray River block.

The comments made on gravel extraction in the Millewa block also apply to the gypsum extraction operations in this block.

E. Significance

The Sunset block has significance for nature conservation, due to its size and relatively undisturbed condition. It also has some significance for apiculture, wilderness forms of recreation, and extraction of salt and gypsum.

4. BIG DESERT BLOCK

A. General

(1) Location and tenure

This block occupies the south-western corner of the study area. It contains 448,500 ha of public land, most of which occurs in one large area known as the Big Desert. Many small parcels are scattered through the settled areas, particularly in the north-east of the block.

Most of the public land is Crown land. Wyperfeld National Park occupies 57,000 ha, Wathe Wildlife Reserve occupies 5,700 ha, and five small areas of reserved forest total about 2,000 ha.

(2) General description

Most of the public land consists of irregular and parabolic dunes and sand plains of the Big Desert land system, carrying heath, mallee-heath, and scrub-mallee. Flood-plains carrying woodlands of red gum and black box, grassy lake-beds, and associated woodlands of cypress pine (Tyrrell Creek land system) follow the northwards course of Outlet Creek from Lake Hindmarsh to Lake Albacutya and thence to Pine Plains.

(3) Present use

Wyperfeld National Park was established in 1927. Parts of it are used for intensive recreation (camping and picnicking) and the remainder for nature conservation and extensive recreation (walking and nature study).

When full, Lake Albacutya is used for water sports and fishing. The Walpeup Lake in the Timberoo forest and Lake Lascelles at Hopetoun are used for swimming and boating.

Tourists use the Nhill--Murrayville Road, and the wilderness nature of the Big Desert makes it increasingly popular with hikers. Wathe Wildlife Reserve south-west of Turriff was established in 1958 to preserve the habitat of the mallee fowl.

Small quantities of posts and firewood are cut from the frontage to Outlet Creek, which includes four reserved forests. Broom-bush in the north of the Big Desert is cut and used as brush fencing in suburban gardens. Bee-keepers use the area for over-wintering hives and honey production - lack of access limits more intensive use.

The irregular dunes of the Big Desert where they meet Pine Plains (oblique aerial photograph)

While the whole block 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, and some small areas on the fringes of the Big Desert. The largest licence is Pine Plains, west of Patchewollock (31,000 ha). Some of the public land held under grazing licence has been cleared for wheat-growing.

All of the public land in the Big Desert, with the exception of Wyperfeld National Park, has been proclaimed an Army Training Area under the *Defence Act*.

B. Nature of the Land

(1) Climate

Average annual rainfall ranges from 375 mm in the south-western corner of the block to 300 mm in the north. The variability of the rainfall increases in the north.

(2) Geology and physiography

The Big Desert consists of irregular and parabolic dune chains and sand plains of the Lowan Sand. The sands are continuous with those in the south of the Sunset block and in the Little Desert. The Parilla Sand outcrops in a few places, notably at Red Bluff in the south-west.

Heavy alluvial clays of the Coonambidgal Formation occur along Outlet and Yarriambiack Creeks, effluents of the Wimmera River. In some places the clays are covered by grey or brown sands of variable depth. Lake Albacutya and the other larger lakes (Brambruk, Brimin,and Coorong) associated with these streams have lunettes of sandy materials on their eastern side. Dunes and plains of the Woorinen Formation occur throughout the settled areas to the north, east and south-east of the Big Desert sands.

(3) Soils

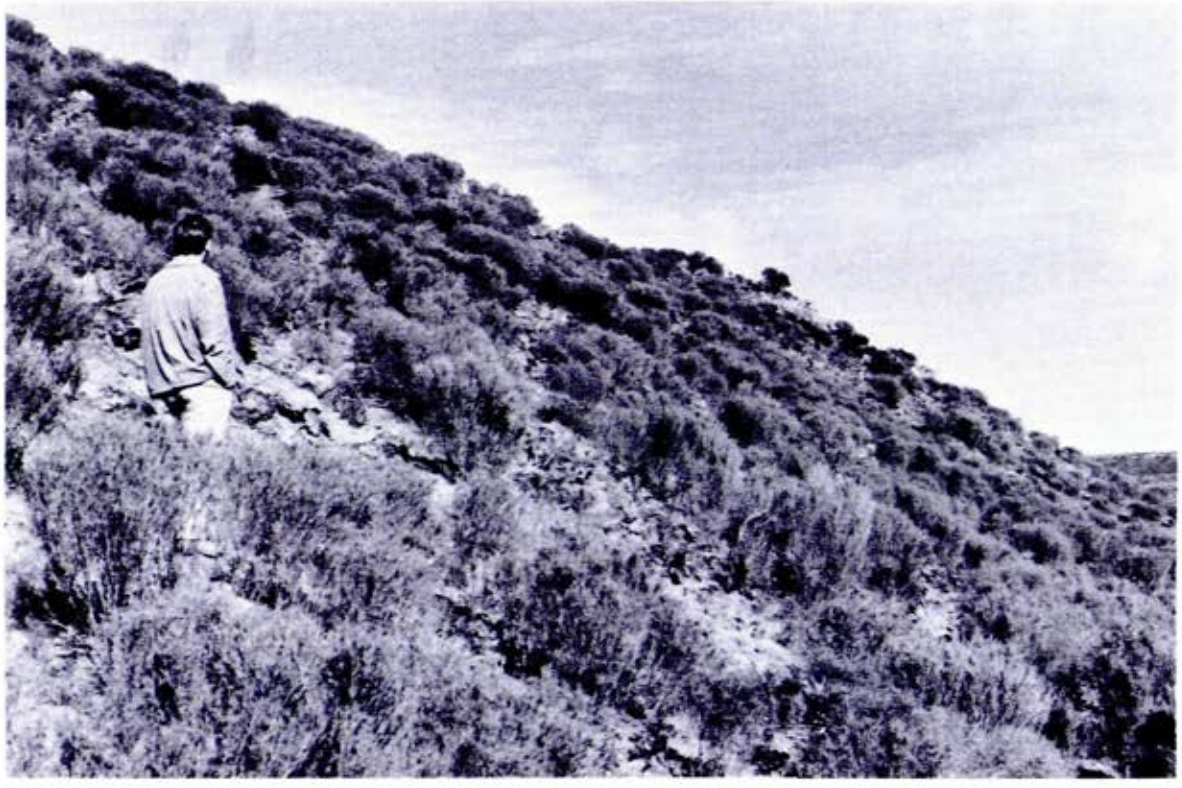
Deep sands are by far the most common soils on public land in this block. Grey cracking clays occur along Outlet

Creek, and these are partly overlain by grey and brown sands, which predominate in the Pine Plains area. Medium-textured calcareous gradational soils are the most common types on the small areas of public land in the north-east of the block.

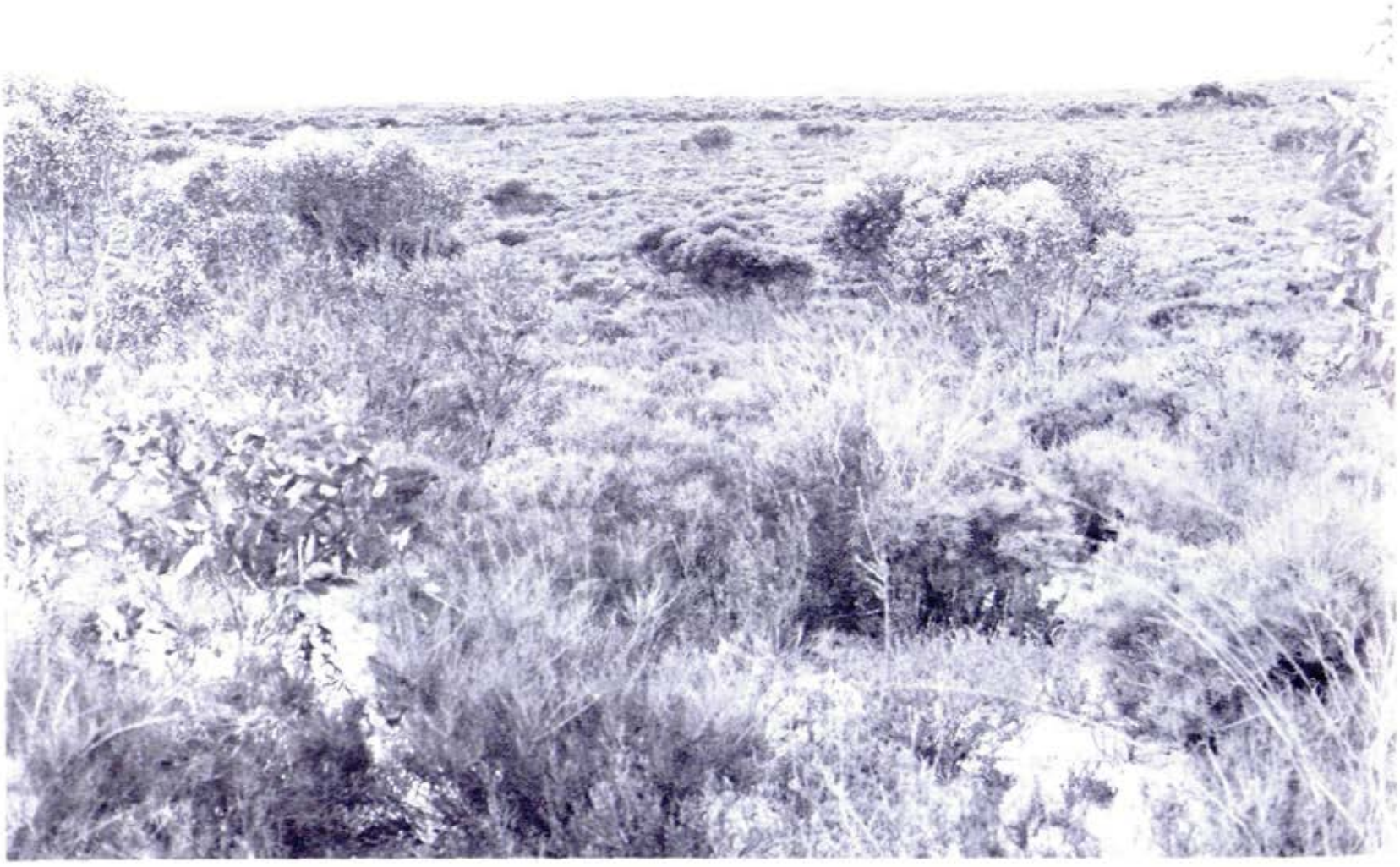
(4) Vegetation

Scrub-mallee covers the north of the Big Desert, and is also widespread in the south and east. Yellow mallee is the most common species, with mallee tea-tree, scrub pine, and broombrush in the scrub layer.

Heath and mallee-heath are the most widespread formations in the centre and south of the Big Desert. The most common eucalypts are red, dumosa, slender-leaf, and yellow mallees, while bull mallee is less common. Brown stringybark occurs with a mallee habit



Red Bluff, in the south-west of the Big Desert



Heath and mallee-heath in the Big Desert

on the crests of sand dunes, and yellow gum grows on heavy flats near the south-western boundary. The heath formation contains a very large number of species, and many of the genera are also found on the sandy heaths of southern Victoria.

The most common genera are *Aotus*, *Astroloma* (2 spp.), *Baeckea* (3 spp.), *Banksia* (2 spp.), *Brachyloma* (2 spp.), *Calytrix* (2 spp.), *Cassytha* (2 spp.), *Casuarina* (2 spp.), *Correa*, *Cryptandra* (2 spp.), *Dillwynia*, *Drosera* (2 spp.), *Eriostemon*, *Exocarpos*, *Grevillea* (3 spp.), *Hakea*, *Hibbertia*, *Hypolaena*, *Kunzea*, *Lepidobolus*, *Lepidosperma* (3 spp.), *Leucopogon* (5 spp.), *Lomandra* (5 spp.), *Loudonia*, *Melaleuca* (4 spp.), *Phyllota*, *Pultenaea*, *Schoenus* (2 spp.), *Spyridium* (2 spp.), *Styphelia*, and *Triodia*.

Mallee interspersed with scrub-mallee and thickets of tea-tree occurs on the sand sheets and dunes east of Outlet Creek. The Wathe Wildlife Reserve, south-west of Turriff, contains these two formations and also includes formerly cleared areas that are now revegetating. These areas at present carry grassland and small areas of shrubland, and add greatly to the diversity of the reserve.

Unusual woodlands of slender cypress pine and yellow gum with big mallee, open grassy areas, and dense thickets of scrub pine, occur immediately to the north-west of Dattuck. Small areas of atypical country carrying slender

Black flat, on Outlet Creek, Wyperfeld Park

cypress pine, red gum, and buloke also occur in the Big Desert near its northern boundary.

The course of Outlet Creek meanders north from Lake Hindmarsh to Lake Albacutya, and then to Pine Plains. The vegetation along the Creek and around the small lakes it feeds differs considerably from that of the surrounding dry country. Red gum woodlands fringe the lakes, with black box and cypress pine woodlands on higher ground. There are also some small areas of buloke woodlands. Grey mulga, three-nerve wattle, small cooba, wallowa, lignum, and grasses grow beneath the woodlands. Grasslands occupy the dry lake-beds.

Outlet Creek ends in Pine Plains, a mosaic of grasslands, black box woodlands, and lines of red gum on the shores of old lakes. Saltbush occurs on the Wirrengren Plain. Most conspicuous, however, are the woodlands of slender cypress pine, which cover about 4,000 ha in three main stands. Buloke, belar, weeping pittosporum, and cattle-bush occur through the pine stands, which are slowly degenerating as the trees age and die. There is very little regeneration.

The Timberoo forest, 20 km south-west of Ouyen, carries some good stands of slender cypress pine, with scattered buloke and big mallee. Small cooba, weeping pittosporum, and cattle-bush are common shrubs. Stock have been excluded from the forest, and there is heavy growth of spear and wallaby grasses. The cypress pine is regenerating, especially under the small cooba bushes. Other common plants are hakea wattle, desert cassia, austral carrot, hop bush, ruby saltbush, and twin-leaf. Walpeup Lake in the south-western corner of the forest contains many aquatic plants, including milfoil, reeds, rushes, and sedges.

Of the other small areas of public land scattered through the cleared parts of the block, the Nyang Reserve south of Torrita is noteworthy because of its healthy stands of cypress pine, with regeneration. The public land south of Walpeup contains a good example of belar woodland with many colourful understorey species.

Lake Coorong at Hopetoun is fringed with red gum and black box. The bed of the lake, which is usually dry, supports grassland. Most of the isolated areas of public land around Patchewollock, Speed, and Turriff carry woodlands of slender cypress pine.

(5) Fauna

The public lands on this block contain a large assemblage of animals adapted to an arid environment.

More than 90 bird species have been recorded from the plant communities of the Big Desert. Honeyeaters, parrots and cockatoos, birds of prey, and warblers are particularly well-represented groups.

More than 20 mammal species occur in this block, more than half of them being bats and introduced terrestrial mammals. Characteristic native terrestrial mammals still remaining include the echidna, mouse dunnart, western grey kangaroo, Mitchell's hopping mouse, and silky desert mouse.

Reptiles are well represented, with more than 50 species recorded from this and the Sunset block. Families represented are dragons, geckos, skinks, legless lizard, goannas, poisonous snakes, and blind snakes.

Few amphibians occur in the Big Desert, with only the arid-adapted frog, *Neo-*

batrachus centralis, being widespread. A few other species occur along the edge of the block.

Fish also are poorly represented, but Lake Albacutya contains redfin, tench, and carp when it fills in wet years.

C. Capabilities

(1) Nature Conservation

The capability for nature conservation is high.

The large undisturbed areas of the Big Desert contain a very rich flora, and many species reach their northern-most limits here. The stands of slender cypress pine at Pine Plains, Wyperfeld National Park, and Timberoo have a high capability for the preservation of this association, the area of which has decreased greatly since settlement. The buloke woodlands, especially those on the northern boundary of the Wyperfeld Park, are also important, as few stands of this species remain. The stand of belar and associated species at Walpeup is a good example of this type, which is now rare in the district.

The largeness and inaccessibility of the Big Desert, and the undisturbed vegetation it contains, give it a high capability for fauna conservation. It is particularly significant for the large number of reptile species present. This block and the Annuello, and the Sunset blocks contain more than 50 species (more than any other area in Victoria), and the majority of these species occur in Victoria only in this region.

Birds are well represented, and the continued survival in Victoria of many of the species depends on the conservation of habitats such as occur in the Big Desert, Annuello, and Sunset blocks. An important characteristic of the birds in this area is their nomadic nature. Relatively large areas are required to maintain populations of many of these species, particularly when droughts and fires occur. The breeding aspects mentioned for Sunset block also apply here.

The habitats of this block are important for the survival of the mallee fowl,

A large mallee-fowl mound in the Wathe Reserve

The bed of Outlet Creek, south of Pine Plains

dark thornbill, red-throat, striated grass-wren, mallee emu-wren, and western whipbird. This last species is very rare. It was seen at Red Bluff in 1969, and calls were heard by a survey team west of Moonlight Tank, on the Murrayville--Yanac road 28 km from the study area boundary, at Easter 1974. Its habitat is low mallee and broom-bush. The same survey team observed the brush bronzewing at Big Billy Tank, 32 km south of Murrayville, thus extending the range of this rather rare bird considerably to the north.

Reports of the rare and endangered scarlet-chested parrot (not listed in Appendix 6) have recently been received from Wyperfeld National Park.

Large numbers of Major Mitchells use the cypress pine stands at Pine Plains.

Significant mammal species in this block include the mouse dunnart, western grey kangaroo, and Mitchell's hopping mouse. The main occurrence in Victoria of the silky desert mouse is in the Big Desert. The western pigmy possum, which is rare in Victoria, may be present here.

The diversity of habitats provided by the course of Outlet Creek running through dry sandy country gives the eastern part of the block a very high capability. Similarly the different habitats found in Wathe, including small pools fed by a water supply channel, give this area special value.

The nature conservation capability of the land around Lake Albacutya and Outlet Creek is limited by lack of water. Lake Albacutya last filled in 1957, (although Outlet Creek began flowing into it during the winter of 1974), and Outlet Creek flowed to the southern boundary of Wyperfeld National Park that same year. The Creek last flowed through the Park in 1917. Any scheme that could achieve more frequent flows of water into Lake Albacutya and the Wyperfeld Park would greatly increase the value of these areas for nature conservation.

The only naturally occurring water in the Big Desert occurs in isolated soaks, and these dry up in summer. Permanent water is now available at the Broken Bucket Tank on the Murrayville--Yanac Road, and this attracts wildlife to the surrounding scrub.

Outcrops of the Parilla Sand in the Big Desert, particularly the one at Red Bluff, are of geological interest.

Public land in this block adjoins the South Australian border for a distance of 65 km. Most of the adjacent land in South Australia still carries native vegetation. In the north, the Scorpion Springs Conservation Park abuts the border for about 30 km, and in the south the Mount Shaugh Conservation Park abuts the border for a distance of about 7 km. Crown lands lie between the two Parks.

(2) Recreation

The capability for recreation is moderate.

The Big Desert offers wilderness conditions for the few people interested in this exacting form of recreation. The present level of use is low - walkers from surrounding districts walk to places of interest, such as Red Bluff and other features.

The high dunes and vegetation of the Big Desert and specific areas, such as Red Bluff and Pine Plains, have moderate potential as tourist attractions. Lack of easy access and lack of water prevent popular use of these areas. This block is attractive to those interested in nature study, and most of this activity occurs in Wyperfeld Park. The Park has a high capability for camping and walking, although the sandy land forms cannot withstand heavy use. Lack of an assured water supply limits the numbers that can be accommodated at present. Small areas such as Lake Lascelles at Hopetoun and Walpeup Lake at Timberoo attract many people in summer.

(3) Timber production

Capability is low. At present some minor produce is cut from the red gum--black box woodlands on Outlet Creek, but this is being phased out. The pine stands at Pine Plains and Timberoo are not utilized, although the stands at Timberoo were thinned in the 1930s. One licensee cuts broom-bush in the north of the Big Desert for fencing suburban gardens.

(4) Agriculture

Capability is very low. The deep sands that cover most of the public land are infertile, and are extremely erosion-prone.

Land in the south-west of the block has been developed by the AMP Society, but the conditions here (higher rainfall, soils with a clay horizon at shallow depth, and the presence of extensive sand plains with few dunes) do not occur to any extent elsewhere in the block. Small areas of better soils occur on the margins of the public land, but are usually mixed with poorer soils on dunes; compared with existing settled areas, such areas are marginal for cropping and grazing, and serious erosion problems are likely to occur following clearing.

The wheat-growing capability of Pine Plains and the small parcels of public land in the north-east of the block is similar to that of the adjacent farms (average 1.1 tonnes per ha). This productivity is low on a State-wide basis. The erosion hazard is high, particularly on dunes, and many of the areas have a dryland salting hazard.

Supplies of good-quality groundwater from the Duddo limestone are available

throughout the Big Desert, west of a line from Pine Plains to Lake Hindmarsh.

Pine Plains has a low capability for grazing based on the native vegetation.

The Big Desert has a high capability for honey production and for over-wintering bees. Public land carries 60 permanent sites, and many temporary sites are occupied when a good budding occurs. An estimated 10,000 hives are placed in the various sites during a good season. A variant of yellow mallee, called giant angular mallee, is the most reliable and heavy-yielding species. At present, lack of access prevents further utilization of the Big Desert.

(5) Minerals

The sandstones in outcrops of the Parilla Sand are suitable for road-making. No other commercial deposits of minerals are known on the public land.

(6) Utilities

The S.E.C.'s 220-v Horsham--Red Cliffs transmission line runs north--south in a 37-metre easement through Yarto in the eastern part of the block.

All public land west of Patchewollock, with the exception of Wyperfeld Park, is a declared Army Training Area. Armoured units equipped with tracked personnel carriersuse about one-third of the area every 3 years for training purposes.

D. Hazards and Conflicts

A severe wind erosion hazard exists on the deep sands that cover most of the block. At present the native vegetation maintains stability throughout the landscape except on the crests of steep dunes. Some sand dunes near Lake Albacutya and at Pine Plains are eroding as a result of over-grazing by stock and rabbits. Land on the edge of the Big Desert that has been cleared for agriculture, including some public land held under grazing licence, usually includes eroding dunes. Under the dry conditions of the Big Desert, careless use of vehicles for recreation or Army training will result in wind erosion of the sandy soils.

The activities of rabbits pose a constant threat to soil stability, and numbers of these vermin have often reached high levels in the areas along Outlet Creek and at Pine Plains. Rabbit numbers, although low at present, fluctuate widely depending on seasonal conditions.

Large wildfires are also a serious hazard. The last big fire in 1959 burnt more than 400,000 ha of the Big Desert. Fire control is difficult on most of the block due to lack of access.

Grazing at Pine Plains has caused serious erosion, particularly during droughts, and degeneration of pastures is most obvicus around water supply points. It also seems to be at least

partly responsible, along with browsing by rabbits, for the lack of cypress pine regeneration. Other conflicts associated with grazing are discussed in the Murray River block.

E. Significance

The Big Desert block is significant for nature conservation and, to a lesser extent, recreation and apiculture.

5. ANNUELLO BLOCK

A. General

(1) Location and present tenure

The Annuello block lies in the central Mallee. It is bounded on the north and east by the Murray River, and in the south by a line linking Nyah West with Ouyen. It contains 66,500 ha of public land, which consists of one large area of 46,250 ha (in the west of the block) and many small parcels. The Wandown Wildlife Reserve, about 15 km north-east of Annuello, occupies 1,500 ha, and the remainder is Crown land.

(2) General description

East--west longitudinal dunes of the Central Mallee land system cover most of the block. Dunes and ridges of the Hopetoun land system, and hummocks of the Boigbeat land system, cover small areas. Small salinas and gypsum playas of the Raak land system occur in the south of the block. The most common native vegetation is mallee and hummock grass-mallee, with some pine--belar woodlands and small areas of saltbush.

(3) Present use

Many of the small reserves, with the exception of the saltbush areas, are licensed for grazing. The western and southern parts of the large area of public land north-east of Ouyen are also held under grazing lease and licence. Many of the areas held under grazing licence are cleared and used for wheat-growing, particularly those east of Ouyen and south of Robinvale. Powdered gypsum is extracted from the saltbush areas in the south-east of the block, and salt has been harvested from Lake Daytrap, north of Lake Tyrrell.

Some of the small reserves are used for honey production.

B. Nature of the Land

(1) Climate

Average annual rainfall is 300 mm and is highly variable.

(2) Geology and physiography

The aeolian sands to clays of the Woorinen Formation cover almost all of this

block. Some small salinas and gypsum playas (Yamba Formation) occur in the south. Over most of the block the aeolian deposits have been fashioned into east--west longitudinal dunes. In some places these are absent, and hummocks are the dominant land form.

(3) Soils

Medium-textured calcareous gradational soils and reddish yellow sandy calcareous soils are the major types on public land. Medium-textured calcareous gradational and duplex soils occur in the area south of Robinvale, and saline soils occur on the gypsum and salt flats in the south of the block.

Dense mallee in a small reserve

(4) Native vegetation

Mallee, hummock grass-mallee, pine--belar woodland, and saltbush are the most common formations on the public land in this block.

Mallee and hummock grass-mallee cover the large area of public land north-east of Ouyen. The vegetation in the uncleared area here is relatively undisturbed, although the effects of several fires are apparent. The major eucalypts are slender-leaf, white, yellow, acorn, and grey mallees. Wattles include grey mulga, small cooba, and manna, spiny, and harrow wattles. Other common plants are hop-bush, bell-fruit tree, needlewood, ballart, crassula, lavender halgania, and pussy tails. Less common species include ridged everlasting, wirewort and scarlet mint-bush.

The Wandown Wildlife Reserve, north-east of Annuello, carries dense mallee, some of which is regrowth following clearing in the 1920s. Several small reserves, notably those north-west of Annuello and near Bannerton carry woodlands of pine and belar, often mixed with big mallee.

Many of the small areas of public land in the south and south-west of this block are salinas or gypsum playas supporting saltbush on the flats and saltbush--mallee on the transverse dunes

Bailey's Plains (oblique aerial photograph)

The sand goanna is found mainly in undisturbed areas, and is a fast runner

(copi-islands). The largest of these are Bailey's Plains, west of Piangil, and Towan Plains, west of Nyah West.

(5) Fauna

The habitats of the land in the western part of this block resemble those in the Sunset block, and so the same animals are probably present in both.

The small public land areas are valuable as habitat because they are the sole remnants of the habitats of the eastern Mallee; while they do not contain the full complement of the animals that occurred in the region, they provide habitat for the smaller animals. They are particularly valuable for birds, and resident, nomadic, and migratory species use them. The area north of Ouyen and the Wandown Reserve support populations of Mallee fowl, while the saltbush areas support crimson and orange chats, avocets, black-capped sitellas, blue and white wrens, and tree martins.

C. Capabilities

(1) Nature conservation

The capability for nature conservation is high. The public land north-east of Ouyen carries relatively undisturbed vegetation and land forms and is typical of large areas of the central and eastern mallee that have been cleared. It covers 46,000 ha and should be large

enough to support a full complement of animals.

Many of the small reserves scattered through the remainder of the block have high capability for nature conservation because they contain the only remnants of vegetation types, with their associated birds and other small animals, that were widespread in the eastern Mallee. These vegetation types are mallee, big mallee, saltbush, and pine--belar wood land. The small reserves around or near the townships of Manangatang, Annuello, Kulwin, Kooloonong, Chinkapook, and Yungera (some are not shown on Map No. 1) are particularly valuable in this respect. Strips of native vegetation retained in road reserves are also valuable as habitat and refuges for birds. Saltbush areas are not widespread in this block and most of them are still public land. They often contain old mallee trees with hollows suitable for nesting, and are important for birds.

The small areas of native vegetation, including road reserves, in otherwise cleared agricultural districts have high value for landscape preservation.

(2) Recreation

Capability for recreation is moderate. The public lands offer environments suitable for picnicking and walking, and are of special interest to naturalists. However, they lack any outstanding features.

(3) Timber production

Capability is low. A few reserves carry stands of belar and cypress pine, but these are not utilized at present.

(4) Agriculture

The large area of public land north-east of Ouyen contains very dense dunes, and sandy soils predominate. Its productivity for wheat-growing is lower than that of the adjacent farmlands to the south-east, which produce 1.1 tonnes per ha. The erosion hazard on the dunes is high.

Many of the small reserves have capability similar to the adjacent farmlands. However, on a State-wide basis, the capability of all these areas is low. The saline soils are not suitable for agriculture.

The capability for grazing the native vegetation is low. Capability for honey production is moderate, and permanent and temporary sites have been taken on many of the small reserves in the east of the block. Poor access restricts the use of the large area north-east of Ouyen.

(5) Minerals

Some 670 tonnes of salt were taken from Lake Daytrap, north of Lake Tyrrell, during 1969--1973. Powdered gypsum is extracted from Bailey's Plains, Towan Plains, and areas south and south-east

of Bolton. No production figures are available.

(6) Utilities

The Kerang--Red Cliffs transmission line runs in a 52-metre easement through the north-east of the large area of public land in the west of the block.

D. Hazards and Conflicts

A severe wind erosion hazard exists on the dunes in this block, although the native vegetation maintains stability on the public land at present. A seepage salting hazard also exists on the country that carries dunes.

The hazard from fires is moderate. A large area of public land in the west of the block was burnt 10--12 years ago. The scattered blocks of public land are susceptible to fires originating on farms, which are likely to burn all of a small reserve, with serious short-term consequences for the fauna living there.

The small blocks of public land are also prone to invasion by weeds and vermin, and can act as reservoirs from which farmlands can be re-infested. Weeds are more common on disturbed areas such as road and rail reserves. Rabbits are under control in the eastern Mallee at present.

Extraction of gypsum from the small playas carrying saltbush and saltbush--mallee conflicts with nature conservation. The loose gypsum is removed from the transverse dunes with front-end loaders, completely disrupting the vegetation. Old mallee trees (which often contain nesting hollows) are knocked over, and there is little attempt at reclamation. Often the areas containing gypsum are the only ones in the district still carrying native vegetation. Their exploitation also conflicts with preservation of the landscape.

Road-making works, which destroy native vegetation on road reserves, conflict

Extraction of powdered gypsum from a dune at Bailey's Plains

with nature conservation and landscape preservation.

Grazing the native vegetation also conflicts with nature conservation (see Murray River block).

E. Significance

The Annuello block is significant for nature conservation, honey production, and (to a minor extent) gypsum extraction.

6. TYRRELL BLOCK

A. General

(1) Location and present tenure

This block lies in the south-eastern Mallee. Almost all of the land suitable for agriculture has been alienated and cleared. Only 33,000 ha or 4.4% of the total area of the block is public land and this consists of Water Reserves, stream frontages, and unoccupied Crown land. There are four reserved forests, with a total area of 925 ha.

(2) General description

The plains of the Wycheproof, Tyrrell Creek, and Culgoa land systems, and the hummocks of the Boigbeat land system, are the main land forms in the south and east. The dunes and ridges of the Tempy and Hopetoun land systems and the irregular and longitudinal dunes of the Big Desert and Central Mallee landy systems predominate in the west and the north-west respectively.

Three large salt lakes (salinas) and their associated lunettes (Raak land system) lie in the north of the block. The courses of three streams, which flow infrequently, run through the block from the south and terminate in the salt lakes.

Mallee with some woodlands was the original vegetation over most of the area, with black box woodlands on the flood-plains and saltbush around the salt lakes. Remnants of these vegetation types remain on the public land.

(3) Present use

Salt is harvested from several areas at the southern end of Lake Tyrrell. Most of the small areas of public land scattered through the block are held under grazing licence. Many of these, particularly in the north-western corner of the block, have been cleared for wheat-growing. Green Lake, south of Sea Lake, is used for water sports and camping during summer. Duck-hunters use Lake Lalbert and the Tcham Lakes.

B. Nature of the Land

(1) Climate

Average annual rainfall ranges from 375 mm in the south to 320 mm in the north. Rainfall varies widely from year to year.

(2) Geology and physiography

The sands and clays of the Woorinen Formation cover most of the block. They are fashioned into dunes and hummocks in the north, but towards the south they form a featureless plain. A small tongue of the Lowan Sand intrudes into the north-western corner of the block. Alluvial deposits occur in the south. The clays and sandy clays of the Shepparton Formation occur from Birchip to Wycheproof, while similar but younger deposits of the Coonambidgal Formation occur on the flood-plains of the present-day streams. Some low-lying deposits of the Parilla sand occur around Birchip, and the low, broad Cannie Ridge of the same formation lies west of Lalbert.

Red gum woodlands in Lake Lalbert

Lakes Tyrrell, Wahpool, and Timboram (and several small areas to the east) consist of salinas and gypsum playas (Yamba Formation). Transverse dunes of gypsum occur on the bed of Lake Tyrrell, and all three lakes have lunettes on their eastern shores.

Dunmunkle Creek, which flowed to Lake Tyrrell via Sea Lake, has been converted to a water supply channel, and very rarely carries natural flows. Tyrrell and Lalbert Creeks, which flow to Lake Tyrrell and Lake Timboram respectively, are effluents of the Avoca River and flow about once every 5 years or so. Lalbert Creek also fills the shallow Lake Lalbert.

(3) Soils

Saline soils occur in and around the salt lakes, and grey cracking clays, sometimes covered by red or grey sand, are the most common soils on the remainder of the public land. Deep sands occur in the north-west, and more fertile sandy loams occur on the public lands south and south-west of Chinkapook.

(4) Vegetation

Remnants of mallee and scrub-mallee occur on some of the public land in the north-west, and near Chinkapook. Small

Bluebush growing on the shore of Lake Tyrrell

areas of dumosa and acorn mallees grow at Green Lake. The main formation here is woodland of black box, with some grasslands of wallaby and spear grasses. Lignum, gold-dust acacia, dense crassula, and nodding saltbush are common understorey species. Black box woodlands are the dominant vegetation on most of the public land in the south of the block, including stream frontages. Lignum is a common understorey species. Red gum occurs with black box in and around Lake Lalbert.

Saltbush - containing bluebush, bladder saltbush, and grey glasswort - occurs on the edges of the salt lakes, and on transverse dunes and lunettes.

Two blocks of slender cypress pine and belar, buloke, and cattle-bush occur to the south and south-west of Chinkapook.

The Tcham Lakes, east of Birchip, receive water from stock and domestic channels, and support dense thickets of reeds and other aquatic plants.

(5) Fauna

The small scattered areas of public land support populations of small birds and animals and provide refuge for nomadic birds. The painted quail, hooded robin, little thornbill, and black-capped sitella were recently recorded in the Eureka forest, south of Chinkapook. Many waterbirds inhabit the Tcham Lakes and Lake Lalbert when these hold water.

C. Capabilities

(1) Nature conservation

In general the capability for nature conservation is low because little public land remains in this block. However

The white-faced heron feeds on aquatic animals taken from shallow lakes and swamps

the remnants of the native vegetation on the isolated reserves and frontages, including road reserves, contribute significantly to the viability of populations of birds in the block. To varying degrees they provide shelter, food, and nesting sites for both migratory and resident birds.

The Tcham Lakes and Lake Lalbert provide valuable habitat for waterbirds in this dry environment.

Lake Tyrrell is the largest salt lake in Victoria, and is of general scientific interest.

The larger reserves in the north of the block, especially the Eureka forest south of Chinkapook, contain stands of pine-belar--buloke woodlands and mallee, which are now rare in the eastern mallee. These areas still contain a rich flora and fauna, and have a high capability for nature conservation.

The scattered public lands carrying native vegetation have moderate value for landscape preservation.

(2) Recreation

Generally, capability is low, because the areas available are so small. Green Lake has a high capability for water-based recreation, and Tcham Lakes and Lake Lalbert are used by duck-hunters

Remnants of mallee retained on a road reserve

when conditions are suitable. The reserves in the north are useful for nature study.

(3) Timber production

Capability is low. The pine--belar stands are suitable for some uses, but are not utilized at present. The small areas of black box can produce posts and other minor produce.

(4) Agriculture

The wheat-growing capability of the land carrying mallee or pine--belar woodland is similar to that of the adjacent farms (1.1 tonnes per ha), which is low on a State-wide basis. The saline soils are not suitable for agriculture. The capability for grazing the native vegetation is low.

Apiarists use some of the public land areas in the south but the capability is low.

(5) Minerals

Lake Tyrrell has a moderate capability for salt production. Total production from four leases on the western side of the lake, during the period 1968-73, was 123,200 tonnes.

(6) Utilities

Lake Tyrrell has been proposed as an evaporation basin for the disposal of saline drainage water from the irrigated lands in the Kerang region.

D. Hazards and Conflicts

The soil erosion hazard is moderate in the south and high in the north. The dryland salting hazard is high in some places, especially near salinas.

The small areas of public land are prone to fires and invasion by weeds and vermin. They can also act as harbours from which farmlands can be re-infested.

Grazing on public land conflicts with its use for nature conservation (see Murray River block).

Use of Lake Tyrrell for disposal of saline drainage water would conflict with salt extraction if large volumes of water were put into the lake.

E. Significance

The public lands have significance for nature conservation, landscape preservation, and, at Lake Tyrrell, salt extraction.

7. AVOCA BLOCK

A. General

(1) Location and present tenure

This block lies on the eastern edge of the study area, east of a line from Swan Hill to Quambatook. It contains 16,500 ha of public land, broken into numerous small blocks. These include more than 30 lakes or swamps, most of which are Water Reserves. Lake Bael Bael and the Marsh (1,800 ha) comprise the Koorangie Game Reserve, and the Water Commission and the Fisheries and Wildlife Division manage the Reedy Lakes for waterbirds. Bael Bael forest (Second and Top Marshes) (1,400 ha) is also managed for waterbirds as a co-operative venture by the Forests Commission and the Fisheries and Wildlife Division.

Five other reserved forests, with a total area of 4,100 ha, comprise most of the dryland public lands. Unoccupied Crown land and stream frontages make up the remainder.

(2) General descritpion

Plains of the Tyrrell Creek and Lindsay Island land systems are the dominant land form. The Loddon, Avoca, and Murray Rivers flow through broad flood-plains, and water from the Avoca and Loddon fills a series of lakes between Kerang and Swan Hill. The patterns of flow have been modified by distribution and drainage systems associated with the irrigation settlements. Many of the smaller lakes and swamps scattered through the block receive water only during wet years. Almost all the higher areas (Culgoa land system), which carried mallee vegetation, have been cleared. The flood-plains carried wood-lands dominated by black box, and some of these remain on public land.

(3) Present use

A series of lakes north-east of Kerang forms part of the Water Commission's system for distributing water for irri-gation. Lake Tutchewop is used to store saline drainage water. The larger lakes support a small professional fishery.

The lakes and swamps are intensively used for duck-hunting in suitable years. Some lakes provide swimming, boating, and water-skiing. Salt is harvested from a small salina near Lake Boga, and powdered gypsum is extracted from three areas. Minor forest produce is cut from

the black box stands and some are grazed under licence. Temporary apiary sites cover two small areas south of Lake Boga. Leaghur Forest Park is managed for nature conservation and recreation.

B. Nature of the Land

(1) Climate

Annual average rainfall varies from 375 mm in the south to 325 mm in the north.

(2) Geology and physiography

Two low north--south trending ridges of the Parilla Sand, the Cannie and Gredgwin Ridges, lie on the western boundary and in the centre of this block. Floodplains consisting of the clays of the Coonambidgal Formation and older alluvial sediments lie between the ridges, and to the east and north.

The Loddon and Avoca Rivers flow northwards into the block. The main channels of both streams are too small to carry large flows; both have numerous anabranches and effluent streams, and water frequently spills over the banks.

The many lakes have lunnettes of clayey materials on their eastern sides.

(3) Soils

Grey cracking clays occur on most of the public land. Small areas of saline soils occur in low positions.

(4) Vegetation

Black box woodlands grow on most of the public land. The Mystic Park forest carries low black box over grey glasswort and bladder saltbush. At Bael Bael the trees are larger, with a grassy understorey. Eumong is a common shrub. This area also contains red gum woodland.

Dartagook forest, on the Loddon River north of Kerang, and the Wandella forest

The Avoca River near Sandhill Lake

west of Kerang contain low black box above lignum, sedges, and grasses. The Leaghur and Appin forests contain large old trees over grasses, sedges, and nardoo.

The drainage reserve at Round Lake, south of Lake Boga, contains a remnant of mallee with a rich flora of Mallee plants.

Red gum and black box fringe the lakes, although many of the trees are now dead.

Red gums on the shore of The Marsh

Cumbungi and other rushes grow on the edges of the lakes, and other water plants such as azolla and pondweed are also common.

(5) Fauna

The shallow lakes and streams of the Loddon and Avoca systems comprise one of the most important areas for waterbirds in Victoria. Over the years, a total of 260 birds have been recorded there. During years of moderate to high flooding, ten species of ducks, royal spoonbills, white and straw-necked ibis, gull-billed terns, black swans, cormorants, grebes, herons, and bitterns breed in this area.

The eastern water rat and brush-tailed possum are common, and the fat-tailed dunnart and echidna are widespread. Platypus are occasionally seen.

The Macquarie and long-necked tortoises are both common, and many other reptiles have been recorded in the block - dragons, geckoes, skinks, goannas, poisonous snakes, and blind snakes. The carpet snake is present, but is uncommon.

Eight of the nine species of frogs recorded for the Mallee have been collected in this block, while 16 of the 28 fishes occur in the Loddon and Avoca systems. However, the native fish populations appear to be declining, and at present introduced species such as redfin, carp, and tench predominate.

C. Capabilities

(1) Nature conservation

The capability for nature conservation is high. The lakes and swamps constitute some of the most important waterbird habitat in Victoria. Vast numbers of birds nest in these areas, particularly in years of moderate to high flooding, and contribute significantly to the total production of waterfowl in Victoria.

The aquatic habitat is also important for platypus, eastern water rats, reptiles, amphibians, and fish.

Incorporation of the Reedy, Racecourse, and Kangaroo Lakes into the water distribution system means that they now have water permanently, and this greatly increases their value for nature conservation.

The scattered black box forests, and the mallee at Round Lake, have value as remnants of the original native vegetation, and provide habitats for birds and other small animals. The Leaghur forest contains many trees from which Aborigines have taken bark for canoes, mia mias, shields, or coolamons.

(2) Recreation

Capability for recreation is high. Many of the waters are used for boating, skiing, fishing, picnicking, and camping.

The wood duck is a relatively common species in the wetlands of the Avoca block.

Lake Boga, Lake Charm, and Lake Meering are popular areas at present. The lakes and swamps, along with others to the east of the study area, comprise one of the most popular duck-hunting localities in the State. Up to 10,000 hunters use the region during a good season, and at least 1,000 use the Koorangie Game Reserve. Cullen's Lake is also intensively used. Due to the diversity of the birdlife, the lakes are a popular bird-watching locality, and used by ornithologists from overseas.

The black box forests, especially Leaghur, have a moderate capability for picnicking, walking, and nature study.

(3) Timber production

The black box forests have a moderate capability to produce durable posts and other farm timbers. The small areas these stands cover and their relatively slow growth rate mean that production from them is low.

Black box woodlands in the Leaghur forest

(4) Agriculture

Of the dryland areas, Mystic Park forest has a very low capability, as the soils there are saline. Bael Bael and Dartagook forests are often flooded. The capability of the Wandella, Leaghur, and Appin forests is similar to that of the adjacent farms, and they are suitable for irrigated pasture.

Capability for grazing native vegetation is low, except in very wet years.

The black box stands have a low to moderate capability for honey production.

Four professional fishermen who live in the district, plus several others who use the area occasionally, net the large lakes in the north of the block. The main species caught are redfin, tench, goldern perch or callop, silver perch, and a few Murray cod. Since the number of European carp has increased, this fish is netted and used for pet food.

(5) Minerals

A total of 24,000 tonnes of salt was harvested from Lakes Kelly and William and Little Lake during the period 1969--1971. From 1972 these lakes have been used for disposal of drainage water from the adjacent irrigation areas, and salt production has ceased. Official figures show that Lake Kunat, south of Lake Boga, has produced 50 tonnes of salt over the last 6 years.

Leases for the production of powdered gypsum cover two small areas of public land, south of Lake Boga and north of Lake Charm. No production figures are available.

D. Hazards and Conflicts

The erosion hazard is low on the public land in this block, due to the heavy soils and low relief. The hazard of fire is low to moderate.

A salting hazard exists for those lakes that do not receive water as part of the irrigation distribution system. Nearly 100 years of irrigation have raised the water table in and around the irrigation areas to within 1--2 metres of the surface. This highly saline groundwater seeps into the lakes, which occupy low positions in the landscape, and they thus become saline unless flushed by fresh water.

Rabbits are a constant problem, and if not controlled can re-infest farmland and public land. There is a conflict between grazing and nature conservation, and this is discussed in the Murray River block.

E. Significance

The Avoca block has significance for nature conservation and recreation.

APPENDICES

APPENDIX 1

METRIC CONVERSION FACTORS

QUANTITY	METRIC UNIT	IMPERIAL UNIT	METRIC TO IMPERIAL	IMPERIAL TO METRIC
Length	millimetre (mm)	inch (in)	1 mm = 0.0394 inch	1 inch = 25.4 mm
	centimetre (cm)		1 cm = 0.3937 inch	1 inch = 2.54 cm
	metre (m)	foot (ft	1 m = 3.281 feet	1 foot = 0.305 m (30.5 cm)
	kilometre (km)	mile	1 km = 0.6214 mile	1 mile = 1.61 km
Area	hectare (ha)	acre (ac)	1 ha = 2.47 acre	1 acre = 0.405 ha
	square kilometre (sq km) (= 100 ha)	square mile (sq mile)	1 sq km = 0.3861 sq mile (247 ac)	1 sq mile = 2.592 sq km
Mass	kilogram (kg)	pound (lb)	1 kg = 2.20 lb	1 lb = 0.454 kg
	tonne (t) (= 10,000 kg)	ton	1 t = 0.984 ton	1 ton = 1.02 t
Volume	cubic metre (m^3)	cubic foot (ft^3)	1 m^3 = 35.31 ft^3	1 ft^3 = 0.0283 m^3
		super foot (timber)	= 423.7 super feet true	1 super foot true = 0.00283 m^3
			= 332.6 super feet (Hoppus log volume)	1 super foot HLV = 0.003 m^3
	megalitre (Ml) (= 1,000,000 litres)	acre feet (ac ft)	1 Ml = 0.8098 ac ft	1 ac ft = 1.235 Ml
Temperature	degree Celsius (^oC)	degree Fahrenheit (^oF)	1^oC = 5/9 (^oF - 32)	1^oF = 9/5 (^oC + 32)
Compound Units	tonnes per hectare (t/ha)	bushels/acre	1 t/ha = 14.9 bushels/ac (wheat)	1 bushel/ac = 0.087 t/ha
			= 17.9 bushels/ac (barley)	= 0.056 t/ha
			= 22.2 bushels/ac (oats)	= 0.045 t/ha
	milligrams per litre (mg/l)	parts per million (ppm)	1 mg/l = 1.000 ppm	1 ppm = 1.000 mg/l
	litres per second l/s	gallons per hour (gph)	1 l/s = 791.7 gph	1 gph = 0.00126 l/s

APPENDIX 2

SCIENTIFIC NAMES OF PLANTS MENTIONED IN THE REPORT

Reference : Willis, J.H. A Handbook to Plants in Victoria. Vols I and II, Melbourne University Press (1962 & 1972)

Common name	Scientific name
acorn (oil) mallee	*Eucalyptus oleosa*
arabian grass	*Schismus barbatus*
austral carrot	*Daucus glochidiatus*
azolla	*Azolla pinnata; A filiculoides*
barley grass	*Hordeum leporinum*
bassia	*Bassia diacantha* and other spp.
belar	*Casuarina cristata*
billy-buttons	*Craspedia glauca*
bitter quandong	*Santalum murrayanum*
black box	*Eucalyptus largiflorens*
bladder saltbush	*Atriplex vesicaria*
blown grass	*Agrostis avenacea*
bluebush	*Kochia pyramidata*
bone-fruit	*Threlkeldia salsuginoea*
bramble wattle	*Acacia victoriae*
brome grasses	*Aniesantha* spp.
broom ballart	*Exocarpus spartea*
broombush	*Melaleuca uncinata*
broom heath myrtle	*Baeckia behrii*
brown stringybark	*Eucalyptus baxteri*
bull mallee	*Eucalyptus behriana*
buloke	*Casuarina luehmanii*
buloke mistletoe	*Amyema linophylla*
camel grass	*Schismus barbatus*
cattle-bush	*Heterodendron oleifolium*
common actus	*Actus eriocides*
common reed	*Phragmites communis*
correa	*Correa reflexa*
cottony saltbush	*Rhagodia gaudichaudiana*
cotula	*Cotula* spp.
crassula	*Crassula* spp.
creeping mistletoe	*Muellerina eucalyptoides*
crested goosefoot	*Chenopodium cristatum*
cumbungi	*Typha angustifolia*
daisy-bush	*Olearia pimeleoides*
dense crassula	*Crassula colorata*
desert banksia	*Banksia ornata*
desert banksia	*Banksia ornata*
desert cassia	*Cassia nemophila*
desert glasswort	*Pachycornia triandra*
desert heath myrtle	*Baeckia crassifolia*
dillonbush (nitre bush)	*Nitraria schoberi*
dodder-laurel	*Cassytha glabella, C. melantha*
duckweed	*Lemna oligorrhiza*
dumosa mallee	*Eucalyptus dumosa*
dwarf mealie	*Acacia wilhelmiana*
dwarf she-oak	*Casuarina pusilla*
eelweed	*Vallisneria spiralis*
emu bush	*Eremophila* spp.
eumong	*Acacia stenophylla*
flatweed	*Hypochoeris* spp.
frosted goosefoot	*Chenopodium desertorum*
giant angular mallee	*Eucalyptus incrassata* var *costata*
grey mallee	*Eucalyptus socialis*
grey mulga	*Acacia brachybotrya*
groundsel	*Senecio* spp.
gold-dust acacia	*Acacia aoinacea*
guinea flower	*Hibbertia* spp.
hakea-wattle	*Acacia hakeoides*
ham-and-eggs daisy	*Myriocephalus stuartii*
hard-leaved wattle	*Acacia sclerophylla*
harrow wattle	*Acacia acanthoclada*
hedge saltbush	*Rhagodia spinescens*
heliotrope	*Heliotropium europaeum*
holly grevillea	*Grevillea ilicifolia*
hopbush	*Dodonaea* spp.
Indian hedge mustard	*Sisymbrium orientale*
lavender halgania	*Halgania lavandulacea*
leek lily	*Bulbine semibarbata*
lignum	*Muehlenbeckia*
love grasses	*Agrostis* spp.
mallee tea tree	*Leptospermum lanigatum* var *minus*
manna wattle	*Acacia microcarpa*

Common name	Scientific name
mat saltbush	*Atriplex prostrata*
medic	*Medicago* spp.
milfoil	*Myriophyllum* spp.
moonah	*Melaleuca pubescens*
nardoo	*Marsilea drummondii*
native poplar or bellfruit tree	*Codonocarpus cotinifolius*
nealie	*Acacia rigens*
needlewoods	*Hakea vittata; H. leucoptera*
New Zealand spinach	*Tetragonia tetragonioides*
nodding saltbush	*Rhagodia nutans*
oldman saltbush	*Atriplex nummularia*
pale turpentine	*Beyeria lechenaultii*
pigface	*Carpobrotus aequilaterus*
podolepis	*Podolepis* spp.
pondweed	*Potamogeton* spp.
porcupine grass	*Triodia irritans, T. scariosa*
prickly bottle brush	*Callistemon brachyandrus*
pussy tails	*Ptilotus spathulatus*
red gum	*Eucalyptus camaldulensis*
red mallee	*Eucalyptus calycogona*
ridged everlasting	*Helichrysum octadromum*
river bluebell	*Wahlenbergia fluminalis*
river mint	*Mentha australis*
ruby (barrier) saltbush	*Enchylaena tomentosa*
samphire (glasswort)	*Arthrocnemum halocnemoides*
sandalwood	*Myoporum platycarpum*
scarlet mint-bush	*Prostanthera aspalathoides*
scrub pine	*Callitris verrucosa*
sea heath	*Frankenia* spp.
slender-leaf (hooked) mallee	*Eucalyptus foecunda*
small cooba	*Acacia ligulata*
soft-horned saltbush	*Malacocera tricornis*
spear grasses	*Stipa* spp.
spiny flat-sedge	*Cyperus gymnocaulus*
spiny wattle	*Acacia spinescens*
spike rush	*Eleocharis acuta; E. pusilla*
slender cypress pine	*Callitris preissii*
sugarwood	*Myoporum platycarpum*
swamp couch	*Cynodon dactylon*
sweet quandong	*Santalum acuminatum*
three-nerve wattle	*Acacia trineura*
twinleaf	*Zygophyllum* spp.
umbrella wattle	*Acacia oswaldii*
velvet bush	*Lasiopetalum behrii, L. baueri*
wait-a-while	*Acacia colletioides*
wallaby grasses	*Danthonia* spp.
wallowa	*Acacia calamifolia*
warrego grass	*Paspalidium jubiflorum*
weeooka	*Eremophila oppositifolia*
weeping pittosporum	*Pittosporum phillyreoides*
white mallee	*Eucalyptus gracilis*
willow acacia	*Acacia salicina*
windmill grasses	*Chloris* spp.
wirewort	*Athrixia athrixioides*
white cypress pine	*Callitris columellaris*
yellow gum	*Eucalyptus leucoxylon*
yellow mallee	*Eucalyptus incrassata*

SCIENTIFIC NAMES OF WEEDS MENTIONED IN THE TEXT

Common name	Botanical name
amsinckia	*Amsinckia* spp.
bathurst burr	*Xanthium spinosum*
bindweed	*Convolvulus arvensis*
blackberry	*Rubus fruticosus*
boneseed	*Chrysanthemoides monilifera*
boxthorn	*Lycium ferocissimum*
buffalo burr	*Solanum cornutum*
californian burr	*Xanthium orientale*
caltrop	*Tribulus terrestris*
camel thorn	*Alhagi pseudalhagi*
colocynth	*Citrullus colocynthis*
dodder	*Cuscuta* spp.
drooping prickly pear	*Opuntia vulgaris*
erect prickly pear	*Opuntia stricta*
fennel	*Foeniculum vulgare*
five-spined saltbush	*Bassia quinquecuspis*
flax-leaved broom	*Genista linifolia*
hemlock	*Conium maculatum*
hoary cress	*Cardaria draba*
horehound	*Marrubium vulgare*
ivy-leaf sida	*Sida ispnoa*
khaki weed	*Alternanthera pungens*
musk weed	*Hyssopum perfoliatum*
noogoora burr	*Xanthium pungens*
nut-grass	*Cyperus rotundus*
one-leaf cape tulip	*Homeria breyniana*
onion weed	*Asphodelus fistulosus*
pampas lily-of-the-valley	*Salpichroa origanifolia*
paterson's curse	*Echium plantagineum*
perennial ragweed	*Ambrosia psilostachya*
prairie ground cherry	*Physalis viscosa*
sand rocket	*Diplotaxis tenuifolia*
skeleton weed	*Chondrilla juncea*
soursob	*Oxalis pes-caprae*
spiny burr-grass	*Cenchrus longispinus*
spiny rush	*Juncus acutus*
stinkwort	*Inula graveolens*
sweet briar	*Rosa rubiginosa*
thistle-golden	*Scolymus hispanicus*
hard head	*Centaurea repens*
saffron	*Carthamus lanatus*
slender	*Carduus tenuiflorus*
soldier	*Cirsium acarna*
spear	*Cirsium vulgare*
spotted or variegated	*Silybum marianum*
star	*Centaurea calcitrapa*
stemless	*Onopordum acaulon*
thorn apple	*Datura ferox; D. innoxia; D. stramonium*
tree of heaven	*Ailanthus altissima*
two-leaf cape tulip	*Homeria miniata*
white horse nettle	*Solanum elaeagnifolium*
wheel cactus	*Opuntia robusta*
wild garlic	*Allium vineale*
wild mignonette	*Reseda lutcola*

APPENDIX 3

RARE, LOCALIZED PLANT SPECIES

MURRAY RIVER BLOCK

1. *Acacia loderi* - in Victoria now restricted to a small stand on private property ± 5 miles south of Cowra Lagoon (west of Merbein), constituting the most southerly point of its range..

2. *Atriplex angulata* - in Victoria known only from Boundary Bend on the Murray River (east of Bannerton).

3. *Bossiaea walkeri* - in Victoria now restricted to a few bushes on private land between Boundary Bend and Kenley, the most southerly limit of its range.

4. *Caesia lateriflora* - in Victoria known only from a small occurrence near Lake Hattah, the most southerly and easterly point of its range.

5. *Chloanthes parviflora* - if ever Victorian, then doubtless long extinct here, the only record (last century) being "near Swan Hill".

6. *Crinum flaccidum* - in Victoria only on the Murray flood plain where it is scattered near and west from Cowra Lagoon, the most southerly of its occurrences. This is Victoria's largest native flower, and was the subject of special comment by Capt. Charles Sturt in his voyage along the lower Murray (Jan. 1830).

7. *Cyperus aristatus* - in Victoria only from Lake Hattah and near Dimboola, the latter outside the present study area.

8. *Cyperus flaccidus* - in Victoria known only from Sandalong Park at Mildura and near Dimboola, the latter outside the present study area.

9. *Cyperus nervulosus* - in Victoria known only from Lake Hattah, the most south-

-erly and westerly point of its range.

10. *Eremophila bignoniiflora* - restricted in Victoria to a few individual plants near Cowra Lagoon (west of Merbein) and on Lindsay Island, its most southerly occurrences.

11. *Eremophila polyclada* - in Victoria known only by a few small occurrences west of Merbein (between Cowra Lagoon and Lake Walla-walla), its most southerly range.

12. *Eremophila sturtii* - restricted in Victoria to a very few small occurrences between Merbein West and Boundary Point (on the South Australian border), except for a single bush noted at Boundary Bend, the most southerly and (apparently) easterly limit of its range.

13. *Eriocaulon australasicum* - perhaps now extinct in Victoria, where known only from the type collection (Dec. 1853) on the Murray River near Yungera.

14. *Geijera parviflora* - now restricted in Victoria to a small area in and close to Wilga Park (between Piambie and Kenley), the most southerly point of its range.

15. *Heliotropium asperrimum* - apart from a Wimmera occurrence, known in Victoria only from Robinvale.

16. *Hibiscus farragei* - in Victoria known only from sparodic and short-lived colonies near Merbein West, Hattah and Bolton, the most southerly limit of its range.

17. *Lawrencia berthae* - in Victoria known only by a single collection (± 1935) from near Mildura, the most easterly point of its range.

18. *Psoralea cinerea* - in Victoria known only from Psyche Bend on Murray River (east of Irymple) and Lake Coorong near Hopetoun, the most southerly point of its range.

19. *Ptilotus nobilis* - in Victoria known only from near Abbotsford Bridge on the Murray River near Yelta, Red Cliffs and Kulkyne Forest, the most southerly point of its range.

20. *Santalum lanceolatum* - restricted in Victoria to a few plants at Boundary Bend and a single old tree in the Warby Range (outside the present study area and the most southerly point of its range).

21. *Scaevola depauperata* - restricted in Victoria to sandhills at the north-west of Hattah Lakes National Park, also Swan Hill (where probably now extinct), the most southerly point of its range.

22. *Solanum lacunarium* - restricted in Victoria to small isolated occurrences between Walpolla and Lindsay Islands along lower Murray River, the most southerly limit of its range.

23. *Stipa tuckeri* - in Victoria known only by two collections, from Robinvale (June 1961) and Boonoonar salt pans west from Carwarp and Nowingi (Sept. 1955), the most southerly point of its range.

24. *Swainsona greyana* - restricted in Victoria to Lindsay Island (along Murray River near the South Australian border), the most southerly point of its range.

MILLEWA BLOCK

25. *Abutilon fraseri* - in Victoria known only from a small block of private land at Sunny Cliffs (north of Red Cliffs), where now probably extinct through cultivation in recent years.

26. *Bassia caput-casuarii* - in Victoria known only from the type locality 5--6 miles south of Benetook, the single other recorded Australian occurrence being Yudnapinna Station, South Australia (north-westerly from Port Augusta).

27. *Cheilanthes lasiophylla* - in Victoria known only by a few individual plants on limestone at Boundary Point and on sandstone near Rock Hole Bore, the most southerly limit of its range.

28. *Eremophila scoparia* - in Victoria known only from the Meridian Road ± 6 miles south of Benetook, its most easterly occurrence.

Lawrencia berthae - (see details under No. 17)

Ptilotus nobilis - (see details under No. 19)

29. *Sida fibulifera* - in Victoria known only from private land at Sunny Cliffs (north of Red Cliffs) where now endangered through cultivation in recent years.

30. *Zygophyllum compressum* - in Victoria known only from gypsum flats about 5 miles south-west of Morkalla, the most easterly point of its range.

SUNSET BLOCK

31. *Acacia havilandii* - probably now extinct in Victoria, where known by only two collections, at Ouyen (Sept. 1913) and Gerang Gerung (Oct. 1918), the later outside the study area.

31. *Arthrocnemum lylei* - in Victoria known only from two localities, namely the saltpans of the Raak (south-west of Nowingi) and Tyrrell Creek at the southern end of Lake Tyrrell, the most southerly and easterly occurences of the species, which otherwise occurs in Western Australia but apparently not in South Australia.

Cheilanthes lasiophylla - (see details under No. 27)

Hibiscus farragei - (see details under No. 16)

33. *Olearia subspicata* - in Victoria known only from Hattah Lakes National Park near Lake Mournpall) and mallee scrub west of Annuello, the most southerly point of its range.

Scaevola depauperata - (see details under No. 21)

34. *Spyridium tridentatum* - in Victoria known only from isolated occurrences in the Wimmera, along Calder Highway near Hattah and mallee scrub west of Annuello, the most easterly point of its range (which includes Western Australia but apparently not South Australia.

Stipa tuckeri - (see details inder No. 23)

ANNUELLO BLOCK

Acacia havilandii - (see details under No. 31)

Hibiscus farragei - (see details under No. 16)

Olearia subspicata - (see details under No. 33)

Spyridium tridentatum-(see details under No. 34)

BIG DESERT BLOCK

Acacia havilandii - (see details under No. 31)

35. *Microcybe pauciflora* - in Victoria known only from Murrayville and north-west of Lake Albacutya, the most easterly point of its range.

Psoralea cinerea - (see details under No. 18)

36. *Psoralea patens* - in Victoria known only from vicinity of Lake Albacutya, the most southerly point of its range.

37. *Pultenaea densifolia* - in Victoria known only from Gypsum (north of Tempy) and Wyperfeld National Park, its most easterly and southerly occurrences respectively.

TYRRELL BLOCK

Arthrocnemum lylei - (see details under No. 32)

38. *Boronia inornata*-perhaps now extinct in Victoria, where recorded from

LAKE TYRRELL BLOCK (contd.)

only two localities, namely Lake Lalbert (Dec. 1853) and the south-eastern extremity of Little Desert (before 1913), the latter outside the present study area.

39. *Kochia rohrlachii* - apart from recorded occurrences near Minyip and at Gooroc (north of St. Arnaud) - both outside the present study area - known in Victoria only fromQuambatook, the most easterly point of its range.

AVOCA BLOCK

Kochia rohrlachii - (see details under No. 39)

40. *Swainsona plagiotropis* in Victoria known only by three collections, namely from Kerang (Sept. 1925), Murray Valley Highway near Torrumbarry (Oct. 1956), and Lower Campaspe River (Oct. 1875), the two latter localities outside the present study area. Possibly crossing the Murray into New South Wales, otherwise endemic in Victoria

APPENDIX 4

ALL MAMMAL SPECIES RECORDED AS OCCURRING IN THE MALLEE STUDY AREA OVER THE PAST 120 YEARS

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

MONOTREMATA

Tachyglossidae:

Tachyglossus aculeatus	Echidna

Ornithorhynchidae:

Ornithorhynchus anatinus	Platypus

MARSUPIALIA

Macropodidae:

	Macropus fuliginosus	Western grey kangaroo
	Macropus giganteus	Great grey kangaroo
	Macropus rufogriseus	Red-necked wallaby
	Megaleia rufa	Red kangaroo
*	*Onychogalea fraenata*	Bridle nail-tailed wallaby
*	*Lagorchestes leporides*	Eastern hare-wallaby
*	*Bettongia pencillata*	Brush-tailed rat-kangaroo

Burramyidae:		
	Acrobates pygmaeus	Feather-tailed glider
	Cercartetus concinnus	Western pigmy possum
Peramelidae:		
	Isoodon obesulus	Short-nosed bandicoot
	Perameles bougainville	Barred bandicoot
	Chaeropus ecaudatis	Pig-footed bandicoot
Dasyuridae:		
*	*Dasyurus geoffroii*	Chuditch
*	*Phascogale calura*	Red-tailed wambenger
	Antechinus flavipes	Yellow-footed antechinus
	Sminthopsis crassicaudata	Fat-tailed dunnart
	Sminthopsis murina	Mouse dunnart
*	*Antechinomys laniger*	Kultarr

LAGOMORPHA

Leporidae:		
	Oryctolagus cuniculus	Rabbit (introduced)
	Lepus europaeus	Hare (introduced)

RODENTIA

Muridae:

	Hydromys chrysogaster	Eastern water rat
*	*Leporillus conditor*	Stick-nest rat
*	*Leporillus apicalis*	White-tipped stick-nest rat
	Notomys mitchellii	Mitchell's hopping mouse
*	*Pseudomys hermannsburgensis*	Sandy inland mouse
	Pseudomys albocinereus	Silky desert mouse
*	*Pseudomys desertor*	Brown desert mouse
	Mus musculus	House mouse (introduced)

CHIROPTERA

Vespertilionidae:

Nyctophilus timoriensis	Greater long-eared bat
Nyctophilus geoffroyi	Lesser long-eared bat
Chalinolobus gouldii	Gould's wattled bat
Chalinolobus morio	Chocolate bat
Eptesicus pumilus	Little bat
Nycticeius greyi	Little broad-nosed bat

Molossidae:

Tadarida australis	White-striped bat

Tadarida planiceps	Little flat bat
Emballonuridae:	
Taphozous australis	Northern sheath-tailed bat

CARNIVORA

Canidae:	
Canis familiaris	Dingo
Vulpes vulpes	Fox (introduced)
Felidae:	
Felis catus	Cat (introduced)

ARTIODACTYLA

Suidae:	
Sus crofa	Pig (introduced)
Bovidae:	
Capra hircus	Goat (introduced)

* Probably now extinct in the Victorian Mallee.

APPENDIX 5

DESCRIPTIONS OF MAMMAL SPECIES (EXCLUDING BATS) IN THE MALLEE STUDY AREA IN TERMS OF THEIR ABUNDANCE, DISTRIBUTION, FOOD, HOME RANGE, NEST SITES, HABITAT PREFERENCE AND SPECIMENS COLLECTED

Abbreviations used are: FWD = Fisheries and Wildlife Division (Victoria)
NMV = National Museum of Victoria

Tachyglossus aculeatus - Echidna

Abundance and distribution: Although evidence of activity is widespread throughout the Mallee study area, sightings of animals are rare. In the Sunset Country survey (1973) only one animal was observed in hundreds of acres traversed. It was not recorded in the area by Krefft (1866), so it may be a recent colonizer.

Food: Insects; chiefly termites and ants.

Home range: Currently under study, but judging by their rarity, they probably roam over large areas.

Nest sites: In semi-arid, hot areas several individuals can sometimes be found huddled into sandstone or limestone caves. Where rocky outcrops do not occur, relief from temperature extremes is probably gained beneath mallee roots.

Habitat preference:Probably restricted to wooded areas. In the study area it probably does not occur in saltbush, heath and grassland habitats.

Most recent specimens: 1967 (NMV); observed in the 1973 survey (FWD).

Ornithorhynchus anatinus - Platypus

Abundance and distribution: Occurs throughout the major river systems in the study area, including the Murray, Loddon and Wimmera rivers. Although

uncommonly observed, this species is probably secure in these areas, but increased pollution will be deleterious.

Food: Aquatic invertebrates; chiefly crustaceans and annelids.

Home range: Little is known of its foraging habits.

Nest sites: Burrows are constructed in banks of streams. Loose soils are preferred. Burrows are usually about a foot beneath the surface of the ground, but often only inches separate the burrow from the surface. Thus, trampling of cattle on river banks could be detrimental.

Habitat preference: Almost all streams, billabongs and freshwater lakes of adequate size in the study area are suitable; the platypus appears only to require permanent waters with muddy substrates.

Most recent specimens: 1963 (NMV).

Macropus fuliginosus - Western grey kangaroo

Abundance and distribution: Common and often seen throughout the larger areas of native vegetation in the study area (i.e., occurs throughout the Sunset Country, Big Desert, Hattah Lakes and Annuello areas).

Food: Chiefly grasses, but in absence of grass will browse on sclerophyllous shrubs.

Home range: This species usually occurs in groups of from 2 to 6 individuals and is relatively sedentary from day to day if undisturbed, but will travel long distances when activity over a year is considered.

Nest sites: Resting animals usually seek the shade of low dense shrubs or trees such as *Callitris preissii*, under which they dig depressions for resting.

Habitat preference: All mallee, river woodland and pine woodland. More open areas such as grassland, shrub steppe and heath are generally avoided during the day, but utilized for foraging at night.

Most recent specimens: 1967 (FWD); observed in 1973 surveys (FWD, NMV).

Macropus giganteus - Great grey kangaroo

Abundance and distribution: No specimens of *M. giganteus* from the Mallee area are held in either the National Museum of Victoria or the Fisheries and Wildlife collections. However, the studies of Kirsch and Poole (1972) suggest that both the western and the eastern grey kangaroos are present in the Mallee study area.

Food: Grasses and shrubs.

Home range: Not accurately known, probably seasonally dependent.

Nest sites: Unknown in this area.

Habitat preferences: Unknown in this area

Most recent specimens: No specimens lodged in official Victoria collections.

Macropus rufogriseus - Red-necked wallaby

Abundance and distribution: Reported by Mr. C. Crouch of Nhill as occurring along the southern fringes of the Big Desert.

Food: Grasses and shrubs.

Home range: Unknown.

Nest sites: Unknown.

Habitat preference: Unknown in this area, but in other areas it is seldom far from thick undergrowth.

Most recent specimens: No specimens from the study area are lodged in official Victorian collections.

Megaleia rufa - Red kangaroo

Abundance and distribution: Comparatively rare in Victoria, but it has its last Victorian stronghold in the Mallee study area. It occurs in the plains of the Kulkyne Forest, Ned's Corner and the eastern end of the Sunset Country. Reservation of areas such as these would enhance its chances of survival in Victoria.

Food: Grasses and shrubs.

Home range: Will move according to seasonal availability of food.

Nest sites: Resting sites are usually situated in the shade of trees where the animals avoid hot midday temperatures.

Habitat preferences: Typically observed in thinly wooded grasslands, as is typical of the areas mentioned above.

Most recent specimens: 1967 (FWD); reliable reports indicate that it is still present (1973).

Trichosurus vulpecula - Brush-tailed possum

Abundance and distribution: It has a restricted distribution in the study area, but is common in local areas. It is also common throughout other parts of Victoria.

Food: Predominantly vegetarian; mainly fruit and leaves.

Nest sites: It usually nests and rests in hollow trees, but a variety of sites have been recorded including sheds, machinery and rabbit burrows.

Habitat preference: It is typically a woodland inhabitant such as in the Murray River red gum woodland and, in the south, it occurs in black box and buloke woodlands.

Most recent specimens: 1972 (NMV).

Acrobates pygmaeus - Feather-tailed glider

Abundance and distribution: Common throughout most of south-eastern Victoria, but restricted and rare in the study area.

Food: Insects and nectar.

Nest sites: Usually hollow limbs of trees, but there are records of nests occurring in a variety of unusual locations. This usually happens in situations where natural nesting sites are limited.

Habitat preference: Restricted to woodland and forest habitats throughout Victoria. It probably does not occur in mallee vegetation, but museum records indicate that it is widespread through red gum and black box associations.

Most recent specimens: 1968 (NMV).

Cercartetus concinnus - Western pigmy possum

Abundance and distribution: Restricted and rare in the study area. The only other Victorian records are from the Little Desert.

Food: Insects and nectar.

Nest sites: Tree hollows or birds'nests such as those constructed by babblers.

Habitat preference: Typically occurs in woodlands (mallee or otherwise) that have a dense or medium dense understorey of sclerophyllous shrubs such as *Banksia, Callistemon* or *Melaleuca*. At present this type of formation is best represented in the Big Desert.

Most recent specimens: 1911 (NMV). Recent sightings (around 1960) are reported by Wakefield (1963).

Antechinus flavipes - Yellow-footed antechinus

Abundance and distribution: Although common in the Mallee area in the nine-

teenth century and common now in other dry forest or woodland areas of the State, this species is now rarely recorded in the study area. It probably still exists in the east of the study area and along the Murray River.

Food: Arthropods and small vertebrates obtained in the litter layer.

Nest sites: Usually in hollow limbs or stumps; often on or near the ground.

Habitat preference: This species usually is found in woodlands that have well-developed litter and shrub layers (e.g., red gum woodlands).

Most recent specimens: 1963 (NMV).

Sminthopsis murina - Mouse dunnart

Abundance and distribution: Possibly not as rare in the Sunset Country as previously considered. Paucity of specimens may reflect difficulty of capture rather than rareness. This species is restricted to the west and north-west portion of Victoria.

Food: Arthropods.

Nest sites: Described as being an excavation made beneath a dense shrub such as porcupine grass *(Triodia)* and lined with grasses.

Habitat preferences: Recent (1973) captures of specimens and daylight observations of 'mice' presumed to be *S. murina* indicate that this species is often associated with porcupine grass. It generally occurs in mallee vegetation.

Most recent specimens: 1973 survey (FWD).

Sminthopsis crassicaudata - Fat-tailed dunnart

Abundance and distribution: Uncommon, but widespread through plains and grazing land of western Victoria.

Food: Arthropods.

Nest sites: Holes excavated under rocks, logs and pieces of iron have been recorded.

Habitat preferences: The distribution of this species within the study area excludes the mallee and heath areas, but includes most woodlands and plains. Intensive farming such as crop-growing would, however, be detrimental.

Most recent specimens: 1971 (NMV).

Hydromys chrysogaster - Eastern water rat

Abundance and distribution: Restricted to the Murray River system or rivers, lakes and swamps. Common throughout rivers, lakes and particularly irrigation areas of Victoria.

Food: Generally carnivorous, including invertebrates such as yabbies and mussels. Also will eat offal near or in the water.

Home range: Information is scant, but there are records of long distances (1 or 2 miles) being travelled in water or on land in search of food.

Nest sites: The species make extensive runs and burrows along the margins of the waters it inhabits. Hollow logs and burrows appear to be the most favoured nesting sites.

Habitat preference:Essentially a semi aquatic species; it is nearly always associated with water, but as described above will cover relatively large distances over land in search of food. Permanent water appears to be the most important requisite because the animal is recorded from streams in a variety of localities, altitudes and forest types.

Most recent specimens: 1971 (FWD).

Notomys mitchelli - Mitchell's hopping mouse

Abundance and distribution: Restricted to the Mallee area in Victoria. It has been depleted since discovery of the species in 1836, but probably remains secure in areas of Crown land within the study area. Populations are thought to undergo fluctuations in numbers.

Food: Vegetarian. It thrives on seeds and fruits in captivity and probably eats seeds and fruit of plants such as *Leptospermum, Banksia, Melaleuca* and *Casuarina* in the wild.

Nest sites: An elaborate burrow with a vertical entry is constructed. Access tunnels may go to a depth of 3 feet, where they link up with a labyrinth of horizontal tunnels. The absence of soil heaps makes detection difficult.

Habitat preference: Scrub-mallee with a sandy substrate.

Most recent specimens: 1973 surveys (FWD, NMV).

Pseudomys albocinereus - Silky desert mouse

Abundance and distribution: In Victoria, this species is restricted to the western portion. Abundance is determined by local conditions and can range from common to rare.

Food: In captivity it eats fruit and seeds; presumably wild populations have a similar diet.

Nest sites: Burrows into the soil are constructed. Entry to the burrows is by vertical tunnels which lead to a series of horizontal tunnels. The spoil heap is taken out through an inclined construction tunnel which is later filled in.

Habitat preference: Generally heathlands on dry sandy soils.

Most recent specimens: 1973 Surveys (NMV).

Canis familiaris - Dingo

Abundance and distribution: Now rare or extinct in the Mallee region.

Food: Carnivorous; insects to vertebrates are consumed.

Home range: Variable according to the season. Movements of up to 30 miles in a night have been recorded in East Gippsland. In drier areas considerable nomadism is exhibited.

Habitat preference: In the study area predator control has restricted this species to the large areas of Crown land. There are no recent records of dingoes from the study area, but wild dogs are occasionally trapped.

APPENDIX 6

BIRDS

This appendix contains a list of birds recorded in the area, with an indication of the habitats in which they are likely to occur, their abundance and general breeding and feeding information. The species are listed by common names, which follow the nomenclature of the C.S.I.R.O.'s "An Index of Australian Bird Names" (1969). Species recorded in the area as accidents or as vagrants have not been included in the list.

Horizontal lines are used to separate families.

Habitats

1. Aquatic
2. Mallee
3. Big mallee
4. Hummock grass-mallee
5. Scrub-mallee
6. Woodland (red gum, black box)
7. Woodland (pine, belar, buloke)
8. Grassland
9. Saltbush
10. Heath and mallee-heath

Abundance

+++ common ++ uncommon + rare

Information on habitat preferences and abundance has been extracted for more than 300 publications (Gilmore and McVicar, 1973). Additional comments on distribution were provided by C.N. Austin, R.E. Corbould, W.R. Wheeler, H.E. Tarr, V.T. Lowe, H.R. Johnson and The Bird Observers Club.

Breeding information was obtained from N.J. Favaloro (personal communication), W. Middleton (personal communication), N.J. Favaloro (1966) and J. Frankenberg, (1971). General information on nest locations and foods was extracted from Cayley, N.W. (1931). References are given on pages 89-90.

COMMON NAME	HABITAT										ABUNDANCE	BIRDS IN MALLEE AREA	NEST LOCATION	FOODS
	1	2	3	4	5	6	7	8	9	10				
Emu		X	X	X	X	X	X	X	X	X	+++	Yes	Ground	Vegetation
Australian pelican	X										+++	-		Fish, crustaceans
Darter	X					X					+	Yes	Tree branches	Fish
Black cormorant	X					X					+++	Yes	Rock ledges, tree branches	Fish, crustaceans
Little black cormorant	X					X					+++	Yes	Tree branches	Fish, crustaceans
Pied cormorant	X					X					+	Yes	Tree branches	Aquatic animals
Little pied cormorant	X					X					+++	Yes	Tree branches	Fish, crustaceans
Little grebe	X										+++	Yes	Floats on water	Aquatic animals and plants
Hoary-headed grebe	X										+++	Yes	Floats on water	Aquatic animals and plants
Great crested grebe	X										+	Yes	Floats on water	Aquatic animals and plants
White-necked heron	X					X		X	X		+++	Yes	Tree branches	Variety of animals
White-faced heron	X					X		X	X		+++	Yes	Tree branches	Aquatic animals
Cattle egret	X										+	-	-	-
White egret	X										+++	Yes	Tree branches	Aquatic animals
Little egret	X										++	-	-	Aquatic animals
Plumed egret	X										+	Yes	Tree branches	Aquatic animals
Nankeen night heron	X					X					++	Yes	Tree branches	Aquatic animals
Little bittern	X							X			+	Yes	Emergent aquatic vegetation	Aquatic animals
Brown bittern	X										+	Yes	Emergent aquatic vegetation	Aquatic animals
White ibis	X							X			+++	Yes	Emergent aquatic vegetation	Insects
Straw-necked ibis	X							X			+++	Yes	Emergent aquatic vegetation	Insects
Glossy ibis	X							X			+	Yes	Tree branches	Insects
Royal spoonbill	X					X					++	Yes	Tree branches	Aquatic animals
Yellow-billed spoonbill	X					X					+++	Yes	Tree branches	Aquatic animals
Water whistling duck	X										+	-	-	Terrestrial herbage
Grass whistling duck	X										+	-	-	Terrestrial herbage
Black swan	X										+++	Yes	Ground	Aquatic animals and plants
Freckled duck	X										+	-	-	Aquatic animals and plants
Mountain duck	X							X			+++	Yes	Hole in tree	Herbage, aquatic animals
Black duck	X										+++	Yes	Ground	Herbage, aquatic animals
Grey teal	X										+++	Yes	Ground, hole in tree	Aquatic animals and plants
Chestnut teal	X										++	Yes	Ground, hole in tree	Aquatic animals and plants
Blue-winged shoveler	X										++	Yes	Ground	Aquatic animals and plants
Pink-eared duck	X										++	Yes	Ground, hole in tree	Aquatic animals and plants
White-eyed duck	X										++	Yes	Ground, hole in tree	Molluscs
Wood duck	X							X			++	Yes	Hole in tree	Herbage
Blue-billed duck	X										+	Yes	Ground	Aquatic animals and plants
Musk duck	X										++	Yes	Ground	Aquatic animals and plants
Black-shouldered kite		X	X	X	X	X	X	X	X	X	++	Yes	Tree branches	Small mammals, lizards, insects
Letter-winged kite						X		X			+	-	-	Small mammals
Pork-tailed kite		X	X	X	X	X	X	X	X	X	+	-	-	Small mammals, lizards, insects, garbage
Square-tailed kite	X	X	X	X	X	X	X	X	X	X	+	-	-	Birds
Black-breasted buzzard	X	X	X	X	X	X	X	X	X	X	+	-	-	Rabbits, lizards
Whistling eagle	X	X	X	X	X	X	X	X	X	X	+++	Yes	Tree branches	Mammals, birds, reptiles, carrion
Grey (white) goshawk						X		X			++	-	-	Small birds, insects
Australian goshawk	X					X	X				++	Yes	Tree branches	Birds
Collared sparrowhawk		X	X	X	X	X	X				+	Yes	Tree branches	Small birds
Australian little eagle	X					X	X				++	Yes	Tree branches	Mammals, reptiles, carrion
Wedge-tailed eagle		X	X	X	X	X	X	X	X	X	+++	Yes	Tree branches	Mammals, birds, carrion

COMMON NAME	HABITAT										ABUNDANCE	BIRDS IN MALLEE AREA	NEST LOCATION	FOODS
	1	2	3	4	5	6	7	8	9	10				
White-breasted sea eagle	X										+	Yes	Rock pinnacles, trees	Mammals, reptiles, fish
Spotted harrier						X		X			+	Yes	Tree branches	Mammals, birds, reptiles
Swamp harrier	X	X	X	X				X			++	Yes	Ground	Small mammals, birds
Black falcon	X					X					++	Yes	Tree branches	Birds
Peregrine falcon						X	X				++	Yes	Rock ledges	Birds
Little falcon	X		X			X					++	Yes	Tree branches	Small birds, insects
Grey falcon	X		X			X					+	Yes	Tree branches	Mammals, reptiles, birds
Nankeen kestrel	X	X	X	X	X	X	X	X	X	X	+++	Yes	Rock crevices, tree branches	Insects, birds, reptiles, mammals
Brown hawk		X	X	X	X	X	X	X	X	X	+++	Yes	Tree branches	Mammals, birds, insects
Mallee fowl		X	X	X	X						++	Yes	Mounds	Berries, seeds, insects
Stubble quail					X			X	X		++	Yes	Ground	Seeds, grasses, insects
Brown quail	X							X			+	Yes	Ground	Seeds, insects
Painted quail						X					+	Yes	Ground	Seeds, insects
Little quail								X			+	Yes	Ground	Seeds, insects
Plain wanderer								X			+	-	-	
Brolga	X										++	-	-	Omnivorous
Banded landrail	X										++	Yes	Grass tussocks	Molluscs, aquatic insects and plants
Marsh crane	X										++	Yes	Emergent aquatic vegetation	Molluscs, aquatic insects and plants
Australian spotted crake	X										+++	Yes	Grass tussocks	Aquatic insects and plants
Black-tailed native hen	X					X		X	X	X	++	-	-	Grasses, aquatic animals and plants
Dusky moorhen	X										+++	Yes	Tussocks, aquatic vegetation	Aquatic insects and plants
Swamphen	X										+++	Yes	Tussocks, aquatic vegetation	Molluscs, grass, aquatic plants
Coot	X							X			+++	Yes	Emergent aquatic vegetation	Aquatic animals and plants
Australian bustard								X			+	-	-	Omnivorous
Australian painted snipe	X							X			+	Yes	Ground	Aquatic animals and plants
Spur-winged plover	X								X		+++	Yes	Ground	Insects, herbage, crustaceans
Banded plover	X							X	X		++	Yes	Ground	Insects, seeds
Red-kneed dotterel	X										+++	Yes	Ground	Terrestrial insects
Red-capped dotterel	X							X			++	Yes	Ground	Aquatic insects, crustaceans
Double-banded dotterel	X										+	No	-	Aquatic animals
Black-fronted dotterel	X									X	+++	Yes	Ground	Aquatic insects, crustaceans
Australian dotterel	X								X	X	+	Yes	Ground	Insects, seeds
Turnstone	X										+	No	-	Aquatic animals
Little whimbrel	X										+	No	-	Aquatic animals
Whimbrel	X										+	No	-	Aquatic animals
Eastern curlew	X										++	No	-	Aquatic animals
Little greenshank	X										+	No	-	Aquatic animals
Greenshank	X										++	No	-	Aquatic animals
Wood sandpiper	X										+	No	-	Aquatic animals
Common sandpiper	X										+	No	-	Aquatic animals
Great knot	X										+	No	-	Aquatic animals
Sharp-tailed sandpiper	X										+++	No	-	Aquatic animals
Red-necked stint	X										+++	No	-	Aquatic animals
Long-toed stint	X										+	No	-	Aquatic animals
Curlew sandpiper	X										++	No	-	Aquatic animals
Sanderling	X										+	No	-	Aquatic animals
Buff-breasted sandpiper	X										++	No	-	Aquatic animals
Black-tailed godwit	X										++	No	-	Aquatic animals
Bar-tailed godwit	X										++	No	-	Aquatic animals

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	ABUNDANCE	BIRDS IN MALLEE AREA	NEST LOCATION	FOODS
Ruff	X										+	No	-	Aquatic animals
White-headed stilt	X										+++	Yes	Ground	Aquatic animals and plants
Banded stilt	X										++	Yes	Ground	Aquatic crustaceans
Avocet	X										++	Yes	Ground	Aquatic animals and plants
Southern stone curlew						X	X				+	Yes	Ground	Insects
Australian pratincole	X							X			+	Yes	Ground	Insects
Silver gull	X										+++	Yes	Ground	Aquatic animals, garbage
Whiskered tern	X										++	Yes	Floats on water	Fish, aquatic insects
White-winged black tern	X										++	No	-	Aquatic animals
Caspian tern	X										++	-	-	Small fish
Gull-billed tern	X										+	Yes	Ground	Fish, insects, reptiles
Domestic pigeon						X					++	-	-	-
Peaceful dove						X					+++	Yes	Tree branches	Seeds
Diamond dove	X					X			X		++	Yes	Shrub or tree	Seeds
Common bronzewing		X	X	X	X	X	X	X	X	X	+++	Yes	Shrub or tree	Seeds, berries
Crested pigeon					X	X	X	X	X		+++	Yes	Tree branches	Seeds
Musk lorikeet			X			X					++	Yes	Hole in tree	Nectar, fruits, berries
Purple-crowned lorikeet		X	X	X	X	X					+++	Yes	Hole in tree	Nectar, fruits, berries
Little lorikeet						X					+	Yes	Hole in tree	Nectar, fruits, berries
Swift parrot			X								+	-	-	Nectar
Sulphur-crested cockatoo		X	X	X	X	X	X	X	X	X	++	Yes	Hole in tree	Seeds, roots
Major Mitchell			X	X	X	X	X	X	X	X	+	Yes	Hole in tree	Seeds, roots
Little corella			X			X	X	X			+++	Yes	Hole in tree	Seeds, roots
Galah		X	X	X	X	X	X	X	X	X	+++	Yes	Hole in tree	Seeds
Cockatiel		X	X	X	X	X	X	X	X	X	++	Yes	Hole in tree	Seeds
Superb parrot							X	X			+	-	-	Seeds, nectar
Regent parrot		X	X	X	X	X	X	X	X	X	++	Yes	Hole in tree	Seeds
Yellow rosella						X	X				++	Yes	Hole in tree	Seeds
Eastern rosella						X					+	Yes	Hole in tree	Seeds, berries
Ringneck parrot			X	X	X	X	X	X	X	X	+++	Yes	Hole in tree	Seeds, berries
Blue bonnet		X	X	X	X	X	X	X			+++	Yes	Hole in tree	Seeds
Red-rumped parrot		X	X	X	X	X	X	X	X	X	+++	Yes	Hole in tree	Seeds
Mulga parrot		X	X	X	X	X	X				+++	Yes	Hole in tree	Seeds
Elegant parrot								X	X		++	-	-	Seeds
Blue-winged parrot			X	X	X	X		X	X		++	-	-	Seeds
Scarlet-chested parrot					X	X					+	-	-	Seeds
Budgerygah		X	X	X	X		X	X	X		++	Yes	Hole in tree	Seeds
Pallid cuckoo		X	X	X	X	X	X	X			++	Yes	Parasitic	Insects
Fan-tailed cuckoo						X	X				++	-	-	Insects
Black-eared cuckoo		X	X	X	X	X	X				+	Yes	Parasitic	Ground Insects
Horsfield bronze cuckoo						X	X	X	X		++	Yes	Parasitic	Insects
Golden bronze cuckoo			X			X	X				+	-	-	Insects
Barking owl						X	X				+	Yes	Hole in tree	Mammals, birds
Boobook owl		X	X			X					+++	Yes	Hole in tree	Insects, rodents, birds
Barn owl		X	X			X					+++	Yes	Hole in tree	Mammals, birds, insects, reptiles
Masked owl						X					+	-	-	Mammals, reptiles, birds
Tawny frogmouth		X	X	X	X	X	X				+++	Yes	Tree branches	Insects, small mammals
Owlet-nightjar		X	X	X	X						++	Yes	Hole in tree	Insects
Superb blue wren						X					++	Yes	Near ground in shrub	Insects
Black-tailed blue wren		X	X	X	X		X				+++	Yes	Near ground in shrub	Insects

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	ABUNDANCE	BIRDS IN MALLEE AREA	NEST LOCATION	FOODS
Blue and white wren						X			X		+	Yes	Near ground in shrub	Insects
Variegated wren		X	X	X	X	X			X		++	Yes	Near ground in shrub	Insects
Mallee emu-wren				X							+	Yes	Near ground in shrub	Insects
Western warbler		X				X					+	Yes	Tree branches	Insects
Weebill		X	X	X	X	X	X	X	X	X	+++	Yes	Attached to leaf cluster (tree)	Insects
Little thornbill						X	X				+++	Yes	Tree branches	Insects
Brown thornbill					X	X					+++	Yes	Near ground in shrub	Insects
Red-tailed thornbill (Broad-tailed thornbill)					X						++	Yes	Near ground in shrub	Insects
Chestnut-rumped thornbill		X	X	X	X	X	X				+++	Yes	Hole in tree	Insects
Samphire thornbill									X	X	++	Yes	Small shrub	Insects
Buff-rumped thornbill						X	X	X			++	Yes	Hole in tree, shrub, ground	Insects
Yellow-rumped thornbill			X			X	X	X			+++	Yes	Tree branches	Ground insects
Redthroat				X	X					X	+	Yes	Near ground in shrub	Ground insects
Mallee heath-wren		X		X	X					X	++	Yes	Ground	Insects
Field-wren rufous									X		+	Yes	Near ground	Insects
Whiteface		X	X	X	X	X	X	X			++	Yes	Cavity in post, thick shrub	Insects
Striated grass-wren				X							+	Yes	Near ground	Insects
White-fronted chat						X		X	X	X	+++	Yes	Low shrub, tall grass	Insects
Crimson chat					X				X		++	Yes	Low shrub	Insects
Orange chat						X			X		++	Yes	Low shrub	Insects
Jacky winter			X			X					+++	Yes	Tree branches	Insects
Scarlet robin							X				++	-	-	Ground insects
Red-capped robin			X	X	X	X	X	X			+++	Yes	Tree branches	Insects
Flame robin				X				X			++	Yes	Tree branches	Ground insects
Hooded robin			X			X	X			X	+++	Yes	Tree branches	Ground insects
Grey fantail		X	X	X	X	X	X				+	-	-	Insects
Willie wagtail	X	X	X	X	X	X	X	X	X	X	+++	Yes	Tree branches	Insects
Restless flycatcher		X	X		X	X	X				++	Yes	Tree branches	Insects
Golden whistler			X			X					+++	Yes	Shrub, small tree	Insects
Rufous whistler		X	X		X	X	X				+++	Yes	Shrub, tree	Insects
Red-lored whistler				X	X						+	Yes	Low shrub	Ground insects
Gilbert whistler				X	X	X	X				++	Yes	Low shrub	Ground insects
Grey shrike-thrush			X	X		X	X				+++	Yes	Shrub, tree, ground	Insects
Spotted nightjar		X	X	X	X						+	Yes	Ground	Flying insects
Spine-tailed swift											++	No	-	Flying insects
Fork-tailed swift								X			++	No	-	Flying insects
Azure kingfisher	X					X					++	-	-	Aquatic insects, crustaceans, fish
Laughing kookaburra						X	X				++	Yes	Hole in tree	Reptiles, insects, fish
Red-backed kingfisher	X	X	X	X	X	X	X				++	Yes	Tunnel in bank	Insects, reptiles
Sacred kingfisher	X					X					++	Yes	Hole in tree or bank	Lizards, fish, insects
Rainbow bee-eater						X	X	X			++	Yes	Tunnel in sand	Flying insects
Dollar bird						X					++	-	-	Flying insects
Singing bushlark			X						X		+	Yes		Seeds, insects
Skylark									X		+++	-	-	Seeds, insects
White-backed swallow						X	X				++	Yes	Tunnel in bank	Flying insects
Welcome swallow		X	X	X	X	X					+++	Yes	Underbridge, eaves, in cave	Flying insects
Tree-martin			X			X	X	X			+++	Yes	Hole in tree or cliff	Flying insects
Fairy martin						X					+++	Yes	Under eaves, ledges, in cave	Flying insects

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	ABUNDANCE	BIRDS IN MALLEE AREA	NEST LOCATION	FOODS
Australian pipit							X	X	X		+++	Yes	Ground	Insects, seeds
Ground cuckoo-shrike						X	X	X			+	Yes	Tree branches	Insects
Black-faced cuckoo-shrike		X	X	X	X	X	X			X	+++	Yes	Tree branches	Insects, berries
Little cuckoo-shrike						X					++	Yes	Tree branches	Insects
Southern scrub-robin		X		X	X						++	Yes	Shrubs, ground	Ground insects
Blackbird											++	Yes	Shrub, thicket	Insects, fruits
Chestnut quail-thrush	X	X		X	X	X					+	Yes	Ground	Insects, seeds
Grey-crowned babbler						X					+	Yes	Tree branches	Ground insects
Chestnut-crowned babbler			X		X	X					++	Yes	Tree branches	Ground insects
White-browed babbler		X	X	X	X		X	X			+++	Yes	Tree branches	Ground insects
Golden-headed fantail-warbler	X										+++	-	-	Insects
Little grassbird	X										+++	Yes	Rushes, teatree	Insects, seeds
Reed-warbler	X										+++	Yes	Stems of reeds	Insects
Brown songlark						X		X	X		++	Yes	Ground	Insects, seeds
Rufous songlark						X	X				+++	Yes	Ground	Insects, seeds
Shrike-tit						X					+	Yes	Tree branches	Insects
Crested bell-bird		X	X	X	X		X			X	+++	Yes	Low tree	Ground insects
Wedgebill				X	X						+	-	-	Insects, seeds
Western whipbird					X						+	Yes	Low shrub	Ground insects
Black-capped sittella			X			X					++	Yes	Tree branches	Insects
Brown tree-creeper			X	X	X	X	X	X	X	X	+++	Yes	Hole in tree	Insects
White-browed tree-creeper							X				+	Yes	Hole in tree	Insects
Mistletoe bird	X		X			X	X				+++	Yes	Tree branches	Berries, insects
Yellow-rumped pardalote		X	X	X	X	X	X				+++	Yes	Tunnel in ground, hole in tree	Insects
Striated pardalote	X	X	X	X	X	X	X				+++	Yes	Hole in tree, bank	Insects
Grey-backed silvereye										X	++	Yes	Shrub, small tree	Insects, fruit, berries
Black honeyeater		X	X	X	X	X				X	++	Yes	Low shrub	Insects, nectar
Pied honeyeater						X					+	Yes	Shrub, tree	Insects, nectar
Singing honeyeater					X	X			X	X	++	Yes	Shrub	Insects, nectar
Fuscous honeyeater					X						+	-	-	Insects, nectar
Yellow-fronted honeyeater		X									+	Yes	Shrub, low tree	Insects, nectar
Purple-gaped honeyeater				X						X	++	Yes	Shrub, low tree	Insects, nectar
White-plumed honeyeater		X	X	X	X	X	X	X	X		+++	Yes	Tree branches	Insects, nectar
Yellow-plumed honeyeater		X	X	X	X	X	X				+++	Yes	Shrubs, low tree	Insects, nectar
White-eared honeyeater		X	X	X	X	X	X	X	X	X	+++	Yes	Low shrub	Insects, nectar
Yellow-tufted honeyeater				X	X					X	+	Yes	Low shrub	Insects, nectar, fruit
Brown-headed honeyeater		X	X	X	X	X	X	X		X	+++	Yes	Tree branches	Insects, nectar
White-naped honeyeater		X			X						+	-	-	Insects, nectar
Black-chinned honeyeater					X						+	-	-	Insects, nectar
Blue-faced honeyeater					X	X					++	Yes	Tree branches	Insects, nectar
Little friar-bird		X	X	X	X	X	X				++	Yes	Tree branches	Insects, nectar, berries
New Holland honeyeater				X						X	+++	Yes	Low shrub	Insects, nectar
White-fronted honeyeater		X	X	X	X					X	+++	Yes	Low shrub	Insects, nectar

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	ABUNDANCE	BIRDS IN MALLEE AREA	NEST LOCATION	FOODS
Tawny-crowned honeyeater		X	X	X	X					X	+++	Yes	Low shrub	Insects, nectar
Striped honeyeater		X	X	X	X	X	X				+++	Yes	Tree branches	Insects, nectar
Painted honeyeater						X					+	Yes	Tree branches	Insects, nectar
Eastern spinebill										X	++	-	-	Insects, nectar
Noisy miner			X			X	X				+++	Yes	Tree branches	Insects, nectar, berries
Yellow-throated miner	X	X	X			X	X				+++	Yes	Shrub, tree	Insects, nectar, berries
Black-eared miner (Dusky miner)		X									+	Yes	Tree branches	Insects, nectar
Spiny-cheeked honeyeater	X	X	X	X	X	X	X			X	+++	Yes	Tree branches	Insects, nectar
Red wattle-bird			X		X	X				X	+	Yes	Tree branches	Insects, nectar
Diamond firetail						X	X				++	Yes	Shrub, tree	Seeds
Zebra finch						X	X		X		+++	Yes	Shrub, hole in tree, burrow	Seeds
House-sparrow						X		X			+++	Yes	Crevice, hole in tree, shrub	Seeds, fruit, flowers
Goldfinch						X		X			++	Yes	Shrub, low tree	Seeds
Starling						X	X	X			+++	Yes	Hole in tree, crevice	Seeds, insects, fruit
Olive-backed oriole						X					+	-	-	Insects, fruit, berries
Magpie lark	X	X	X	X	X	X	X	X			+++	Yes	Tree branches	Ground, insects, snails
White-winged chough		X	X	X	X	X	X				+++	Yes	Tree branches	Insects
Apostle bird						X					+	Yes	Tree branches	Insects, seeds
White-breasted wood-swallow						X	X				+	Yes	Small tree	Flying insects
Masked wood-swallow		X	X	X	X	X	X				++	Yes	Shrub, stump	Flying insects
White-browed wood-swallow		X	X	X	X	X	X				+++	Yes	Shrub, tree	Flying insects
Black-faced wood-swallow							X				+	Yes	Shrub, stump	Insects
Dusky wood-swallow						X	X				+++	Yes	Tree branches	Insects, nectar
Black-winged currawong		X	X	X	X		X				++	Yes	Tree branches	Insects
Pied butcher-bird	X					X	X				+	Yes	Tree branches	Insects, birds, reptiles, mammals
Black-backed magpie		X	X	X	X	X	X	X	X		+++	Yes	Tree branches	Insects, birds, reptiles,
Grey butcher-bird	X	X	X	X	X	X					++	Yes	Tree branches	Insects, birds, reptiles, mammals
Spotted bower-bird						X	X				+	-	-	Insects, seeds, berries
Australian raven						X	X				+++	Yes	Tree branches	Omnivorous
Little raven					X	X	X				++	Yes	Tree branches	Insects, reptiles
Little crow			X	X	X	X	X				++	Yes	Tree branches	Insects, reptiles

APPENDIX 7 REPTILES

SCIENTIFIC NAME	COMMON NAME	HABITAT										HABITS AND BIOLOGY											DISTRIBUTION IN ZOOGEOGRAPHIC REGIONS		
		1	2	3	4	5	6	7	8	9	10	ABUNDANCE	DIURNAL	NOCTURNAL	GROUND-DWELLING	WATER-DWELLING	ARBORIAL or SCANSORIAL	FOSSORIAL or BURROWING	THIGMOTHERM	HELIOTHERM	OVIPAROUS	VIVIPAROUS	EYREAN	RIVER CORRIDORS	WARM TEMPERATE BASSIAN
Chelodina expansa	Broad-shelled tortoise	X										+	X			X			X		X			X	
C. longicollis	Snake-necked tortoise	X										+++	X			X			X		X			X	
Emydura macquarrii	Murray River short-necked tortoise	X										+++	X			X			X		X			X	
Amphibolurus barbatus	Bearded dragon		X	X	X	X		X			X	+++	X		X					X	X		X			X
A. fordi	Spinifex dragon				X	X						+++	X		X					X	X		X			
A. muricatus	Tree dragon						X	X			X	+	X				X			X	X					X
A. nobbi coggeri	Coggers dragon					X					X	+++	X				X			X	X		X			
A. pictus	Painted dragon		X	X		X				X		+++	X		X					X	X		X			
Tympanocryptus lineata	Earless dragon											+	X		X					X	X		X			X
Diplodactylus ciliaris	Spinytailed gecko		X	X	X	X					X	+++		X	X				X		X		X			
D. damaeus	Beaded gecko							X				+++		X	X				X		X		X			
D. elderi												+		X	X				X		X		X			
D. tessellatus	Variegated gecko											+		X	X				X		X		X			
D. vittatus	Stone gecko											++		X	X				X		X		X			
Underwoodisaurus milii	Thick-tailed gecko											+++		X	X								X			
Rhynchoedura ornata	Beaked gecko											-							X		X		X			
Oedura variegata	Dtella											+++		X			X		X		X		X			
Heteronotia binoei	Bynoe's gecko											+++		X	X				X		X		X			
Phyllodactylus marmoratus	Marbled gecko						X	X				+++		X			X		X		X		X			X
Aprasia striolata	Pretty snake lizard											+	X					X	X		X		X			X
Delma fraseri	Mimicking snake lizard				X	X						+++	X						X		X		X			
D. impar	Spinifex lizard				X	X			X		X	+++	X						X		X		X			X
Lialus burtonis	Burton's legless lizard											+++	X						X		X		X			
Pygopus lepidopodus	Scaly foot				X	X					X	+++	X						X		X		X			
Cryptoblepharus boutoni	Wall lizard						X					+++	X				X			X	X		X			
Ctenotus brachyonyx	Murray River striped skink				X							+	X		X					X	X		X			
C. regius	Striped skink				X	X				X		++	X		X					X	X		X			
C. robustus	Larged striped skink										X		X		X					X	X		X			X
C. schomburgkii	Miniature striped skink												X		X					X	X		X			
C. uber orientalis	E. coppertailed striped skink	X	X									++	X		X					X	X		X			
Hemiergis decresiensis	Three-toed skink											+						X	X			X				X
H. initialis					X							+						X	X			X				X
H. peroni	Four-toed skink											+							X			X	X			
Lerista bipes	Two-toed skink											+							X			X	X			
L. bougainvillii	Bougainville's skink						X	X				++							X			X	X			X
L. elegans	Elegant skink						X					+						X	X			X				
L. lineata	Lined burrowing skink						X					+						X	X		X		X			
L. punctatovittata	Burrowing skink						X	X				+++						X	X			X				
L. timidus	Timid skink											+						X	X		X		X			
Menetia greyi	Grey's skink				X	X						+++						X	X		X		X			
Morethia adelaidensis	Adelaide skink									X		+	X		X					X	X		X			
M. boulengeri	Boulengers skink		X	X	X	X	X	X				+++	X		X					X	X		X			
M. limacellatus	Ocellated skink					X					X	+++	X		X					X	X		X			
Sphenomorphus fasciolatus	Fasciolated ghost skink											+						X	X			X	X			
S. quoyi	Quoy's water skink	X					X					++	X		X					X	X		X	X		
Egernia inornata	Desert skink				X		X					+++	X		X					X	X		X			
E. striolata	Tree skink						X					+++	X				X			X	X		X			
Tiliqua occipitalis	Western blue-tongue											+	X		X					X	X		X			
T. scincoides	Common blue-tongue								X			++	X		X					X	X		X			X
Trachydosaurus rugosus	Stumpy-tailed lizard		X	X	X	X	X	X		X	X	+++	X		X					X	X		X			X

SCIENTIFIC NAME	COMMON NAME	HABITAT										HABITS AND BIOLOGY											DISTRIBUTION IN ZOOGEOGRAPHIC REGIONS			
		1	2	3	4	5	6	7	8	9	10	ABUNDANCE	DIURNAL	NOCTURNAL	GROUND-DWELLING	WATER-DWELLING	ARBORIAL or SCANSORIAL	FOSSORIAL or BURROWING	THIGMOTHERM	HELIOTHERM	OVIPAROUS	VIVIPAROUS	EYREAN	RIVER CORRIDORS	WARM TEMPERATE BASSIAN
Varanus gouldii	Sand goanna		X	X	X	X		X				+++	X		X		X			X	X		X		
V. varius	Tree goanna						X					+++	X							X	X		X		X
Morelia argus variegatus	Carpet snake						X					+					X		X		X	X	X	X	
Acanthophis antarcticus	Death adder											+		X	X				X			X	X		
Brachyaspis curta	Bardick											+		X					X			X	X		
Damaseia peammophis	Yellow-faced whip snake											+	X							X	X		X		
Denisonia deviati	DeVis' snake						X					+		X					X			X	X		
Drysdalia mastersii	Marster's snake											++	X		X					X		X	X		
Notechis scutatus	Tiger snake						X					+++			X					X		X	X	X	X
Oxyuranus scutellatus	Taipan											+	X		X					X	X		X		
Pseudechis australis	Mulga snake											+	X		X					X		X	X		
P. porphyriacus	Red-bellied black snake						X					++	X		X					X		X	X	X	X
Pseudonaja nuchalis	Collared brown snake		X	X	X	X						++	X		X					X	X		X		
P. textilis	Brown snake	X	X	X	X	X	X	X	X			+++	X		X					X	X		X		X
Rhynchoelaps australis	Australian coral snake											+							X		X		X		
Suta brevicauda	Mitchell's short-tailed snake											++							X			X	X		
S. dwyeri	Dwyer's snake											++							X			X	X		
S. suta	Curl snake						X	X				++							X			X	X		
Vermicella annulata	Sandy bandy		X	X	X	X		X				+						X	X		X		X		
Typhlops australis	Blind snakes											+						X	X		X		X		
T. bituberculatus												+++						X	X		X		X		
T. broomi												+++						X	X						
T. ligatus												+++						X	X		X		X		
T. nigrescens												+++						X	X		X		X		
T. polygrammicus												+++						X	X		X		X		
T. pinguis												+++						X	X		X		X		
T. proximus												+++						X	X		X		X		
T. unguirostris												+++						X	X		X		X		

Prepared by the Fisheries and Wildlife Division and the National Museum of Victoria

APPENDIX 8

FISHES

Scientific name	Common name	Occurrence in Mallee study area				Introduced species	Species of commercial, recreational or culinary value	Forage# species	Relative abundance
		Murray River	Avoca River	North Loddon River	Lake Albacutya				
Mordacia mordax	Short-headed lamprey	x							+
Anguilla australis occidentalis	Short-finned eel	x		x					*
A. reinhardti	Long-finned eel	x		x					*
Fluvialosa richardsoni	Bony bream	x		x				x	+
Retropinna semoni	Australian smelt	x						x	+
Galaxias planiceps	Flat-headed galaxias		x	x				x	+
Tandanus tandanus	Freshwater catfish	x	x	x			x		+
Melanotaenia fluviatilis	Rainbow fish	x						x	+
Craterocephalus fluviatilis	Mitchellian freshwater hardyhead	x						x	+
C. eyresii	Lake Eyre hardyhead		x					x	+
Ambassis castelnaui	Western chandra perch	x						x	+
Maccullochella peeli	Murray cod	x	x	x			x		+
M. macquariensis	Trout cod	x					x		**
Macquaria australasica	Macquarie perch	x					x		**
Plectroplites ambiguus	Golden perch or callop	x	x	x			x		++
Bidyanus bidyanus	Silver perch	x	x	x			x		++
Nannoperca australis australis	Southern pigmy perch	x						x	+
Perca fluviatilis	English perch or redfin	x	x	x	x	x	x		+++
Hypseleotris klunzingeri	Western carp gudgeon	x						x	+++
Philypnodon grandiceps	Flat-headed gudgeon	x						x	+
Mogurnda striata	Purple-spotted gudgeon	x						x	+
Gadopsis marmoratus	River blackfish	x		x			x		+
Salmo trutta	Brown trout		x	x		x	x		+
Carassius auratus	Goldfish	x	x	x	x	x			+++
C. carassius	Crucian carp	x	x	x	x	x	x		+++
Cyprinus carpio	European carp	x		x		x	x		+++
Tinca tinca	Tench	x	x	x	x	x	x		+++
Gambusia affinis	Mosquito fish	x				x		x	+++

** Present occurrence in Mallee questionable

* Few individuals, not normal range

Usually small fishes used as food by larger fishes

Prepared by Fisheries and Wildlife Division

C. H. Rixon, Government Printer, Melbourne

SUBMISSIONS

LAND CONSERVATION COUNCIL
VICTORIA

MALLEE STUDY AREA

1:500,000

MILES 16 12 8 4 0 16 MILES
KILOMETRES 15 10 5 0 15

LEGEND

PUBLIC LAND

BOULKA — NAMES AND PARISH BOUNDARIES

Some narrow stream frontages are not shown

MAP No 4

PUBLIC LAND
AND
DESCRIPTIVE BLOCKS

LAND CONSERVATION COUNCIL
VICTORIA

MALLEE STUDY AREA

1:500,000

MILES 16 12 8 4 0 16 MILES

KILOMETRES 15 10 5 0 15

LEGEND

- PUBLIC LAND
- AVOCA — BLOCK NAME
- BLOCK BOUNDARY

Some narrow stream frontages are not shown

MURRAY RIVER
MILDURA
RED CLIFFS
MILLEWA
SUNSET
BIG DESERT
MURRAY RIVER
RUBINVALE
MURRAY RIVER
ANNUELLO
MANANGATANG
MURRAY RIVER
SWAN HILL
TYRRELL
SEA LAKE
AVOCA
KERANG
QUAMBATOOK
BIRCHIP
HOPETOUN
RAINBOW
OUYEN

MAP No. 1