

II Physical Environment

A.V. Milewski

Climate

The climate of the Edjudina–Menzies Study Area is arid and has been described by UNESCO–FAO (1963) as Desert using the system of Bagnouls and Gaussen (1957). Hot, dry summers alternate with cool winters. Rain falls in both the warm and the cool seasons of the year. In the Köppen classification (Dick 1975) the climate is BWh i.e. hot arid desert climate with the possibility of precipitation in any month. According to the Thornthwaite system, which is preferable to the Köppen system for Australian conditions (Gentilli 1948), the climate of the Edjudina–Menzies Study Area is arid mesothermal, rainfall deficient in all seasons. Beard (1975) regards the Study Area as desert with summer and winter rainfall.

Light falls of rain in winter are associated with the cold fronts of low pressure systems arriving from the south-west. Summer rain is generally derived from northerly weather systems and takes the form of thunderstorms. The Study Area receives about 190–230 mm mean annual precipitation, although the eastern parts may receive slightly less than the western parts (Beard 1975). Climatic data are presented in Table 1 and Figure 2.

Table 1. Meteorological data recorded at Menzies (29°41'S, 121°02'E). The rainfall data refer to 82 years of observations (1896–1978) while the temperature data refer to 52 years of observations (1926–1978). Source is Bureau of Meteorology (1975).

	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
Daily Maximum Temperature (°C) Mean	35	34	31	27	22	19	17	19	23	28	31	34	27
Daily Minimum Temperature (°C) Mean	20	19	17	14	10	7	5	6	8	12	16	18	13
Rainfall (mm) Mean	24	27	24	21	27	29	22	19	10	10	13	13	239
Median	11	8	12	9	19	22	19	14	6	5	7	7	225
Raindays (No.) Mean	3	3	3	3	5	6	6	5	3	3	3	3	46

The average evaporation rate is about 2540 mm per year (Williams *et al.* 1976). The Study Area receives an average of about 170 cal cm⁻² d⁻¹ of global radiation, with far more radiation in summer than in winter. Average values for December and June are 670 cal cm⁻² d⁻¹ and 85 cal cm⁻² d⁻¹ respectively (Fitzpatrick 1979).

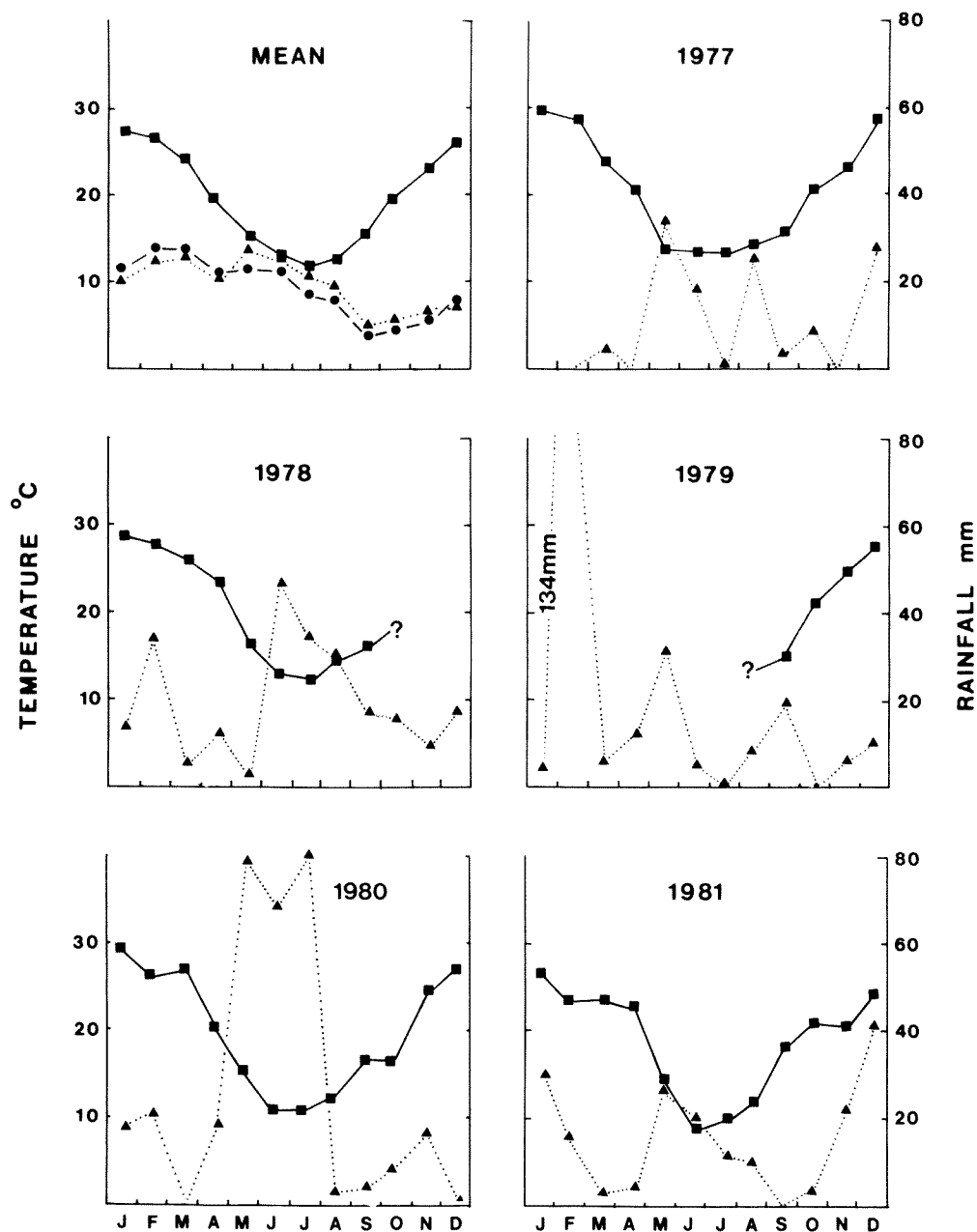


Figure 2 Ombrothermic diagrams showing the mean monthly rainfall and average monthly temperature for the years 1977-1981 and the long-term mean. These figures incorporate data from the Menzies, Yundamindra and Leonora meteorological stations.

Four different types of precipitation occur, viz. (i) winter frontal rains (light and usually ineffective), (ii) summer convective rains (intense but brief), (iii) rainstorms derived from tropical cyclones (intense and effective), and (iv) epi-tropical rainstorms (intense and effective). These are described by Milewski (1981). In addition, frost can be expected several times each year on calm, clear winter nights. During most rain events, the rain falls too lightly to be effective, but sporadic heavy falls of 20 mm or more are effective and can be expected to occur 2-3 times a year on average, contributing about 50 per cent of total precipitation. Thus precipitation adequate for plant growth occurs as sporadic and unreliable rainstorms, varying in frequency and timing from year to year. Periods of up to 26 months without effective falls have been recorded (Beard 1975).

The unpredictability of the rainfall is shown clearly by the large differences between mean and median monthly values (Table 1). This is particularly apparent in the late summer and autumn months when occasional downpours are brought by degenerating tropical cyclones and epi-tropical storms. For example the ratio of the mean to the median rainfall for Leonora is 2.0-3.0 for each of the months January, February, March and April (Bureau of Meteorology 1975).

Landforms

The main landform features of the Edjudina-Menzies Study Area are shown in Figure 3. The Study Area is a plain of great age, developed on Archaean rocks, which has not suffered mountain building or glaciation for the last 30 million years. Eroded into the plain are portions of several ancient, shallow river valleys. The topography is generally subdued with a maximum relief of less than 200 m. The general elevation increases gradually northwards and reaches about 500 m above sea level in the highest hills immediately east and west of Lake Carey. The predominant landforms are areas of undulating relief of 6 to 30 m, denudational plains of relief less than 15 m and depositional plains of relief less than 15 m (Campbell *et al.* 1975). The Study Area lies near the eastern edge of the salt lakes of Salinaland physiographic division as defined by Jutson (1950).

Parent rocks are of two main kinds although many different units are distinguished by Williams (1976). Granites and gneisses of the Yilgarn Block are exposed in places and mafic and ultramafic rocks ('greenstones' e.g. dolerite, gabbro, basalt and serpentinite), are exposed throughout the Study Area except for its eastern edge. The physiography of the Edjudina-Menzies Study Area is related to the underlying rock types, since recent erosion has stripped the land surfaces which were composed of laterite, sandplain and deeply weathered rock, and redeposited the material at a lower elevation. The base level of erosion corresponds to the salt lakes which are situated in three long and narrow basins running roughly north-west-south-east. These salt lakes provide internal surface drainage although waters in Lake Raeside occasionally flow south-eastwards a limited distance towards the Nullarbor Plain. Lake Carey cuts across the north-eastern part of the Study Area, Lake Raeside runs diagonally across the centre,

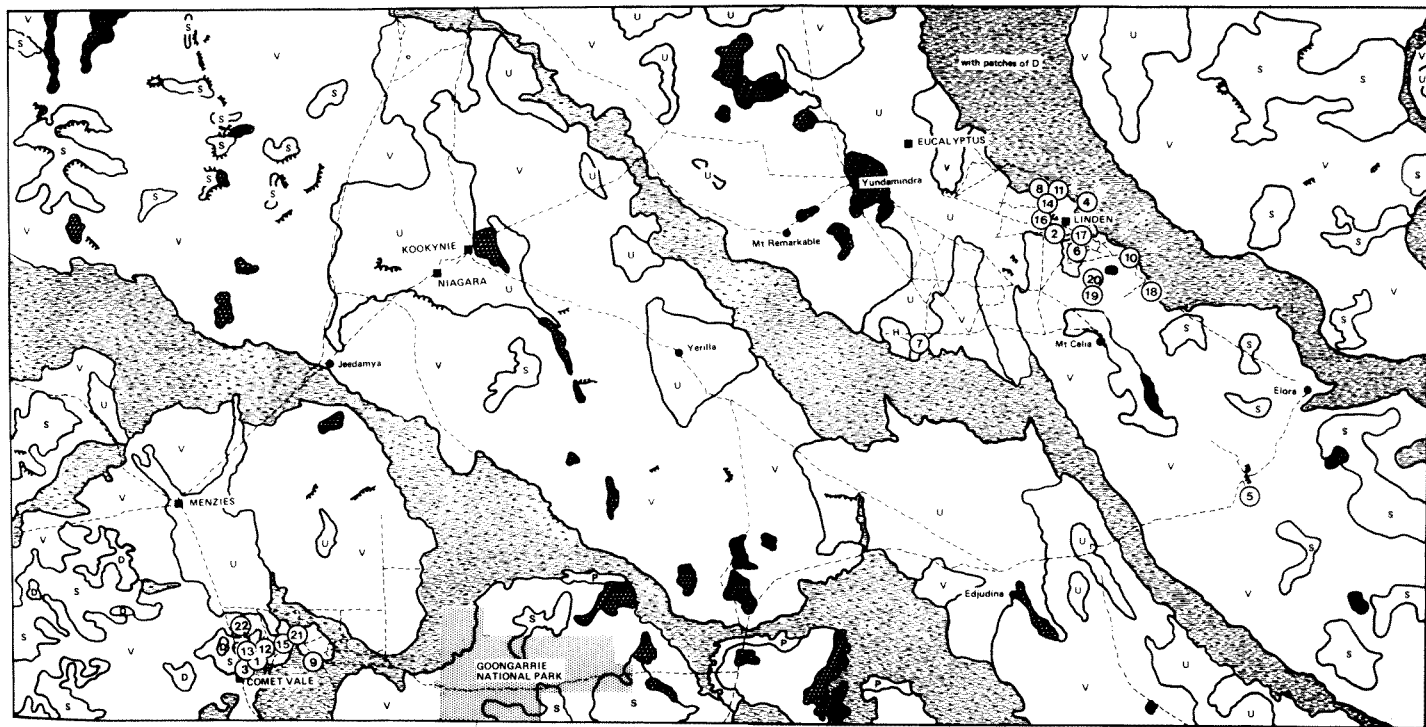


Figure 3 The main landform units of the Edjudina-Menzies Study Area. Field traverses for the vegetation study are indicated with numbers identifying the vegetation sites described.

and a chain comprising Lakes Ballard, Marmion and Rebecca across the south-western part. The salt lake margins consist of an alluvial pediment which is being actively eroded on the western side to expose fresh or deeply weathered bedrock. Eastern margins are usually flanked by dunes and claypans while western margins have greater relief and may form steep breakaways (Williams *et al.* 1976).

The Study Area lacks permanent streams although water may stand in the large salt lakes for several months after heavy rain, as happened during our survey in 1980. The ephemeral creeklines are short, incised into the uplands often in parallel patterns, and merge in their lower reaches with the flat pediment of the salt lakes. Drainages on the sandy land surfaces are poorly coordinated and there is often merely sheet flooding (Jutson 1950, Williams *et al.* 1976).

Hilly country is confined to the divides between the major drainages. A relatively high land surface of deeply weathered bedrock of various kinds remains as mesas or buttes bounded by abrupt breakaways or low scarps up to 15 m high. Where this surface has been removed by recent erosion, the underlying rocks determine the topography. Low hills form over mafic rocks (e.g. Mount Percy) and long, prominent hogback ridges over banded ironstone (e.g. Edjudina Ranges). Outcrops of granitic rocks vary from flat sheets to prominent hills or extensive well-jointed outcrops (Williams *et al.* 1976).

Over about half of the Study Area, the underlying rocks are mantled by superficial deposits (Williams 1976). These are of two main kinds, viz. (i) clay, loam, silt, sand, ironstone and quartz pebble veneer, containing sheet and nodular kankar at shallow depth (residual and colluvial deposits on low slopes and undulating surfaces), and (ii) clay, silt, gravel, sand, gypsum and halite: lacustrine deposits in playa lakes and mixed aeolian and alluvial deposits marginal to playa lakes. In addition, small areas are scattered throughout the Study Area of laterite, ferricrete, silcrete, ironstone nodules and gravel in yellow sand, and duricrust. In the eastern parts of the Study Area, there are red quartz sands, some sandy silt and aeolian deposits in longitudinal dunes and sheets (including reworked sand-plain or duricrust surface).

Soils

The soils of the Eastern Goldfields have been described in very general terms by Beard (1976). They are generally sandy loams, although skeletal stony soils occur on the rocky ridges, sands occur in dunes, and sandy clays occur in the bottomlands. Depressions throughout the Eastern Goldfields are generally saline, and large areas of alkaline soil occur where parent materials are close to the surface. Although some landforms in the Edjudina–Menzies Study Area have soils resulting from current processes of erosion and wasting, in general the soil is a relic from past geological periods when the climate was first wetter and then drier than that reigning today (Beard 1976, 1980). A feature of the southern parts of the Study Area is the development of a calcrete hardpan, which presumably reflects present-day climatic factors (Northcote *et al.* 1968, Campbell *et al.* 1975, Beard 1975).

A widespread soil in the Edjudina—Menzies Study Area is a friable red loam overlying a partly siliceous hardpan (Northcote *et al.* 1968). This was mapped by Campbell *et al.* (1975) as Earthy Loam with Red-brown Hardpan on land of undulating relief of 6 to 30 m or in some areas, on denudational plains. In the south-western parts of the Study Area these are replaced by Red Massive Earths (with a calcareous hardpan). The eastern fringe of the Study Area has mainly sands with an earthy fabric, described by Campbell *et al.* (1975) as Red Earthy Sands on denudational plains. Salt lakes are regarded as Calcareous and Siliceous Loams, an example of which is red sand 15 cm deep, over a 15 cm thick layer of red loam over a 60 cm thick layer of very compact clay loam, over a calcareous hardpan at 90 cm depth (Beard 1975).

The soils of the Eastern Goldfields are generally very infertile. They are derived from acidic, siliceous parent rocks and they are deeply weathered, sandy, and leached. Fertility is ecologically important even in arid areas where the availability of moisture is undoubtedly the major limiting factor for plant growth (Specht 1972). Probably all the soils in the Eastern Goldfields are nutrient poor by world standards. Several mineral elements affect fertility, but phosphorus is one of the most important. Data were collected on the phosphorus content of soils in the Study Area (Table 2). Published information on the phosphorus content of the outcropping rocks subject to modern-day weathering processes is reviewed (Table 3).

Table 2. Soil phosphorus concentrations in landforms in the Edjudina-Menzies Study Area. Analysis, to nearest 0.01% (100 ppm) only, was done courtesy of Messrs Don Moir and Adrian Knowles of Anaconda Australia Inc.

Unit	Total Composition (ppm)	
	Granite	Dolerite
SiO	705900	452100
TiO	800	9300
Al ₂ O	149300	128900
Fe ₂ O	7700	19800
FeO	4500	93900
CaO	5800	82700
Na ₂ O	63200	22800
P ₂ O ₅ *	400	700
K ₂ O	42500	3000
MnO	400	1200
MgO	3200	61600

* Average of P₂O₅ content for 14 granite samples and 10 dolerite samples listed by these authors were 800 and 1300 ppm respectively (ranges 300-2500 and 400-2000 ppm). Converted to total P these values were: averages, 320 and 520 ppm, ranges 120-1000 and 160-800 ppm.

Table 3. Example comparing the chemical composition of acid and basic rocks in the Kalgoorlie area, as analysed by Bartram and McCall (1971) and Glikson (1979). World averages for ppm total P presented by Turekian and Wedepohl, Table 2 *Geological Society of American Bulletin*, vol. 72 are: ultrabasics 220, low-calcium granitic rocks 600, shales and syenites 700-800, high-calcium granitic rocks 920, and basalt or dolerite 1100.

Landform	Depth of Soil Sample (cm)	Notes on Rock Fragments	Total Phosphorus	
			%	ppm
Salt Lake	2		0.05	500
Features	80		0.05	500
(siliceous sand)				
Salt Lake	2		0.06	600
Features	60		0.06	600
(saline loam)				
Broad Valleys	2		0.02	200
(Triodia area)	80	(hardpan)	0.02	200
Broad Valleys	2		0.01	100
(mulga area)	80	(hardpan)	0.01	100
Undulating Plains	2	Four rock types mixed: laterite, quartz,	0.04	400
	40	metabasalt and ferruginous chert		
		(hardpan present)	0.02	200
Undulating Plains	2	Banded ironstone and porphyritic felsic	0.02	200
(base of Hills)	70	schist	0.01	100
Undulating Plains	2		0.03	300
(broad rise)	50	(hardpan present)	0.03	300
Hills	2	Metadolerite and metagabbro	0.03	300
(lower slopes)		(hardpan present)		
Hills	2	Three rock types mixed: amphibolite	0.03	300
(upper slopes)	50	(metagabbro), mafic schist and quartz	0.02	200
		(bedrock below this)		

Hardpan was composed of kankar with grains of limonite; this rock was a replacement of the underlying bedrock and was chiefly composed of carbonate.

Phosphorus content in the soils varied from less than 100 ppm to more than 600 ppm. Poorest in this element were the Sandplain and Broad Valley, both derived largely from deeply weathered granite. The highest concentrations were found in the loams and clays of Salt Lake Feature at abutting exposures of 'greenstones'. Subsoils were found to be poor in phosphorus even where they were calcareous, and directly overlay mafic rocks. For example, the lime hardpan over metabasalt had as little as 100 ppm, i.e. 100-200 ppm lower than those of surface soils. The average phosphorus content of rocks in the Study Area appears to be low compared to the world averages for the same rock types (Table 3). This is borne out by data in Hallberg (1972), Hallberg and Williams (1972) and Williams and Hallberg (1973). Even where phosphorus is found in moderately high concentrations, it is probably accompanied by toxic levels of other elements such as sodium and possibly also nickel and chromium.