Australian and New Zealand Association for the Advancement of Science

HANDBOOK

OF

WESTERN AUSTRALIA

26th
Meeting - Perth
Western Australia
August - - 1947

PREPARED FOR THE USE OF MEMBERS OF THE ASSOCIATION

AUSTRALIAN AND NEW ZEALAND
ASSOCIATION FOR THE ADVANCEMENT
OF SCIENCE

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Australian and New Zealand Association for the Advancement of Science

TWENTY-SIXTH MEETING
PERTH, WESTERN AUSTRALIA
AUGUST, 1947

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THE HANDBOOK

THIS Handbook has been prepared with the object of giving members of the Association a general picture of Western Australia and its activities, with particular emphasis on the south-western part of the State. It is not intended as a tourist guide, a State year book or as a complete statistical record.

An attempt has been made to include material which is peculiar to the State, as against that which is more or less common to the Commonwealth. Hence, for example, the subject of education has not been dealt with.

Some attention has been given to bibliographic references in the various sections, where possible, as a means of amplifying the information on specific points of interest or particular aspects of activity. In addition to the particular references given, there is available a substantial general bibliography in such publications as "The Story of A Hundred Years," the Commonwealth Year Book, the State Statistical Register and other publications of the Government Statistician's Office, the Geological Survey, the Journal of the Royal Society, bulletins and other publications of the Departments of Agriculture and of Mines, and the Historical Society publication, "Early Days."

All the information in the Handbook has been supplied by specialised officers and teachers. It has not been possible directly to acknowledge authorship in each instance, as several sections contain the composite writings of a number of authors, but grateful acknowledgment is here made to the following:—Professor L. J. H. Teakle, Professor E. de C. Clarke, Professor E. J. Underwood, Mr. T. N. Stoate, Dr. R. W. Fairbridge, Dr. D. L. Serventy, Dr. R. T. Prider, Mr. L. Glauert, Mr. C. A. Gardner, Mr. A. G. Akeroyd, Mr. B. S. Crimp, Mr. A. C. Staples, Mr. G. B. Lancaster, Mr. J. B. Jukes, Mr. Robert Smith, officers of the Mines Department, the Department of Agriculture, the Lands Department and the Fisheries Department, and the late Mr. R. W. Fletcher.

HISTORY OF SETTLEMENT

During the seventeenth century the Indian Ocean became the waterway for the Dutch trade between the Spice Islands and Holland. It is not surprising, therefore, that the shores of the Indian Ocean, African and Australian, should have come to be well known to sailors navigating by the inexact methods of the time and subject to the vagaries of the wind. Early in the previous century, when Portugal was a free country, her sailors established trading stations in the Indian Ocean, one of them marking the chart with the danger signal "Abrolhos" —Beware—where he encountered a dangerous archipelego which lies off the West Australian coast. The Dutch went further afield sailing to new stations in Java and the surrounding islands bringing them closer to West Australian shores. Sailing east from the Cape many shipmasters, through faulty navigation and the strength of the westerlies, found themselves on the inhospitable shores of what came to be called New Holland. They stayed long enough to chart their landfall and then hastened on to Batavia; but by 1700 nearly all the coast of Western Australia had become known to the Dutch.

An Englishman, William Dampier, made two visits to the coast of this New Holland, first, in 1688 as a member of the mutinied crew of the "Cygnet," second, in charge of the "Roebuck" when he landed and named Shark Bay. The Dutch and Dampier were repelled by the desolate sand-dunes of the western coast of New Holland. Their reports discouraged all settlement. Seventy years later Captain Cook charted the more kindly eastern shores of the South Land. Reports of his voyage directed the attention of English prison authorities to the possibility of using Botany Bay as a convict settlement. The desirability of settling Western Australia did not arise until the nature of the colony of New South Wales had changed. In 1821 Macquarie was recalled and Governor Brisbane was directed to make provision for the easy entry of free settlers with capital. With the development of the wool industry, Australia became an attractive area for the investment of English capital. The interest of the French in Western Australian shores led to the planting of a small convict settlement at King George's Sound (Albany) in 1827. A very favourable report on the Swan River, by Captain J. Stirling of the "Success," caused Governor Darling to send Stirling to England to explore the possibility of making a further settlement. Interest in Australia called together a group of men ready to invest capital in the Swan River Settlement.

Western Australia was formally annexed for the Crown in May, 1829, by Captain Fremantle. The first settlers, under James Stirling as Lieutenant Governor, arrived at Garden Island on 1st June, 1829, and spent there a very uncomfortable winter. Before the end of the year the sites of Fremantle and Perth were selected and the settlement moved to the mainland.

Investment.

Investment in the Swan River Settlement was made attractive to men of capital by making grants of 40 acres of land for every £3 worth of capital or equipment imported, together with further land according to the number of

labourers brought to the colony. The only further obligation was that the grantee should within 10 years perform 1/6 per acre in improvements, after which a freehold title was granted. The Crown, therefore, received nothing for the land. With claims like Colonel Lautour's for 103,000 acres and James Henty's for 60,000 acres, it was soon realised that the Crown would lose its control of the land. The larger investors were given the first choice with the result that all the fertile river fronts were taken up, driving later claimants further into the interior to brave isolation and the fear of the blacks. Many settlers remained in Perth and Fremantle rather than risk the difficulties of an unknown country; they had little aptitude for dealing with colonial conditions which were so different from what they had expected. Others, like the Hentys and Gellibrand, left for Van Diemen's Land. Grants were discontinued in 1832, after which land was available from the Crown only by purchase at 5/- per acre. Similar regulations were proclaimed a few months earlier in New South Wales.

Though the colony made little progress in these early years, every effort was made to spy out land suitable for settlement. Surveying and exploring parties under Stirling and Roe made careful reports of the south coastal areas, and the land between Perth and Albany. Good land "over the hills" was discovered by young Ensign Dale. The north coastal plain was explored by Grey who reported very favourably on the Champion Bay area.

Originally, Western Australia was a settlement of men of substance without the assistance of convicts, those at King George's Sound (Albany) being recalled to Sydney in 1831. The difficulties of this new type of Australian settlement were encountered both in New South Wales and Western Australia, leading to the formulation of a new theory of colonisation put forward by E. G. Wakefield in his "Letter from Sydney," published in the year that Western Australia was first settled. This soon found support among those who were concerned with the failure of free settlement in Australia. The year 1836 saw the creation of a Wakefield Colony in South Australia. The British Government in 1837 decided to accept Wakefield's plan for existing colonies and the price of land was raised to £1 per acre for the purpose of financing the supply of labour. In Western Australia the price rise was delayed till 1841. The sale of Crown land almost ceased; there were still no funds for the importation of labour.

During the 30's the population remained almost stationary, but a good deal of consolidation took place, persuading the settlers that at least a living could be made by relying on their own industry to provide their wants. Exports were few, but by 1834 there was an export of 7,500 lbs. of wool. New towns were formed at Guildford, Augusta, York, Northam and Vasse, while the English pattern of society began to show itself in Perth by the establishment of a weekly newspaper in 1833 and the opening of a bank in 1837. In spite of the "Battle" of Pinjarra and a number of murders of whites, little real difficulty was experienced with the aborigines.

The W.A. Company.

The Colony received a very welcome increase of population in 1841 and 1842 by means of the Australind experiment in private Wakefield settlement conducted by the W.A. Company. This company purchased the Lautour and Stirling grants adjacent to the Leschenault Estuary and planned to settle farmers on 100-acre blocks, the expenses of settlement to be met from the payments for the land. Unforseen difficulties made real success almost impossible, but many good settlers were brought to Western Australia to open up the hinterland of the port of Bunbury.

At the end of the first 10-year period the Crown was able to regain much of the land granted before 1832 by resuming land on which improvements had not been performed. However, if land was prodigally alienated at the beginning of the settlement, the rise in price to £1 in 1841 seriously restricted the expansion of cultivation. To meet the squatting threat, licenses were granted for the temporary occupancy of Crown land. Thus the decade in 1840-1850, in Western Australia as in New South Wales, saw the working out of a system of leasehold land tenure in the interests of the pastoralist.

The Convicts.

The year 1850 saw the turning point in Western Australian history, but it was produced not by gold as in New South Wales and Victoria, but by the introduction of convicts, 10 years after transportation to New South Wales had ceased. The end of the '40's saw Australia, the Eastern States and Western Australia very short of labour. In New South Wales the squatters pressed for the resumption of transportation and were only defeated in 1848 by the energetic protests of the townspeople. In Western Australia there were no such complications. The need for extra labour was recognised by the majority. Transportation was planned to provide a number of free immigrants equal to the number of convicts who were to be carefully chosen. Considerably more than 9,000 convicts and an equal number of free immigrants were landed in the colony during 18 years, the total population increasing from 5254 (1849) to 22,733 (1868). This extra labour made possible the construction of roads, bridges, and public buildings, as well as the expansion of local industry.

Under the impetus provided by the increase of labour and population the colony began to expand. First, Grey's trip from Champion Bay was recalled and settlers moved in to the Geraldton area. Explorers were opening up land further afield. The Gregory brothers had been working north from Perth for some time, Frank Gregory opening up the North-West district in 1861.

John Forrest.

It was not long before the good sheep and cattle country of the Murchison, Gascoyne and Ashburton was attracting the more adventurous sons of the settlers. In less than six years pastoral land was trebled in extent while the wool clip was more than doubled (2,000,000 lbs. in 1867). Expeditions were made into country between the coast and South Australia, pointing the way to later settlement. The year 1869 saw a young surveyor named John Forrest, born at Bunbury in 1847, in charge of a party that set out to investigate a report about some possible relics of the lost Leichhardt in the Lake Barlee area. In 1870 Forrest retraced Eyre's journey in the opposite direction, giving himself opportunities of investigating the country inland from the Bight, discovering much well grassed country. A more dangerous trip was undertaken in 1874 from the Murchison across the Centre to the telegraph line from Adelaide to Darwin. Ernest Giles soon made a trip in the opposite direction. A particularly valuable trip was made in 1879 by Forrest's brother Alexander, from the De Grey to the Fitzroy and then east to the telegraph line, traversing the rich Kimberley pastoral country which soon attracted cattle men and gold seekers.

The colonist enjoyed few rights of representative government before the end of the convict period, though he took every opportunity to make his voice heard both at Government House, Perth, and at Downing Street. Though they had

no Parliament, there was the Agricultural Society prepared to draw up a memorial with all signatures attached, for presentation to the Home Government relating to the difficulties and grievances of the Colony. Before 1870 there existed an Advisory Council of five officials and five unofficial members nominated by the Governor. In 1870, however, the Council similar to the 1842 New South Wales Council was created, numbering at first 18 then later 21 members, two-thirds of whom were elected. As in N.S.W. the great forward step towards self government was made after the cessation of transportation.

During the next 20 years steady progress was made and the economy of the colony took a more modern shape with the introduction of up-to-date methods of transport and communication. This was the "Railway Age" in Australia, though building was more extensive in the Eastern States because of the existence of prosperous goldfields guaranteeing public investments. By 1888 Walkaway and Northampton were connected by rail to Geraldton, while a line ran from Fremantle through Perth to Beverley, branching to Northam and Toodyay. Some private timber lines were operating in the South-West. The telegraph link between Perth and Adelaide was completed in 1877 by which time all the chief centres of the colony were in telegraphic communication with Perth.

Following his notable work in opening up new land John Forrest received quick promotion in the Surveys Department becoming by 1883 Surveyor-General and Commissioner of Crown Lands, responsible for the administration of land settlement policy in W.A. His policy was to ensure the creation in the South-West (then the Central district) of a "bold yeomanry" living on compact small freehold farms rather than a settlement of leaseholders practising a type of farming more extensive and less economical of land. The leasing of land was made less attractive in this farming area than in the North-West and Eastern districts. Generally, W.A. avoided the Eastern States' difficulty of legislating for small farms in areas already leased by sqatters, by giving the cattle and sheep men a free hand in the more obviously pastoral districts, while encouraging small farmers in the South-West.

The drought and depression experienced by the Eastern States after 1890 passed over W.A. where rich gold finds were made. Solid farmers left drought-stricken areas in South Australia and Victoria, landed at Albany in great numbers and found good wheat lands north along the Great Southern railway. They brought strange new implements and stranger methods to the conservative West. To the disgust of the "Gropers," "t'Othersiders" successfully made farms and money where failure had been predicted.

The Gold Rush.

A still greater influx was caused by the discovery of gold. With finds in the Kimberleys, Yilgarn, Pilbara and the Murchison as a prelude, the opening up of Coolgardie, Kalgoorlie and Boulder (the "Golden Mile") made W.A. the foremost gold producing country of the period. In 1886 the year of the Kimberley find, the population was 39,000 (value of trade, about £1,400,000); in 1896 the population had increased over three times to 138,000, the trade to well over £8,000,000. This increase was mostly on account of mining. It was necessary to ensure that gold would bring about permanent development of the State.

Responsible Government.

The year 1890 saw W.A. at last with responsible government and in complete control of her own affairs. The leader of the government was the native born John Forrest, newly knighted, courageous explorer and far-sighted Surveyor-General, a Commissioner of Crown Lands interested in the establishment of a

firmly based agricultural settlement. Gold gave him the opportunity he needed to push ahead with his plans. With the help of the Irishman, Charles Yelverton O'Connor as his Engineer-in-Chief, Forrest pushed ahead public works that would make W.A. attractive to investors in gold and encouraging to those who wished to settle on the land. By the turn of the century the main Government railway lines were completed—Geraldton to Cue, Perth to Kalgoorlie, Albany, Bridgetown and the Midland Company's line from Walkaway to Midland Junction. Fremantle Harbour was nearly finished ready for the transfer of the mail port from Albany. An engineering wonder of the world—a pipe line to carry water from the coast range for 350 miles into the dry interior to Kalgoorlie—was completed in 1903. In the 10 year period from 1896 to 1906 population doubled and trade more than doubled, while cultivation increased from 112,000 acres to 461,000 acres, an indication of the success of Forrest's planning for the development of W.A.

Federation.

The advent of Federation found in W.A. divided against itself, "t'Othersiders" and miners favouring entry into the Australian Commonwealth with the conservative "Gropers" fearing control from Sydney and Melbourne. Sir John Forrest, the "Groper" asked his price—the transfer of the mail port to Fremantle and a promise to build a railway from Kalgoorlie to Adelaide as a concrete tie with the Eastern States. The Referendum was carried by a narrow majority. The tapering off of spectacular development in W.A. coincided with her entry into Federation. Her development in the first 47 years of the present century has been comparatively slow. There have been many setbacks. Soon came the First World War and the Great Drought of 1914, but in spite of these there was substantial expansion in the Wheat Belt.

Group Settlement.

Ambitious schemes for closer land settlement were put in hand after the war, W.A. taking early opportunities to co-operate with Empire and Commonwealth immigration schemes. In this State the establishment of the Group Settlements was closely linked with immigration. This scheme resulted in a partial success and a partial failure. It is true that there was an insufficient realisation of the difficulties in the way of the ideas of closer settlement that inspired the Australind settlers and John Forrest, but successful large-scale immigration was impossible in an Australian economy running down to the depression of 1929-33. Like the Australind experiment, however, immigrants came to W.A. and found a place in her economy, if not as farmers. Some settlers achieved notable success and a result of knowledge and experience gained was that the dairying industry was assisted to enter a period of rapid expansion. That alone, in some degree at least, justified the settlement plans undertaken by Sir James (then Mr.) Mitchell, now Lieutenant-Governor of the State.

Western Australia now looks forward to an expansion of her secondary industries encouraged by wartime decentralisation. A Government Department of Industrial Development has operated for several years and effort has been directed towards assisting the establishment and development o secondary activity in spite of competition with the Eastern States. An Electricity Commission has been appointed and is laying firm foundations to the electrification of the South-West where already work is in hand to extend the irrigation systems.

An extensive water supply scheme is proposed to relieve the Great Southern areas of their complete dependence on rainfall. The possibilities of closer settlement in the Ord River valley south-east of Wyndham are being carefully investigated. It is by such bold measures, scientifically planned and executed by trained personnel that the latent possibilities of Western Australia will be realised.

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Much valuable original material in the newly formed Archives Department of the Public Library awaits the attention of the student of Western Australian history.

CLIMATE AND METEOROLOGY

The types of climate represented in Western Australia are less numerous than is usual in many other regions of similar area, and may be broadly generalised as consisting of three main varieties—the tropical monsoonal type with a mainly summer rainfall of moderate reliability, an arid type with low and unreliable rainfall distributed somewhat irregularly throughout the year, and a Mediterranean type of reliable rainfall, the bulk of which occurs in the winter months.

The main factors controlling the Western Australian climate are:—(a) the latitudinal situation of the State, and its extension from approximately latitude 14° South to latitude 35° South, (b) the presence of ocean areas to the North, West and South of the State and (c) the presence of a vast land mass on and eastwards from the State's eastern boundary. The presence of this land mass may be regarded as Western Australia's major climatic misfortune, as, were Western Australia an island, the easterly winds which prevail over most of its eastern districts, instead of being usually dry as at present, would normally contain a high proportion of water vapour and might be expected to yield rains sufficient for agriculture over a large eastern belt which (except in the North and East Kimberley divisions) is now of little value.

In proportion to its area W.A. possesses remarkably few important topographical diversities and its climate is not much affected by mountains. In the south-western divisions, however, the north-west to south-east trend of river valleys with a convergence towards the south-east causes convergence and uplift in the north-westerly winds from which so much of the winter rainfall is derived and, besides affecting the distribution of the rainfall from this source, probably increases its amount. The south and south-west coastal districts are favourably situated in relation to the principal rain-bearing winds. In these areas the angle of incidence of the westerly winds upon the coast is fairly direct, and is most favourable for the cooler south-westerly winds, precipitation from which is more dependent upon orographical uplift, than for north-westerly winds which bear a higher proportion of moisture at the middle altitudes. The south-eastern coast east from Esperance has, however, an unfavourable trend. In the tropics the directional trend of the coastline is fairly favourable, particularly as regards north-westerly winds on the North-West coast, and the north-easterly winds in sections of the North Kimberley division.

The Western Australian tropics derive most of their rainfall from the north-west monsoon which operates during the summer months when the thermal equator is situated over the northern inland sections of Western Australia, and particularly over the latitude of the Pilbara region. The inland heat which attracts the inflow of moist maritime air from the northward is continuous and intense, and, under extreme conditions has been marked by as many as 160 consecutive days of temperature of 100 degrees or more at one meteorological station (Marble Bar). The resultant monsoonal indraft is, however, somewhat weak in proportion to the extent and intensity of the inland heat, probably as a result of the moderate altitude of the principal high temperature region.

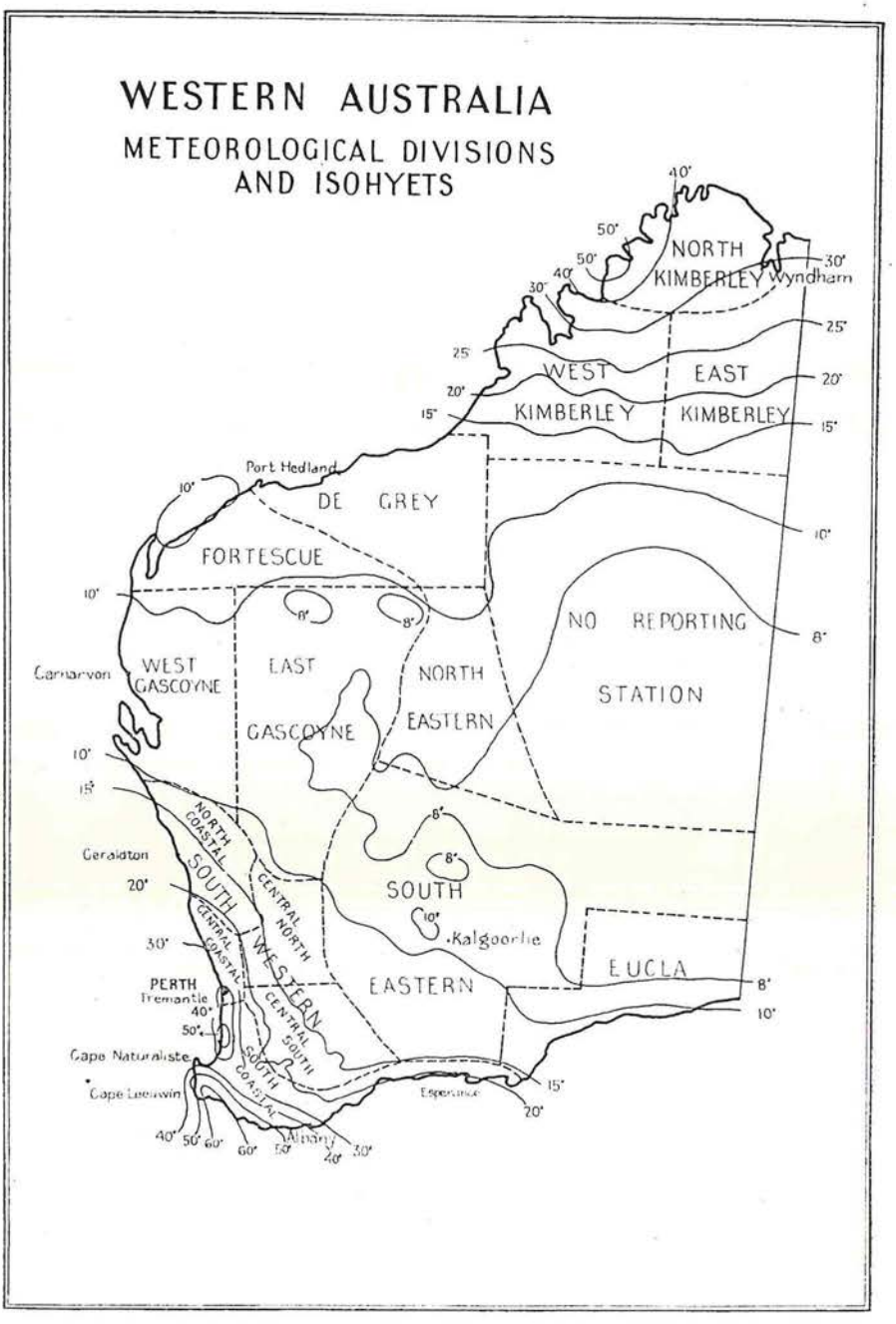
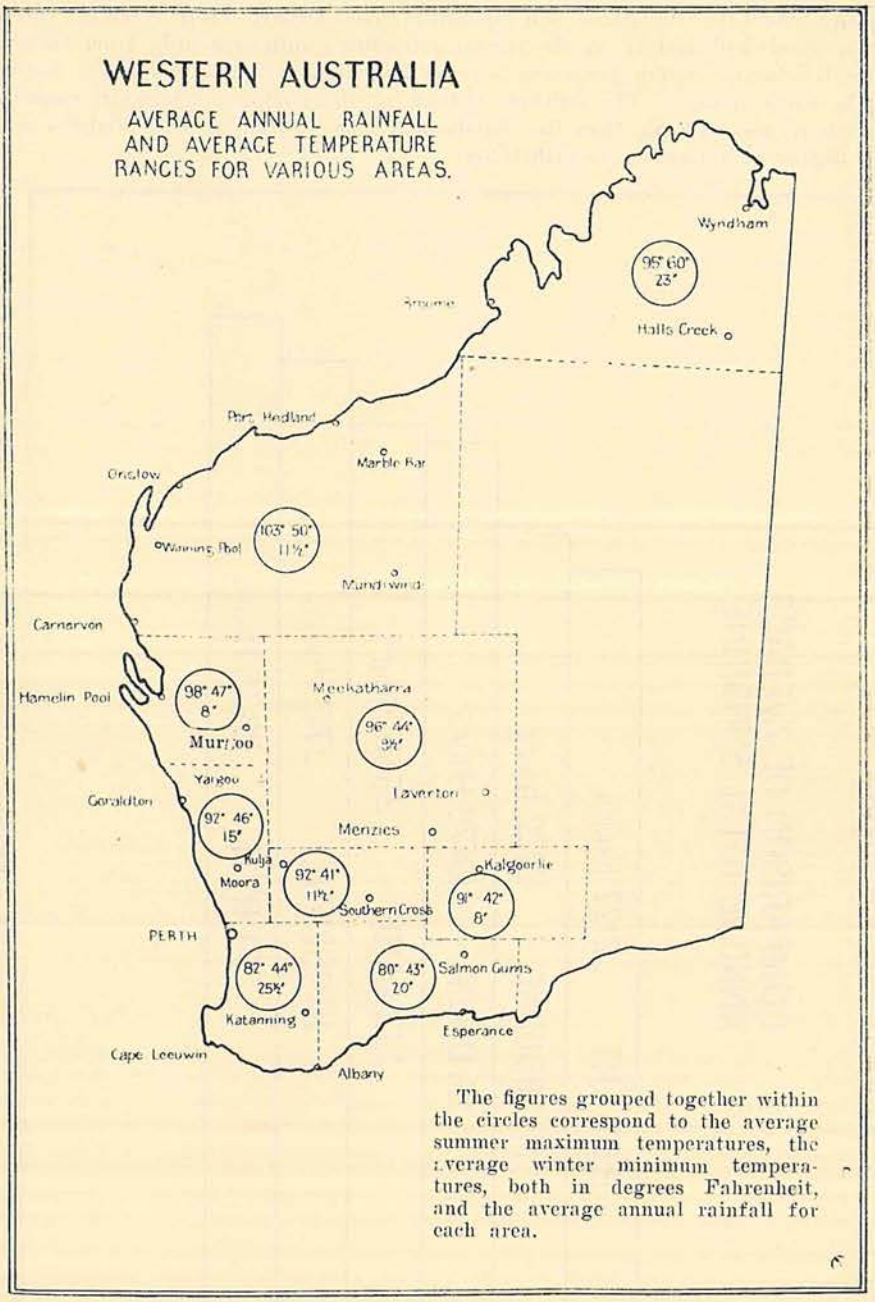


Fig. 1.

Were the heated areas of Northern Western Australia near sea level, the contrast in temperatures between air over land and sea respectively would be greater and the monsoonal indraft stronger and productive of a heavier rainfall.



Heavy North-West Rains. Fig. 2.

However, the rainfall amounts to more than 50 inches annually in the northern portion of the West Kimberley division, and, though steadily decreasing towards the south still exceeds 20 inches in the latitude of Broome. This climate has proved favourable for cattle raising particularly along belts running

southwards from Wyndham and eastwards from Derby. More recently, sheep have fared well mainly in the region extending south-eastwards from Derby. The Kimberley region possesses several important rivers suitable for large-scale water storage. The southern section of the northern monsoonal rainfall region is less valuable than the Kimberleys; the rainfall is much lighter, and its degree of reliability is rather low.

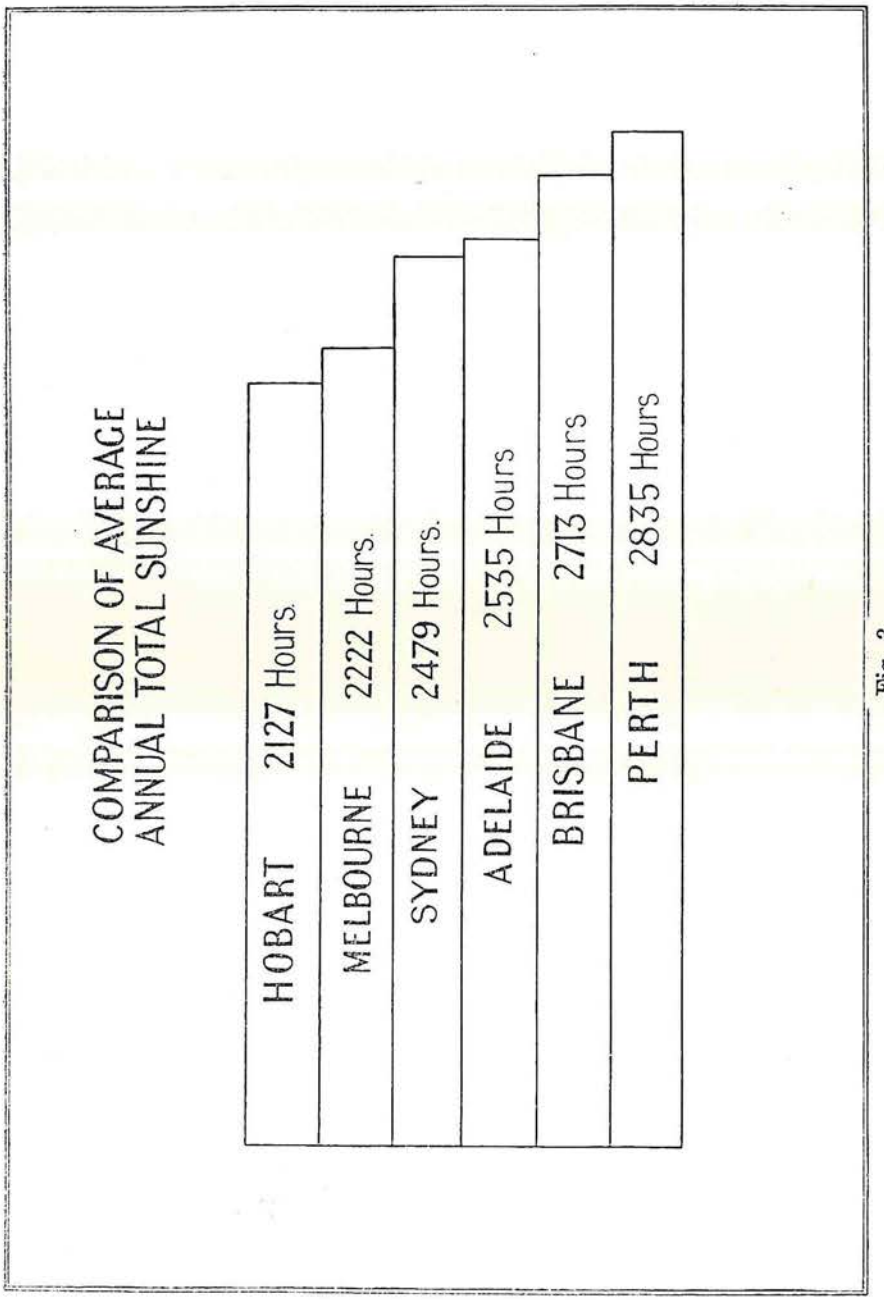


Fig. 3.

The central climatic region (the arid region) of Western Australia covers a vast area between the south-western divisions, the northern monsoonal rainfall region (the Kimberleys and the De Grey), and the South Australian border. It is situated too far north to obtain much benefit from the southern rainstorm system, and too far south to receive much rain from the North-West monsoon. Its rainfall is light, unreliable, and distributed irregularly throughout the year. Agriculture is impracticable in all except a few small sections of this region. The cattle and sheep raising industries—chiefly the latter—are established throughout a considerable part of this arid region; important aids are the drought resistant properties of much of the natural vegetation and at many places the existence of valuable and fairly reliable supplies of subterranean water; but the amount of grazing land necessary for the support of each unit of the sheep and cattle population is very large.

The most valuable portion of Western Australia is the south-western division which may roughly be defined as all that territory situated to the westward of a line extending north-westwards from Esperance on the south coast to a point situated on the lower Murchison River and about 100 miles from that river's mouth. This region has a Mediterranean climate with mostly mild to warm temperatures, and a rainfall received chiefly in the months from April to October. The amount and reliability of the rains attain a highly satisfactory maximum in the central and south coastal divisions, but diminish in the more northerly coastal sections, and suffer even greater diminution in the inland sections, and particularly those nearest the eastern boundary of the division.

The following table shows:—(i) The mean rainfall at certain selected stations during the period April to August inclusive and the percentage of occasions when the rainfall exceeds 75 per cent. of the normal; (ii) similar data for the wheat maturing period September and October; (iii) the mean rainfall during the main harvesting period November and December, together with the percentage of occasions upon which the rainfall does not exceed the normal by more than 25 per cent.

RAINFALL RELIABILITY FIGURES FOR THE WHEAT GROWING AREAS OF W.A.

Division.	April-August.		September-October.		November-December.	
	Mean Rainfall.	Reliability.	Mean Rainfall.	Reliability.	Mean Rainfall.	Reliability.
	Pts.	%	Pts.	%	Pts.	%
North Coastal ...	1,135	66	193	37	71	70
Central Coastal ...	2,582	77	583	55	125	63
South Coastal ...	2,439	81	655	50	192	75
Central North ...	908	68	189	45	92	70
Central South ...	1,080	68	291	45	121	78

N.B.—The reliability in November-December is the percentage of rainfalls which do not exceed 25 per cent. above the normal.

The reliability for April-August (the growing period), and for September-October (the maturing period), is the percentage of rainfalls which exceeds 75 per cent of the normal.

THE FAUNA OF WESTERN AUSTRALIA

Mammals.

Even a superficial glance at the composition of the mammalian fauna of this State reveals the fact that it may be divided into three main groups. (1) The northern assemblage closely related to that of the Northern Territory of which it is actually a part; (2) The Eremean which ranges over a vast area of the interior, impinging upon the North West coast at the Ninety Mile Beach and to a less degree even as far south as the Shark Bay area; (3) The South Western species whose distribution extends roughly from Geraldton in the North to Esperance in the South East with an uncertain eastern boundary as some forms seem to be limited by the 20-inch isohyet, while others extend much further inland, the Grey Kangaroo, for instance, being occasionally met with in the vicinity of Southern Cross. Indications of the gradual degradation of the climate may be seen here and there. The Boodie, *Bettongia lesueurii,* survives on islands in Shark Bay though when white settlement began it was not found on the mainland north of the Moore River. Another species the Tammar, *Macropus eugenii,* has not been found north of Perth for more than 50 years and yet is seen to thrive on the Wallabi group of the Abrolhos and on Garden Island off Fremantle. On the other hand the Quokka, *Macropus brachyurus,* so plentiful on Rottnest, still manages to exist in some of the secluded valleys in the Darling Range.

As an evidence of the retreat of the northern fauna the presence of *Lagorchestes conspicillatus* on Barrow Island may be cited. Like *Dasyurus hallucatus,* which still retains a foothold, it was once also common on the adjacent mainland. The presence of the little Flying Fox, *Pteropus scapulatus,* on the Fortescue and even as far south as Tamala Station, south of Shark Bay, must be regarded as an invasion in recent times.

Many Eremean species have a very wide range, the Marsupial Mole almost reaching the coast at Wallal and *Antechinomys* has been found near Lake Grace in the south west on more than one occasion. The Ghost Bat, *Macroderma gigas,* presumed to be on the verge of extinction in the eastern part of its range, survives in many localities south of the Fitzroy and west to the Pilbara where it has been collected in recent years.

The desert species *Dasycercus cristicauda* and several *Notomys* become extraordinarily abundant in places where the season is good and food plentiful. Plagues of *Mus musculus* have also been recorded.

The mammals of the South-West show a marked resemblance to those of South Eastern Australia. Some of them are identical, some classed as distinct sub-species while a few have been accorded full specific rank.

Pseudochirus occidentalis which still survives in a few scattered localities and the Potoroos, *Potorous gilberti* and *P. platyops,* now probably extinct though related to forms still flourishing in the Eastern States may be cited along with the Pleistocene, or perhaps even later Thylacine, Sarcophilus, Wombats and Koalas as evidence of the gradual deterioration of the climate which the animals were unable

to withstand. Now almost or quite restricted to the region are *Sminthopsis granulipes, Phascogale calura, Tarsipes spenserae, Pseudochirus occidentalis, Macropus irma, Macropus* (*Setonyx*) *brachyurus* and the most striking and anomalous *Myrmecobius fasciatus.* The only southern aquatic mammal, *Hydromys fuliginosus,* now being trapped for its valuable skin, is confined to the permanent fresh water rivers, lakes and swamps south of the Moore River and extending to the east of Albany.

The Birds.

The problem presented by the birds is of a different order. The South-West fauna seems to have had its origin mostly through South-Eastern Australia, supplemented by a minor amount of colonisation from the north. It cannot be said, as some earlier writers maintained, that the avifauna of the South-West was so peculiar or distinctive as to demand a distinctive sub-region. Through being a derivative from South-Eastern Australia fewer species are represented here than in the East, while furthermore, remarkably little evolution has continued to produce new types. Many of our birds show little differentiation; many differ but sub-specifically and where full specific distinction is admitted as in the case of the Western Spinebill, *Acanthorhynchus superciliosus,* the Red Winged Wren, *Malurus elegans,* the Blue breasted Wren, *Malurus pulcherrimus,* the Red-eared Firetail, *Zonaeginthus oculatus,* and the Western Magpie, *Gymnorhina dorsalis,* such species are clearly recognisable as representative species (semi-species in modern parlance) not far removed from Eastern Australian or in the case of the northern immigrants, Northern Australian allies. Despite these general principles obtaining it must be admitted that some highly distinctive types do occur in the South-West. The W.A. King Parrot, *Purpureicephalus spurius,* belongs to a genus, the only one peculiar to the South-West. It apppears to be a survival of a form allied to the common ancestor of the Ring-necked Parrot, *Barnardius,* and the Rosellas, *Platycercus,* which formerly must have had a wider distribution. A more distinctive local form in the South-West is the White breasted Robin, *Quoyornis georgianus,* which appears to have had a Northern origin, its only existing ally being *Quoyornis leucurus* of the Northern mangrove belt.

Our peculiar and recently extinct Noisy Scrub Bird, *Atrichornis clamosus,* (the last-known specimen was collected at Albany in 1889) is a close ally of the Eastern *A. rufescens,* now lingering as a relict form in some of the sub-tropical brushes of northern New South Wales and southern Queensland. It is quite likely that, as mentioned in the remarks upon the mammals, other forms have become extinct because of the sub-recent deterioration of the climate, but bird remains are rarely preserved as fossils. It is not unlikely that the Lyre Bird, Satin Bower Bird and other elements of the Bassian bird fauna once existed here. Certainly had the Noisy Scrub Bird become extinct a century before it did no one would have suspected its former presence here on the basis of the existing distribution of the genus in the East.

Many of the South-Western birds are limited in their range northwards by ecological barriers which may vary, such as rainfall, and the threshold limits differ widely between species. It cannot be said that any major break in bird distribution is met with until we come to the Ninety-Mile Beach and its desert hinterland which separates the Kimberley Division from the rest of the State. This is a fundamental bird dividing line which does not appear to be wholly due to ecological factors and there is no perceptible outlier of Kimberley types in the Pilbara region as can be recognised by the botanist, the mammalogist and the herpetologist.

In the Kimberley country there are whole series of birds not occurring further south in this State, though some of them penetrate as far south as Tasmania in the East. Such birds include the Scrub Fowl, *Megapodius,* the whole of the Fruit Pigeons, *Treronidae* Native Companion, White Ibis, the Lorikeets of the genera *Trichoglossus* and *Psitteuteles,* White Cockatoo, *Kakatoe galerita,* and among the Passeres all of the Pittas, Rufous Fantail, the Friarbirds, many of the Weaver finches and many others. A few Northern species have, however, penetrated varying distances to the south but there is no common southern boundary—one species, the Brown Honeyeater, *Stigmatops ocularis,* has even managed to colonise the State as far as the south coast. It is interesting to note that in the East it has penetrated no further south than Sydney.

Introduced species are few; they comprise the Indian and African Turtle Doves, the European Goldfinch and, most unfortunately, the Kookaburra which is playing havoc with the small bird life in those parts of the South-West where it has become established.

The Reptiles.

Turtles and tortoises are represented by marine and fresh water forms. The marine turtles though usually confined to tropical seas occasionally venture further south. Both *Chelonia mydas,* and *Chelonia imbricata* have been found near Fremantle in their young stages whilst adult *Caretta caretta* and *Dermochelys coriacea* have been recorded off the south coast. Of the fresh water Tortoises *Emydura macquarrii* is known from the Kimberley ranging as far south as the Fitzroy River system. *Chelodina steindachneri* inhabits suitable localities from the De Grey to the Murchison extending inland at least as far as the neighbourhood of Wiluna. The South-Western *Chelodina oblonga* seems to be confined to fresh water from the Moore River in the North to the Pallinup in the South-East. Its range appears to be almost co-intensive with that of the fresh water Crayfishes *Cheraps* spp., and the fishes *Galaxias Nannoperca* and *Bostockia*; the two latter of which have also been noted in the Phillips River further east where the tortoise appeared to be absent.

Our Crocodilians are confined to the Kimberley area. *Crocodilus porosus* in the estuaries and *Crocodilus johnstoni* in the fresh water portions of the rivers.

About 60 species of snakes are known of which one *Demansia nuchalis* (s.l.) seems to be increasing in the settled areas probably owing to the abundance of house mice which seem to be a favourite article of diet (one opened last summer contained no less than seven in an undigested state). On the whole snakes are scarce though more prolific in certain localities. About a dozen blind snakes are recorded from Western Australia of which several southern forms, *Typhlops pinguis, T. bituberculatus, T. wiedii* and *T. australis* occur also in the Eastern States. Through lack of knowledge the range of many of the others within Western Australia is still uncertain.

The *Boidae* contain three genera, all more or less widely distributed. *Liasis fuscus* is confined to the Kimberley Division. *L. olivaceus* extends as far south as Cue and *Aspidites melanocephalus ramsayi* has been found as far south as Beverley.

Of the *Colubridae* the Green Tree Snake, *Dendrophis punctulatus,* the Brown Tree Snake, *Boiga fusca,* and the two fresh water snakes, *Cerberus australis* and *Fordonia leucobalia* have as yet not been recorded south of the Fitzroy River system. *Myron richardsoni,* although reputed to come from "North-West Australia" is not in the Museum collection and may be a Northern Territory species. Eleven sea snakes have been listed. They are essentially tropical but at times odd ones

may come further south. *Pelamis bicolor* is washed up on metropolitan beaches every winter and occasionally appears as far south as Bunbury where *Hydrophis ornatus* has also been collected. *Hydrophis elegans* is known from Cottesloe.

The Elapine snakes are represented by 25 species in Western Australia. *Denisonia gouldii, Rhynchelaps bertholdi* and *Pseudechis australis* seems to be everywhere in suitable environments. *Demansia psammophis, D. modesta, Rhynchelaps semifasciatus* and *Acanthophis pyrrhus*, absent in the Kimberley Division, extend almost as far as the lower South-West. *Denisonia fasciata* is an inland form extending as far north as Cue. *Rhynchelaps fasciolatus* reaches Geraldton and *Furina bimaculata* is known to range as far north as Menzies. *Brachyaspis curta* often called the Desert Snake possibly because it occurs in the Eastern Goldfields, has a wide range in the South-West. It occurs near Perth as well as at Busselton, the Albany district and Esperance. True desert species such as *Rhynchelaps anomalus* which reaches the coast at Onslow and *Pseudelaps diadema* known from King Sound, Wurarga and Gnows Nest on the Murchison are included in our fauna.

The puzzling Brown Snake, *Demansia nuchalis* (including *affinis*), has a very wide range, *affinis* being the form usually met with on the coastal plain and *nuchalis* east of the Darling Range and to the north. Coastally it is the "Kabarda," on the Wheat Belt the name "Gwardar" has been adopted. Confined to the South-West and Esperance the Western Tiger Snake, *Notechis scutatus* seems to have adopted a coloration and a mode of life separating it from its eastern kin. It is usually found in situations where frogs abound and so not very far from fresh water. In all probability it will in time receive recognition as a distinct sub species. Other snakes confined to the South-West are *Denisonia coronata*, a melanic form of *D. gouldii, Elapognathus minor*, (Bornholm and Denmark), *Furma calonota*, (near Perth only) and *Rhinhoplocephalus bicolor* (Wagin and Augusta). The Eastern *Denisonia coronoides* has been recorded from Mondrain Island in the Archipelago of the Recherche.

The lizard fauna of the State is a rich one when compared with the snakes comprising 138 species and varieties belong to 27 genera. Of these 12 are confined to the Kimberley or northern area. They include the bizarre *Nephrurus asper* and *Chlamydosaurus Kingi;* also the remarkable *Diplodactylus ciliaris* which like its southern relative, *D. spinigerus*, from which it is easily separated by the arrangement of the soft spines on the tail, can expel an evil smelling and noxious liquid in self defence. Another species not found south of the Fitzroy is *Chelosania brunnea*.

The lizards from the North-West or Pilbara are mostly Eremean types. *Tiliqua occipitalis multifasciata* reaches the coast at Wallal on the Ninety Mile Beach and accompanied by other Central Australian forms has been found near Shark Bay. Two species of *Nephrurus* occur, *N. wheeleri* and *N. laevis*, the latter being known from as far south as Gibberding, East of Wubin. Agamids and Skinks are predominant in the interior where but four of our ten slow worms have as yet been recorded. *Pygopus baileyi* is known only from the goldfields. Of our nine goannas four are known from the far North, four from the North-West, five from the centre and two only from the higher rainfall area of the South-West. One of these, *Varanus gouldii*, has often been found guilty of using termite mounds as hatcheries for its eggs.

Some of our species are not limited in distribution by ecological factors. The geckoes *Gymnodactylus milii* and *Peropus variegatus*, the snake-lizard *Lialis burtonii* and the agamids *Amphibolurus maculatus* and *A. reticulatus* have a range

extending from the far north to the south coast. The central Australian *Amphibolurus barbatus minor* has been collected at Broome, on the goldfields and wheat belt whilst the still smaller *Amphibolurus barbatus minimus* is known from the Abrolhos and the South-West. Of special interest is the genus *Lygosoma* because of the range of forms from active running species with well developed limbs to the wriggling "sand snakes" whose fore limb is a "bud" and the hind limb tiny with two useless toes.

The Amphibians.

Frogs are represented by a number of species belonging to two families, the *Hylidæ* and the *Leptodactylidæ* (*Cystignathidæ* auct). They may be sub-divided into three main groups—the Northern, the Eremean, and the South-Western. In the Kimberley area are to be found the following Hylids: *Hyla aurea, H. nasuta* and *H. latopalmata* which are not known to occur further south, together with *Hyla rubella*—known to range from the far north, Napier Broome Bay, into the interior at least as far south as the Geraldton-Cue Railway, and so has a range almost coinciding with that of the Spangled Perch, *Terapon unicolor*. In the South Western area, which includes the Avon River system, *H. aurea* and *H. adelaidensis* occur with *H. cyclorhynchus* further to the east, thus showing a close affinity to South Eastern Australia, supported by *Heleioporus australiacus, Limnodynastes dorsalis* and *Crinia signifera* among the *Leptodachylids*. Many of this family have a wide distribution, particularly the forms adapted to more arid conditions, but several are more circumscribed. *Notaden nichollsi* has been found in the Kimberley Division, at the northern end of the Canning Stock Route and on "the Rabbit Proof Fence, far North." *Cyclorana platycephalus* is a true inhabitant of the Eremea where it may be accompanied by *Heleioporus wilsmorei* and *H. centralis*. On the wheat belt *H. albopunctatus* is dominant with *H. pelobatoides*. *H. australiacus* survives in the Darling Range and *H. eyrei* is abundant on the coastal plain to the north and south of Perth. Four Crinias are confined to the South-West proper where *Limnodynasts dorsalis* also occurs. *Pseudophryne guntheri* ranges as far north as Geraldton with *P. occidentalis* in the eastern wheat belt and the Eastern Goldfields. Of more circumscribed range are *Glauertia russelli,* known only from the valley of the Gascoyne River, the remarkable *Myobatrachus gouldii,* a true denizen of the South-West as far north as Geraldton, and the unique *Metacrinia nichollsi* of the "Karri Country" where participants in the excursion may be able to find evidence of the quaint association this frog sometimes has with the Bullant, *Myrmecia regularis*. Nothing is known of the frogs of the Pilbara where interesting types doubtless occur.

The Fishes.

The fish fauna of the southern half of the State both in respect to Teleosts and Elasmobranchs, resembles in general that of Eastern Australia. The food fishes are broadly similar, though the Eastern visitor may be troubled by a different usage of vernacular names. Those standing in highest esteem are the Snapper, *Pagrosomus auratus,* and the Jewfish, *Glaucosoma herbraicum,* the latter being congeneric with the Pearl Perch of New South Wales. The Jewfish of the East, *Sciaena antarctica,* is known as the River Kingfish in Western Australia and has a considerably more northward range than it has in the East.

In the absence of a trawl fishery some of the better-known Eastern fish are little seen on the local market, but most of them occur, though the Deep Water Flathead is represented by an allied species, *Neoplatycephalus conatus* off the south coast. Several well known economic species are limited to the Flindersian

Region and hence do not extend east, in strength, beyond South Australia. These include the Sea Herring, *Arripis georgianus,* and the King George or Spotted Whiting, *Sillaginoides punctatus.*

An interesting difference between similar species, east and west, is the much larger size to which some of the western species grow. This phenomenon is seen in the western race of the Salmon, *Arripis trutta,* which reaches a weight of 20 lbs., the Sweep, *Scorpis aequipinnis,* the King George Whiting, the Gummy Shark *Mustelus antarcticus,* the Tailer, *Pomatomus saltator,* and many others.

The fresh waters are characterised by poverty of species and, except for the Fresh Water Catfish, *Plotosus unicolor,* are diminutive in size. The forms represented are the Pigmy Perch, *Nannoperca vittata,* the W.A. Minnow, *Galaxias occidentalis,* and the nocturnal Mud Fish, *Bostockia porosa.* There are no fresh water eels in south-western Australia, but a Lamprey, *Geotria australis,* ascends the rivers to breed. Further north, the Spangled Perch, *Terapon unicolor,* has an immense range in the interior.

The economic exploitation of the fisheries has been largely confined to netting on the estuaries and marine beaches and hook and line fisheries on off shore banks. Productive but not yet exploited trawling areas are known to occur in the Great Australian Bight and off the north-west coast. Extensive occurrences of pelagic fishes, Pilchards, *Sardinops neopilchardus,* Mackerel, *Scomber australasicus* and Tuna have been disclosed by recent aerial surveys by the C.S.I.R. but the existing fishery operatives possess neither the specialised gear and technique nor the vessels to exploit them. Experiments aiming at solving the admittedly difficult problem of the "mechanics of capture" of these fish are now in hand.

The more important existing fisheries comprise the following:—The salmon fishery on the south and lower west coasts; the Abrolhos Islands fishery for crayfish (*Panulirus longipes*); the snapper fishery in the Geraldton-Shark Bay region and the west coast estuarine fisheries where the dominant species are mullet (*Mugil dobula*) and yellow-eyed mullet (*Aldrichetta forsterii*). (Whitley.)

Re-establishment last year of the pearlshell industry on the north-west coast foreshadows the production of pearlshell, *Pinctada maxima,* on a scale comparable with that of pre-war years. The Shark Bay pearlshell, *Pinctada radiata,* is available for commercial exploitation and an investigation of the beds is to be made within the next few months.

The Invertebrate Groups.

The Insects.

In a short note on the insects of Western Australia which appeared in the Year Book for 1898-99, the late A. M. Lea expressed the opinion that it was quite probable that there are 30,000 species of insects indigenous to the colony, of which more than half are new to science. Much has been learnt since that time, and there is no suggestion that Lea's figure is an over-estimate.

The varied environmental conditions represented by climate, geological structure, and vegetation, are naturally reflected in the insect fauna which present a remarkable diversity of types. But it is again possible to distinguish three main groups:—

(1) The Northern Territory assemblage which extends over the Kimberleys and has even sent advanced parties into the North-West as far south as Roebourne and the valley of the Fortescue.
(2) The much restricted South-West with many endemic species, and
(3) The vast ill-defined Eremean mass which may be subdivided into hosts of species linked with the Mallee, the Mulga, or the Desert zones.

Lepidoptera.

The visitor from the East cannot fail to be impressed by the poverty of our butterfly fauna; the bright gaudy tropical forms are absent, their place being taken by the less conspicuous Brown and Skippers. The swallow-tail (*Papilio demoleus sthenelus*), the Mistletoe butterfly (*Delias aganippe*), and the Lesser Wanderer (*Danaida chrysippus petilia*) are no strangers to Perth, occasionally appearing in swarms. Most of our south-western species are, however, members of the *Hesperiidæ, Skippers,* or *Lycænidæ,* Blues. Of the former, 21 species are recorded for the State, of which no less than 15 occur in the South-West or are peculiar to that area. *Anisynta sphenosema, Anisyntoides argenteo-ornata* and *Taractrocera papyria agraulia* occur in large numbers near Perth during their season. Perhaps in course of time the rareties of the lower South-West will prove less so when their habits are better known.

Among the *Lycænidæ* the smaller less conspicuous forms are the most abundant. *Ogyris amaryllis, Ogyris idmo, Lampides bœticus, Ialmenus inous,* as well as several species of *Candalides* occur in the areas visited by the excursion, though not necessarily flying at the time of the visits.

The *Satyridæ* or Browns are represented by three species in the southern part of the State, the fine *Heteronympha merope duboulayi* being the most attractive. The other species *Xenica Klugi and Xenica minyas* are extraordinarily plentiful during their season.

The Lepidoptera-Heterocera are numberless and offer the widest scope to the research worker, as so many species are as yet undescribed. The fine *Antheræa helena* (*Saturniidæ*) and *Cartea saturnoides* (*Oenochromatidæ*) are often brought to the Museum by their finders, and so are the less interesting *Cossidæ* and *Hepialidæ* as well as the destructive Orange-piercing Moth (*Ophideres materna*), whose range seems to be almost co-extensive with the citrus orchards.

The Diptera.

Diptera are with us at all times of the year. They range in size from the huge Robberflies (*Phellus piliferus*) from the interior, with a length of 2 inches and a wing-spread of 3½ inches, and the more coastal *Phellus glaucus,* slightly smaller, which is so common on Rottnest in the height of the summer, to the tiny sandflies and other minute forms.

Bombylids or Bee-flies attract attention by their erratic and speedy flight and long proboscis, which, however, is not used on man after the fashion of the unpopular March-flies (*Tabanidæ*). Not very unlike these and likewise never mistaken for March-flies are the interesting *Nemesrinidæ,* of which several species are known.

The Neuroptera.

The Neuroptera of the State are varied and often distinctive. In addition to the various antlions with their familiar pits, there are forms which hunt their prey actively on the ground or upon the vegetation—*Stilbopteryx napoleo, Acmonotus magnus* and *Periclystus aureolatus* may be mentioned. In addition to the many so-called golden-eyed Lacewings, there are present the remarkable Spoon-winged Lacewings, *Chasmoptera,* of which two species are known; three forms at least of the Threadwing, *Croce,* and the Mothwings, *Psychopsis.* Mantispids and Ithonids are also known to occur.

The Hymenoptera.

All our Bees except the tiny *Trigona* of the far North are solitary forms belonging to the families *Colletidæ*, *Hylæidæ*, *Andrenidæ*, *Melectidæ*, *Anthophoridæ*, *Megachilidæ*, *Xylocopidæ*, and *Ceratinidæ*, by far the most conspicuous being the Colletid and Megachilid species on account of their size and coloration. The Leafcutter Bees also come under notice because of their habit of cutting pieces out of the leaves of rose trees for the making of their nests, these leaves apparently being more suitable than the stiffer leaves of the native vegetation. Although they may differ in size they resemble one another fairly closely in general outline and coloration, so that they are easily recognised.

The Anthophorids are banded Bees, rather small in size and distinguished by their rapid and hovering flight. They are present during spring and summer, and like the Colletids usually make their burrows in the soil. They are now and again accompanied by the Melectid Cuckoo Bees, *Crocisa*, of which two species are known to occur in our area.

The Ceratinid Bees, which differ from their fellows by preferring to make their nests in the stems of vegetation, are mostly small, many species having a smooth polished thorax and a reddish abdomen. Hylæids differ from these in that they may be larger or smaller and usually have contrasting markings on the head and/or thorax. Their numbers are surprising; on one occasion a few sweeps of a net over tea-tree flowers yielded more than 250 specimens.

The small *Andrenidæ* are at times equally numerous, especially *Halictus victoriæ*.

By far the most conspicuous are the hairy burrowing Bees of the family *Colletidæ*. Most of them are of fair size, and some of them most attractive because of their bright colours. The banded *Paracolletes marginatus* is very common near Perth in the early spring. *Paracolletes friesei*, with its red-haired thorax and steel blue abdomen occurs on Rottnest, whilst a related form with a grey-haired thorax has been observed in hundreds burrowing in a small grass plot in front of a local post office in September and October. One of the largest and most conspicuous W.A. species is *Stenotritus glauerti*, of the Wheat Belt, no less than 21 millimeters in length and coloured a bright metallic green.

Sphecid Wasps are much in evidence during the spring and summer, the black and yellow *Ammophila* and the various black species of *Sphex* being dominant forms.

Of the *Vespidæ*, *Polistes*, our only social wasp, is known to occur in the Kimberleys, and so far has not been reported from further south.

The *Mutillidæ* or solitary ants vary considerably in size and colour, one of the largest, the black *Ephutomorpha rugicollis* is the most widely distributed and best known. The Hairy Flower Wasps, *Scoliidæ*, can be seen in two-colour forms, the blackish and yellow and black species, the huge females measuring up to 35 millimetres. That Thynnids should be very abundant and varied in size and colour is not surprising, as Australia is considered to be the headquarters of the family. The energetic collecting by the late R. E. Turner may be regarded as an indication of the wealth of species that can be expected to occur in Western Australia. The familiar Sand Wasps or Spider Hunters, *Psammocharidæ*, call for no comments.

The Ant population of Western Australia is immense, so that an adequate summary is impossible within these limits. At the same time attention may be directed to some of the Ponerines. Of the nine species of *Myrmecia* (s.s.), *M. regularis* may be mentioned. Its range is more or less that of the karri, where it may at times be found harbouring in its nest a number of individuals of the

frog, *Metacrinia nichollsi*, as tolerated guests. There are about twice as many species of the smaller *Promyrmecia*, or Jumpers, some red and black, others black, but all provided with stings that are more or less efficient. *Rhytidoponera*, with several species, has a very wide range, whilst *Leptogenys neutralis* is confined to the South-West. The remarkable *Lithomyrmex glauerti* has as yet been found only in the valley of the Irwin River, where it was collected during an excursion of the Perth meeting of 1926.

Cuckoo Wasps, *Chrysididæ*, are represented by a metallic blue-green species of the genera *Tetrachrysis*, *Hexachrysis*, *Heptachrysis* and *Stilbum*, the last-named being the largest and best known member of the family.

Of the other families, the *Evaniidæ* contain many quaint forms—*Evania*, *Hyptiogaster* and *Gasteruption* (*Fœnus*) being represented. Two species of Long-tailed Wasps, *Megalyridæ*, *M. fasciipennis* and *M. Shuckardi*, have been recorded from W.A. The *Tenthredinidæ* were revised by Benson a few years ago.

The Coleoptera.

In 1939 Burr estimated that 250,000 species had already been described. It, therefore, is not surprising that the beetle fauna of Western Australia should be enormous, bearing in mind that many forms yet remain to be made known to science. By far the most attractive and conspicuous family is the *Buprestidæ* or Jewel Beetles with over 160 described Western Australian species ranging in size from *Stigmodera heros*, 65 m.m. long to a tiny *Neocuris* measuring but 3, and including almost every conceivable colour.

Of the vast family of Scarabs, the Cetoniids or Rosechafers are the most gaudy: the "W" Beetle (*Eupœcila inscripta*) is regarded as a curiosity and *Trichaulax phillipisi* as a nuisance, for it enters the hives of honey bees after the honey.

Much work still remains to be done before a satisfactory account of our Tiger Beetles, *Cicindelidæ*, can be written. It would seem that each of our lakes east of the Darling Range has its own peculiar form. Little or nothing is known of the coastal species of the North.

The *Cerambycidæ* or Longicorns include a variety of types and sizes, including the gigantic *Eurynassa* and the wasp-like *Hesthesis*, of which several species are known. The Tenebrionids are mostly dark unattractive forms, though the Pie-dish Beetles *Helœus* and *Pterohelœus* are often picked up because of their dish-like appearance resulting from a flange which has developed around the body; some are flighters.

Finally, the large family of carnivorous ground Beetles, the *Carabidæ*, must be mentioned because of their size and variety. The species of *Scaraphites* and *Eurycaphus* include some of our largest beetles, and *Carenum* some of the most brightly coloured. All are carnivorous and as far as we know are nocturnal.

Space does not permit even a reference to the other groups of insects nor to the host of other Invertebrates known to occur in or around Western Australia.

For a concise summary of many which already have been worked to some degree, the reader is referred to Professor G. R. Nicholls' "The Composition and Biogeographical Relation of the Fauna of Western Australia," Ref. A.N.Z.A.A.S., Vol. XXI., 1933, pp. 93-138. A history of Zoology in Western Australia up to the year 1840 has been compiled by W. B. Alexander and published in the Journal, Nat. Hist. Sci. Soc. W.A. Vol. V., 1914, pp. 49-64, and in Journals R. Soc. W.A., Vol. I., 1916, pp. 83-149, Vol. III., 1918, pp. 37-69. The five volumes, Fauna Sudwest-Australiens by Michaelsen & Hartmeyer, 1907-1930, and the Reports of the Swedish Expedition under Dr. E. Mjoberg, contain a wealth of information.

OUTLINES OF THE VEGETATION

Western Australia can be conveniently divided into three phytogeographical-climatic provinces, each of which has its own distinctive flora—the Northern Province, the Eremean Province and the South-West Province.

The Northern Province.

The Northern Province is characterised by a summer rainfall of a monsoonal character, the precipitations ranging on the average from above 60 to 12 inches, extending from about the end of November until the end of March. This is followed by a drought period from April until November, a limiting factor of considerable importance. The vegetation is therefore in the main of a savannah character, ranging from savannah to savannah-and-monsoon-woodland, with Triodia steppe in the drier areas. The rivers on the Hann Plateau, fed from springs and large swamps, are some of them permanent, and from the telluric water available extensive paludal and riverain formations are developed, the latter sometimes being large enough to be termed gallery forests. Savannah and savannah woodland however, are the dominant features of the area, and it is only where the red sand and climatic aridity are too severe for these that Triodia steppe becomes dominant.

The herbaceous vegetation is mostly composed of grasses. The perennial species are generally of a tussocky nature, such as species of *Eriachne, Astrebla, Themeda, Schima, Heteropogon, Xerochloa, Triodia, Aristida,* with *Chionachne, Oryza,* and numerous other species along the watercourses. Other important herbage is provided by the families *Amarantaceae, Papilionaceae, Goodeniaceae, Portulacaceae* and *Aizoaceae.* The smaller shrubs are poorly developed, and consist principally of *Euphorbiaceae, Papilionaceae, Malvaceae, Sterculiaceae* and *Tiliaceae.* The larger shrubs and trees offer a wide range. *Eucalyptus* in general provides the keynote of the savannah, some, like *E. clavigera* with an *Angophora*-like habit, others, like *E. platyphylla, E. perfoliata,* and the hairy-leaved *E. setosa* have no counterpart in the south. In those formations dependent upon telluric water, *Eucalyptus* is either absent or poorly represented, and its place is taken by other plants, mostly representative of the Indo-Melanesian Element—trees like *Ficus, Sarcocephalus, Sesbania, Cryptocarya, Albizzia, Pithecolobium, Canarium, Buchanania, Eugenia, Planchonella, Lucuma, Mimusops, Randia* and *Gardenia.*

In the monsoon-woodland we find *Cochlospermum, Dolichandrone, Livistona, Terminalia, Mallotus, Gyrocarpus, Cycas, Erythrophloeum, Celtis, Trema, Melia, Owenia, Xylocarpus, Byronia, Zizyphus, Lumnitzera, Mimusops, Maba, Diospyros, Strychnos, Ehrhetia, Callicarpa, Premna, Cleorodendron, Dolichandrone, Plectronia, Ixora* and *Pavetta.* Here and there are patches of *Pandanus,* one species of which is however restricted to the banks of the streams. A strange note is added by *Adansonia,* which grows both in the monsoon-woodland and the savannah between the Victoria and Fitzroy rivers, the other species of this genus being in Africa and Madagascar. In the savannah, apart from *Eucalyptus* we commonly find *Bauhinia, Gyrocarpus, Acacia, Dolichandrone, Atalaya, Mallotus, Terminalia, Cassia, Erythrophloeum,* and a few other trees, some of which are deciduous. In the monsoon

woodland, a large number are deciduous, and while *E. platyphylla* commonly loses many of its leaves, *E. brachyandra* may become almost totally deciduous.

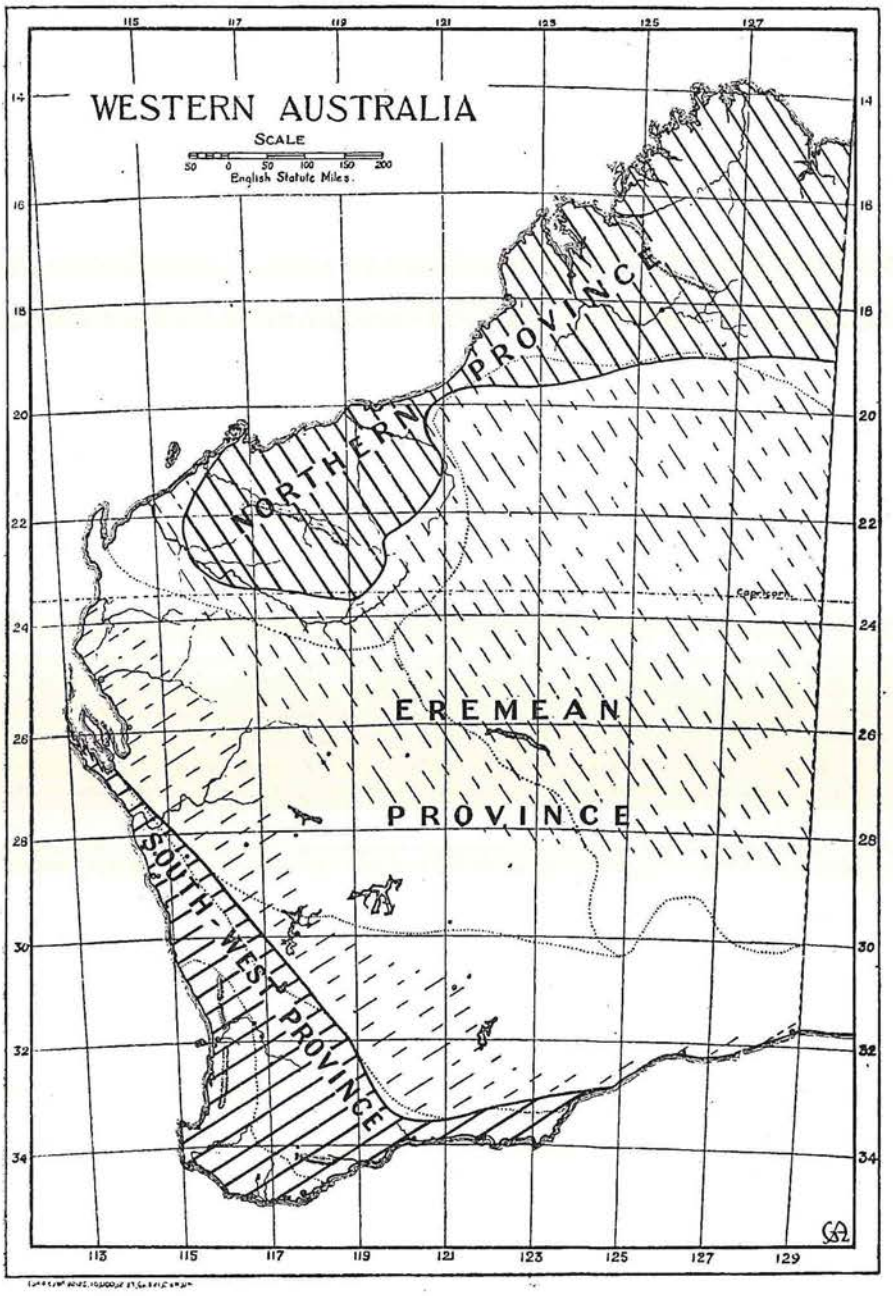


Fig. 4.—Vegetation and Climate Provinces.

In the northern Kimberley, especially on the Hann Plateau—a region consisting of a deeply dissected high plateau—the formations are varied, ranging from *Eucalyptus* and *Triodia* on the arid sandstone plateaux to paludal and riverain

mesophytic associations in the more favoured depressions. To the south of the Fitzroy River, the country has a low rainfall, and the red sand dominates the landscape. The country is here given over to harsh *Triodia* steppe, the principal species being *Triodia pungens*, with shrubby species of *Acacia* and bloodwood trees, the whole association with well-spaced individuals. This formation in turn gives place to the true desert with its sand ridges and clay or stony flats, often saline. *Triodia* remains dominant over a wide area in Western Australia. Although it is essentially a species inhabiting those regions which have principally a summer rainfall, it does, to some extent, extend as far south as the latitude of 32 degrees, but always associated with red sand or the rocks of the Nullagine Series and is only really at home in the regions north of the tropic of Capricorn.

The Eremean Province.

The Eremean Province, as its name implies, is the dry or desert province in its broadest sense. The rainfall is capricious, never averaging more than 13 inches per annum, with a wet season of four or five months, during which the average precipitation is less than seven inches. This season extends from December to March in the nothern zone, January to April in the middle zone, and May to August in the southern zone. There are three principal formations: Triodia steppe, mulga bush, and sclerophyllous woodland, interspersed here and there by saline depressions commonly called "salt lakes" or "salt pans," which are usually portions of ancient watercourses. In addition the sand-heath formation, so common in the South West Province, occurs usually in the southern zone, occupying high sandy ground. The Triodia steppe formation is much like that of the Northern Province, but more extensive, and *T. pungens* less dominant, being associated with other species, notably *T. Basedowii* and *T. lanigera*, while to the south, *T. irritans* becomes dominant. The Triodia steppe is the common formation of the northern zone, where it sometimes extends for miles without the amelioration of a single tree, extending eastwards to and participating as a major factor in the red sandy desert. Towards the coast a few trees enter into the general physiognomy, especially *Acacia pyrifolia*, some *Proteaceae*, (*Grevillea* and *Hakea*) and a few stunted *Eucalyptus* trees, and shrubs, notably *Cassia*. As in the Northern Province, *Triodia* holds sway in the red sand, and the stony soils of the Nullagine series of rocks. It also encroaches to some extent into the formation next to be described.

The mulga bush which occupies in the main the middle zone of the Eremean Province, is an association of species of *Acacia* all possessing phyllodes, mostly rigidly branched, with dull glaucous foliage. Associated with these are a large number of species of *Eremophila* which assume many forms, ranging from the broad bright green-leaved *E. Fraseri*, heavily lacquered with a viscid resin, to species thickly invested with wool or the pinoid and glutinous *E. abietina*. Few genera are of greater interest from this point of view. Remarkable for the size of their blooms, many of them also possess calyces which enlarge and become coloured after anthesis, and may be even more coloured and attractive than the corolla. Other plants which take an active part in the composition of the mulga bush are species of *Cassia*, *Dodonaea*, and the *Chenopodiaceae* (especially *Kochia* and *Bassia*). The mulga plants themselves comprise several species. *Acacia aneura*, commonly called the "sugar-brother" occurs on soils which have a hard subsoil not far below the surface. It is often associated on these soils with *A. Kempeana* and *A. craspedocarpa*. Where the soil is sandy, we find mainly *A. linophylla*, the bogada bush, *A. brachystachya*, and *A. ramulosa*, often associated with *Triodia* and *Aristida*. On the clay flats, and especially along the watercourses we

find the snakewood and "minni-ritchie" (*A. Cuthbertsoni, A. eremea,* and *A. Grasbyi*), with *A. palustris* and *A. cyperophylla,* and the curara, *A. tetragonophylla.* By far the greater number of the mulga plants belong to the *Juliflorae* which have their flowers in cylindrical spikes. The presence of granite is often indicated by the presence of a number of *Myrtaceae,* usually *Thryptomene* and *Baeckea,* and the "Irish mulga" (*A. quadrimarginea*) associated with *A. Burkittii,* which is the Eremean form of *A. acuminata.* Few species of *Eucalyptus* inhabit the mulga bush apart from *Eucalyptus Kingsmillii* and *E. Ewartiana.* The *Proteaceae* too are relatively unimportant except for a few species with terete leaves, often pungent-pointed. The saline depressions carry their typical growth of *Chenopodiaceae,* with *Arthrocnemum* occupying the inner fringe next to the salt, species of *Atriplex* in turn succeeded by *Bassia, Eragrostis, Myrtaceae, Casuarina cristata,* and *Eremophila pterocarpa.* Sand heath formations in the mulga bush are rare, but where they occur we find South Western Elements in some array, notably *Myrtaceae, Verbenaceae, Xanthorrhoea* and *Labiatae.*

The outstanding, and at the same time one of the most interesting characteristics of the mulga bush is its apparent immutability in a delicate stage of equilibrium. It is essentially monotonous, for apart from its component *Acacias,* many, or most of the woody plants have a share in the basic plan of its uniformity. It remains an unparalleled example of the epharmonic convergence of systematically widely differing and unrelated plants assuming the same tectonic structure. *Proteaceae* (especially *Hakea*), *Mimosaceae,* and many *Papilionaceae* are often indistinguishable to the casual observer except when in flower. This quiescent condition is broken only when suitable precipitations bring forth a change by the woody plants in the fullness of their blossoming, which reveals their true identity. Such a state of things may occur twice during one year with both summer and winter rains of sufficient adequacy, or it may not occur again for several years. Remarkable too is the germination of the ephemeral flora brought into existence by such rains. Summer rains produce a sudden development of annual grasses of aestival duration only, and cause a rejuvenation of the perennial grasses. Winter rains, that is rains in May, June, or July, call into being a remarkably rich herbaceous flora almost entirely deficient in grasses, but generous in *Compositae, Goodeniaceae* and *Amarantaceae,* the ground being carpeted by extensive areas of white and pink everlastings intermixed with the pink and yellow of *Velleia* and *Goodenia,* the blue of *Brunonia* and *Erodium,* and the yellow of numerous *Compositae.* The brief seasonal pageant provided is rapidly succeeded by seed formation, usually prodigal, and later by desiccation and disintegration, the ground once more becoming barren, and a return to the general picture of drab and monotonous uniformity is restored, a state which continues for longer or shorter periods until the return of conditions suitable for this seasonal metamorphosis.

The permanent herbaceous vegetation of the mulga bush consists primarily of grasses. Besides *Triodia,* important grasses are *Eriachne Helmsii, Eragrostis, Neurachne* and *Amphipogon strictus.*

Eucalyptus Species.

The third formation of the Eremean Province is the sclerophyllous woodland and thicket often associated with and merging into sand heath. The woodland formation consists primarily of *Eucalyptus* species, occurring either in the form of large trees, or as mallees, and many species assume both forms. All have the same growth-form—upright branches all produced more or less to the same height, and a convex shallow crown of foliage supported by a rich development

of branchlets, the whole having something of the outline of an extended umbrella. The advantages of this type of growth form in resisting the desiccating effects of dry winds will be readily apparent, and it is shared to a large extent by some of the smaller shrubs, notably the *Myrtaceae,* and *Verticordia* in general. The principal trees are *Eucalyptus salmonophloia* (salmon gum), *E. salubris* (gimlet), *E. longicornis* (morrel), *E. gracilis* (yorrel), and a large number of mallee species, occurring either in the woodland, forming independent thicket associations, or constellated over the sand heaths. The character of the Eremean sclerophyllous woodland undergoes changes which are apparently dependent upon climatic gradations and soil chemistry; for example, the calcareous soil is often the most open in its undergrowth, and supports *E. longicornis* in particular. It may on the other hand have a fairly dense undergrowth of *Cratystylis*, known as "grey-bush." The red loamy soils support salmon gum and gimlet, while yorrel (*E. gracilis*) is the most salt tolerant of these trees within this area. Although *Acacia,* and often *Melaleuca* are subdominant among the lower trees and shrubs, the Eremean woodland is characterised by the presence of species of *Eremophila* and *Cassia, Exocarpus, Templetonia* and *Alyxia,* and species of *Atriplex* and *Bassia* are not infrequently of importance, especially in yorrel country. Grasses, especially *Stipa* and *Amphipogon* are of importance too, especially during the succession which follows burning, and the influence of summer precipitations over their existence here is not unimportant.

The thicket formations vary in their component species according to the soil and situation. Species tending to become gregarious in the sand or sandy loam, especially with a hard subsoil, are *Melaleuca uncinata* and *Acacia acuminata,* the latter a small shrub with narrow foliage. The gravelly soils produce mainly *Acacia* and *Casuarina,* and the granitic soils *Thryptomene, Rutaceae,* and various genera of the *Chamaelaucieae,* as well as *Leptospermum* and *Kunzea,* and their particular species of *Acacia.* Dense thickets of *Acacia* with flat rigid phyllodia (e.g. *A. neurophylla* and *A. Beauverdiana*) growing in gravelly lateritic soil are collectively called "wodjil." Such are a common feature in the western margins of the Eremea, sometimes associated with *Casuarina* and *Hakea.*

Finally there are the sand-heath formations, which, in the Eremean Province occur principally in red or yellow sand. It is in such formations that we find the strongest affinity to the South-West Province through the elements found here, e.g., *Boronia, Gastrolobium, Eriostemon, Baeckea, Verticordia, Mirbelia, Conosperum, Gompholobium,* and a host of others. Here too are found several endemic forms, some of them of generic status, which may owe their origin to the impact of opposing elements. The families *Myrtaceae, Proteaceae,* and *Papilionaceae* are particularly well represented, and there is a rich development of *Acacia.* It is interesting to note the high degree of endemism in the heath species in general, and the further the formation penetrates into the Eremean Province, the more marked is this quality, especially in those forms which have been derived from the central area of Australia—plants such as *Newcastlia* and *Dicrastyles,* most of them with a densely felted and highly coloured indument on the flowers, and occurring in rare spots of very limited extent, and cohabiting with elements more properly at home in the South-West Province.

No mention of the Eremea would be complete without a reference to the formations of the granite rocks, especially those large bosses of granite found here and there throughout the country. The water collected at the bases of these rocks is important, and provides an environment quite different from that of the surrounding country. It is associated with the granite rocks that we observe the

most southern extension of the Indo-Malayan Element: *Trichodesma* and *Cynanchum* for example being found as far south as the 31st parallel of latitude, while on the other hand, it is principally associated with granite that southern elements such as *Calythrix* and *Baeckea* reach far to the north of their general area of distribution. Occasionally we find ferns in the desert regions, and other tender herbaceous species which are afforded partial shade and a moisture content from the rock crevices which is denied the plants of the plains.

The South-West Province.

The South-West Province is that portion of the State which has a winter wet season and one of summer drought except for a narrow margin along the south coast, where the summer rainfall may be in excess of 10 inches. It is the provincial area where the Antarctic Element holds sway, and the richness of the endemic flora most fully displayed. This alone of the three provinces is the region where the kangaroo paws (*Anigozanthos*), *Conostylis, Nuytsia,* the *Epacridaceae,* and several genera of the *Papilionaceae* and *Proteaceae* have their limits restricted by the provincial boundary; nowhere do they exceed it. It can be arbitrarily limited by the isohyet of 175 mm. (682 points) for the winter months, May to August. On the other hand, plants like *Duboisia,* most *Myoporaceae* (especially the broom-like species of *Eremophila*), *Bursaria, Cassia, Indigofera, Psoralea. Tephrosia, Swainsona, Glycine, Tribulus, Geijera, Brachychiton, Bergia, Pentatropis, Marsdenia, Ipomoea, Heliotropium, Trichodesma,* several *Scrophulariaceae,* the *Bignoniaceae, Pedaliaceae, Acanthaceae,* and *Cucurbitaceae* are wanting. The genera *Pittosporum, Alyxia* and *Eremophila* it is true occur near the western coast as dune plants, but otherwise they remain essentially Eremean elements.

The annual rainfall is as high as 60 inches in the extreme south where the rain period is prolonged, but from the coast inwards there is a gradual diminution. More correctly, this diminishes as one goes inland from the plateau escarpment. This climatic gradation results in a zoning of the principal formations. The floristic wealth of this province is best represented in the poor sandy soils and the gravelly country, the lighter leached and older soils of the area. The heavier soils, mostly exposed by natural erosion and the built-up products of the process of denudation, have a much less varied flora. It is estimated that of the species of the South-West Province nearly 75 per cent. are endemic. The province extends from the Murchison River in the north to Israelite Bay on the south coast, its inland boundary generally traversing the Wongan Hills-Mullewa railway between Mullewa and Pithara, thence to the vicinity of Koorda, Bencubbin, Kununoppin, Burracoppin, Ravensthorpe and Grasspatch. As a floral entity it has its closest relationships with the coastal flora of Eastern Australia, especially in its woodland and forest formations and their component species, but its sand formations are quite distinct.

The western littoral has in general a dune formation which is not specially worthy of mention, being like dune formations elsewhere in Australia, but a matter of interest is the number of Eremean elements found here, e.g. *Santalum, Exocarpus, Atriplex, Eremophila, Alyxia, Pittosporum,* &c. Between the Darling escarpment and the strand is a broad sandy plain with here and there the alluvial clay of swamps or stream courses. The white sand carries woodland of jarrah and *Eucalyptus Todtiana,* with *Nuytsia,* several species of *Banksia, Dryandra, Casuarina Fraseriana, Jacksonia, Melaleuca, Kunzea, Hakea, Grevillea, Isopogon* and *Petrophila,* and numerous *Papilionaceae* and species of *Acacia,* notably *A. cyanophylla.* Where limestone lies near the surface the tuart tree

(*Eucalyptus gomphocephala*) grows, sometimes associated with the jarrah, but to the south, especially in the Ludlow-Capel district, forming areas of forest of almost pure stands of this tree, with an under-storey of *Agonis flexuosa*, the "peppermint." This latter, is almost a type of savannah forest, not because the ground flora is naturally rich in grass, but because it consists primarily of herbaceous or suffrutescent species which give it an aspect at once different from that of the other sclerophyllous formations.

Karri Forest.

The hilly country of the extreme South-West, where the annual rainfall is in excess of 40 inches, and the summer rainfall more than 12 inches, supports, in certain soils, the karri forest. Trees of *Eucalyptus diversicolor* attain a height of nearly 300 feet, and are thus among the world's tallest trees. Although this tree maintains an open crown, its leaves are more dorsiventral, and more inclined to a horizontal plane than any other Western Australian *Eucalyptus*. The undergrowth is more mesophytic, more dense, and the under storey of smaller trees more highly developed than in other formations. Sometimes the karri occurs in pure stands, more frequently there is an admixture of other trees, notably marri (*Eucalyptus calophylla*), the smooth-barked bullich (*E. megacarpa*), blackbutt (*E. patens*), and two large rough-barked trees, the larger known as red tingle (*E. Jacksoni*), more or less confined to the Frankland River district, and related to the jarrah, the smaller, known as yellow tingle (*E. Guilfoylei*), more closely related to the karri, and of somewhat wider distribution. The larger trees of the under-storey are *Banksia verticillata, B. littoralis, Casuarina decussata, Agonis flexuosa* and *A. juniperina*, and a few others. *Acacia pentadenia* and *A. Gilberti* are two common pinnate-leaves species, and of the shrubby and frequently dense undergrowth, the most common are *Pimelea clavata, Trymalium spathulatum*, two species of *Chorilaena, Hovea elliptica* and species of *Boronia* and *Crowea*. *Pteridium aquilinum*, the bracken, becomes of importance in the more open spaces. Within its climatic area the karri forest receives its edaphic requirements from the soils derived from granitoid and gneissic rocks.

Jarrah Forest.

Just as the karri forest stands as the most highly developed of the forest formations of the South-West Province, so does the jarrah forest by contrast stand as a xerohylium, not so much because of its climatic environment, but rather because of the poor nature of the porous lateritic soil which supplies its edaphic requirement. At the same time it is climatically demarcated, its limitations conforming so exactly to the 30-inch winter isohyet as to be worthy of comment. But, in considering the forest area however, it must always be borne in mind that laterite remains essentially its dominant requirement, for apart from the presence of these trees in certain sandy areas within its confines, jarrah is noticeably absent from the clay and granitic soils, especially those richer soils of the eroded valleys, where wandoo becomes important. The trees and shrubs of the jarrah forest are all sclerophyllous. This is also true of the lower undergrowth except where the southern limits of the jarrah impinge upon and sometimes dovetail into the karri forest. The elements of the lower undergrowth are here more mesophytic. Like the karri forest, the jarrah forest is poor in tree species, its only associates being blackbutt (*E. patens*), marri (*E. calophylla*) and *Eucalyptus accedens*. The canopy is light in texture, and suffers no overlapping of the crowns. The smaller trees of note are *Banksia* (especially *B. grandis*), *Persoonia, Casuarina, Xylomelum, Hakea* and *Dryandra, Xanthorrhoea* and *Macrozamia*. The smaller shrubs are numerous and consist largely

of *Acacia, Papilionaceae, Myrtaceae* and *Epacridaceae.* Lianas are represented by *Kennedya, Hardenbergia, Clematis* and occasional *Pittosporaceae. Pteridium* becomes of importance only in its southern areas of distribution.

Throughout a great part of the jarrah forest, conforming to a soil pattern, and entering into the general mosaic, but more or less confined to the heavier clay soils or with granite, is the wandoo (*Eucalyptus redunca* var. *elata*). This tree, with a smooth bark stands in contrast to the arboreal elements of the jarrah forest. Sometimes it is associated with powder-barked wandoo (*E. accedens*), at other times it occurs alone. Its typical soil supports an undergrowth different to that of the jarrah associations, and is usually more rich in *Epacridaceae, Proteaceae* and *Goodeniaceae.*

Temperate Savannah Woodland.

To the east of the jarrah forest, and thence northwards to the Murchison River, is the zone of savannah woodland in which the jam tree (*Acacia acuminata*) and the York gum (*Eucalyptus foecunda* var. *loxophleba*) are the dominant arborescent species, occurring associated with *Acacia cyanophylla* and *Acacia microbotrya,* and other large shrubs or small trees. Here the undergrowth is largely herbaceous consisting mainly of *Borya nitida*—the pin-grass—*Neurachne alopecuroides*—the club grass—*Amphipogon strictus,* and certain *Liliaceae,* with scattered shrubs, mostly *Grevillea, Dryandra* and *Hakea.* In the spring the ground is carpeted with everlastings—the rose-pink of *Schoenia* and *Helichrysum,* the yellow of *Waitzia,* and the blue of *Brunonia. Dampiera,* too, with its rich blue blossoms, is in evidence generally. The soils are usually derived from granite or diorite, and the open structure of the formation differs from that of other South-Western landscapes.

Immediately east of the jarrah forest, between the latitude of Pingelly and that of Tambellup, the stony lateritic hills are clad with a dense formation in which *Eucalyptus astringens, E. Gardneri,* and *E. falcata* are dominant. This is the mallet country, the commonest species of which is the brown mallet (*E. astringens*). The species may occur in both tree and mallee form, and regenerate rapidly from seed, forming dense thickets. These trees are also peculiar among most western *Eucalyptus* in that they do not coppice or sucker after destruction by fire. The poor laterite soil in which they grow provides a dense undergrowth of shrubs, in which *Proteaceae, Epacridaceae, Gastrolobium* and *Oxylobium* grow, the last two containing some toxic species.

The wandoo woodland which we found entering into the jarrah domain also stands intermediate between the jarrah forest and the savannah woodland, entering to some extent into the composition of the latter, especially in its southern areas of distribution. It favours granitic or sandy soils in this area, but usually there is a clay subsoil, the near approach of which to the surface is indicated by certain species of *Hakea.* Its undergrowth is comparatively scanty, or of low shrubs, and towards the south mat-like shrubs are common. In the clay depressions to the south of Wagin, it is associated with *Eucalyptus occidentalis,* the flat-topped yate, especially around Cranbrook.

Sclerophyllous Woodland.

The sclerophyllous woodland lies generally to the east of the habitat of the wandoo and the savannah woodland. Usually occupying the lower heavier soils, it contains a mixture of species greater than any of the other forest or woodland formations. Salmon gum (*Eucalyptus salmonophloia*), gimlet (*E. salubris*), morrel (*E. longicornis*), yorrel (*E. gracilis*) and *E. oleosa* are in its main trees.

This is the mallee country also of which there is a large number of species, ranging from large forms of *E. oleosa,* to small species occurring in thicket form. According to the nature of the soil the formation varies to some extent, and to the eastward it becomes more and more open in texture, with smaller and more lightly spaced shrubs until the Eremean province is reached. Trees of the soils high in salinity are *Eucalyptus gracilis, E. leptophylla* (much resembling the salmon gum) and *E. Sargenti.* The generally prevailing tree throughout is the salmon gum, a tree with a smooth bark, orange-pink after decorticating, afterwards almost white. Its umbrella-like top is formed of a dense crown of deep green glossy leaves and it stands as one of the finest species of this large genus. The marginal zones of the sclerophyllous woodland are often fringed with thicket formations, in which mallee, and *Melaleuca uncinata* and other species are common. Occasionally it is bordered by country in which *Casuarina acutivalvis* and *Acacia acuminata* (a shrubby form) are common. The former type usually leads us into the sandheath, or the mallee country, the latter into the wodjil country, which may or may not contain *Eucalyptus redunca,* and *Callitris Morrisoni.* Indeed, in a depauperate form, the wandoo extends to the boundary of the Eremaea, and is usually there associated with poor lateritic clay soils and thicket formations which suggest wodjil country.

Finally there are the heath formations, soils of a poor sandy nature, or clay soils derived from sandstone rocks. Their infinite variety and their multitudinous plants defy general description. These heaths are of greatest extent near the west coast between the Murchison and Hill Rivers and on the south coast between Cape Riche and Esperance Bay, finally terminating at Israelite Bay.

The flora of Western Australia is estimated at about 6100 species, belonging to 158 families. Two families have been added during the last two years, *Rafflesiaceae* and *Aquifoliaceae,* the former from the South-West Province (*Pilostyles*), the latter, with *Byronia,* from the Northern Province. The largest family is *Myrtaceae,* with 588 species, next is the *Papilionaceae,* 546 species; *Proteaceae* contribute 458 species, and *Gramineae* 412 species. The largest genus is *Acacia* with over 320 species, which equals the number of *Compositae* found here. The endemic families are *Tremandraceae, Byblidaceae* and *Cephalotaceae,* but there are below the rank of family several subfamilies which are quite or almost quite confined to Western Australia, such as the kangaroo-paw group (*Haemodoraceae-Conostylidiae*), the *Myrtaceae-Chamaelauciae,* the *Verbenaceae-Chloanthoideae,* and the *Sterculiaceae-Buttnerieae.* In addition there are numerous genera of various families endemic here alone.

This flora is derived from three main sources:—An Antarctic element represented principally by the *Restionaceae, Centrolepidaceae, Epacridaceae, Stylidiaceae* and *Proteaceae;* a Palaeotropic element finding expression through a large number of families, and an Australian element, the least important of the three, expressed by certain smaller groups, but perhaps including the *Goodeniaceae,* and a subfamily of the *Myrtaceae.*

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INDUSTRIAL DEVELOPMENT AND COMMUNICATIONS.

From the time of the establishment of Federation up to the outbreak of the last war, Western Australia made only minor gains in the development of its secondary industries. A survey of the State's manufacturing activities at the end of the thirties reveals the existence of few types of manufacture that were not already being undertaken at the beginning of the century. A chemical fertiliser industry, a woollen and worsted mill, a plant for the production of tanning extract, an essential oil distillery, a match factory, a fellmongering industry and a milk concentrating industry, then represented the more important of the limited innovational developments since Federation.

Isolation from the rest of the continent had aggravated the difficulties which Western Australia shared with other of the smaller States in securing the development of new secondary industries in the face of the superior attractive force exercised by the more industrially advanced and heavily populated States of New South Wales and Victoria. As a result, the pattern of factory production in Western Australia tended to remain static with activity concentrated in industries of the kind which require to be located in proximity to the market served or to the source of raw materials treated, and the State was obliged to draw the bulk of its requirements of unsheltered manufactures from Eastern States and overseas markets.

The inability of the State to bring about any substantial measure of import replacement meant that increases in factory employment and production generally depended upon population growth. This in turn implied some decrease in the relative numbers engaged in factory activity as manufacturing efficiency improved. Such a decrease is actually shown in the figures of employment for the pre-war Federal period. Thus, per 10,000 of population, there were employed in Western Australian manufacturing establishments during the period 1903 to 1905, an average of 559 persons, whereas for the period 1936-37 to 1938-39 the figure had fallen to 505.*

Drive for Industry.

With the termination of an era of agricultural expansion by the onset of the depression in the "thirties," the lack of progress being made in the industrialisation of the State came to be viewed with concern. Rural industry and its ancillaries no longer offered opportunities for the employment of increasing numbers of breadwinners, and the future of the goldmining industry, although hopeful, was uncertain. Under these circumstances, the development of "a more balanced economy" as a means of holding and attracting population and also of rendering the community less vulnerable to economic shocks transmitted from outside, became a specific aim of Government policy.

The creation of a ministerial portfolio and a department of Industrial Development in 1933 marked the beginning of purposive attempts to promote this policy. The functions of the Department include the sponsoring of new enterprises, the

* Because of changes in the statistical definition of "factory," this figure somewhat overstates the true measure of the decline.

investigation of openings for the establishment of new industries, the provision of technical advice to manufacturers and also, where necessary, the arrangement of financial assistance. The drive for a more industrialised economy was given impetus by wartime developments. Yet from the viewpoint of total additional numbers employed and output produced, factory industry made relatively smaller gains in Western Australia during the war period than in any other State. This will be seen from the following tables.

FACTORY EMPLOYMENT.

Indexes of Average Numbers Employed in each State.

Base: 1938–39 as 100.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.*	Tasmania.
1938–39 ...	100	100	100	100	100 (23,211)	100
1939–40 ...	104	105	103	104	99 (22,967)	106
1940–41 ...	116	118	106	117	98 (22,734)	115
1941–42 ...	130	128	114	150	103 (23,980)	127
1942–43 ...	138	130	119	168	111 (25,813)	133
1943–44 ...	141	129	120	160	121 (28,101)	143
1944–45 ...	138	128	119	151	126 (29,146)	141

* Figures in parenthesis refer to actual numbers employed.

INDEXES OF NET VALUE OF FACTORY PRODUCTION.

Base: 1938–39 as 100.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.*	Tasmania.
					(£,000)	
1938–39 ...	100	100	100	100	100 (8,776)	100
1939–40 ...	107	112	109	105	103 (9,028)	116
1940–41 ...	127	135	112	124	103 (9,017)	117
1941–42 ...	154	168	129	180	115 (10,101)	134
1942–43 ...	170	184	150	207	131 (11,454)	150
1943–44 ...	180	187	157	208	143 (12,512)	168
1944–45 ...	177	185	160	199	148 (12,960)	165

* Figures in parenthesis refer to actual net value of production.

What engage the interest of Western Australians are, of course, the prospective effects of these war-time changes upon the structure of their economy. The significance of the war-time expansion of factory activity in Western Australia may prove to have been even relatively greater than that of the other States. Much of the capital equipment, new skills and experience gained during the war years were capable of being turned to account in the replacement of imports and in the increasing of exports. There is already evidence that the local manufacturers have been successful in these directions. The danger lies in an expansion based on short-term demands to make good shortages accumulated during the war, to replace temporarily unavailable imports, and to supply temporary export markets. That manufacturers in other States were more restricted in their opportunities for such conversion may be indicated by the fact that Western Australia was the only State to increase average monthly factory employment during the first year of post-war transition.

A comparison of employment and net production values for 1938-39, 1944-45 and 1945-46 by the main industrial groups below shows the broad changes which occurred in Western Australian manufacturing during the war and the extent of subsequent changes in 1945-46.

WESTERN AUSTRALIA: FACTORY EMPLOYMENT—AVERAGE NUMBERS EMPLOYED (INCLUDING WORKING PROPRIETORS), 1938-39, 1944-45, AND 1945-46.

Industry.	1938-39.	1944-45.	1945-46.
	No.	No.	No.
I.—Treatment of Non-Metalliferous Mine and Quarry Products	764	448	670
II.—Bricks, Pottery, Glass, etc.	616	352	517
III.—Chemicals, Dyes, Explosives, Paints, Oils and Grease	818	1,166	1,396
IV.—Industrial Metals, Machines, Implements and Conveyances	7,003	11,749	10,869
V.—Precious Metals, Jewellery, Plate	73	58	109
VI.—Textile and Textile Goods (inclusive of Knitted Goods)	382	867	740
VII.—Skins and Leather (not Clothing or Footwear)	334	509	526
VIII.—Clothing (except Knitted)	3,176	3,225	3,568
IX.—Food, Drink and Tobacco	3,706	5,072	5,189
X.—Wood-working and Basketware	2,682	2,557	2,189
XI.—Furniture of Wood, Bedding, etc.	825	615	872
XII.—Stationery, Paper, Printing, Book-binding, etc.	1,723	1,310	1,515
XIII.—Rubber	78	113	135
XIV.—Musical Instruments	24	9	5
XV.—Miscellaneous Products	206	313	446
XVI.—Heat, Light and Power	801	783	880
Total	23,211	29,146	30,256

FACTORY PRODUCTION—NET VALUE OF PRODUCTION BY INDUSTRIAL GROUPS, 1938-39, 1944-45, AND 1945-46.

Industry.	1938-39.	1944-45.	1945-46.
	(£1,000)	(£1,000)	(£1,000)
I.—Treatment of Non-Metalliferous Mine and Quarry Products	296	214	269
II.—Bricks, Pottery, Glass, etc.	231	150	221
III.—Chemicals, Dyes, Explosives, Paints, Oils and Grease	522	695	831
IV.—Industrial Metals, Machines, Implements and Conveyances	2,332	4,958	4,726
V.—Precious Metals, Jewellery, Plate	23	24	46
VI.—Textile and Textile Goods (inclusive of Knitted Goods)	92	242	254
VII.—Skins and Leather (not Clothing or Footwear)	105	215	227
VIII.—Clothing (except Knitted)	555	791	919
IX.—Food, Drink and Tobacco	2,186	2,967	3,274
X.—Wood-Working and Basketware	825	981	1,095
XI.—Furniture of Wood, Bedding, etc.	220	239	362
XII.—Stationery, Paper, Printing, Book-binding, etc.	672	673	796
XIII.—Rubber	28	62	65
XIV.—Musical Instruments	9	3	1,192
XV.—Miscellaneous Products	36	92	128
XVI.—Heat, Light, and Power	644	654	612
Total	8,776	12,960	13,827

These tables show up the salient changes. The main increases in manufacturing activity since 1938-39 have been in the industrial metals group, which, during the war, made substantial gains in equipment, employment and production in the execution of munition orders. Marine and other heavy engineering, ship and boat building, the manufacture of electrical machinery (including motors), industrial machinery making (including marine and combustion engines), sheetmetal working (particularly the manufacture of dairying and domestic utensils), and the manufacture of machine tools are among the activities stimulated by defence demands. During the conversion period, employment and output in these fields have been maintained at levels well above those of the pre-war years.

A legacy of the war is being turned to useful account. The buildings which housed the small arms ammunition factory established by the Ministry of Munitions at Welshpool are now being utilised for civil production. Together with 60 acres of adjoining vacant land they have been acquired by the State Government and are providing valuable housing for new industries at a time when the shortage of materials is impeding the construction of new buildings. Already 18 private firms have leased accommodation from the Government in the area. They include manufacturers of metal furniture, aluminium household appliances, electrical goods, plumbing equipment. Three of the largest buildings will be occupied by an Eastern States company which has notified its intention of establishing a factory for the manufacture of agricultural tractors. It is expected that the project will be in full production in two years' time, when a thousand employees will be producing 2,000 tractors per year.

Wundowie Iron Project.

It has been recognised that the establishment of a basic iron and steel industry would substantially assist the expansion of heavy industry in Western Australia. Through the Department of Industrial Development, the State Government has been investigating the possibilities of such a development. Under legislation enacted in 1943, it authorised, and provided funds for, the erection of a wood distillation and charcoal iron production plant at Wundowie (41 miles from Perth and on the Perth-Kalgoorlie railway line), which will be operated to test the economic practicability of a project on a larger scale. In itself the test plant will represent a significant addition to the State's manufacturing potential. The plant will have annual capacity of 10,000 tons of pig iron, 500 tons of acetic acid and 127,000 gallons of wood naptha. The plant is expected to come into production in 1947. Waste of red gum (*E. calophylla*), wandoo (*E. redunca* var. *elata*) and jarrah (*E. marginata*) timber milled in the vicinity will be destructively distilled in externally heated retorts for the production of distillates and charcoal. The distillation plant will be integrated with a blast furnace which will utilise the charcoal for the reduction of limonite ore to be obtained from a nearby source at Clackline.

Chemical Industries.

In the chemical industries group, Western Australia had already developed two production specialities prior to the war. To commercialise the results of original research in the production of tanning extract, a factory had been established at Boddington (90 miles from Perth) in 1935, and subsequently, in response to the growth of demand for their product in Australian and overseas markets, Industrial Extracts Ltd. had opened a further factory at Boddington and another at Belmont in the metropolitan area. Employing between 160 and 180 operatives, the three factories produce approximately 8,500 tons of extract per annum. The

main source of the extract is the wood of the wandoo (*E. redunca* var. *elata*) which is treated by a disintegration process similar to that employed abroad for the production of chestnut, oak and quebracho extracts.

The other chemical industry referred to produces essential oils, natural aromatic isolates and synthetic aromatic chemicals. Production is carried out in a factory operated by Plaimar's Ltd., which is probably the leading establishment of its kind in the Commonwealth. For many years it has successfully competed in Eastern States and overseas markets.

Alunite.

During the war the scope of operations of the State's chemical industries was widened with the establishment of the "State (W.A.) Alunite Industry." Under State Government auspices, the industry is engaged in the exploitation of the alunitic clay deposits of Lake Chandler in the Merredin district for the production of potash fertilisers. Present output is 300 tons of potash fertiliser (30% K_2O) per month, at which level 130 men are employed at the works or in the extraction of the clay. Ultimately the expansion of annual output to 12,000 tons of fertiliser (50% K_2O) is contemplated. If this expansion is effected, economies of large scale production are expected to reduce the cost of manufacture to a point where it will be possible to market the product at a price competitive with that of imported potash. Investigations are proceeding to determine whether by-products such as alum, various sodium and potassium salts, magnesium sulphate and hydrochloric acid can be produced at competitive prices.

Textiles.

Of industries the location of which is independent of considerations as to proximity to markets or raw materials, the Albany Woollen Mills (established in 1925) represents the only example of a factory of significant size established outside the metropolitan area. From imported tops it weaves worsteds, flannel, rugs and blankets for the local and Eastern States markets. Production during 1945-46 was as follows:—Tweed and cloth, 218,017 square yards; flannel, 7,311 square yards; rugs, blankets and shawls, 13,836 pieces.

There is the prospect that a top-making plant will shortly be established in the State to supply the requirements of the Albany Mills and also to produce for export.

Flax.

A war-time development having prospects of permanency and possibly of further development is the flax processing industry. (See Rural Industry.) The Government has been negotiating with a leading Eastern States firm in an endeavour to secure the establishment of a flax weaving and spinning industry in the South-West which probably offers opportunities superior to those elsewhere. Experiments are now being carried out to provide further data.

Food Processing.

Between the beginning of the century and the last war such basic food processing industries as flour milling, butter making and bacon curing had shown considerable relative expansion and others like cheese making and milk concentrating had been initiated. In the manufacture of foodstuffs of a more specialised type, however, there had generally been a notable absence of progress, which

may have been partly accounted for by the difficulty of establishing new products on a market which has tended to become progressively more quasi-monopolistic since the advent of modern methods of merchandising. During the period only two entrants into this field of manufacture were successful in building up a regular if modest export trade. They comprised a confectionery and a biscuit manufacturing establishment. Following developments in response to wartime demands, however, the food processing industries to-day present a rather more diversified range of production. The gains have been mainly on the side of canning, new factories having been established or established factories expanded to produce various type of meat, fish and vegetable packs.

Woodworking.

From the early years of settlement, the milling of native timbers, notably jarrah, has been an important secondary industry in Western Australia. During 1945-46, the State's forest sawmills (*i.e.*, mills operating on logs) numbered 94 and employed 1,863 persons, excluding bush workers. At this level there had been some reduction in the pre-war level of activity, millers being generally unable to operate to the limit of the cut permitted by the Forests Department. No significant extension of output beyond its pre-war level is contemplated under the schedule of production planned by the Forests Department for the conservation of the State's forest assets. A start has been made, however, in the development of new wood processing operations. In the metropolitan area, a factory was established during the war for the manufacture of plywood from karri logs. Additional machinery recently acquired will enable the company to treble its output and also to operate on jarrah logs. Tool handle manufacture represents another wartime development.

Tobacco Processing.

Tobacco manufacture was an activity carried out in Western Australia at the time of Federation. It was subsequently extinguished but later revived and expanded. In 1945-46, 123 operatives were employed in the industry which produces for an export as well as a local market. Locally grown tobacco is utilised extensively as a raw material.

Other Developments.

To be included in the catalogue of war and post-war industrial gains are extensions in the clothing manufacturing trade, the establishment of a linseed oil mill, the expansion of paint manufacturing, the revival of the ceramic industry and the development of an industry for the manufacture of scientific instruments. In their totality, these and the gains noted in the preceding sections have meant a substantial addition to the State's industrial capacity. With industries in Australia and other countries either engrossed in the problems of reconversion or moving towards a period of restocking boom, it is still too early, however, to gauge the extent to which this expansion will prove permanent or can be further increased. Factors which may in future tell in favour of the establishment of new industries in the State are its lower building costs and its relative freedom in the past from serious industrial disputes. Moreover, the State can also offer certain advantages to industrialists seeking to acquire suitable sites for factories. New legislation enacted in 1945 empowers the State Government to resume private land for factory purposes where it can be shown that it is desirable on economic grounds that an industry should be established on a required site.

Plans for the provision of adequate supplies of power at low cost are being developed. An Electricity Commission to control the generation and distribution of electricity throughout the State has been established and a power scheme

projected for the South-West which is at present served by a number of small low efficiency plants. Work has been commenced on a new power house at South Fremantle to relieve the load on the Commission's East Perth power house, and the latter will be converted from its present 40 cycle frequency to the standard 50 cycles.

COMMUNICATIONS.

Low population density, the patchiness of settlement even in the more naturally favoured portions of the State and the large areas to be served have rendered the provision of transport facilities in Western Australia an unusually costly undertaking. The density of traffic handled in relation to capital employed is low and in the result capital charges tend to press heavily on State Government budgets.

RAILWAYS.

Lines open for general and passenger traffic comprise the system of the State Government Railways (5,381 route miles, 3 feet 6 inch gauge), the Midland Railway Company line of 277 route miles (3 feet 6 inch gauge) linking Perth and Geraldton, and the Commonwealth Railways line linking the Kalgoorlie eastern terminus of the State system at Kalgoorlie with the Eastern States. The Commonwealth line, which is of standard 4 feet 8½ inches gauge, covers 454 route miles in Western Australia. Totalling 5,112 miles, the State Government, Midland and Commonwealth lines represent 10.35 miles per 1,000 of population. This is 6.97 miles more than the corresponding figure for Queensland, which is the State having the second greatest mileage of railways in relation to size of population. Lines operated in connection with the mining and timber industry, but not open to general traffic, comprise 569 miles of additional route.

As may be seen from the accompanying map (Fig. 16), the system in its entirety comprises a ramified series of lines in the south-western portion of the State to which are connected northward and eastern extensions to goldfields (and pastoral) districts, together with the Marble Bar-Port Hedland line in the North-West and Ravensthorpe-Hopetoun line on the south coast. The two last-mentioned are not connected with the main system. Lines in the south-western portion of the State serve an area roughly bounded by the 12-15 inch isohyets and form a network of routes linked to the ports between Geraldton and Albany.

The first railway line in Western Australia was constructed in 1871 when the State's population was little more than 25,000. It was only twelve miles in length, was operated by a private company and ran from Busselton to a railhead in the adjacent jarrah forests. In 1879 a line was opened connecting the port of Geraldton with Northampton, then a centre of copper mining. Two years later, Fremantle was connected with Guildford (via Perth) and in 1884, 1885 and 1886, respectively, extensions were made to Chidlows Well, York and Beverley. Branch lines from Spencers Brook to Northam and from Clackline to Northam had been opened by 1888. Concurrently with these developments in the agricultural districts adjacent to the metropolitan area, a branch line was constructed to Walkaway in the Geraldton region to serve farmers in the Greenough Flats district, and in 1889 Albany, which was then the Western Australian port of call for mail steamers, was connected with Beverley, the southern terminus of the Eastern Railway.

Construction, in the nineties, which was primarily stimulated by the gold discoveries, more than trebled the mileage open for traffic at the beginning of the period. The main Eastern Goldfields centres at Coolgardie and Kalgoorlie were connected by rail with the port of Fremantle, there was a line linking Menzies with Kalgoorlie in the Murchison district, with another connecting the

port of Geraldton and the line in the Murchison Goldfields. A South-West system was in operation comprising a trunk line between Perth and the port of Bunbury with branch lines to the newly opened coal fields at Collie, and to the old established agricultural town of Bridgetown. The original northern system based on Geraldton had also been connected with the Eastern and South-West systems.

As a result of these developments, the main outlines of the system had been shaped by the end of the nineties. In the period which followed and up to the end of the nineteen twenties, however, there was considerable construction for the purpose of agricultural development as well as extension of facilities in the goldfields areas. Construction during this period increased the route mileage of State Government railways from 1,355 miles in 1901 to 4,079 miles in 1929. The opening in 1917 of the Commonwealth railway connecting Kalgoorlie and Port Augusta represented a further addition of 452 miles to the lines completed during this period.

Operations.

Summarised in the following table are data of the operations of the State Government Railways and Midland Railway Company for 1945-46:—

	W.A.G.R.	Midland Railway Company.
Traffic—		
Train Mileage (1,000)	6,409	260
Passengers Carried (1,000)	17,136	58
Paying Goods and Livestock Carried (1,000 tons)	2,728	127 (*a*)
Paying Traffic Carried per average mile worked (tons)	623	459 (*a*)
Rolling Stock—		
Locomotives ... ... No.	424	21
Coaching Stock:		
Ordinary ... ... No.	411	23
Motor ... ... No.	16	...
Wagons and Brake Vans ... ... No.	11,045	559
Earnings—		
Total ... ... (£1,000)	4,107	209
Per average mile worked ... ... £	937	755
Working Expenses—		
Total ... ... (£1,000)	4,027	133
Per average mile worked ... ... £	919	483

(*a*) Including a small amount of non-paying traffic.

The total cost of construction and equipment of the State Government railway lines open for traffic during 1945-46 was approximately £27,000,000. Interest charges on capital amounted to £1,040,000, so that with the surplus of earnings over working expenses amounting to only £80,000, there was a net financial loss for the year of £960,000.

PORTS.

In Western Australia, where a relatively large proportion of productive resources are concentrated in export industries, the provision of facilities for external trade assumes unusual importance. Until the opening of the Transcontinental railway, all such trade was conducted by means of sea transport. Even under the abnormal conditions of 1945-46, the value of goods shipped by sea to and from the State amounted to over £43,000,000, or 92% of the total value of external trade.

The relative importance of the several ports as measured by the value of external trade handled, is indicated in the following table, which gives figures for 1938-39 and 1945-46.

Port.	Value of External Trade.			
	Imports.		Exports.	
	1938-39.	1945-46.	1938-39.	1945-46.
	(£1,000)	(£1,000)	(£1,000)	(£1,000)
Fremantle	16,701	16,959	19,529	22,717
Albany	204	197	596	179
Broome	9	...	77	...
Bunbury	130	108	1,043	1,715
Busselton	4	...	84	93
Carnarvon	8	...	55	...
Cossack	1	...	32	...
Derby	2	...	8	...
Esperance	125	106	17	9
Geraldton	212	89	506	1,452
Onslow	6	...	8	3
Port Hedland	6	...	112	...
Wyndham	82	79	292	...
Total Ports	17,490	17,538	22,359	26,159
Rail and Air	559	3,413	631	386
Total	18,049	20,951	22,990	26,545

Except in the North-West, which is not connected by rail with the southern portion of the State, intra-state cargo shipments represent only a small proportion of the volume of goods handled at ports. Figures of tonnage of intra-state (coastal) and other cargoes loaded and discharged during 1945-46 are as follows:—

TONNAGE OF CARGO HANDLED AT THE SEVERAL PORTS.

Port.	Inward.			Outward.		
	Overseas.	Interstate.	Coastal.	Overseas.	Interstate.	Coastal.
	1,000 tons.	1,000 tons.	1,000 tons.	1,000 tons.	1,000 tons.	1,000 tons.
Fremantle	551	395	33	381	187	30
Albany	9	8	...	3	...	...
Broome	...	...	5	...	...	4
Bunbury	33	1	...	50	87	...
Busselton	...	...	...	...	15	...
Carnarvon	...	...	6	...	...	5
Derby	...	...	4	...	...	4
Esperance	3	3	...	...	...	...
Geraldton	27	...	5	62	34	1
Onslow	...	...	10	...	...	7
Port Hedland ...	...	...	8	...	...	5
Point Samson ...	...	...	3	...	...	2
Wyndham	2	...	5	...	...	5

Pre-eminent amongst the ports is Fremantle, which can accommodate vessels drawing up to 36 feet. The main harbour works, which are protected by two ocean moles at the head of the Swan River estuary, were commenced in 1892. Length of wharf berth accommodation available is over 10,000 feet. Following the fall of Singapore during the last war, Fremantle was the headquarters in the Indian Ocean for the British, U.S.A. and Netherlands Navies, and the principal operating base in the Southern Hemisphere for submarine warfare against the Japanese.

Distances by Sea.

Shown below are the distances between the principal ports, which are specified in geographic sequence from north to south:—

	Nautical Miles.	Distance from Fremantle via Ports Specified Nautical Miles.
Wyndham to	...	2,068
Derby	550	...
Derby to	...	1,518
Broome	225	...
Broome to	...	1,293
Port Hedland	265	...
Port Hedland to	...	1,028
Cossack	93	...
Cossack to	...	935
Onslow	173	...
Onslow to	...	762
Carnarvon	270	...
Carnarvon to	...	492
Geraldton	278	...
Geraldton to	...	214
Fremantle	214	...
Fremantle to	...	86
Bunbury	86	...
Fremantle to	...	343
Albany	343	...
Albany to	...	553
Esperance	210	...

ROADS.

Made roads in existence in 1946 had total length of 40,241 miles. Roads unprepared except for clearing but used for traffic comprised an additional 34,175 miles. The types of roads available in various parts of the State are shown below:—

Statistical Division.*	Bituminous.	Other Constructed Surfaces.	Formed only.	Total Prepared.	Unprepared except for Clearing.
	miles.	miles.	miles.	miles.	miles.
Metropolitan Area	1,027	245	35	1,307	93
South-West—					
No. 1 Subdivision ...	774	3,424	3,328	7,526	3,209
No. 2 Subdivision ...	473	3,630	8,922	13,025	7,600
Northern Agricultural ...	437	2,108	7,174	9,719	7,937
Eastern Goldfields	94	620	1,726	2,440	3,032
Northern Goldfields ...	15	760	2,930	3,705	4,739
North-Western	13	159	1,353	1,525	4,415
Northern	6	179	809	994	3,150
Total	2,839	11,125	26,277	40,241	34,175

* *See* Fig. 16 for divisional boundaries.

In the following table, length of roads is shown in relation to divisional areas:—

Statistical Division.*	Area.	Length of Road per 100 Sq. Miles.	
		Prepared.	Unprepared.
	square miles.	miles.	miles.
Metropolitan Area	191	84·3	48·7
South-West—			
No. 1 Subdivision	18,253	41·2	17·6
No. 2 Subdivision	32,328	40·3	23·5
Northern Agricultural	50,059	19·4	15·9
Eastern Goldfields	167,302	1·5	1·8
Northern Goldfields	281,150	1·3	1·7
North-Western	116,135	1·3	3·8
Northern	310,502	0·3	1·0
Total	975,920	4·1	3·5

* *See* Fig. 16 for divisional boundaries.

Roads aggregating 3,154 miles have been classified "declared" roads, and as such are maintained by the State Government Main Roads Department from funds provided by way of Federal Aid Roads Grants. For 1945-46 such grants to the State amounted to £621,267.

AIR TRANSPORT.

Climatic and topographical conditions in Western Australia are favourable for the use of air transport and since the war there has been a considerable expansion of commercial aviation traffic. Perth is linked with the Eastern States by daily services provided by two operators, and there are also intra-state services providing passenger and freighting facilities as delineated on an accompanying map (Fig. 16).

ELECTRICITY AND FUEL RESOURCES

Electricity supply in Western Australia is controlled by the State Electricity Commission which was constituted by an Act of Parliament enacted in 1945, to undertake the establishment and operation of works for the generation and supply of electricity throughout the State. The commission at present has three main functions—the operation of the East Perth power station which supplies the whole of the metropolitan area including the City of Perth, City of Fremantle and a number of local authorities, the establishment of a power scheme to supply the South-West portion of the State and the administration of Parliamentary Acts relating to electricity.

The East Perth power station is the largest in the State. East Perth "A" has a capacity of 32,000 k.w. and East Perth "B" a capacity of 25,000 k.w. Both sections of the station burn coal railed from the Collie coalfields approximately 125 miles to the south, the "A" section using small coal and the "B" section pulverised coal. The station is situated on the banks of the Swan River from which cooling water is drawn. The steam conditions in the original "A" station were 200 lbs. square inch 600°F. but the "B" extension uses steam at 600 lbs. square inch pressure and a temperature of 800F. During the year ended June, 1946, the station generated 186,000,000 k.w.h. of electricity. Electricity is generated at 6,000 volts and transmitted at 6,000 volts and 20,000 volts. Most of the distribution is carried out by local authorities who buy in bulk from the commission and the distribution voltage is 440/250 volts. The existing supply is 40 cycles, but following on an investigation and report by the Chief Electrical Engineer N.S.W. Department of Works, the State Government has decided to change the metropolitan supply to 50 cycles. The first step in the changeover will be the establishment of a new 50-cycle power station on the coast at South Fremantle and the foundation works for this station are now under construction. The initial capacity of the new station will be 50,000 k.w. and it will burn pulverised Collie coal. The steam conditions will be 600 lbs. 825°F and it will generate at 20,000 volts. The East Perth and South Fremantle stations will be linked through two 66,000 volt tie lines and a frequency changer at East Perth.

South-West Scheme.

The South-West power scheme, in the first place, will be centred on a 5,000 k.w. steam station situated at Collie. This station was originally erected by a private company to supply the requirements of the coal mines. It was taken over by the Commission in 1946 and will be extended to 12,500 k.w. capacity. In the later development of the scheme, it is proposed to erect another power station at Bunbury and link the two South West stations to the metropolitan scheme. The existing Collie station burns pulverised Collie coal. The steam conditions are 250 lbs. square inch pressure and 600°F. and electricity is generated at 6,000 volts 40 cycles. The present output of the station is approximately 14,000,000 k.w.h. per year. A spray pond is used for cooling water, make-up water being pumped from the mines. The new extensions will generate at 50 cycles and when they are complete the existing section of the station will be changed over to 50 cycle operation. The South West power scheme will supply electricity to towns and rural areas in

the South West portion of the State bounded by the south and west coasts. the Great Southern Railway and an east-west boundary approximately 60 miles south of Perth. Transmission lines operating at 66,000 volts will feed main centres and primary distribution lines will operate at 22,000 volts.

Apart from the two stations operated by the Commission, the only other major steam station in the State is the Kalgoorlie Power Corporation's station at Kalgoorlie, which supplies a large proportion of the power requirements of the goldmining industry in that centre. The capacity of the station is approximately 19,000 k.w. and it burns local wood fuel. Condenser water obtained from the Goldfields Water Supply main is cooled in natural draft towers. Proposed extensions to this station may use Collie coal.

Most of the rural towns in the State obtain their electricity supply from local diesel or producer-gas engine stations operated by the local authorities or by private concessionaires. The supply is usually direct current but some of the larger towns have changed or are in the process of changing, to alternating current. Gold mining companies usually operate in isolated centres, and have their own diesel power stations, the largest being at Big Bell, Wiluna and at the Lake View and Star Gold Mines at Kalgoorlie.

Lack of Water Power.

The water power resources of the State are practically negligible. A small unit is operated at Pemberton for town supply and it may prove economical to instal small units on the larger irrigation dams in the South-West to supplement supply from the coal stations of the South-West Power Scheme. A proposed irrigation scheme for the Ord River area in the extreme north of the State envisages hydro plant at the irrigation dam to supply power for irrigation pumping and amenities for the residents.

The most important coalfield in the State and the only one producing is situated at Collie about 125 miles south of Perth and about 40 miles inland from the coast. There are 6 mines and 2 open cuts operating on the field, and the annual output of coal is approximately 600,000 tons. The estimated coal available at Collie to a depth of 2,000 feet is 3,500 million tons. The coal is a black sub-bituminous non-coking variety, the analysis of which is shown in the following table.

Mine.	Fixed Carbon.	Volatiles.	Ash.	Moisture.	Cal. val. as mined.
Proprietary	46·37	25·86	5·48	22·29	9,412
Stockton	43·88	26·15	5·36	24·61	8,805
Griffin	41·85	34·00	4·41	19·74	10,017
Co-operative	48·57	24·75	5·54	21·14	9,773
Cardiff	38·48	30·74	4·11	26·67	8,486
Wyvern...	42·66	28·98	2·41	25·95	9,337

The bulk of the coal produced at Collie is used by the Government Railways and the State Electricity Commission's power stations.

An extension of the Collie coal measures has been proved at Wilga, 15 miles south of Collie. The coal is similar to that at Collie but is of inferior quality. There has been some investigation at Eradu and the Irwin River, south-east and east of Geraldton. The interest in these coals is due to the desirability of developing a source of fuel for the northern areas. Coal beds have been reported in the South-West and along the South coast at Donnybrook, Fly River,

Deep River, Nornalup, Pallinup River and Fitzgerald River and in the Kimberleys south of Derby, but none of these coals approach Collie coal in quality, most of them being lignites.

There has been some interest in recent years in the gasification of Collie coal following the successful gasification of similar coals in the U.S.A. At present, gas supply in Perth, Fremantle, Geraldton and Albany depends on the importation of gas making coal from New South Wales. Research on gasification has had heartening success and is being continued.

WATER SUPPLY AND IRRIGATION

The water supplies in the State of Western Australia are best dealt with under four headings, namely:—

1. The water supply for the Perth Metropolitan Area.
2. The water supply for the Goldfields.
3. The water supply for the Agricultural Areas and Towns.
4. The water supply for the Irrigation Districts.

Perth Metropolitan Area.

The water supply for this area is controlled by the Metropolitan Water Supply Department under the direction of the Minister for Water Supply, and the area served extends from Fremantle to Greenmount, a distance of twenty-one miles along a south-west axis through the City of Perth, whilst on an axis approximately north-west the distance from Armadale to North Beach is some twenty-four miles. The total area controlled by the Department, including the catchment areas in the Darling Range, is 1,187 square miles.

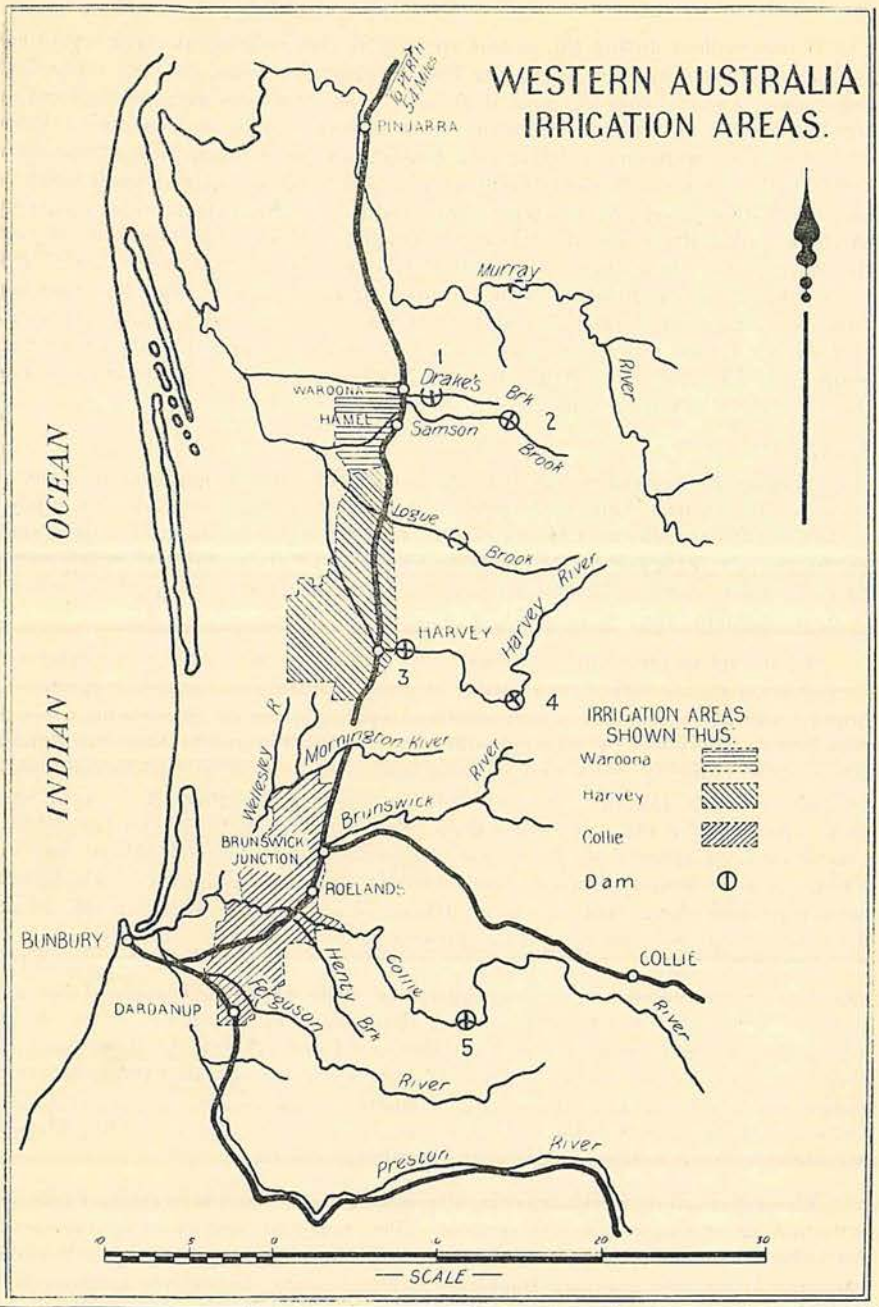
The main source of supply is from the Canning River and its tributaries, Churchman Brook, Wungong Brook and Mundays Brook. The secondary source of supply, which is used only in exceptional cases for meeting peak demands during the summer, is from the artesian basin underlying Perth. A third source of supply is the Mundaring Reservoir, the Goldfields Water Supply Reservoir on the Helena River, which can be drawn on when necessary for the Midland Junction-Greenmount area of the metropolis. Conversely, Canning River water can be pumped (as it was in 1941) to the Mundaring Reservoir to safeguard any shortage at that source.

The population of Perth up to 1896 was 3,200 but was increasing, so that after the acquisition of the Victoria Reservoir in 1896 by the Government from the original City of Perth Waterworks Company and before any further major conservation was undertaken in the Darling Range, steps were taken to develop the artesian supplies underlying Perth, together with a small amount of conservation of minor importance on the Bickley Brook. By 1906 the Mundaring Reservoir was connected to the metropolitan area and about one million gallons a day were made available through a 13 inch diameter cast iron main to the Greenmount Service Reservoir, 9¾ miles from the Mundaring Reservoir.

Victoria Reservoir.

The Victoria Reservoir on Mundays Brook has a catchment area of 10,000 acres, and a capacity of 212,000,000 gallons. The dam is a curved concrete structure, 750 feet long. The maximum depth of wall is 104 feet from overflow level to the deepest point reached by the foundation.

Prior to 1902 four artesian bores were in existence but from 1902-1921, fifteen artesian bores were sunk in Perth, Fremantle and the adjacent suburbs, the maximum output being approximately 11,000,000 gallons per day. A further bore was sunk on the Mounts Bay Road in 1931, with an output of 5,000,000 gallons per day.



Storage Dam.	Type.	Capacity. to T.W.L.	Height to T.W.L.	Crest Length.
		Million Gallons.	Feet.	Feet.
1. Drakesbrook ..	Earth Fill	504	54	580
2. Samson's Brook	Earth Fill	1,800	100	800
3. Harvey	Concrete (Gr.) ..	2,250	60	797
4. Stirling	Earth Fill	12,000	150	900
5. Wellington ..	Concrete (Gr.) ..	8,700	65	1,200

Fig. 5.—Western Australia—Irrigation Areas.

It was evident during the period up to 1921 that serious attention would have to be given to developing the Darling Range catchment areas, the bore water being unsuitable, salinity being the main drawback. Investigations were put in hand and resulted in the Government deciding to construct a dam at Churchman Brook. This was put in hand in 1924, and consists of an earthen bank, impounding 480,000,000 gallons. The catchment area is 3,828 acres and maximum height of bank above river bed level 75 feet; concurrently pipe head dams were constructed on the Canning River and its tributary, Wungong Brook. The pipe lines to carry the water from these three points to Perth are: 16 inch diameter main from Churchman Dam to junction with Canning River pipe line from the pipe head dam, a distance of 1 mile 52 chains; 30 inch diameter main from junction of Churchman Brook pipe line to Kelmscott (2 miles 73 chains); 36 inch diameter main from Kelmscott to Perth (16 miles 75 chains); 30 inch diameter main from the Canning River pipe head dam to Kelmscott (8½ miles).

Canning Dam.

Canning Dam construction was started in 1933 and completed in 1940. It is one of the highest dams in Australia, of gravity masonry type and its capacity is 20,550,000,000 gallons. Other statistics are: Catchment area: 282 square miles; height above stream bed level: 218 feet; length of crest: 1,534 feet; width of top: 24 feet; width of base: 170 feet; length of basin: 8 miles; cubic yards of concrete in dam: 356,000; tons of masonry in wall: 620,000 tons.

Additional to the main pipe lines conveying water to Perth, the Canning Dam is connected to the city by a contour channel and 42 inch diameter main. The contour channel consists of a concrete-lined open channel of trapezoidal cross section laid on a grade of 2 feet per mile. It follows this grade along the Canning River valley for 7½ miles and delivers into a pipe head in the foothills above Gosnells railway station. Inverted siphons, twelve in number, of 30 inch or 42 inch pipes, convey the water over deep lateral valleys met with on the route of the channel. Capacity of the channel at present is 33,000,000 gallons per day. From the pipe head the water is conveyed through 6½ miles of 42 inch diameter steel pipe laid along Mills Road to Albany Road; thence alongside the 36 inch main to Cannington where for the present it terminates by connecting to the 36 inch main. This is a continuously welded steel main and forms at present the most advanced work of its type in Australia. The southern branch of the main Canning pipe line consists of a 24 inch diameter main which leaves the 36 inch main at Cannington and proceeds via Railway Road, Fremantle Road and Canning Highway to the traffic bridge. It delivers water to the Fremantle service reservoirs, the Fremantle and North Fremantle distribution systems and under certain conditions to Buckland Hill reservoir, Cottesloe and even Mt. Eliza reservoir through the Stirling Highway distributing main.

The distribution works may be classified as:—Service reservoirs, major distribution net work, minor and services. The principal service reservoirs are:—Mt. Eliza, 1, 2 and 3: capacity 33,500,000 gallons; Osborne Park, 1, 2 and 3: capacity 13,000,000 gallons; Buckland Hill: capacity 13,000,000 gallons; Richmond: capacity 1,250,000 gallons; Melville: capacity 9,500,000 gallons; Greenmount: capacity 1,000,000 gallons. With a total capacity of 71,250,000 gallons.

The minor service reservoirs are:—Scarborough service tank: capacity 200,000 gallons; East Scarborough tank: capacity 15,000 gallons; Osborne Park high level tank: capacity 15,000 gallons; Mon Repos: capacity 15,000 gallons; Applecross: capacity 38,000 gallons; Greenmount: capacity 100,000 gallons. A total capacity of 383,000 gallons.

The total service reservoir capacity is approximately 72,000,000 gallons.

The principal mains of the major distribution network form a series of great loops, or closed circuits. The advantages of this arrangement are in the maintenance of pressures and continuity of supply. The major network forms the main arteries from which the minor network ramifies into every street. From the minor network the house services are taken and upon it the bulk of the fire hydrants are fixed. The principle of forming closed circuits where economically feasible applies to the minor network as well as to the major network.

The metropolitan area is growing. The maximum demand that has been experienced is 48,000,000 gallons per day, but the average over the summer months, say from mid November to mid March, is 32,000,000 gallons per day. In the mid winter months, however, the demand falls approximately to 13,000,000 gallons per day. The total that can be supplied by pipe lines and bores is 37,000,000 gallons per day. To meet the estimated requirements of the next few years the following major works are required:—

1. Extension of 42 inch main from Cannington to Victoria Park.
2. Replacement of 36 inch main from Gosnells to Victoria Park with 42 inch main.
3. Duplication of 30 inch main Victoria Park to Belmont.
4. Laying of 36 inch main from Belmont to Mt. Yokine.
5. Construction of a service reservoir at Mt. Yokine of capacity of 30,000,000 gallons.
6. Laying of a 30 inch main from Mt. Yokine to Osborne Park.
7. Duplication of 24 inch main from Melville Reservoir to Fremantle.

It is estimated that these works will provide, with the bores, about 58,000,000 gallons per day.

Principal Statistics.

The Metropolitan Water Sewerage and Stormwater Drainage area extends from Fremantle to Greenmount and Armadale and embraces 1,187 square miles and five stormwater districts. Capital expenditure as at 1946 is:—Water: £5,355,908; sewerage: £3,188,674; drainage: £696,911; total: £9,241,493.

The principal sources of supply are:—Canning Dam: capacity 20,550,000,000; Churchman Brook Reservoir: capacity 480,000,000 gallons; Victoria Reservoir: capacity 188,914,000 gallons; and Wungong Brook Diversion Weir.

Other general information is:—Proclaimed catchment area: 700 square miles; service reservoirs: 16, with capacity of 73,138,000 gallons; services installed: 68,310; meters installed: 41,923; total mains laid: 1,053 miles; annual consumption (1945-46): 8,040,523,000 gallons; maximum day's consumption: 42,213,115 gallons; average daily consumption (1945-46): 22,028,830 gallons; consumption per head per day (1945-46): 89.15 gallons; population served: 247,090.

The Goldfields Scheme.

The Goldfields Water Supply Act was introduced in 1902 to provide for management and control of water supplied from Mundaring Reservoir. Following on the discovery of rich gold deposits at Coolgardie in 1892, the Government was faced with the problem of providing water for the large population that soon spread over the auriferous areas northwards and eastwards from Coolgardie. In 1892 the population of the State was 58,658, whereas in 1897 it had grown to 161,694, a considerable number of the new arrivals becoming residents in the eastern goldfields. A gigantic and extremely difficult task faced the authorities in providing water for a population of "mushroom" growth in a hot and almost

waterless area 400 miles from the coast and from rivers. The Government spent about £400,000 in providing water by conservation in excavated tanks, by boring and well-sinking and by distillation of salt water. The boring showed that no large underground supply of fresh water existed in the vicinity of Coolgardie or Kalgoorlie, and conservation of rain water was costly and uncertain, as the rainfall averaged only about nine inches and had been as low as four inches in one year.

A number of proposals for bringing a large supply of water to the goldfields were considered by the Engineer-in-Chief, the late Mr. C. Y. O'Connor, who reported to the Director of Public Works in July 1896, that the best way of attaining this object was by pumping from an impounding reservoir to be constructed in the Darling Ranges a supply of 5,000,000 gallons daily. This project was a noble and daring conception. The scheme known then as the Coolgardie Water Scheme was adopted by the Government. The source of supply is the Mundaring Reservoir on the Helena River, 26 miles from Perth. The concrete overflow dam is 100 feet high, 755 feet long, has a capacity of 4,650,000,000 gallons. The catchment area is 569 square miles. Water is pumped to Kalgoorlie through 346 miles of steel main, mostly of 30 inch diameter, by a series of eight pumping stations, involving a total net lift of 1,280 feet. Construction of the scheme was commenced in 1898, completed in 1903 and officially opened at Kalgoorlie on January 26th, 1903. In the past 40 years the reservoir has failed to fill on only four occasions.

Since the completion of the original works, many hundreds of miles of branch and reticulation mains have been laid to mining districts, towns, and farming lands within economical distance of the main conduit. The most important extension was laid in 1937 from Coolgardie to Norseman—a distance of 101 miles, the distance from Mundaring Reservoir to Norseman being 430 miles. Ten years ago a programme was undertaken for reconditioning the main conduit. Leakage from it was excessive and the security of supply was threatened. Since then, the whole of the conduit has been renovated. The practice for several years has been to cement-line pipes to avoid internal corrosion and maintain capacity; and wherever possible to use continuously-welded pipes laid above ground. This has eliminated external corrosion from the soil and from lead joints originally used. There still remain about 2¾ miles of the conduit that has not been cement lined and about 50 miles which is cement lined but with lead joints. These sections will be improved as conditions permit.

In addition to supplying 34 towns, water is reticulated to 970,000 acres of farming land. Length of mains, including the main conduit, is 1,750 miles. The number of services is 14,528, of which 12,699 are metered. The estimated population supplied is 50,000.

The total quantity of water pumped through No. 1 Pumping Station at Mundaring in each of the past seven years has been as follows:—

1937-1938	1,846,000,000
1938-1939	1,882,000,000
1939-1940	1,889,000,000
1940-1941	1,999,000,000
1941-1942	1,799,000,000
1942-1943	1,723,000,000
1943-1944	1,899,000,000
1944-1945	1,987,000,000
1945-1946	2,024,000,000

Prices per thousand gallons charged for domestic supplies range from 2s. to 6s. 8d. Kalgoorlie domestic prices are:—

6s. 8d. in return for the water rate;
4s. for the first 5,000 gallons excess, and
2s. 6d. for the balance in each year.

Prices for mining supplies are fixed by agreements. The predominant price at Kalgoorlie and Boulder for the mining industry is 5s. 1d. per 1,000 gallons. Revenue from mining comprises about 50 per cent. of the total revenue of the undertaking.

Under the 1911 Goldfields Water Supply Act Amendment Act, provision was made whereby rates could be levied on any holding of country land situated wholly or partly within 10 chains of any pipe from which the Department was prepared to supply water, provided such holding shall be rateable only as it extends to a distance of 1½ miles from the pipe. Acreage at the present varying rates are: 70,000 acres at 2d.; 708,000 acres at 3d.; 4,400 acres at 4½d.; 187,000 acres at 6d. (A rebate of 1d. per acre is allowed on land rated at 6d. provided a sum equal to one year's rates is paid within the year.) In addition to the acreage rate a holding fee of £5 per annum is charged on each separate holding of farming land.

Financial Aspect.

The cost of the original works was £2,866,454 and on supplementary works £2,797,381 was spent from loan funds; £388,046 raised by debenture and £126,802 obtained by way of a grant from the Commonwealth. The total was £6,178,683. Of the amount £2,500,000 was redeemed from the sinking fund, debentures were repaid in full and the grant transferred to general revenue, leaving a total expenditure less redemptions of £3,163,835.

The amount due by the undertaking to the Treasury (being the amount short paid in relation to Sinking Fund) was at June 30, 1946—£2,095,254.

The water area embraces 16,000 square miles. The total length, from west to east of the water area is approximately 380 miles. Under present conditions from the main reservoir, it takes approximately two weeks to reach Kalgoorlie. Other statistics are:—

HELENA RESERVOIR, MUNDARING.

Cost	£249,000	
Capacity	4,650,000,000	gals.
Surface Area at full supply level	672	acres.
Catchment Area	569	sq. miles.
Concrete in wall	82,000	cub. yds.
Height of wall above river bed	100	feet.
Length of wall	755	feet.
Thickness of wall at bottom	85	feet.
Thickness of wall at crest	11	feet.
30 *inch Main Locking-bar Steel Conduit.*		
Cost (original construction)	£1,800,000	
Length	346	miles.
Maximum delivery capacity per diem	7,000,000	gals.

Pumping Stations.	Distance from Main Reservoir. Miles.
No. 1	
No. 2 situated near Mundaring	1½
No. 3 situated near Cunderdin	78
No. 4 situated near Merredin	140
No. 5 situated near Yerbillon	172
No. 6 situated near Ghooli	218
No. 7 situated near Gilgai	250
No. 8 situated near Dedari	295
Cost of eight stations	£432,220

Tanks.

	Capacity. Gallons.
Regulating Tank at Mundaring Reservoir	1,000,000
Receiving Tank at No. 2 Pumping Station	500,000
Receiving Tank near No. 3 Pumping Station	47,000,000
One Receiving Tank at each of Pumping Stations Nos. 4, 6, 7 and 8	4,000,000
Two Receiving Tanks at No. 5 Pumping Station	2,000,000
Regulating Tanks along line (11)	10,500,000
Main Service Reservoir at Bulla Bulling	12,000,000
Coolgardie and Kalgoorlie—2 reservoirs	13,000,000
Total Capacity	90,000,000

Reticulation.

Towns supplied	34
Reticulation mains	310 miles.
Supply mains—agricultural areas	81 miles.
Supply mains—mining centres	230 miles.
Agricultural extensions	777 miles.
Total mains	1,750 miles.
Drawn from Reservoir, 1944–1945	*1,972,000,000 gals.
Daily average draw, 1944–1945	5,403,000 gals.

*Includes 380,000,000 gallons from Canning Dam.

Country Supplies.

Meeting the water requirements of a State comprising almost 1,000,000 square miles, inhabited by slightly less than half a million people, is a problem of considerable magnitude, when account is taken of climatic, geological and geographical conditions.

In the southern and most populous portion of the State, rainfalls adequate for conservation purposes fall only around the coastal fringe in the vicinity of the chief range of hills which are situated only a few miles from the coastline. Whilst the rainfall on the coast may be as heavy as 35 inches, it is quickly reduced on the eastern side of the hills and within a distance of 150 miles might be as low as 7 or 8 inches. The wheat belt, nearly 60,000 square miles in extent, has a range of average rainfall from 10 to 20 inches per annum, most of which falls in the winter months. This vast tract of country is devoid of rivers and lies generally as a plateau some 1,000 feet above sea level. Underground sources of supply are generally poor. At the northern end of the belt, sub-artesian water of indifferent quality exists, but the geology changes proceeding southward and the underlying rock becomes granitic and water in any quantity or quality is so indifferent as to be practically negligible for the purpose of agricultural activities. After the drought of 1911 over 1,500 bores were sunk, of which 200 yielded reasonably fresh water, 130 water fit for stock only and 1,186 showed either no result or yielded water too salty for sustaining life. The same indifferent results have resulted from later borings in areas not previously tested. Over successive years of rainfall exceeding the general average, the improvised supplies which pioneered the wheat belt were sufficient, but one or two years of rainfall below the annual average quickly proved their inadequacy.

Evaporation is a very important factor to any type of water supply in the wheat belt area, where water is impounded in dams ranging from a 2,000 cubic yard farmer's dam to an impounding reservoir of 100,000,000 gallons, which, for example, represents the Wicherina supply for Geraldton. Until this reservoir was roofed, 40,000,000 gallons annually were taken by the sun out of the 100,000,000

gallons impounded. The evaporation records indicate that the average dam found on any farm throughout the wheat belt yields somewhere between six and seven feet depth of its water to the sun each year.

Legislation.

Over the years, action taken to meet the varied requirements includes the passage in 1912 of the Water Supply Sewerage and Drainage Act, which constituted the Department of Water Supply, Sewerage and Drainage and appointed a Minister of Water Supply, Sewerage and Drainage. It authorised the appointment of an Under Secretary and staff to administer all hydraulic undertakings constructed under the special Acts and not under control of boards. The Metropolitan Water Supply is controlled by a separate Department under the same Minister and issues an independent annual report.

The Water Board's Act was passed in 1904 to control reticulated rated supplies to country towns not connected with the Mundaring supply. In 1925 an amendment was passed dealing with supplies to farming lands. Schemes may be controlled by either the Minister or by Water Boards (ordinarily the local government authority). The following 19 towns are under Ministerial control: Albany, Big Bell, Boyup Brook, Bridgetown, Brookton, Bruce Rock, Brunswick, Collie, Cue, Derby, Geraldton, Leonora, Meekatharra, Narrogin, Pingelly, Port Hedland, Reedy, Serpentine, Youanmi. Water Boards administer 17 towns, namely: Broome, Bunbury, Busselton, Carnarvon, Harvey, Katanning, Manjimup, Moora, Onslow, Pinjarra, Quairading-Dangin, Roebourne, Sandstone, Wagin, Wiluna, Wyndham, Yarloop.

The Minister also controls three District Farming Land Schemes, Barbalin, Narembeen and Kondinin, all in the wheat belt. Local extensive granite outcrops have been utilised. The rain falling on these outcrops is impounded at the foot of the rocks, pumped to a tank on the top and gravitated through reticulation to the farms.

Barbalin District.

The largest of these independent schemes is known as the Barbalin or No. 1. Three outcrops have been utilised in this project, the total capacity of the reservoirs being 70½ million gallons made up as follows: Barbalin Rock, 41,000,000 gallons; Waddouring, 21,750,000 gallons; Knungagin, 7,750,000 gallons; the area of the rock catchments being respectively, 272 acres, 160 acres and 87 acres. Each of the units has a concrete service reservoir and pumping plant. 300 occupied farms are supplied, comprising 340,000 rated acres. The total mileage of pipes is 329. A number of small country towns are also supplied. A series of drought years rendered it necessary to connect the Barbalin reservoir with the Mundaring main conduit with an 8-inch link main which was laid in 1936 at a cost of £65,000. Water from the Mundaring Scheme is only drawn on during the summer months when it is evident that the rock catchment reservoirs are not likely to fill. A rate of 6d. per acre with a rebate of 1d. per acre if a year's rate is paid within the currency of the rating year is levied on all farming lands within the prescribed distances of the mains. Four shillings per 1,000 gallons is charged for water in return for the rate and for excess. A holding fee of £5 per annum is charged in addition to the rate.

Narembeen District.

This comprises a 9,500,000 gallon reservoir, pumping unit and reticulation. lation and the area of rock catchment is 119 acres. It serves 86 occupied farms

totalling 88,000 rated acres. The rates and charges are the same as in the Barbalin District. Capital expenditure at 30th June, 1945, was £74,749.

Kondinin District.

This comprises a 9,500,000 gallon reservoir, pumping unit and reticulation. The area of rock catchment is 70 acres. The scheme supplies 38 occupied farms, totalling 40,000 acres, rated at 4½d. per acre, plus £5 per annum holding fee, rebate and excess water, 4s. per 1,000 gallons. Capital expenditure at 30th June, 1945, was £40,543.

IRRIGATION.

The irrigation areas of this State are situated upon the South-West railway line between the towns of Waroona, 70 miles from Perth, and Dardanup, 116 miles from Perth. The three areas, as they exist at the moment, consist of the Waroona Irrigation Area, the Harvey Irrigation Area, which is approximately 87 miles from Perth, and the Collie Irrigation Area, which extends from Brunswick Junction, 99 miles from Perth, to Dardanup.

In 1917 a concrete gravity dam, with a capacity of 1840 acre-feet was built on the Harvey River, 2½ miles east of Harvey. The resultant conservation plus the summer flow of the river (3,000 to 4,000 acre-feet) was for the purpose of irrigating 2,928 acres, the main crop being citrus trees and the allocation being one acre-foot per acre. The citrus orchard proved a failure and the area gradually went over to pasture production. By 1930 the demand for water so exceeded the supply that the reservoir was enlarged to a capacity of 8,300 acre-feet, and an additional district, (Harvey No. 2), of 13,344 acres, was constituted. The water allotted was 1½ acre feet per acre, on the basis of 1 acre in 3. At the same time the allotment for the original area was increased to 1½ acre-feet per acre. Concurrently with the raising of the Harvey Weir, the Waroona District, consisting of 10,325 acres was constituted. An earthen dam on the Drakesbrook with a reservoir capacity of 1,855 acre-feet was constructed some three miles east of Waroona. This reservoir and the summer flow of the Samsons Brook and tributary McKnow Brook was allotted to 1 acre in 3½ of the district on the basis of 1½ acre-feet per acre to be irrigated.

At the same time the Collie River District, 28,762 acres in extent was constituted. A concrete gravity dam with a reservoir capacity of 27,800 acre-feet was built on the Collie River, about 14 miles east of Roelands which is 103 miles from Perth. This Reservoir was planned to allow 1½ acre-feet to each acre watered on a basis of 1 acre in 3 of the district. As the Collie River summer flow is small, no allowance was made for summer inflow.

Extensive research and experimental work, carried out by the Department of Agriculture, in connection with improved pastures resulted in a demand for more frequent waterings. To cope with this demand a programme of increased storages was embarked upon the allotment of water, to each acre irrigated was increased to 2½ acre-feet with an additional provision of 1¼ acre-feet for distribution, seepage and evaporation losses. Up to date this programme has resulted in the construction of Samson's Dam, an earthen dam, situated on the Samsons Brook, about nine miles east of Waroona with a reservoir capacity of 6,540 acre-feet. Work has recommenced on construction of the Stirling Dam, an earthen embankment which will impound 44,344 acre feet, when completed.

In addition to increasing the allotment of water to the Harvey Irrigation districts to 2½ acre-feet per acre rated, an additional District 16,390 acres in extent has been constituted, the area to be irrigated being one acre in three of the district. The remaining position of the programme, raising the Wellington Dam is not yet in hand, but will provide a reservoir capacity of 35,770 acre-feet when complete.

Although the irrigation areas enjoy an average annual rainfall approximating 40 inches, the bulk of this falls in the months of May to September inclusive, with little or no rainfall during the subsequent summer months. In fact, December, January, February and March have an average over the years of approximately half an inch of rain per month.

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RURAL INDUSTRY IN WESTERN AUSTRALIA

Over 20 per cent. of the State's breadwinners are directly engaged in agricultural or pastoral pursuits and many others gain their livelihood from transporting and processing primary products. In 1939 the gross value of agricultural production in W.A. was £16,000,000 and of exports from the State £10,000,000. This latter figure represented 42 per cent. of the value of the total exports, about the same proportion as gold and came chiefly from wool, wheat and flour. Exports of meat and fresh fruit, however, were also of some importance.

For nearly 70 years after the foundation of the Swan River Colony in 1829 agricultural production barely kept pace with the modest requirements of the small population, but the gold discoveries of the 1890's were followed by a period of rapid expansion. The extent of this development can be gauged from the following figures. In 1890 the area of cleared arable land was barely 250,000 acres. By 1905 the area had increased to about 1,000,000 acres and by 1940 to 14½ million acres.

Climate and soil type are the principal factors determining the utilisation of land in W.A. Large areas of the State are too arid to support even the most extensive type of pastoral activity. Outside this area about 200 million acres are occupied as pastoral leasehold and utilised for wool production under range conditions. The rainfall is sparse and irregular but before the recent cycle of drought years, the pastoral areas carried a sheep population of about 5 million head. Apart from a small irrigation area at Carnarvon on the west coast 600 miles north of Perth, agriculture is confined to the South-West Division of the State, an area of nearly 100,000 square miles, slightly more than half of which has been alienated.

Climate.

The northern part of the State is an area of summer rainfall and the south-west portion a winter rainfall region. In the former area the wet season extends from December to March, but the rain falls during the hot season and though often torrential, is frequently erratic in its distribution through the season. In the Kimberley Division annual recordings of over 50 inches have occurred, while in the pastoral areas further south periods of as long as two years have occurred in which virtually no rain has fallen. The south-west part of the State comes under the influence of the great westerly wind system between April and October resulting in a remarkaby regular rainfall incidence. About three-quarters of the year's rain falls during this cool April-October period. The summers are hot and dry. Rainfall is heaviest on the south-west and falls away sharply as distance from the coast increases. Dairying is largely confined to the wetter parts (30-60 inches); in the intermediate area (20-30 inches) fat-lamb raising, baby-beef production and wool-growing are the main industries. Many of the finest Merino and British breed stud flocks in the State are maintained in this area. In the 12-20 inch rainfall belt further east, the Wheat Belt, wheat-growing, in conjunction with sheep-raising, is the main

industry. Further north and east again the rainfall becomes too sparse and too unreliable for successful wheat-growing and sheep-raising under pastoral and semi-pastoral conditions is the main activity of the area.

Development of the Wheat Belt.

A combination of factors was responsible for the rapid development in wheat-growing which occurred from about 1905. The gold industry declined about this time resulting in considerable numbers of men seeking a means of livelihood; the clearing of land was relatively inexpensive even in forest country; many of those turning from goldmining had had experience of dry farming methods in the Eastern States; wheat varieties suitable for the dry inland areas were being produced largely from the work of Wm. Farrer in N.S.W.; the great value of the superphosphate on W.A. soils was just becoming apparent; and the construction of the Goldfields Water Supply scheme enabled farmers to explore more easily the wheat-growing potentialities of some of the drier country. In addition, the Government of the day was very sympathetic towards agricultural development and the transition from mining to agriculture. Generous financial assistance to settlers was provided. Increasing areas under wheat and increasing total yields occurred until 1930 when the record crop of 53 million bushels was obtained from nearly 4 million acres. The economic depression and a cycle of dry years which occurred about this time revealed, however, that expansion had been pushed too far into areas in which the rainfall was too low and uncertain for successful wheat-growing.

Low prices for wheat had the important effect of stimulating the development of more mixed farming in the Wheat Belt. The numbers of sheep increased greatly and in recent years almost three-quarters of the State's sheep population have been carried in the agricultural districts. Pig-raising was also greatly stimulated and in some years nearly 75 per cent. of the pigs in the State have been found on wheat farms. Along the wetter western edge of the Wheat Belt, in the 17-20 inch rainfall areas, pasture development, particularly from the use of a very early maturing strain of subterranean clover, became an important part of the farming enterprise and fat lamb production expanded considerably. Malting barley became a valuable crop in some of the wetter parts of the Wheat Belt and oats, which had always been the crop second in importance to wheat, was sown in increasing quantities, not only for hay and grain, but in recent years, particularly for grazing purposes.

The Wheat Belt is roughly 500 miles in length and 150 miles broad at its widest part and extends over an area of approximately 60,000 square miles. The area generally is gently undulating and forest country runs through it like ribbons, frequently following broad shallow valleys. As the ground rises the forest gives way to mallee thickets, then brushwood and usually at the highest elevations to scrub-plain, light-land or sand-plain. Large areas of such poor sand-plain country occur throughout the Wheat Belt. This has seriously interfered with its economic development because expansion has tended to be confined to patches of better forest country and to follow these out into the low rainfall districts. An obvious result of this has been the large railway mileage —9.5 per thousand of population.

The soils of the Wheat Belt vary widely in character often within very short distances. This is chiefly due to the extensive areas, in practically all districts, of the sandy and gravelly soils associated with laterite, just referred to as sand-plain, light-land or scrub-plain. These soils are of low inherent fertility and are still largely undeveloped. However, with adequate dressings

of superphosphate, the sand-plain in many districts has been shown to grow luxuriant subterranean clover pastures resulting in tremendous improvement in soil fertility and great increases in subsequent crop yields. The profitable utilisation of this type of land in other parts of the Wheat Belt presents a challenge to the agricultural scientist and the farmer of great potential benefit to W.A. agriculture.

The most fertile of the Western Australian wheat soils occur in the lighter rainfall areas (below 15 inches) where the main soils, apart from sand-plain, are grey and brown solonised types associated with salmon gum (*Eucalyptus salmonophloia*) and gimlet (*E. salubris*). The higher rainfall western parts of the Wheat Belt lie in what is called the "red brown earth" zone. However, the soil colours within the zone vary from grey to red-brown and the surface texture varies from sands and sandy-loams to heavy clay loams, all however, overlying sandy clay and clay subsoils. Important groups of soils in this zone, which have proved very productive for cereal crops, were associated originally with York gum (*E. foecunda* var. *loxophleba*) and jam (*Acacia acuminata*).

Development of the South-West.

The term "the south-west" is popularly applied to that portion of the South-West Land Division which is bounded on the one hand by the coast and on the other approximately by the 30 inch isohyet. This represents an area of roughly 20,000 sq. miles and contains a great diversity of soils. The opening up to production of this area was almost as rapid as that of the wheat belt, although it occurred much later and was due to a different combination of factors. Some of the better types of country had been developed for many years, in fact from the earliest years of the colony, but large areas were not cleared and brought into production until after the end of World War I. Twenty-five years ago most of the dairy-cattle of the State were to be found along the Great Southern railway on the south-western fringe of the wheat belt. Butter fat production was only 2 million pounds a year and £1,000,000 worth of butter, cheese and condensed milk had to be imported annually from the Eastern States. Since that time butter fat production has risen to some 16 million pounds per annum, making W.A. a net exporter of butter; cheese production has expanded rapidly and condensed milk is exported. A very high proportion of this production now comes from the South-West. In addition, most of the fruit and all the potatoes, flax and tobacco produced in the State are grown in this area.

Many factors are responsible for the rapid development of the South-West. After the first world war the Government made a determined effort to develop some of this country for dairying. An ambitious Group Settlement Scheme was embarked upon to bring people from the United Kingdom and settle them on virgin forest country in the extreme south-west. For a variety of reasons the scheme fell short of its original intentions but by 1942 there were some 1,100 settlers on what had once been Group Settlement holdings and an area of about 145,000 acres had been cleared and developed. Butter-fat from this area was estimated to be about 4 million pounds annually, about a quarter of the State's total. Moreover, many lessons were learned from its trial and error methods which were no doubt applied to the development of other land in the same region.

However, the most potent factor in the development of the south-west was undoubtedly the demonstration of the extra-ordinary suitability to the area of subterranean clover as a pasture species when treated with superphosphate annually. The combination of "super and sub." literally effected a farming revolution and

the area of developed land in this region rose from 150,000 acres in 1920 to almost 1 million acres in 1942. At the present time subterranean clover forms the dominant constituent of nearly all pastures in the dairy districts and topdressing of pastures with from 1-3 cwts. of superphosphate is standard practice.

The virgin soils of the south-west are generally leached and in many cases podsolised and mostly acid in reaction. They are almost invariably low in phosphate and the regular use of superphosphate, as indicated above, is essential to the maintenance of productivity. In recent years it has been found that this is not the only deficiency with which farmers of the area have to contend. A number of "minor" or "trace" minerals have also been found to be deficient, resulting in serious falling off in productivity of both plants and animals in some areas and acute "deficiency" diseases in restricted localities. Copper, in the case of plants and animals, and cobalt with animals only, are the most important of these deficiencies. Spectacular improvements in pasture growth and in the health and productivity of dairy stock have resulted from the use of copper-containing fertilisers such as bluestone and copper ore in the Busselton-Margaret River areas and elsewhere. In the Denmark district and other coastal areas cobalt "licks" for stock and top-dressing of pastures with minute amounts of cobalt have brought about remarkable improvements in the productivity of both cattle and sheep. With the opening up of new areas and the continued use of the old it is not unlikely that further deficiencies will be revealed. Technical officers of the State Department of Agriculture are constantly on the alert for such possibilities.

A coastal plain 10-25 miles wide, extends from north of Perth to the vicinity of Busselton and forms a contrast to the remainder of the south-west which is undulating, hilly country dissected by a number of rivers. This hilly country is mostly underlain by rocks of granitic type with basic dykes from which gravelly soils with yellow clay subsoils have been formed. Brown and red-brown loams with reddish clay subsoils have formed in places from more basic rocks. These gravelly and loamy soils are those which have responded so remarkably to "super and sub." and which have been extensively developed for dairying. Alluvial soils in the valleys are also of considerable agricultural importance and are utilised for the growth of summer pastures and for the growth of tobacco at Manjimup, and for fruit at Donnybrook, Capel and Bridgetown. Vegetable crops, including potatoes, are also produced on these soils. In the summer months potatoes and other vegetables are grown very successfully on the many swamps which occur in the west and south coastal areas. These have been drained and show a variety of soils ranging from black peats and mucks to black organic clays. In some cases, especially between Albany and Denmark, these swamp soils have been shown to need supplements of copper and manganese for the production of satisfactory vegetable crops. Besides the swamps, which are comparatively restricted in area, there are large areas in the southern parts of the south-west which are relatively flat and in winter very poorly drained. The soils are sandy, strongly acid in reaction, and generally carry a native vegetation of scrub and heath-like plants. So far these areas have been little utilised and, as in the case of the sand-plain soils of the wheat belt, present a challenge to the agricultural scientist and the farmer. The development of means of successfully utilising these soils would be a notable contribution to the agriculture of the south-west.

Between the coastal plain and sand-hill area and the foothills of the Darling Range is a belt of soils about 130 miles long and 4-7 miles wide formed on alluvial deposits from the rivers draining from the Darling Scarp. This area includes some of the most fertile soils in the State and considerably increased agricultural development is likely to take place in this belt. Great variation exists in the

surface soils which range from rich chocolate loams to leached grey sands with a yellow clay subsoil. The agricultural value of this land was greatly limited by serious waterlogging in the winter months but irrigation and drainage schemes have now been developed at three centres between Perth and Bunbury. By holding back a great deal of the winter flow of the rivers, these schemes in conjunction with extensive drainage works, have substantially increased the productivity of the area in the winter months. In the dry summer months the areas irrigated have enormously increased in productivity. About 90 per cent. of the water is used to maintain pastures grazed by dairy cows. The three irrigation districts of Waroona, Harvey and Collie include 76,000 acres of country. About 13,000 acres of this are actually irrigated at the present time.

Land values in the South-West naturally show a wide range of variation. Cleared land outside irrigation districts suitable for dairying, ranges upwards from £10 an acre. First class land in the irrigation areas suitable for perennial pastures or potato growing may be as high as £40 per acre.

Principal Crops.

Wheat was the pioneer crop for the lighter rainfall parts of the agricultural areas of W.A. and is still easily the most important crop grown in the State, in spite of wartime restrictions of acreage. The total production of wheat for grain and the average yield per acre for each year since 1930 is given in the table below. The marked decline in area and total yield during the latter years of the war is apparent.

Year.	Area harvested for grain.	Total yield.	Average yield per acre.
	(million acres.)	(million bushels.)	(bushels.)
1930	3·96	53·50	13·5
1931	3·16	41·52	13·1
1932	3·39	41·79	12·3
1933	3·18	37·30	11·7
1934	2·76	26·98	9·8
1935	2·54	23·31	9·2
1936	2·57	21·56	8·4
1937	3·03	36·22	11·9
1938	3·41	36·84	10·8
1939	2·97	40·86	13·8
1940	2·63	21·06	8·0
1941	2·65	37·50	14·1
1942	1·75	20·60	11·8
1943	1·57	16·55	10·6
1944	1·52	15·93	10·5

The average yields per acre for the ten-year period, 1935-44, for the main producing districts are given in the next table. The State average during this period was 10.9 bushels. As would be expected, some districts average considerably more than this figure, while several districts are very much lower. This is very largely a reflection of climatic differences. The three districts Mukinbudin, Mt. Marshall and Koorda averaged only 4.6, 5.5 and 7.5 bushels per acre respectively for this ten-year period. All three of these districts are on the north-eastern fringe of the wheat belt where there is considerable risk of

experiencing seasons in which the rainfall is too light and the growing season too short for successful wheat-growing, even with the earliest maturing varieties and most modern "dry-farming" methods.

District.	Average yield per acre, 1935–1944.	District.	Average yield per acre, 1935–1944.
	(bushels.)		(bushels.)
Carnamah	13·0	Perenjori	9·6
Chapman, Upper ...	10·9	Three Springs	13·4
Dalwallinu	10·1	Wongan-Ballidu	12·1
Dowerin	12·8	Wyalkatchem	11·9
Goomalling	13·8	Bruce Rock	12·6
Kellerberrin	10·7	Corrigin	11·7
Koorda	7·5	Dumbleyung	13·7
Kununoppin	9·7	Gnowangerup	13·8
Meckering	12·9	Kondinin	10·5
Merredin	9·3	Kulin	11·7
Moora	14·7	Lake Grace	11·4
Morawa	10·2	Narembeen	11·5
Mount Marshall	5·5	Quairading	13·9
Mukinbudin	4·6	Wickepin	11·8
Mullewa	9·1		

Western Australian wheats are white wheats and are sought after for blending purposes on account of the colour and bloom of the flour made from them. They are usually slightly below "filler" strength, although varieties of high flour strength are grown in small quantities and used for blending by local millers. The bulk of the cropped area is now sown with locally bred varieties of wheat. In the late 1920's the variety "Nabawa" became the most popular wheat in Australia and in 1930, the record year for this State, accounted for 41 per cent. of the 4 million acres cropped in W.A. The more prolific variety "Bencubbin," also bred in W.A., later displaced it in popularity and more recently "Bungulla," an early maturing selection from "Bencubbin," is becoming increasingly popular.

Wheat production is highly mechanised on most farms and on a large well-equipped farm the production of grain per labour unit can reach a remarkably high figure. Tractors have been steadily replacing horse teams as traction units for the last 20 years. A factor of considerable importance in the use of tractors is the size of farm and the area under crop, since a large and expensive tractor with its accompanying costly equipment must be used to somewhere near its capacity if its potentialities for low cost production are to be realised. An average wheat farm in W.A. is between 1,500 and 2,000 acres in area but individual farms range from 600 to 10,000 acres or more. On a typical farm of 1,500 acres approximately, 500 acres might be cropped in the autumn (April-June) each year, the whole or major portion on land fallowed the previous winter and spring (July-September). From 300 to 500 acres are fallowed for the following season and the balance under grazing. A flock of 400 to 600 sheep can comfortably be carried on a property of this size.

It is exceedingly difficult to give worthwhile figures of production costs for wheat-growing, as these vary so widely from farm to farm, from season to season and from district to district. In addition, they are complicated by the production of other commodities, particularly wool and meat, which are almost universally produced in conjunction with wheat. In 1935 a Royal Commission estimated the median cost of production for Western Australian growers f.o.r.

ports at 3s. 3d. per bushel, but many of the cost items have risen considerably since then and during the war shortages of manpower and of superphosphate, an essential requirement for wheat crops in W.A., and compulsory wartime acreage restriction, frequently have reduced the operational unit to an uneconomical size.

Oats, Barley, Hay.

Many of the oats in W.A. are grown on wheat farms but some are also produced on farms in the wetter parts of the State where no wheat is grown. In 1944 the area of oats harvested for grain was about 25 per cent. of the area harvested for wheat but, if the area sown for hay and grazing is also included, it amounts to nearly 50 per cent. of the total area sown to wheat. The oat crop is a valuable one to use in a rotation with wheat as its immunity from the soil-borne disease "Take-all" assists in the control of that disease. Also, although the seeding period is approximately the same as for wheat, the grain can usually be harvested before the wheat is ready. Yields of grain in bushels per acre are very similar to those of wheat but in the Wheat Belt the crop is usually regarded as of secondary importance to wheat; cultural practices are less intense and a smaller proportion is sown on fallow. As a result working costs are generally lower. Most of the grain is used for stock-feeding purposes on the farms where it is produced. There is practically no export trade in oats. Barley is of minor importance in W.A. compared with wheat or oats. Methods of cultivation and harvesting are similar to those employed for wheat and oats. About half of the comparatively small area sown with this cereal is used for malting purposes and half for feed grain.

Both cereal and meadow hay are produced in W.A. but the amount of the former far exceeds that of the latter. Meadow hay production is largely confined to the dairying districts; subterranean clover is the main constituent and most of it is consumed on the farms where it is made. Most of the cereal hay, in which wheat and oats are approximately equally favoured, is also consumed on the farms where it is made, but its production is largely confined to the Wheat Belt. Commercial production of cereal hay and chaff is concentrated along the western edge. About 30,000 tons of chaff are marketed annually. Cultural practices for cereal hay are similar to those employed for cereal grain crops in the same district.

Cereal Crops for Grazing.

A feature of Wheat Belt farming in recent years has been the increasing areas of cereal crops grown for grazing. The areas of oats, wheat and barley sown for this purpose now far exceeds those of all other green crops combined. In 1944 the area of oats sown for grazing was 259,000 acres, of wheat 30,000 and of barley 28,000. They are of great value for the provision of stock-feed in the early winter months before natural pastures are available in quantity and, in most seasons, are essential for the successful production of fat lambs for export. In the past the efforts of plant breeders have been largely directed towards the production of cereal varieties for maximum yields of grain, but attention is now being given also to the problem of developing and publicising varieties with the capacity for rapid early growth and ability to withstand grazing.

Flax and Tobacco.

Flax growing was undertaken in Western Australia as a wartime measure. Factories were erected at Yarloop, Donnybrook and Boyup Brook and contracts made with farmers in the surrounding district to grow flax for delivery to the

mills. The areas grown each year since the inception of the industry were:—1940, 980 acres; 1941, 6,175 acres; 1942, 8,780 acres; 1943, 7,812 acres; 1944, 8,700 acres; 1945, 6,500 acres. It is possible to grow excellent quality straw but outbreaks of rust and attacks by the climbing cutworm in the spring months have proved handicaps to the industry. However, the prospects for combating rust by the use of a resistant variety and controlling cutworm with one of the recently evolved insecticides are both considered to be bright. In these circumstances it is likely that flax production will persist at the Boyup Brook centre as land values are relatively low and the country is suitable for large scale mechanised farming operations. In this particular area the main farming activities are sheep raising for wool production on subterranean clover pastures, beef production and, to a smaller extent, dairying. Subterranean clover seed is also produced. The average rainfall is 28 inches per annum.

Tobacco growing is centred about the country township of Manjimup in the heavy forest country of the extreme south-west. The average rainfall is 50 inches per annum. The tobacco is grown during the summer months on those soil types which are particularly water retentive. Apart from the operations of a tobacco manufacturing company, which has its own plantations, the industry is composed of small scale units of 4-10 acres, the majority of which are worked by Southern Europeans. Clearing costs are heavy and improved land suitable for tobacco growing costs at least £25 per acre. Tobacco production from 1931-32 to 1943-44 is shown in the table.

Area of tobacco, total yield and value of crop—Western Australia—1932-1944.

Year.	Area planted.	Total yield.	Total value of crop.
	(acres.)	(lbs.)	(£000)
1931–32	348	211,230	18
1932–33	466	334,768	30
1933–34	291	199,284	19
1934–35	313	289,640	27
1935–36	636	500,000	48
1936–37	1,067	650,000	65
1937–38	1,215	788,559	72
1938–39	911	780,000	72
1939–40	1,019	712,214	71
1940–41	1,385	1,006,542	124
1941–42	1,295	1,111,303	125
1942–43	1,579	1,335,557	148
1943–44	1,407	846,733	69

Tropical Agriculture.

The growing of tropical crops is confined to a small area at Carnarvon, some 600 miles north of Perth, where bananas are produced on a commercial scale for the Perth market. A few mangoes are also grown and in recent years the production of tomatoes and beans in the winter months has become of some importance.

The banana is usually grown in regions where there is a combination of high temperatures, heavy rainfall and high humidity yet Carnarvon is probably the windiest place on the Western Australian coast and it has an average annual rainfall of approximately 8 inches. Average maximum temperatures are 85 deg. in summer and 70 deg. in winter. About 300 acres are under cultivation of which

200 acres are devoted to bananas. The plantations are on the bank of the Gascoyne river but the stream has only a seasonal flow. In fact in some years it does not run at all. Despite this uncertainty it is irrigation from the river, combined with the erection of windbreaks around the plantations and the selection of an appropriate variety of banana, that has made production commercially possible. Beneath the sand of the river bed there is a slowly moving stream of water which persists after the river itself has dried up. By sinking wells and bores in the dry bed of the river this stream can be tapped and utilised for irrigation purposes. The varieties of banana grown are Cavendishii and Golden Gros. The average yield is 350 cases (each 1½ bushels) per acre. Holdings are usually of about 40 acres in size and plantations in bearing are worth about £150 per acre. Working costs for 6 acres of bananas would range from £12-£15 per week depending on location and irrigation equipment. Under peace time conditions net incomes would range around £100-£110 per acre but these figures have been greatly exceeded in recent years.

Fruit.

The main fruit crops grown in Western Australia are apples, pears, citrus and stone fruits, and apples are by far the most important of these. The bulk of the apple crop in normal times is exported and in pre-war years considerable quantities were sent overseas, chiefly to the United Kingdom. The chief production centres are the Kendenup, Mt. Barker, Manjimup, Bridgetown and Donnybrook districts, while considerable quantities are also grown in the Hills District close to Perth. The annual rainfall in the apple growing districts ranges from 25-45 inches. Holdings vary in size from 5-180 acres, the majority being between 10 and 40 acres. Yields vary according to the age and condition of the trees and may range from 100-500 bushels per acre. Cleared land suitable for planting an orchard averages in price from £20-£30 an acre. The main varieties grown in their order of production are Granny Smith, Cleopatra, Dunns, Jonathan, Yates, Rokewood and Dougherty, and all these varieties are particularly suitable for export purposes. The Granny Smith in particular has become noted as an excellent quality export apple. The estimated area of apple orchards was 11,794 acres in 1945-46. Production for each of the past 5 years is shown in the following table.—

Year.	Production. (bushels.)
1941–42	(*a*)* 1,161,142
1942–43	(*a*) 2,126,936
1943–44	(*a*) 1,560,441
1944–45	(*b*)* 1,452,030
1945–46	(*a*) 1,408,050

(*a*) *Measured crop plus deliveries of unmeasured crop. (*b*) Collected figure.

Pears are usually grown in small areas in conjunction with apple orchards. There was a small export trade in pears before the outbreak of war. The estimated area in 1945-46 was 939 acres and production in that year was 119,478 bushels. The main varieties grown are Bartlett, Josephine, Winter Nelis, Beurre Bosc, Packham and Comice.

The recognised citrus growing districts in Western Australia range from Mooliabeenee-Bindoon and Chittering in the hills and foothills some forty miles north of Perth, Kalamunda and other centres in the Darling ranges to the east, through Gosnells, Armadale, Serpentine, Harvey to Boyanup, Donnybrook and Capel on the coastal plain and over a hundred miles south of Perth. Apart from

the three first-mentioned districts where citrus culture is the main activity in the fruit-growing pursuit, citri-culture is often combined with the growing of stone-fruits and in some places with apples. The main citrus fruits grown are oranges, lemons, mandarins and grapefruit and the orange crop is composed almost entirely of the two varieties—Navels and Valencias. In 1945-46 the total area of citrus fruits was 3,943 acres and the production was:—Oranges: Navels, 162,055 bushels; Valencias, 140,588 bushels; others, 12,789 bushels; total, 315,432 bushels; Lemons, 97,487 bushels; Mandarins, 14,747 bushels; Grapefruit, 19,760 bushels.

The main stone fruits grown are plums, peaches, apricots and nectarines, and these are grown mainly in the Hills Districts and on the coastal plain at the foot of the Darling Range. Small quantities are also produced at Donnybrook, Bridgetown and Mt. Barker. In 1945-46 the total area of stone fruits grown was 2,317 acres.

Grapes are a crop of some importance and are utilised for wine, for drying and as fresh fruit. Roughly two-thirds of the area under vines is in the Upper Swan Valley, a few miles to the north-east of Perth. Most grapes are grown in an area where the average rainfall is 30 inches and mainly concentrated in the April-October period. The long dry summer is an important factor in the production of high quality fruit. In Western Australia grapes are seldom grown under irrigation. Currants comprise approximately 70 per cent. of the quantity of dried fruit produced. Wine varieties yield 2-3 tons per acre, table grapes 4-5 tons per acre and drying varieties 4-6 tons to the acre. Vineyards range in size from 10-250 acres and the price of suitable cleared land from £8-£50 per acre. The areas under grapes, together with the production in 1945-46 were:—Wine Grapes, 2,796 acres, 3,764 tons; Table Grapes, 1,440 acres, 2,342 tons; Drying Grapes, 5,347 acres, 3,343 tons; Total, 9,583 acres, 9,449 tons.

Potatoes.

Most potato growing is carried out in combination with other farming activities, chiefly dairying. The average area planted per grower is approximately 7 acres. Potato growing is practically confined to districts with an annual rainfall of over 30 inches. There are two main crops—the winter crop planted in June and July and harvested in October and November, and the summer crop planted in December and January and harvested in April and May. The latter crop is grown either under irrigation or on drained swamps. Intermediate crops are grown in low lying land and under irrigation and are harvested in January to March, while small areas are sown for harvesting in the July-September period. The chief centres of production are located in the coastal belt extending southwards from Perth for approximately 150 miles. Another important potato growing district lies immediately to the west of Albany on the south coast. The "Delaware" is the only variety which is extensively grown in Western Australia. The price of cleared land suitable for potato growing ranges from £20 to £30 per acre for good winter land and up to £50 per acre for swamp land. It is estimated that the cost of producing the potato crop and placing it on rails is £30-£45 per acre. It is customary to use a complete fertiliser for the potato crop containing nitrogen, potash and phosphoric acid. The usual rate of application is 12-15 cwts. but some growers use up to 1 ton. The area harvested increased from about 6,000 acres in 1940-41 to nearly 12,000 acres in 1944-45 but has since declined again. The average yield during the last few years has been about 5 tons per acre.

Market Gardening.

In the pre-war years the total area of market gardening was about 3,500 acres which concentrated in the districts adjacent to Perth. Some years ago drained swamps were the most favoured locations for market gardens, but there has since been a steady movement away from the swamps to the surrounding higher land. Although the soil is very poor the sandy country has some decided advantages as a site for gardens. It is well drained and easily worked. Fresh water is obtainable in quantity at shallow depths and as electricity is available for pumping irrigation is relatively cheap. The quality of the soil is improved by heavy applications of stable manure, most of which is brought from the agricultural areas. Heavy dressings of organic and mineral fertilisers are applied to the crops. Southern Europeans predominate in the industry which is one mostly of small scale units of 2-5 acres. Vegetables, notably tomatoes, peas and beans, are produced in the Geraldton and Carnarvon districts, the produce coming forward during the winter period when supplies from other districts are scarce. A large proportion of the Geraldton tomato crop is exported to the Eastern States. Vegetables grow well in the Albany district, and the Kalgoorlie market draws a considerable parts of its requirements from this area. The greatly expanded demand for fresh vegetables during the war period brought about a considerable increase in the area of market gardens. Much of this increase took place in the metropolitan area but some of it was in the form of large scale mechanised units in the irrigation districts. The cessation of war time demand seems certain to cause a contraction of market garden production unless the export demand grows.

Dairying.

In the earlier section dealing with the development of the South-West reference was made to the rapid agricultural expansion in this area, through the utilisation of pastures improved by subterranean clover and superphosphate. Dairying is the principal activity in this 30-50 inch rainfall belt. In 1924-25 the total whole milk production of the State, i.e., including that used for butter, cheese and processed milk, was about 13 million gallons. By 1934-35 the figure had increased to 37 million gallons and in 1943-44 to 47 million gallons. In 1944 there were 138 thousand dairy cows in W.A. Although dairying is the main agricultural activity of the South-West it is generally combined with pig-raising, fruit-growing, sheep-raising, fat-stock production, potato-growing or poultry-raising. The sale of surplus stock and pig-raising contribute a small amount to the income of most dairy farmers, but butter-fat, in the more southerly parts of the dairying areas, and whole milk in the districts nearer Perth provide the bulk of the income.

A feature of the dairy industry in W.A. is the highly seasonal nature of the production. Apart from the irrigation areas, or patches of soil which remain moist throughout the summer, the dairying pastures are dominated by annual species, of which subterranean clover is easily the most important. Dairy production therefore rises to a peak in October and November when pasture growth is greatest and falls away to a low figure in March and April, at the end of the dry summer period, when the pastures are at their poorest, both as to quantity and quality. Fodder conservation, mainly as meadow hay, is practised by most dairy farmers for feeding during the autumn and early winter months. Mill offals are also used widely for this purpose, although the amounts fed per cow are generally small.

Most properties on which dairying is the main occupation range in size from 50-500 acres, with a "typical" property of the lower south-west about 150-200 acres in area. One hundred acres of improved pasture is considered about the minimum from which a farmer in the non-irrigated areas can obtain a modest living. Average production of butter-fat from a property of this type is 30-40 lbs. per acre and the farm would be worth about £10 per acre of cleared land. The chief breeds of cattle are Illawarra Shorthorns, Jersey and Guernseys. About three-quarters of the cows in the dairying areas are now milked by machine and the proportion is increasing. The machines already installed are capable of milking many more cows than at present.

Although the expansion of dairy production in W.A. has been very great during the last twenty years it is capable of considerable further expansion. There are approximately 15 million acres of land in the south-west of the State receiving more than 30 inches of rain annually. Only 5 millions of this are at present alienated. Much of this land which is alienated is only partially developed, i.e., not fully cleared or carrying improved pastures. Moreover, the last word on pasture improvement in these areas has not been said with "super and sub." Better pastures, better management of cows and pastures, more fodder conservation, better feeding and breeding of cows, more effective disease control (particularly mastitis and contagious abortion) and many other aspects of dairy husbandry are all capable of considerably raising the level of production. The present average yield for all cows in W.A. is only 170 lbs. of butter-fat per year. It has been calculated that this could be raised to about 220 lbs. by better feeding alone.

Pig Raising.

There are three distinct types of pig-raising in Western Australia. The first and most important is associated with wheat-growing. Pigs are kept on wheat farms as a side line and used for converting surplus wheat into meat. The number of pigs in the wheat belt fluctuates considerably, chiefly according to the price of wheat. In years of good prices wheat farmers lose interest in pigs and the numbers in the wheat-growing districts may fall to a low figure. When wheat prices are low, however, interest is greatly stimulated and three-quarters of the pigs in the State are sometimes to be found on wheat farms. This increase may occur despite low prices for pigs. The next most important type of production is associated with dairy farming. In the dairying districts the pig population is below what might be expected due, in part, probably to the marked seasonal fluctuations in milk supply. Numbers do not fluctuate so violently as in the wheat belt but they are responsive to changes in the price of cereal grains (used for feeding) and the price of bacon pigs and porkers. The third type of production is by specialist feeders in the metropolitan area. This was on a relatively small scale before the war.

The peak year for pigs was 1940, when there were 218,000 in the State. Two-thirds of this number were in the wheat belt. Since that time the total has fallen to about 160,000, but the proportion between the wheat belt and the rest of the State has remained at approximately two to one. Berkshires and Tamworths are easily the most popular breeds and a cross between them is the type most favoured for the production of baconer carcases for export. W.A. is a net exporter of pig meats, the chief outlet being the trade in frozen carcases with Great Britain. These carcases are cured for bacon on arrival and it is mainly through the influence of the exacting demands of the export market that the quality of Western Australian baconers has attained such a satisfactory standard.

Wool Growing.

The raising of sheep for wool is the most important and the most widespread of the State's agricultural and pastoral activities. An idea of the magnitude of the industry can be obtained from the table below setting out for the last ten years the numbers of sheep shorn, the total weight and value of the clip and the average weight of wool cut per head of sheep. About 80 per cent. of the sheep carried are Merinos. Crossbreds and British Breeds occur only in the agricultural areas, where mutton and lamb production, as well as wool, is an important aspect of sheep-raising.

There are three fairly distinct types of wool production in the State, each associated with a different region. These are:—(i) The northern and eastern pastoral areas. (ii) The Wheat Belt. (iii) The "clover" belt which includes the south-western fringe of the Wheat Belt and the north-eastern fringe of the dairy belt.

NOS. OF SHEEP SHORN, WOOL PRODUCED AND VALUE OF CLIP WESTERN AUSTRALIA, 1936-1945.

Year.	Sheep Shorn.	Total Weight of clip	Average Weight cut per head of Sheep.	Value of clip.
		(greasy lbs.)	(lbs.)	£
1936–37	9,385,815	63,537,200	6·8	2,884,976
1937–38	8,761,252	64,739,400	7·4	2,270,359
1938–39	9,386,526	72,475,000	7·7	2,293,906
1939–40	9,687,393	75,400,000	7·8	4,216,567
1940–41	9,876,776	69,427,000	7·0	3,962,752
1941–42	9,924,959	74,985,000	7·6	4,129,490
1942–43	10,885,520	92,697,000	8·5	5,916,223
1943–44	11,724,077	97,635,000	8·3	6,520,416
1944–45	10,902,571	81,082,600	7·4	5,232,724
1945–46	10,317,596	79,242,100	7·7	5,291,708

(i) In the pastoral areas the rainfall is sparse and uncertain and a very "extensive" form of husbandry is practised. The grazing consists of natural grasses, herbage and top-feed, i.e. native bush, especially acacias, and virtually no conservation of fodder or supplementary feeding is possible making the sheep very susceptible to droughts, which occur with varying frequency throughout the pastoral areas. A recent series of droughts reduced the sheep population of these areas from over 6 million to about 3 million. The pastoral properties, called stations, are held under lease and vary in size from 100,000 to one million acres. The carrying capacity varies with the region and the seasonal conditions, but a sheep to 20-30 acres is regarded as an average for the area. Most properties at the present time are stocked far below this level.

(ii) As indicated in earlier sections, almost all farms in the Wheat Belt carry sheep. In the drier parts these are mostly Merinos, but crossbreds are becoming increasingly important even in these areas. Sheep fit particularly well into the economy of the wheat farm. They help control the weeds on fallow paddocks, they utilise the cereal stubbles and the volunteer grazing which follows cropping, and they do not seriously compete for time and labour at those times of the year when the cereal programme is making its greatest demands on the farmer. In the late summer and autumn months when the stubbles are depleted and the new season's grazing not yet available, supplementary feeding with cereal hay and grain is generally practised. Adequate supplies of good stock water are

a problem in some areas as very few natural sources of permanent water exist. The chief sources of supply are scooped-out earthen tanks or "dams" and wells. Some parts of the Wheat Belt are served by the Goldfields Water Supply Scheme or by water reticulated from large rock catchments.

(iii) In the pasture and clover belt, with its higher rainfall and longer growing period than the Wheat Belt proper, cropping is no longer the main activity—sheep generally represent the principal source of income to the farmer. Large numbers of crossbreds occur but the majority of the Merino studs of the State are located in this area. Much of the best agricultural wool of the State is produced here and the production of high quality rams for sale to the pastoral areas and the Wheat Belt is a further important activity.

Carrying capacity varies with the degree of improvement of the property and its pastures but a sheep to the acre is quite common. Properties mostly range in size from 1000-3000 acres and the land values from £3-£7 per acre with improvements. Very large areas exist within the pasture and clover belt which are not yet fully cleared or carrying "improved" pastures, i.e., pastures sown with the early strain of subterranean clover and regularly treated with superphosphate.

Meat Production.

The production of meat for export and for home consumption is an important industry in W.A. as indicated by the table below, giving the figures for the total production of the various types of meat, the volume of exports in each case and, by difference, the local consumption for the year ending March, 1946.

For the twelve months ended on 31st March, 1946, production, imports and consumption were:—

	Production.	Exports.	Apparent Consumption.*
	Tons.	Tons.	Tons.
Lamb	6,613	2,002	4,611
Mutton	15,025	538	14,487
Beef	20,105	4,706	15,399
Veal	410	7	403
Pork	4,071	3,347	1,354
Bacon and Ham	4,888	723	4,165
Total	51,742	11,323	40,419

* Includes quantity for canning.

The production of pork, bacon and ham has previously been discussed in the section dealing with the pig industry and will not be dealt with further. The production of lamb and mutton and of beef and veal, however, deserve further consideration. The export lamb industry is a comparatively recent development in W.A. and only commenced on a permanent basis in 1930 when 25,452 carcases were treated. By 1938 the numbers had reached a peak of 371,722. There has been some decline in the numbers of lambs exported since that time. For the 1946-7 export year 210,000 lambs were treated. The decline has not been due to a reduction in the numbers of ewes mated to British breed rams but to unsatisfactory seasons and to increased local consumption following greater spending power. The best quality lambs are obtained by mating a ram of one of the

British "Downs" breeds (preferably a Southdown) with the ewe progeny of a long-wool British breed (Border-Leicester, English Leicester or Romney Marsh) ram and a Merino ewe. The first-cross animal also commands a good price as a fat lamb on both the local and export markets so that the supply of first-cross ewes for mating to the "Down" ram is usually limited.

The lambs are dropped in the autumn and marketed direct from their mothers at 12-16 weeks of age. The numbers available for export (of best quality) are therefore influenced considerably by seasonal conditions. Early autumn rains are particularly valuable, provided they are not followed by a long spell of hot, dry weather, since they produce the early growth of pastures and crops necessary to supply the best nutritive conditions for the ewe and lamb. Late opening rains, especially in the lighter rainfall districts, make it very difficult to secure the necessary rapid growth and "finish" of lambs before the warm weather of early summer has dried off the annual species causing a reduction in nutritive value of the grazing and a risk of loss through reduction in carcase grade due to the effects of grass seeds. The greatest concentration of the fat lamb industry is in the 15-25 inch rainfall belt where it is associated with cereal growing, but some export lambs are also produced in the 30-50 inch rainfall area of the extreme south-west. These two areas overlap with those parts of the "wheat-belt" and "clover-belt" just described in the foregoing section dealing with wool production. It is obvious that wool and meat production are intimately related in these areas. The mothers of the fat lambs are important sources of wool and a proportion of the predominantly wool-producing sheep, especially wethers, are fattened and sold for mutton. Some meat production in the form of mutton is a regular feature of almost all farms where sheep are kept.

In the Kimberley region in the extreme north of the State a beef cattle industry exists in which the cattle are run under range conditions on large "stations" up to one million acres in extent. As with the sheep stations of the pastoral areas these cattle stations are leasehold and rents are 10s. per thousand acres per annum. The cattle are mostly of the beef Shorthorn type and take an average of about five years to reach marketable condition. About 70 per cent. of the annual output of the region goes to the Wyndham meat works for treatment; the remainder, about 15,000 head on an average, is shipped south to the Perth market. Most of the beef for local consumption, however, comes from the southern agricultural districts. A high proportion of this beef, has, in the past, been from the dairy breeds and has been of very variable quality, but in recent years increased quantities of quality beef from the beef types of animals have appeared on the Metropolitan and Goldfields markets. This is produced, very largely in the "clover-belt" and in the higher rainfall parts of the wheat-belt where the beef breeds have become increasingly popular. A feature of beef production in these areas is the use of "beef" bulls, particularly Aberdeen-Angus, on cull dairy cows and on cows of the same breeds, resulting in rapidly-growing, well-fleshed progeny usually marketed as "baby-beef" at 18-30 months of age. No beef of this type is at present exported but even if consumption is restricted to local requirements a considerable expansion in production of beef of this quality can reasonably be anticipated.

Poultry.

Egg production is an activity which has expanded considerably in W.A. in recent years, particularly under the stimulus of war-time conditions. At the beginning of the war the production was about seven million dozen eggs; in 1944-5 it was almost 10 million dozen, together with a further three million dozen estimated as produced and consumed at home. There is little specialist production of poultry

meat; the demand is relatively small and is met mainly with roosters and cull laying hens. Poultry production in W.A. is of three main types, not dissimilar in geographical distribution and organisation to the three main types of pig production discussed in the section dealing with the pig industry.

About 60 per cent. of the eggs are produced in the wheat-belt, mostly as a sideline to cereal growing, and is normally a profitable and efficient means of utilising some of the wheat produced on the farm. About 15 per cent. of the eggs come from the higher rainfall areas of the South-West and 25 per cent. are produced on small specialist poultry farms in the vicinity of Perth. These are usually 3-20 acres in area and the land costs £15-£20 per acre. The chief advantages possessed by these producers are proximity to markets and availability of relatively cheap power and water. The White Leghorn is easily the most popular breed of fowl, followed by the Australorp and the Rhode Island Red.

Agricultural Education and Research.

Technical education in agriculture exists in W.A. at three levels, the farm school, the agricultural college and the University. Two farm schools, one at Narrogin and one at Denmark, are controlled by the Education Department and provide a two-year course, especially adapted to the needs of farmers' sons 13-16 years of age. This course is essentially a vocational and practical one, but does not neglect post-primary general education. An agricultural college at Muresk provides a more advanced three-year course in the science and practice of agriculture, leading to the Muresk Diploma in Agriculture. A special two-year course leading to the Muresk Diploma in Dairying is also provided. A general post-primary education up to the standard of the Junior Certificate is required of all students prior to commencing at Muresk. At the University level a four-years' course leading to the degree of Bachelor of Science in Agriculture is provided at the University of W.A. This course is designed to train men and women to undertake advisory and administrative work in the various technical branches of agriculture and to carry out research into farmers' problems. General education to the Leaving Certificate level at an ordinary secondary school is required of all students before commencing their University course, but holders of the Muresk Diploma in Agriculture may, under certain conditions, proceed to the University degree in Agriculture. It is also possible for exceptional students to proceed right through the three levels of agricultural education, from farm school, to agricultural college to university.

Educational work among farmers in the field, usually known as extension work, is one of the chief functions of the State Department of Agriculture. This department is also responsible for the administration of various Acts relating to agriculture and has a staff of specialist technical officers who carry out research into farmers' problems. The Department of Agriculture has for many years adopted the policy of recruiting its technical staff from University graduates in agriculture and pure science and has had conspicuous success in the producton of improved varieties of cereals and other crops and in the solving of many farmers' problems, notably those relating to soil deficiencies and to animal health and production.

The Council for Scientific and Industrial Research, a Commonwealth body, is also active in W.A., particularly in relation to pasture problems and works in close co-operation with the State Department of Agriculture. The Institute of Agriculture, of the University of W.A., is a third institution actively engaged upon research into some of the more basic problems of the farming and pastoral industries. Close co-operation is maintained with the State Department of Agriculture and the Council for Scientific and Industrial Research.

FORESTS AND FORESTRY

The major portion of the 624,589,000 acres of Western Australia carries a sparse crop of trees, practically the whole of which are of the hardwood class. The important commercial forests are restricted, however, to the South-West corner of the State. The timber industry of Western Australia has always been one of the most important of the State's industries. It has had a high value in the production of wealth, employment of people, general development of the South-West and as a form of settlement of major importance in a young country.

Employment is found normally for 3,500 men in the saw mills, while this number is increased to approximately 6,000 by the addition of men engaged in timber yards, firewood cutting, mallet bark stripping, sandalwood pulling, etc. The value of the industry on the return to full production will be more than £3,000,000 per annum.

Western Australia is one of the two States in the Commonwealth, Tasmania being the other, which produces enough timber for her own needs. The difficulty now being met with in importing timber to make up Australia's requirements illustrates the value of the comparatively small area of economic forest now remaining on the continent.

Jarrah.

In this State, jarrah (*E. marginata*) is the principal tree species, having grown originally on an area of some 13,000,000 acres, but the prime jarrah forest, having a high merchantable value is limited to about 2,500,000 acres. This forest, which forms a compact belt some 20 miles wide and 200 miles long, stretching along the Darling Range from Perth in the north to Manjimup in the south, is mainly restricted to the 35 inch and higher rainfall belt. Associated with it are marri (*E. calophylla*), blackbutt (*E. patens*), and bullich (*E. megacarpa*) while in some of the poorest situations, mountain marri (*E. haematoxylon*), becomes a component of the forest.

Jarrah reaches its best development on uncultivable ironstone ridges, and attains a height of 100 to 150 feet, and a breast high diameter of 4 to 6 feet, with a clear log length of 40 to 60 feet. In virgin forest, the volume of mature timber suitable for sawmilling measured in the round, may reach 5,000 to 6,000 cubic feet per acre over extensive areas, but the average is nearer 1,000 cubic feet per acre. Jarrah is a durable timber of well recognised utility throughout the world, its special value for high grade uses being less generally appreciated outside Australia. With the more general adoption of standard grading rules, and the installation of modern kiln drying facilities, a larger proportion of the output is now being used for panelling, joinery and cabinet work.

Karri.

Karri (*E. diversicolor*), is restricted in its habitat to the wettest portion of the State where the average rainfall is 40 inches and over. The northern boundary is a line between Manjimup and Nannup and from there south and south east to Denmark. Except for an isolated area from the Leeuwin to the Margaret River, it

does not extend westwards beyond a line drawn from Nannup to a point on the Warren River, 6 miles above the mouth. Another small and isolated area of karri occurs in the Porongorups hills. It is generally separated from the sea by a belt of sand-plain country though at Nornalup it comes down to the edge of the estuary formed by the Deep and Frankland Rivers. The karri forests, unlike the jarrah, do not extend in a pure state over the whole area of 240,000 acres described above, but are intersected by belts of jarrah and by belts of mixed karri and marri, pure marri and blackbutt and marri.

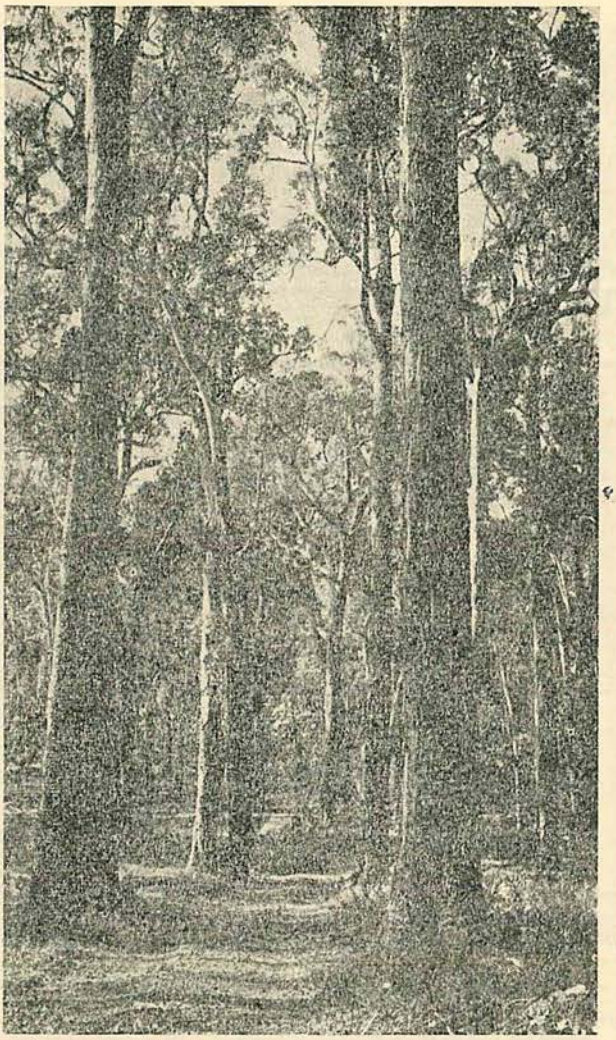

Fig. 6.
Jarrah Forest
(*Eucalyptus marginata*)

Karri is one of the most magnificent of Australian trees. The prime forest belt extends over 75,000 acres, practically the whole of which is now dedicated State Forest. It is one of the tallest of the eucalypts and trees over 250 feet high with a diameter of 8 to 10 feet at the base, and a clear log

of up to 150 feet are not uncommon. The density of the stocking in the virgin karri is very great, 20,000 cubic feet of merchantable timber having been removed from one acre, though the average is much lower than this. Owing to the large size of karri logs, some of which contain 400 to 600 cubic feet of timber weighing up to 25 tons, very heavy equipment is necessary to handle them. The timber is stronger than jarrah but otherwise greatly resembles it in general appearance. It is of average durability, but is not recommended for use in contact with the ground unless it has been subjected to a preservative process.

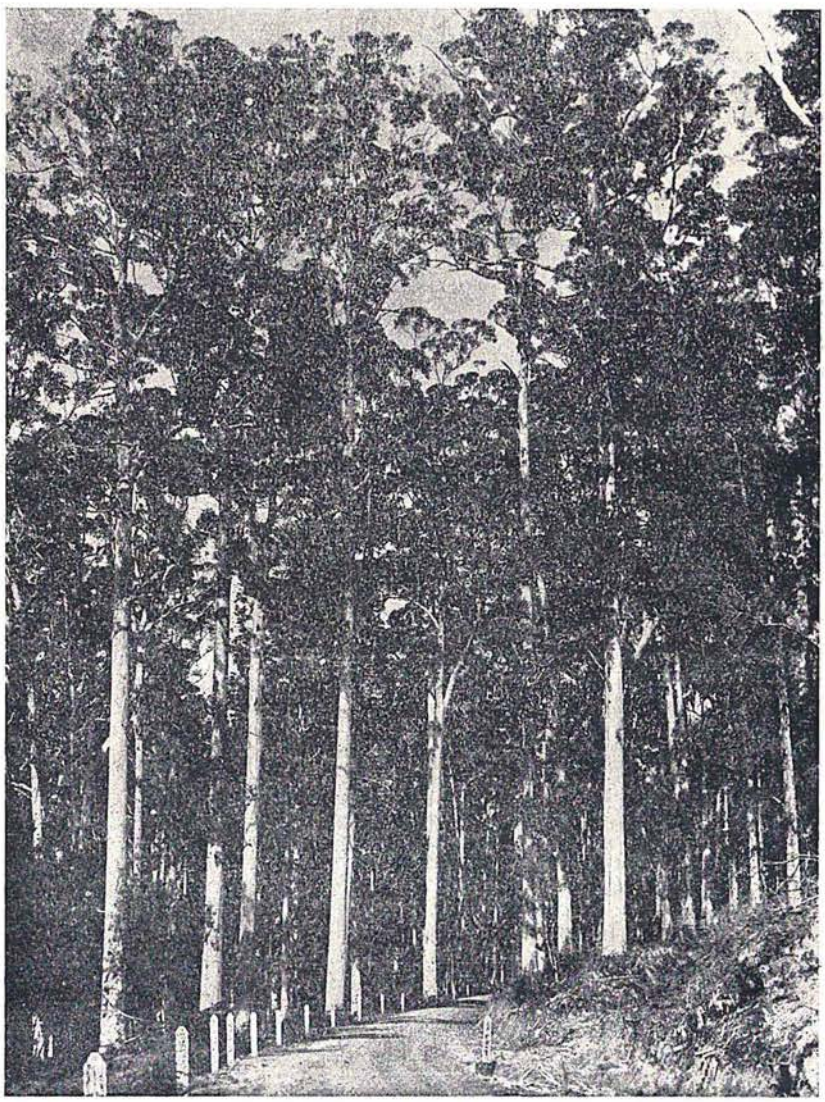

Fig. 7.
Virgin Karri Forest—Pemberton

Around Nornalup on the south coast, a mixed forest of karri and the two tingle tingles (*E. Jacksoni* and *E. Guilfoylei*) is found. The area of the tingle-

tingle forests is small, however, the prime forest being confined to 8,660 acres near the mouths of the Deep and Frankland Rivers. First quality tuart forest (*E. gomphocephala*) is confined to an area of State Forest of less than six thousand acres, on the coastal limestone formation between Bunbury and Busselton though the species also follows the coast in a northerly direction for some distance beyond Perth.

Wandoo.

The better quality wandoo (*E. redunca, var. elata*) forests are limited to areas a few thousand acres in extent to the north and east of the prime jarrah forest. The forests of the southern interior consist of a large number of species which may vary from a mallee form with a large number of shoots arising from a flattened root stock to large trees reaching 60 to 80 feet in height. Salmon gum (*E. salmonophloia*) is the commonest species, extending throughout the entire formation from 20 inch rainfall on the west to 8 inch on the east. Other common tree species are red morrell, yorrell, gimlet, York gum, brown mallet, blue mallet, merrit, redwood, Goldfields red flowering gum, Goldfields blackbutts, and Goldfields yellow flowering gum.

Milling.

The logging and milling of timber from State Forests are carried out by saw-milling companies who hold exclusive rights over specific areas. Including those mills which are also operating on private property, during the year 1945-46 there were 128 mills registered and producing a total of 8,883,888 cubic feet of sawn timber. These mills vary in size, the largest jarrah mill being the Railway Department's mill at Banksiadale which produced 611,695 cubic feet of sawn timber during the last twelve months. The State Saw Mills at Pemberton with a production last year of 644,430 cubic feet, is the largest mill cutting karri in Western Australia. Full production when, as manpower becomes available, the industry returns to normal, will mean the output of more than 12,500,000 cubic feet.

These companies, in many cases, have their own railway systems, totalling some 400 miles of lines, for the haulage of logs from the forest to the sawmills. Haulage to the log lines is done by steam haulers or tractors. With the smaller milling plants, log supplies are carted direct to the mill by motor transport. Timber for export is railed from the mill to the port, the main port being Bunbury, while timber is also exported from Busselton, Fremantle, and Albany.

Exports.

Timber has been exported regularly every year from the forests of the South-West since the year 1846. In the early years of the trade, the export value was only a few hundred pounds per annum, but by 1878 it had grown to a value of £64,000 per annum and the peak was reached in 1927 when £1,651,000 worth of timber, exclusive of sandalwood, was sent out of the State. In 1924, the export of sandalwood reached a value of £348,713. The value of timber exported from the State has averaged nearly £1,000,000 per annum over the last twenty years. The local market now absorbs rather more sawn timber than is exported, resulting in a total production valued at £1,500,000 to £1,750,000 per annum. Approximately 90 per cent. of Western Australian timber consumption is hardwood, practically all other than variety timber for furniture work being from our own forests.

In pre-war years, West Australian timbers were exported throughout the world (United Kingdom, India, China, Ceylon, Pacific Islands, Iran, Portugese East Africa, British West Indies, Europe, etc.) but these exports have now been limited temporarily to allow sufficient supplies made available to the local market and for Commonwealth requirements. However, during 1946, £722,061 of timber was exported to other States of the Commonwealth, United Kingdom, New Zealand, South Africa and Egpyt, mainly for sleepers and general hardwood purposes.

Jarrah and karri are the most important commercial timbers of the State and form the basis of the overseas export trade. They are found in no other part of the world and during the last 15 years the forests of these two species have provided nearly £15,000,000 worth of timber for export, in addition to very large quantities used within the State.

Forest Protection and Control.

Until 1918, practically no attempt was made to control or regulate the extent or methods of timber production, but in that year a modern Forests Act was placed on the Statute Book and has provided the basis for the subsequent development of a sound policy of forest protection, regeneration and management. The Forests Act provided for the establishment of a Forests Department under a Minister for Forests, for the permanent dedication of State Forests and the provision of a Trust Fund for reforestation work, into which is paid three-fifths of the net forestry revenue.

For many years now the sawmilling operations have been conducted in accordance with the provision of a Working Plan which regulates the total mill intake, reduces the former overcutting and aims at long life in the industry. The General Working Plan for karri and jarrah has now received its second revision, the term of the plan being for 10 years, but tentative provision has been made for a continuity of the cut for 30 years. Efforts have been directed to securing a better return from a limited output by seeking more profitable markets for the highest grade products which the forests are capable of yielding. With this object, the Department has co-operated with the timber industry in investigating improved methods of sawmilling, seasoning and marketing and by preparing and publishing under the aegis of the Standards Association of Australia, standard grading rules for jarrah and karri. The result of this sound policy of forest conservation is that an immensely valuable national asset is being built up to the advantage of the whole of the Commonwealth.

Reforestation.

The Department, dependent for its funds on three-fifths of the current timber revenue, had no chance, however, of overtaking the serious leeway in reforestation resulting from neglect of these measures prior to 1918. Fires continued to exact an annual toll from large areas of valuable forest. Other extensive areas of cut-over forest had not been restocked and were in danger of reverting to waste scrub-land. Between 1931 and 1936, loan funds were made available and large numbers of relief workers were employed to rehabilitate the forests. As a result of this expenditure, a considerable area of the good quality cut-over forest was brought under intensive management and fire control measures extended to embrace some of the virgin forests of the south-west. The main reforestation work of the Department has been the regeneration of the jarrah and karri forests cut-over in the past by sawmillers and hewers. The area of jarrah forest which has received intensive regeneration treatment amounts to 450,000 acres and of karri 25,000 acres. More recent trade cutting, since the forests have

been brought under management, has been under close control by tree marking in lieu of the old minimum girth restriction. More effective utilisation of the older mature elements of the virgin crops has been secured. An adequate growing stock, with a suitable distribution of size classes for cutting in the next felling cycle, is being provided for by the retention of the vigorously growing immature trees. The basis of reasonably adequate regeneration measures has been established by seeing that the regeneration should be the result of the fellings themselves and careful avoidance in felling of damage to the younger trees. In addition, the stocking of the cut-over karri forest is being completed by regeneration from seed by a judicious programme of debris disposal by burning according to the occurrence of seed years. The Forests Department maintains a well-organised inspection branch and a large proportion of the timber exported is inspected and branded in accordance with the buyer's specifications before being forwarded to the ports of shipments.

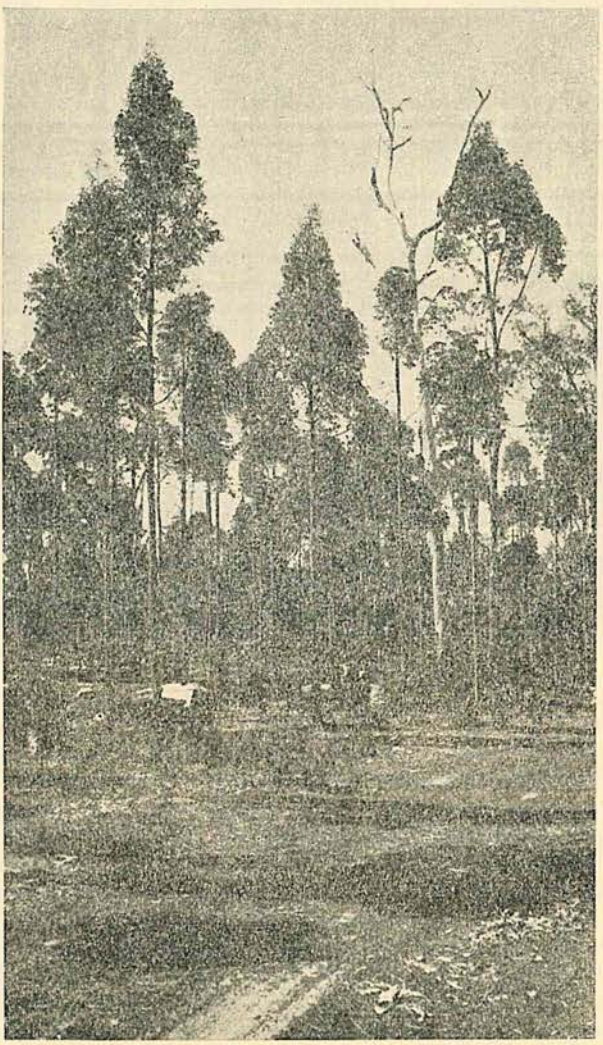

Fig. 8.
Jarrah Saplings following regeneration operations, Dwellingup District.

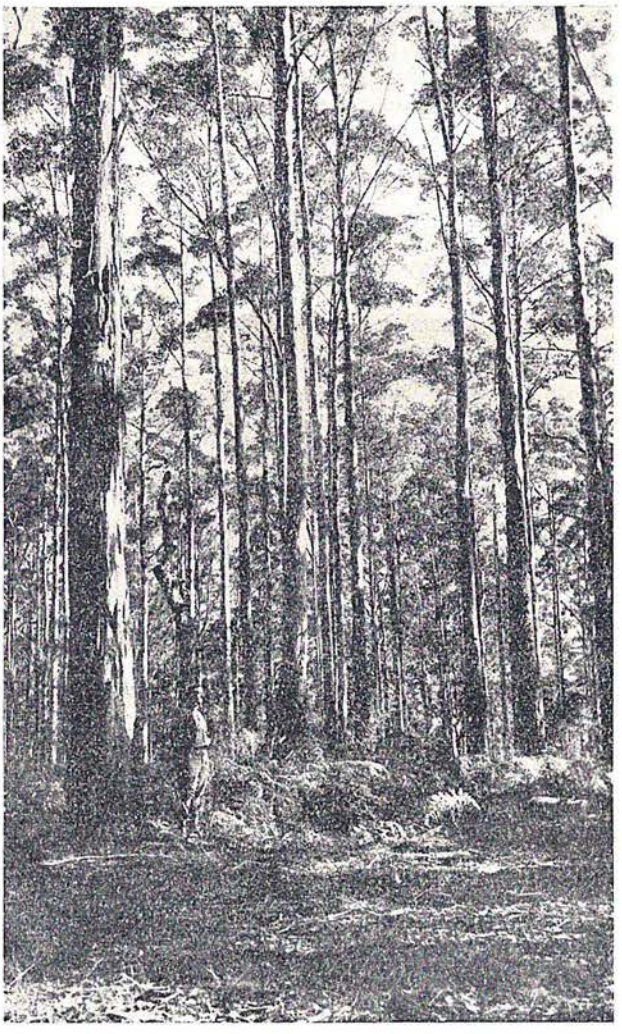

Fig. 9.
Karri Regrowth

Versatile Hardwoods.

The versatile nature of local hardwoods is well illustrated by the way they have been utilised for cases. This timber is now being used for all forms of crates and cases on the local market and production for this purpose is extending because of present difficulties in securing imported softwood. Although three quarters of the timber for cases is supplied from general purpose mills from the off-cuts in cutting larger timber, there are a number of smaller mills producing cases only, the timber being made available in country cut over by general sawmillers or in virgin country where the timber is not up to the standard required for a big mill. Estimated requirements for the next twelve months are 1,750,000 fruit cases and 1,250,000 other cases. Jarrah and karri are mainly used for fruit cases but the use of blackbutt and marri for this purpose has increased during the last few years.

Due to the shortage of hoop pine, tests have been carried out to determine the suitability of local timbers for butter boxes, when properly sprayed on the inside with a casein formaline mixture. Jarrah butter boxes were found to be free from taint while karri plywood was also shown to be a quite satisfactory butter box timber. Considerable numbers of these containers are now being used in the trade locally. A trial shipment of export butter sent to the United Kingdom has been very favourably reported on.

Local hardwoods have been utilised for many other purposes. Sheoak has found a ready market as barrel staves in the manufacture of beer casks and karri is used in the making of wine vats. After many experiments, it has now been established that jarrah and karri can be peeled for plywood. Jarrah and karri plywood is now being produced in a Western Australian plywood factory and is being used for a variety of purposes including linings, the making of butter boxes and furniture.

Sandalwood.

Among other products of the forest which continue to support valuable industries are sandalwood, mallet bark, and tanning extract from wandoo timber. Sandalwood is an insignificant but valuable tree, now obtainable only at considerable distances from the railway termini in the interior. The wood has been exported for many years to China where it is used for incense in their temples. The total value of sandalwood exported for this purpose to date amounts to over £5,000,000. During recent years, sandalwood has also been used for the manufacture of sandalwood oil, which has developed into a successful local industry. This oil is used for medicinal purposes, but mainly in the manufacture of soaps and perfumes as a base for the perfume itself. This has resulted in £620,000 worth of sandalwood oil having been exported to date.

Mallet is best known on account of the high percentage of tannin content of the bark which was formerly the basis of an important export trade with Europe. The establishment of artificial stands of mallet over considerable areas of waste land, carrying a crop of poison plants, has been remarkably successful. Over the last two or three years, prior to the war, about 1,500 acres per annum had been established but this work was suspended during the war. The total area of such plantations being now over 17,000 acres. Recent trials indicate that special uses may be found for mallet timber, which is one of the strongest of the lighter eucalypts.

The use of poor quality wandoo logs for the production of a tannin extract has resulted in the development of two large factories which are utilising annually tens of thousands of tons of timber which at one time was regarded as valueless, thus demonstrating the possibilities of turning to commercial account minor forest products, the value of which is not yet appreciated. The barks of some of our eucalypts, such as *E. pallidifolia,* found in the Kimberleys, karri, tuart and marri have been tested and proved to have important tannin contents.

The low rainfall forests of the interior have been of great importance in the successful development of the farming, pastoral and mining industries. On the Goldfields extensive railway systems have been built to tap these forests for the supply of firewood and general mining timber. In addition, however, considerable quantities of jarrah and karri are railed from the coast for general construction work, squared shaft timber and cage runner guides.

State Nursery.

Aboriculture in the country districts has for a long time been given prominence in Western Australia and a State Forest Nursery has been maintained for this purpose. Formerly trees were distributed free to settlers and public bodies but

now the trees are issued at cost price to persons residing outside the metropolitan area. Owing to technical difficulties, mainly associated with the comparatively wet climate experienced at the State Nursery at Hamel, the raising of trees suitable for planting in the lower rainfall areas of the wheat-belt has presented a problem. Experimental work is now being carried out at Kalgoorlie with 24 species, 18 of them Eucalypts, suitable for dry country planting.

Pine Plantations.

With a view to providing internal requirements of softwood timber, pine planting operations on otherwise waste land were being extended, up to the war years, at the rate of about 1,000 acres per annum, the total area of pines now established being 13,000 acres. These plantations have been established in proximity to main centres of consumption and already thinnings are being marketed. Owing to the poor class of soils and the long period of drought each year, the establishment of pine plantations in Western Australia presented considerable difficulties. Initial troubles in raising plants in the nurseries were associated with a lack of mycorrhyzal fungus which had to be introduced to the particular nurseries. It was then early found that disorders were occurring in the young pine stands even though planted in many instances on sites which had formerly carried Eucalypts with a height of 150 ft. and in the case of sample plots on karri soils, over 200 ft. The soils of the coastal plain used for planting were the old dunes while the soils of the Darling Range were mostly of laterite origin or in some cases derived from the granite or more rarely dolerites from which the laterite had been denuded in the small valleys.

Chemical analyses revealed the low content of the main plant nutrients except on the dolerite soils. In the sands, figures as low as three or four and even no parts per million were recorded. Using phosphate as an indicator, it was established that for satisfactory growth of *Pinus radiata* on virgin soils, 350 parts per million were required and for *P. pinaster* 200 parts per million. Reasonable stands can be grown in much poorer soils with cultivation and other artificial aids.

The first steps taken in trials with corrective measures were the use of the manures containing the main plant nutrients, calcium, phosphorus, potash and nitrogen. Notable success with phosphate was obtained in some cases, especially with the *P. pinaster* plantations on the coastal sands. Trials with minor elements showed the remarkable curative powers of zinc salts on certain soil groups with both *P. radiata* and *P. pinaster.*

Fire Control.

The forest fire problem is the greatest single obstacle to successful forestry in Western Australia. Without the constant threat of fire during the summer months, the task would be comparatively simple. Fire causes damage to trees at all stages of their growth and particularly during the early years. The loss which can be occasioned in the forest by fire is perhaps best exemplified by fire-tender eucalypts such as mountain ash of Victoria, the mallets of Western Australia and the pines which are completely killed by fire. Even the more resistant eucalypts, however, such as jarrah and karri show great loss of merchantable timber by the repeated unrestricted fires which occurred in past years.

The Forests Department of Western Australia now maintains an important fire control organisation. Twelve thousand miles of tracks have been opened for access by fire trucks and to provide fire lines to facilitate the early burning of hazards particularly along railways, main roads, and adjoining private property. A system

of fire towers, totalling 30 in number, extends from one end to the other of the protected belt. These are manned constantly during daylight hours in the fire season. A network of bush telephone lines of special design links towers with forest officers and settlements, mill towns and many adjoining private property owners. Radio is now used for communication between gangs at fires and district headquarters. Power pumpers of various types are used to throw water both from portable tanks and from dams, water holes and permanent streams.

Weather Research.

Weather plays a most important part in this problem as fires are far more severe on days when wind, temperature and low relative humidity combine to produce conditions under which fires spread rapidly. Foresters express these conditions by speaking of the fire weather as being low, moderate, average summer, high summer, severe and dangerous and, according to the conditions expected for each day, take steps to organise work to the best advantage.

It is of course very important to be able to forecast in advance what weather is to be expected for the day and to provide this forecast during the summer a fire weather research station operates in the forest at Dwellingup. All the weather factors are studied and the dryness of the forest fuel is measured by studying the weights of small wood cylinders which, of course, vary with changing atmospheric conditions. As the result of this study of weather factors and the forest fuel, the officer in charge of the weather forecasting is able to send out to all forest districts every morning an estimate of what the fire weather will be. Forecast of fire hazard are given for two different regions, the northern, called for convenience the Jarrah Zone, and the southern called the Karri Zone and applicable to country approximately south of a line through Margaret River, Nannup and Narrogin to Denmark. The fire weather hazard given by the Divisional Meteorologist is broadcast over the air through the courtesy of the Australian Broadcasting Commission and is of importance to farmers and settlers in the South-West as well as the forester.

MINING

The total mineral production from Western Australia at the end of 1946 was valued at £304,662,990. The most important mineral is gold, the value of the total production being £283,098,192.

Gold.

The first discovery of gold in Western Australia was at Hall's Creek in the Kimberleys in 1885, and this was followed by many other discoveries, the most important being the Murchison and Coolgardie fields in the years 1891-3. Several mines have worked continuously since their discovery, but mining reached a low ebb in 1929 because of the depletion of the richer and more easily mined parts of the ore bodies.

Increases in the price of gold commencing in 1930 brought about a revival and the peak year was in 1940, when 1,191,482 fine ounces, valued at £12,696,503, were recovered from the treatment of 4,291,709 tons of ore. The number of men employed in the industry was 14,593 and the dividends distributed amounted to £1,059,936.

During the war years labour was not available for gold mining and machinery was removed for use in war industries. Several mines were forced to close down and the production declined to 466,265 fine ounces derived from 1,777,128 tons of ore and valued at £4,899,997 for the year 1944. Since the end of the war, the position has improved, but the scarcity of supplies, particularly heavy machinery, has retarded post-war development.

Gold is found over a wide area extending from Marble Bar in the north to Ravensthorpe in the south and from Mt. Magnet in the west to Laverton in the east, and also in the Kimberley area. Occurrences of gold are confined mainly to the greenstone rocks. Many different types of ore body are encountered and the gold may be associated with several different minerals.

The East Coolgardie.

The most important deposit in W.A. is the "Golden Mile" at Boulder in the East Coolgardie Goldfield. Gold was first found in this area by Paddy Hannan in 1893. The deposit is remarkable for the extent and value of the lodes and for the occurrence of tellurides of gold and other metals. The well known mines in this field, Great Boulder, Perseverance, Associated, Lake View and South Kalgurli, have operated, practically since the discovery of the field. Golden Horseshoe Ivanhoe and Chaffers were amalgamated with Lake View under the name of Lake View and Star and in recent years have developed large reserves of ore and set up a fine treatment plant. North Kalgurli and Paringa, which were smaller mines, have also developed well, while Gold Mines of Kalgoorlie has developed a group of old leases, including the Iron Duke and the Oroya.

On the north end of the field the Broken Hill Pty. operates the Hannans North Mine. The development of the Mt. Charlotte leases, which was interrupted by the war, is expected to provide further supplies of ore.

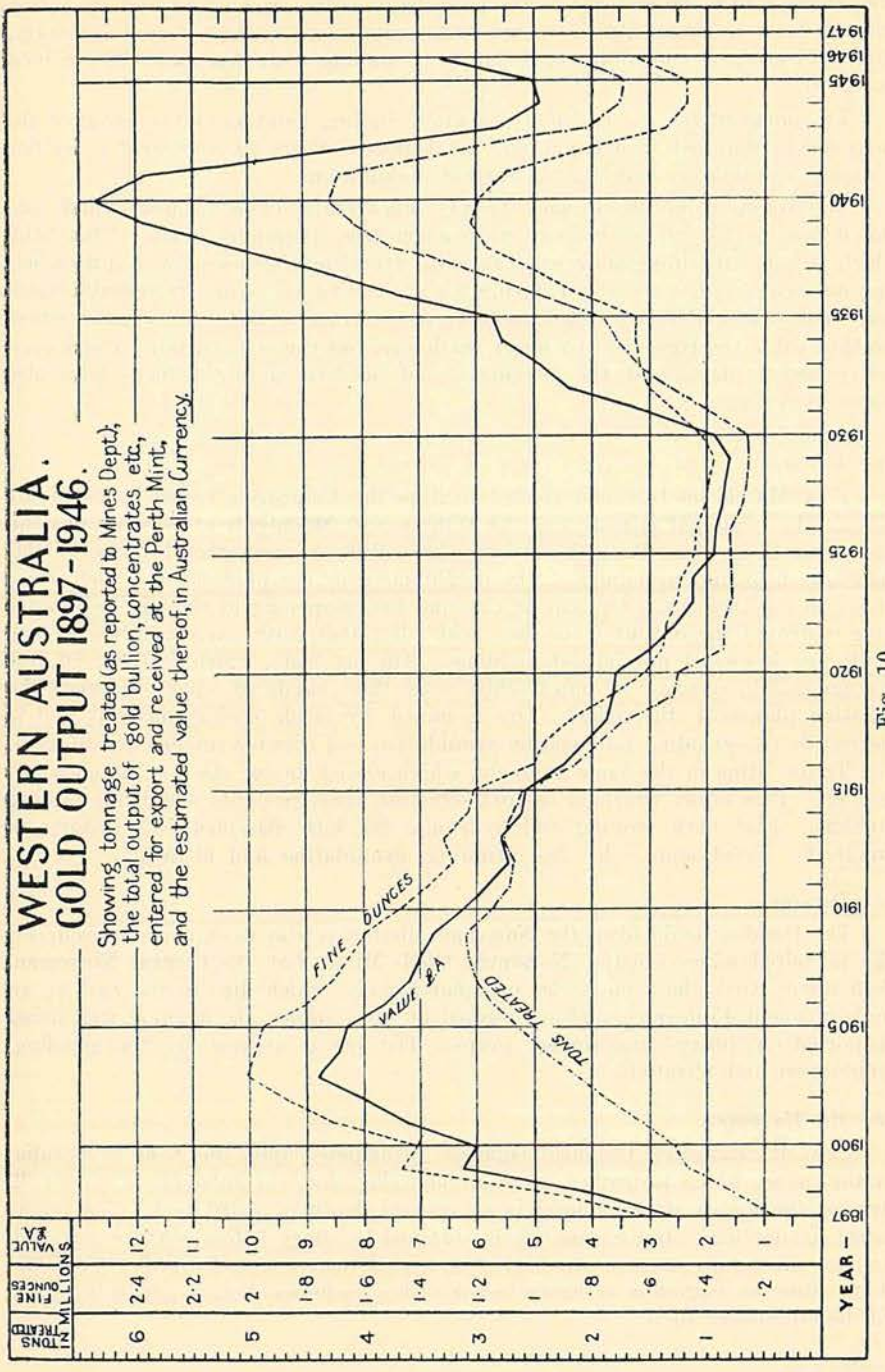

Fig. 10.

The ore bodies of the Golden Mile are of metasomatic origin and follow major north and south shears, which are either vertical or dip steeply to the west. Caunter shears and cross-lodes also exist and although they may carry good values,

are subordinate in importance to the main lodes. The ore may be won by shrink stoping down to about 2,000 feet, but below that depth filling becomes necessary, Rill stoping with sand filling and flat back stoping with hydraulic fill are both practised.

Treatment of the ore is usually by fine grinding, flotation and roasting of the concentrate, followed by cyanidation. At Hannans North the treatment is by fine grinding, cyanidation and counter current decantation.

The White Hope Mine, some twenty miles south of Kalgoorlie, which was closed during the war, is preparing to commence operations again. This field, which was in a declining state in 1929, with several mines closed down and dwindling ore reserves, has recovered during the succeeding years in a remarkable manner. The principal factor is undoubtedly the increase in the price of gold, which made possible the treatment of lower grade ore, but the construction of economical treatment plants and the introduction of modern mining methods have also played a part.

The Murchison.

East Murchison Goldfield ranked next to the Coolgardie Goldfield for many years. The principal mines were the Wiluna and Moonlight at Wiluna and the Emu mine at Lawlers. With the decline of the Wiluna mines, the Murchison Goldfield has come into prominence. The development of the phenomenally rich shoot of ore in the Day Dawn Options at Cue and the re-opening of the Big Bell mines have improved the output from this field. Big Bell, with large reserves of low grade ore, is one of our important mines. The ore body, which is about 80 feet average width, consists of mica schist with thin bands of quartz between the foliation planes of the schist. Ore is mined by block caving methods and is treated by fine grinding followed by cyanidation and counter current decantation. The Triton Mine in the same goldfield, which closed during the war, is about to re-open. This mine, which is in soft schistose rock, presents a difficult mining problem. Flat back stoping and hydraulic fill with classified mill tailings is practised. Treatment is by fine grinding, cyanidation and filtration.

The Dundas.

The Dundas Goldfield in the Norseman district is also an important producer. The principal mines are the Norseman Gold Mines and the Central Norseman. Both mines work the same series of quartz reefs, which dip to the east at an angle of about 45 degrees, and are worked by open stopes, the hanging wall being supported on pillars and timber props. The ore is treated by fine grinding, cyanidation and filtration.

The Mt. Margaret.

The Mt. Margaret Goldfield depends principally upon the Sons of Gwalia. In this mine, which is worked from an underlay shaft at an angle of about 42 degrees, the lowest working level is at vertical depth of 3,380 feet. The ore is mined by flat back stoping and fill is obtained by glory holing surface material. Another interesting mine in this field is the rich Boomerang at Burtville. The Porphyry Mine at Edjudina is being tested and it is hoped that a producing mine will be established there.

Coolgardie.

The principal producer in the Coolgardie Goldfield is the Phoenix at Coolgardie. Ore is mined by shrinkage and open underhand stoping and milled by battery and cyanide treatment. Tindals and Spargo's Reward were closed

during the war period, but it is hoped that they will soon resume. New discoveries in the Hampton Plains area, the Surprise and the Barbara are attracting considerable attention and promise to develop into regular producers.

Yilgarn.

Consistent returns have been received from the smaller mines in the Yilgarn Goldfield. The Evanston Mine, which was closed during the war, is re-opening.

Pilbara.

The two principal mines in the Pilbara Goldfield are the Comet at Marble Bar and the Blue Spec at Nullagine. At the Comet a rich shoot of ore is mined by open stoping methods and treated by flotation, roasting and cyanidation. The ore body at Blue Spec contains both pyrite and stibnite. The mine produces an antimonial concentrate and a pyritic concentrate as well as some strake gold.

Broad Arrow.

Ora Banda Amalgamated in the Broad Arrow Goldfield has resumed operations after being closed during the war years, but has not yet reached regular production. Production figures for the year 1946 have just been completed and show that the previous year's total has been exceeded by 148,413 fine ounces.

Coal.

Next in importance is coal. Although coal is known to exist in several localities, the only producing field is at Collie. Coal was discovered there by Arthur Perren in 1883. The series of rocks containing the coal is of Permian age and is contained in a basin formed in the underlying granite rocks. The area of the basin is approximately 76 square miles and the thickness of the measures is estimated at not less than 2,000 feet. Fifteen seams of 5 feet or more are recorded and there are several smaller seams. The coal has been divided into three horizons—the lower, or Co-operative; the middle, or Collie-burn; and the upper, or Cardiff horizon. The coals from the lower horizon are "harder" than coals from other parts of the field. They are lower in hydrogen content and lower in volatiles and generally are more suitable for steaming under severe conditions. (See Electricity and Fuel Resources.)

The principal output has been from this horizon. At the present time the Co-operative, Proprietary and Stockton Collieries and the open cuts on the Stockton and Old Proprietary Mines are all winning coal from the main seams in the Co-operative horizon. The Griffin and Wyvern Mines are in the Collie-burn horizon, while the Cardiff Mine is in the Cardiff horizon. The seams dip generally to the south at an average grade of about 1 in 10 and the mines have been opened up by tunnels from the surface in a southerly direction. Local folding and distortions in the vicinity of faults have produced changes in the attitude of the beds and in some cases the dip is to the north.

The Co-operative Mine, situated at the western end of the Co-operative series, is intersected by two faults roughly parallel to the strike which interfered very seriously with the working of the mine. The barrier between the faults has been penetrated by a stone drive, which has improved the position.

The Wallsend Open Cut is working coal on the outcrop of the area formerly worked by the Wallsend Mine. This coal is loaded either at the Proprietary gantry or at a siding on the side of the old Wallsend Mine.

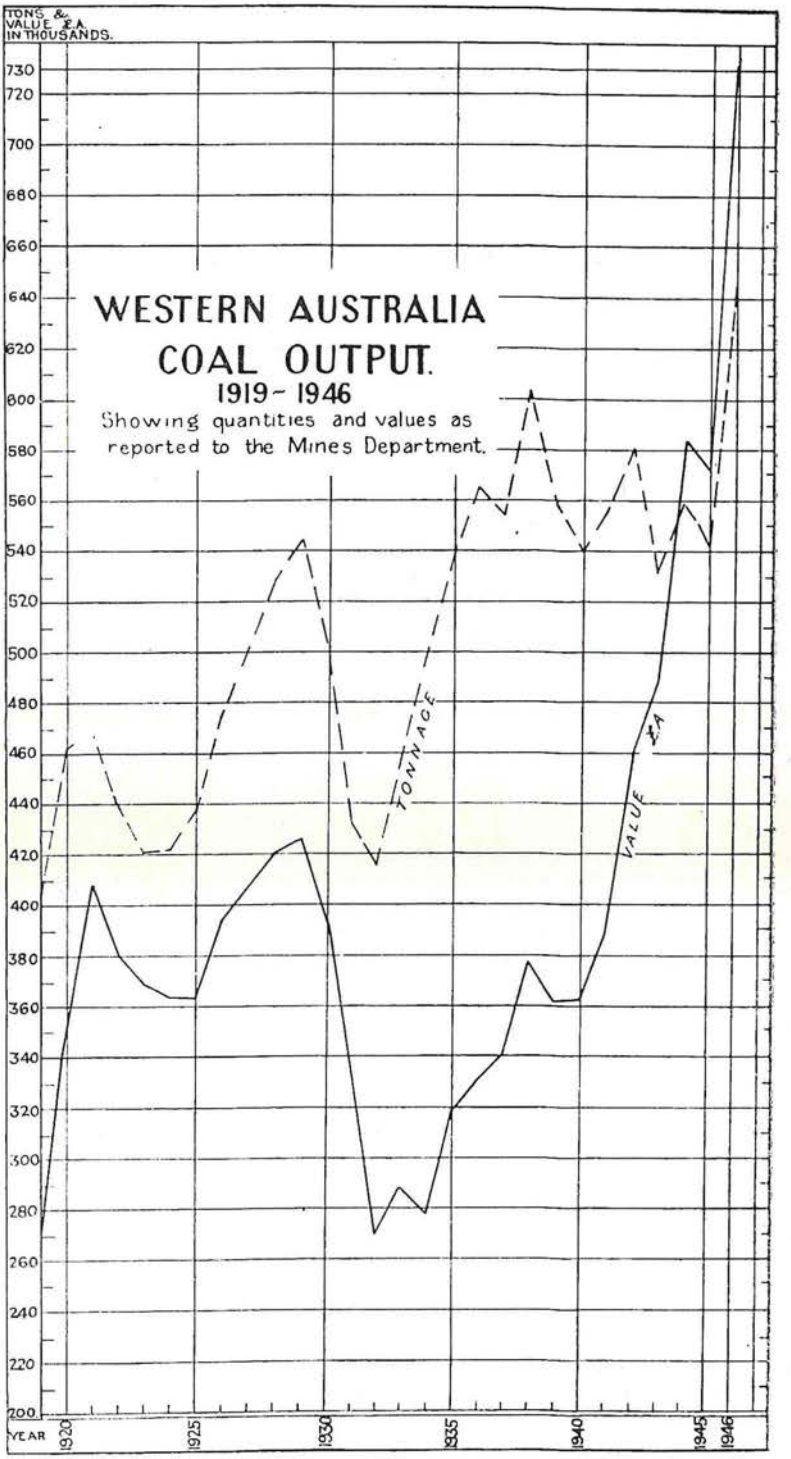
TONS & VALUE £A IN THOUSANDS.
730
720
700
680
660
640
620
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
WESTERN AUSTRALIA
COAL OUTPUT.
1919 - 1946
Showing quantities and values as reported to the Mines Department.
TONNAGE
VALUE £A
YEAR
1920
1925
1930
1935
1940
1945
1946

Fig. 11.

The Proprietary Mine, in about the centre of the same series, is the largest producer. It is served by an endless rope haulage. Development of this mine has been somewhat hampered by faults and by a creep in the lower part of the mine which occurred in 1940.

The Stockton Colliery is situated at the eastern end of the Co-operative series and works two seams. There is an anticline in this area and the workings dip away to the north in one section of the mine. Coal from the open cut is loaded at the mine gantry.

Two mines, the Griffin and the Wyvern, are working the Collie-burn series at the western extremity. The Wyvern is equipped for mechanical working, the coal being gathered by scraper loaders and hoisted by a belt conveyor.

The Cardiff is the only mine in the Cardiff series and is in a synclinal area, the workings in the southern portion of the mine rising to the south.

Coal is mined by bord and pillar methods. The extraction of pillars is proceeding in the Cardiff Mine, but has not been attempted in other mines.

Collie coals are described as hydrous, non-coking, sub-bituminous coals. On account of the high moisture content, the coal tends to break up into fines when exposed to the air, and for this reason Collie coal cannot be stored for long periods in the open.

Efforts to sink to the coal seam at Eradu east of Geraldton are in progress, but owing to the heavy flows of water encountered and the soft ground, progress has been very slow. The coal which has previously been tested by boring is at a depth of about 140 feet below the surface and the seam is about 18 feet thick. Analyses of the samples secured by boring indicate a coal of similar quality to that at Collie, but somewhat higher in ash.

The production of coal for the year 1945 was 543,363 tons. Production for 1946 was 642,287 tons, of which approximately one-fifth was derived from open cut operations.

Base Metals.

Base metal mining, which has never been extensively practised in the State, will commence on a large scale with the mining of iron ore at Yampi Sound. Australian Iron and Steel are developing this deposit and an early commencement of production is anticipated. The State Government is constructing a plant to smelt lateritic iron ore from the Darling Range deposits with charcoal obtained from the distillation of local hardwoods. By-products produced in the distillation process will be recovered. Interest in lead has been stimulated by the high prices now offering and some prospecting has been done in the Northampton district. One small mine is in regular production. Copper is not mined, but a few tons of copper are obtained each year from ores treated principally for their gold content. Extensive deposits of gold-copper ore at Ravensthorpe are receiving attention and the treatment of trial parcels gives promise of success. Small quantities of tin are obtained by alluvial mining from Coolegong and from Greenbushes, where the tin is associated with tantalite.

Minor Minerals.

Among the minor metals, antimony and arsenic have been produced at Wiluna. Antimony is produced by the Blue Spec Mine at Nullagine. Arsenic is also associated with gold in several mines, as, for instance, Evanston and Spargo's Reward, but no effort has been made to recover the arsenic. Bismuth is found occasionally in the northern areas, while scheelite is widely distributed. Scheelite

and wolfram concentrates were recovered from accumulated tailings at the Edna May Mine by Wilfley tables and flotation, but other efforts have not proved successful.

Deposits of blue asbestos (crocidolite) in the Hamersley Ranges, about 200 miles west of Roebourne, form the basis of a potential industry. Efforts were made to develop the area during the war years. Significant quantities of asbestos fibre of good quality were produced, but the scale of production must be greatly extended if costs are to be reduced to an economical level. The Australian Blue Asbestos Company has established a mill at Wittenoom Gorge and is proceeding with the development of its mine. An interest in the mine at Yampire Gorge owned by West Australian Blue Asbestos Fibres has been obtained by the same company. Deposits of white chrysotile asbestos of very good quality are also found in this area, but up to date these have only been worked on a small scale. Anthophyllite asbestos is obtained from Bindi Bindi. Ore from this locality is brought to Perth in the crude state and milled and bagged for export.

Felspar of excellent quality is obtained from a quarry at Londonderry, near Coolgardie, and is exported to Sydney, where it is used in the ceramic and glass industries. The output of the quarry, which is operated by Australian Glass Manufacturers Company Pty. Ltd., is about 2,000 tons per annum.

Gypsum occurs at several places and usually between 3,000 and 4,000 tons annually is mined and processed locally in the manufacture of plaster board, but during 1946 the production exceeded 15,000 tons.

Mica was mined at Yinnietharra during the war years, but there has been no production during the past two years

Vermiculite, a hydrated mica, which is expanded by the application of heat and used as an insulator, has been produced at Bulong and at Young River in the South West.

The mining of pyrite for sulphur at the Iron King at Noresman was commenced during the war because of the shortage of sulphur as a base for the manufacture of sulphuric acid. This industry is continuing and is supplying both crushed high grade ore and flotation concentrates to superphosphate manufacturers, who recovered 45,000 tons of sulphur between 1942 and 1946.

Alunite from lake deposits is treated in the State works at Chandler, about 30 miles from Merredin. The product containing both potassium and sodium sulphate is used as a fertilizer.

Glauconite, which is derived from greensand obtained in the Gingin area, is processed near Perth and used in water treatment processes.

Red ochre is mined at Wilgie Mia, which is an ancient aboriginal source of ochre, and at Roy Hill in the Pilbara District. The crude ore is milled in Perth and used in the manufacture of paint.

Talc is mined at Mount Monger in the East Coolgardie field, and after being milled and packed in Perth, is exported to Singapore for use in the rubber industry.

Kyanite, which is used as a refactory, is obtained near Manjimup. Trial parcels of this material have been exported recently.

Extensive deposits of graphite exist in various parts of the State, but attempts to develop them have so far proved unsuccessful. Some interest is being shown at the present time and efforts are being made to commence production.

Rare Minerals.

The rare minerals which have been mined in Western Australia are tantalite and beryl. Tantalite and columbite occur in several places, the principal producing areas being Wodgina, in the Pilbara Goldfield, and Greenbushes in the south-west. The production of tantalite during the war years was given high priority and valuable contributions were made from Western Australian sources. No concentrates are being marketed at the present time. Beryl was also in urgent demand during the war and high grade beryl was obtained from the Pilbara district. The occurrence of this mineral is very irregular and production is spasmodic. Occasional patches are found in the felspar quarry at Coolgardie and prospectors in the Pilbara area produce occasional parcels.

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Information on many subjects connected with mining may also be found in the Annual Reports of the Mines Department and the Bulletins of the Geological Survey.

GEOLOGY OF PERTH AREA

The Perth Area is composed of an eastern strip of Pre-Cambrian metamorphic and igneous rocks, and a western, larger part (the Swan Coastal Plain), which is covered by younger sedimentary rocks. The Pre-Cambrian strip consists mainly of the igneous-metamorphic Archaeozoic complex which extends far to the east, but, on its western margin just south of the Perth Area, a narrow belt of low-grade metamorphic rocks—the Cardup Series (Prider, 1943)—is exposed. It is probably contemporaneous with the Proterozoic Nullagine System which covers large areas in the northern parts of the State. Small exposures of the Cardup Series have been found along the flank of the Darling Scarp in the Perth Area, but it is generally hidden by talus, etc.

Many basic dykes invade both these groups of Pre-Cambrian rocks and a structural pattern has been suggested by Dr. R. T. Prider in his 1945 presidential address to the Royal Society of W.A. to be published shortly. The Cardup Series at Armadale, a few miles south of the Perth Area, has a northerly strike and dips west steeply.

The boundary between the Pre-Cambrian and the much younger rocks to the west runs north and south with some minor embayments and has generally been stated to have been formed by a large fault (the "Darling Fault") with downthrow to the west. Prider (1943) has found that the minor structures in the Cardup Series indicate that it owes its present attitude to monoclinal folding and, in a paper ("The Geology of the Darling Scarp at Ridge Hill" near Kalamunda) presented to the Royal Society of W.A. he has described a series of conglomerates and ferruginous sandstones, which may be as old as Mesozoic, lying on a worn surface of Pre-Cambrian rocks and suggests that, in Kainozoic times, there has been slow downwarping of the present coastal plain area accompanied by uplift of the Pre-Cambrian massif.

The unaltered sediments (mudstones, sands and gravels) of the Swan Coastal Plain have been pierced by many artesian bores, some more than 2,000 feet deep. Material from two of these, on Mounts Bay Road, close to the Swan Brewery, from depths of between 120 and 708 feet, has yielded foraminifera which indicate an Upper Eocene age (Parr, 1938), but the only correlation of the strata in a number of the bores is by Forman, who finds that there are three major water-bearing horizons which are in a general way horizontal (Clarke, Prider, and Teichert, p. 284). Prider's discovery of an aquifer near Ridge Hill at a height of 250 feet above sea-level accounts for the "head" of the artesian bores which has formerly been a puzzle.

The sediments just described are overlain by the "Coastal Limestones" which probably extend in places to 50 feet below sea-level. They form a belt, in places of rather broken country, extending from the shoreline as much as six miles inland. The lower part of this series is marine, but this part is overlain by and erosion gaps in it are filled with consolidated dune sand, strongly cross-bedded, as is well seen along Mounts Bay Road. The Coastal Limestones are, in places, very fossiliferous, and, outside the area, contain small coral reefs. The mollusca indicate an age no greater than Pleistocene.

The earlier Kainozoic rocks of the Swan Coastal Plain are everywhere concealed by recent superficial deposits some wind-borne, some water-borne and some (diatomite, marl, and peat) deposited in shallow lakes and swampy areas. The Coastal Limestones are also covered in many places. The soil pattern therefore does not reflect that of the underlying rocks as it does in many parts of the State.

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SOIL FORMATIONS OF PERTH AREA

The soil scientist, in studying the very superficial layers of the earth's crust, finds that unconsolidated detrital materials more often than definite geological horizons, provide the parent material for soils. This is true of the Perth area where the soils fall within five broad groups which are defined principally by the nature of the parent material (see accompanying map).

Group 1 comprises the sandy soils of the coastal plain. These soils are derived from ancient calcareous dune formations which have been extensively leached and partially resorted by wind and water action. Segregation of the calcium carbonate into secondary limestone is a feature of the coastal section, whereas, inland there is a greater depth of sand. Remnants of old dunes in places extend inland as far as the Darling scarp but generally there is a buffer zone of alluvial and talus material. Near the scarp where the soils are more heavily leached deep grey sands predominate, but in the coastal sector yellow colours are more common. Away from the main streams drainage is poor; many swamps indicate old drainage lines which were blocked by encroachment of dunes, probably during the Pleistocene glacial periods.

Group 2 includes alluvium of the Swan and Canning River systems. The orientation of the alluvial areas indicates that the rivers have been deflected to the south and to the north respectively by encroachment of the dune systems. The alluvium consists of an older, heavily leached group of grey soils at the higher levels and more recent brown loams adjacent to the present stream courses.

Group 3 comprises the brown, gravelly soils of the talus slope which forms an interrupted band, approximately one mile wide, adjacent to the Darling scarp. The talus is derived in part from erosion of crystalline rocks and in part from overthrow of the lateritic cap. Pisolitic ironstone gravels predominate in the upper horizons of the soil profiles.

Group 4 includes the skeletal brown soils of the Darling scarp and of the steep sided valleys which are cutting back into the laterite covered plateau. This is an area of steep slopes, frequent rock outcrops and shallow stony soils. The country rock consists of gneisses, granites and basic intrusions, all of Pre-Cambrian age.

Group 5 comprises the lateritic soils of the plateau. They are found on the undulating land surface above the 700 foot contour. The dominant profile is characterised by a surface horizon of massive laterite, several feet thick, overlying many feet of white clay. In the small valleys where sand and pisolitic gravel overlie a clay subsoil the soil is suitable for agricultural purposes. The uniform lateritic formation of the plateau is interrupted only by isolated residual hills such as Eagle Hill, Mount Dale and Mount Randall which are outside the area shown on the map.

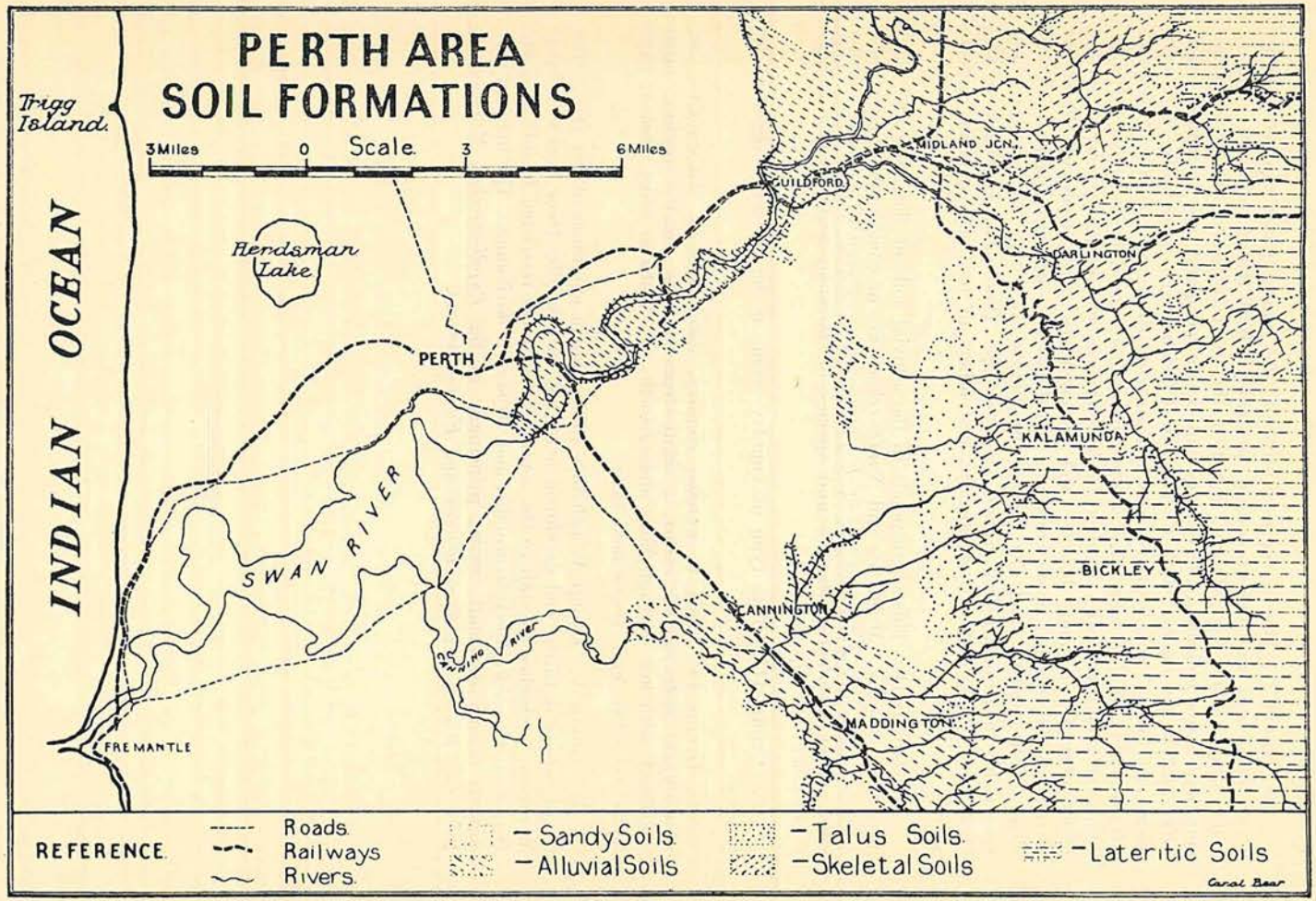

Fig. 12. *(Original map by Robert Smith)*

Vegetation.

A. Group I. This is representative of the coastal plain, characterised by a very poor sand, with limestone near the strand. With the exception of the latter type, which carries a vegetation in which the tuart trees are the largest members, and a few endemics, the country supports a woodland type in which jarrah (*Eucalyptus marginata*) and *Eucalyptus Todtiana* are practically the only eucalyptus trees. Smaller trees such as *Casuarina Fraseriana*, species of *Banksia* (*B. attenuata, B. littoralis, B. Menziesii, B. prionotes,* and *B. ilicifolia*) are common over wide areas, with *Nuytsia floribunda*, a remarkable arborescent *Loranthaceous* parasite. Damp hollows and watercourses carry trees of *Melaleuca parviflora*, the common paper-bark, and sometimes also *M. rhaphiophylla*. Otherwise shrubs prevail, and the herbaceous plants are mainly *Restionaceae*, here very richly developed, a few grasses, such as *Stipa, Danthonia, Amphipogon*, &c., *Cyperaceae, Compositae, Goodeniaceae,* and others of less physiognomic importance.

B. Group II. This corresponds to the alluvial soils of the Avon and Canning river systems. *Melaleuca* and *Xanthorrhoea* are of considerable importance, species of *Agonis*, and a number of *Leguminosae*. Conspicuous elements are the red-flowered *Melaleuca lateritia*, and species of *Boronia*, together with a high development of *Cyperaceae*.

C. Group III. This type of country seems to be primarily occupied by wandoo.

D. Group IV. This is wandoo country, dominated by the wandoo tree (*Eucalyptus redunca* var. *elata*), a white-stemmed tree usually forming open woodland, with low sclerophyllous undergrowth of shrubs in which *Hakea, Dryandra, Grevillea,* and *Acacia* hold sway.

E. Group V. Group V. provides the optimum environment for the jarrah forest, which is fairly well developed here, but with smaller trees than are found in regions of higher rainfall to the south. Small trees restricted to this type are *Persoonia elliptica, Banksia grandis,* and *Dryandra floribunda*. The undergrowth consists mainly of small shrubs, principally of the *Papilionaceae,, Mimosaceae, Rutaceae, Proteaceae, Epacridaceae* and *Euphorbiaceae*.

EXCURSIONS

KALGOORLIE EXCURSION—"GOLDEN MILE"

The East Coolgardie Goldfield of Western Australia embraces an area of 1,800 square miles and consists of two divisions, East Coolgardie and Bulong. From the East Coolgardie Division, which covers an area of only 810 square miles and includes the mining centres of Boulder, Kalgoorlie, Mount Monger, Celebration and Golden Ridge, the total yield to the end of 1946 was 27,261,457 ounces fine gold. Of this, approximately 74,000 ounces was obtained from alluvial workings and from specimens. The remainder resulted from the treatment of 51,590,107 tons of ore and was almost entirely won from the Kalgoorlie-Boulder centre.

The twin cities, approximately three miles apart, lie immediately to the west of an auriferous belt of country which strikes north west-south east in the form of a ridge, and measures seven miles in length by two miles in width. The bulk of the producing mines are confined to the south-west portion of this belt and are contained in an area measuring three miles by one and a half miles. This section of the field has been named the "Golden Mile" and it embraces the following mines:—Lake View and Star, Great Boulder, Boulder Perseverance, Enterprise, South Kalgurli, Paringa, Gold Mines of Kalgoorlie, North Kalgurli and Croesus Proprietary. North of the Golden Mile the only producing mine at present is the Hannans North. A group of leases in the vicinity of Mt. Charlotte will shortly be opened up.

Boulder is 1,280 feet above sea level and is 379 miles by rail from Perth. It is linked with Kalgoorlie by road and rail, the railway line passing through part of the mining area. A tram and bus service, covering a triangular circuit from Kalgoorlie to Boulder City, Kalgoorlie to Boulder Block, and Boulder City to Boulder Block, provides the main transport for mine workers. The Boulder Block (more commonly referred to as "The Block") consists of an acre of ground on which originally stood six hotels. There are now only two of these, and one of them is at the Block tram terminus, in the heart of the Golden Mile.

Gold was first discovered in Kalgoorlie in 1893 by Patrick Hannan and the township, which immediately sprang up, was at first called Hannans. Shortly afterwards, gold was found at Boulder and, although Kalgoorlie is now the official centre of the East Coolgardie Goldfield, the Golden Mile may be regarded as forming part of Boulder. The most recent accounts of the geology and ore deposits of the Kalgoorlie-Boulder centre are those of Stillwell (1929) and Gustafson & Miller (1937). Both contain complete bibliographies.

General Geology.

The oldest rocks in the Kalgoorlie-Boulder belt are basaltic pillow lavas ("Older Greenstones") with interbedded bands of sedimentaries. This, the Kalgoorlie Series, is overlain by the sedimentary rocks of the Black Flag series which consist mainly of slates, metamorphosed tuffs and grits. Between the two series, a large quartz dolerite intrusion (Younger Greenstone) appears as a sill or laccolith. The entire assemblage has been gently folded along east-west axes and more strongly so along north-south axes. The major structure in the Golden Mile is the Kalgoorlie Syncline which pitches flatly to the south. The core is Younger Greenstone flanked and underlain by Older Greenstone. Through fractures formed in the folded assemblage long narrow dykes of porphyry were intruded. Later fracturing in the already weakened structure was followed by ore-deposition which is now largely to be found in the coarse-grained, Younger Greenstone. Minor folds, on the flanks of the Kalgoorlie Syncline, are considered to have had an important bearing on ore deposition.

The axial plane of the Kalgoorlie Syncline contains the so-called "Boulder Dyke." This is a steep, tabular body, of composite formation, consisting of slates, porphyry and, possibly, arkose. Gustafson & Miller hold the opinion that the "Boulder Dyke" represents the sharp infolding of the overlying Black Flag sediments with subsequent porphyry intrusion. The "Boulder Dyke" shows every gradation from perfectly bedded slate, through porphyritised sediments to unquestionable porphyry. Although there is no proof of the age of the ore bodies and associated rocks, it is considered, from analogy with similar formations in the North-West and Kimberley Divisions, almost certain that they are Pre-Cambrian. Correlation with exposures in other goldfields has, in the past, been based on the assumption that granite with its associated gneisses, pegmatite and aplite dykes, and porphyry sills and dykes throughout the State, are all of the one age. The latest attempt at correlation is that of Forman (1937).

Lodes.

Mineralogically, the ore bodies of Kalgoorlie-Boulder show a stronger resemblance to those of the Kirkland Lake district in Canada than to any other gold-bearing formation in Western Australia. Gustafson & Miller have described them as "gold-pyrite-telluride replacement lodes occupying sheared zones. They are generally steep, tabular and lenticular in form." Early accounts of the discovery of tellurides at Kalgoorlie are excellently summarised by Compton (1946). Two distinct lode systems are recognised and these are separated by the "Boulder Dyke." Gustafson & Miller compare the two systems as follows:—

Western Lode System.

(1) Consists of fewer lodes but larger ones which are more regular and persistent.

(2) Contains more numerous large, regular ore bodies owing to (a) the regularity and persistence of the lodes and (b) the more even distribution of gold within them.

(3) Is confined, so far as is known, to the Golden Mile proper.

(4) Lodes considerably more disturbed by post-ore faulting.

Eastern Lode System.

(1) Contains some large persistent lodes, but is characterised rather by swarms of smaller lodes and pipe-like ore shoots which present a most complex and irregular pattern.

(2) Extremely uneven distribution of gold within the lodes with low grade stretches, and numerous locally enriched portions of great value.

(3) Continues intermittently for three miles north of the richly productive section in the Golden Mile.

(4) Lodes on the whole less disturbed by post-ore faults.

Surrounding Country.

Field work carried out by Gibson (Simpson & Gibson, 1912), Honman (1916), and more recently by geologists of Western Mining Corporation, has enabled us to gain a fairly good idea of the geology and structure of the whole East Coolgardie Goldfield. The rock formations are:—

Recent: Laterite and superficial deposits.

Later Basic Dykes: Olivine dolerite, norite, basaltic dolerite.

Ore Deposition: Gold-pyrite-telluride lodes.

Porphyry Dykes: Small intrusives of albite porphyry and "basic porphyrite."

Younger Greenstone: Intrusive masses of varying size (dykes, sills or possibly laccoliths) of quartz dolerite or quartz gabbro constitution with probably more basic phases.

Kurrawang Series: Grits, sandstones and conglomerate.

Kundana Series: Grits, sandstones, shales and conglomerate. Possibly part of the Kurrawang Series.

White Flag Series: Andesite and dacite flows with tuffs and agglomerates. (Part, if not the whole, of Gibson's & Honman's "Porphyrite"). Intrusive representatives are hornblende porphyrites.

Mungari Granite: True granite in no way resembling the porphyry which is assumed to be of later age. Occurs as a core underlying the Black Flag Series.

Black Flag Series: A sedimentary series of grits, shales, tuffs, banded quartzite, and slate with rhyolite flows and rhyolite agglomerates. Quartz porphyry intrusives are possibly present.

Kalgoorlie Series: Fine grained greenstones (Older Greenstone) of basaltic composition, often showing pillow structure, with inter-bedded sediments.

The Kurrawang Series and Mungari Granite are shown in different sequence from that shown in previous tabulations. The Kurrawang Series is regarded as being older than the Younger Greenstone for the following reasons:—(1) The Kurrawang Series has participated in the general folding which is considered by everybody to be pre-gold. In the Kurrawang syncline, which is flanked by a basal conglomerate, the fold axis agrees in strike direction with that of the Kalgoorlie Syncline. The pitch is likewise flat and to the south. The Kundana Series appears to underlie the Kurrawang conformably and, as it contains several conglomerate bands, there seems to be no reason why it should not be considered as part of the Kurrawang. (2) The Kurrawang Series is cut by quartz gabbro

in the North-West corner of the area and by porphyry in the South-West. The quartz-gabbro shows no marked difference from that of the Kalgoorlie-Boulder exposures (e.g., Warden's House, abattoirs, Mt. Hunt, etc.) and there is no reason to show why it should not be considered as belonging to the Younger Greenstone.

Western Mining Corporation geologists agree that the Kurrawang Series is pre-gold.

The Mungari Granite is placed low down in the sequence because it is the only true granite exposed in the area and it seems to form a core to the Black Flag Series. Its position here is by no means certain and further field work may show it to be contemporaneous with the Porphyry Dykes. However, the presence of acid volcanics (rhyolite) and their pyroclastics in the Black Flag suggests the possibility of the Mungari Granite having been the cupolas from which the extrusives emanated.

At Kanowna (Blatchford & Jutson, 1912) quartz-felspar-porphyry pebbles occur in a conglomerate which is definitely cut by later porphyry dykes. In the auriferous zones, the later porphyry bears a close resemblance to the Kalgoorlie-Boulder porphyries. Here is definite proof of two ages of acid igneous rock and it is reasonable to assume that there may be plutonic, intrusive and extrusive representatives of both periods.

Post-gold basic dykes are rare, but two have been mapped. In the Black Flag area a long, east-west olivine dolerite dyke cuts through the White Flag and Kundana series. Some distance south of Kalgoorlie Honman has traced an east-west norite dyke for 10 miles. It cuts across Black Flag and White Flag sediments and volcanics, and also cuts several porphyry dykes. Both the norite and the olivine dolerite are considerably less altered than the quartz gabbros and dolerites of the Younger Greenstone series.

The geology of the district could well be covered by the following excursions:—

(1) Visit to mines of the Golden Mile to examine the lodes, country rock and the "Boulder Dyke."

(2) Excursion to Coolgardie via Binduli and Kurrawang to examine exposures of White Flag volcanics, Porphyry Dykes, Kurrawang conglomerate, Black Flag sediments, Mungari Granite, Coolgardie Pillow Lavas.

(3) Excursion to Ora Banda to examine exposures of Black Flag sediments and acid volcanics and White Flag volcanics.

(4) Excursion to Mt. Hunt to examine Kalgoorlie Series (pillow lavas), White Flag volcanics, Younger Greenstone, and Porphyry Dykes.

(5) Excursion to Kanowna to examine a conglomerate, probably of White Flag age, which is cut by later porphyry dykes.

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THE SOUTH-WEST EXCURSION

The Route.

Assuming the trip is taken by rail, the route lies south for 122 miles, traversing the coastal plain to Boyanup near Bunbury. From Boyanup it ascends the Darling scarp and continues south through undulating country 94 miles to Pemberton. Returning to Donnybrook the line runs generally eastwards 131 miles through Boyup Brook and Kojonup to Katanning, an important centre on the Great Southern Railway, about 100 miles in a direct line from the south coast at Albany. The circuit is completed along the Great Southern Railway through Narrogin and York bringing the distance by rail to 656 miles.

The most important industry in the South-West is the timber industry which, with an annual value of £3,000,000, is the fourth most important in the State. The forest country, however, is not traversed by the south road and lies on the top of what is known as the Darling Range, the eroded edge of the plateau of the interior. The first State forest seen on the trip is at Greenbushes 170 miles from Perth.

Perth to Boyanup.

The coastal plain, or Swan region falls into four sub-regions:

1. The dune sands of the Quaternary coastal limestones which fringe the coast. Here there are varying depths of sand over limestone and a characteristic tree is the tuart (*Eucalyptus gomphocephala*). While the tuart forms practically pure stands in some sites, over much of this sub-region it is associated with jarrah (*E. marginata*), marri (*E. calophylla*), *Banksia spp.*, *Casuarina Fraseriana*, and sclerophyllous undergrowth. The coastal limestone formations are covered by heath in some portions.

2. Highly leached dune sands immediately east of the coastal limestone country. Twenty miles north of Perth at the Gnangara pine plantation, the dunes support in the virgin state *Banksia spp.* with scattered coastal blackbutt (*E. Todtiana*), while on the flats between the dunes where coffee rock is generally found beneath the sand at shallow depth, jarrah and marri, and some paperbark, *Melaleuca parviflora*. Further south at 70-100 miles from Perth, jarrah is found on the dunes, the forest type becoming poorer with decrease in the fertility of soil as indicated by the phosphate content. The soils are of extremely low fertility and little agricultural development is apparent, but success has been met with in the establishment of plantations of exotic conifers after original nutritional disorders were overcome. These two sub-regions are generally poor agricultural country. Some of the sands are used for forestry, plantations of pines having been established at Gnangara, Applecross, Myalup and Ludlow. Phosphate and zinc deficiency have been observed in certain of the plantations. Around the metropolitan area under sprinkler irrigation and very liberal fertiliser practice, vegetable growing is successful. Some vines are grown and whole milk is produced, the cattle receiving generous hand-feeding to supplement the production on sandy soils. Limestone is quarried for building and for burning lime.

3. Alluvial outwash country at the foot of the Darling Range runs almost continuously as a belt from north of Perth to the neighbourhood of Brunswick Junction and probably hides in most places the Proterozoic Cardup series. The belt is of varying width and is characterised by a variety of timbers including marri, jarrah and flooded gum (*E. rudis*). The country slopes gently coastward and ends in swamps and areas liable to inundation where the drainage is blocked by the sand-hills. Prior to the establishment of drainage works these soils were poorly drained and of low agricultural value. About 1,200 miles of drains have been constructed and are serviced by the Public Works Department and there has been considerable development.

North of Perth this area carries the chief vineyards of the State and is the mainstay of the dried fruits and wine industries, but only two vineyards of any size lie to the south of Perth, near Armadale. From Waroona southward are the main irrigation areas where water impounded in the short coastal streams, notably Samson's Brook and the Harvey and Collie Rivers, is used largely for the growing of pastures and, to a small extent, for vegetables, fruit and summer fodder crops.

4. The talus country and skeletal soils on the face of the Darling escarpment: This area is underlain by Archaeozoic, metamorphic and igneous rocks (chiefly granite and gneiss in contrast to the scarp region north of Perth) and possibly by Proterozoic rocks of the Cardup series. It carries jarrah, marri, and wandoo (*E. redunca* var. *elata*). In patches of better soil, due in some cases to underlying basic dykes or to the clayey rocks of the Cardup series, fruit growing and pasture production are practised, but much of this area is still rough grazing country.

Harvey.

Harvey is one of the best-known towns of the alluvial area. Within a mile of Harvey on the main Perth road is a group of buildings which, during the war, formed part of a camp site used first as a P.O.W. camp, and later as an officers' training school. These buildings now constitute the Rural Training Centre established under the Commonwealth Reconstruction Training Scheme for returned servicemen. Some 50 men, mostly approved applicants under the Land Settlement Scheme, are in residence undergoing an intensive 8 week's course following completion of practical experience on farms.

In the neighbourhood of the town irrigation on a considerable scale was commenced over 40 years ago and was used largely for production of oranges. Probably owing to the poor winter drainage, the oranges were unthrifty over much of the area and now are cultivated only on more favoured sites. Most of the area is now under irrigated pasture and is used largely for milk production. Interesting orchards which are well maintained and productive are the orangery of Mr. A. Smith, and the apricot orchard of Mr. J. Lowe.

Of considerable interest are the Harvey and Stirling dams, to the east of the town, and the large diversion channel which has relieved the drainage difficulties associated with the winter flooding where the Harvey River debouches onto the plain.

West of Harvey, in the sandhill belt, is the Myalup pine plantation in which interesting nutritional work has been carried out. A small amount of timber milling is carried out in the district.

Collie.

The Collie coalfield, the only producing coalfield in the State, is about 25 miles up the Collie River from our route. It has an area of about 100 square miles and is composed of rocks of Permian age which are surrounded by Pre-Cambrian gneiss, etc. The Wellington Dam on the Collie River provides water for the southern part of the irrigation area. It is proposed to increase the storage in this catchment for an ambitious reticulation scheme to serve the wheatbelt towns and farms to the east. Consideration is also being given to the development of a rural electrification scheme from Collie. A grain distillery was constructed at Collie during the war period, but has never been used.

The South-West Corner.

For about 100 miles south of Perth the western side of the continent is a coastal plain (the "Swan Coastal Plain") 10 or 15 miles wide which abuts on the east against the "Darling Scarp" (notes on Perth Region). The Cape Naturaliste-Leeuwin coast descends abruptly to the sea and is comprised either of Pre-Cambrian gneiss etc. or of a narrow belt of "Coastal Limestones" lying against the "old rocks." The old rocks form a strip about 10 miles wide, east of which is low-lying country about 30 miles wide which abuts against the higher ground of the Darling scarp. The interesting tholeiites (Edwards 1928), the most accessible of which is the "Bunbury basalt," are seemingly confined to this region.

Boyanup to Pemberton.

From Boyanup the line follows the Preston Valley to Donnybrook, taking advantage of the river gradient to mount the Darling scarp. In this vicinity the scarp is faced by the "Donnybrook sandstones" which are thought to be either of Permian or of Triassic age. Examples of carved pillars of the sandstone may be seen on the exterior of Winthrop Hall at the University. More than 800 oz. of gold have been won from the Donnybrook sandstone (Forman 1936).

The Preston Valley is small but the soils are good and it is recognised as one of the best apple districts of the State. Some citrus and stone fruits are grown and potatoes produced, particularly south of Donnybrook. Donnybrook is the site of a fruit products factory. Dried apples and fruit juices are produced. During the war, potatoes were dried.

From Donnybrook the route rises over a divide between the Preston and Blackwood Rivers. The elevations of the plateau generally run from 800-1,200 feet. Kirup (800 feet) stands on high-level country, laterite covered, and in the vicinity are some excellent jarrah forests which are being milled. This area is a very good example of the laterite of the Western Australian peneplain and the characteristic soils are rich in ironstone gravel and sometimes boulders. On the better soils, apple growing and grazing are practised but much of the country is virgin and reserved for forestry. The heavy clearing and the unattractive gravelly soils restrict agricultural development. Near Mullalyup a rather deep railway cutting shows numbers of rounded boulders encased in a white sand. Similar deposits have been found in other places in this district and are thought to mark the course of an ancient river which flowed over the peneplain before the present physiographic cycle began.

Balingup, 8 miles south of Kirup, is only 360 feet above sea level and is in the centre of a fertile agricultural district on a tributary of the Blackwood River.

Bridgetown.

To reach Bridgetown the line rises to Greenbushes, about 950 feet above sea level, once a thriving mining town. Tin has been the chief product but there is now little activity. The discovery of tantalite during the war gave a fresh impetus to mining and valuable quantities were shipped overseas. Miners even dug up the main road to extract large lumps of heavy black tantalite ore.

In a previous geological era this territory was cut by large swift-flowing streams, the remains of which are now visible as strips of water-worn boulders which are encountered in many places across the countryside. Tin ore was extensively mined in the so-called deep leads which are buried stream beds.

Bridgetown is one of the most important south-west country towns. It is established in the Blackwood River Valley, just north of the river. The river has deeply dissected the area and exposed large areas of basic rocks as well as the more common acidics. It is similar in general pattern to the Balingup district but very much more extensive. Marri grows on the better soils and jarrah and marri on the lighter, more gravelly types.

Bridgetown is the centre of a thriving apple industry and orchards extend to the tops of many steep hills. Erosion has been severe in some cases. Pasture establishment has been general and cattle are raised for fattening and milk production. There is an important sheep population for wool and meat.

A feature of the town is Paterson's apple packing shed. It is unfortunate that the Blackwood River water is somewhat brackish over much of the summer and cannot be used generally for irrigation. The salt comes down the Beaufort and Arthur Rivers which rise in the Great Southern districts near Wagin.

The line rises steeply after crossing the Blackwood River, just south of the town, to the plateau with an elevation of 800-1,000 feet—chiefly jarrah and marri country. This high level area is a watershed between the Blackwood, Donnelly and Warren Rivers. It is of considerable interest, as it represents a relatively undissected relic of the old peneplain where topography renders drainage restricted and large areas of flat country are subject to winter inundation.

Manjimup is on the southern fringe of this elevated area and is a thriving centre supported by dairying, fruit, potatoes, timber and tobacco. It is also on the fringe of the karri country. In the town are butter and cheese factories and nearby a tobacco research station. The tobacco industry is very interesting, as the climate would be considered too dry in summer for satisfactory cultivation. By selecting sheltered valleys and planting on the lower slopes favoured by depth of soils as well as a degree of seepage moisture, satisfactory crops are raised. It is unfortunate that many of the wells of the district, although fresh in winter, are slightly saline in summer and unsuitable for irrigation.

Proceeding southward from Manjimup the line drops into the Warren Valley, famous for karri forests. These centre about Pemberton, which boasts the largest timber mill in the southern hemisphere—a tribute to State enterprise. The majestic forests compare favourably with the redwoods of California and the mountain ash of Victoria.

Like the Blackwood at Bridgetown, the Warren Valley is deeply dissected and the spectacular karri timber clothes the steep slopes. Cut-over forest areas have been developed for agriculture and a Group Settlement Scheme operated after the 1914-18 war. Clearing costs have been very high but when developed it is a pleasant and productive country, well watered and with a mild climate and a wide range of crop possibilities. Hops grow well and berries, apples and stone fruits may be cultivated. The country is not without agricultural problems. Phosphate, copper and potash deficiency have been detected and others are suspected.

Donnybrook to Katanning.

Leaving Donnybrook, the railway follows the Preston Valley for over 20 miles. At Beelerup, 3 miles out, is a flax mill. This was used during the war period. Leaving the Preston Valley the line rises to another slightly dissected relic of the old peneplain, similar to that near Manjimup but which constitutes a divide between the Collie, Preston and Blackwood River systems. This country is being developed for pasture and for forestry where the jarrah stands are suitable. In the more lightly timbered areas pasture establishment can be effected cheaply over the course of about 5 years by ringbarking and judicious firing. Subterannean clover is the pioneer pasture and is used for the grazing of sheep and cattle.

Boyup Brook, the next important centre, is on the Blackwood River, about 20 miles upstream from Bridgetown. Some orcharding is practised but sheep raising is by far the most important activity. Some farmers are turning their attention profitably to fattening cattle and raising high-quality beef.

On the outskirts of the town is a three-unit flax mill. Both dew and tank retting are practised. It is hoped that a factory for processing the flax fibre may be established. The production of a rust-resistant variety of flax, Wada, by the Department of Agriculture, promises to improve the prospects.

The prosperity of Boyup Brook was built largely on the subterranean clover industry. This plant, with superphosphate, has raised the fertility of thousands of acres of low productivity country. Under lower rainfall conditions the segregation of an early strain, commonly known as Dwalganup or first early strain of subterranean clover, was discovered by Mr. P. D. Forrest about 20 years ago on his property about 18 miles south of the town. This clover will grow on suitable soil types in the wheatbelt where the rainfall is as low as 14 or 15 inches per annum. It promises to be one of the most important plants in our soil conservation programme over about 25 million acres of the wheatbelt.

The Boyup Brook district has also been the pioneer in mechanical clover seed harvesting. In fact, the use of the sheep-skin roller was initiated on Mr. P. D. Forrest's property, Dwalganup, and has revolutionsed the clover seed industry. From Boyup Brook the train follows the Blackwood River for some distance on the route to Katanning and then rises to traverse the plateau which is dissected by small and large streams of which the Balgarup and Kojonup are the most important. Rainfall diminishes and the first early subterranean clover becomes the dominant strain over much of the improved country. With this is associated the Dystocia and infertility problem of sheep which has caused so much loss to farmers and pastoralists.

The dissection has exposed country rock over a considerable proportion of the country, giving rise to a complex of soil associations including ironstone gravelly types, generally on the high levels, and soils on granites, gneisses, quartz

blows and basic rocks or on their weathering products where partial truncation has occurred. Approaching Katanning the line rises to one of the highest sidings in the South-West, Holly being 1,248 feet above sea level.

Katanning was once an important wheat centre but the main wheat areas are now largely to the eastward, in the drier country. Agriculture around Katanning is now devoted largely to stock raising and a number of important merino studs have been established in the districts. There is a flour mill in the town. Katanning has considerable civic pride. It boasts an attractive swimming pool. Like other Great Southern towns, it suffers from water shortage. The situation has recently been improved by the building of a bitumen catchment but the town stands to benefit from the comprehensive country water supply scheme.

Katanning to Perth.

The Great Southern Railway was built 60 years ago to link Perth and Albany and serve one of the early agricultural districts of the State. Early development was for wheat farming with grazing on the cleared land and supplemented by the virgin country. A certain amount of fruit was grown. As at Katanning, grazing is now the chief activity in the immediate vicinity of the line, and the wheat is grown to the eastward. The line is fed by a number of feeders coming in from the east and west, the main junctions being Katanning, Wagin, Narrogin, Brookton and York. Narrogin is the largest town and an important railway centre. The Narrogin School of Agriculture for boys lies 4 miles west of the town.

These districts lying along the Great Southern Railway form part of a former peneplain, now more or less dissected, the characteristic mesas representing the ancient level of laterite formation. High level parts, particularly around Cuballing, exhibit a large proportion of the old peneplain country but the dissection has been extensive, the main streams being the Arthur, Beaufort, Hotham and Avon. Unlike the valleys of the Blackwood and Warren, the valleys are broad and senile. The sections exhibited by the mesas suggest deep weathering of the rocks underlying the laterite cap. The tops of the mesas carry open wandoo and scrub and on the sides stands of mallet (*E. astringens*). Of interest is the Forests Department mallet plantation west of the railway at Cuballing, just north of Narrogin. Wandoo and jam appear to predominate on the more or less gravelly soils formed on the weathered underlay or lithomarge of the laterite. Jam and York gum predominate on the soils derived from the country rock, particularly the more basic types. Along some of the rivers are flats of solonised soils on which salmon gum (*E. salmonophloia*) and morrel (*E. longicornis*) are characteristic trees.

Generally, the Great Southern districts are suitable for subterranean clover, cereals, stock and fat lamb raising, dairying and pigs. An interesting industry at York is vegetable production, where Mundaring water is used for irrigation. From York the line follows the Avon River to Spencer's Brook and, after passing through a narrow wandoo belt, crosses the plateau to the Perth coastal plain.

VEGETATION

On the way from Perth to Bunbury the base of the Darling Range escarpment and portions of the coastal plain are traversed. Where the former is touched upon, we find a lateritic or granitic soil with woodland or forests of jarrah and wandoo, with the characteristic undergrowth of these formations.

Plants expected to be in blossom at this time of the year are *Leucopogon, Leschenaultia biloba,* the latter with gentian-blue flowers, *Grevillea Wilsoni* with intense scarlet flowers, *Lambertia multiflora,* with yellow flowers, species of *Boronia, Eriostemon, etc.* The long-spiked blackboy is *Xanthorrhoea Preissii,* and the somewhat similar grass-tree, usually found in clay soils on flats or in depressions, and differing from *Xanthorrhoea* by having "drum-stick" inflorescences in place of long spikes, is *Kingia australis. Kingia australis* is the plant from which Brown described for the first time the structure of the ovule in plants. Here and there, in the sandy or sandy-gravelly soils, is a small tree known as the native pear (*Xylomelum occidentale*) closely resembling the X. *pyriforme* of Eastern Australia. After leaving Armadale, we find, first to the east of the road, then on both sides, a small white-barked tree with pale leaves. This is *Eucalyptus Lane-Poolei,* a tree restricted to the escarpment foot between Armadale and Dandalup, which we reach shortly before arrival at Pinjarra.

Beyond Pinjarra, and as far as Picton, there is pasture country in which little of the original vegetation, apart from trees and some of the larger roadside shrubs, remains.

Towards Donnybrook we enter the jarrah forest with large trees of jarrah, marri and blackbutt. The last-named somewhat resembles jarrah, but its bark is more deeply longitudinally fissured, and more friable, and the foliage is somewhat paler. It grows principally in the depressions and along the streams. The lateritic soil has once more the characteristic jarrah undergrowth, composed mainly of *Epacridaceae, Myrtaceae, Proteaceae* and *Rutaceae. Boronia spathulata,* with pink flowers and glaucous thick erect leaves is common, and here and there is the remarkable verticillately leaved *Leucopogon verticillatus* with broad green leaves, and elongated clustered spikes of flowers. Still further on, especially in the Kirup district, we encounter our sole representative of the *Podocarpaceae* (*Podocarpus Drouynianus*) the female plants of which have fruits resembling damsons or black plums. The species has strong underground stems and the aerial shoots are rarely in excess of four or five feet.

Big Timber.

Southwards from Manjimup we find our first karri trees (*Eucalyptus diversicolor*), so named from the bark, which decorticates in March or April, the freshly exposed bark being a rich orange-yellow in colour, but soon fading to a white hue with patches of pale violet older bark. The karri is our largest tree and the karri forest in its most highly developed form forms the nearest approach to a mesophytic association of any formation in South Western Australia. Conspicuous trees of the lower storey are *Casuarina decussata,* with bright green slender branchlets and distorted cones, the handsome *Banksia verticillata,* or river-banksia. *Persoonia longifolia,* a geebung with linear yellowish-green leaves and a purplish flaky bark, *Agonis juniperina,* a tall tree of wet situations and small leaves, together with the peppermint (*Agonis flexuosa*) with larger dropping branchlets and foliage. Among the shrubs are a number of leafy *Acacias,* especially *Acacia pentadenia,* the karri-wattle, and the broad and soft-leaved hazels (*Trymalium spathulatum, Chorilaena quercifolia* and *Ch. hirsuta*), and the lowly violet-blue-flowered *Tremandra stelligera.* There are many species of *Boronia,* mostly with red or rose-pink flowers, and the allied *Crowea* with strongly scented white flowers. It is perhaps too early for the bush hovea (*Hovea elliptica*) which comes into blossom with large trusses of intense violet flowers. *Dampiera hederacea* is the low trailing rusty-leaved plant with deep blue flowers.

Leaving Bridgetown for the east we are again in the jarrah forest, but soon leave it for the more open wandoo woodland, here an extensive formation, with at first a rather dense but low undergrowth of harsh small shrubs, but soon opening out to receive the jam tree (*Acacia acuminata*), when the undergrowth is more sparse and herbaceous species appear in profusion in their due season. Pink everlastings of the genera *Helichrysum, Helipterum* and *Schoenia* mix with the golden-yellow flowers of *Waitzia* and many other genera of the *Compositae* to provide a riotous profusion, in which the pale blue of *Erodium* take a part. The clay flats and stream courses are timbered with flooded gum (*Eucalyptus rudis*) and *Casuarina*. In general, the wandoo remains the principal tree, the further eastwards we travel, so does the formation continue to open up, until we find wandoo occurring as an occasional tree in soil types quite different from those we have seen. We find it, for example, mixed with *Casuarina*, and even taking its place in the poor sandy soils towards Katanning.

Leschenaultia.

Northwards from Katanning we traverse undulating country with sandy rises and extensive clay flats often partially inundated in wet seasons. The most striking plants are those lowly individuals which form dense cushion-like tufts on the ground, notable amongst which are the brilliant *Leschenaultia formosa* with flowers of deep scarlet, and the dwarfed species of *Anigozanthos*. Where trees occur on these flats, they are mainly the swamp—or flat-topped—yate (*Eucalyptus occidentalis*). Still further north, between Wagin and Narrogin are lateritic hills which are clothed with dense stands of brown mallet (*Eucalyptus astringens*) and the blue mallet (*Eucalyptus Gardneri*), often forming thicket-like patches. The undergrowth in the mallet country is remarkably hard-leaved, and here too are many of the toxic plants which have made this type of country notorious to the pastoralist—species of *Gastrolobium, Oxylobium* and *Isotropis*.

The Great Southern Railway roughly traverses the 30 inch annual isohyet, and the vegetation types remain fairly constant, except that at Narrogin we are again on the fringe of the jarrah country, just as at Wagin, and Cuballing we are on the edge of the salmon gum and morrel country. This type continues until we reach Spencer's Brook, where we join the main west-east railway line, and traverse wandoo and jarrah country to the foot of the Darling escarpment, close to Perth.

FAUNA

Mammals:

The western form of the Grey Kangaroo (*Macropus major ocydromus*), and the Brush Wallaby (*Macropus irma*), the two largest native mammals likely to be encountered in the south-west, may be seen from the car on lonely bush roads in the mornings or towards dusk. The Common Possum or Kumarl (*Trichosurus vulpecula*), formerly abundant, is now too scarce to warrant an open season for trapping, but local strongholds at present are the Manjimup area, around Augusta and in the Dale country. Curiously, it is plentiful in the bush parks within the city boundaries, such as King's Park, the University grounds and Queen's Gardens, where the animals tend to be a nuisance to local householders. The lesser marsupials are now so rare or inconspicuous that they are unlikely to be met with during the excursion.

The Emu (*Dromaius novae-hollandiae*), survives in small parties in the unaltered bush, especially around the south coast and the Darling Range country east of Perth, but is rarely seen by the casual observer. The small bird species frequently show an interesting zonation in distribution. The most conspicuous bird on the coastal plain is the Western Magpie, (*Gymnorhina dorsalis*), which combines the plumage characters of the two eastern species—the male is white-backed and the female black-backed. Formerly it did not occur in the dense forest country of the lower south-west, the southern limit on the coast being the Carbadup River, south of Busselton. The opening up of the country, however, has extended its habitat and it is now plentiful in the farm country all the way to Augusta. Further inland, it is still an absentee and one will not normally see magpies south-west of a line joining Nannup, Mt. Barker and Albany. In these parts, the Squeaker (*Strepera versicolor plumbea*), our representative of the eastern Currawong, takes its place, and the loud gong-like call of this bird will be frequently heard in the forest country. The Grey Butcher-bird, (*Cracticus torquatus*), is also restricted in its distribution southward. It does not occur south of Yallingup and Kirup.

The block of heavy forest country, jarrah and karri, is avoided by several species which are found on the coastal plain on the west and in the savannah woodland and sandplains to the east. Such species include the Dusky Miner, (*Myzantha obscura*), which extends south on the plain a little beyond Pinjarra, the Yellow Plumed Honeyeater, (*Meliphaga ornata*), which is specially common in the tuart belt down to Busselton, the Hooded Robin (*Melanodryas cucullata*), and the Brown Song-lark, (*Cinclorhamphus cruralis*). Some however have begun to invade the forest belt in the wake of settlement and forms like the Singing Honeyeater, (*Meliphaga virescens*), the Brown Honeyeater, (*Gliciphila indistincta*) and the Rufous Whistler (*Pachycephala rufiventris*), have now appeared in well-cleared localities like Bridgetown.

An interesting zonal distribution is exhibited by some coastal plain species. Thus, the open flats of the longitudinal belt of clays and loams along the Darling scarp is the favoured haunt of the Tawny-crowned Honeyeater, (*Gliciphila melanops*), the Black-faced Wood Swallow, (*Artamus melanops*), the Hooded Robin, the Rainbow-bird, (*Merops ornatus*) and the Southern Emu-wren, (*Stipiturus malachurus*). The last-named has a remarkably extensive distribution in comparison with the same bird in the Eastern States where it is confined to humid localities strictly around the coastline. In Western Australia, it occurs quite far inland in the south-west and has a wider range of habitats. It may be seen near Perth on the Welshpool Road by the scarp and on the wet *Melaleuca lateritia* flats at Coolup as well as in the low scrubs of the beach dunes at Bunbury. In the banksia groves of the sand-belt, the Spine-bill Honeyeater, (*Acanthorhynchus superciliosus*), the Brown Honeyeater and Dusky Miners are prevalent.

In the heavy forest belt, the common birds—though not confined to it—are the Scarlet Robin, (*Petroeca multicolor*), White-naped Honeyeater, (*Melithreptus lunatus*), Splendid Blue-wren, (*Malurus splendens*), Western Thornbill, (*Acanthiza inornata*) and the Fan-tailed Cuckoo (*Cacomantis flabelliformis*), whose plaintive trilling will be heard everywhere at this time of the year, especially in the lower south-west. This cuckoo is comparatively scarce in the latitude of Perth, where the main one is the pallid, (*Cuculus pallidus*).

The Western King Parrot, (*Purpureicephalus spurius*) is also plentiful here and may be quickly distinguished from the Twenty-eight or Ring-necked Parrot,

(*Barnardius zonarius*), when flushed from the roadside by the light-coloured lower back.

The White-breasted Robin, (*Quoyornis georgianus*), although found in brookside thickets in the Darling Range as far north as Pinjarra, is not really common outside of the lower south-west (Cape Naturailste to Albany). A somewhat similar distribution is exhibited by the Red-eared Fire-tail, (*Zonaeginthus oculatus*), but which in the early days of the colony occurred as far north as Perth. The third species which is common in the lower south-west and is now rare or exterminated in the Perth area, is the lovely Red-winged Wren, (*Malurus elegans*), once a breeding species at Herdsman's Lake but now plentiful only in the south-west. It can be really observed in the sword-grass margins of swamps and brooks at Bridgetown, Manjimup, Pemberton and other localities.

Those interested in the historical side of zoology might well make a slight detour at Waroona on the motor run south and visit the Drakesbrook Weir about 2 miles west of the main road. The Weir occupies the site of the type locality of the famous and aberrant Noisy Scrub-bird, (*Atrichorinus clamosus*), collected there in November, 1842, by John Gilbert, when in company with James Drummond, the first colonial botanist. The species, which has not been collected since 1899 and is believed to be extinct, has as its only surviving relative the Rufous Scrub-bird, (*A. rufescens*), of the sub-tropical brushes of New South Wales and southern Queensland.

Reptiles.

Snakes are rarely seen so early in the season unless they happen to be disturbed by man when it is possible that any of the south-western species may be found. The Tiger Snake, *Notechis scutatus,* usually occurs in damp situations where its principal victims, frogs, abound. Species of *Rhynchelaps* and *Furina* prefer sandy soil in which they can burrow with ease whilst the Blind snakes, *Typhlops spp.,* are not similarly handicapped, being more efficient. They may now and again be found in or on ant nests and termitaria. The Little Whip snake, *Denisonia gouldii,* is so frequently found in firewood and among old roots that it may be met with at any time for it has a very wide range. *Brachyaspis curta* and the rare *Elapognathus minor,* and *Rhinhoplocephalus bicolor* are prizes that no naturalist should underestimate.

Lizards of many kinds may be found under bark, fallen logs and stones, *Gymnodactylus milii* and *Diplodachylus spinigerus* usually occurring in such situations. Other geckos may also be discovered together with skinks of the genera *Egernia* and *Lygosoma* (*s.l.*) too numerous to mention. The goannas, *Varanus gouldii* and *Varanus tristis,* are easily recognised and so also is the familiar Bobtail or Shingleback, *Trachysaurus rugosus,* often wrongly referred to as the Bobtailed Goanna. Of the *Pygopodidae, Pygopus lepidopodus, Liatis burtonii, Delma fraseri,* though not common may be met with among the vegetation and the smaller worm lizards *Aprasia spp.* in the soil where they have at times been dug up from two feet below the surface. The Dragon Lizards, *Amphibolurus adelaidensis* and *A. barbatus minimus,* may be met with on the coastal plain.

The Freshwater Tortoise, *Chelodina oblonga,* is very common.

Amphibians.

In the coastal south-west *Crinias* may be seen or heard near every freshwater lake or swamp often accompanied by the western form of *Limnodynastes* and *Hyla.* The burrowing *Heleioporus eyrei* also occurs in this area, its place beyond

the Darling Range being taken by the larger *Heleioporus albopunctatus* and *Heleioporus pelobatoides*. The little *Pseuduphryne güntheri* is more independent of water and so is the remarkable *Myobatrachus gouldii* whose life-history is as yet unknown.

Fishes of the freshwater.—Many of the rivers of the south-west being permanent streams, or at least surviving as strings of freshwater pools, contain a rich fish fauna confined to a few species. The W.A. Minnow, *Galaxias occidentalis*, occurs from Perth southwards and so also does the Pigmy Perch, *Nannoperca vittata*. The range of the Nightfish or Mudfish, *Bostockia porosa*, is slightly less extensive but much has still to be discovered about this little nocturnal species. All three are common at Pemberton where the Common Trout and the Rainbow Trout are now firmly established through the efforts of the local society.

The Lamprey, *Geotria australis* enters many of the rivers from the Swan southwards for breeding purposes. It is possible that other species occur in unexplored lakes and streams as a second species of *Galaxias* was recently collected near Albany. Hardy marine species may invade the lower reaches of rivers but never extend far inland.

Invertebrates:

At this time of the year, the clay flats on the coastal plain along the foothills and along which the main Bunbury road passes, are water-logged and some of the pools in them, contain a distinctive fauna. These pools are shallow, generally free of plants, and are turbid through colloidal clay in suspension. They are the only coastal plain freshwaters with phyllopod crustacea as regular inhabitants: two species of *Conchostraca* occur, the larger *Eulimnadia cygnorum Dakin* and the smaller *Lynceus tatei* (Brady)—both have been recorded as far south as Capel and Busselton. The *Cladoceran, Simocephalus australiensis* (Dana) always accompanies them and near Perth, on the Cannington flats, the Phreatoicid isopod, *Amphisopus palustris* (Glauert) is common. In the summer, the pools dry up completely.

Of the fresh-water crayfish, Jilgies, (*Chaeraps quinquecarinatus*) and Coonacs (*C. bicarinatus*), are generally distributed but the fine large Marron (*C. tenuimanus*), occurs only in the river systems between the Harvey and the Frankland. It has been introduced into the Canning River. *Onychophora "Peripatus"* of two species have been found in many localities in or near the foot of the Darling Range from the vicinity of Perth southwards under logs and stones and among fallen leaves.

Myriopoda, Chilopoda, Diplopoda and *Turbellaria* are abundant, the last named being represented by terrestrial as well as fresh water species throughout the area visited. *Mollusca*: The dominant form among terrestrial molluses is the genus *Bothriembryon* which appears in numbers during or just after showers and attracts attention by the size and coloration of some of the species. Other genera are *Themapupa, Omegapilla, Austrusuccinea* and *Westralaoma*.

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IRWIN RIVER, GERALDTON AND ABROLHOS EXCURSION

The Route:

The route, with miles from Perth in parenthesis, is: Perth to Guildford-Bullsbrook, (30); Bullsbrook-Chittering-New Norcia-Moora, (118); Moora-Watheroo-Marchagee-Coorow, (174) Coorow-Carnamah-Three Springs, (206); Three Springs-Mingenew-Irwin River, Mingenew-Dongarra-Port Denison, (275); Dongarra-Greenough River-Geraldton, (313).

This excursion may be undertaken either by road or by rail (via Midland Railway line). The two routes lie so closely parallel that there is scarcely any difference in the types of country traversed, except on the section Bullsbrook-Moora, where the railway goes via Gingin and Gillingarra, 10 to 15 miles west of the road via Chittering and New Norcia. A weekly boat service communicates with all groups in the Abrolhos Islands, taking tourists and fishermen's supplies from Geraldton.

Perth-Guildford-Bullsbrook.

Leaving Perth, going north-east, we pass over sections of the Coastal Plain with its poor white and yellow sands. These are believed to be originally fairly calcareous coastal sands, which have become progressively more and more leached as one approaches the Darling Scarp, where already no calcareous elements remains and the sands are mostly wind-polished quartz. This country supports a characteristic *Banksia* flora with stunted jarrah and blackboys. Most of the route, however, lies over rich clays of the Swan alluvium where several striking terrace levels may be seen, especially near Guildford. Here some fine flooded gums may be seen.

Turning north at Midland Junction we pass over more of these extensive high alluvial terraces, which form the site for some of W.A.'s best vineyards, until after Upper Swan we pass on to the unproductive coastal plain sands once more. For the next 15 miles we follow very closely to the Darling Scarp, which is nowhere better or more sharply defined as a geomorphological break between the Pre-Cambrian plateau to the east of the Coastal Plain on the west.

In the foothills near Bullsbrook, just below the scarp, some fresh-water sandstones with Lower Cretaceous plant fossils have been found (see Clarke, Prider and Teichert, 1944, p. 274). Just after leaving the village we pass the principal R.A.A.F. aerodrome in W.A., Pearce, which is built on a great outwash fan.

Alternative Route via Gingin.

North of Bullsbrook the railway (and a secondary road) continue along the foot of the Darling Scarp via Muchea to Gingin. Here and there along the scarp foot are considerable lenses of yellow quartz sands (leaching white on the surface), which may be relics of high Pleistocene sea-levels. Down on the plain the heavily

leached white sands in places are replaced by small patches of marly limestones, probably formed in Pleistocene lakes. From Bullsbrook northwards most of this escarpment is reduced in character and is underlain, not by the old crystalline rocks, but by Upper Jurassic to Lower Cretaceous fresh-water sandstones, grits and shales. At Gingin these are overlain by marine Upper Cretaceous chalks and greensands, of astonishingly similar lithology to the English equivalents and giving rise to a small area of rounded "downland" hills.

Interesting soils at Gingin are the red sands of the sandstones and the black clays of the chalk. Landslips are common in the latter. Agriculturally the area was developed in very early days, but is less active now. Stock-raising is the main activity. Citrus (especially the Jaffa orange) was formerly important. Some dried vine fruits are produced now. The centre is interesting in connection with the copper therapy discovery, which was used to control "Gingin rickets." Copper has also been used with success on sultana and currant vines.

The railway turns east at Gingin and then north to follow more or less the main scarp (here greatly reduced) to Moora.

Bullsbrook-Chittering-New Norcia-Moora.

Ten miles north of Bullsbrook the road swings in a north-easterly direction and almost imperceptibly climbs the scarp, which is just here very much reduced in character. The change in vegetation however is immediately apparent as we pass on to the alternating patches of red lateritic gravels and white sands. The typical tree is the jarrah, and wildflowers include the strikingly blue *Leschenaultia*.

After eight miles of this undulating country we drop steeply into the rich Chittering valley where dark red and brown soils overlie high grade metasediments such as sillimanite and kyanite gneisses and schists which are intruded by dolerites, many of which have subsequently been sheared into hornblende schists (Miles, 1938, pp. 13-41). The regional strike here is in a north-south direction and the alternating hard gneisses and soft schists probably control the unusual north-south direction of Chittering Brook with its several longitudinal "lakes." There are some interesting kyanite schists near the Gingin turn-off.

Leaving Chittering, we climb eastwards up Bindoon Hill, passing into the metasedimentary country again with its lateritic red gravels and white residual sands. In the hill cuttings a few dolerite dykes may be seen. On the crest of the hill is the turning to St. Joseph's Boys' Town and Farm School.

After Bindoon follows a long section of fairly flat country in metasediments characterised by softer topographic outlines and insequent stream patterns. This leads on down into the broad valley of the Moore River (south branch), which likewise is deflected here into a north-south course, until we get to New Norcia Mission. This Spanish Benedictine Mission was established one hundred years ago. Its main objective was to care for the aborigines but its scope has since extended to include secondary education, and a boys' and a girls' college are now located here. Both the library and the art gallery contain material of great historical interest.

Little change in this topography is apparent until we pass Walebing, where we leave the Meekatharra road and turn westwards to run down into Moora. In this section we pass out of the older Pre-Cambrian rocks on to the flat 600 foot plain of the Moore River (north branch). It is here that we cross back over the northern extension of the Darling Scarp, which, however, owing to the slight topographic contrast (about 200 feet) and the broad fluviatile plain,

is hardly noticeable at all. In the vicinity of the town slate and claystones are known (see report by Blatchford), which probably occupy a position analogous to the Proterozoic Cardup series of the Armadale area, 20 miles south-east of Perth.

Moora is a fair-sized country centre with a road leading westwards to Dandarragan, one of the few known outcrops of marine Cretaceous, an outlier in the broad sandstone belt of probably Lower Cretaceous to Jurassic age, which from Gingin northwards separates the Pre-Cambrian plateau from the Coastal Plain.

Moora-Watheroo-Marchagee-Coorow.

From Moora we turn north again following a wide sandy alluvial valley rising about five feet per mile northwards. While it forms the northward extension of the north-south trend of the Moore River (north branch), its drainage system has degenerated into series of short streams feeding into swamps and Lake Delaroo. To the east may be seen the low Pre-Cambrian escarpment and near Coomberdale a quartzite is exposed in a large ballast-pit.

North of Watheroo (milepost 142) we cross the railway and climb a low watershed and Pre-Cambrian granite outcrops may be seen accompanied by a sudden change in soil with some prominent yellow sandhills. Poor sandy soil continues practically as far as Marchagee associated with heath and scrubland. Characteristic trees are the native cypress, the native pear and between mileposts 150 and 154 there are examples of a small eucalypt with a particularly large and fine flower (*Eucalyptus pyriformis* var. *elongata*).

At Marchagee we cross the railway again near an outcrop of basic rocks, but north of here granite and yellow sands with low shrubs reappear. At milepost 168 one of the first salt pan creeks is seen.

Coorow-Carnamah-Three Springs.

From Coorow on we pass mostly along the margins of typical salt swamps or salinas which are partly filled by rich red and black alluvial material. Two miles north of Coorow a Pre-Cambrian quartzite outcrop, and near Touche (milepost 179) a yellow sand is seen. Lateritic gravels just south of Carnamah (milepost 191) crown a hill of quartz dolerite. To the west, in the wet season, the Yarra Yarra Lakes often form a very extensive sheet of water. They form the end of a long series of salinas which are sometimes filled by water for a hundred miles, up to Morawa, Yalgoo and beyond. To the south-west of Three Springs, Pre-Cambrian metamorphic sediments with a muscovite garnet schist have been reported. Three Springs (milepost 206) marks the end of the salina country.

Three Springs-Mingenew-Irwin River.

About four miles north-west of Three Springs we cross the watershed and pass the Arrowsmith River, flowing west. The country is Pre-Cambrian with laterite capping. Around Arrino, once the site of a small copper mine (milepost 215) we see numerous flat-topped, laterite-capped mesas left by advanced erosional dissection, and after some scrubby plain before Yandanooka, we run into more flat-topped mesas, but in this area the Pre-Cambrian is replaced by almost flat-lying Jurassic sandstones, and the soil is consequently excessively arenaceous

too. Some of the hills in this section are however built of tuffeaceous rocks—probably representing Woolnough's Mullingarra (Proterozoic) Series. The very dissected country now drains down into the Lockier and Irwin River basin.

We now enter Mingenew (milepost 238) where there is a typical Jurassic sandstone mesa just north-west of the town. About one quarter of a mile east of the town rather poorly preserved Permian marine fossils have been found in a red sandstone.

The road to Dongarra runs west, that to the Irwin River coal seams runs first east and then north from Mingenew, while the main road to Mullewa goes north. On the Mullewa road plant fossils (*Otozamites*) may be found in the red Jurassic sandstones. From here up the valley we pass on to the broad anticline of Irwin River Permian rocks which contain, not only the most southerly marine Permian in the State, but also interesting glacial beds, and coal (which has so far not been exploited). (Refer to papers by Campbell, 1910; and Woolnough and Somerville, 1924.)

Mingenew-Dongarra-Port Denison.

Between Mingenew and Dongarra near the coast, we cross several times over the lower Irwin alluvial flats, but otherwise we are on the very barren Jurassic sands most of the way. Just south of the river at Dongarra may be seen an interesting section of Pleistocene Coastal Limestone, which may in places be subaqueous but is mostly aeolian.

Port Denison is a cray-fishing centre some three miles away near Leander Point. Here there is a Pleistocene coral reef in the cliffs and on the outer edge of the broad shore reef which has been eroded in the old coral limestone there are actually living corals today (see Michaelsen and Hartmeyer, 1907).

Dongarra-Greenough River-Geraldton.

From Dongarra to the north, the road runs between ranges of parallel Pleistocene sand dunes with their characteristic flora. Nine miles north of the town is an old Afghan well, a relic of the old camel transport down this coast. A track over the sandhills here leads to an interesting shore bench in the coastal limestone. Six miles north again there is a turning inland to Mt. Hill, where there is the most southerly marine Jurassic resting on red sandstones with Otozamites. Coming onto the Greenough River flats we see fine agricultural alluvium (of late Pleistocene age) lying between the parallel sandhills (earlier Pleistocene). It appears as if the mouth of the Greenough was deflected over ten miles to the north by the early sand movement.

Geraldton and District.

Crossing a few more sandhills we come to Geraldton, an important artificial harbour and regional centre. It is the base for the Abrolhos fisheries and has a newly developed crayfish cannery. On the Chapman River alluvial flats, the best early tomatoes are grown. Flat-topped ranges behind the town consist of red Jurassic sandstones with marine bands containing numerous ammonites and other fossils. These are best seen around Bringo 16 miles east of the town,

and on the adjoining stations of Newmarracarra and Moonyoonooka. Severe soil erosion may be seen. Some 14 miles beyond Bringo is Eradu where Permian coal seams have been discovered by drilling under the Greenough alluvium; little can be seen on the surface.

North of Geraldton the Jurassic may be seen resting on Pre-Cambrian, and at White Peak there is a large quarry in Pre-Cambrian gneiss. Nearby are some small galena mines.

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VEGETATION.

The coastal plain, which is traversed as far as Bullsbrook, is briefly discussed elsewhere. Leaving Bullsbrook we ascend the Darling Escarpment gradually, for here it is not very well defined. The trees in the sandy soil of the lower slopes are mainly *Eucalyptus Todtiana*, characterised by distorted trunks, small stature, and dull foliage, otherwise somewhat resembling jarrah, although the fibrous bark is much more loose. Later on we encounter the jarrah tree, predominant where gravelly soils occur, and in the clay soils, either with or without gravel is the wandoo, here intermixed with the powder-barked wandoo (*Eucalyptus accedens*) only to be distinguished in passing by its pink-hued bark and broader dull foliage.

After leaving the Chittering Valley we ascend the Bindoon Hill, and here a change takes place. It may not be too early to see two remarkable species of *Hibbertia*—one orange-red (*H. miniata*) the other more or less prostrate, with very large golden-yellow flowers (*H. lasiopus*), and occasionally the striking large-flowered *Hibbertia quadricolor*. Here too is a wealth of *Proteaceae*, especially *Dryandra*, and a few local endemic species.

The country is now undergoing a gradual change; the entry of the rough-barked York gum (*Eucalyptus foecunda* var. *loxophleba*) in richer soils, and occasional jam trees (*Acacia acuminata*) are indicative of drier conditions. Near New Norcia we are in the savannah woodland formation with a noticeable decrease in the density of the shrubs of the undergrowth, and a considerable proportion of native grasses. Unfortunately this country is rarely to be found here in a virgin condition, for it should be remembered that this class of country was the first to be settled, on account of the natural herbage, much of which has now disappeared.

North of New Norcia lies Walebing, where the road bifurcates, the west bend leading to Moora, which we follow, and soon we see woodlands of salmon-gum, morrel and occasional gimlet trees. The undergrowth is mainly *Acacia*. There are also stony rises with a sandy soil in which we find a vegetation strangely diversified, and a host of species. Here are *Eucalyptus eudesmioides,* with dense, yellowish-blue foliage, and *Eucalyptus leptophylla*. Further on is a small area of sand-heath, and by the side of the road we may see *Lachnostachys verbascifolia,* one of that strange endemic group of the *Verbenaceae* with felted stems, leaves and inflorescences, the delicate corolla alone being without hairs or wool.

No striking changes occur until we reach Watheroo, where, to the north we see the first sand-heath of any extent. Outstanding features are the *Banksias,* the sandplain cypress (*Actinostrobus*), the smoke-bush (*Conospermum stoechadis*) with woolly white inflorescences, the curious *Lachnostachys eriobotrya,* a shrub two to three feet high with globular flowers in woolly panicles and we may see still in flower the spectacular *Verticordia grandis,* one of the feather-flowers. There are three other noteworthy small shrubs—one an orange-yellow pea with terminal crowded blossoms (*Urodon capitatus*), *Geleznowia calycina,* a shrub with lemon-yellow bracts and sepals quite concealing the insignificant corolla, and the vermilion-flowered *Pileanthus peduncularis* with purple stamens and yellow calyx. Two outstanding *Proteaceae* are the sandplain pear (*Xylomelum angustifolium*) with narrow erect foliage and pendulous argenteous fruits, and the spherical-fruited *Hakea platysperma,* with fruits the size of a tennis ball, each containing two broadly annular-winged seeds curiously attached by processes to the follicle. The sand-heath continues with but little interruption until Coorow is reached. Visitors will no doubt find much of interest near here, especially in the wealth of species of infinite variety, and the brilliant colourings, especially in *Calythrix, Verticordia, Dampiera,* and *Melaleuca.*

Heath Country.

Northwards from Coorow the country is of less interest, and we pass through alternating types of country. Only near Arrino is an interesting heath vegetation with some endemic forms, and we pass on until when approaching Mingenew, we again encounter heath country, which is only seen to advantage in September. It is interesting to find here a remarkable mosaic of soil types, each with its distinctive flora, and this applies particularly to the long descent to the Irwin River. Many of the plants of this district are found nowhere else on this route, but extend southwards to the Hill River, several are local endemics. The orange-flowered *Eremaea beaufortioides,* with bud-scales covered with a gummy latex, and the comparative wealth of *Stylidium* is noteworthy. Later in the year, perhaps in November, we find the remarkable *Pileanthus filifolius* with large geranium-red flowers covering extensive tracts of sand. Northwards from Mingenew, on the upper Irwin River, not far beyond Nangetty Station, we encounter the Eremean vegetation. There are flats covered with *Kochia sedifolia* and Curara (*Acacia tetragonophylla*), and among the herbaceous species, *Bassia, Amarantaceae* (notably *Trichinium*), *Velleia,* and a host of everlastings occur widespread.

Towards the west is Dongarra, a coastal town, with the typical dune formations of the west coast, and the road turns abruptly once more to the north. This road is of more than passing interest, for along its margins, and some little distance inland, many species occur not found elsewhere. For example, we find here, *Anthobolus foveolatus,* a Santalaceous plant with bright green stems and leaves and scarlet berries, masses of *Hibiscus Hueglii* with petals which do not

expand, entanglements of *Clematis pubescens, Keraudrenia hermannifolia* with masses of dull violet blossoms, and everywhere a thicket like density of shrubs mainly recruited from *Acacia, Gyrostemon, Rhamnaceae, Solanaceae* and *Rutaceae,* Here and there we may find *Diplolaena grandiflora* with large bracted heads of crimson flowers. In the vicinity of Bokara we find limestone hills with thickets of *Anthocercis littorea* whose star-shaped yellow flowers are present on the plants almost throughout the year. Here too, but some distance to the east of the road are small areas of *Eucalyptus erythrocorys,* a species perhaps the most attractive of the whole genus, and rendered at once distinct by its scarlet biretta-shaped operculum and cruciform staminal arrangement of yellow filaments. Other Eucalyptus species in this area are comparatively scarce, but interest centres round the wind-blown trees of *Eucalyptus rudis* on the Greenough Flats, in some of which the trunks are bent almost horizontally through the action of strong sea-breezes. This tree is conspecific with the smooth-barked white-stemmed trees of the Lockier and Irwin Rivers, which might easily be mistaken for *Eucalyptus camaldulensis,* the "Murray-River red gum" which, in Western Australia, is found to the north, extending from the north coast southwards to the Wooramel River, and found again along the dry watercourses of the Eremea, notably around Leonora and Wiluna.

Before we sight Geraldton, we will see to the north-east, the flat-topped Howatharra Hills, and directly north, the domed summit of White Peak, on which grows *Philotheca ericoides,* a curious plant of the *Rutaceae,* known from nowhere else, and in danger of extinction by grazing animals. The Howatharra Hills are of considerable interest in supporting a wealth of species not found elsewhere, including a large number of endemic *Myrtaceae* and *Goodeniaceae.*

AGRICULTURE

The excursion from Perth to Geraldton via the "Midlands" (Moora-Three Springs-Mingenew) is not without interest agriculturally. For the first 10 miles from Midland Junction to Upper Swan we pass through the centre of the main vineyard districts of the State. Through the Chittering Valley and hills in addition to vineyards (mainly devoted to dried vinefruits) there are extensive areas of high quality citrus orchards grown also with little irrigation. A little dairying and some stock raising (sheep and cattle) are practised, but the principal stock production is probably the fattening of store stock for the metropolitan market. At Gingin (about 10 miles west of the main road) and again at Dandarragan (west of Moora) large areas of the W.A. blue lupin (*Lupinus varius*) have been developed for stock fattening during the summer and autumn months. This plant is not grazed to any extent in the winter and spring, but during the dry period up to 10 sheep to the acre can be fattened. The most valuable part of the plant is the seed (about 30-35 per cent. protein) although cattle eat appreciable amounts of the dried stalks and pods.

Between New Norcia, Walebing and Moora the principal agricultural production is sheep but cereals including wheat for grain, and malting barley are grown extensively. High quality export lambs are produced in large numbers on many farms.

From Moora to Mingenew (about 120 miles) although the route is broken by stretches of undeveloped lateritic sand plain, we pass through one of the best wheat districts of the State. The low curved corrugated iron structures at the railing sidings are bulk wheat silos or bins of the type developed and used in W.A.

Although merino sheep are carried on many farms this district is a big producer of export lambs. The lambs grow very quickly and are the earliest in the State and also the Commonwealth. At the time of our visit (August) many will have already been forwarded to the abattoirs.

In the Mingenew-Dongarra districts in addition to wheat and sheep, beef cattle raising and the fattening of store cattle from the lower northern pastoral areas are practised extensively. There are several very fine herds of both polled and horned beef shorthorns. From Dongarra to Geraldton the agricultural pattern is still much the same although stock raising is of greater importance than wheat production. The Irwin River flats and the Greenough flats are very fertile and have been cultivated since the early sixties. The latter was probably the first "granary" of the West, and at one time supported several local flour mills all now closed. Superphosphate has only been used in recent years, and it is still possible to find an odd farmer producing wheat crops without this fertiliser. Lupins are grown extensively.

Geraldton Tomatoes.

At this time of the year (August) the Geraldton tomato gardens will be in full production. For a radius of about 10 miles, owing to the absence of frosts, tomatoes are grown in the winter months. Planting starts as early as February and the picking season extends to December. Some sprinkler irrigation is used at the beginning and end of tomato season. Water is supplied from the Geraldton town supply at 3s. per 1,000 gallons. This supply comes from Eradu, about 35 miles east from Geraldton. About 250,000 cases of tomatoes are forwarded annually from Geraldton, half of which go to Melbourne. In addition some 30,000 packages of early beans and peas are also produced.

THE HOUTMAN'S ABROLHOS ISLANDS.

This group lies 25 miles off Geraldton and represents the southernmost growth of large coral islands in the Indian Ocean. It consists of a large number of islets and innumerable reefs in which many fine species of coral are flourishing. The islets form bird sanctuaries and in the lagoon waters there is a great variety of fish. A lively cray-fishing industry is supported.

Formerly guano and rock phosphate were exported, but since the exhaustion of the deposits, the only development has been for tourists, for whom there is accommodation on the southern end of Pelsart Island. The islands are exclusively of old coral material and lagoon limestones. Vegetation is strictly limited, the only trees being the mangrove *Avicennia officinalis.*

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AIR DISTANCES AND BEARINGS FROM PERTH, W. A.

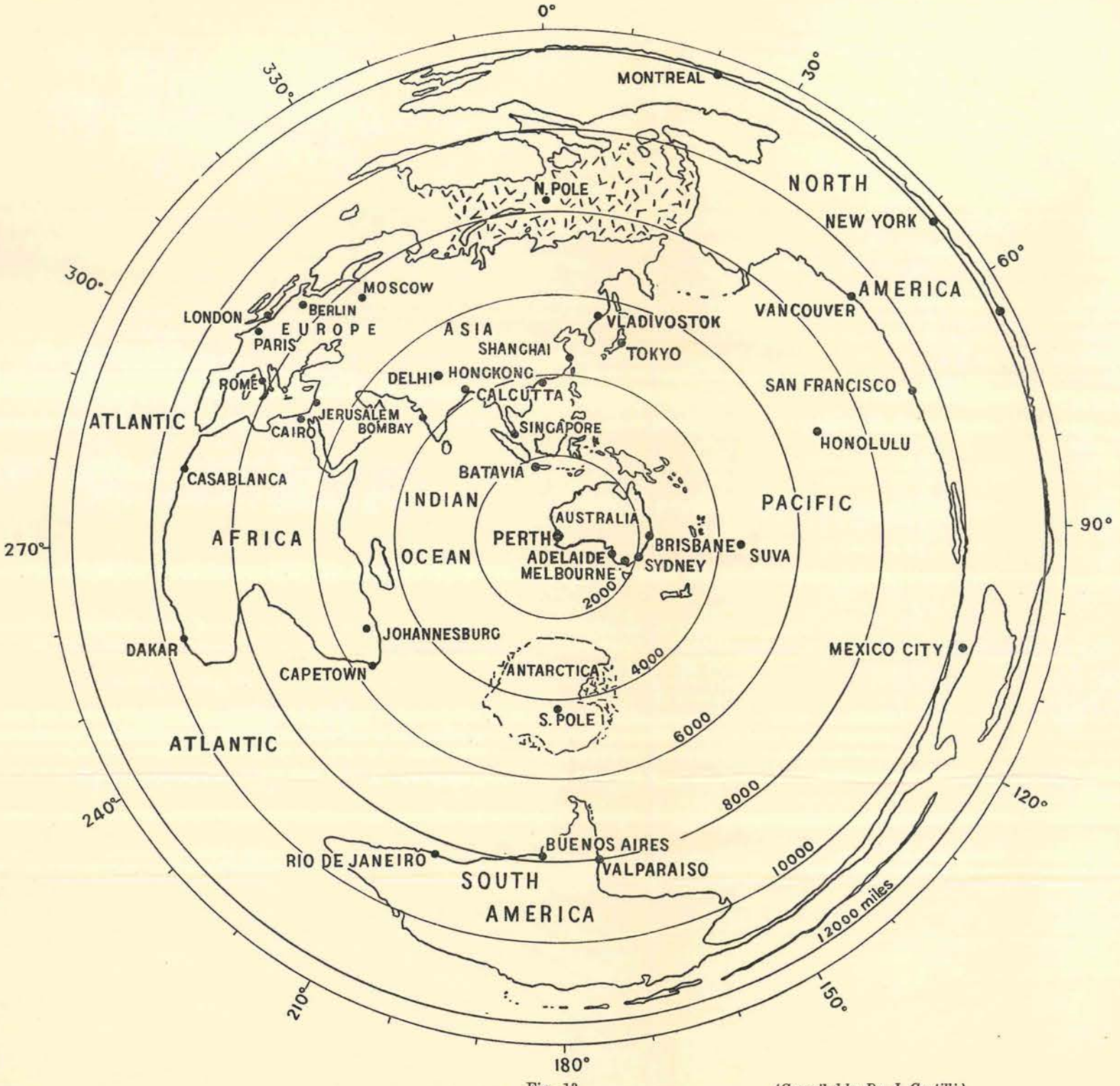
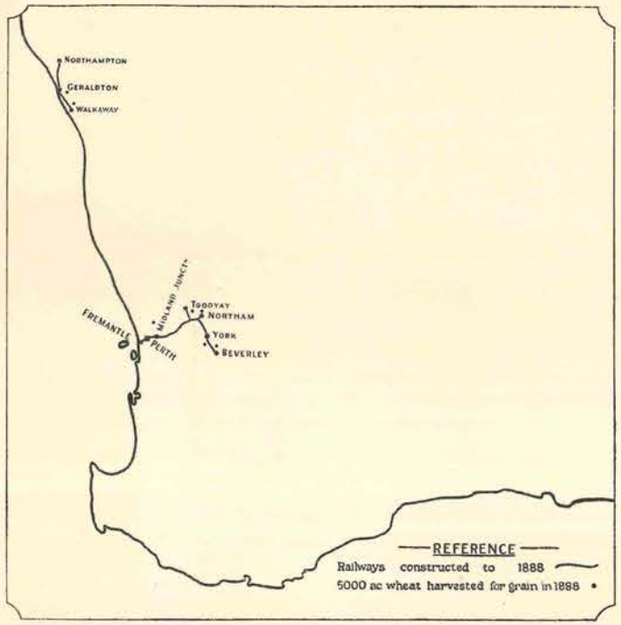
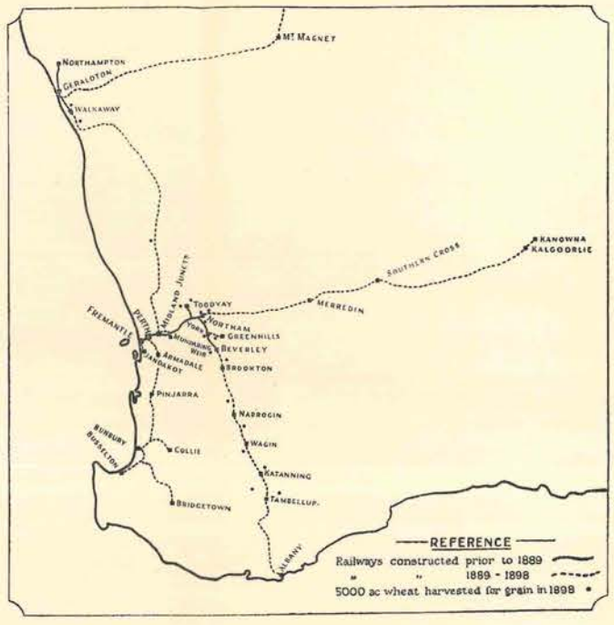


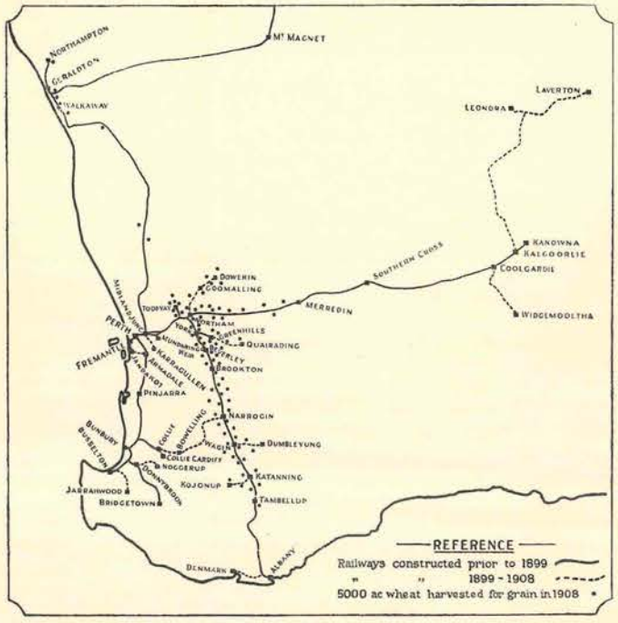
Fig. 13.

(Compiled by Dr. J. Gentilli.)

DEVELOPMENT OF THE WESTERN AUSTRALIAN WHEAT BELT AND RAILWAY SYSTEM.







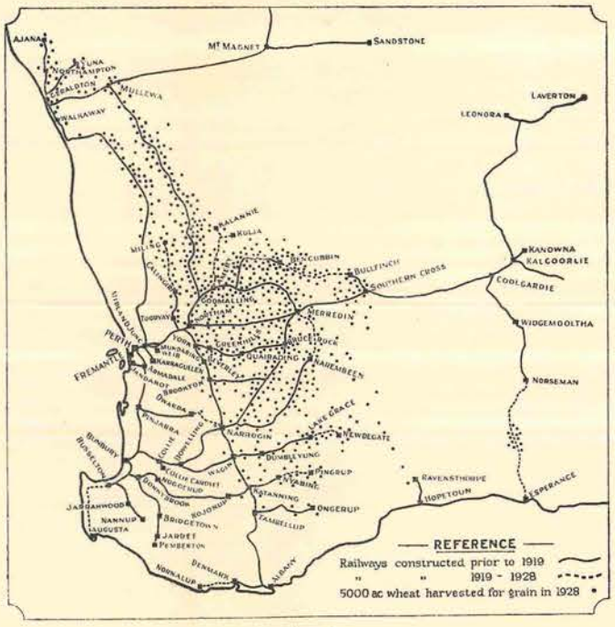


Fig. 14.

(Compiled by R. P. Roberts.)

Figure No. 15
OBLIQUE AERIAL VIEW LOOKING NORTH OF ORD RIVER AREA IN FAR NORTH-EAST CORNER OF WESTERN AUSTRALIA.
PHOTO BY U.S. ARMY AIR CORPS, SEPTEMBER, 1943.

1. Ord River.
2. Denham River.
3. Carlton Reach, Ord River.
4. Carlton Reach Hills.
5. Carlton Reach Plain, about 40,000 acres (proposed for irrigation).
6. Kimberley Research Station.
7. Former Research Station at Carlton Reach.
8. Ivanhoe Station Homestead.
9. Deception Range.
10. Mantinea Flats, about 14,000 acres (proposed for irrigation).
11. House Roof Hill.
12. False House, Roof Hill.
13. Mouth of Cambridge Gulf.
14. Alluvial flats.
15. Pincombe Range.
16. Mt. Cecil.
17. Western Australia-Northern Territory Border.
18. Keep River.
19. Sandstone Hills and Cockatoo Sands.

Wyndham is 26 miles west of House Roof Hill (11).

MAP OF WESTERN AUSTRALIA

STATISTICAL DIVISIONS AND RAILWAYS AND AIR ROUTES

Scale of Miles

50 40 30 20 10 0 50 100 150 200

Note: Bounderies of Road Districts are taken as Statistical Districts.

STATISTICAL DIVISIONS SHOWN IN BLUE

T.S. Parry
Surveyor General

Government Printer, Perth.