PART II

An Outline of the Physiography of Extra-tropical Western Australia

CHAPTER 1 GENERAL GEOGRAPHY

I. Physical Geography

For the purposes of our discussion, temperate Western Australia may be considered to extend from the Tropic of Capricorn southwards to the ocean. To the east it is arbitrarily bounded by the meridian of 128°E longitude.

Within these limits the Southwest Province is rather sharply marked off from the rest of the area by an oblique line running from Shark Bay to Russell Range.

The inland country extending to the east of the area forms, we consider, a part of Central Australia. This arid region, known as the Eremaea, extends over the greater part of the continent. It consists of a monotonous flat expanse of the Australian plateau at an elevation of 400-500 m. While it is more or less level over extensive areas, the surface frequently shows, however, a gently undulating appearance due to the occurrence of isolated hills or dune-like structures. All the features which give Central Australia its special character are present. These include extensive arid almost waterless areas, slightly depressed salt pans and steep bare hills rising out of the plain. The whole produces a timeless effect without any hint of change such as that we see expressed in the Eyre basin area which lies to the east of the Eremaea. Even the operation of present-day climatic forces appears to have little effect on the uniformity of its development.

On the western margin of the Eremaea, however, under the influence of a very marked change in climate, the everlasting monotony of the plateau begins to change. Two contrasting factors are involved in this. Firstly, towards the north the occurence of reliable and heavy summer rains begins to determine the nature of the country. The land-locked salt lakes gradually disappear, being replaced by valleys. The Ashburton, Gascoyne, Murchison and Greenough Rivers have cut relatively large valleys. They are in fact the largest in the whole of Western Australia. Essentially the rivers flow only during the wet period and intermittent flooding occurs. Because of this the operation of the forces of erosion is capricious and irregular.

As we move southwards the regular summer rains rapidly decrease, leading to a temporary deterioration in the situation along the western margin of the Eremaea. Thus, south of the Greenough River for instance, the valleys once again become considerably shorter and smaller. Soon, however, we pass into a region where heavy winter rains become effective. This is indicated by the changing configuration of the land which rapidly begins to show features characteristic of the greater part of the Southwest Province. The change is clearly apparent in the Moore River district where a deep valley has been eroded. The plateau characteristic of the interior no longer sinks gradually towards the coast but shows a sharp break. A steep escarpment is formed which is separated from the sea by a coastal plain of varying width. Further south, the rivers, under the influence of increasing annual rainfall, tend to flow all the year round and pleasant valley landscapes penetrate more deeply into the granite basement rocks of the country. The Blackwood River, in the region of highest rainfall, has the longest valley in the south. In contrast to the large northern rivers, it only stops flowing in exceptionally dry years. From this point eastwards to Tor Bay, the edge of the plateau is dissected by many short or long valleys. Usually the river valleys tend to run from north to south. The slope is gradual and so the streams mostly flow slowly along very winding courses. Still further east the river slopes become even more gradual and we get a return to the conditions observed between the Moore and Greenough Rivers in the more northerly part of the Southwest Province. The configuration of the country noted towards the north and which was due to the effect of tropical rains is, however, not repeated here. Instead, as we move eastward along the coast, the valleys gradually become smaller. Beyond Cape Arid they disappear altogether. On this eastern side of the Southwest Province the coastal area gradually begins to show

again the monotonous character of the Eremaea. This rapidly intensifies so that soon the whole western shore of the Great [Australian] Bight appears Eremaean-like.

The coastline shows few estuaries and lacks the beautiful bays found in the tropical north-west. Some diversity, however, does occur along the more westerly parts of the granitic south coast. We may note, for example, the group of small islands which constitute the Recherche Archipelago and the beautiful region in the vicinity of King George Sound. Along the west coast there are two basins and the development of Shark Bay is quite interesting. All these areas are, however, of limited extent. In effect they prove the exception rather than the rule and only slightly lessen the impression of a long, uninterrupted and monotonously uniform coastline. As compared with the area of the interior, the length of the coast line of south-west Australia is extraordinarily short.

In many places a zone of recent limestone occurs along the coast. Its development is relatively weak but it can be reasonably assumed that it once extended over the whole length. It remains excellently preserved in places, although it may be covered over with sand. Good outcrops occur only in the neighbourhood of river mouths as, for example, the Osborne Cliffs on the Swan River and the banks of the Chapman River at Champion Bay. Elsewhere the limestone is hidden or has disappeared. Remnants of varying extent are present on the south coast but in general the rough seas there break directly onto the granite basement rocks. All that the voyager sees from Cape Leeuwin to the Great [Australian] Bight are gloomy-appearing cliffs.

Over the whole length of the coastline from Shark Bay to near Eucla only moderate tides occur. In fact, in some places there is no discernible tidal change. The small variations in sea level at the Swan River mouth, for instance, depend entirely upon the prevailing direction of the wind and the kind of sea that is running. It is only when one travels north beyond the Gascoyne River that the difference between ebb and flood tide becomes obvious. As one journeys still further north this difference increases and gradually tides of notable dimensions may be observed.

The topography of the land surface of the whole of temperate south-west Australia is predictable from the conditions of erosion mentioned above. The Stirling Range is the only mountain system present. It extends for 70 km and is located north of King George Sound. This peculiar formation consists of several largely independent peaks of uniform and almost pyramidal shape. Some of them reach a height of more or less 1100 m and are thus the highest elevations in the south-west. The rather sketchy accounts of these mountains in the literature must be read with great caution. Many are without doubt quite incorrect. The idea of them being volcanic, for example, as many people thought, is quite wrong.

The steep western margin of the Australian plateau, when viewed from the coastal plain, looks in places quite like a range of mountains. As a matter of fact, however, the margin of the plateau has been eroded to gently undulating hilly landscapes. Different names have been applied to it in different localities. The best known one is the 'Darling Range', east of Perth. The average height lies between 350 - 450 m. Few places rise above this, the highest point recorded being Mount Williams at 530 m[1].

II. Geology

In summary we may say that extra-tropical Western Australia consists of a massive complex of old country rock. Both in the Eremaea and in the Southwest Province, the Archaean rock is the foundation of all other deposits and sedimentary formations. It is most commonly exposed in the valleys, where it shows interesting rocky outcrops. In the south coastal area it outcrops almost everywhere in great rounded masses and its dull gloomy appearance dominates the scenery of this region. Inland, however, it is often exposed in low-lying areas where it forms smooth, bare, slightly convex bosses or tors. The water which runs off these collects round the edges at the base so that most of it is retained. These form the 'soaks' which have saved the lives of many pioneers and explor-

1 The height of this mountain is still indicated on many of the best maps as 3600 feet or 1122 m. From where these completely unfounded numbers come, I do not know. The current official government maps of the west Australian give the height correctly; indeed as early as the forties Drummond noted M William as being 1630 feet high.

ers in these desolate areas.

The extent of the sedimentary formations in south-west Australia is still unknown. This is in keeping with the overall paucity of any worthwhile geological information about the country as a whole. The brief notes in the otherwise excellent works on Australia contain many inaccuracies.

This state of affairs is most unfortunate, particularly with reference to the plant geography of the area. Lack of information on the geology and geological history makes it almost impossible to carry out any worthwhile vegetation analysis.

The botanist can only state that rocks of archaean age, poor in lime, form the greater part of the basement. An earlier Government Geologist, H. P. Woodward, distinguished six parallel zones of archaean rock running from north to south. The most western of these, formed of slate-like schistose material, is almost everywhere hidden and covered by sand plain. The second forms the edge of the mostly steeply-sloping plateau and consists of hard material, particularly gneisses and schists, together with quartz, granite and diorite. The third zone begins, on an average, about 150 km east of the coast and extends eastwards for about the same distance. It also is composed of gneisses and granite, as indicated by the outcrops in the surface depressions. Usually, however, it is covered by a thick layer of sand. The fourth zone which is about 30 km broad consists of hornblendelike minerals, mica and talc schist. The quartz veins present contain mineral inclusions and this is the real gold-bearing zone of the country. Further east again, another granite-gneiss belt about 150 km wide occurs. This is very similar to the third zone and never contains gold. Finally the sixth zone resembles the fourth, and is exceedingly rich in gold deposits. It appears to extend eastward for some considerable distance.

These archaean rocks are very rarely of any direct importance insofar as the vegetation of the area is concerned. The strata which have direct significance are the recent deposits, particularly the diverse soils on primary and secondary deposits which owe their origin to the weathering of the archaean massif.

The already mentioned narrow band of littoral limestone found bordering the west coast and to some extent also the south coast, is regarded as being Pleistocene in age by the Australian authorities. This formation contains fossils (particularly molluscs) which are very similar to recent forms. Their origin is probably due to a recent uplift of the coast.

The recent deposits, the surface layers of sand and soil etc., are by far the most important for the vegetation of Western Australia. Unfortunately, information regarding their nature and origin is very sparse. A detailed scientific investigation of their geology has not as yet been made. All geological studies so far have of necessity been concentrated on purely applied aspects, in particular the needs of the mining industry.

Conglomerate [lateritic] soils, coloured red-brown or brownish-yellow by iron oxide, are very widespread in the south-west area. The present Government Geologist of Western Australia, A. Gibb Maitland (writing in the latest (12) edition of the West Australian Year Book, 1900-1901) simply lists them as “surface deposits” and expresses himself as follows with regard to them (p. 115):

“Under this heading comes a large series of deposits not already referred to, the main ones of which are the “gravel” and “ironstone” which cover a considerable extent of the south-western portion of the colony.

These deposits are in reality hardened, nodular, ferruginous “claystones” called gravel, sometimes cemented by iron and forming conglomerates [laterites] and ferruginous sandstones. Both of the latter are locally known as “ironstone”. They result from the disintegration of the different underlying strata (mostly crystalline rocks), and show their strongest development in the forest ranges. The best stands of Jarrah, for instance, occur on this conglomerate [laterite]. The so-called “gravels” are often of considerable thickness and are largely used for ballast along the railways. Their origin is difficult to understand, as they cap the highest ridges up to an elevation of 400 m”. It will be apparent from these remarks of Gibb Maitland how little the professional geologists know of these deposits.

Sand, whose extensive distribution has made the colony notorious from the farmer's point of view, comes into the category of detritus formations. Among these sand formations even the layman can distinguish two kinds: the common sand deposits and the true 'Sand Plains'. Gibb Maitland (*loc. cit.)* follows this customary usage and separates the recent coastal sandplains from the sandplains of the interior, which he considers to be Pliocene in age. Why these sand plains of the interior should be considered Pliocene I do not know. No reasons have been given for this assumption and I consider it quite incorrect. However, Gibb Maitland has given an excellent description of the sand plains as such and this is set out below (loc. cit. p. 114). "Sand Plains - These form one of the characteristic features of Western Australia, extending as they do from one end of the colony to the other. The great sand plains of the interior are often 30 to 50 km wide. In places, however, they contain a good deal of clay and iron which cement the grains of sand together. Consequently, as there is a reasonable rainfall, they are covered with a hardy vegetation which, during the two spring months is ablaze with flowers. Later during the summer months they provide good grazing ground. These sand plains mostly appear to overlie the desert sandstone formations which form the tableland of the interior of Australia." On what evidence the last statement is made I do not know. In the areas mentioned I have only seen basic archaean rock, never desert sandstone.

With regard to the sandplains of the coastal plain, Gibb Maitland makes the following remarks (*loc. cit.* p. 115): "Coastal Sand Plains - These plains are met with in the southern portion of the Colony, extending from the foot of the ranges, and covering the lower ground between the scarp and the sea. The sand here is much looser than in the interior, and is often of considerable thickness. It appears reddish-yellow in colour below the surface, and exhibits false bedding, indicating that it is aeolian or windblown in origin. There are many lakes and swamps on the plains. The water in these is often retained by deposits of peat."

The fine detritus, loam and clay deposits, collect in the coastal districts at the foot of the edge of the plateau or in valleys of the coastal plain, particularly in river-beds. Because of the mostly less intense rainfall in the Southwest Province, the extent of these deposits is not nearly as great there as in the more northerly regions with their frequent, flooding tropical summer rains.

In the Eremaea, the alluvial material forms salt pans which have been briefly described by Gibb Maitland as follows (*loc. cit.* p. 114): "Alluvium of lakes basins - Throughout the interior there occurs a series of what are called lakes. In reality they are nothing more than large salt flats, boggy marshes or clay pans. They are almost on a dead level and drain one into the other and eventually, if the season has been wet enough, discharge into the upper reaches of some river. This however, rarely happens, owing to the enormous surface they present for evaporation. One result of this is that in almost every year these large flats receive a fine covering of clay upon which the salts contained in the water crystallise out. Later they may redissolve and continue to be added to from time to time. Finally, in some places, which may be at a slightly lower elevation than the rest, or where some obstruction occurs to check the flow of water, very large deposits of salt accumulate. These lakes are surrounded by red clay flats, which also contain a great deal of salt. In fact the whole interior of the Colony is salty, since the salts which are leached from the rocks are either carried away to the clay or are redistributed over the surface of the country by the wind."

From these descriptions it is apparent that there are many gaps and uncertainties in our knowledge of these soil deposits. A thorough investigation of such soil deposits in the region is clearly one of the most urgently needed studies.

We can, however, make one very important point at the present time. That is, that when the character of the West Australian surface and soil deposits is considered as a whole, the land appears to be a playground in which steady uniform action, under the influence of external factors, has been going on over a long period. This action, both in its direction and strength, differs very little from that operating now.

CHAPTER 2 CLIMATE

Over the last few years, considerable advances have been made with respect to our knowledge of the climate of west Australia. For this we are indebted in particular to the work of the present Government Astronomer, Mr. W. E. Cooke who, in 1901 wrote an excellent review and summary of the meteorological conditions entitled “The Climate of Western Australia from Meterological Observations made during the years 1876-1899”, Perth 1901, 128 pgs., with numerous maps.

So far as the extra-tropical [temperate] portion of the State is concerned, this report contains a mass of useful data. Not only are the average monthly temperatures given, but also the mean temperatures together with the maxima and minima. The rainfall is also recorded. Physiologically important features are also touched upon, as for example, the number of hot days (over 32°C) and cold nights (under 4.5°C), the number of rainy days, and the quanity of rain in single continuous downpours.

No information is available, however, on such biologically important factors as relative humidity, duration of sunshine or strength of the wind. We must, however, be very grateful for the large amount of work which has been carried out in such a short time. It includes a table showing the rate of evaporation at Perth. While this is not completely accurate, it is at least helpful and allows some degree of orientation.

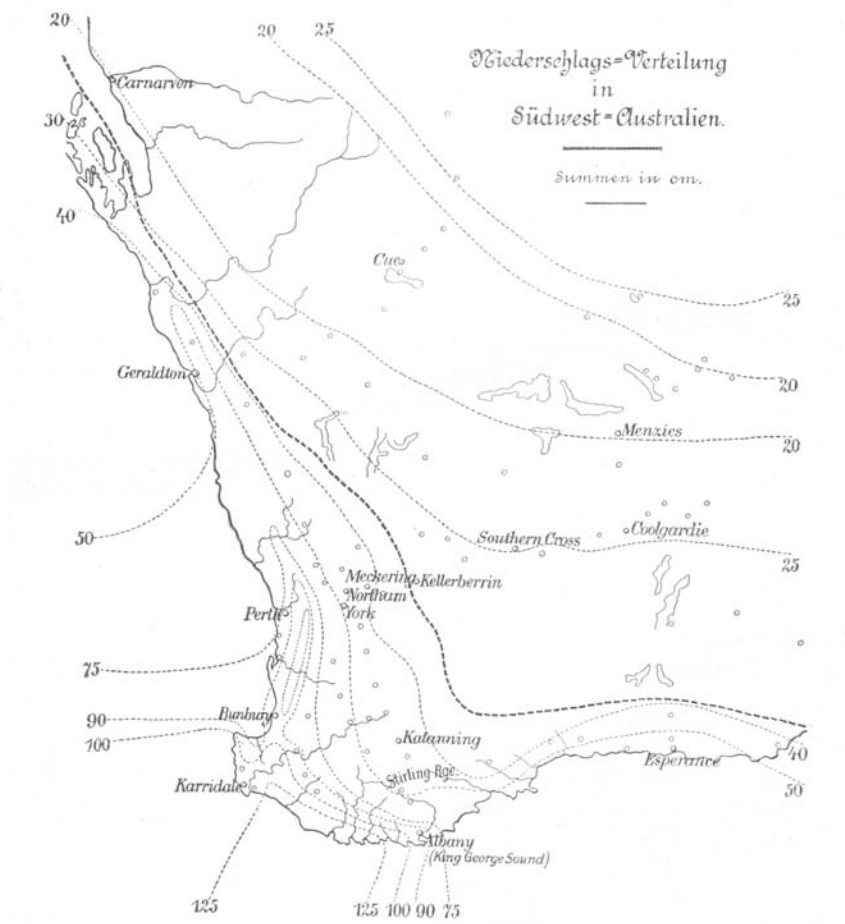

Fig. 2. Niederschlags-Verteilung in Südwest-Australien. Summen des durchschnittlichen jährlichen Niederschlags in Centimetern.
Die stärkere gebrochene Linie gibt die Grenze zwischen Südwest-Provinz und Eremaea an.

I. Rainfall

The distribution of rainfall over the region is given in Figure 2. From this it may be seen that the south-west corner of the country receives most. On the coastal area between the Swan River and King George Sound the average annual rainfall lies between 75 – 100 cm. It will be noted also that within this region the highest rainfall (rather more

than 125 cm) falls between Cape Leeuwin and the Denmark River. In addition, due to the rising air currents over the edge of the plateau, the rainfall here reaches 100 cm or more per annum.

The 60 cm, 40 cm and 30 cm isohyets each run almost parallel to the line which marks the boundary of the rainy district. These isohyets indicate the zone of medium rainfall. The zone begins just north of the mouth of the Murchison River, widens slowly towards the interior reaching its greatest breadth at about 33°S latitude and then turns gradually towards the east, approaching the south coast as gradually as it left the west coast. The 30 cm isohyet marks almost exactly the floristic boundary between the South-west Province and the Eremaea.

The decrease in rainfall as one passes inland from the edge of the plateau is very uniform everywhere. Although the observation stations from Perth to Southern Cross are, unfortunately, still incomplete, the readings which are available are sufficiently representative. The monthly rainfall (in millimetres) at these stations is given below. It should be noted that it is only for those marked with an asterisk (*) that the records extend over ten years. Records for the others are for shorter periods and consequently are less reliable. Naturally, with more stations and over a longer period, the statistical value of the data will increase. The distances of stations inland from the Darling Scarp are given in kilometres.

km		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
49 w	*Fremantle	5	10	18	43	113	145	143	125	65	43	15	18	738
31 w	*Perth	10	10	20	45	122	168	160	145	73	53	20	18	825
20 w	Guildford	10	3	33	15	103	170	178	108	70	50	8	10	750
-	Mundaring	3	8	43	23	98	120	213	195	108	50	18	23	1000
Stations are missing here														
67 e	Northam	5	13	33	10	40	85	93	133	35	13	3	8	375
102 e	Meekering	0	3	13	25	60	70	48	45	30	25	3	3	350
168 e	Kellerberrin	0	8	8	15	38	50	40	40	28	13	8	8	250
241 e	Burracopin	8	20	10	28	50	50	40	40	18	5	3	3	250
322 e	Southern Cross	10	13	23	10	30	38	30	25	15	13	13	13	225

In the extra-tropical Eremaea, insofar as it may be said to belong to Western Australia, the average annual rainfall lies between 30 cm and 20 cm To the north-west, stretching from Shark Bay inland, the region becomes increasingly drier, and at many places less than 20 cm per year is recorded In contrast to this, as we approach the upper reaches of the Murchison River, the influence of the tropical summer rains begins to be felt. Thus the rainfall at Lake Way and at Peak Hill, for instance, rises to about 30 cm per annum.

Because of its seasonal distribution, the rainfall in our region may be divided into an area of winter rain and an area poor in winter rain. Both areas are almost, but not quite, separated by the 25 cm isohyet. Winter rains often make themselves felt on the dry side of this line. On the coast at Shark Bay, however, the whole of the scanty rainfall (often less than 20 cm per annum) belongs to the winter type.

The true region of winter rain extends over the triangle bounded by a line running from Shark Bay to Esperance. It is characterised by a marked periodicity. The rains during the months May to August provide about 50% or more of the yearly total[1].

This periodicity tends to decrease as one moves down the coast from the north towards the south-east. At Carnarvon the average rainfall from May to August is about 76% of the yearly total; in Geraldton it is 78% at Perth 71%; at Karridale 68%; at Albany 58% and at Esperance only 50%

An important point brought out by these figures relates to the slight extension of

1 In Supan's representation in the Ergäenzungscheft 124 of Petermanns Geogr. Mitteilungen (1898) Table. 3, this does not stand out with sufficient clarity.

the rainy season into the warmer part of the year. This is the case along the whole of the south coast, and it also holds good for some distance inland. Thus, between October and December, Esperance and even Coolgardie receive more than Geraldton.

This distribution of rainfall, together with the quantity, is important in defining the dry season. If one regards as very dry months those for which less than 3 cm of rain is recorded, then the length of the dry season in months may be determined. The table below gives the results for different locations.

Southwest coast		South coast		Eremaea	
Geraldton	7	Karridale	2	Carnarvon	10
Perth	5	Albany	3	Cue	11
York	7	Esperance	5	Southern Cross	9

Values for the degree of cloud cover may also be considered. The figures for the south coast are the highest, as may be seen from in the following table (after Hann).

	Max.	Min.	Year
Perth	6.0 (June)	2.1 (Jan.)	3.8
Bunbury	6.4 (June)	2.5 (Jan.)	4.5
Albany	6.4 (May)	5.5 (Dec.)	5.8

The periodicity of rainfall in the northern part of the Eremaea, insofar as it concerns us, tends to approach that of the summer rain areas. Thus at Lake Way and Peak Hill more than half of the annual rainfall occurs during the warmer months of January to April thereby clearly showing the influence of a tropical regime. While this condition mostly holds good for the whole of the Eremaea and also may extend as far as the south-eastern coastal regions, it never extends as far as the south-west coast. The observations of W. E. Cooke have shown that tropical depressions occasionally cross the whole continent obliquely from the North West Cape to the Great Bight and then the Eremaea receives quite heavy rains. This is the cause of the great floods which are responsible for certain features of the surface of the interior. In the more northern and western parts, where such rainy periods are more regular, one finds well-defined valleys (Gascoyne, Murchison, etc.). Further south where heavy rains are sporadic, they result in salt-pans. One such cross country cyclone took place in April 1900, and because of its importance for the vegetation of the Eremaea, an extract of Cooke description is appended (from "The Climate of Western Australia" p. 16). It must be noted, however, that this particular occurrence was of greater intensity than any previously described in Western Australia. At the end of April 1900 Cooke wrote:

"This month will long be remembered as the month of the great floods. These were so severe that all telegraphic communication north of Geraldton was interrupted, and the postal service in the interior completely disorganized. The extensive dry plains were converted into inland seas or lakes and the rivers became raging torrents. Peak Hill and Lake Way Stations, situated in the great inland desert, were completely cut off from all food supplies. At Peak Hill where almost 25 cm of rain has fallen this month one can now sail a boat over 100 km. The weather was of a monsoonal character, and traveled from the north-west coast in a more or less south-easterly direction, towards the head of the Great [Australian] Bight. It may be said to have first set in on the 2nd of March. After the main storm passed away, the weather continued unsettled, with occasional showers throughout the remainder of the month. Rain recommenced in earnest on the 1st April, and from then until the 20th a dense cloud bank covered nearly the whole of Western Australia, and the rain was almost unceasing. Perth (i.e. typical of the Southwest Province) escaped even the cloudy weather but the edge of the rain could be seen day after day behind the Darling Range. We have, unfortunately, scanty records from which

to make a comparison with past years, but, from all that can be gathered, the present fall has been the heaviest, the most general, and the most persistent ever known and no man living has ever seen the country flooded to the same extent."

In concluding this section on the rainfall, a table is appended which gives the actual monthly rainfall at various places in the Southwest Province and in the Eremaea.

	Monthly Rainfall (cm)												
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
South-West													
Geraldton	1	1	1	3	17	12	10	7	3	2	1	0	45
Perth	1	1	2	5	12	17	15	15	7	5	2	2	83
Karridale	2	2	3	6	15	23	20	18	10	8	3	3	110
Albany	2	2	3	7	12	13	12	13	10	7	3	3	85
Esperance	2	2	3	3	7	10	9	10	6	5	3	2	61
York	1	1	2	2	6	8	8	8	3	3	1	1	43
Katanning	1	1	3	2	5	6	7	6	5	4	1	1	40
Eremaea													
Southern Cross	1	1	2	1	3	4	3	3	2	1	1	1	23
Coolgardie	1	2	1	1	3	3	2	2	2	2	2	2	20
Menzies	1	4	1	1	3	4	1	2	1	1	1	1	19
Cue	2	2	2	3	2	5	1	1	0	0	0	1	19
Carnarvon	1	2	1	1	2	8	5	2	1	1	1	1	20

II. Temperature

Temperature conditions in Western Australia correspond exactly with its geographical position and physiography. Of the two littoral regions, the west coast is by far the warmer and consequently less temperate than the south coast. This will be seen below, which gives the average temperatures for the two extreme months.

	February	July	Difference
Geraldton	24°C	15°C	9°C
Perth	24°C	13°C	11°C
Albany	19°C	11°C	8°C

The surprising influence of the southern ocean is highlighted by the figures. It is responsible for the lower summer temperatures of Albany and almost all the south coast. Perth, and likewise Albany, however, for the same reason, show a considerable warming effect in winter. This moderating influence of the sea is quite considerable but it is confined essentially to the coast. Consequently there is a very great contrast between the climates of the inland areas and the coastal region. This becomes clearly apparent when we compare the average maximum and minimum temperatures for coastal and inland stations.

Coast				Interior			
	Max January	Min July	Difference		Max January	Min July	Difference
Perth	31	8	23	York	33	7	28
Albany	22	8	14	Katanning	31	4	27
				Menzies	35	6	29
				Cue	39	7	32

A further example of the favourable effect of the sea on the south coast may also be noted. Thus at an inland station, e.g. Katanning, which is only 160 km from the coast, the difference between the two daily extremes of temperature (during January and July) is twice as great as at Albany. The fall in temperature during the night is particularly striking. It results in the Katanning area being one of the coldest parts of Western Australia in winter. While the number of July nights when the air temperature falls below 4°C is on the average three for the south coast, the number for Katanning is eighteen. The records also indicate frequent night frosts. These may occur as early as June when

the temperature there may fall 1 or 2 degrees below zero. Frosty nights may continue to occur as late as September.

In the Eremaea the extremes of temperature are even greater than in the lower south-west. This is due to the greater heating up during the day in summer. Thus while Cue is 8° hotter than Katanning in summer, it is only 3° warmer in winter. For details, see below.

Mean Temperature of the Different Months (°C)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Soulhwest												
Perth	24	24	23	19	16	13	13	14	15	17	20	22
Karridale	19	19	18	16	15	13	13	12	13	14	16	18
Albany	18	19	18	16	14	12	11	12	13	14	16	18
Esperance	20	20	19	17	15	13	12	13	14	16	18	20
York	25	25	22	18	14	11	10	11	13	16	21	24
Katanning	22	21	19	16	12	10	9	10	12	14	18	20
Eremaea												
Cue	31	30	28	23	17	13	14	14	16	20	25	29
Menzies	28	26	24	20	15	12	12	13	16	19	24	27
Coolgardie	26	25	23	19	14	11	12	13	16	18	22	25
Southern Cross	26	25	23	18	14	11	11	12	14	17	22	25

Mean Daily Variation of the Differences (°C)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept	Oct.	Nov	Dec
Southwest												
Perth	14	14	13	13	11	9	9	10	10	11	12	13
Karridale	10	11	11	10	11	8	8	9	9	8	9	11
Albany	7	6	7	7	7	7	7	7	7	7	7	7
Esperance	10	9	10	11	10	9	9	10	10	10	10	10
York	15	15	13	13	12	10	10	11	12	13	14	15
Katanning	18	15	15	14	12	9	10	11	13	14	16	17
Eremaea												
Cue	15	15	16	14	14	9	12	13	15	15	17	16
Menzies	15	14	15	14	12	9	12	11	14	15	15	16
Coolgardie	17	15	15	14	13	9	11	11	14	15	16	17
Southern Cross	18	17	17	15	14	11	14	13	15	17	18	18

III. Evaporation

Due to the character of the climate, evaporation necessarily reaches very high values in Western Australia. Data, however, are available only for Perth. Even here, at this sub-littoral station, the figures show quite high values (see below).

Evaporation Figures at Perth (average for 24 years, after Cooke)

October	15 cm	April	11 cm
November	21 cm	May	8 cm
December	25 cm	June	5 cm
January	28 cm	July	5 cm
February	23 cm	August	6 cm
March	20 cm	September	10 cm

Comparative data from other places on the earth are unfortunately scarce. One comparison may be made with Europe. According to Hann, the maximum evaporation at Vienna reaches 11.3 cm in July, while in October it is 4.7 cm and in January it reaches the minimum of 1.3 cm.

IV. Yearly Weather Cycle

a. SOUTHWEST PROVINCE

The periodicity of the weather in the winter rain area is indicated by the much higher rainfall in the winter months. It may also be noted that on the south coast light falls of rain do occur throughout the whole of summer. This does not apply, however, in the Swan River area. Here the rainfall is only very slight between November and April. The climate of Perth may consequently be regarded as being more typical of the winter rain area. The two seasons, winter wet and summer, are sharply separated.

Towards the end of April or in early May at the lower latitudes, the onset of stormy winter weather commences. A rapid fall of the barometer indicates the approach of rain and the wind in Perth veers round to the north and north-west. It often blows very strongly and the whole of the west coast may sometimes experience a severe storm. The rain falls in very heavy showers which, however, seldom last for more than a few hours. Almost every year falls occur in which 3-7 cm are precipitated within 24 hours. The wind then veers round from the north through the west to the south, while heavy seas are experienced at Cape Leeuwin. In the Swan River area, however, the showers gradually become lighter and shorter in duration. Sunny, cloudless days tend to become the rule again.

This type of weather now prevails from May to the beginning of October. It of course shows some variation, being rather longer in some years and shorter in others. Cloudy days occur between the sunny periods and may sometimes last for from 8 to 14 days. But on the whole, even during the cyclonic period, there is plenty of sunshine. The pleasant daytime temperatures, together with the fact that the nighttime temperatures rarely drop to zero, gives support to the view that during the winter the climate in the Swan River area makes the place almost a paradise to live in.

Modifications to this climatic scene take place according to the geographic conditions encountered as one moves towards the north, the south, or inland to the east.

As we travel north, the peak for the rainy season occurs earlier and the temperatures are also higher. The effect of this is that, at Champion Bay [Geraldton] for instance, even in the middle of winter one may experience quite warm humid weather.

Passing inland, even by the time York is reached, we may observe that the intensity of the rainfall has decreased well below that experienced on the coastal plain. Due to the high radiation, great diurnal extremes of temperature occur (see Table 9).

On the south coast, however, each cyclone makes itself felt, and the unsettled weather which often follows is particularly noticeable. In most years, therefore, the winter months are really unpleasant there, with a great deal of rain and few really bright days. This is an important difference from the climate of the west coast. In addition, the transition from winter weather to summer-type weather occurs later in the year, and is more gradual. Antarctic depressions sometimes bring a succession of rainy days in the middle of the dry season.

In Perth the summer dry season does not set in as suddenly as does the rainy season. In October the rains become markedly less frequent and the thermometer may rise to over 30°C. A cool sea breeeze, however, frequently blows in the afternoon and the nights are cool. The clear air, the constant blue skies, and the low humidity make the first months of the dry season very pleasant. However, the heat in January, when for days the temperature rises to about 35°C in the early afternoon, can sometimes be very trying. It is in February and March, when the sirocco-like east wind predominates for longer periods, however, that the dry season really becomes intolerable. With the coming of late March there is a gradual increase in the number of days when the sky becomes overcast. In the evenings, lightning becomes visible towards the interior. The bush is

tinder dry and fierce bushfires frequently occur. The smoke fills the air and everybody eagerly awaits the rains which eventually must come.

On the whole, the climate of the south-west is characterised by its regularity. The differences between individual years are not nearly so great as, for example, they are in eastern Australia. Extreme conditions, such as severe droughts and floods, changes from almost unbearable heat to chilly conditions, in short all the influences of the Eremaean climate which so radically affect the climate of eastern Australia do not occur here.

b. EREMAEA

The Eremaea part of south-west Australia benefits, although to a lesser degree, from the more favourable conditions of the deep south-west. It would be a desert region of the worst type if the tropical rains from the north and the winter rain area of the south-west did not exert an ameliorating influence. The climate is consequently the result of the interaction of opposing factors. "Sometimes[2] the tropical rains pass right across it, while at other times the winter storms of the south-west and south extend rather further inland. When, as sometimes happens, both types of rainfall fail to occur, drought follows." As a rule, apart from exceptional years, one can expect a certain mixture of Mediterranean-type weather up to about 30°S latitude. This occurs because, in winter, light rains can still occur up to this line and, in summer, the heat waves may be interrupted now and then by cool spells passing from west to east along the south coast. In unfavourable years when both are absent no amelioration of conditions is possible north of the 30° parallel. Consequently the summer there becomes almost unbearable. The heat is extreme and it is often windy, with the result that the atmosphere is full of dust. The only relief which may occur comes from an occasional tropical thunder storm, which can be quite destructive. The winter season, however, provides some degree of compensation due to periods of quite dry, cold, clear weather and the air may be quite bracing.

CHAPTER 3. SUBDIVISION OF THE REGION BASED ON ITS GEOGRAPHIC CHARACTER AND ITS VEGETATION

From the discussion of the general geography of the extra-tropical part of Western Australia, it became clear that the area fell naturally into two parts of unequal extent. These comprised the Southwest Province which was bounded on the interior by a line from Sharks Bay in the north-west to Russell Range near the south-east coast, and the Eremaean Province which accounted for the remaining area. Physiographically these two regions are very different and this is closely related to the differences in climate. It is not, therefore, surprising that the vegetation in the two regions should also show great differences. Any study of the vegetation and the floristic features of extra-tropical Western Australia must first and foremost take account of this duality.

The Southwest Province is, in climate and vegetation, an area which shows considerable but very finely graded degrees of diversity. Zones of vegetation run almost exactly parallel with the boundary from Shark Bay to Esperance, and coincide with the zones of varying rainfall. Along the coast one first meets shrubland and light woodland. Next we encounter the compact denser Jarrah forest region. Further inland still, we meet the lighter stands of other *Eucalyptus* communities and finally the end of the western tree zone is reached. Following on this we come to the zone of low shrubby undergrowth on the sand heaths and the areas invaded by the eremaean vegetation. These are the chief steps in the change of vegetation. Paralleling them we find a similar sequence of stages in the distribution of those units of the flora with a smaller growth-form. The adaptability of the Australian hard-leaved sclerophyll vegetation to different conditions is a well developed feature in Western Australia, and it is more extensive in the Southwest Province than anywhere else.

2 Cooke in Climate W. Austr. p. 16

The Eremaean Province occupies quite a different position and it is difficult to draw a parallel with the Southwest Province. The latter is a closed unit, a world in itself, while the Eremaea extends far beyond the conventional boundaries of Western Australia. It stretches almost unaltered, in fact, to the far east of the continent. Over this huge area the climate, vegetation and flora are very uniform and so contrasts markedly with the adjacent province. This at least holds good for by far the greater part of the region. Only the south-west border, from about 129°E longitude is affected favourably by the winter rains and has produced woody vegetation. Otherwise it is only along the banks and beds of moist valleys that we may find well-grown species of *Eucalyptus*. In the wilderness of sand only gnarled trees survive. The usual plant cover that is present on the hard reddish soil consists of sparse, straggly *Acacia* bushes and a number of desert shrubs. Areas occur where the frightful *Triodia* grass deserts have crowded out other growths. It is only rarely and for short periods that the stern visage of the Eremaea presents a more smiling appearance-that occurs when the rain flora awakes for its transient existence.