VEGETATION AND FLORA

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Background

The vegetation of the Boorabbin–Southern Cross Study Area was described from plotless sample sites, as specified by the Biological Surveys Committee of Western Australia (1984). Forty-two vegetation sites were chosen to represent the 6 landform units that occur in the Study Area (Figure 2). On the basis of structure and species composition of the upper stratum, the sites are broadly classified into vegetation-types. One of these types (Granite) was referred to as a vegetation complex, because attributes such as structure and species composition changed markedly over distances of a few metres.

Full descriptions of the 42 vegetation sites are provided in Appendix 1, together with relevant data on geology, landforms and soils. Although these detailed site descriptions are central to this paper, they 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 provide a cross-reference summary, and to be read in conjunction with the text below, in which brief vegetation descriptions are integrated with landform units and landform elements. The commonest species are listed in the text below, but all may not occur together. Introduced species are indicated by an asterisk. Some of the vegetation sites described below are not listed in Appendix 1. Reference to Appendix 2, however, provides a complete listing, by landform unit, of the flora we recorded in the Boorabbin–Southern Cross Study Area.

Plates 1–16 provide examples of the various vegetation types present in the Study Area (see Appendix 1). Fifteen of the 16 sites that were re-visited in September 1993 showed no visible change from the original survey period (1979–1982). Only at site BS26 (BN1) had the vegetation changed substantially. This site had been burnt in a bushfire since sampling, and was regenerating as a mixed *Grevillea* spp. open shrubland with no dominance of *Grevillea excelsior*, as noted in 1981.

Vegetation Descriptions

Breakaways (B)

<u>Slopes and summits</u>. *Eucalyptus capillosa* Low Woodland was present on Breakaways in the western and middle sections of the Study Area. This species was replaced by *Eucalyptus loxophleba* Mallee south-west of Coolgardie. The Breakaway seen at the latter location was eroded into a rubble slope of *ca.* 5°. The lower vegetation strata under *Eucalyptus capillosa* graded from those with steep scree slopes, to those reduced by erosion to gentle scree slopes. On Breakaways with steep slopes, tall shrubs were absent under *E. capillosa*, and *Calytrix tetragona* with *Acrotriche patula* were the only low shrubs present. Several annuals were present, the most prominent being **Mesembryanthemum nodiflorum*, **Vulpia myuros* and *Calandrinia calyptrata*. On the moderate slopes were tall shrubs of *Grevillea paradoxa*, the low shrubs *Beyeria lechenaultii* and *Spyridium complicatum* over sedges of *Schoenus brevisetis* and *Lepidosperma drummondii* with the perennial grass *Triodia scariosa*. Under

Eucalyptus loxophleba were tall shrubs of *Alyxia buxifolia, Eremophila alternifolia* var. *angustifolia* and *Melaleuca leiocarpa* over the low shrubs *Dodonaea boroniifolia, D. inaequifolia* and *Maireana georgei*. Sedges and annuals were absent.

Granite Exposures (G)

Several annuals, common in almost all vegetation types on Granite Exposures throughout the Study Area, are listed here, but not repeated in subsequent descriptions: *Actinobole uliginosum, *Aira caryophyllea, Hyalochlamys globifera, Calandrinia calyptrata, C. granulifera, Chthonocephalus pseudevax, Crassula exserta, Gnephosis tenuissima, *Pentaschistis airoides* and *Waitzia acuminata*.

Skeletal soil sheets and inner aprons. The skeletal soils (5–50 cm thick) on and peripheral to the exposure supported Granite Complex, consisting of tall shrubs such as *Thryptomene australis, Leptospermum erubescens* and *Kunzea pulchella* over the low shrubs *Isotoma petraea, Borya nitida, Stypandra imbricata* and *Stackhousia huegelii* with perennial grasses of *Aristida contorta, Eriachne ovata* and *Spartochloa scirpoidea*. Also present were the ferns *Cheilanthes austrotenuifolia, Pleurosorus rutifolius* and *Ophioglossum lusitanicum*, the sedge *Lepidosperma resinosum* and annuals such as *Podolepis lessonii, Pterostylis nana* complex, *Drosera glandulifera* and *D. subhirtella* ssp. *moorei*. Some other species were restricted to sections of the Study Area: tall shrubs of *Dodonaea attenuata* and *Acacia dempsteri* (southern), annuals of *Drosera andersoniana* and *D. peltata* (northern) and mallees of *Eucalyptus websteriana* near Coolgardie. Small and shallow pools were present on most exposures during the winter and early spring. *Glossostigma drummondii* occurred in pools less than 5 cm deep, and occasionally *Myriophyllum petraeum* in deeper pools.

Outer aprons. Tall shrubland, mallee and low woodland were present on the outer apron where the thickness of the soil profile was 50–120 cm. *Acacia acuminata* Tall Shrubland was present around the periphery of almost all exposures sighted during field work, while *Acacia coolgardiensis* Tall Shrubland was rare in this situation. Growing with *A. acuminata* were tall shrubs such as *A. beauverdiana, Santalum acuminatum* and *Melaleuca uncinata* with the low shrubs *Borya nitida, Prostanthera grylloana* and *Disphyma crassifolium*. Perennial grasses were variable and included *Aristida contorta, Eragrostis dielsii* and *Triodia scariosa* while sedges of *Lepidosperma viscidum* were sometimes present with annuals such as *Helipterum hyalospermum* and *Calocephalus angianthoides*. Other tall shrubs present in *Acacia coolgardiensis* Tall Shrubland were *A. acuminata, Leptospermum erubescens* and *Thryptomene australis*. The low shrub *Baeckea crispiflora* occurred with the sedge *Lepidosperma drummondii* and annuals such as *Drosera subhirtella* ssp. *moorei, Gonocarpus nodulosus* and *Trachymene cyanopetala* var. *cyanopetala*. Tall shrubs of *Acacia sessilispica* were present only in the western section.

Eucalyptus loxophleba Mallee was common on the outer apron, in the deeper soils. Also present were mallees of *E. gracilis* over tall shrubs such as *Acacia beauverdiana, A. hemiteles, A. jennerae, Exocarpos aphyllus* and *Eremophila paisleyi* with the low shrubs *Acacia erinacea, Carpobrotus rossii, Olearia muelleri* and *O. pimelioides*. The perennial grass *Stipa trichophylla* grew over annuals such as *Helipterum demissum, H. laeve* and *Schoenia cassiniana*. *Allocasuarina huegeliana* Low Woodland was only sighted once near the western

boundary of the Study Area. Tall shrubs such as *Acacia acuminata* and the annuals *Nicotiana rotundifolia* and **Vulpia myuros* were also present in this community.

Salt Lake Features (L)

Lake floors. *Halosarcia* Low Shrubland occurred on Saline Soils of most salt lake floors, associated saline flats and drainage lines. Often the floors of larger salt lakes were devoid of vegetation. The main low shrubs were *Halosarcia halocnemoides* ssp. *halocnemoides, H. undulata, H. doleiformis, Maireana glomerifolia* and *Disphyma crassifolium* over annuals such as *Pogonolepis stricta, Brachycome pusilla* and *Hyalochlamys globifera.*

Lake slopes and dunes. The western and southern margins of most salt lakes were normally fringed by low peripheral dunes (1–3 m high) of Aeolian Sands and Loams. *Eucalyptus hypochlamydea* Mallee was the principal vegetation of low sandy dunes, while *Eucalyptus salicola* Low Woodland was present on the higher dunes.

With the mallee vegetation were tall shrubs such as *Callitris preissii* ssp. *verrucosa, Acacia jennerae, A. hemiteles* and *Santalum acuminatum.* Low shrubs such as *Olearia muelleri, Phebalium filifolium* and *Westringia rigida* occurred with perennial grasses, usually *Triodia scariosa,* and sedges such as *Lepidosperma drummondii, Lepidobolus preissianus* and *Lomandra effusa* (all mainly in south-western section). The annual community included *Podolepis capillaris, P. tepperi* and **Erodium crinitum.*

The *Eucalyptus salicola* Low Woodland consisted of tall shrubs such as *Callitris canescens, Bossiaea walkeri* and *Templetonia sulcata.* The low shrubs *Disphyma crassifolium* and *Darwinia diosmoides* grew over annuals such as *Calandrinia granulifera, Gunniopsis intermedia* and *Trachymene pilosa.*

Dunes consisting of Aeolian Loams supported *Callitris columellaris* Low Woodland that included trees such as *Casuarina cristata* with tall shrubs of *Grevillea sarissa* and the low shrubs *Frankenia cinerea, Halosarcia syncarpa* and *Maireana oppositifolia.* Where the proportion of gypsum (kopi) was high in these dunes, *Casuarina obesa* Low Woodland occurred. This vegetation included tall shrubs of *Callitris canescens* over the low shrubs *Frankenia cinerea, Darwinia diosmoides* and *Halosarcia halocnemoides* ssp. *halocnemoides.*

Where dunes were absent from the margins of salt lakes, there was a gentle slope from the lake floor that graded into well-drained flats consisting mainly of Aeolian Sands but occasionally Aeolian Loams. Where the flats were between 30–100 cm above the level of the lake floor, *Dodonaea angustissima* Tall Shrubland occurred on the sandier soils. *Acacia lineolata* Tall Shrubland was present on the more loamy soils in the north-western section. The tall shrublands sometimes merged into one another.

Other tall shrubs present with *Dodonaea angustissima* were *Exocarpos aphyllus* and the low shrubs *Frankenia cinerea, Maireana oppositifolia, Halosarcia syncarpa* and *Rhagodia drummondii.* The perennial grasses *Stipa eremophila, Aristida contorta and Eragrostis dielsii* occurred over annuals such as *Brachycome pusilla, Hyalochlamys globifera* and *Calocephalus angianthoides.* Sedges of *Lomandra effusa* were largely restricted to the western section. With *Acacia lineolata* Tall Shrubland were tall shrubs of *Lycium australe* and low shrubs such as *Frankenia cinerea, Sclerostegia moniliformis* and *Disphyma crassifolium.*

Aeolian sheet deposits and well-drained flats. Flats more than one metre above the salt lake

floor level, although rarely sighted, supported *Eucalyptus gracilis* Low Woodland on Aeolian Sands. Growing under trees of *E. salicola* were tall shrubs such as *Eremophila paisleyi, Acacia colletioides* and *Dodonaea angustissima* over low shrubs of *Atriplex bunburyana* and *Olearia muelleri.* Also present were the perennial grasses *Stipa eremophila* and *Aristida contorta* with sedges of *Lomandra effusa* and annuals such as *Helipterum roseum, Podolepis capillaris, Brachycome pusilla* and *Pogonolepis stricta.* At one site south of Boorabbin, trees of *Eucalyptus pileata* were present and common.

Eucalyptus myriadena Low Woodland, occurring on Aeolian Loams, was confined to the south-western section. Other species present were the tall shrubs *Exocarpos aphyllus* and *Santalum acuminatum* over low shrubs of *Atriplex vesicaria* ssp. *variabilis, Frankenia* sp. (KRN 6592) and *Microcybe pauciflora.* Also occurring were the perennial grasses *Eragrostis dielsii* and *Stipa trichophylla* along with annuals such as *Brachycome pusilla, Calandrinia granulifera, Hyalochlamys globifera* and *Pogonolepis stricta.*

Sandplains (S)

Some species occurred in most vegetation types on Sandplains throughout the Study Area and they are not listed under each type: the tall shrub *Allocasuarina corniculata,* low shrubs of *Melaleuca cordata* and the sedges *Ecdeiocolea monostachya, Lepidobolus preissianus* and *Mesomelaena preissii.* An important aspect of sandplain vegetation was that only about two thirds of the area had distinct vegetation types; the remainder consisted of broad ecotones between these types.

Plains. *Allocasuarina corniculata* Tall Shrubland on Gravelly Sands was widespread on slight rises and higher portions of the Sandplains. Also present were tall shrubs such as *Melaleuca uncinata, Acacia beauverdiana* and *Allocasuarina campestris* ssp. *campestris* over the low shrubs *Baeckea maidenii, Grevillea paradoxa* and *Phebalium tuberculatum* ssp. *tuberculatum* with the sedge *Schoenus brevisetis* and the perennial grass *Triodia scariosa.*

Two distinct groups of tall shrublands occurred on yellow Deep Sands. The first group had numerous low shrubs and few tall shrubs. Dense stands of tall shrubs characterised the second group; few low shrubs were present.

The first group was widespread and consisted of tall shrublands dominated by either *Callitris preissii* ssp. *verrucosa* or *Grevillea excelsior,* or classified as Mixed Tall Shrubland as no single species dominated the upper stratum. Vegetation characterised by *Callitris preissii* ssp. *verrucosa* also had tall shrubs of *Hakea erecta* with low shrubs such as *Melaleuca scabra, Melaleuca* aff. *leptospermoides* (KRN 8375) and *Verticordia roei* over the perennial grass *Triodia scariosa.* Tall shrubs occurring with *Grevillea excelsior* included *G. hookeriana* and *Hakea erecta* over low shrubs such as *Beaufortia* sp. nov. (KRN 9168), *Astartea heteranthera* and *Logania tortuosa* with the perennial grass *Triodia scariosa.* In Mixed Tall Shrubland, *Hakea morrisoniana, Allocasuarina acutivalvis* and *Calothamnus gilesii* were the main tall shrubs.

Tall shrublands of the second group were dominated in the upper stratum either by *Acacia beauverdiana, A. coolgardiensis, Allocasuarina acutivalvis,* or uncommonly by *Melaleuca uncinata*; *Acacia signata* as a dominant was almost confined to the western portion of the Study Area. Sedges were absent from all but the *Melaleuca uncinata* Tall Shrubland. Present with *Acacia beauverdiana* were tall shrubs such as *Baeckea elderiana* and *Leptospermum*

roei over the low shrubs *Baeckea maidenii* and *B. ochropetala*. Tall shrubs growing with *Acacia coolgardiensis* included *A. assimilis* and *Leptospermum roei* with low shrubs such as *Thryptomene kochii, Prostanthera grylloana* and *Wehlia thryptomenoides* (north-eastern section only). Sedges were absent but perennial grasses such as *Triodia scariosa* were sometimes present. *Grevillea paradoxa* and *Allocasuarina campestris* ssp. *campestris* were the main tall shrubs growing with *A. acutivalvis* while *Thryptomene kochii* was the main low shrub. With *Melaleuca uncinata* were tall shrubs such as *Callitris preissii* ssp. *verrucosa* and *Calothamnus gilesii* over the low shrub *Melaleuca scabra* and perennial grasses such as *Triodia scariosa. Banksia laevigata* ssp. *fuscolutea* and *Allocasuarina acutivalvis* were the common tall shrubs growing with *Acacia signata* while low shrubs were dominated by *Phebalium lepidotum* var. *obovatum.*

A number of Mallee vegetation types were confined to soils with a sandy A horizon. On yellow Deep Sands were *Eucalyptus leptopoda, E. hypochlamydea* or *E. burracoppinensis* Mallees. Present in all of these mallees were tall shrubs of *Leptospermum roei*, the low shrub *Thryptomene kochii* and the usual sedges and grasses of the Sandplains. Usually growing with *Eucalyptus hypochlamydea* were other mallees of *E. yilgarnensis* while the main tall shrub was *Acacia nyssophylla*. Numerous low shrubs were present without any dominants. Sedges were few and *Triodia scariosa* was present as the main perennial grass. Growing with *Eucalyptus burracoppinensis* were the tall shrubs *Grevillea excelsior* and *Hakea francisiana* over low shrubs such as *H. erecta, Baeckea maidenii* and *Lhotskya violacea* var. *merrelliana* while sedges were absent.

On Shallow Sands in the northern sections of the Study Area were Mallees of *Eucalyptus platycorys*, replaced in western areas by *E. scyphocalyx* or *E. transcontinentalis* Mallees. Tall shrubs growing with *E. platycorys* included *Hakea francisiana, Allocasuarina acutivalvis* and *Acacia signata. Astartea heteranthera* and *Thryptomene kochii* were the main low shrubs while sedges were sparse.

Undulating Plains, greenstone (UN)

Three areas of Undulating Plains were mapped in the Study Area (Figure 2) but one was not sampled (the northern section of the Bremer Range). The north-south belt through Southern Cross is divided into two sections (Yilgarn Hills and Parker Range) as each has distinct patterns of vegetation.

Colluvial flats. In the greenstone area south of Coolgardie, *Eucalyptus salubris* Low Woodland was common on the colluvial flats of Deep Calcareous Earths, *E. lesouefii* Low Woodland was less common and *E. salmonophloia* Woodland was sometimes present. Sedges and perennial grasses were often absent.

On the flats, *Eucalyptus salubris* Low Woodland contained tall shrubs such as *Eremophila scoparia* over the low shrubs *Maireana georgei* and *Sclerolaena diacantha.* An occasional small area of this low woodland was without tall shrubs and the low shrubs were dominated by *Eremophila veronica.* Under *Eucalyptus salmonophloia* were tall shrubs such as *Acacia hemiteles, Eremophila ionantha* and *E. scoparia* with the low shrubs *Atriplex vesicaria* ssp. *variabilis* and *Scaevola spinescens.*

In the low Yilgarn Hills, the colluvial flats of Deep Calcareous Earths supported *Eucalyptus melanoxylon* Low Woodland. Growing with *E. melanoxylon* were tall shrubs of *Melaleuca*

pauperiflora and *Eremophila scoparia* over low shrubs such as *Acacia ferox* var. *nodiflorus*, *A. merrallii* and *Templetonia sulcata.* with the perennial grass *Stipa elegantissima* and annuals that included *Asteridea athrixioides.*

Within the higher Parker Range, *Eucalyptus salubris* Low Woodland dominated the colluvial flats of Deep Calcareous Earths. Small areas of *E. longicornis* Low Woodland were present where the soil pH exceeds 8.2.

Growing with *Eucalyptus salubris* were tall shrubs of *Melaleuca pauperiflora* and *Exocarpos aphyllus* with low shrubs of *Acacia merrallii* and *Templetonia sulcata* over annuals of *Asteridea athrixioides* and **Trisetaria cristata.* Where the flats graded into Salt Lake Features, the soil had an increasing salt content. Tall shrubs were absent while low shrubs, mainly *Sclerostegia disarticulata*, occurred over the annuals *Pogonolepis stricta* and **Mesembryanthemum nodiflorum.* With *Eucalyptus longicornis* on the flats were other trees of *E. myriadena*, the tall shrub *Melaleuca pauperiflora* and low shrubs such as *Atriplex vesicaria* ssp. *variabilis* and *Sclerostegia disarticulata.*

Low rises and ridges. The greenstone area south of Coolgardie consisted of low rises supporting Low Woodlands of either *Eucalyptus clelandii*, *E. lesouefii* or *E. torquata* on Shallow Calcareous Earths.

Growing with *Eucalyptus clelandii* were other trees of *E. torquata*, the tall shrub *Eremophila scoparia* and low shrubs such as *Atriplex vesicaria* ssp. *variabilis*, *Acacia erinacea* and *Maireana georgei.* Occasionally, *Eucalyptus clelandii* Low Woodland occurred on low stony rises. Trees of *E. griffithsii* were sometimes present, as well as the tall shrubs *Eremophila oldfieldii* var. *angustifolia*, *Dodonaea lobulata* and *Acacia tetragonophylla* over low shrubs such as *Cassia nemophila* var. *nemophila*, *D. boroniifolia* and *Prostanthera semiteres* ssp. *semiteres.*

Also present with *E. lesouefii* were the tall shrubs *Eremophila scoparia, Exocarpos aphyllus* and *Atriplex nummularia* ssp. *spathulata* with low shrubs of *Cratystylis conocephala*, *Olearia muelleri* and *Maireana appressa* over annuals such as *Eriochiton sclerolaenoides*, *Zygophyllum apiculatum* and *Z. ovatum.* Species growing with *Eucalyptus torquata* included tall shrubs of *Alyxia buxifolia* and *Santalum spicatum.* The low shrubs *Ptilotus obovatus* var. *obovatus* and *Scaevola spinescens* grew over annuals such as *Helipterum fitzgeraldii, Maireana pentatropis* and *Zygophyllum ovatum.*

On the low Yilgarn Hills, *Eucalyptus corrugata* Low Woodland occurred on the low and often stony ridges covered with Shallow Calcareous Earths. Present with *E. corrugata* were tall shrubs of *Acacia acuminata, Melaleuca pauperiflora* and *Eremophila interstans* with the low shrubs *Acacia erinacea*, Euphorbiaceae genus indet. (KRN 9622) and *Dodonaea stenozyga.* Also occurring were the perennial grass *Stipa elegantissima*, sedges of *Lepidosperma drummondii* and annuals such as *Eriochiton sclerolaenoides, Helipterum fitzgibbonii* and *H. rubellum.*

The ridges of the Parker Range are higher than those of the Yilgarn Hills and supported *Eucalyptus longicornis* Low Woodland on Shallow Calcareous Earths. *Eucalyptus corrugata* Low Woodland was sometimes present on stony ridges of the northern section of the range. *Eucalyptus conglobata* Low Woodland was often present on the same soil type on the slopes of the higher ridges.

Growing with *Eucalyptus longicornis* on the ridges were tall shrubs of *Melaleuca*

pauperiflora and low shrubs of *Atriplex vesicaria* ssp. *variabilis*. With *Eucalyptus conglobata* on the slopes were other trees of *E. annulata* with tall shrubs of *Melaleuca pauperiflora* and *Santalum acuminatum* over low shrubs of *Acacia nyssophylla* and *Templetonia sulcata*.

The gossanous cap on Mt Caudan, and nearby ridges in the Parker Range, supported the distinctive *Hakea pendula* Tall Shrubland on Gritty Loams.

Broad Valleys (V)

These graded from valley floors (with aeolian soil sheets) to the lower valley slopes (with colluvial soils). Two freshwater claypans were seen during the field survey on valley bottoms. The smaller (40 m across), supported *Melaleuca uncinata* Tall Shrubland while the larger (150 m across), supported *Melaleuca* sp. (KRN 8430) Tall Shrubland. A short drainage line, fed by run-off from a large Granite Exposure, supported *Eucalyptus loxophleba* Mallee.

Drainage lines. *Eucalyptus loxophleba* Mallee on the drainage line contained tall shrubs of *Acacia acuminata, A. colletioides* and *Melaleuca uncinata* with the low shrubs *Dodonaea bursariifolia, Enchylaena tomentosa* var. *tomentosa* and *Sclerolaena diacantha* over annuals such as *Schoenia cassiniana, Brachycome pusilla, Daucus glochidiatus* and *Helipterum demissum*.

Valley floors, slopes and aeolian soil sheets. The valley floor consisted of Deep Calcareous Earths that supported vegetation types associated mainly with a particular range of pH and texture of the A horizon. Soils with pH 7.0–8.0 supported *Eucalyptus salubris* Low Woodland on sandy loams to clay loams while *E. salmonophloia* Woodland occurred on sandy loams and loams. In the eastern third, *E. campaspe* Low Woodland was sometimes present on crumbly clay loams. The loamy sands supported *E. transcontinentalis* Low Woodland. Near the lower western boundary, the latter vegetation type was replaced by *E. transcontinentalis* Mallee. On loams with pH greater than 8.0 were *Eucalyptus longicornis* Low Woodland and *E. flocktoniae* Low Woodland, or mixed Low Woodlands in the Boodarding Rock area. Aeolian sheets on the valley floor supported either *E. hypochlamydea* Mallee or *E. gracilis* Low Woodland.

Growing with *Eucalyptus salubris* on the valley floors were trees of *E. gracilis* over the tall shrubs *Eremophila ionantha, E. scoparia, Melaleuca pauperiflora* and *Exocarpos aphyllus* with low shrubs such as *Scaevola spinescens, Acacia nyssophylla* and *Olearia muelleri*. The perennial grass *Stipa elegantissima* occurred over annuals that included *Plantago debilis, Helichrysum tepperi, Podolepis capillaris* and *Pogonolepis stricta*.

Where *Eucalyptus salmonophloia* was present, other trees included *E. salubris* and *E. gracilis* over tall shrubs such as *Acacia nyssophylla, Eremophila ionantha, Exocarpos aphyllus* and *Melaleuca pauperiflora*. The low shrubs *Scaevola spinescens, Acacia hemiteles, A. merrallii, Cassia nemophila* var. *nemophila* and *Atriplex vesicaria* ssp. *variabilis* grew over the scattered perennial grass *Stipa elegantissima* and annuals such as *Helipterum demissum, Calandrinia calyptrata, Crassula exserta* and *Eriochiton sclerolaenoides*.

Growing with *Eucalyptus campaspe* on crumbly clay loams were tall shrubs of *Eremophila scoparia* and *Melaleuca pauperiflora* with low shrubs of *Scaevola spinescens* and *Eremophila caerulea*. Also present in *Eucalyptus transcontinentalis* Low Woodland on sandy loams were other trees of *E. gracilis* with the tall shrubs *Melaleuca pauperiflora, Daviesia benthamii* ssp. *benthamii* and *Alyxia buxifolia*. Low shrubs such as *Acacia hemiteles, A. merrallii, Scaevola*

spinescens and *Eremophila caerulea* occurred with the annual *Podolepis capillaris*. The *Eucalyptus transcontinentalis* Mallee occurred as two distinct structural types. On the sandier soils, the vegetation type contained other mallees of *E. eremophila* over the tall shrubs *Melaleuca pauperiflora* and *M. eleuterostachya* with low shrubs of *M. laxiflora, Daviesia sarissa* and *Templetonia sulcata*. On the loamier soils, other mallees and tall shrubs were absent while the low shrubs consisted of *Melaleuca lateriflora, M.* aff. *pungens* (KRN 8716) and *M.* aff. *cymbifolia* (KRN 6274).

Growing with *Eucalyptus longicornis* on Deep Calcareous Earths with a pH greater than 8.0, were tall shrubs of *Melaleuca pauperiflora* and *Eremophila ionantha* with the low shrub *Atriplex nummularia* ssp. *spathulata* and the annual *Asteridea athrixioides*. Also present with *Eucalyptus flocktoniae* were tall shrubs of *Melaleuca* sp. (KRN 8369), *Exocarpos aphyllus* and *Daviesia benthamii* ssp. *benthamii* with the low shrubs *Templetonia sulcata, Scaevola spinescens* and *Acacia merrallii*. The Mixed Low Woodland near Boodarding Rock consisted of the trees *Eucalyptus longicornis, E. salubris* and *E. gracilis*. Tall shrubs of *Acacia nyssophylla, Melaleuca pauperiflora* and *Exocarpos aphyllus* occurred over the low shrubs *Acacia merrallii* and *Templetonia sulcata* along with annuals such as *Helipterum fitzgibbonii* and *H. rubellum*.

The species growing with *Eucalyptus hypochlamydea* Mallee on aeolian sheets graded from west to east. In the west were tall shrubs of *Melaleuca uncinata, Leptospermum erubescens* and *Hakea multilineata* with low shrubs such as *Melaleuca scabra* complex, *M. pentagona* and *Grevillea apiciloba* over the sedge *Lepidosperma drummondii*. In the east were other mallees of *E. platycorys* with the tall shrubs *Melaleuca uncinata* and *M. eleuterostachya* over low shrubs such as *Phebalium lepidotum* var. *obovatum* and *Beyeria brevifolia* var. *robustus* along with the perennial grass *Triodia scariosa*. Also on the same soil type was *Eucalyptus gracilis* Low Woodland containing tall shrubs of *Cassia artemisioides* and *Exocarpos aphyllus* with the low shrubs *Atriplex vesicaria* ssp. *variabilis, Cassia nemophila* var. *nemophila* and *Rhagodia crassifolia* over annuals such as *Actinobole uliginosum, Pogonolepis stricta, Helipterum zacchaeus* (restricted to central northern areas) and *Zygophyllum apiculatum*.

On the smaller claypan, growing with *Melaleuca uncinata* were low shrubs of *Muehlenbeckia cunninghamii* with the perennial grass *Eragrostis dielsii* and annuals such as *Gnephosis* aff. *pygmaea*. (KRN 8635), *Heliotropium* sp. (KRN 6982), *Limosella australis* and *Actinobole uliginosum*. On the larger claypan, present with *Melaleuca* sp. (KRN 8430) were the low shrub *Muehlenbeckia cunninghamii* over sedges of *Juncus aridicola* with the fern *Marsilea hirsuta* and annuals such as *Centipeda minima*.

Valley slopes. On the lower valley slopes were *Eucalyptus gracilis* Mallee or *E. pileata* Mallee. On the colluvial soils of lower valley slopes, *Eucalyptus gracilis* Mallee contains other mallees of *E. transcontinentalis* and *E. pileata* with tall shrubs of *Acacia nyssophylla, Daviesia benthamii* ssp. *benthamii* and *Melaleuca eleuterostachya* over the low shrub *Atriplex vesicaria* ssp. *variabilis*. Also present were the perennial grass *Triodia scariosa* and annuals such as *Actinobole uliginosum, Helipterum pygmaeum* and *Trachymene cyanopetala* var. *cyanopetala*. On similar soils, occurring with *Eucalyptus pileata* were other mallees of *E. gracilis* and *E. loxophleba* with tall shrubs of *Exocarpos aphyllus* and *Melaleuca uncinata*. The low shrubs *Acacia erinacea, Beyeria lechenaultii* and *Alyxia buxifolia* were also present

over the perennial grass *Triodia scariosa* with sedges of *Lepidosperma drummondii* and annuals such as *Waitzia acuminata, Helipterum demissum, Trachymene cyanopetala* var. *cyanopetala* and *Blennospora drummondii.*

Discussion

The Boorabbin–Southern Cross Study Area is located largely within the Coolgardie Botanical District of the South-western Interzone (Beard 1980). The western boundary of the Study Area lies within the Avon Botanical District of the South-western Botanical Province.

The structural formations have been described and mapped at a scale of 1:250,000 (Beard 1969, 1972) and were assessed for reliability during field work. These maps only provide an overview of the vegetation structure. However, mapping of the Boodarding Rock and Boorabbin survey areas (Figure 2) highlighted the difficulty of separating some areas of low woodlands, mallees and heaths.

The entire Study Area is situated south of the mulga-eucalypt line and contains extensive areas of mallees, tall shrublands and low woodlands of the South-west Interzone (Beard 1980). Almost all of the interzone is within the Eastern Goldfields.

Thirteen vegetation systems are present in the Study Area (Beard 1981). Both the Parker Range and the Yilgarn Vegetation Systems are confined to the Study Area, as is a large proportion of the Boorabbin Vegetation System and about half of the Skeleton Rock Vegetation System.

The Study Area was dominated by low woodlands (8–15 m), mallees (3–5 m) and tall shrublands (1.5–3 m). Low woodlands dominated calcareous Broad Valleys and Undulating Plains, as well as siliceous and leached Breakaways. Mallees occurred on siliceous, ancient and highly leached soils of the Sandplains and aeolian soil sheets associated with Broad Valleys. On the outer aprons of Granite Exposures, mallees occurred on soils younger than those of Sandplains and Broad Valleys. Tall shrublands dominated the Sandplains and also occurred on outer aprons of Granite Exposures, and on some aeolian soil sheets associated with Salt Lake Features. Low shrublands (0–0.5 m) occurred on Salt Lake Features. Granite Complex occurred on skeletal soils on and peripheral to Granite Exposures.

Most of the tall shrublands and mallees of the Sandplains also extended south and west of the Study Area, but changes in structure and species composition occurred within 20–30 km of the northern boundary. Low woodlands on Broad Valleys and shrublands on Salt Lake Features are very similar north, west and south of the Study Area.

Two vegetation patterns within the Boorabbin–Southern Cross Study Area are unique to the Eastern Goldfields. First is the low woodlands of *Eucalyptus melanoxylon* and *E. corrugata* on the Yilgarn Hills. The second is the Parker Range covered by low woodlands and *Hakea pendula* Tall Shrubland on the gossanous caps of Mt Caudan and nearby ridges. *Eucalyptus myriadena* Low Woodland, rare in the Eastern Goldfields, was recorded once in the Study Area.

One vegetation type was known only from the Study Area: *Hakea pendula* Tall Shrubland on Mt Caudan and nearby ridges. The major areas of three other vegetation types were within the Study Area: *Acacia beauverdiana* and *A. coolgardiensis* Tall Shrublands on Sandplains and *Eucalyptus melanoxylon* Low Woodland on Undulating Plain, greenstone.

Apart from a strip along its western boundary, the Study Area is within the Coolgardie Botanical District of the South-western Interzone (Beard 1980). The strip is part of the South-west Botanical Province and consists almost entirely of the Avon Botanical District, with a very small area of the Roe Botanical District. The Yilgarn Hills-Parker Range greenstone belt is a distinctive dividing line between the vegetation of the South-western Interzone and the South-west Botanical Province.

The Yilgarn Hills–Parker Range greenstone belt is also the inland margin of some plant species of the South-west Botanical Province e.g. *Acacia flavopila, A. pulchella* var. *subsessilis, Chamelaucium halophillum, Drosera bulbosa, Goodenia tenella, Kennedia prostrata* and *Spiculaea ciliata.* Many species characteristic of South-west Botanical Province Sandplains, extend to their eastern range limits on this landform feature in the Borrabbin–Southern Cross Study Area e.g. *Allocasuarina acutivalvis, A. corniculata, Conospermum brownii, Grevillea excelsior, Eucalyptus leptopoda, Leptospermum spinescens* and *Xanthorrhoea nana.*

Only one of the 58 vegetation types recorded in the Study Area is unique: *Hakea pendula* Tall Shrubland occurs only on the gossanous caps of the higher ridges of the Parker Range. Modification of this vegetation has been restricted to grid lines cut for mineral exploration.

The Study Area includes the mosty extensive known areas of three vegetation types: Tall shrublands of both *Acacia beauverdiana* and *A. coolgardiensis* are frequent in crown land on Sandplains in the western part of the Study Area; *Eucalyptus melanoxylon* Low Woodland is confined to the Yilgarn Hills. Some of these hills have been cleared for agriculture and much of the remainder has been disturbed by mineral exploration or grazing.

Rare vegetation types in the Study Area included *Eucalyptus myriadena* and *Eucalyptus conglobata* Low Woodlands. Elsewhere, *E. myriadena* Low Woodland has been recorded near Lake Cronin (Newbey & Hnatiuk 1988) and in the Hyden–Lake Grace area (Newbey unpublished data). The last localities have been almost entirely cleared for agriculture, or the areas are on farms and have been heavily grazed by stock. *E. conglobata* Low Woodland occurs on the Parker Range. It has also been recorded in the Forrestania area, and on Undulating Plain (greenstone) by Newbey & Hnatiuk (1988).

In the Parker Range, Low woodlands of *Eucalyptus corrugata, E. conglobata, E. longicornis* and *E. salubris* occur on the slopes and colluvial flats, while *Hakea pendula* Tall Shrubland is sometimes present on the gossanous caps of the adjacent ridges. This vegetation pattern is peculiar to the Range, and is at present within a Mineral Field. Another unusual vegetation pattern occurs on the Yilgarn Hills, but extends into the Jackson–Kalgoorlie Study Area (Newbey & Hnatiuk 1985): *Eucalyptus melanoxylon* Low Woodland occurs on the colluvial flats amongst low ridges covered with *E. corrugata* Low Woodland. Some of the Yilgarn Hills is farmland; the remainder within a Mineral Field.

The flora of the Study Area has not previously been systematically recorded and documented. During our survey of the Boorabbin–Southern Cross Study Area, 1084 taxa were recorded: 8 species of ferns, 3 gymnosperms and 1073 taxa (300 genera, 77 families) of flowering plants. This includes the Gazetted Rare Flora *Grevillea prostrata* and *Myriophyllum petraeum* (Atkins 1993). Three other species of Gazetted Rare Flora are known from the Study Area (*Eremophila inflata, E. virens* and *Eucalyptus crucis* ssp. *crucis*), as are 25 species of priority flora (Mollemans *et al.* 1993). The families with the largest number of taxa

were Myrtaceae (143), Asteraceae (100), Proteaceae (71), and Chenopodiaceae (53). Genera with numerous species were *Acacia* (73), *Eucalyptus* (48) and *Melaleuca* (34). A total of 386 species of vascular plant were recorded in Boorabbin National Park, and 309 in Jilbadji Nature Reserve (Appendix 2). These combined lists totalled 613, about 55% of that recorded during the survey, and there is a 33% dissimilarity between them.

Two species were recorded for the first time: *Harperia* sp. nov. (GJK 13,928), south of Queen Victoria Rock, and *Thelymitra* sp. nov. (GJK 13,941) to the south of Woolgangie. Other undescribed species from the Study Area included *Beaufortia* sp. nov. (KRN 9168) and *Baeckea* sp. nov. (KRN 9269).

Several species were recorded that had been previously poorly collected: *Acacia rendlei, Acrotriche patula, Atriplex nana, Banksia lullfitzii, Bossiaea peduncularis, Eriostemon coccineus, Eucalyptus occidentalis* var. *stenantha, Gnephosis intonsa, Grevillea prostrata, Hakea pendula, Helipterum fuscescens, Hydrocotyle hispidula, Lawrencia diffusa, Myriophyllum petraeum, Neosciadium glochidiatum, Patersonia rudis* var. *lanata, Thryptomene glaucosa, Verticordia stenopetala* and *Wurmbea graniticola.*

A few major extensions of range were recorded: *Hydrocotyle hispidula* (coastal from Perth to Recherche Archipelago, and Mt Ridley), *Neosciadium glochidiatum* (Shark Bay), *Lawrencia diffusa* (Ongerup–Ravensthorpe), *Eriostemon gardneri* (Albany–Lake Grace–Cape Arid), *Grevillea petrophiloides* (central wheatbelt), *G. prostrata* (Lake King) and *Leptospermum spinescens* (central wheatbelt).

Taxa which appeared to be confined to the Study Area are *Chamelaucium halophillum* ssp. nov. (GJK 12540), *Drummondita wilsonii, Eriostemon coccineus, Hakea pendula, Harperia* sp. nov. (GJK 13,928), *Patersonia rudis* var. *lanata, Phebalium clavatum, Thelymitra* sp. nov. (GJK 13,941), *Thryptomene glaucosa* and *Verticordia stenopetala.*

The plant families present in the Study Area are typical of the Eastern Goldfields. Proteaceae and the Leguminosae subfamily Papilionoideae are prominent on Sandplains; Myrtaceae and Chenopodiaceae on Broad Valleys and Undulating Plains, greenstone; Chenopodiaceae on Salt Lake Features; and Asteraceae and Myrtaceae on Granite Exposures (see Appendix 2).

About two-thirds of the Study Area was surveyed in sufficient detail to provide an overview of the vegetation and the flora. Two areas are in need of additional detailed study. The first is the central southern section, including the northern portion of the Bremer Range of Undulating Plain, greenstone. The second is the portion of the South-west Botanical Province (Beard 1980) west of the Yilgarn Hills–Parker Range. Some plant collections were made in this area but few vegetation types were sampled in detail. The design of the biological survey of the Eastern Goldfields called for detailed sampling to be concentrated in natural areas wherever possible (Biological Surveys Committee 1984). Also, a large section south-west of Parker Range may be considered for agricultural development (RAIC 1979) and the present survey is far below the requirements of adequate surveys for rural land use planning (Newbey 1983). An area worthy of further study is the Parker Range. Landform units that should reward further study are Granite Exposures and Salt Lake Features.

Collections at times of the year other than July, August and September would provide a better understanding of the Study Area's flora. In particular, collections are needed from the eastern third of the Study Area in spring, following good rains. When we re-visited site

BS43a in September 1993, after good winter rains, we recorded 5 species of orchid and 53 annuals, an addition of 37 species.

A broad strip along the western boundary of the Study Area has largely been cleared for agriculture. Light grazing by stock has modified a small area near Lake Seabrook, and over-grazing has affected a larger area near Londonderry.

Timber has been cut from most of the low woodlands and woodlands in the eastern half of the Study Area, mostly to provide fuel for the mining industry and for the towns of Coolgardie and Kalgoorlie (Jarvis 1979). Timber was also cut within 70 km of the pipeline that supplyies water to the Goldfields from Mundaring Weir. This timber was used by wood-burning pumping stations that are now powered by diesel or electric motors. Quantitative comparisons between modified and natural areas were not undertaken because it is no longer possible to determine the dates or intensity of the wood extraction. Nevertheless, the tree stratum of cut-over areas appeared more open. In some places, tall shrubs of *Melaleuca pauperiflora* or *Melaleuca* aff. *pauperiflora* were also less abundant. *Melaleuca* spp. were the main source of fence posts for pastoral leases, as well as having limited use in the mining industry. Another feature of these disturbed woodlands was the presence of two common introduced grasses (*Aira caryophyllea* and *Vulpia myuros*). Our sites will provide useful areas to monitor these weeds now that the disturbance has ceased.

Mineral exploration and mining operations have been restricted almost entirely to the Undulating Plain, greenstone. The exception is open-cut mining of gypsum sands at the southern end of Lake Seabrook. Modification by the mining industry has varied greatly in intensity. Almost all of the woody vegetation has been removed from abandoned mining centres such as Londonderry and Burbanks. Their surrounding areas have suffered extensive removal of vegetation and numerous, shallow exploration shafts have been dug. Similar types of modification have occurred in the Yilgarn Hills, Parker Range and Toomey Hills. Grid lines for mineral exploration are prominent in almost all greenstone areas.

Much of the tall shrublands and mallees on the Sandplains had been burnt during the last 10 years. Fire patterns on aerial photography indicate that Broad Valleys and Salt Lake Features are effective barriers against fire. Observations of burnt Sandplains suggest that the vegetation takes 20–25 years after a fire to have grown sufficient material to carry another fire. Trees, shrubs and perennial grasses of low woodlands are too far apart to carry a fire. The biomass of annuals varies greatly in relation to rainfall during the growing season. Even during a year with adequate rainfall, sufficient biomass to carry a fire on a hot day was rarely seen. Even then, the patches were small and discrete. Halophytes dominate the vegetation of Salt Lake Features. Most are succulent and will not burn under wildfire conditions. The use of fire by Aborigines in the Study Area is unknown.

Conservation reserves within the Study Area are listed in Table 3. Henry-Hall (1990) reviewed the existing and proposed conservation reserves of the Study Area. The majority of the smaller reserves consist of Granite Exposures surrounded by small areas of Broad Valley or Sandplain. Jilbadji Nature Reserve and Boorabbin National Park are the two largest conservation reserves in the Study Area that are vested for nature conservation purposes. The vegetation, flora and fauna of Boorabbin National Park have been surveyed in moderate detail while the surveying of Jilbadji Nature Reserve was less intense. We estimate that our basic flora list for Jilbadji Nature Reserve is about 50% of that expected, compared to that of

Boorabbin National Park which is about 75% complete.

Representation in reserves appears adequate for the landform units Sandplains and Granite Exposures; moderate for Broad Valleys; but poor for Breakaways, Salt Lake Features and Undulating Plain, greenstone. Breakaways were rarely sighted during field work.

Of the thirteen vegetation systems present, both the Parker Range and the Yilgarn Vegetation Systems are confined to the Study Area (Beard 1981). The Boorabbin System covers the whole of Boorabbin National Park and almost half of Jilbadji Nature Reserve, and is well represented. Skeleton Rock is the only other vegetation system that appears to be well represented in conservation reserves. None of the unique Yilgarn Vegetation System is within a reserve, and only 106 km^2 out of 800 km^2 of the restricted Parker Range Vegetation System is reserved.

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