

VEGETATION AND FLORA

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Background

During the present survey of the Sandstone–Sir Samuel and Laverton–Leonora Study Areas, vegetation was described from plotless sample sites as specified by the Biological Surveys Committee of Western Australia (1984). From the survey, 31 vegetation sites were selected to cover the 10 landform units across both Study Areas. The locations of these vegetation sample sites are shown in Figure 2 (Sandstone–Sir Samuel Study Area) and Figure 3 (Laverton–Leonora Study Area). The sites are broadly classified, on the basis of structure and species composition of the upper stratum, into vegetation types. One of the types (Granite) was referred to as a vegetation complex, as the structure and species composition changed markedly over a few metres.

The vegetation sites are described in Appendix 1, together with relevant data on geology, landforms and soils. These detailed site descriptions, central to this paper, are too bulky to be presented in text or as tables. Table 1 summarises the relationships between landform units and elements, lithology, soils, vegetation structure, floristic composition and site codes. This Table has been designed to be read as a cross reference, in conjunction with the following text. Brief vegetation descriptions are listed below under landform unit and by landform element, while full descriptions of the 31 vegetation sample sites (site codes are marked in text) are detailed in Appendix 1. Other vegetation sites, not listed in Appendix 1, are only briefly described below. Reference to Appendix 2, however, provides a complete listing of the flora recorded during the biological survey of the Sandstone–Sir Samuel and Laverton–Leonora Study Areas, by landform unit.

Examples of the range in vegetation types present throughout the Study Areas are shown in Plates 1–15 (see Appendix 1). When revisited in September 1992, the majority of the sites (e.g. SS1–2, SS18–19, SS21–22, LL1–2, LL4) showed no visible change from the survey period (1979–1982). However, the vegetation of sites SS20, SS23, LL3 and LL5–6 had changed substantially.

Vegetation Descriptions

Breakaways (B)

Breakaways are scattered throughout both Study Areas. Breakaways that occur on a metabasalt substrate within Undulating Plains, contrast from those associated with Broad Valleys and Sandplains. Four distinct elements comprise the breakaway landform: summit flats, scree slopes, colluvial base and drainage channels.

Species composition recorded on breakaways varied with geographical spread across the Study Areas. Although the tree or tall shrub layer invariably comprised *Acacia aneura* (Mulga), the shrub layer was considerably more diverse, variable and characteristic. Each breakaway complex had an annual flora influenced by both the substrate and position within the breakaway landform. Drainage channels flowing off the breakaway supported the richest communities.

Several distinctive species were only recorded on breakaways, such as *Eucalyptus carnei*, *Dodonaea petiolaris* and *Nicotiana cavicola*. Ephemerals commonly recorded on breakaways included *Actinobole uliginosum*, *Calotis hispidula*, *Helipterum battii*, *H. craspedioides*, *H. davenportii*, *H. maryonii*, *Trachymene ornata* and *Waitzia acuminata*. Perennial and annual bunch grasses occurred on most breakaways throughout the Study Areas: *Aristida contorta*, *Eragrostis dielsii*, *E. falcata*, *Eriachne pulchella*, *Stipa trichophylla* and *Tripogon loliiformis*.

Slopes, colluvial base and drainage channels. A breakaway within the Wanjarri survey area, in the north-eastern part of the Sandstone-Sir Samuel Study Area, supported a Low Woodland of *Acacia aneura* (for a complete list see SS1 in Appendix 1). The drainage channel (Qpv) supported a richer and more diverse flora than the sparse shrublands and ephemeral communities normally recorded on breakaway slopes (Czo/Agl) and the colluvial base (Qqc).

At this site, *Acacia quadrimarginea*, *Dodonaea petiolaris* and *Hakea suberea* occurred over tall shrubs of *Gastrolobium laytonii* and *Acacia tetragonophylla*. The diverse low shrub layer included *Cassia chatelainiana*, *Enchylaena tomentosa* and *Rhagodia spinescens*. The rich ephemeral community (40 species) was influenced by the drainage channel and included *Calandrinia Ptychosperma*, *Helipterum charleyae* and *Ptilotus chamaecladus*.

The base of another breakaway (Qqc), also in the Wanjarri survey area, supported low trees of *Acacia aneura* and *Callitris columellaris*. The sparse understorey, dominated by *Ptilotus obovatus*, also contained the bunch grass *Triraphis mollis*. In places there was an admixture of *Acacia quadrimarginea*. A seasonal cover of ephemerals (over 30 species) commonly included *Helipterum forrestii*, *H. tenellum* and *H. splendidum*.

Recorded on the steep slopes (Agl) of a breakaway, situated just to the west of the Wanjarri survey area near Albion Downs, were the distinctive perennials *Cassia sturtii* and *Dodonaea petiolaris*. Ephemerals, restricted to cracks in the laterite face, included *Calandrinia eremaea*, *Daucus glochidiatus* and *Helipterum forrestii*.

Colluvial soils (Qpm) on flats immediately below the breakaway bluff, supported Low Woodlands of *Acacia aneura*. Also present were shrubs of *Canthium attenuatum* and a few clumps of *Triodia basedowii*. Ephemerals were common (canopy cover approaching 50%) and represented a return to the community composition of the adjacent Broad Valleys.

Breakaways also occur on a metabasalt substrate within Undulating Plains in both Study Areas. Species such as *Casuarina cristata* and *Eremophila oldfieldii* ssp. *angustifolia*, characteristic of Undulating Plains, were recorded on these breakaways.

A breakaway (Aba,Tl), between Sandstone and the Montague Range (27°38'S 119°27'E), supported a Low Open Woodland of *Acacia aneura* with *Casuarina cristata* over scattered tall shrubs of *Eremophila oldfieldii* ssp. *angustifolia*, *E. platycalyx* and *Hakea arida*. The lower strata included *Maireana trichoptera*, *Sclerolaena eriacantha* and the grass *Cymbopogon bombycinus*. The ephemeral community was similar in composition to other breakaways within the Study Areas, with the exception of alkaline soil species such as *Salsola kali* and *Enneapogon caerulescens*. Observed among lateritic detritus on a broken segment of the breakaway escarpment were *Isotoma petraea* and *Chenopodium saxatile*.

A breakaway (Czl,Ad) near Murrin Murrin to the east of Leonora, occurs within Undulating Plains in the southern portion of the Laverton-Leonora Study Area (see LL7). A total of nearly 100 species were recorded on all three elements of the breakaway landform: summit flats, scree slopes and colluvial base.

The majority of species (over 50) were present throughout the breakaway. These included the perennial shrubs *Acacia aneura*, *Casuarina cristata*, *Ptilotus obovatus* and the grass *Eriachne concava*. Most of the ephemeral species (over 30) were also recorded on all parts of the breakaway. These included *Crassula exserta*, *Goodenia berardiana*, *Gunniopsis septifraga* and *Synaptantha tillaeacea*.

Several species, absent from the summit flats, were only recorded on the scree slopes and colluvial base of the breakaway. They included *Halosarcia pruinosa*, *Maireana tomentosa*, *M. villosa* and *Streptoglossa liatroides*. A number of species (e.g. *Schoenia cassiniana*, *Streptoglossa liatroides*, *Swainsona kingii* and *Vittadinia arida*) were restricted to the breakaway scree slopes (20°). The colluvial base also supported distinctive species not recorded elsewhere on the breakaway. These included *Grevillea sarissa*, *Hakea arida*, *Helipterum roseum* and *H. sterilecens*.

A small drainage channel (Qpv) occurred at the base of this breakaway near Murrin Murrin. The firm, slightly cracking soil supported trees of *Acacia aneura* over *Cassia artemisioides*, *Eremophila oldfieldii* ssp. *angustifolia*, *E. oppositifolia*, *Maireana pyramidata* and *M. triptera*. Ephemerals recorded within the drainage channel included *Calotis multicaulis*, *Podolepis lessonii* and *Zygophyllum ovatum*. *Gnephosis brevifolia* was restricted to the gravelly channel edges.

Summit flats. Flats on the top of a breakaway (Czo/Agl), in the north-eastern section of Sandstone–Sir Samuel Study Area within the Wanjarri survey area, supported Tall Shrublands of *Acacia aneura* (see SS2). Tall shrubs of *Acacia linophylla* and *A. quadrimarginea* occurred over *Calytrix praecipua*, *Dodonaea petiolaris*, *Eremophila latrobei*, *Podolepis capillaris* and *Sida corrugata*. The ephemeral community was not as rich or diverse as the one recorded along the drainage channel (see SS1).

The majority of species recorded on the flats at the top of a breakaway (Czl,Ad), within Undulating Plains in the southern portion of the Laverton–Leonora Study Area, were also found on the slopes and at the base (see LL7). Several species (*Helipterum charsleyae*, *Ptilotus lazareidis*, *Thyridolepis mitchelliana*) were only recorded on the breakaway summit.

At the transition from sandplains to breakaway edge, just to the west of the Wanjarri survey area near Albion Downs, the shallow and lateritic soils (Agl) supported *Acacia aneura* and *Acacia quadrimarginea* Tall Shrublands. Also recorded were the grasses *Eriachne mucronata* and *Triodia pungens*, *Prostanthera wilkieana* and *Myriocephalus guerinae* restricted to the *Triodia* clumps. Ephemeral species included *Gnephosis pusilla* and *Velleia rosea*.

The plateaux of large breakaway systems in the north-western section of the Laverton–Leonora Study Area, supported essentially the same vegetation as the surrounding landforms. An extensive breakaway complex (Czo/Agb) near Bundarra (Chandler's Breakaways), was characterised by sand sheets (Qps) mantling the lateritic duricrust. In places, deeper sands supported *Eucalyptus gongylocarpa* with scattered *E. kingsmillii* over *Triodia basedowii*. Where the laterite was exposed, *Acacia aneura*, *A. tetragonophylla* and *Hakea suberea* occurred over low shrubs of *Baeckea elderiana* and *Thryptomene australis*. *Callitris columellaris* characterised the breakaway cliff edges. The vegetation of these breakaways was very similar to those of the Wanjarri survey area.

Drainage Lines (C)

Scattered throughout the Study Areas are abrupt, well-defined creeklines with relatively deep channels supporting *Eucalyptus camaldulensis* Woodlands and Low Woodlands. Drainage lines are one of the few landforms in the Study Areas where introduced weeds were consistently recorded.

Poorly developed drainage channels, however, are relatively narrow and shallow with similar vegetation structure to the surrounding landform. Many of these minor creeklines are included within the surrounding landform units. Drainage channels are frequently associated with Breakaways and Undulating Plains throughout both Study Areas. Drainages bordering salt lakes are poorly defined for most of the year. Smaller drainages in the Study Areas were dominated by *Acacia aneura*, *A. burkittii* and *Eucalyptus loxophleba* Low Woodlands.

Banks. The best developed Drainage Lines bore tracts of tall *Eucalyptus camaldulensis* (12–15 m). Within the Wanjarri survey area, in the north-eastern part of the Sandstone–Sir Samuel Study Area, the banks of a well defined creekline (Qpv) supported *Eucalyptus camaldulensis* Low Woodland (see SS3). Growing under *Eucalyptus camaldulensis* trees were shrubs of *Acacia burkittii*, *Cassia artemisioides*, *Eremophila longifolia* and *Santalum spicatum*. The dominant species in the diverse ephemeral community (over 50 species recorded) were *Brachycome ciliocarpa*, *Calotis multicaulis*, *Goodenia occidentale*, *Helipterum maryonii*, *Pogonolepis stricta* and *Stenopetalum filifolium*.

A Drainage Line (Qa) to the west of Lake Mason, in the central portion of the Sandstone–Sir Samuel Study Area (27°37'S 119°27'E), supported *Eucalyptus lucasii* Low Woodland. The soil was a pebbly loam of alluvial origin similar to the surrounding Broad Valleys. Scattered high (to 9 m) *Eucalyptus lucasii* occurred over trees of *Acacia aneura*. Tall shrubs included *Acacia craspedocarpa* and *Santalum lanceolatum* over sparse *Acacia tetragonophylla* and *Canthium attenuatum*. The low shrub strata, dominated by *Ptilotus obovatus*, also comprised *Eremophila granitica* and *Spartothamnella teucriflora*. Bunch grasses such as *Enneapogon caerulescens* were also present.

Drainage Lines are scattered throughout the Laverton–Leonora Study Area. A well defined creekline (Qpv) near Laverton, in the south-eastern portion of the Study Area, occurs within Undulating Plains. Growing under trees of *Acacia aneura* and *A. tetragonophylla* were shrubs of *Eremophila leucophylla*, *E. serrulata*, *Indigofera brevidens*, *Sclerolaena convexula*, *Sida corrugata* and *Solanum cleistogamum*. The bunch grasses, dominated by *Eriachne flaccida*, also included *Enneapogon caerulescens*, *Eriachne helmsii* and *Tripogon loliiformis*. A rich ephemeral community (over 30 species), recorded on the clay loams of the drainage channel, included *Bulbine semibarbata*, *Daucus glochidiatus*, *Digitaria ammophila*, *Glycine clandestina*, *Triglochin centrocarpa* and the introduced weed *Trisetaria cristata*.

Dunefields (D)

Dunefields are associated with two landforms within both Study Areas: Sandplains and Salt Lake Features. Dunefields associated with Sandplains shared few structural or vegetational links to salt lake dunes.

Vegetation on sandplain dunefields varied with the height and structure of the dune system. Broad, low dunes had a cover of tall *Eucalyptus gongylocarpa* over *Triodia basedowii* while narrow, abrupt dunes had a lower vegetation, sometimes with discernible zonation from crest

to swale. Low Woodlands of *Eucalyptus gongylocarpa* dominated the surrounding sandplains, the dune slopes supported mallees of *Eucalyptus kingsmillii* and *E. youngiana* while the dune crests and upper slopes were characterised by tall shrublands of *Grevillea* spp. The hummock grass *Triodia basedowii*, prominent on the slopes and swales, was replaced by *Plectrachne schinzii* on the dune crests and upper slopes. The ephemeral flora was essentially the same on dunes and surrounding sandplain areas.

The Great Victoria Desert, to the east of the Study Areas, influenced the vegetation on sandplain dunefields. Species such as *Eucalyptus kingsmillii* and *Hakea francisiana* tended to be replaced by *Eucalyptus youngiana* and *Hakea minyma* in the Laverton–Leonora Study Area and north-eastern portion of the Sandstone–Sir Samuel Study Area. Species characteristic and common on Dunefields associated with Sandplains to the east, such as *Levenhookia chippendalei* and *Thryptomene maisonneuvei*, were at the margins of their distribution in the Study Areas.

There appeared to be little variation in vegetation on gypsum dunes across the Study Areas. Low woodlands of *Callitris preissii* and *Eucalyptus striatocalyx* alternate in dominance depending on dune topography. A characteristic flora is associated with the hard crusted soil surface of the gypsum dunes. Distinctive elements associated with these kopi dunes were *Grevillea sarissa* and *Lawrenciacela helmsii*.

Slopes and summit. Dunefields are scattered within Sandplains in the western and northern portions of the Sandstone–Sir Samuel Study Area. Sandplain dunes are restricted to the extreme north-western corner near Wildara, and the eastern half of the Laverton–Leonora Study Area. These dunes shared many of the plant species found on the surrounding Sandplains.

A dune crest (Qps) within the Wanjarri survey area supported a *Grevillea integrifolia* Tall Shrubland (see SS23). The dune was dominated by *Grevillea integrifolia* along with low shrubs of *Calytrix watsonii* and the bunch grass *Paractaenum novae-hollandiae*. Other prominent species were *Eucalyptus kingsmillii*, *Grevillea juncifolia* and *G. nematophylla*. Ephemerals were chiefly recorded under shrubs and included *Calandrinia* sp. nov. (GK 13001), *Murchisonia volubilis*, *Ptilotus polystachyus*, *Thiseltonia dyeri* and *Uldinia ceratocarpa*.

The slopes and crest of a gently sloping dune (Qps), near Nuendah Station Homestead on the north-eastern boundary of the Sandstone–Sir Samuel Study Area, supported the mallee *Eucalyptus leptopoda* with tall shrubs of *Acacia ligulata* and *Grevillea juncifolia*. *Calothamnus aridus* and *Thryptomene maisonneuvei* were prominent in the shrub layer. The dune was dominated by the hummock grass *Triodia basedowii*. The ephemeral community included *Brunonia australis* and *Helichrysum davenportii*.

A broad abrupt dune (Qps), near Albion Downs in the north-eastern part of the Sandstone–Sir Samuel Study Area, is 3–10 m higher than the surrounding Sandplain. Sharp dune crests appeared to have a similar vegetation to gentle sloping dunes. The upper stratum, composed of *Hakea francisiana* and *Eucalyptus youngiana*, was much denser than the surrounding Sandplain. Shrubs of *Thryptomene maisonneuvei* were also present in the loose sand.

Sandplain dunes (Qps), near Wildara in the Laverton–Leonora Study Area, are similar to those described for the Sandstone–Sir Samuel Study Area to the north-west. Surrounding sandplains were characterised by *Eucalyptus gongylocarpa* Low Woodlands while sands piled

higher into dunes supported a Tall Shrubland dominated by *Grevillea juncifolia* and *Eremophila leucophylla*.

Sandplain dunes in the eastern portion of the Study Area are similar to those of the Great Victoria Desert. A dune slope of Deep Red Sands (Qps) in the Erlistoun survey area supported *Eucalyptus gongylocarpa* Low Woodland over *Triodia basedowii* Hummock Grassland (see LL6). Trees of *Eucalyptus youngiana* (swales) and *Callitris preissii* (crest) were prominent with the shrubs of *Grevillea stenobotrya* and *Prostanthera baxteri*. The hummock grass *Triodia basedowii* dominated the dune. The ephemeral community, similar to the one on the surrounding sandplains, comprised *Myriocephalus gueriniae* and *Pimelea trichostachya*.

Dunefields associated with salt lakes occur with Lake Mason, in the central portion of the Sandstone–Sir Samuel Study Area, and within Lake Miranda in the south-eastern corner. In the Laverton–Leonora Study Area, salt lake dune systems occurs in the vicinity of Lake Raeside, Lake Carey and salt lakes within the Erlistoun survey area.

A number of gypsum (kopi) dunes (Qpk) are associated with Lake Miranda, just to the south of the Wanjarri survey area. On the northern slopes of the lake, small dunes had *Pittosporum phylliraeoides* while larger dunes with very pale gypsum soils supported *Callitris preissii*, *Casuarina cristata* and *Eucalyptus striatocalyx*. Within Lake Miranda, a low dune scarp and surrounding kopi flats, have *Grevillea sarissa* and *Lawrencia helmsii*. The vegetation on undulating gypsum dunes comprised fairly dense pure stands of *Lawrencia helmsii* interrupted by large depressions of *Halosarcia*. *Melaleuca lanceolata* occurred where the dunes abutted the lake flats.

In the Laverton–Leonora Study Area, a gypsum dune (Qpk) supported a *Eucalyptus striatocalyx*–*Callitris preissii* Low Woodland (see LL1 under Salt Lake Features in Appendix 1). Subdued lake dunes within the Erlistoun survey area had pure *Callitris preissii* Low Woodlands while *Eucalyptus striatocalyx* was prominent where the gypsum had formed higher dunes. The characteristic dune flora also included *Lobelia* sp. nov. (GK 13,008).

Within Lake Raeside, in the south-western corner of the Laverton–Leonora Study Area, a gypsum dune (Qpk) supported *Eucalyptus striatocalyx* Low Open Woodland over *Grevillea sarissa*, *Kippistia suaedifolia*, *Lawrencia helmsii*, *Minuria cunninghamii* and *Scaevola collaris*. Where the soil was lower in gypsum, open *Acacia aneura* Low Woodlands occurred with an understorey of *Rhagodia drummondii* and scattered *Lycium australe*. A small dune of red sands (Qrs) in the lake supported *Acacia craspedocarpa* over *Atriplex vesicaria* and *Gunniopsis quadrifida*.

Granite Exposures (G)

Granite Exposures are concentrated in the western and eastern portions of the Sandstone–Sir Samuel Study Area while small areas are scattered throughout the Laverton–Leonora Study Area. The vegetation structure and composition of granite rocks did not appear to differ markedly across the Study Areas.

Outer aprons and colluvial flats. In the northern part of the Sandstone–Sir Samuel Study Area (27°07'S, 119°37'E), a flat exposure of granite (Czo/Agb,Qpm) occurs at the base of a breakaway. Loamy soils over weathered granite supported *Acacia aneura* and *A. quadrimarginea* over *Canthium latifolium*, *Dodonaea petiolaris*, *Eremophila compacta* and *Hakea leucoptera*. *Calotis multicaulis* only occurred on the colluvial flats (Qpm) surrounding

the granite exposure while the following species were taller and more common than among the rocks: *Brachycome ciliocarpa*, *Ptilotus chamaecladus*, *Helipterum craspedioides* and the grasses *Aristida contorta*, *Eragrostis dielsii* and *Eriachne pulchella*.

Granite rocks (Age), bordering Lake Raeside in the south-western corner of the Laverton–Leonora Study Area, had Low Woodlands of *Acacia burkittii* and *A. craspedocarpa* fringing the rock itself. On the widespread stony areas associated with the granite apron *Eremophila miniata* Low Shrubland becomes dominant while on the shallow loamy soils of the apron proper *Eremophila fraseri* dominates. Scattered shrubs of *Acacia acuminata*, *Eremophila granitica* and *E. platycalyx* were found on the rock itself.

Inner aprons and skeletal soil sheets. In the Sandstone–Sir Samuel Study Area a Granite Exposure (Agl), within the Wanjarri survey area, supported *Acacia quadrimarginea* Tall Shrubland (see SS5). Low shrubs of *Eremophila exilifolia* were common. Other species recorded on the sloping apron of the exposure included *Cassia desolata*, *Santalum spicatum* and the grass *Aristida contorta*. Prominent in the diverse ephemeral community (over 30 species) were *Chthonocephalus pseudevax*, *Goodenia havilandii*, *Helipterum craspedioides*, *H. maryonii* and *Ptilotus gaudichaudii*.

A granite rock (Agb) at Cosmo Newbery, just on the north-eastern boundary of the Laverton–Leonora Study Area supported a complex vegetation (see LL8). Growing on the apron were trees of *Acacia aneura* over *Abutilon cryptopetalum*, *Cymbopogon ambiguus*, *Dodonaea filifolia* and *Eremophila abietina*. *Calotis multicaulis* was prominent in the rich ephemeral community (over 40 species), which also included *Helipterum pterochaetum*, a distinctive granite species.

In the Erlistoun survey area, flat granite exposures (Agp) were severely degraded by grazing and burning. Over 30 species however, were shared between the Cosmo Newbery and Erlistoun granite rocks. These included the bunch grasses *Aristida contorta*, *Eragrostis dielsii*, *Eriachne mucronata*, *E. pulchella*, *Monachather paradoxa*, *Stipa trichophylla* and *Tripogon loliiformis*. Other perennial species recorded on granites in the vicinity of the Erlistoun Homestead were *Acacia grasbyi*, *A. ramulosa*, *Cassia cardiosperma*, *C. desolata*, *Dianella revoluta*, *Eremophila metallicorum*, *Hakea preissii* and *Thysanotus patersonii*. The ephemeral community complex was essentially the same on most of these granite rocks.

Hills, Granite (HG)

Granite Hills supported very similar vegetation types to those of Granite Exposures in both of the Study Areas.

Slopes and summit. A granite hill (Ag), in the north-western corner of the Sandstone–Sir Samuel Study Area near Barrambie Homestead, supported *Acacia aneura* Tall Shrubland (see SS6). Other prominent shrubs on the slopes and crest included *Dodonaea petiolaris*, *Santalum spicatum*, the bunch grass *Cymbopogon ambiguus* and over the ephemerals *Brachycome ciliaris*, *Erodium cygnorum*, *Helipterum maryonii* and *Trachymene ornata*.

Rugged granite country (the Barr Smith Range area) in the eastern part of the Sandstone–Sir Samuel Study Area supported distinctive vegetation, with an upper stratum of *Acacia quadrimarginea* over a clearly defined low shrub stratum dominated by *Eremophila exilifolia*. The most common ephemerals on granite hills were *Trachymene ornata* and *Helipterum maryonii*, distinguishing this association from lower granite exposures. In the Wanjarri survey

area, aprons of deep pale loams (Agl) on the edge of this rugged granite landscape supported *Eremophila leucophylla* over a dense covering of ephemerals, that included *Helipterum adpressum*. On stonier soils *Eremophila fraseri* dominated.

Hills, Banded Ironstone (HI) and Greenstone (HN)

Hills of banded ironstone (HI) and Greenstone (HN) are scattered within Undulating Plains of Greenstone (UN) in both of the Study Areas. Many of these hills had been heavily disturbed by mining activities throughout the Study Areas. The species composition was largely dependant upon the bedrock type.

Slopes and summit. The vegetation on Hills of Banded Ironstone in the Laverton–Leonora Study Area was characterised by a number of distinctive elements. Species of *Cassia* were prominent as shrubs in a shrub understorey that included *Dodonaea filifolia*, *Eremophila latrobei*, *Ptilotus obovatus*, *Sida filiformis* and *Solanum lasiophyllum*. *Brachychiton gregorii* and *Eremophila leucophylla* occurred on the relatively deep colluvial soils at the base of hills and in small valleys. A number of ephemerals (*Helipterum battii*, *H. craspedioides*, *H. maryonii* and *Waitzia acuminata*) were also commonly found on Breakaways and Granite Exposures. *Trachymene ornata* was the dominant ephemeral on many banded ironstone hills.

A banded ironstone hill (Af), near Mt Jumbo south-west of Laverton in the south-eastern corner of the Laverton–Leonora Study Area supported *Acacia aneura* Low Woodland (see LL9). Growing on the slopes with *Acacia aneura* were sparse trees of *Casuarina cristata* and *Grevillea nematophylla*. Shrubs and ephemerals commonly recorded on banded ironstone hills included *Acacia ramulosa*, *Eremophila latrobei*, *Eriostemon brucei*, *Euphorbia boophthona*, *Maireana georgei*, *Sida filiformis*, *Symphyobasis macroplectra*, *Trachymene ornata* and *Wurmbea deserticola*.

A banded ironstone hill (Aw) occurs near Mt Windarra in the Erlistoun survey area. Skeletal soils, with some quartz areas, supported essentially the same vegetation type recorded on banded ironstone at Mt Jumbo. The majority of the species were shared between the two sites. In contrast, at Erlistoun the usually common *Ptilotus obovatus* was absent and *Triodia*, recorded on the surrounding plain, also occurred in the rocks of the hill. Other distinctive species included *Eriachne mucronata*, *Prostanthera wilkieana*, *Ptilotus aevroides*, *P. macrocephalus* and *Thysanotus patersonii*.

Smaller greenstone hills and ridges as well as the lower slopes were generally covered by Low Woodlands of *Acacia aneura*, while higher ridges, the upper slopes and summits supported *Acacia burkittii* Tall Shrublands.

A greenstone hill (Adj,Alm), near Barrambie Homestead in the western section of the Sandstone–Sir Samuel Study Area, supported *Acacia burkittii* Tall Shrubland (see SS7). Tall shrubs growing with *Acacia burkittii* on the slopes were *A. aneura* and *Santalum spicatum*. Other prominent shrubs included *Eremophila platycalyx*, *Lycium australe* and *Rhagodia spinescens*. The main grasses were *Aristida contorta* and *Stipa trichophylla* while the ephemeral community was dominated by *Helipterum maryonii*, *Lepidium phlebopetalum* and *Sclerolaena densiflora*.

In the Laverton–Leonora Study Area, greenstone hills (Ab,Ad) supported *Casuarina cristata* Low Woodland over tall shrubs of *Acacia aneura*, *A. burkittii*, *Eremophila alternifolia* and *Cassia nemophila*. Mt Ross in the south-western corner of the Study Area, was characterised

by open Tall Shrublands of *Acacia burkittii* on the slopes and summit. Numerous introduced weeds such as *Rumex vesicarius*, recorded on many greenstone hills, reflects the heavy mining disturbance over parts of the Study Areas.

Salt Lake Features (L)

Salt Lake Features are prominent in the Laverton–Leonora Study Area. Two large salt lake systems intruded into the southern half of the Study Area. Lake Raeside occurred in the south-western corner while Lake Carey was located between Laverton and Leonora. Another large un-named salt lake extended from the north into the Erlistoun survey area. Salt Lake Features were less extensive in the Sandstone–Sir Samuel Study Area. Salt lakes occur in the extreme north-western corner of the Study Area, the central portion (Lake Mason), and in the vicinity of the Wanjarri survey area (Lake Miranda).

In both of the Study Areas, Salt Lake Features are characterised by a series of associated landform elements. These ranged from bare lake floors and saline bottomlands to sub-saline and well-drained flats. Dunes of gypsum (kopi) and red sands are scattered throughout most salt lakes.

Lake floors and saline flats. Low shrublands characterised by *Halosarcia* dominated salt lake floors and saline flats in the two Study Areas. The increased soil salinity of these lower-lying areas was indicated by the presence of *Halosarcia* and a reduced species diversity. On sites with moderate salinity, however, several other perennials (*Atriplex*, *Frankenia*, *Maireana*) coexisted with *Halosarcia* and a considerable community of ephemerals appeared. Large expanses of bare mud on lake floors, a characteristic of the Laverton–Leonora Study Area, were not observed in the Sandstone–Sir Samuel Study Area.

A lake floor (Ql), on Yarrabubba Station in the north-western corner of the Sandstone–Sir Samuel Study Area, supported *Halosarcia* Low Shrubland (see SS10). Dominant shrubs were *Halosarcia halocnemoides*, *H. indica*, *Frankenia desertorum* and *Maireana amoena*. The ephemeral community was relatively extensive (over 20 species) in comparison to other salt lake floors. Common species included *Angianthus tomentosus*, *Gunniopsis glabra*, *Helipterum humboldtianum*, *Pogonolepis stricta*, *Senecio glossanthus* and *Stenopetalum robustum*.

Lake floors (Qrm) in the Laverton–Leonora Study Area also supported *Halosarcia* Low Shrublands. Saline soils of salt lakes within the Erlistoun survey area (see LL2) supported were *Halosarcia indica*, *H. pruinosa*, *Frankenia cinerea* and *Maireana amoena*. Between the lake floor and an adjacent gypsum dune *Atriplex vesicaria* became prominent in a clearly defined band. The ephemeral community only comprised 7 species and included *Senecio lautus*, a distinctive and conspicuous ephemeral recorded on salt lakes in the Laverton–Leonora Study Area.

Another lake floor (Qrm) in the Erlistoun survey area supported *Atriplex lindleyi*, *Halosarcia halocnemoides* and *H. indica*, the grasses *Eragrostis dielsii* and *E. pergracilis* with *Lycium australe* and *Cratystylis subspinescens* restricted to the margins. Ephemerals were again rare (13 species) and included the fern *Marsilea hirsuta* and *Senecio lautus*.

In the Sandstone–Sir Samuel Study Area, on the northern side of Lake Mason, the vegetation consisted of low shrubs of *Halosarcia* and virtually no other perennial plant species. Soil salinity was indicated by the distinctive colour. An ephemeral component was present, especially towards the edge of the lake floor (Ql), which included *Angianthus*

tomentosus, *Helipterum floribundum* and *Senecio glossanthus*.

In the south-western corner of the Laverton-Leonora Study Area, saline soils (Qrm) adjacent to the floor of Lake Raeside supported alternating Low Shrublands of *Atriplex vesicaria* and *Maireana pyramidata*. Saline flats bordering salt lakes in the Erlistoun survey area were characterised by the presence of *Atriplex vesicaria*, *Sclerolaena uniflora*, a number of grasses (7 species) and a varied ephemeral community (14 species) that included *Gnephosis macrocephala* and *Stenopetalum robustum*.

Lake slopes and lake margins. The slopes and margins of salt lakes in both of the Study Areas were essentially of two main types. Poorly drained sub-saline soils and clays supported Low Shrublands of *Cratystylis*, *Halosarcia* and *Maireana*. Sandier soils and loams had *Acacia aneura* Low Woodlands and were often characterised by the presence of *Triodia basedowii*.

On the margins of salt lakes in the Sandstone-Sir Samuel Study Area, where salinity was less extreme, a considerable ephemeral community existed. Commonly recorded species included *Calotis hispidula*, *Gnephosis brevifolia*, *Helipterum charsleyae*, *H. maryonii*, *H. roseum*, *H. strictum*, *Lepidium phlebopetalum*, *Pogonolepis stricta* and *Triglochin centrocarpa*.

Where lake margins graded into the adjacent landform, the transition was often indicated by a distinctive ephemeral community that included both salt lake and Broad Valley elements. These included *Actinobole uliginosum*, *Brachycome ciliocarpa*, *Chthonocephalus pseudevax*, *Helipterum tenellum*, *Isoetopsis graminifolia*, *Podolepis kendallii* and *Ptilotus gaudichaudii*.

Lake margins (Qz), in the north-western corner of the Study Area on Yarrabubba Station, supported *Maireana pyramidata* Low Shrubland (see SS9). Tall shrubs of *Acacia grasbyi* and *Hakea arida* occurred over *Atriplex bunburyana* and *Maireana pyramidata*. The grasses *Aristida contorta* and *Eragrostis dielsii* grew with low shrubs that included *Atriplex hymenotheca* and *Eremophila delisseri*. Although the cover of ephemerals was relatively dense, most were low and inconspicuous. Dominant species were *Brachycome ciliocarpa*, *Gnephosis eriocephala*, *Senecio glossanthus* and *Stenopetalum sphaerocarpum*.

A diverse and abundant ephemeral stratum was also characteristic on poorly drained soils that were not strongly saline. The vegetation comprised shrubs of *Maireana pyramidata* and *Cratystylis subspinescens* with scattered groves of mixed trees and tall shrubs that included *Acacia aneura*, *Acacia victoriae*, *Hakea arida*, *Eremophila longifolia*, *Pittosporum phylliraeoides* and *Santalum lanceolatum*.

Other lake margins in the north-western corner of the Study Area had a similar topsoil, but with a greater component of gravel-size rock fragments. The flat surface was also characterised by numerous shallow clay depressions, with the vegetation (similar to SS9 above) concentrated at their edges. Several grass species were also common in the depression floors. Common herbaceous species were *Gnephosis burkittii*, *Ptilotus exaltatus* and *Sclerolaena densiflora*.

Poorly drained soils on the margins of a salt lake (Qg), between Barrambie and Yarrabubba Homesteads in the north-western part of the Sandstone-Sir Samuel Study Area, supported a *Halosarcia* Low Shrubland. The main species was *Halosarcia indica* but *Gunniopsis quadrifida*, *Eremophila maculata*, *E. delisseri*, *Minuria leptophylla* and *Ptilotus lazaridis* were also present. Scattered emergents were occasional low trees of *Acacia tetragonophylla*, *Lycium australe* and *Pittosporum phylliraeoides*. The ephemeral *Angianthus tomentosus*,

dominant in pure *Halosarcia* Low Shrubland, was replaced on the lake margins. Other ephemerals included *Calandrinia lehmannii*, *Helipterum floribundum*, *H. humboldtianum* and *Plantago drummondii*.

In the Laverton–Leonora Study Area, poorly drained soils on lake slopes and margins supported *Cratystylis subspinescens* Low Shrublands mixed with species of *Halosarcia*, *Frankenia* and *Maireana*. On the margins (Qrd) of a small salt lake in the Erlistoun survey area *Cratystylis subspinescens* occurred with *Brachycome halophila*, *Cassia chatelainiana*, *Eremophila delisseri* and *Senecio lautus*. In the eastern portion of the Study Area salt lake margins graded into Broad Valleys. *Cratystylis subspinescens* occurred with *Billardiera coriacea* and *Eremophila maitlandii* over the grasses *Danthonia caespitosa* and *Paspalidium gracile*. The rich ephemeral community (over 30) reflected the influence of the adjacent landforms and included *Ptilotus macrocephalus*, *Lepidium rotundum*, *Senecio lautus* and *Schoenia filifolia*.

In contrast, margins of Aeolian Loamy Sands with some gypsum at depth (Qg), on the northern edge of Lake Mason in the central part of the Sandstone–Sir Samuel Study Area, supported *Acacia aneura* Low Woodland. Low trees of *Acacia aneura* grew over shrubs of *Lycium australe*, *Melaleuca lanceolata* and *Rhagodia eremaea*. Other low shrubs included *Atriplex bunburyana*, *Enchylaena tomentosa*, *Maireana triptera*, *Podolepis capillaris* and *Scaevola spinescens*. Also recorded was the hummock grass *Triodia basedowii* while *Gnephosis brevifolia* was the dominant ephemeral. Species characteristic of gypsum included *Grevillea sarissa* and *Dissocarpus paradoxus*.

Lake margins of Deep Red Sandy Loams (Qrd), in the Laverton–Leonora Study Area, also supported *Acacia aneura* Low Woodland (see LL3). In the Erlistoun survey area, undulating lake margins had Aeolian sand overlying in places, *Acacia aneura* grew over an understorey dominated by *Maireana pyramidata* and *Atriplex vesicaria*. The bunch grass *Eragrostis eriopoda* was prominent in the lower strata along with the characteristic *Triodia basedowii*. The rich ephemeral community (over 30 species) reflected the sandier soils and included *Calandrinia calyptata*, *C. primuliflora*, *Crassula colorata* and *Gnephosis macrocephala*.

In the south-western corner of the Study Area, poorer drained soils on undulating margins (Qrd) of Lake Raeside supported *Maireana pyramidata* Low Shrublands while adjacent sandier rises (Qqz) had scattered *Acacia craspedocarpa* and *Hakea arida*.

On the eastern boundary of the Laverton–Leonora Study Area near White Cliffs Station, salt lake margins of Sandy Loams (Qrd,Qps) at the threshold of plains dominated by *Triodia basedowii*, supported a very similar vegetation (see LL3). Trees of *Acacia aneura* occurred with *Hakea arida* and *Santalum spicatum* over essentially the same understorey dominated by *Atriplex vesicaria*, *Maireana pyramidata* and *Podolepis capillaris*. The ephemerals were a mixture of salt lake elements (*Senecio glossanthus* and *Crassula exserta*) and Broad Valleys (*Brachycome iberidifolia*, *Calandrinia lehmannii*, *Calotis multicaulis*, *Goodenia occidentalis* and *Synaptantha tillaeacea*).

Salt lake dunes. Gypsum dunes are associated with most salt lakes in the two Study Areas. Dunes of Aeolian soils (Qgd,Qpk) supported *Eucalyptus striaticalyx* and *Callitris preissii* Low Woodlands while *Atriplex vesicaria* Low Shrublands characterised the transition zone between salt lake floors and dunes. Ephemerals were sparse on all gypsum (kopi) dunes. Higher dunes were characterised by *Eucalyptus striaticalyx* while lower dunes and adjacent

salt lake flats, with a strongly gypseous soil (Qpk), supported *Callitris preissii*. Flats marginal to salt lakes (Qrd,Czk,Qpk) often graded into Calcareous Plains (see below).

In both Study Areas, acidic siliceous sands (Qrs) form into dunes in the vicinity of some salt lakes. These dunes supported vegetation dominated by *Acacia* or *Triodia* similar to the vegetation described for lake margins with sandier soils (see LL3).

In the Laverton–Leonora Study Area, a mixed Low Woodland of *Eucalyptus striatocalyx* and *Callitris preissii* occurred on gypsum dunes (Qpk) associated with salt lakes within the Erlistoun survey area (see LL1). Low trees of *Eucalyptus striatocalyx* and *Callitris preissii* were the prominent species on the dune slope and base. The vegetation included elements characteristic of gypsum (*Grevillea sarissa* and *Lawrencia helmsii*) and those associated with salt lakes (*Frankenia desertorum*, *F. setosa*, *Halosarcia pruinosa*, *Kippistia suaedifolia*, *Scierolaena fimbriolata* and *Zygophyllum tetrapterum*).

Flats of gypsum soils (Qpk) on salt lake margins in the Erlistoun survey area were dominated by *Atriplex vesicaria* Low Shrublands with *Halosarcia indica*, *Maireana oppositifolia* and *Scierolaena longifolia*. Marginal species were *Callitris preissii*, *Dissocarpus paradoxus*, *Grevillea sarissa* and *Lawrencia helmsii*.

Sand soils bordering Lake Raeside, in the south-western corner of the Laverton–Leonora Study Area, are piled into low subdued dunes (Qrs) and supported *Acacia craspedocarpa* trees over *Gunniopsis quadrifida*.

Calcareous Plains (P)

Calcareous Plains are associated with salt lakes in the Sandstone–Sir Samuel and Laverton–Leonora Study Areas. Extensive areas of Calcareous Plains bordered salt lakes in the north-western, central and eastern sections of the Sandstone–Sir Samuel Study Area. Calcareous Plains, marginal to most salt lakes, occur in the western, central and eastern sections of the Laverton–Leonora Study Area. Extensive areas of Calcareous Plains border Lake Raeside, Lake Carey and salt lakes in the Erlistoun survey area.

Calcareous Plains are one of the few landforms in the Study Areas where *Acacia aneura* did not dominate the vegetation. The characteristic vegetation recorded on Calcareous Plains in the Sandstone–Sir Samuel Study Area were Tall Shrublands of *Acacia burkittii*, *A. nyssophylla* and *A. sclerosperma* over a continuous carpet of ephemerals that included the distinctive lime species *Asteridea athrixioides*, *Gnephosis skirrophora* and particularly *Helipterum sterilecens*.

In the Laverton–Leonora Study Area, Calcareous Plains supported scattered trees of either *Casuarina cristata*, *Melaleuca lanceolata* or *Eucalyptus striatocalyx*. However, *Acacia sclerosperma*, characteristic of Calcareous Plains of similar origin and soils in the Sandstone–Sir Samuel Study Area, was absent. Also present in the Laverton–Leonora Study Area were *Acacia burkittii*, *A. nyssophylla* and *A. victoriae* with *Enneapogon caerulecens*, *Gnephosis skirrophora*, *Schoenia filifolia*, *Stipa trichophylla* and *Zygophyllum ovatum*.

Flats marginal to salt lakes. Calcareous Plains are transitional between salt lakes and Broad Valleys in both of the Study Areas. The vegetation on these three adjacent landforms tended to merge and was often difficult to distinguish from each other. The landscape graded from heavier poorly drained soils closer to the salt lake and associated well drained sandier rises to a transition with the adjacent flat plains.

The vegetation present on Calcareous Plains however, differed clearly from that of flats bordering salt lakes. These saline and sub-saline flats were often directly adjacent and immediately below the edge of Calcareous Plains. They supported a variant of Salt Lake Features vegetation, characterised by almost pure stands of *Cratystylis subspinescens* and other species generally absent from Calcareous Plains.

Calcareous Plains bordering salt lakes (Czk), in the extreme north-western corner of the Study Area near Yarrabubba, supported Tall Shrublands dominated by *Acacia sclerosperma* (see SS12). Other prominent shrubs included *Acacia burkittii*, *A. linophylla*, *Lawrenciacia densiflora*, *Rhagodia drummondii* and *Sclerolaena spinosa*. The relatively poor ephemeral community (12 species) included *Angianthus tomentosus*, *Asteridea athrixioides*, *Helipterum sterilecens* and *Podolepis canescens*.

Some areas of Calcareous Plains in the Sandstone–Sir Samuel Study Area supported Low Woodlands of *Casuarina cristata*. Calcareous Plains along the northern border of Lake Mason (27°33'S lat., 119°36'E long.) supported *Casuarina cristata* Low Woodland on Shallow Calcareous Earths (Czk). Tall shrubs of *Acacia burkittii*, *A. nyssophylla* and *A. victoriae* occurred over the perennial grasses *Enneapogon caerulecens*, *Eragrostis dielsii* and *Stipa elegantissima*.

On the western edge of Lake Mason (27°32'S 119°39'E), the *Melaleuca lanceolata* Low Woodland vegetation reflected a transition between Calcareous Plains and Salt Lake Features (Qg,Czk). The calcareous, well drained soil occurred on a surface slightly elevated above the level of the salt lake. Despite its similar surface, the soil was deeper and less stony than under *Casuarina cristata* on adjacent Calcareous Plains. The vegetation was a Low Woodland dominated by *Melaleuca lanceolata*. Other perennials, such as *Rhagodia eremaea* and *Lycium australe*, were very sparse and strongly clumped under the trees. Common ephemerals were *Atriplex inflata*, *Dissocarpus paradoxus*, *Gnephosis skirrophora*, *Podolepis capillaris* and *Zygophyllum glaucum*.

Calcareous Plains (Qrd,Czk) in the Laverton–Leonora Study Area were characterised by *Melaleuca* thickets on marginal salt lake flats while the adjacent rises supported *Acacia aneura* Low Woodlands.

In the Erlistoun survey area, flats marginal to salt lakes (Czk) supported *Melaleuca lanceolata* Tall Shrubland (see LL13). The vegetation however, was formerly *Melaleuca lanceolata* Low Woodland as most of the large trees had been removed. Tall shrubs of *Melaleuca lanceolata* and *M. uncinata* grew over low shrubs of *Ptilotus obovatus* and *Dissocarpus paradoxus*. Prominent in an ephemeral community of over 25 species were *Helipterum floribundum* and *Zygophyllum iodocarpum*. Other characteristic species were *Euphorbia australis*, *Pogonolepis muelleriana*, *Schoenia filifolia*, *Tetragonia eremaeum* and *Triraphis mollis*.

Another area in the Erlistoun survey area, closer to the salt lake, also supported Tall Shrublands of *Melaleuca lanceolata*. The influence of the nearby salt lake was reflected by the presence of *Atriplex vesicaria*, *Cratystylis subspinescens*, *Halosarcia doleiformis*, *Kippistia suaedifolia* and a rich ephemeral community of over 25 species that included *Ptilotus exaltatus* and *Crassula colorata*.

At the edge of salt lakes in the Erlistoun survey area, *Melaleuca uncinata* thickets also occurred. The common shrubs *Acacia nyssophylla*, *Pimelea microcephala* and *Santalum*

acuminatum grew over a sparse ephemeral community. The higher areas adjacent to these *Melaleuca* flats supported *Acacia acuminata* over *Maireana sedifolia*. Other shrubs included *Acacia aneura*, *A. stowardii*, *A. victoriae*, *Atriplex bunburyana* and *Sclerolaena uniflora*. Dominant in slightly depressed areas nearby were *Melaleuca uncinata* and *M. lanceolata*, both uncommon in this vegetation. The ephemeral community comprised *Asteridea athrixioides*, *Gnephosis burkittii*, *Helipterum floribundum*, *Ptilotus aervoides* and *Salsola kali*.

In the Laverton–Leonora Study Area, Calcareous Plains on the northern border of Lake Carey near Mt Margaret (Qrd,Czk) were dominated by *Eucalyptus striaticalyx* and *Maireana sedifolia*. Other shrubs included *Chenopodium curvispicatum*, *Eremophila pantonii*, *Maireana pentatropis*, *Melaleuca lanceolata* and *Pittosporum phylliraeoides*. The grass *Paspalidium gracile* was one of eight grass species recorded while the ephemerals included *Bulbine semibarbata*, *Tetragonia eremaea* and *Swainsona rostellata*. The transitional nature of this vegetation was reflected by a number of salt lake elements (*Brachycome cheilocarpa*, *Kippistia suaedifolia*, *Ptilotus lazardis*, *Senecio lautus*) that occurred alongside species typical of Calcareous Plains (*Acacia nyssophylla*, *Asteridea athrixioides*, *Eragrostis basedowii*, *Goodenia pinnatifida*).

In the Sandstone–Sir Samuel Study Area, sandy sites on Calcareous Plains were characterised by the presence of perennial grasses and emergent eucalypts. On the south-western corner of Lake Mason, just north of Sandstone (27°49'S 119°20'E), Aeolian Loams (Czk) supported *Eucalyptus oleosa* Low Woodland. Sandy loams over calcrete supported *Eucalyptus oleosa* over *Acacia aneura*, *A. ligulata*, *A. victoriae* and widely scattered *Eremophila longifolia*. Perennial grasses were common as were ephemerals (up to 35 species in season). The most distinctive species were *Calocephalus knappii*, *Dysphania kalpari*, *Haloragis gossei*, *Helipterum floribundum*, *Menkea australis* and the calcium tolerant species *Gnephosis skirrophora* (rare).

Another site in the same vicinity (27°47'S 119°22'E), with slightly deeper and sandier soil, had enough *Triodia* to constitute a separate stratum of open Hummock Grass, with large expanses of bare ground. Additional species of shrubs were *Acacia nyssophylla*, *A. ramulosa*, *Eremophila leucophylla* and *Maireana triptera*.

In the Sandstone–Sir Samuel Study Area, sites intermediate between Broad Valleys and Calcareous Plains supported *Acacia burkittii* Tall Shrubland. In the north-western corner of the Study Area, the vegetation included some typical elements of Salt Lake Features. The soil, a gravelly, partly calcareous clay loam, supported a vegetation that comprised a relatively dense ephemeral community with a conspicuous grass component. Mixed in with *Acacia burkittii* were trees of *A. aneura* over occasional shrubs of *Acacia sclerosperma*, *A. victoriae*, *Eremophila longifolia* and *Exocarpos aphyllus*. The ephemerals were distinguished by the dominance of the characteristic Calcareous Plains species *Helipterum sterilescens* and the abundance of other lime indicators such as *Asteridea athrixioides*, *Helipterum floribundum* and *Salsola kali*.

In the Laverton–Leonora Study Area, north of Lake Carey and Mt Morgan, a transition from Broad Valleys (Qqf,Qqz) to Calcareous Plains (Qrd,Czk) occurred. Non-calcareous clay loams supported *Acacia victoriae* and *Melaleuca uncinata* over *Cratystylis subspinescens* and *Maireana pyramidata*. *Acacia aneura*, dominant on the adjacent Broad Valleys, was sparse.

The ephemeral community included *Calotis multicaulis*, *Lepidium rotundum*, *Helipterum strictum*, *Senecio gregorii* and *Stenopetalum robustum*. In the vicinity of Lake Carey near Mt Margaret (Qqz,Czk), shallow saucers with flat calcareous-free slightly cracking surfaces, were dominated by *Acacia aneura* over *Maireana pyramidata* with *Helipterum charsleyae*, *H. floribundum* and *Goodenia pinnatifida*.

Calcareous Plains (Qrd,Qpk,Czk) on the eastern border of the Laverton–Leonora Study Area, to the west of White Cliffs Station, were characterised by the presence of *Acacia burkittii* and *Grevillea sarissa*. These areas also supported *Aristida contorta*, *Cephalopterum drummondii*, *Enneapogon caerulescens* and *Eremophila scoparia*. In this area, *Acacia burkittii* and *Grevillea sarissa* appeared to be infallible indicators of calcareous soils. Bordering the Calcareous Plains were *Acacia aneura* and *Triodia basedowii* communities. Within the *Acacia aneura* Low Woodlands were uncommon small patches of *Atriplex vesicaria*, *Cratystylis subspinescens*, *Maireana pyramidata*, *M. sedifolia* and *Vellea rosea*. In this eastern part of the Study Area, Calcareous Plains graded into the *Acacia aneura* communities of the adjacent Broad Valleys.

Sandplains (S)

Sandplains are one of the dominant landforms of the Study Areas. Extensive Sandplain areas occur throughout both Study Areas, particularly in the eastern half of the Laverton–Leonora Study Area.

Sandplains of the adjacent Great Victoria Desert strongly influence the landforms in the eastern half of the Laverton–Leonora Study Area. These eastern Sandplains (Qps) extend south from Cosmo Newbery, in the north-eastern corner of the Study Area, east to White Cliffs Station and west to the Erlistoun survey area. The sandplains supported a typical association characterised by various *Eucalyptus mallees* over a dense cover of *Triodia basedowii*. Small Broad Valley areas (Qpv), supporting *Acacia aneura* associations, intrude into the extensive Sandplains (see Broad Valleys).

The Sandplain vegetation in both Study Areas had characteristic variation within the composition of the upper stratum. Typical species were *Eucalyptus gongylocarpa*, *E. kingsmillii* and *E. youngiana*. At sites where sands mantled loamy soils there was an admixture of *Acacia aneura* in the upper stratum (see Broad Valleys). The lower stratum, in contrast, consisted almost entirely of *Triodia basedowii*. Other bunch grasses present were *Aristida contorta*, *Eragrostis eriopoda*, *Eriachne helmsii*, *Monachather paradoxa*, *Paractaenium novae-hollandiae* and *Stipa trichophylla*.

Ephemerals on sandplains were very sparse and generally had a low diversity. Characteristic ephemeral species recorded were *Brachycome ciliaris*, *Brunonia australis*, *Helipterum maryonii*, *H. stipitatum*, *Podolepis canescens*, *Ptilotus polystachyus*, *Stenopetalum anfractum*, *Velleia daviesii*, *V. glabrata* and *Waitzia acuminata*. Other common species included *Calandrinia polyandra*, *Calotis hispidula*, *Myriocephalus guerinae* and *Vellea rosea*. After exceptional rains, the collections made in September 1992 added species such as *Murchisonia volubilis*, *Pimelea trichostachya*, *Podolepis capillaris* and *Trachymene glaucifolia*.

Flat plains. In the south-western section of the Sandstone–Sir Samuel Study Area, Sandplains (Qs) supported *Eucalyptus gongylocarpa* Low Woodland (see SS13). Trees of *Acacia aneura* occurred over the prominent shrubs *Acacia coolgardiensis*, *Cassia nemophila*, *Eremophila*

longifolia and *Ptilotus exaltatus*. The hummock grass *Triodia basedowii* dominated the lower strata while the bunch grass *Amphipogon caricinus* was also recorded. The characteristic sandplain ephemeral community included *Calocephalus multiflorus* and *Gnephosis brevifolia*.

The lower slopes of a subdued dune in the Wanjarri survey area supported *Eucalyptus gongylocarpa* Low Woodland over Hummock grasses of *Triodia basedowii* (see SS22). The mallee *Eucalyptus rigidula* occurred with *Acacia aneura* over shrubs of *Acacia coolgardiensis*, *Cassia chatelainiana*, *Eremophila leucophylla* and *Jasminum calcareum*. The rich ephemeral community (30 species) included numerous species not recorded from previous sampling in 1980 (*Calandrinia eremaea*, *Haloragis trigonocarpa*, *Lobelia winfridaea*, *Thiseltonia dyeri*, *Thysanotus exiliflorus* and *Zygophyllum angustifolia*).

In the Laverton–Leonora Study Area, the transition from Sandplain to Dune was marked by many similarities in vegetation structure and species composition. Tall *Eucalyptus gongylocarpa* trees, common on the flats and surrounding sandplains, tended to be replaced by low trees or mallees of *Eucalyptus youngiana* on the dune slopes and at the base.

Sandplains of loamy sands (Qps), surrounding a dune near Mt Windarra in the Eristoun survey area, supported tall *Eucalyptus gongylocarpa* trees over a dense cover of *Triodia basedowii*. Scattered *Eucalyptus youngiana* and *Acacia aneura* occurred with *Acacia ligulata*, *Brachychiton gregorii*, *Kennedia prorepens* and the grass *Monachather paradoxa*. The ephemerals were slightly more common than in the vicinity of the dune.

Flat Sandplains of deep red sands (Qps), at the base of the dune, supported *Eucalyptus youngiana* Low Woodland over *Triodia basedowii* Hummock Grassland. The vegetation was essentially the same as the dune (see LL6). Sparse trees of *Eucalyptus youngiana* replaced *E. gongylocarpa* while *Triodia basedowii* dominated both the dune and surrounding swales. *Bonamia rosea* and *Kennedia prorepens* was prominent in a sparse lower strata. Rare shrubs included *Brachysema daviesioides*, *Callitris preissii*, *Choretrum glomeratum*, *Grevillea didymobotrya* and *Hakea suberea*. The ephemeral *Ptilotus polystachyus* and the grass *Eriachne mucronata* were abundant, while *Pimelea trichostachya* and *Poranthera microphylla* were also recorded.

Eucalyptus youngiana Mallee occurred on deep red sands (Qps) in the Eristoun survey area (see LL10). *Acacia aneura* was absent from this sandplain site. Sparse shrubs of *Goodenia mueckeana*, *Hakea minyma* and *Keraudrenia integrifolia* grew over *Triodia basedowii*. Other bunch grasses included *Eragrostis lanipes*, *Eriachne flaccida* and *Tragus australianus*. Other ephemerals along with those commonly recorded on sandplains were *Actinobole uliginosum*, *Actinotus* sp. nov. (GK 13005), *Convolvulus erubescens* and *Gnephosis tenuissima*.

In the Laverton–Leonora Study Area, Deep Sandy Earths (Qps) mantle the underlying broad valley (Qqz). Just north of Eristoun Homestead, a mixed *Eucalyptus youngiana* and *E. rigidula* Low Woodland occurred over *Triodia basedowii* Hummock Grassland. Trees of *Acacia aneura* were indicators of the loams and clays beneath the sand veneer. Tall mallees of *Eucalyptus youngiana* and *E. rigidula* occurred over sparse shrubs of *Abutilon cryptopetalum*, *Acacia ramulosa*, *Spartothamnella teucriflora*, rare bunch grasses of *Eragrostis eriopoda* and uncommon ephemerals such as *Calocephalus knappii* and *Chenopodium melanocarpum*.

A similar site occurred in the south-western corner of the Sandstone–Sir Samuel Study Area. These sandplains of Deep Sands (Qs) are marginal to adjacent Broad Valleys (Qz) and supported *Eucalyptus kingsmillii* Mallee (see SS14). Emergent mallees of *Eucalyptus oleosa*

occurred with shrubs of *Acacia coolgardiensis* over the hummock grass *Triodia basedowii*, *Indigofera brevidens* and *Trachymene croniniana*. Ephemerals included *Calandrinia lehmannii*, *Goodenia peacockiana*, *Helipterum verecundum* and *Thysanotus patersonii*.

Sandplains north of the Montague Ranges in the northern section of the Study Area (27°10'S lat., 119°34'E long.) supported *Acacia coolgardiensis* Tall Shrubland on Deep Sands (Qs). The mallee *Eucalyptus kingsmillii*, shrubs of *Hakea suberea* and the hummock grass *Triodia basedowii* were prominent. Other species included *Eucalyptus leptopoda*, *Kennedia prorepens*, *Keraudrenia integrifolia*, *Wehliia thryptomenoides* and the ephemeral *Wurmbea deserticola*. Also occurring in the extreme north of the Study Area were scattered tall trees of *Eucalyptus centralis* which entered marginally in areas of deep sands.

Near Albion Downs, in the north-eastern part of the Sandstone–Sir Samuel Study Area, Sandplains and Dunefields (Qps) occur on the high-lying ground above a Breakaway. Sandy loams retained a firm crust mantled by a veneer of loose sand. *Triodia basedowii* was relatively dense while *Acacia aneura*, dominant on the adjacent Broad Valleys, occurred as widely scattered plants. Occasional mallees *Eucalyptus youngiana* were present over shrubs of *Acacia coolgardiensis*. Ephemerals were virtually absent, with spaces between the hummocks of *Triodia* completely bare. The only ephemeral species noted were *Helipterum stipitatum*, *Myriocephalus gueriniae* and *Waitzia acuminata*.

Sandplains at the base of a sand dune (Qps) in the same vicinity, supported *Eucalyptus youngiana*, *Grevillea juncifolia* and *Hakea francisiana* on loamy sands. Low shrubs of *Thryptomene maisonneuvei* were codominant with *Triodia basedowii*. Ephemerals were limited to very occasional plants and included *Thysanotus patersonii*.

In the northern part of the Sandstone–Sir Samuel Study Area, occasional Sandplain areas have ridges of siliceous rock coated with a hard calcrete, and mantled by siliceous sand. These loamy sands supported Low Woodlands of *Acacia jamesiana*, *Callitris preissii* and *Eucalyptus leptopoda* over the hummock grass *Triodia basedowii*. Scattered shrubs included *Acacia ligulata*, *Eremophila exotrachys*, *Hakea francisiana*, *Keraudrenia integrifolia*, *Pimelea microcephala* and *Santalum acuminatum*. The occasional clumps of *Dianella revoluta* were at the northern limit of their distribution.

To the north of the Montague Ranges, sandplains with more gravel at depth (Czs,Tb,Czl), were characterised by unusually low vegetation dominated by *Eucalyptus leptopoda* or scattered *Xanthorrhoea thorntonii* over well developed *Triodia basedowii*. *Xanthorrhoea thorntonii* grew with occasional *Acacia pachyacra*, *Calothamnus aridus*, *Dampiera incana*, *Daviesia grahamii*, *Hakea francisiana*, *Leptosema chambersii*, *Schoenus globifer* and *Stylidium desertorum*.

Undulating Plains, Greenstone (UN)

Undulating Plains occur in two north-south belts within the Sandstone–Sir Samuel Study Area. Greenstone uplands to the north of Sandstone include the Montague Ranges. In the eastern portion of the Study Area, the Violet Range extends north from Leinster into the Wanjarri survey area.

Undulating Plains are a dominant feature of the Laverton–Leonora Study Area. Greenstone areas extend north-south along the eastern and western borders, and cover the majority of the southern portion of the Study Area.

The vegetation of Undulating Plains in both Study Areas was poorly developed, in comparison with other Study Areas in the Eastern Goldfields. The similarity between the vegetation of Undulating Plains and Broad Valleys made them difficult to distinguish. The general cover was *Acacia aneura* and *A. burkittii* with little perennial understorey apart from sparse *Ptilotus obovatus*. On relatively loose soils of colluvial flats, *Eremophila leucophylla* and grasses of *Eragrostis* occurred.

The herbaceous stratum, however differed markedly from that of adjacent Broad Valleys. Characteristic ephemerals recorded on Undulating Plains included *Brachycome ciliocarpa*, *Calotis hispidula*, *Cephalopterum drummondii*, *Gnephosis brevifolia*, *Helipterum maryonii*, *Helipterum tenellum*, *Helipterum verecundum*, *Isoetopsis graminifolia*, *Lepidium oxytrichum*, *Menkea australis*, *Omphalolappula concava*, *Podolepis canescens*, *Ptilotus aevroides*, *Ptilotus exaltatus*, *P. helipteroides*, *Salsola kali*, *Senecio glossanthus*, *Stenopetalum filifolium*, *S. lineare* and *Vittadinia eremaea*.

Slopes. In the Sandstone–Sir Samuel Study Area, Greenstone uplands (Ab,Qqc) of the Wanjarri survey area supported *Acacia pruinocarpa* Low Woodland (see SS17). Trees of *Acacia pruinocarpa* grew over shrubs of *A. aneura*, *A. burkittii*, *Eremophila oldfieldii*, *E. scoparia* and *Santalum spicatum*. Low shrubs and grasses were very sparse with *Enneapogon caeruleus* the only dominant. The ephemeral community included *Erodium cygnorum*, *Gnephosis skirrophora*, *Haloragis trigonocarpa*, *Lepidium phlebopetalum* and *Thysanotus patersonii*.

Vegetation on Undulating Plains, around the town of Sandstone on the southern boundary of the Study Area, was similar to that described for the adjacent Youanmi–Leonora Study Area (Milewski and Dell 1992). Gravelly soils, derived from deeply lateritized greenstone, supported vegetation dominated by *Acacia aneura*. Tall shrubs of *Acacia ramulosa*, or *Acacia quadrimarginea* and *A. burkittii* (where bedrock was exposed) tended to replace *Acacia aneura* on rises. Other prominent shrubs included *A. tetragonophylla*, *Eremophila macmillaniana* and *E. longifolia* while *Acacia craspedocarpa* was present in areas of run-on. A notable absentee from this vegetation was *Acacia pruinocarpa*, recorded in the northern part of the Study Area and the adjacent Duketon–Sir Samuel Study Area (Milewski and Keighery 1992). The herbaceous stratum differed from that of adjacent Broad Valleys. The diverse ephemeral community included *Gnephosis foliata*, *Helipterum charsleyae* and *Stenopetalum anfractum*.

On Undulating Plains near Laverton in the south-eastern corner of the Laverton–Leonora Study Area were scattered areas of *Acacia aneura* over *Maireana sedifolia*. Bedrock was exposed in places as vertically ribbed blades. Trees of *Acacia aneura* were mainly in small drainage lines within the Undulating Plain. Other shrubs included *Acacia stowardii*, *Casuarina cristata*, *Eremophila scoparia*, *Hakea arida*, *Lepidium pholidogynum*, *Maireana glomerifolia*, *M. triptera*, *Podolepis capillaris*, *Ptilotus obovatus* and *Sida calyxhyemia*. *Helipterum tenellum* was the most common ephemeral in a characteristic community that included *Ptilotus aevroides*, *Salsola kali*, *Senecio glossanthus* and *Stenopetalum lineare*.

Outcrops of Basalt bedrock in Undulating Plains near Laverton supported *Acacia aneura* Tall Shrublands. Other shrubs growing on the outcrop and slopes were *Acacia tetragonophylla*, *Cassia sturtii*, *Podolepis capillaris*, *Santalum spicatum*, *Thysanotus patersonii* and the ephemerals *Haloragis gossei*, *Helichrysum ayersii*, *Stackhousia clementii*

and *Swainsona incei*. Near the outcrop *Cassia desolata*, *Dodonaea filifolia* and *Eremophila leucophylla* occurred with *Euphorbia drummondii*, *Podolepis canescens* and *Stenopetalum filifolium* where bedrock was close to the surface. Present on the lower slopes were the ephemerals *Calotis multicaulis*, *Lepidium rotundum*, *Ptilotus aervoides* and *P. helipteroides*. Associated with areas around mining excavations, where the calcareous sub-soil had been brought to the surface, were *Enneapogon caeruleus*, *Ptilotus exaltatus*, *Salsola kali* and *Vittadinia arida* while *Brachycome ciliocarpa*, *Calotis hispidula*, *Daucus glochidiatus*, *Helipterum oppositifolium* and *Senecio glossanthus* were recorded in with surface leaf litter.

In the south-eastern corner of the Laverton–Leonora Study Area, trees of *Acacia aneura* occurred with the shrubs *Eremophila margarethae* and *Maireana convexa* over bunch grasses such as *Eriachne mucronata*. The ephemerals included *Brachycome iberidifolia*, *Calocephalus skeatsianus*, *Helipterum laeve* and *Sida filiformis*.

In the extreme north-eastern corner of the Study Area near Cosmo Newbery, Undulating Plains of greenstone supported *Acacia grasbyi* over *Eriachne helmsii* and *Ptilotus obovatus* with *Acacia aneura* on the lower slopes.

Colluvial flats. In the western section of the Sandstone–Sir Samuel Study Area near Barrambie, colluvial flats (Qqc) within Undulating Plains supported *Maireana pyramidata* Low Shrubland (see SS16). *Maireana pyramidata* dominated a sparse vegetation that included *Atriplex vesicaria*, *Cratystylis subspinescens*, *Hakea arida* and *Sclerolaena cuneata* over bunch grasses. Prominent in the ephemeral community were *Calandrinia eremaea*, *Dichromochlamys dentatifolia*, *Gunniopsis septifraga*, *Helipterum strictum*, *Plantago drummondii*, *Quinqueremulus linearis* and *Zygophyllum aurantiacum*. A small depression present within this area had a denser covering of *Acacia tetragonophylla*, *Pittosporum phylliraeoides*, *Scaevola spinescens* and *Exocarpos aphyllus*. These species were rare in the main portion of the site.

Colluvial flats and lower slopes (Qqc,Ab) near Mt Morgans, in the southern half of the Laverton–Leonora Study Area, supported *Acacia aneura* Low Woodland (see LL12). Trees of *Acacia quadrimarginea* occurred over a sparse but diverse shrub layer that included *Acacia ramulosa*, *Cassia artemisioides*, *Eremophila platycalyx*, *Euphorbia drummondii*, *Maireana georgei*, *Rhagodia drummondii* and *Solanum sturtianum*. The lower strata of shrubs were dominated by species of *Sclerolaena* (*S. convexula*, *S. eriacantha*, *S. gardneri*, *S. obliquicuspis* and *S. patentiscuspis*). The rich ephemeral community (nearly 50 species) included *Calotis multicaulis*, *Daucus glochidiatus*, *Euphorbia boophthona*, *Helipterum craspedioides*, *Velleia glabrata* and *Wahlenbergia gracilis*.

A colluvial flat (Qqc) within gently Undulating Plains near Laverton supported *Acacia aneura* over bunch grasses of *Aristida contorta*, *Eragrostis eriopoda*, *E. mucronata* and *Monachather paradoxa*. The soils appeared to be derived from banded ironstone bedrock in the vicinity as a number of perennials show links to those occurring on Banded Ironstone Formations (see Hills). Perennial shrubs were sparse and included *Eremophila margarethae*, *E. leucophylla*, *Maireana carnosae* and *Solanum lasiophyllum*. The distinctive *Helipterum verecundum* was prominent in the rich ephemeral community recorded on the colluvial slopes and flats that also included *Helipterum battii*, *Ptilotus macrocephalus*, *Symphobasis macropectra* and *Trachymene ornata*.

Flats (Qqc) at the base of Basalt outcrops near Laverton, supported Low Woodlands of

Acacia aneura over a fairly dense cover of herbs. The ephemeral *Myriocephalus gueriniae* was only observed on deep colluvial soils at the base of the outcrop where occasional sandy-bottomed drainage channels occurred.

Broad Valleys (V)

Broad Valleys supporting *Acacia aneura* associations were the dominant landform and vegetation type in the Sandstone–Sir Samuel and Laverton–Leonora Study Areas.

These vegetation associations, characterised by *Acacia aneura*, reflected their position and the influence of drainage within the Broad Valley landform. These ranged from flat plains and valley slopes to areas that accumulated run-on and valley floors. Within Broad Valleys, the vegetation extended onto shallow, stony soils (Qqz, Qqc) and relatively sandy soils (Qps).

The general vegetation of Broad Valleys in the Study Areas had an upper stratum that consisted of *Acacia aneura* over tall shrubs and herbs. The most commonly recorded annual species were *Calandrinia polyandra* and *Waitzia acuminata*. Other ephemerals characteristic of Broad Valleys were *Actinobole uliginosum*, *Brachycome ciliocarpa*, *Brunonia australis*, *Calandrinia eremaea*, *Calocephalus knappii*, *Calotis hispidula*, *Crassula colorata*, *Erodium cygnorum*, *Gnephosis tenuissima*, *Goodenia havilandii*, *Haloragis trigonocarpa*, *Helipterum craspedioides*, *H. roseum*, *Isoetopsis graminifolia*, *Myriocephalus rhizocephalus*, *Podolepis capillaris*, *P. canescens*, *Ptilotus gaudichaudii*, *P. polystachyus*, *Stenopetalum anfractum* and *Velleia hispida*.

Valley slopes and flat plains. In both Study Areas soils are shallow and stony on the relatively elevated parts of Broad Valleys (Qqz, Qqc, Qz). The vegetation was low and open and tended to be severely degraded by domestic stock. In places, the upper stratum of *Acacia aneura* was largely dead, leaving unpalatable shrubs of *Eremophila fraseri* and *Eremophila spectabilis*. About 30 ephemeral species coexisted (see list above for the most common species).

In the northern half of the Sandstone–Sir Samuel Study Area, structural complexity in the *Acacia aneura* Low Woodland was increased by trees of *Acacia pruinocarpa* and *A. craspedocarpa*. Occasional *Acacia linophylla*, *A. sclerosperma* and *A. tetragonophylla* were also present. There was a well developed herbaceous component that consisted of *Lepidium phlebopetalum*, *Ptilotus exaltatus* and *Sclerolaena gardneri*. Ephemerals included *Calocephalus francisii*, *Helipterum floribundum*, *Helipterum maryonii*, *Menkea villosula* and *Ptilotus gaudichaudii*.

Flat plains (Qqz) in the Wanjarri survey area supported *Acacia aneura* Low Woodland (see SS19). Low shrubs of *Eremophila spectabilis* were prominent in the sparse understorey. Other shrubs included *Acacia tetragonophylla*, *A. craspedocarpa*, *Dianella revoluta* and *Eremophila leucophylla*. Perennial grasses included *Eragrostis eriopoda* and *Monachather paradoxa*. Small areas of the hummock *Triodia basedowii* were also present. The ephemeral community recorded on these flat plains was not as rich as those found in drainage and run-off areas. Prominent amongst the ephemerals were *Actinobole condensatum*, *Quinqueremulus linearis* and *Ptilotus macrocephalus*.

In the north-eastern part of the Sandstone–Sir Samuel Study Area near Albion Downs, flat plains (Qqz) have moderately shallow, colluvial soils typically found within Broad Valleys. The soil, a dark reddish brown loam, supported degraded *Acacia aneura* with some *Acacia pruinocarpa*, *Acacia tetragonophylla* and *Eremophila fraseri* and a very sparse lower stratum

dominated by *Ptilotus obovatus*. Very sparse tufts of wanderrie grasses (*Eragrostis*, *Monachather*) were present. The ephemerals included *Cephalipterum drummondii*, *Gilruthia osbornei*, *Goodenia mimuloides*, *Podolepis kendallii* and *Maireana carnososa*.

In the Laverton–Leonora Study Area, alluvial plains (Qqz) of the Erlistoun survey area supported *Acacia aneura* Tall Shrubland. Other species included *Acacia tetragonophylla*, *Dianella revoluta*, *Eucalyptus lucasii*, *Hakea suberea* and *Santalum lanceolatum*. In addition to annuals commonly found on Broad Valleys, the ephemeral community (over 30 species) also included *Gnephosis pygmaea* and *Plantago drummondii*.

Linking flat plains and low-lying drainages are broad sloping areas. Broad Valley quartz gibber slopes (Qqc) in the Wanjarri survey area supported *Eremophila fraseri* Tall Shrubland (see SS20). The *Acacia aneura* upper stratum had been effectively removed by fire. Other shrubs were *Eremophila foliosissima*, *E. latrobei*, *E. margarethae* and *Spartothamnella teucriflora*. Several grasses formed a distinctive understorey comprised of *Aristida contorta*, *Eriachne helmsii*, *E. pulchella*, *Eragrostis dielsii*, *E. eriopoda*, *E. falcata* and *Monachather paradoxa*. Prominent ephemerals included *Calandrinia creethae*, *Calocephalus multiflorus*, *Cephalipterum drummondii* and *Gnephosis tenuissima*.

In the north-eastern part of the Sandstone–Sir Samuel Study Area, slopes strewn with stones of white quartz (Qqc) beneath a breakaway, are marginal to Broad Valleys. The *Acacia aneura* cover was once again sparse and replaced by *Eremophila fraseri*. Ephemerals were typical of shallow stony soils: *Chthonocephalus pseudevax*, *Euphorbia boophthona*, *Pogonolepis stricta*, *Gnephosis burkittii*, *Helipterum craspedioides*, *Pogonolepis stricta* and *Ptilotus aervoides*.

In many parts of the two Study Areas, sands (Qps) mantle the underlying flat plains (Qqz). In other areas, the Broad Valleys border Sandplains which also has a marked influence on the vegetation structure and composition. Distinctive species included *Acacia aneura* and *Eremophila leucophylla* along with *Eucalyptus kingsmillii*, *E. rigidula* and *E. youngiana* while *Triodia basedowii* was a characteristic dominant in the lower strata.

In northern parts of the Wanjarri survey area, thin sheets of red sands (Qps) cover the flat valley plains (Qqz). Where the Broad Valleys are influenced by the adjacent Sandplains, Mallees of *Eucalyptus kingsmillii* and *E. rigidula* occurred with *Acacia aneura* Tall Shrubland (SS21). The characteristic hummock grass *Triodia basedowii* was also indicative of the Sandplain influence. Other shrubs included *Acacia coolgardiensis*, *A. ligulata* and *Eremophila leucophylla*. Ephemerals included *Goodenia occidentalis*, *Haloragis odontocarpa*, *Helichrysum davenportii*, *Poranthera microphylla* and *Symphyobasis macropectra*.

On Broad Valleys at the edge of Sandplains in the Sandstone–Sir Samuel Study Area, sandy soils were characterised by an emergent stratum of *Eucalyptus oleosa* var. *plenissima* or a tall shrub stratum of *Acacia ramulosa*. *Acacia aneura* grew with *Eremophila leucophylla* which formed an open but conspicuous lower stratum while the hummock grass *Triodia basedowii* was also present. The ephemerals had strong links to Sandplain communities and although common, were strongly clumped under shrubs, leaving bare ground in the spaces between. The following combination of ephemerals was typical of the threshold between Mulga and spinifex communities throughout the northern half of the Eastern Goldfields: *Erodium*

cygnorum, *Helichrysum davenportii*, *Myriocephalus gueriniae*, *Stenopetalum anfractum* and *Waitzia acuminata*.

At the edge of Sandplains, the soils of Broad Valleys are dark reddish brown sandy loams with a brittle crust. Ephemeral species noted on Broad Valleys sites at the edge of Sandplains included *Actinobole uliginosum*, *Brunonia australis*, *Chrysocoryne pusilla*, *Goodenia peacockiana*, *Helipterum maryonii*, *Podolepis canescens* and *Ptilotus polystachyus*.

Broad Valleys at the edge of Sandplains near Albion Downs in the north-eastern part of the Study Area, have a slightly sandier soil, characterised by more Wanderrie grasses and traces of *Triodia*. *Eremophila foliosissima* and *E. leucophylla* entered as an understorey while *Actinobole condensatum*, *Goodenia occidentalis*, *Haloragis odontocarpa*, *Helipterum craspedioides* and *Velleia rosea* were common ephemerals. Other areas in the vicinity also tended towards sandier soils. *Triodia basedowii* was dominant under an upper stratum of *Acacia aneura*, *A. pruinocarpa* and *A. ramulosa*. Ephemerals were clearly concentrated around the perennial plants and the main species were *Calotis hispidula*, *Helichrysum davenportii*, *Podolepis canescens* and *Myriocephalus gueriniae*.

In the Laverton–Leonora Study Area, *Eucalyptus* Mixed Mallee and *Acacia aneura* Low Woodland over *Triodia basedowii* Hummock Grassland (see LL4) bordered salt lakes in the Erlistoun survey area. Mallees and low trees of *Acacia aneura*, *Eucalyptus kingsmillii*, *E. youngiana* and *E. rigidula* grew over shrubs of *Acacia colletioides*, *A. ligulata*, *A. murrayana*, *Atriplex vesicaria*, *Duboisia hopwoodii*, *Eremophila exotrachys*, *Hakea suberea*, *Maireana pyramidata* and *Olearia subspicata*. The grasses, dominated by *Triodia basedowii*, included *Aristida contorta*, *Eragrostis eriopoda* and *Eriachne helmsii*. The ephemeral community comprised *Brunonia australis*, *Calandrinia primuliflora*, *Gnephosis foliolata*, *Lepidium phlebopetalum* and *Zygophyllum eremaeum*.

Sandplain and Broad Valley communities to the east of the Laverton–Leonora Study Area tended to merge. The soil depth influenced the vegetation with *Eucalyptus gongylocarpa* Low Woodlands restricted to deep sands and mallee formations of *Eucalyptus concinna*, *E. leptopoda*, *E. lucasii* and *E. youngiana* occurring on shallow sands. *Triodia basedowii* is however common as the overstorey changes between communities of Low Woodlands, Mulga and Mallees, Mallee Shrublands to Mulga over *Triodia*.

Broad Valleys (Qps) in the eastern portion of the Laverton–Leonora Study Area near White Cliffs Station had scattered *Acacia aneura* co-dominant with the mallees of *Eucalyptus concinna*, *E. leptopoda* and *E. lucasii*. A characteristic of this vegetation was the tendency for the shrubs (species of *Rhagodia*, *Ptilotus*, *Cassia*, *Eremophila*, *Acacia*) to cluster under the *Eucalyptus* canopies. The grasses *Eragrostis dielsii* and *Eriachne pulchella* were present alongside the dominant *Triodia basedowii*. Other plants included *Acacia colletioides*, *Eremophila latrobei*, *Grevillea sarissa* and *Solanum orbiculatum*. Rare ephemerals were *Convolvulus erubescens*, *Calandrinia polyandra*, *Velleia glabrata*, *Waitzia acuminata* and *Zygophyllum ovatum*.

Valley floors. Sheet flooding is a feature throughout Broad Valleys in both of the Study Areas. Some areas tend to accumulate run-on, resulting in vegetation of slightly different composition to sites on the surrounding slopes. The ephemeral communities in particular, illustrated the marked effect these floodways and shallow drainage areas had on species diversity and richness.

Outwash plains (Qa) in the western section of the Sandstone–Sir Samuel Study Area, on the edge of a small area of Undulating Plains near Barrambie, supported low trees of *Acacia aneura* over a distinctive combination of ephemerals. *Acacia aneura* was weakly dominant and grew with *A. craspedocarpa* and *Hakea arida*. A perennial understorey was virtually absent except for *Cassia chatelainiana* and *Sclerolaena burbidgeae*. *Calotis multicaulis* was a common ephemeral characteristic of run-on zones, as was the less common *Podolepis kendallii*.

In the north-eastern part of the Sandstone–Sir Samuel Study Area near Albion Downs, a small wash drained stony breakaway country. Sandy grooves traversed the surface, which was largely free of stones. The upper stratum was composed of *Acacia aneura* with *A. craspedocarpa* and sparse *A. tetragonophylla*. Ephemerals were abundant and diverse: *Helipterum craspedioides* and *H. maryonii* were particularly common, growing with *Actinobole uliginosum*, *Brachycome ciliocarpa*, *Lepidium oxytrichum*, *Maireana carnosae* and *Velleia rosea*.

In the Sandstone–Sir Samuel Study Area, a shallow floodway (Qpv) within the extensive Broad Valleys (Qqz) of the Erlistoun survey area supported *Acacia aneura* Low Woodland (see SS18). Low trees of *Acacia aneura* formed a dense upper stratum over tall shrubs of *Acacia craspedocarpa*, *A. tetragonophylla*, *Eremophila fraseri*, *E. leucophylla* and *Spartothamnella teucriflora*. Both *Santalum lanceolatum* and *S. spicatum* were present. The low shrub strata comprised *Eremophila margarethae*, *Dianella revoluta* and *Ptilotus obovatus* while the bunch grasses included *Aristida contorta*, *Eragrostis eriopoda*, *Eriachne pulchella* and *Monachather paradoxa*.

A very rich and diverse ephemeral community of over 60 species was recorded in the broad drainage channel. Prominent ephemerals included all of the characteristic species found on most Broad Valleys. Owing, in part, to exceptional rains a number of less common ephemerals were also recorded: *Abutilon cryptopetalum*, *Agrostis avenacea*, *Bulbostylis barbata*, *Calotis lappulacea*, *Centipeda cunninghamii*, *Chondropyxis halophila*, *Euphorbia drummondii*, *Phyllanthus lacunellus*, *Plantago drummondii*, *Pogonolepis muelleriana*, *Portulaca oleracea* and *Wahlenbergia gracilis*.

In the Laverton–Leonora Study Area, a drainage valley floor (Qpv) in the Erlistoun survey area supported *Acacia aneura* Low Woodland (see LL5). Trees of *Casuarina cristata*, *Eremophila longifolia*, *Eucalyptus brachycorys*, *Hakea suberea* grew over shrubs of *Acacia tetragonophylla*, *Cassia artemisioides* and *Melaleuca uncinata*. Bunch grasses were dominated by *Eragrostis pergracilis*. Prominent ephemerals were *Calandrinia polyandra*, *Helipterum battii* and *Ptilotus gaudichaudii*. Other annuals included *Euphorbia drummondii*, *Ptilotus macrocephalus* and *Schoenia cassiniana*.

Discussion

The Sandstone–Sir Samuel and Laverton–Leonora Study Areas are located within the Austin Botanical District of the Eremaean Botanical Province (Beard 1980). The eastern side of the Laverton–Leonora Study Area overlaps marginally into the Helms Botanical District (Great Victoria Desert). The adjacent Great Victoria Desert is, however, a major influence on the vegetation of both Study Areas and the survey areas, as Wanjarri and Erlistoun were located in the eastern portion of their respective Study Area.

The Sandstone–Sir Samuel Study Area falls within the Wiluna Subregion of the Austin Botanical District (Eremaean Botanical Province) while the majority of the Laverton–Leonora Study Area is located in the Laverton Subregion of Beard (1974, 1976). The Laverton Subregion is virtually restricted to the Eastern Goldfields. The broadening of the vegetation patterning from southern Study Areas in the Eastern Goldfields could also be clearly discerned. For example, the Kurnalpi–Kalgoorlie Study Area has eight distinct Vegetation Systems (Keighery *et al.* 1992).

The reliability of the previously existing vegetation maps covering the Study Areas was assessed in the light of this present survey. At the scale of 1:600,000 (Carnahan 1976), the vegetation of the Study Areas was mainly *Acacia aneura* communities and *Eucalyptus* low open-woodlands with *Triodia* hummock grasses. Structural formations of vegetation for the Sandstone–Sir Samuel and Laverton–Leonora Study Areas have been described and mapped at a scale of 1:1,000,000 (Beard 1974, 1976), although dyeline maps at a scale of 1:250,000 were prepared to compile these maps. These maps provide a more appropriate view of the vegetation, based on structure and dominant floristics.

The Sandstone–Sir Samuel and Laverton–Leonora Study Areas form part of the extensive Mulga area of arid Australia which stretches virtually across the continent, with many shared features of climate, landforms, soils, vegetation structure and flora (Moore 1973, Jessup 1981). Low Woodlands (4–8 m), chiefly *Acacia aneura*, dominated the entire Sandstone–Sir Samuel and Laverton–Leonora Study Areas, and were only absent from salt lakes, dune crests and parts of the granite complex. *Eucalyptus* communities were prominent on Sandplain and Dunefield areas (*Eucalyptus gongylocarpa* Low Woodlands and mixed Mallees) and along Drainage Lines (*Eucalyptus camaldulensis* and *E. loxophleba*). The dominant *Acacia aneura* communities tended to merge and overlap throughout the Study Areas.

There appeared to be no major transitions of vegetation communities across the Study Areas, in keeping with the broad climatic gradients present. Some floristic comparisons could be made with other Study Areas in the Eastern Goldfields and with the Great Victoria Desert to the east (Beard 1974, Jessup 1981). The exhaustive species lists of perennial plants incorporated into Appendix 1 will form the basis for quantitative analyses in a subsequent overview of the Eastern Goldfields.

The Study Areas of the Eastern Goldfields are located within the eastern portion of the Austin Botanical District (see Figure 1 and Beard 1980). However, the precision of floristic quadrat data to the north and west of these Study Areas, did not allow any appraisal of phytogeographic relationships to be made. There are no equivalent detailed flora descriptions for either the Carnegie Salient of the Ashburton Botanical District (Beard 1980) or for the Austin Botanical District to the west of the Eastern Goldfields.

The communities of the Study Areas contained almost no south-western influences, unlike the Edjudina–Menzies and Barlee–Menzies Study Areas to the south, where some elements are found on the Sandplains and Dunefields (Milewski and Keighery 1988, Keighery *et al.* in prep). In the Sandstone–Sir Samuel and Laverton–Leonora Study Areas, these elements were scattered and confined largely to the southern (*Verticordia interioris*) and western margins (*Hybanthus floribundus* ssp. *curvifolius*). In the northern four Study Areas of the Eastern Goldfields (see Figure 1), the influences on Sandplain communities are almost entirely from the Great Victoria Desert rather than south-western (see also Milewski and Dell 1992,

Milewski and Keighery 1992). The scattered granite areas also tended to support floras with desert affinities rather than of the south-west.

The north-western margins of both Study Areas showed signs of the transition to the Ashburton flora (e.g. *Eucalyptus centralis* entered marginally in areas of deep sands in the extreme north of the Sandstone–Sir Samuel Study Area and *Santalum lanceolatum* occurred on heavier soils in the Study Area), but this transition occurred further north.

The flora list (see Appendix 2) for the Sandstone–Sir Samuel and Laverton–Leonora Study Areas was combined, making precise comparisons with the adjacent Youanmi–Leonora Study Area (Milewski and Dell 1992) and Duketon–Sir Samuel Study Area (Milewski and Keighery 1992) difficult. The vegetation however, displayed a general east-west trend towards the Helms Botanical District across all four of these northern Study Areas, with a gradual transition to the Great Victoria Desert in the east. For example, *Eucalyptus gongylocarpa* communities appeared to reach their western and southern limits in these Study Areas (Milewski and Dell 1992). Also, several sandy desert species, normally found in the Great Victoria Desert, were located in the Dunefields of the Wanjarri survey area at the western edges of their ranges (e.g. *Levenhookia chippendalei* and *Polygala isingii*).

The vegetation of Undulating Plains in both of the Study Areas was poorly developed, in comparison with other Study Areas in the Eastern Goldfields. It was often difficult to distinguish between the similar vegetation of Undulating Plains and Broad Valleys, in contrast to the marked differences apparent in southern Study Areas such as the Kurnalpi–Kalgoorlie Study Area (Keighery *et al.* 1992).

The flora of the Study Areas had not previously been systematically recorded and documented. During the present survey, 784 taxa were recorded from the two Study Areas. The Sandstone–Sir Samuel and Laverton–Leonora Study Areas contained six Priority taxa, some of them geographically restricted, a number of undescribed species but no gazetted rare flora (Atkins 1992).

Priority One taxa were *Calytrix praecipua*, *Eremophila annosocaula*, *E. mirabilis* and *Philotheca tubiflora*. Priority Three taxa recorded were *Verticordia interioris* and *Frankenia georgei*. An apparently undescribed *Lobelia* sp. (GK 13008) was located on a gypsum dune in salt lakes of the Eristoun survey area. This was also the site of a *Stipa* sp. (GK 13007) which was allied to *S. pycnostachya*, and may also prove to be an undescribed species. Range extensions recorded during the survey included *Actinotus* sp. nov. (GK 13005), a poorly known species extended from near *Zanthus*, and *Calandrinia* sp. nov. (GK 13001), extended from the Mt Manning Ranges. Around old mines, roadsides, settlements and bores numerous range extensions of weed (naturalized alien) species were recorded (e.g. *Arctotheca calendula*, *Hymenolobus procumbens* and *Raphanus raphanistrum*).

During the survey, 7 species of fern and 777 taxa (265 genera, 71 families) of flowering plants were recorded from the Sandstone–Sir Samuel and Laverton–Leonora Study Areas. Families with the largest numbers of species were Asteraceae (108 spp.), Chenopodiaceae (83 spp.) and Poaceae (70 spp.). Genera with numerous species were *Eremophila* (47 spp.), *Acacia* (33 spp.), *Helipterum* (24 spp.), *Eucalyptus* (22 spp.), *Maireana* (21 spp.), *Sclerolaena* (21 spp.) and *Ptilotus* (19 spp.).

The flora of the Study Areas is still incompletely known. Due to the large area and poor access, none of the landforms were adequately sampled. Consequently, there is scope for

further intensive botanical investigation of both Study Areas. In particular, Greenstone communities and Breakaways were inadequately surveyed. Archean surfaces, although a major feature throughout the Eastern Goldfields, were generally poorly sampled in these northern Study Areas (see Milewski and Dell 1992, Milewski and Keighery 1992). Breakaways were also not adequately sampled due to their complex, ecotonal nature and their scattered locations. However, sites sampled at Wanjarri exhibited high species diversity (see SS1-2).

Rare or very uncommon species important for conservation were not specifically surveyed for, and often occupied shallow soils and inaccessible habitats on Breakaways and Hills. Because sampling was concentrated on reasonably undisturbed areas, the introduced flora found in disturbed areas was also inadequately documented.

The former use of fire by Aboriginal people in the Study Areas is unknown, although it is generally recognized that hummock grasslands in central Australia were regularly burnt by these nomadic hunter-gatherers (Kimber 1983). The Study Areas have been considerably modified by human activities in the form of mining and pastoralism. The main impacts of human use have been on the Undulating Plains and Broad Valleys, where gold tends to occur or where soils are relatively productive for soft herbaceous growth. Here, the soil cover is shallow, fragile or easily compacted, and the environment suits introduced types of plants. Hence, the Mulga communities of the Study Areas have suffered widespread degradation. The scattered granite rocks throughout the Study Areas have also been heavily used for water and by stock. However, large parts of both Study Areas are highly infertile, unproductive Sandplains (see Figures 2 and 3) which have been little touched by human activity and remain in a virtually natural state.

The only existing conservation reserve in the Sandstone-Sir Samuel and Laverton-Leonora Study Areas is Wanjarri Nature Reserve. On Wanjarri Nature Reserve we recorded 301 species of vascular plants (Appendix 2), 38% of the flora recorded from both Study Areas. Further species would be expected if minor landforms were visited over several seasons. The landforms conserved in this reserve are mainly Broad Valleys along with minor areas of Dunefields, Granite Exposures, Hills, Drainage Lines, Breakaways and Sandplains. Salt Lake Features and Calcareous Plains are not represented while Undulating Plains are marginal. Wanjarri Nature Reserve does not represent the diversity of surface types and vegetation communities that occur across the Study Areas. Also, much of Wanjarri Nature Reserve has suffered intense degradation, in common with other areas of stony slopes within Broad Valleys, where the composition of the Mulga communities has been considerably altered (e.g. see sites SS19 and SS20).

Recommendations for nature conservation reserves in the Eastern Goldfields (Henry-Hall 1990) did not include the mainly pastoral areas of the Sandstone-Sir Samuel and Laverton-Leonora Study Areas. We recommend further study to appraise the conservation values of both Study Areas.

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