PHYSICAL ENVIRONMENT

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Climate

The Sandstone–Sir Samuel and Laverton–Leonora Study Areas have an arid climate with cool winters and hot, dry summers. Rain falls in both the warm and cool seasons of the year. The climate has been classified as very dry and hot with the possibility of precipitation in any month (BWh), according to the classification of Koppen (Dick 1975). Following the Thornthwaite System, which is preferable to the Koppen system for Australian conditions (Gentilli 1948), the climate of the Sandstone–Sir Samuel and Laverton–Leonora Study Areas is Arid Mesothermal, with rainfall deficient in all seasons. Alternatively, the climate is Desert (UNESCO–FAO 1963), according to the system of Bagnouls and Gaussen (1957). Beard (1974, 1976) describes the Study Areas as Desert with bimodal (summer and winter) rainfall distribution.

A number of weather stations, concentrated in the eastern half of the Sandstone–Sir Samuel Study Area, have records of daily rainfall over a long period of time: Mt Samuel (from 1900), Leinster Downs (1902), Sandstone (1904), Booylgoo (1922), Mt Keith (1927), Yeelirrie (1928), Albion Downs (1936), Agnew (1948) and Yakabindie (1961). Long–term temperature records are only available from Yeelirrie (13 years) and Booylgoo (11 years) (Bureau of Meteorology, Australia 1988a).

Long-term rainfall data for the Laverton–Leonora Study Area are available from recording stations at Leonora (from 1898), Laverton (1899), Erlistoun (1907), Weebo (1930) and Windarra (1971) while long-term temperature records are available from Leonora (28 years) (Bureau of Meteorology, Australia 1988a).

Temperature

The average monthly temperatures for 1977–1981 and the long term mean for the Sandstone–Sir Samuel Study Area are shown in Figure 6. Mean annual temperature in the Study Area is approximately 29°C. The average maximum temperature for each month ranges from 37°C (January) to 18°C (July) while the average minimum temperatures range from 22°C (January) to 5°C (July). Recorded extremes of temperature are 45.8°C and –5.1°C (Yeelirrie) with frosts frequently experienced during winter.

The average monthly temperatures for 1977–1981 and the long-term mean for the Laverton–Leonora Study Area are shown in Figure 7. Mean annual temperature in the Study Area is approximately 28°C. The average maximum temperature for each month ranges from 38°C (January) to 18°C (July) while the average minimum temperatures range from 22°C (January) to 6°C (July). Numerous frosts are experienced during winter with the recorded extremes of temperature being –1.1°C and 47.8°C (Leonora).

Rainfall

Average annual rainfall is approximately 210–235 mm in the Study Areas. The rainfall is bimodal, with peaks in summer and winter, and unreliable, with a large variation between annual totals. The other important aspect of rainfall is the localised nature of falls across the Study Areas. During winter, the light falls (associated with the passage of cold fronts originating to the south of Western Australia) decrease from south-west to north-east. Heavy

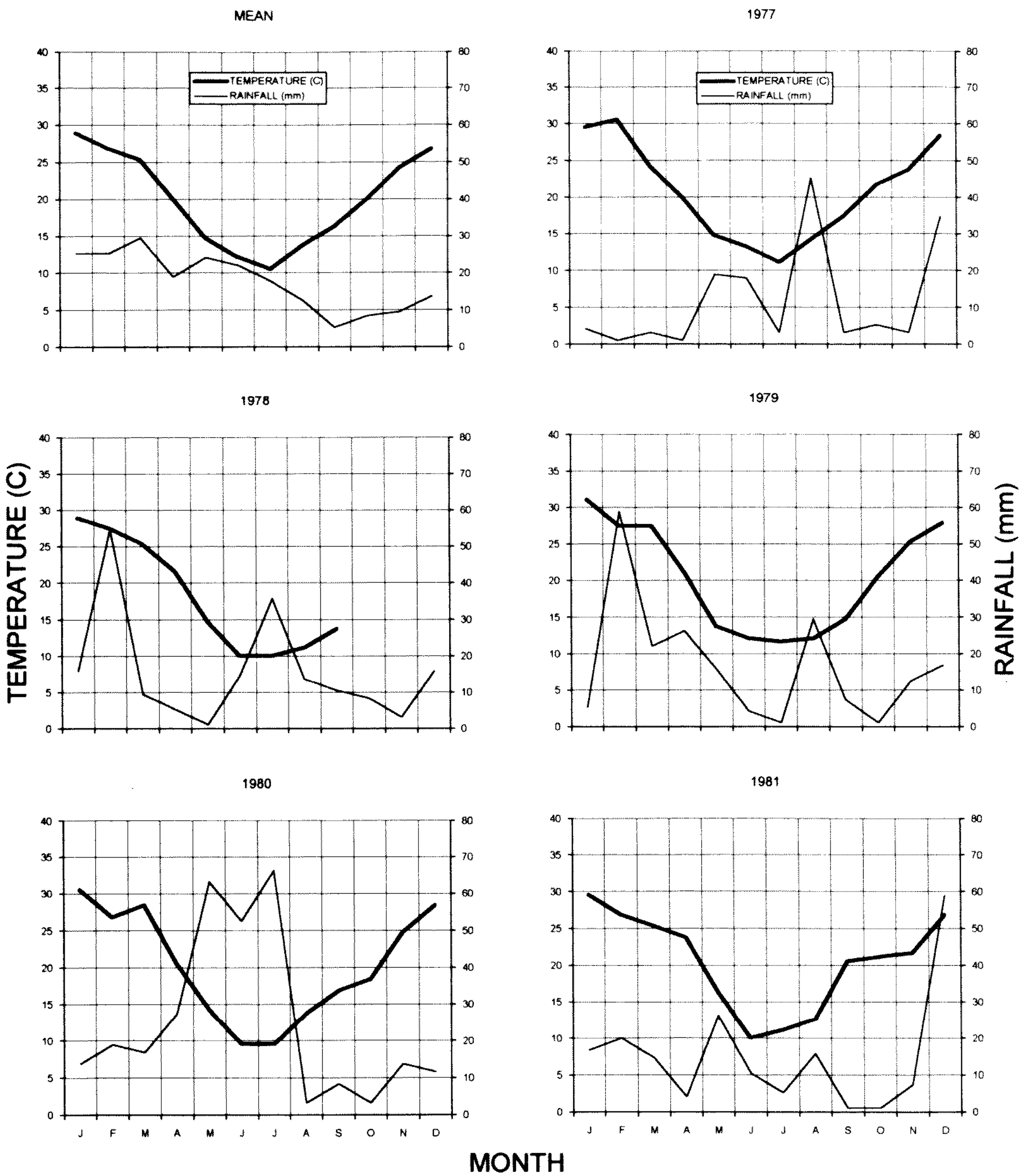

Figure 6 Ombrothermic diagrams showing the mean monthly rainfall and average monthly temperatures for the Sandstone-Sir Samuel Study Area from 1977-1981 and the long term mean.

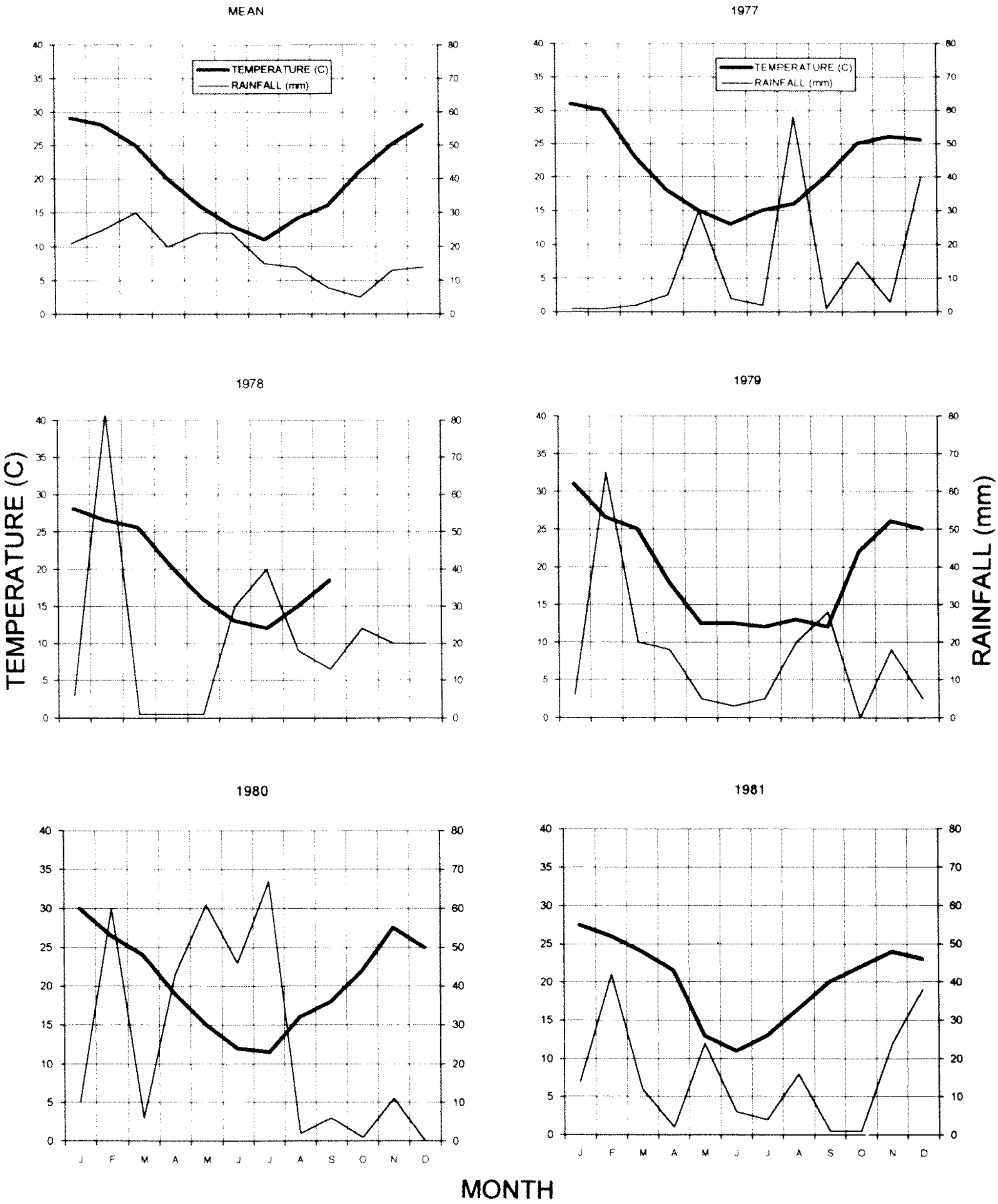

Figure 7 Ombrothermic diagrams showing the mean monthly rainfall and average monthly temperatures for the Laverton-Leonora Study Area from 1977-1981 and the long term mean.

(50–150 mm) falls occur unreliably during summer from thunderstorms, and cyclones of northerly origin which have degenerated into rain-bearing depressions.

These three different types of precipitation differ in their effectiveness for plant growth (Milewski 1981). Winter frontal rains occur fairly reliably each year but are light and usually ineffective for the growth of all plants other than herbs. Summer convective rains are intense but brief. Rainstorms derived from tropical cyclones and epitropical storms are intense, prolonged and effective for the growth of woody plants. Since tropical cyclones occur only a few times each year in the Eastern Goldfields, the effectiveness of the most frequent precipitation events is limited by its intensity and duration. Sporadic heavy falls of 20 mm or more can be expected to occur three times per year on average. This leads to large differences between mean and median rainfall, particularly in the late summer months when all rainfall is convective or tropically derived (Bureau of Meteorology, Australia 1988a).

Annual rainfall across the Sandstone–Sir Samuel Study Area ranges from 235 to 207 mm with records from Sandstone (235 mm), Mt Samuel (223 mm), Yeelirrie (223 mm), Booylgoo (221 mm), Albion Downs (220 mm), Agnew (220 mm), Mt Keith (218 mm), Leinster Downs (215 mm) and Yakabindie (207 mm). There is a marked difference between highest and lowest annual rainfall records: Sandstone (78–697 mm), Mt Samuel (52–536 mm), Yeelirrie (116–507 mm), Booylgoo (96–608 mm), Albion Downs (66–503 mm), Agnew (78–499 mm), Mt Keith (41–526 mm) and Kathleen Valley (74–472 mm).

The mean monthly rainfall for 1977–1981 and the long-term mean for the Sandstone–Sir Samuel Study Area are shown in Figure 6. During the biological survey of the Study Area (1979–1982), annual rainfall was exceptionally good in 1980, with above average rainfall recorded at Sandstone (370 mm), Booylgoo (356 mm), Agnew (286 mm) and Yeelirrie (274 mm). Substantial monthly totals of rainfall (40 mm or more) were recorded in February 1979, May–July 1980 and December 1981 (Figure 6).

Annual rainfall across the Laverton–Leonora Study Area varies from 243–203 mm with records from Windarra (243 mm), Weebo (233 mm), Leonora (224 mm), Laverton (222 mm) and Erlistoun (203 mm). Highest and lowest annual rainfall totals range from 91–517 mm (Leonora), 67–454 mm (Laverton) and 57–552 mm (Erlistoun).

The mean monthly rainfall for 1977–1981 and the long-term mean for Laverton–Leonora Study Area are shown in Figure 7. During the biological survey of the Study Area (1979–1982), annual rainfall was above average for 1980: Leonora (361 mm), Windarra (315 mm), Weebo (279 mm) and Laverton (277 mm). Substantial monthly totals of rainfall (40 mm or more) were recorded in February, May and July (Figure 7).

Evaporation

Average annual evaporation varies from 3200 to 3600 mm across the Sandstone–Sir Samuel Study Area, and 3600 mm to 4000 mm across the Laverton–Leonora Study Area (Bureau of Meteorology, Australia 1988b).

Radiation

The average daily radiation of 600 mWh.cm^{-2} across the Sandstone–Sir Samuel and the Laverton–Leonora Study Areas grades from a high of 850–900 mWh.cm^{-2} in January to 400–450 mWh.cm^{-2} in July (Bureau of Meteorology, Australia 1988b).

Geology

The geology of the Sandstone–Sir Samuel Study Area has been detailed by Tingey (1985) and Bunting and Williams (1979) while Gower (1976) and Thom and Barnes (1977) covered the geology of the Laverton–Leonora Study Area. Data on the landforms, regoliths and soils of an area incorporating portions of both Study Areas were included in Churchward (1977).

Both Study Areas form part of an extensive plain of great age, developed on Archaean rocks, which has not suffered mountain building or glaciation for the last 30 million years. Eroded into this plain are portions of several ancient, shallow river valleys. The topography of the Study Areas is generally subdued, with a maximum relief of less than 200 m. The characteristic undulating relief of 6–30 m also includes depositional plains, formed by internal drainage systems, with a relief less than 15 m (Campbell *et al.* 1975). The Sandstone–Sir Samuel Study Area falls within the Salinaland physiographic division as defined by Jutson (1950) while the Laverton–Leonora Study Area lies at the eastern edge of these salt lakes.

The physiography of the Study Areas is related to the underlying rock types. Gneisses and other granitic rocks of the Yilgarn block form the main bedrock type over most of the Study Areas. In the Sandstone–Sir Samuel Study Area, these are interrupted by several oblong tracts of layered intrusions, roughly aligned in a north-south direction. These intrusions incorporate a complex series of meta-sedimentary and meta-igneous rocks that include metabasalt and banded ironstone. The meta-sedimentary and meta-igneous rocks have formed gently undulating plains at a slightly elevated level, or else abrupt, long, steep-sided hills. In the southern portion of the Laverton–Leonora Study Area, where the bedrock is metamorphic rather than granitic, the landscape tends to be higher and more undulating.

Recent erosion in the Eastern Goldfields has stripped the land surfaces, which were composed of laterite, sandplain and deeply weathered rock, and redeposited the material at lower elevations. These bottomlands, in which salt lake features have formed, run across the other landforms. Salt lakes, situated in long narrow basins running north-west to south-east, provide internal surface drainage in the Laverton–Leonora Study Area. The landforms lying between the major drainages consist mainly of deeply weathered bedrock, that form extensive plains at a slightly higher level than the salt lake systems.

Over most of the Sandstone–Sir Samuel and Laverton–Leonora Study Areas, granite rocks are deeply mantled by weathered material which sometimes constitutes an extensive cover of deep sand to form extensive sandy plains with the configuration of broad, gentle valleys and watersheds. They are often separated by breakaways of lateritized granite eroded to form small cliffs or bluffs. These large tracts of sandy surfaces rapidly absorb rain in both Study Areas. Run-off consequently starts only with relatively heavy falls and is most pronounced on hardsetting soils of heavy texture, or exposures of bedrock. The Study Areas lack permanent streams or standing bodies of water. Most drainage results from sheet flooding or is uncoordinated. With falls of 25 mm or more the creeklines are briefly charged with water, some of which remains available to the local vegetation as soil moisture for several weeks or months afterwards.

Landform Units

Newbey and Milewski (unpublished) have developed a classification of 10 landform units to describe the landscapes of the Eastern Goldfields. All ten units were recorded in the

Sandstone–Sir Samuel and Laverton–Leonora Study Areas. The distribution of these landforms within both Study Areas are shown in Figure 2 (Sandstone–Sir Samuel) and Figure 3 (Laverton–Leonora). One of the landforms (Hills) was divided into sub-units on the basis of bedrock type.

Breakaways (B)

Breakaways are scattered throughout the Eastern Goldfields. They punctuate the plains, often separating Sandplains from Broad Valleys. A large proportion are associated with weathered outcrops of granite. Bluffs with a free face 3–4 m high had scree slopes of 12°–15°, partially covered with gritty loams (Table 1). Soil on the top was restricted to shallow sheets and pockets in exposures of duricrust. Similar soils are found on the scree slopes, and substantial colluvial soils on the pediments. The sections of Breakaways showed great variation in soil moisture content. Some Breakaways were saline in parts.

Breakaways are common throughout the Sandstone–Sir Samuel Study Area. They are formed over both granitic and mafic rocks. However, since granites are far more widespread than greenstone, most areas of Breakaways form enclaves within Broad Valleys rather than within Undulating Plains. A bluff about 3 m high, with small caves, generally occurred on the south-facing side of an escarpment of which the north-facing side was a stony slope descending gently to the plains' level. Soil was a shallow loam, with a variable degree of salinity on the footslope below the bluff.

Breakaways are also scattered throughout the Leonora–Laverton Study Area. Breakaways associated with Undulating Plains are restricted to the southern portion of the Study Area. In places, the deeply weathered bedrock formed low mesas or buttes bounded by abrupt breakaways or scarps up to 15 m high. Other breakaway systems, associated with Broad Valleys, occur in the north-eastern section of the Laverton–Leonora Study Area (Chandler's Breakaways).

Drainage Lines (C)

Drainage Lines are uncommon in either Study Area. They are confined mainly to the areas immediately surrounding Undulating Plains and Hills, where several small creeklines, draining uplands with rocky surfaces, joined. There were generally eroded earth banks 1–3 m high with a sandy or gravelly wash line. In the southern half of the Laverton–Leonora Study Area, small ephemeral creeklines are common within Undulating Plains, developed over metamorphic rocks. In some places these drainage lines connected to produce scoured channels up to 2 m deep with beds of loose detrital material.

Dunefields (D)

Extensive dunes of very deep, uniformly siliceous sands associated with Sandplains occur in several localities within the Sandstone–Sir Samuel Study Area. Lake dunes and lunettes with deep sandy soils containing gypsum are generally neither high nor extensive. Dunefields associated with Salt Lake Features in the Study Area are restricted to a few small areas near Lake Mason and Lake Miranda. The dunes are generally low and confined to the south-eastern edge of the lake floors, presumably originating from the predominantly north-westerly winds. The soil is a sandy loam with variable gypsum content.

Dunefields are associated with both Salt Lake Features and Sandplains in the Laverton–Leonora Study Area. Salt lake dune systems occur in the south-western corner (Lake Raeside), southern section (Lake Carey) and salt lakes of the Erlistoun survey area. Dunefields associated with Sandplains are restricted to the extreme north-western corner of the Study Area. Sandplain dunes also occur in the eastern portion of the Study Area, where they appeared similar to those of the adjacent Great Victoria Desert.

Granite Exposures (G)

Outcrops of granite include relatively low, rounded features (Granite Exposures) as well as large steep-sided hills. Granite Hills are more than 30 m high, with relatively steep slopes.

Each flat to low-domed exposure of bedrock varied in size from a few square metres to 0.5 km^2 and bore shallow sandy loam directly weathered from the bedrock. Exposed granite was mainly bare rock, but skeletal sheets of soil accumulated in slight depressions on the exposure, or along faint drainage lines. Granitic Soils are present on the rock and formed a peripheral apron. The apron consisted of soil up to 2 m thick weathered *in situ* from the underlying granite. In some areas the bedrock was within 2 m of the soil surface but was not exposed at all. Granite Exposures of this kind had soils similar to those of the apron of the other Granite Exposures.

Outcrops of granitic rocks, generally of subdued topography, are found scattered throughout the Study Areas (see Figures 2 and 3). This landform often occurred at the base of Breakaways, where erosion in recent geological time had removed the ubiquitous mantle of deep weathering products. In these situations, allocation of an area to Granite Exposures or Hills (HG) was frequently arbitrary.

Hills (H)

Hills throughout the Eastern Goldfields were divided into sub-units based on their bedrock type. Hills of banded ironstone (HI) are prominent in the Study Areas, although Hills of granite (HG) and greenstone (HN) are also present. Hills rose more than 30 m above the surrounding plains and have slopes ranging from 5° to 15°. Surfaces are largely covered with skeletal and excessively-drained soils, with numerous small areas of bare rock.

There are two main areas of Hills in the Sandstone–Sir Samuel Study Area. Booylgoo Range, along the southern border, is a banded ironstone feature forming a long whaleback. An extensive area of rugged, relatively low granite, associated with the base of a long series of Breakaways near Mt Keith, occurs in the eastern part of the Study Area. This area is notable for its boulder formations. The Montague Range, located in the northern central part of the Study Area, is a subdued upland best regarded as part of the surrounding Undulating Plains.

Hills are largely restricted to the southern portion of the Laverton–Leonora Study Area. The most common type of Hills in the Study Area are composed of Banded Ironstone Formation (HI). These form jumbles of short, abrupt, sub-parallel rocky ridges in steeply rolling landscapes. The Banded Ironstone weathered to form a slightly acidic sandy loam with scarce calcium carbonate. Other Hills (HN) in the Study Area represent small remnants of exposed bedrock at the highest points on the greenstone Undulating Plains.

Table 1 Relationship between landform units and elements, lithology, soils, vegetation structure and floristic composition at sites sampled or visited in the Sandstone-Sir Samuel and Laverton-Leonora Study Areas. Lithological surfaces follow those devised for the map sheets: Sandstone (Tingey 1985), Sir Samuel (Bunting and Williams 1979), Laverton (Gower 1976) and Leonora (Thom & Barnes 1977). Surface types are denoted by (S)=Sandstone, (SS)=Sir Samuel, (L)=Laverton, (Le)=Leonora and (LL)=both Laverton and Leonora map sheets.

Landform	Lithological Surface Sandstone Sir Samuel	Laverton Leonora	Soil	Vegetation Type	Vegetation Sites (Appendix 1)*
BREAKAWAYS (B)					
Slopes, colluvial base and drainage channels	Tl,Qc(S) Czo,Qpm, Qpv,Qqc(SS)	Qqc,Czl Qpv(LL)	Gritty Loams	*Acacia aneura* Low Woodland *Callitris columellaris* Low Woodland	SS1
Summit flats	Tb,Tl(S) Czo/Agl, Czl,Czb(SS)	Czl(La) Czo/Agb (Le)	Gritty Loams	*Acacia aneura* Tall Shrubland *Acacia quadrimarginea* Tall Shrubland	SS2,LL7
DRAINAGE LINES (C)					
Banks	Qa(S) Qpv(SS)	Qpv(LL)	Alluvium	*Eucalyptus camaldulensis* Low Woodland *Eucalyptus lucasii* Low Woodland *Acacia aneura* Low Woodland *Acacia-Eucalyptus* Mixed Low Woodland	SS3
DUNEFIELDS (D)					
Slopes and summit	Qs(S) Qps(SS)	Qps(LL)	Deep Sands	*Eucalyptus gongylocarpa* Low Woodland *Eucalyptus kingsmillii* Mallee *Eucalyptus leptopoda* Mallee *Eucalyptus youngiana* Mallee *Grevillea integrifolia* Tall Shrubland	LL6 SS23
	Qgd(S) Qrs,Qpk (SS)	Qrs, Qpk(LL)	Aeolian Sands	*Callitris preissii* Low Woodland *Casuarina cristata* Low Woodland *Eucalyptus striaticalyx* Low Woodland *Eremophila miniata* Tall Shrubland	

GRANITE EXPOSURES (G)					
Outer aprons and colluvial flats	Ag,Qc(S) Qpm(SS)	Ag,Qpm, Age(LL)	Granitic Soils	*Acacia aneura* Low Woodland *Acacia craspedocarpa* Low Woodland	
Inner aprons and skeletal soil sheets	Ag(S) Agb,Agl (SS)	Agb,Agp (LL)	Granitic Soils	*Acacia quadrimarginea* Tall Shrubland *Acacia* spp. Tall Shrubland Granite Complex	SS5 LL8
HILLS, GRANITE (HG)					
Slopes and summit	Ag(S) Agl(SS)	Age,Agb (LL)	Granitic Soils	*Acacia aneura* Tall Shrubland *Acacia quadrimarginea* Tall Shrubland	 SS6
HILLS, BANDED IRONSTONE (HI)					
Slopes and summit	Aiw(S) Aiw(SS)	Aw,Af (LL)	Red Earths	*Acacia aneura* Low Woodland *Acacia quadrimarginea* Tall Shrubland	LL9
HILLS, GREENSTONE (HN)					
Slopes and summit	Ad,Alm(S) Ab,Ad(SS)	Ab,Ad(LL)	Shallow Calcareous Earths	*Acacia burkittii* Tall Shrubland *Acacia* spp. Tall Shrubland	SS7
Lower slopes	Qc(S) Qqc(SS)	Qqc(LL)	Calcareous Earths	*Acacia aneura* Low Woodland	
SALT LAKE FEATURES (L)					
Lake floors and saline flats	Ql(S) Qra(SS)	Qrm(LL)	Saline Soils	*Atriplex vesicaria* Low Shrubland *Halosarcia* Low Shrubland *Frankenia* spp. Low Shrubland *Maireana pyramidata* Low Shrubland	 SS10,LL2
Lake slopes and lake margins	Qa,Qg(S) Qrs(SS)	Qrd,Qrs, Qps,Qqz (LL)	Aeolian Sands and Loams	*Acacia aneura* Low Woodland *Eremophila miniata* Tall Shrubland *Atriplex vesicaria* Low Shrubland	LL3
	Qg,Qz(S) Qrm,Qrp (SS)	Qrd(LL)	Sub-saline Soils and Alluvium	*Cratystylis subspinescens* Low Shrubland *Maireana pyramidata* Low Shrubland *Halosarcia* Low Shrubland	 SS9

Table 1 (cont.)

Landform	Lithological Sandstone Sir Samuel	Surface Laverton Leonora	Soil	Vegetation Type	Vegetation Sites (Appendix 1)*
Salt lake dunes	Qgd(S) Qpk(SS)	Qpk(LL)	Shallow Calcareous Loams	*Eucalyptus striaticalyx* - *Callitris preissii* Low Woodland	LL1
CALCAREOUS PLAIN (P)					
Flats marginal to salt lakes	Czk, Qsc(S) Czk(SS)	Qrd,Czk, Qpk(LL)	Shallow Calcareous Earths	*Casuarina cristata* Low Woodland	
				Acacia sclerosperma Tall Shrubland	SS12
				Acacia burkittii Tall Shrubland	
				Melaleuca lanceolata Tall Shrubland	LL13
			Aeolian Loams	*Eucalyptus oleosa* Low Woodland	
	Qg,Qsc(S) Qrs,Czk (SS)	Qrd,Czk (LL)	Sub-saline Soils	*Casuarina cristata* Low Woodland	
				Eucalyptus oleosa Low Woodland	
				Melaleuca lanceolata Low Woodland	
SANDPLAIN (S)					
Flat plains	Czs,Qs, Qz(S) Qps(SS)	Qps(LL)	Deep Sands	*Acacia aneura* Low Woodland	
				Eucalyptus gongylocarpa Low Woodland	SS13,SS22
				Callitris preissii Low Woodland	
				Eucalyptus youngiana Low Woodland	
				Eucalyptus kingsmillii Mallee	SS14
Eucalyptus youngiana Mallee	LL10				
				Acacia coolgardiensis Tall Shrubland	
	Czs,Tb Czl(S)	Czl(LL)	Gravelly Sands	*Eucalyptus leptopoda* Mallee	

UNDULATING PLAIN, GREENSTONE (UN)					
Slopes	Tl,Aiw, Qc,Aab(S) Aif,Czj Qqc,Ab, Aiw(SS)	Ab,Ad(LL)	Shallow Calcareous Earths and Red Earths	*Acacia pruinocarpa* Low Woodland *Acacia aneura* Low Woodland *Casuarina cristata* Low Woodland *Maireana pyramidata* Low Shrubland *Acacia burkittii* Low Shrubland	SS17 SS16
Colluvial flats	Qc,Au(S) Qqc,Qqf, Czl(SS)	Qqc,Ab (LL)	Deep Calcareous Earths	*Acacia aneura* Low Woodland	LL12
BROAD VALLEY (V)					
Valley slopes and flat plains	Qc,Qz(S) Qpm,Qqz Qqc,Qps (SS)	Qps,Qqz (LL)	Red Earths, Deep Loamy Sands and Aeolian Loams	*Acacia aneura* Low Woodland *Eucalyptus oleosa* Low Woodland *Acacia aneura* Low Woodland-*Eucalyptus youngiana* Mallee over *Triodia* *Eucalyptus* kingsmillii Mallee over *Acacia aneura* Tall Shrubland *Eremophila fraseri* Tall Shrubland	SS19 LL4 SS21 SS20
Valley floors	Qa(S) Qqz,Qpv(SS)	Qpv(LL)	Loamy Clays	*Acacia aneura* Low Woodland	SS18,LL5

* A total of 90 vegetation sites were sampled, of which a representative set of 31 are presented in detail as Appendix 1. The balance of the sampled sites are held as data sheets in the library at the W.A. Wildlife Research Centre (Dept. of C.A.L.M , Perth).

Salt Lake Features (L)

Salt lakes are flat-floored in both Study Areas, with ephemeral water up to 30 cm deep following rain. Peripheral lake dunes and lunettes, 1–4 m high and rich in kopi, occur in a few places only, mainly on the southern and eastern margins. The soils of Salt Lake Features have a complex history of colluvial, alluvial and aeolian actions with frequent reworkings (see also Calcareous Plains), especially by wind during recent arid periods (Bowler 1976). Saline alluvial flats, 15–30 cm above the level of the lake floor, have endured varying regimes of salinity and waterlogging. Low sandy rises in places alternate with clay-rich swales. The colour of the soil surface in saline bottomlands was pale in some areas and dark in others. Well-drained flats lay 2–4 m above the salt lake floor and had deep, freely drained soils of aeolian origin, never experiencing waterlogging.

Salt Lake Features in the Sandstone–Sir Samuel Study Area are located mainly in the central (Lake Mason) and eastern parts (in the vicinity of the Wanjarri survey area). Salt Lake Features in the Laverton–Leonora Study Area are far more extensive. A major salt lake system, extending from Lake Darlot in the north to Lake Carey in the south, forms a central position in the Study Area. In the eastern section, a narrow choked feature represents a long northern arm of Lake Minigwal while Lake Raeside cuts across the south-western corner of the Study Area.

Calcareous Plains (P)

A few areas of the Eastern Goldfields supported choked remnants of former drainage systems, once active under a past regime of higher rainfall. These valley floors are flat to gently convex due to accumulation of carbonate rubble. The soils have an intricate history of *in situ* weathering, colluvial, alluvial and aeolian action, although the calcareous nature of these soils are their most important feature. These carbonates were derived from leaching of the surrounding Sandplains and Broad Valleys. The main soil types are shallow calcareous earths (Table 1). Calcareous Plains generally form extensions of salt lakes.

Extensive areas of Calcareous Plains border salt lakes in the north-western, central and eastern sections of the Sandstone–Sir Samuel Study Area. Calcrete valley-fills form scattered areas along the major bottomlands. The characteristic topography is a slightly raised, level but gently undulating ramp with abrupt edges, abutting Salt Lake Features or, in some cases, Broad Valleys. The soil is calcareous, pale and stony. On the edges of some Calcareous Plains areas, narrow bands of partly calcareous sandy soil form subdued aeolian banks over calcrete platforms.

In the Laverton–Leonora Study Area, Calcareous Plains occur in the western, central and eastern sections in association with salt lakes (bordering Lake Raeside, Lake Carey and salt lakes in the Erlistoun survey area). Calcareous Plains are restricted to areas where palaeodrainage lines run into Salt Lake Features. This landform consists of slightly raised platforms of calcareous alluvial rubble with a pale friable soil riddled with stone fragments. Calcareous Plains are one of the few landforms in the Laverton–Leonora Study Area with adequate calcium in the soil profile.

Sandplains (S)

Flat upland plains of the Study Areas, as well as some of the middle valley slopes, are referred to as Sandplains. The dividing line between Sandplains and Broad Valleys on the valley slopes is very subtle, and does not always correspond to the change-over from erosional to colluvial. Few Sandplains gradients exceed 2° and internal relief is generally less than 15 m. The red, freely drained coarse soils of the Sandplains have developed from coarse-grained parent rocks (mainly granite) over a great period of time and have been partially lateritized. Most Sandplains in the Study Areas include areas of Dunefields. In some places extensive sand dunes have developed, the now vegetated remnants of past arid epochs. The last major dry period appears to have occurred about 15,000 years ago (Bowler 1976).

Extensive Sandplain areas occur throughout the Study Areas. Sandplains dominate the central section (west of Yeelirrie Station) and western half of the Sandstone–Sir Samuel Study Area. Sandplains also dominate the eastern half of the Laverton–Leonora Study Area (in the vicinity of White Cliffs Station) and the Erlistoun survey area.

Undulating Plains (U)

Throughout the Eastern Goldfields, the Undulating Plains landform (UN) has formed over a greenstone bedrock. Compared to the generally acidic granitic rocks, these greenstones are basic owing to high calcium and magnesium content. The undulating landscape consists of minor ridges, with slopes less than 10°, and colluvial flats, 50–500 m wide and 5 m below the ridges. The ridges (generally of hard metabasalts) and colluvial flats (ultrabasics) bore alkaline soils separated by a lime layer from the under-lying rock. Shallow calcareous earths and deep calcareous earths (to 1 m deep) mantle the ridges and dips (respectively) of Undulating Plains (Table 1). This landform occurs as a few large belts or islands surrounded by Broad Valleys. Colluvial flats are often drained by faint creeklines, too small to be mapped as Drainage Lines.

Undulating Plains over banded ironstone (UI) form relatively small belts, generally within belts of greenstone. The soils are skeletal, sandy and red with relatively low pH. Abrupt strike-ridges are the main topographical form.

Undulating Plains are not extensive in the Sandstone–Sir Samuel Study Area. They are restricted to three areas: at the southern edge near Sandstone, a broad tract in the north-west (Montague Range and Barrambie) and a very narrow north-south belt running along its eastern edge (Leinster and the Wanjarri survey area).

In the southern half of the Laverton–Leonora Study Area, higher-lying undulating landscapes have formed where the bedrock was metamorphic rather than granite. These metamorphic layered intrusives occupy extensive areas of the Study Area. Greenstone Undulating Plains extend north-west from Leonora and east to Laverton. Where the underlying bedrock was banded ironstone, the topography tended towards abrupt, small hills with rocky ridge crests.

Broad Valleys (V)

The Broad Valley landform dominates both of the Study Areas. Overlying most of the extensive granite area are scarcely discernible valleys. These broad valleys are roughly 15 km wide, some of which are saucer-shaped, with an internal relief usually of less than 20 m and slopes generally less than 2°. The ground is well-drained but the indistinct creeklines only flowed following very heavy rainfalls. The soils are generally relatively deep and loamy, with few rock fragments of any kind evident, but with traces of gravel on the surface. A siliceous hardpan is generally present, as elsewhere in the northern parts of the Eastern Goldfields. The main soil types are red earths (Table 1).

Soils

The soils of the Sandstone–Sir Samuel and Laverton–Leonora Study Areas have been described in very general terms by Beard (1974, 1976). They are generally skeletal sandy loams, stony soils on rocky ridges, sands as dunes, and sandy clays in bottomlands. Depressions throughout the Eastern Goldfields are generally saline, with alkaline and slightly saline soils where they are directly weathered from mafic rocks or, in some cases, laterite. Although some landforms are subject to present-day soil formation, in general the soil characteristics are relictual from periods when the climate was first wetter and then drier than that at present (Beard 1976, 1980).

The uniqueness of the Study Areas' red and brown hardpan soils was originally recognized by Teakle (1936). These red-brown soils are occasionally replaced with shallow, stony soils of Undulating Plains and Hills. Clays and gilgai features are unusual. The siliceous hardpan characteristic of the northern part of the Eastern Goldfields was probably formed by solution and redeposition of silica during periodic deep soaking of the soil by exceptionally heavy summer rainstorms (Teakle 1936). Detailed information on soil textures and the physical features of the soil profiles can be found in Northcote *et al.* (1968) and Stace *et al.* (1968).

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