VEGETATION AND FLORA

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Background

During the present survey of the Barlee–Menzies Study Area, vegetation was described from plotless sample sites as specified by Biological Surveys Committee of Western Australia (1984). From the survey, 24 vegetation sites were selected to cover the 8 landform units across the Study Area. The locations of these vegetation sample sites are provided in Appendix 1 and, except for BM24, are shown in Figure 2. The sites are broadly classified, on the basis of structure and species composition of the upper stratum, into vegetation types. Two of the types (Breakaway and Granite) were referred to as vegetation complexes, because their structure and species composition changed markedly over distances of a few metres.

The vegetation sites are described in Appendix 1, together with relevant data on geology, landforms and soils. Although these detailed site descriptions are central to this paper, they were 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. Full descriptions of the 24 vegetation sample sites are detailed in Appendix 1. Reference to Appendix 2 provides a complete listing by landform unit, of the flora recorded during the biological survey of the Barlee–Menzies Study Area.

Plates 1–10 provide examples of the various vegetation types present in the Study Area (see Appendix 1).

Vegetation Descriptions

Breakaways (B)

Occasional breakaways occurred throughout the study area, particularly in the north-east. Many are associated with weathered outcrops of granite, but, particularly in the south-east, lateritic breakaways were common. Four distinct elements comprise the breakaway landform: summit flats, scree slopes, colluvial base and drainage channels. Species composition varied across the study area, with the summit vegetation being *Allocasuarina corniculata* /*A. acutivalvis* shrublands in the south-west and *Acacia aneura* /*A. quadrimarginea* elsewhere (resembling that found on Granite Exposures). On the summit and scree slopes were scattered trees of *Casuarina cristata* and *Eucalyptus ewartiana*, tall shrubs of *Eremophila* spp., low shrubs of *Ptilotus obovatus*, perennial herbaceous plants of *Sclerolaena* spp. and ephemeral species (*Helipterum* spp., *Angianthus* spp., *Gnephosis* spp. and *Ptilotus* spp.). Ephemerals were generally uncommon. Colluvial slopes on the southern margins supported low woodlands of *Eucalyptus capillosa*. Drainage channels in the southern margins supported woodlands of *E. loxophleba* or *E. salubris*.

Dunefields (D)

Dunefields associated with Salt Lake Features were uncommon in the Barlee–Menzies Study Area. These bore trees of *Eucalyptus* and low trees or tall shrubs e.g. *Pittosporum*

Table 1 Relationship between landforms, lithology, soils, vegetation structure and floristic composition at sites sampled or visited in the Barlee-Menzies Study Area. Lithological surfaces follow those devised for the map sheets Barlee (Walker & Blight 1983) and Menzies (Kriewaldt 1970).

Landform	Lithological Surface Barlee	Menzies	Soil	Vegetation Type	Vegetation Sites (Appendix 1)[a]
BREAKAWAY (B)					
Slopes and summits	Tl, Qz	Qt, Qtl, Qqz	Gritty Loams	*Eucalyptus capillosa* Low Woodland *Eucalyptus loxophleba* Mallee	
Colluvial slopes	Qz	Qqs, Qqz	Gritty Loams	*Acacia aneura* Tall Shrubland *Acacia quadrimarginea* Tall Shrubland Breakaway Complex	BM1
DUNEFIELDS (D)					
Slopes, summits and swales	Qs, Qg	Qts, Qak	Deep Sands and Aeolian Sands	*Acacia aneura* Low Woodland *Callitris columellaris* Low Woodland *Casuarina cristata* Low Woodland *Eucalyptus ceratocorys* Mallee *Eucalyptus gracilis* Mallee *Callitris preissii* Tall Shrubland *Grevillea juncifolia* Tall Shrubland	BM24
GRANITE EXPOSURES (G)					
Skeletal soil sheets	Ag	Ag	Granitic Soils	Granite Complex	BM4
Inner aprons	Ag, Qc	Ag, Qpm	Granitic Soils	*Acacia burkittii* Tall Shrubland *Acacia quadrimarginea* Tall Shrubland *Acacia tetragonophylla* Tall Shrubland	BM2
Outer aprons	Qc	Qpm	Granitic Soils	*Eucalyptus ewartiana* Mallee *Eucalyptus loxophleba* Mallee *Acacia aneura/A. ramulosa* Tall Shrubland	BM3
HILLS, GRANITE (HG)					
Slopes and summits	Ag	Ag	Granitic Soils	*Acacia quadrimarginea* Tall Shrubland	
HILLS, BANDED IRONSTONE (HI)					
Slopes and summits	Aiw	Alb	Red Sands	*Acacia aneura* Tall Shrubland *Allocasuarina acutivalvis* Tall Shrubland *Dryandra arborea* Tall Shrubland	BM6 BM7

Slopes	Aiw	Qtc	Red Sands and Red Earths	*Eucalyptus ebbanoensis* Low Woodland *Acacia quadrimarginea* Tall Shrubland *Eucalyptus ebbanoensis* Mallee	BM5
HILLS, GREENSTONE (HN)					
Slopes and summits	Ab, Ad	Alv	Shallow Calcareous Earths	*Acacia aneura* Tall Shrubland	
Lower slopes			Shallow Calcareous Earths	*Acacia aneura* Low Woodland	
SALT LAKE FEATURES (L)					
Saline flats, lake floors and margins	Ql	Qra	Saline Soils	*Frankenia* Low Shrubland *Halosarcia* Low Shrubland	BM11
Claypans and damp flats	Qg, Qc, Qps	Qak, Qo	Sub-saline Soils and Alluvium	*Cratystylis subspinescens* Low Shrubland *Maireana* Low Shrubland Salt Lake Margin Complex	
Well-drained flats and dunes	Qg, Qpf, Qps	Qas, Qak	Aeolian Sands and Aeolian Loams	*Casuarina cristata* Low Woodland *Eucalyptus formanii* Low Woodland *Eucalyptus clelandii* Low Woodland *Acacia ramulosa* Tall Shrubland *Dodonaea angustissima* Tall Shrubland *Eremophila miniata* Tall Shrubland *Atriplex* Low Shrubland	BM8 BM9 BM10
SANDPLAIN (S)					
Flat plains	Tl	Qtg, Qtn	Gravelly Sands	*Acacia coolgardiensis* Tall Shrubland *Acacia resinomarginea* Tall Shrubland *Allocasuarina acutivalvis* Tall Shrubland	BM15
	Ts	Qts	Deep Sands	*Acacia aneura* Low Woodland *Eucalyptus leptopoda* Mallee *Eucalyptus oldfieldii* Mallee *Banksia elderiana* Tall Shrubland	 BM12 BM13 BM14
UNDULATING PLAIN, BANDED IRONSTONE (UI)					
Ridges and colluvial flats	Aiw, Tl, Ag	Alb, Qtc, Qpa	Red Sands and Red Earths	*Eucalyptus ebbanoensis* Low Woodland *Acacia aneura* Low Woodland	

Table 1 (cont.)

Landform Vegetation Sites	Lithological Surface		Soil	Vegetation Type	
	Barlee	Menzies			(Appendix 1)[a]
UNDULATING PLAIN, GREENSTONE (UN)					
Colluvial flats	Ad, Aus, Ab, Alp, Aur, Aup, Qc	Qqc	Deep Calcareous Earths	*Eucalyptus clelandii* Low Woodland *Eucalyptus longicornis* Low Woodland *Eucalyptus salubris* Low Woodland *Eucalyptus transcontinentalis* Low Woodland *Maireana pyramidata* Low Shrubland	BM16
Slopes and ridges	Aab, Tl, Aiw	A1k, A2v, A2r, Qqf	Shallow Calcareous Earths and Red Sands	*Casuarina cristata* Low Woodland *Acacia aneura* Low Woodland Acacia aneura Tall Shrubland *Acacia* Tall Shrubland	BM17 BM18
BROAD VALLEY (V)					
Flat and gentle undulating plains	Qc, Ts, Qz, Qs	Qps	Red Sands and Aeolian Loams	*Callitris columellaris* Low Woodland *Eucalyptus formanii* Low Woodland *Eucalyptus transcontinentalis* Low Woodland	BM23 BM20 BM21
Valley slopes	Qc	Qpa, Qqs	Shallow Calcareous Earths Red Sands	*Eucalyptus longicornis* Low Woodland *Eucalyptus oleosa* Low Woodland *Eucalyptus loxophleba* Low Woodland	BM19
	Qz, Ag	Qqa, Qqz	Red Earths	*Acacia aneura* Low Woodland	BM22
Valley bottoms	Qa	Qpv, Qqs	Deep Calcareous Earths	*Eucalyptus salmonophloia* Low Woodland *Eucalyptus salubris* Low Woodland	

[a] A total of about 50 vegetation sites were sampled, of which a representative set of 24 are presented in detail as Appendix 1. (Due to poor vehicle access, two of these sites are peripheral to the Study Area.) The balance of the sampled sites are held as data sheets at the W.A. Wildlife Research Centre, Perth.

phylliraeoides, Acacia tetragonophylla, Grevillea sarissa, Dodonaea angustissima and *Eremophila miniata.* Ephemerals were common and contained some distinctive elements such as *Gnephosis macrocephala.* Dunefields associated with Sandplains shared few structural or floristic links with salt lake dunefields. Here *Callitris preissii* was dominant instead of *C. columellaris*, Chenopodiaceae were absent, and there was a wide variety of mallee *Eucalyptus* species and south-western floristic elements, such as *Caustis dioica, Chamelaucium ciliatum, Lechenaultia brevifolia* and *Hybanthus floribundus.* This was especially true of Dunefields at the southern edge of the Study Area, such as those in the Riverina area (see site BM24, which although in the Edjudina–Menzies Study Area (Fig. 1), is included in Appendix 1 to illustrate this point.

Dunefields associated with Sandplains occurred on the eastern boundary of the Study Area. Dune slopes supported *Eucalyptus gracilis* and *E. rigidula* mallees with tall shrubs of *Callitris preissii* spp. *verrucosa* over low shrubs and the hummock grass *Plectrachne rigidissima.* Shrublands that included *Grevillea didymobotrya, G. juncifolia* and *Hakea multilineata* dominated the dune crests. Flats between the dunes were characterised by mallees such as *Eucalyptus ceratocorys* over *Melaleuca uncinata, Xanthorrhoea thorntonii* and *Triodia basedowii.*

Granite Exposures (G)

The vegetation associated with Granite Exposures in the Barlee–Menzies Study Area formed a complex pattern rather than a single extensive community. This was closely tied to microsite variation of the neutral and gritty loamy sands of the soil sheets and their peripheral aprons. Sparse vegetation occurred on the exposed rock itself and the inner apron. Shrubs, mainly *Acacia* species were scarce and the main cover was of low annual grasses (e.g. *Eragrostis, Aristida, Tripogon*) and ephemerals of *Gnephosis* and other dwarf Asteraceae, *Calandrinia* and *Goodenia.* Where tall shrubs were able to survive on the rock surface, these were usually *Acacia quadrimarginea.*

Vegetation of the outer apron was general tall shrubland of *Acacia* spp., e.g. *Acacia burkittii*, together with low shrubs of *Dodonaea, Scaevola, Eremophila, Rhagodia* and *Ptilotus*, sedge-like tufts of *Dianella*, and moderately tall to dwarf annuals or ephemerals of *Helipterum, Podolepis* and other Asteraceae, together with minor contributions by a wide range of other life forms and taxa. Also occurring on the outer apron were occasional mallees of *Eucalyptus.* Some Granite Exposures in the southern parts of the Study Area had short creek lines with small stands of low woodland of *Eucalyptus loxophleba.*

Triodia was generally absent from Granite Exposures, in contrast to Study Areas in the southern parts of the Eastern Goldfields. Instead some relatively extensive aprons had a base-rich soil supporting low shrubs of Chenopodiaceae including *Atriplex bunburyana* and *Maireana* spp., together with the usual ephemerals associated with these shrubs, e.g. *Senecio glossanthus, Helipterum strictum* and *Gnephosis* spp. Tall shrubs of *Acacia aneura* and *Acacia craspedocarpa* were present in patches, but emergent eucalypts were absent. This vegetation constituted a form of wooded succulent steppe in the sense of Beard (1975).

Hills (H), (*Granite, Banded Ironstone and Greenstone*): The vegetation of Hills in the Barlee–Menzies Study Area was scrub of *Acacia* spp., particularly *Acacia aneura.* Hills of banded ironstone (HI) were a special feature of the Study Area (see section on Mt Manning

Range Nature Reserve and Mt Manning Range below) although isolated examples of Hills of other rock types were present.

Emergent low trees of *Eucalyptus ebbanoensis* (especially on the lower slopes) and a relatively dense stratum of shrubs 1–2 m high comprising a mixture of Proteaceae, Euphorbiaceae, Casuarinaceae, Sapindaceae, Myoporaceae, Myrtaceae and Epacridaceae, characterised the Hills of banded ironstone. A definite ground stratum of perennial grass, usually *Neurachne* sp. nov. (GJK/J. Alford 1951) and *Plectrachne rigidissima* was present. However, many of these elements were absent from similar substrates in the northern half of the Study Area, where *Acacia aneura* predominated. Ridge lines of banded ironstone hills in the Manning Range were dominated by *Dryandra arborea* Tall Shrubland, whereas Mount Elvire had a low shrubland of *Acacia exocarpoides*

Hills of granite (HG) supported tall shrubland of *Acacia quadrimarginea*, on similar, neutral, gritty loamy sand, with ephemerals such as *Helipterum pygmaeum* and *H. battii* among many others. Hills of greenstone (HN) bore vegetation similar to that on ridges of Undulating Plains over the same bedrock.

Salt Lake Features (L)

The floors of salinas were bare with only small patches of *Halosarcia* Low Shrubland growing around the margin. Also present in peripheral bands around the salt lakes were low shrubs and annuals of *Frankenia, Atriplex, Sclerolaena* and other Chenopodiaceae, as well as Aizoaceae. Introduced herbaceous species were particularly noticeable in these vegetation types.

The loose and fine sands or sandy loams of lake dunes or lunettes supported low woodlands or tall shrublands. The vegetation of extensive, deep sandsheets of this kind was generally low woodland of *Casuarina cristata*, with little representation of *Eucalyptus. Dodonaea angustissima* and *Eremophila* spp. (particularly *E. miniata*) were generally present, and dominated in patches. Other low trees or tall shrubs were of *Grevillea sarissa, Pittosporum phylliraeoides* and *Acacia tetragonophylla.* The understorey usually contained Chenopodiaceae and a considerable number of ephemerals, of which some (e.g. *Waitzia, Podolepis*) were shared with Sandplains, or Dunefields derived from Sandplains. However, hummock grasses (*Triodia*) were absent.

Where the vegetation formed a complex mosaic on small lines of aeolian ridges scattered immediately adjacent to the floors of Lake Barlee itself, *Eucalyptus* and *Casuarina* were represented by isolated, stunted plants only, together with Santalaceae (*Santalum, Exocarpos*). The above-mentioned tall shrubs of Leguminosae, Pittosporaceae and Myoporaceae, low shrubs of Chenopodiaceae, Frankeniaceae and Solanaceae, and numerous ephemerals, mainly Asteraceae (e.g. *Gnephosis, Senecio*) grew together with e.g. *Triglochin* and *Zygophyllum.* A typical pattern was dominance by species of Mimosoideae and Aizoaceae on the rises (where the vegetation consequently exhibited a mixture of elements from Salt Lake Features and other sandy landforms) and Chenopodiaceae and Aizoaceae in the depressions.

The dominant low shrubs of Salt Lake Features in the northern parts of the Eastern Goldfields, *Atriplex vesicaria* and *Maireana pyramidata*, were absent from the coarse, siliceous surface of the ridges. They were replaced by a mixture of shrubs growing in an open stand: e.g. *Acacia ramulosa, Crenidium spinescens, Rhagodia drummondii, Lawrencia* spp.,

Gunniopsis quadrifida and occasional low shrubs (*Darwinia drummondii*) and mistletoes (*Amyema maidenii*). *Podotheca wilsonii* was characteristic although not particularly abundant.

Halosarcia grew in the lowest-lying places, together with *Disphyma clavellatum*. Ephemerals included *Cotula coronopifolia* and **Lophochloa pumila*. Intermediate zones bore *Frankenia setosa* together with *Maireana oppositifolia, Maireana atkinsiana, Solanum nummularium* and grasses (*Eragrostis* or *Eriachne*).

Sandplains (S)

Where the soil consisted of deep sand or lateritic gravel of Tertiary age developed over deeply weathered granitic parent materials, trees were generally absent or stunted and the tallest plants were a mixture of mallee *Eucalyptus* and *Acacia* spp., with a wide variety of other shrub components (e.g. Cupressaceae, Proteaceae, Santalaceae), and a relatively dense perennial understorey of various harsh-leafed plants. Arid forms of mallee-heath (tall shrubland of *Eucalyptus* with a dense, shrubby understorey) and thicket occurred on yellow Sandplains in the southern part of the Barlee–Menzies Study Area.

Eucalyptus leptopoda and other species grew over low shrubs of 3 or 4 species of Myrtaceae on sites where gravel was confined to depth. Occasional plants of the hummock grass were present. Ephemerals were notably rare, their cover less than 0.1% even after good rainy seasons. Up to 10 ephemeral species were present but all grew as occasional, stunted plants found mainly in small mats of fine litter. Litter under shrubs of Santalaceae was virtually the only suitable microhabitat for several of these ephemeral species.

The vegetation of particularly gravelly Sandplains, which in places occupied slightly sloping sites, possibly over banded ironstone, consisted mainly of three species of *Acacia*, which formed about 40% of the cover. *Melaleuca uncinata* formed tall (up to 4 m) shrubs, contributing about 20% of total cover, and *Allocasuarina helmsii* contributed a further 20%. Other components were *Eucalyptus ewartiana* (10%), *Brachychiton gregorii* (5%) and several other shrubs such as sparse low *Eremophila* spp. (5%). The understorey contained sparse shrubs as described above including *Leucopogon* sp. Perennial grasses, common in places, were mainly of *Amphipogon* sp. (KRN 9113). Ephemerals on these gravelly surfaces were not particularly rare but were less common than on virtually all landforms other than Sandplains and, as leached sandy soils away from Salt Lake Features, such as *Podolepis canescens* and *Gnephosis tenuissima*. Elsewhere on leached sandy soils, they were found mainly among the old leaf litter under shrubs.

On Sandplains at the latitude of Lake Barlee, *Acacia resinomarginea* was absent, *Triodia scariosa* was relatively common, and the stand was relatively open owing to the scarcity of various shrubs. The two types of understorey, hummock grass and low shrubs, formed a small-scale mosaic within these areas according to the gravel content and colour of the soil. This was regarded as an intermediate stage to the red Sandplains in the north of the Eastern Goldfields which were dominated by hummock grasses.

Undulating Plains (UN)

The vegetation of Undulating Plains in the Barlee–Menzies Study Area was generally similar to that of salt-free or only weakly salt-affected soils of Salt Lake Features, although many of the actual species differed between the two landforms. Growing on the strongly

calcareous soils on Undulating Plains over greenstone was low woodland of *Casuarina cristata* (ridges, e.g. over amphibolite or metamorphosed basalt) or *Eucalyptus salubris* (colluvial flats, e.g. over peridotite) with tall shrubs of *Eremophila* and *Dodonaea*, and scattered low, soft shrubs of various kinds. Ephemerals such as *Gnephosis skirrophora, Stipa* spp., *Zygophyllum iodocarpum* and *Plantago drummondii* occurred. In contrast to the Edjudina–Menzies Study Area to the east (Milewski & Keighery 1988), the bluebush *Maireana sedifolia* was generally absent. However, *Atriplex vesicaria* and *A. nummularia* were locally common where the Deep Calcareous Soils were subsaline, providing the only kind of vegetation on Undulating Plains which was referable to Beard's (1975) wooded succulent steppe.

On ridges, low woodland of *Casuarina cristata* occurred over mixed shrubs, on Shallow Calcareous Earths. The vegetation was characteristic of relatively base-rich soils throughout the southern parts of the Eastern Goldfields but lacked tall eucalypts. Even on sites showing evidence of some laterite formation, the main species of tall shrubs were *Eremophila oldfieldii* ssp. *angustifolia* and several congeners, *Acacia* spp. including *A. aneura*, and *Scaevola spinescens*. Semi-succulent shrubs (species of *Atriplex, Enchylaena, Rhagodia* and *Maireana*) were fairly common. Ephemerals were common in good seasons. Only where the soil was particularly shallow over the lime hardpan did they cover less than 5% of the ground or aggregate under the cover of shrubs.

Introduced herbaceous species were particularly noticeable on disturbed sites in Undulating Plains (such as old mining townsites). In common with other northern areas of the Eastern Goldfields, the relatively fertile soils of Undulating Plains appeared to be easily overgrazed by domestic stock, particularly where the soil cover was shallow and fragile. Undulating Plains over banded ironstone were confined to small areas and bore vegetation similar to that of Hills of banded ironstone, or Broad Valleys.

Broad Valleys (V)

The vegetation of Broad Valleys in the Barlee–Menzies Study Area varied from south-west to north-east, according to climatic and consequent soil differences. The mulga-eucalypt line, running parallel to the southern border as described for the Kalgoorlie–Kurnalpi Study Area, separated the relatively tall, *Eucalyptus*-dominated vegetation of the partly calcareous soils of the south from the stunted, *Acacia*-dominated vegetation of the siliceous soils of the north.

Typical mulga vegetation occurred on level plains of Red Earths (red-brown siliceous loam with a siliceous hardpan) in the northern part of the Study Area. The simple floristic composition consisted of *Acacia aneura*, with only very occasional eucalypts, over scattered shrubs of other species of *Acacia*. The occasional low shrubs were of mixed composition. *Casuarina cristata* was absent. Perennial grasses were generally scarce but this was perhaps partly owing to grazing. Ephemerals were fairly common (canopy cover greater than 2% in most years), although less common than on some parts of Undulating Plains despite the availability of relatively deep stone-free soil. Outlying patches of mulga vegetation occurred in the southern parts of the Study Area, usually associated with situations where soils were relatively shallow owing to their position on the slopes.

Areas of basic soils on Broad Valleys, in the southern and central parts of the Study Area, bore open stands of *Eucalyptus* low woodland with a *Acacia aneura* stratum. One type consisted of groves of *Eucalyptus longicornis* and scattered plants of other *Eucalyptus* species

with scattered low trees or tall shrubs of *Acacia aneura*. The sparse stratum of low shrubs and herbs was mainly of the succulent steppe type (Beard 1975), i.e. *Maireana, Atriplex, Enchylaena* and *Sclerolaena* spp. Shrubs and herbaceous plants in the Chenopodiaceae with semi-succulent foliage contributed about 45% of the cover of plants lower than 1 m. *Sclerolaena fusiformis* was typical of these eucalypt stands on calcareous soils directly over bedrock. Where ephemerals occurred in eucalypt woodland and low woodland on Broad Valleys, they contained several elements shared with Undulating Plains over greenstone.

Low woodland (or tree mallee) of *Eucalyptus transcontinentalis* and *E. concinna* occurred on slightly raised banks of red aeolian loam with a lime hardpan in the southern part of the Study Area. The understorey was composed of e.g. *Eremophila paisleyi, Cassia nemophila* and *Scaevola spinescens*. Sparse tall shrubs consisted mainly of *Acacia ramulosa*. Despite the sandy surface, *Triodia* was present only as very occasional plants. The sparse ground stratum was instead composed of *Ptilotus obovatus*, scattered palatable grasses and a few other perennial species. On similar sandy banks of soil on Broad Valleys, but with no subsoil lime content, eucalypts were largely replaced by low trees of *Acacia aneura* and *Callitris*. In addition to the tall shrubs of *A. ramulosa* and low shrubs of *Cassia nemophila*, shrubs of *Eremophila leucophylla* were common. Ephemerals were fairly common in season, but not as common as in typical mulga as described above and were mainly clumped under shrubs (e.g. *Helipterum maryonii*).

An unusual variant of Broad Valleys was recorded on sandy plains at the base of Mount Manning, providing a type of vegetation virtually restricted to the Barlee–Menzies Study Area. *Eucalyptus formanii* grew with scattered plants of other eucalypts and *Callitris* over an understorey of spinifex, with relatively few plants of any kind of *Acacia*.

On transitional sites where the soil appeared to be relatively loamy, the main eucalypt was *Eucalyptus ebbanoensis* (also found on Hills of banded ironstone), over shrub of *Acacia ramulosa* (see section on Mt Manning Range Nature Reserve and Mt Manning Range). Ephemerals were surprisingly common in patches, especially along wash lines, in view of the occurrence of *Triodia* which usually indicates a poor environment for ephemerals.

Discussion

The Barlee–Menzies Study Area straddles the boundary between two major phytogeographic areas. The northern three-quarters of the Study Area fall within the Eremaean Botanical Province, represented by the Austin Botanical District, and the remainder is in the South-western Interzone, represented by the Coolgardie Botanical District. This boundary, the so-called mulga-eucalypt line, marks the transition from low woodland of *Acacia*, which covers the drier northern parts of the eastern Goldfields (Beard 1976) to woodland of *Eucalyptus*, which covers the moister southern parts of the Eastern Goldfields (Beard 1980).

The Barlee–Menzies Study Area contains seven Vegetation Systems or Sub-regions according to Beard (1972, 1976). In order of decreasing area within the Study Area, these are (percentage of the total area of each Vegetation System or Sub-region in parentheses): Barlee (28%), Karroun (25%), Jackson, (11%), Jaurdi (7.5%), Die Hardy (15%), Kunanalling (6.5%), and Bungalbin (4%). No Vegetation System or Sub-region is confined to, or even mainly found in, the Barlee–Menzies Study Area, and most are shared with the adjacent Jackson–Kalgoorlie Study Area. Five of the Vegetation Systems present are restricted to the Eastern

Goldfields while the Karroun Vegetation System and Barlee Sub-region of the Murchison Region of the Austin Botanical District are not so restricted.

The reliability of the most detailed previously existing vegetation maps covering the Barlee–Menzies Study Area may be assessed in the light of the present survey. As shown by Carnahan (1976), the vegetation of the Study Area is mainly mulga (*Acacia* Tall Shrubland with low shrubs), with large patches of spinifex (*Eucalyptus* and *Acacia* tall open shrubland with *Triodia* hummock grasses, or, in the south-western part of the Study Area, *Acacia* Tall Shrubland with hummock grasses).

However, in the south, there are belts of *Acacia* open-scrub with low shrubs, which is a common type in the south-western sector of the Eastern Goldfields where it occupies Sandplains which alternate with the Broad Valleys occupied by *Eucalyptus* woodland with low shrubs. However, the latter type does not reach as far north as the Barlee–Menzies Study Area where it is reduced to *Eucalyptus* low woodland with low shrubs. It is noteworthy that Carnahan (1976) depicts a tongue of mulga vegetation in the vicinity of Mt Manning, extending farther south than anywhere else in the Eastern Goldfields. Considering the scale, Carnahan's map provides a remarkably good synopsis of the vegetation of the Barlee–Menzies Study Area.

Beard's maps cover the Study Area at a scale of 1:1 000 000 although his maps at the scale of 1:250 000 (covering the area immediately to the south) refer to several of the vegetation types of the Barlee–Menzies Study Area. Considering the scale, these maps provide an adequate view of the vegetation, based on structure and dominant floristics. For example, Beard's (1976) description of the Mt Elvire survey area is apt if general: low woodland of mulga with scattered cypress pines and, in places, eucalypts, interrupted by patches of scrub (or shrubland with scattered trees) of *Acacia quadrimarginea* and mulga, by areas of succulent steppe of saltbush or bluebush with mulga or wattles, and, along the edge of Lake Barlee, by succulent steppe of samphire. There are substantial areas of Sandplains bearing a mosaic of mallee or wattle scrub and spinifex (hummock grass) and heath (also see section on Mt Manning Range Nature Reserve and Mt Manning Range).

In general, low woodlands of various kinds (4–7 m) dominated the Barlee–Menzies Study Area. However, relatively low vegetation occurred on rock outcrops and excessively drained coarse substrates. Complexes of shrubs, perennial grasses and herbaceous plants were recorded on the skeletal and shallow soils of Granite Exposures, as well as small dunes associated with salt lakes. Hills and aprons of Granite Exposures supported tall shrublands (1.5–3 m), as did Salt Lake Features where the local soil was shallow or saline. Mallees (2.5–4 m) occurred on Sandplains. Low shrublands (0.5 m), consisting almost entirely of halophytes, grew on Salt Lake Features, and formed a marginal band around the entire perimeter of the main salt lake of the Study Area. Breakaways and Drainage Lines were uncommon while Calcareous Plains were absent.

Surface porosity of soils is greatest on the loose soils of Dunefields and Sandplains, but elsewhere there is a hardsetting or crusting surface. Shallow soils cover bedrock outcrops, e.g. Red Sands on banded ironstone. The soils in those parts of the Study Area underlain by greenstone are Shallow or Deep Calcareous Earths (dusky red or dark reddish brown loams, clay loams and clays), while those parts underlain by granite are Granitic Soils and Red Earths (dark reddish brown, in places approaching dark red, very sandy loams).

The main subsoil features are ironstone gravel, a feature of ancient (Tertiary) Sandplains, and lime accumulations, in relatively heavy soils with a relatively moist climate. Lime nodules or hardpan occur in the subsoils in most landforms in the southern part of the Study Area, to a greater extent than is true immediately to the north or south. Some soils of the southern part of the Barlee–Menzies Study Area, with their subsoil hardpan of calcium carbonate, may be regarded as transitional from the calcareous soils of southern parts of the Eastern Goldfields (south and west of Kalgoorlie) to the siliceous, red and brown hardpan soils of the dry country (mulga region, Austin Botanical District) to the north. This is particularly true within the landform Broad Valleys, and appears to reflect a climatic gradient.

Modern-day climate determines the presence and nature of subsoil features in the loamy (non-Sandplains) soils, and in particular the hardpan characteristic of the mulga region (Beard 1976). On a south-west to north-east transect across the Eastern Goldfields, the subsoil acquires first calcareous nodules and then a calcareous hardpan, followed by a siliceous hardpan. This corresponds to the transition from the zone of eucalypt woodland of the south, through the zone of sheoak (*Casuarina*) low woodland, to the zone of mulga (*Acacia*) farthest north-east (Beard 1976). The formation of nodules or hardpan is apparently related to different regimes of soil moisture and temperature owing to latitude and distance from the coast. The siliceous hardpan is probably formed by solution and redeposition of silica under friable red loams during periodic deep soaking by exceptionally heavy rainstorms. Here the soils do not retain unusual quantities of sodium even in fairly low-lying areas, whereas soils in the southern parts of the Eastern Goldfields are generally sodic (Teakle 1936).

As noted previously, the Barlee–Menzies Study Area straddles the boundary between the Eremaean Botanical Province, represented by the Austin Botanical District, and the South-western Interzone, represented by the Coolgardie Botanical District. This boundary (mulga-eucalypt line) marks the transition from low woodlands of *Acacia*, which cover the drier northern parts of the eastern Goldfields (Beard 1976) to woodlands of *Eucalyptus*, which cover the moister southern parts of the Eastern Goldfields (Beard 1980). Owing to the gentle climatic gradient and generally level terrain, this boundary cannot be sharply defined. However, soil changes resulting from climate reinforce purely climatic effects to produce a more abrupt discontinuity in the vegetation than might be predicted from climate alone.

Many species besides *Acacia* spp. and *Eucalyptus* spp. (e.g. *Eucalyptus campaspe* and *E. gracilis* are at their northern limit at Mt Manning Range) are limited by the mulga-eucalypt line. Obvious examples are *Amyema maidenii*, a parasite on *Acacia aneura* (north), and *Acacia hemiteles*, a fire-adapted shrub of soils with calcareous hardpan (south), and *Acacia resinomarginea*, a thicket shrub of Sandplains (south). Numerous ephemeral species of Asteraceae enter just north of the mulga-eucalypt line, forming a tall, continuous carpet of herbaceous plants absent from similar landforms, other than Granite Exposures, in the Eastern Goldfields south of the Barlee–Menzies and Kalgoorlie–Kurnalpi Study Areas. Several annual or ephemeral species, including Asteraceae, reach their northern limit at the mulga-eucalypt line (e.g. *Helipterum manglesii, Rutidosis multiflora*, and several species of *Brachycome*).

The orchid flora currently recorded from the Study Area is restricted to Granite Rocks such as Pigeon Rock or banded ironstone hills such as the Die Hardy Range. This list includes *Caladenia incrassata, Cyanicula amplexans, Drakonorchis mesocera, Microtis parviflora, Prasophyllum macrostachyum, P. ringens, Pterostylis* aff. *nana, Spiculaea ciliata* and

Thelymitra antennifera but is probably incomplete as Mt Manning Range itself has not been adequately surveyed for orchids. The orchids recorded include many at the inland limits of their distributions.

The Study Area contains a small proportion of the woodland and low woodland of the South-western Interzone and is dominated by vegetation referable to the Eremaean Botanical Province. Some floristic elements of the South-west Botanical Province occur in the Study Area. These are mainly associated with Hills, Dunefields and Sandplains and decrease in a north-easterly direction. This is seen as an association partly with moisture but mainly with base-poor, iron-rich soils. Plant communities dominated by *Maireana sedifolia*, representing outliers of vegetation systems of the Nullarbor Plain (Beard 1975), fail to penetrate the Barlee–Menzies Study Area from the Kalgoorlie–Kurnalpi and Edjudina–Menzies Study Areas to the east.

Much of the Barlee–Menzies Study Area supports low woodland typical of Broad Valleys. *Acacia aneura* is characteristic of Red Earths on Broad Valleys in the northern parts of the Eastern Goldfields. This species occurs in pure stands on Broad Valleys only in the north-eastern sector of the Barlee–Menzies Study Area, although it does occur widely on various landforms throughout the Study Area in admixture with other species of trees or tall shrubs. At the southern edge of the Study Area, *Acacia aneura* and its associates such *A. craspedocarpa, A. tetragonophylla* and *Brachychiton gregorii* are characteristic of landforms with shallow soils and excessive drainage (e.g. Granite Exposures and Hills), rather than Broad Valleys.

In the south-western part of the Study Area the understorey on Sandplains is principally ericoid shrubs, including many Myrtaceae, while in the north-eastern part *Triodia* dominates to the near-exclusion of the shrubs. Throughout, ephemerals are very scarce despite the large surfaces of bare ground available between the shrubs or hummock grasses (see above). Other vegetation types as well as individual species, such as *Maireana pyramidata*, undergo similar shifts in habitat from south to north in the Barlee–Menzies Study Area.

The height and density of vegetation strongly reflect the moisture content of soils. In the Barlee–Menzies Study Area, the vegetation on the various landforms all derived from granite or banded ironstone essentially consists of tall shrubland, mallee over hummock grass, and woodland or low woodland over tall shrubland. The shrubland or mallee grows on the rockiest or sandiest soils such as rock outcrops or gravel plains. The woodland occurs on loamy soil over lime. Both types vary in height, density and stratification according to slight variations in soil drainage and the depth of rock fragments or hardpan.

On and around Granite Exposures, vegetation types occur essentially in concentric rings. Skeletal soils on the otherwise base rock and at the immediate periphery support a variable cover of low to tall shrubs. These tolerate long dry periods alternating with waterlogging, despite the benefit of a supply of nutrients in the fresh bedrock. Granitic bedrock clearly bars penetration of tree roots and limits the vegetation to relatively low plants. A range of perennial and annual herbaceous plants occurs.

Substantial deposits of granitic sandy loam in the general vicinity of Granite Exposures support vegetation of various heights, depending on profile thickness. Vegetation height elsewhere over granite ranges from 4 m to 18 m, trees occurring only on loam and clay loam. Vegetation on sites with a hardpan is not necessarily shorter than that where all forms of rock

are absent. Evidently tree roots penetrate the hardpan, and benefit from the good moisture-holding capacity of the associated loamy soil. In addition, extra water running on to these sites from elevated areas may more than compensate for their poor porosity and lime subsoils, and consequently poor rates of infiltration of rainfall. Kankar apparently does not impede the growth of plant roots. Gravelly sand bears vegetation of similar height to that of Sandplains generally. Gravel appears to behave similarly to deep sand as a substrate for plant roots: both are penetrable, but coarse and excessively drained, barring the growth of trees.

Vegetation in the Barlee–Menzies Study Area, and in the Eastern Goldfields generally, is low where both clay and salt content are great: 4 m in subsaline clay basins and only 0.5 m on saline flats. In the salt lakes themselves vegetation is absent. Both the shallow or sandy soils and the deep clay soils appear to have poorer moisture availability to deep roots, such as those of trees, than do some deep clay loams of moderate texture. The heaviest bottomland soils are clearly impermeable to plant roots. This is exaggerated by poor infiltration of moisture at depth and a tendency to crack at the surface. Saline flats receive much extra moisture from runoff, and infiltration at the surface is rapid, but salt and the other adverse edaphic factors limit the vegetation to the most stunted plants.

Climate and soil combine inextricably to determine the flora of the Barlee–Menzies Study Area. The Eremaean (xeric) floristic elements generally hug either the low-lying landforms, or Hills and Undulating Plains of greenstone. The South-western (mesic) floristic elements generally hug Breakaways, Dunefields, Hills and Sandplains. Sandplains contain a considerable number of taxa not found in other landforms. However the general floristic affinity of Sandplains is with the Hills of banded ironstone despite the obvious differences in soil texture and depth.

The xeric types are represented by trees or tall shrubs of *Casuarina*, shrubs of *Eremophila* and low shrubs of Chenopodiaceae or, on sandy soil, the hummock grass *Triodia*. The mesic types are represented by shrubs of e.g. Myrtaceae (e.g. *Baeckea*) and Proteaceae, and sedge-like plants of e.g. Cyperaceae. Other examples of the dichotomy of floristic elements are: *Atriplex, Enchylaena, Frankenia, Halosarcia, Heterodendrum, Pittosporum, Ptilotus, Rhagodia, Sclerolaena* and *Sclerostegia*, versus *Allocasuarina, Leptospermum, Melaleuca, Thryptomene, Keraudrenia, Phebalium, Westringia, Hakea* and *Olearia*. *Eucalyptus* and *Acacia* are referable to the South-western Interzone rather than Eremaean or South-west per se. They are generally important in both types of substrate although the species differ between the substrates.

Although part of the pattern described can be accounted for by the slightly drier climate in the northern and north-eastern parts of the Study Area, the cation exchange capacity of soils is obviously a major factor responsible. The xeric flora grows mainly on basic soils: Shallow and Deep Calcareous Earths, Aeolian Sands, Red Earths, Sub-saline Soils and Saline Soils. The mesic flora grows mainly on soils poor in all bases: Deep Sands and Gravelly Sands (derived from highly leached lateritic podsols) and Red Sands and Granitic Soils.

Several points are worth noting about stratification of the vegetation. Trees are generally composed of *Eucalyptus*, but several other taxa also occur where soil conditions favour them. Examples are *Casuarina* (lime subsoils), *Brachychiton* and *Callitris* and, as low trees only, *Acacia* and *Santalum*. There are normally about 4 tree species in a given community, of which one or two are more common than the others.

The tall shrub stratum contains more taxa than the tree stratum even where the tall shrubs are relatively scarce. There are normally at least 8 species present. This stratum is composed not only of *Acacia*, which is generally dominant, but also of Proteaceae and Myrtaceae (sandy soils poor in nutrients), Myoporaceae (relatively heavy soils) and Santalaceae (sparsely throughout).

Turning to the low shrub stratum, we find that Chenopodiaceae are dominant on the relatively heavy or nutrient-rich soils, while Myrtaceae are dominant on sandy soils poor in nutrients. These are supplemented respectively by Apocynaceae, Goodeniaceae, Amaranthaceae, Frankeniaceae, Asteraceae and Myoporaceae, and by Lamiaceae, Epacridaceae, Proteaceae and Rutaceae. There are generally 10–15 species in the low shrub stratum. The sandy, infertile soils do not have markedly more species than do the heavy, base-rich soils. This is discussed more fully below.

The herbaceous stratum is poor in perennial taxa. These consist mainly of scattered *Sclerolaena* (Chenopodiaceae) and *Ptilotus* (Amaranthaceae) on heavy soils and scattered *Triodia* (Poaceae) on sandy soils. The small geophyte *Wurmbea* is present throughout as an occasional plant. However, if the ephemerals are considered, the heavy, base-rich soils have an extra 15–25 species, e.g. *Helipterum, Calotis* and *Podolepis* (Asteraceae), *Erodium* (Geraniaceae) and *Zygophyllum* (Zygophyllaceae).

Where the vegetation is owing to poor moisture relations or salinity, the strata are eliminated one by one, starting with the trees, until only the ground stratum remains, composed of Chenopodiaceae and annual Asteraceae, with the admixture of a few other families. The floristic composition of the vegetation changes with height above ground. The example used is BM20, the survey campsite at Mount Elvire, low woodland of *Eucalyptus* and mulga. The trees (taller than 6 m) are composed of *Eucalyptus* (Myrtaceae), the only other taxon being *Amyema*, the mistletoe (Loranthaceae). The lower trees and tall shrubs are composed of *Eremophila*, *Cassia*, Santalaceae and Goodeniaceae. The ground stratum is composed of dwarf shrubs and herbaceous plants of Chenopodiaceae, Amaranthaceae, Solanaceae, Malvaceae, Asteraceae, Poaceae and very occasional plants of Liliaceae. The annual and ephemeral component is not shown but consists mainly of Asteraceae, Goodeniaceae, Geraniaceae, Portulacaceae and Zygophyllaceae, or, in summer, Poaceae.

The flora of the Barlee–Menzies Study Area has not previously been systematically recorded and documented. During the survey 3 species of ferns, 2 species of conifers and 577 taxa of flowering plants were recorded from the Study Area. Families with the largest numbers of species were Asteraceae (94 spp.), Leguminosae (66 spp.), Myrtaceae (62 spp.), Chenopodiaceae (41 spp.) and Poaceae (33 spp.). Genera with numerous species were *Acacia* (36 spp.), *Eucalyptus* (28 spp.), *Eremophila* (18 spp.), *Maireana* (19 spp.) and *Ptilotus* (17 spp.).

The Barlee–Menzies Study Area contains no gazetted rare flora (Atkins 1993). Although no plant taxa appear to be confined to the Study Area, some have restricted distributions (such as *Eucalyptus formanii* and *Caladenia incrassata*) and several are endemic to the Eastern Goldfields.

A considerable number of flora species are confined to the area of banded ironstone Hills that straddles the Barlee–Menzies Study Area and the adjacent Jackson–Kalgoorlie Study Area (see Newbey & Hnatiuk (1985) and the section on the Mt Manning Range Nature

Reserve and Mt Manning Range). These included *Dryandra arborea*, *Grevillea georgiana*, and *Neurachne* sp. nov. (GJK/J. Alford 1951)

A number of new, undescribed and rarely collected species were recorded during the survey of the Barlee–Menzies Study Area such as *Acacia* sp. nov. (GJK 11217), *Baeckea* sp. nov. aff. *crispiflora* (GJK 12435), *Calandrinia* sp. nov. (GJK 12976), *Gnephosis* sp. nov. (GJK 12997), *Neurachne* sp. nov. (GJK/J. Alford 1951) and *Tricoryne* sp. nov. (GJK 11230).

Several species were recorded at the limits of their distributions, at either the inland or rarely at the south-western margins of their ranges, within the Study Area. These included *Chamelaucium ciliatum, Caustis dioica, Hybanthus floribundus, Lechenaultia brevifolia* (inland margins, and the first records of these species for the Eremeaen Botanical Province) and *Acacia hemiteles*, *Kennedia prorepens*, *Stylidium humphreysii* and *Xanthorrhoea thorntonii* (south-western margin).

The flora of the Study Area, however, is still incompletely known. In particular, a further search of the inaccessible western parts should reveal additional species where the Study Area approaches the South-west Botanical Province more closely than does any other Study Area in the northern part of the Eastern Goldfields (Youngson & McKenzie 1977, Beard 1980). There is scope for intensive botanical investigation of shallow soils and inaccessible habitats on Breakaways, Granite Exposures, Hills and Salt Lake Features, where easily overlooked species important for conservation are most likely to occur. The terrestrial moss and lichen floras, and introduced flora found in disturbed areas, were also inadequately documented.

A comparison with the flora of the adjacent Jackson–Kalgoorlie Study Area (Newbey & Hnatiuk 1985) shows the reduction of species of South-Western affinities, e.g. Orchidaceae (17 species recorded in the Jackson–Kalgoorlie Study Area compared to 10 in this Study Area), Cyperaceae (18 compared to 6), Droseraceae (5 compared to 2), Proteaceae (45 compared to 23) and Epacridaceae (12 compared to 2) and Dilleniaceae (7 compared to 2). However, many of these species may occur in the poorly known south-western margin of the Study Area.

The Barlee–Menzies Study Area is relatively unmodified by recent human activity. This is attributed to the relative scarcity of mineral deposits and the widespread cover of highly infertile Sandplains unable to support domestic stock. The main impact of human activity has thus been on Undulating Plains over greenstone, where gold and other valuable minerals tend to occur, soils are relatively productive of soft herbaceous growth, soil cover is shallow and fragile, and the environment is suitable for several species of introduced plants.

Most of the Barlee–Menzies Study Area has retained a semi-natural state and parts are in virtually pristine condition. In addition, there has been encouraging recovery where woodcutting and overgrazing have taken place in the past. However, adequate protection of designated areas remains important. The south-west to north-east gradient in the vegetation means that a number of conservation reserves are required to adequately cover all the types present in the Study Area.

A fairly extensive nature conservation area, presently established within the Study Area, incorporates the Mt Elvire pastoral lease (now owned by the Department of Conservation and Land Management and proposed to be declared State forest, CALM 1992) and the Mt Manning Range Nature Reserve. This large conservation area extends south from Lake Barlee but excludes the entire Mt Manning Range. This combined conservation reserve preserves

several representative vegetation communities of the Study Area. It however, excludes the most distinctive vegetation types of the Barlee–Menzies Study Area and the adjacent Jackson–Kalgoorlie Study Area, which are restricted to the Mt Manning Range, Die Hardy Range, Yokradine Hills, Mt Jackson and Bungalbin Hill.

Several vegetation types appear to be adequately served by nature reserves elsewhere to the east (Goongarrie National Park) and west (Karroun Hill Nature Reserve). The description of Goongarrie National Park is also representative of the vegetation occurring in the south-eastern part of the Barlee–Menzies Study Area (see Milewski & Keighery 1988). The adjacent Karroun Hill Nature Reserve is situated at similar latitude but immediately west of the border of the Barlee–Menzies Study Area. Karroun Hill Nature Reserve conserves a number of vegetation types also found in the Study Area (see Youngson & McKenzie 1977).

Sandplains support *Eucalyptus leptopoda* Mallee, *Allocasuarina acutivalvis* Tall Shrubland, *Acacia resinomarginea* Tall Shrubland, and probably *Eucalyptus oldfieldii* Mallee (found in the vicinity of Granite Exposures). Broad Valleys support *Eucalyptus salmonophloia* Woodland, *Eucalyptus loxophleba* Low Woodland, *Eucalyptus salubris* Low Woodland, *Callitris columellaris* Low Woodland and *Acacia aneura* Low Woodland (Youngson & McKenzie 1977).

Karroun Hill Nature Reserve thus provides for the conservation of large areas of several vegetation types poorly represented in the Mt Manning Range Nature Reserve. These extend broadly into the south-western part of the Barlee–Menzies Study Area as the Karroun System, a different vegetation system from that found in the Mt Manning Range Nature Reserve (Beard 1972). However, the flora of Karroun Hill Nature Reserve is still poorly known.

The nature conservation reserves in the adjacent Jackson–Kalgoorlie Study Area have poor representation of Breakaways and Broad Valleys and no representation of Salt Lake Features, Hills (banded ironstone) and Undulating Plains (greenstone). The presence of some of these types within the Mt Manning Range Nature Reserve and Mt Elvire pastoral lease is therefore particularly valuable in the context of these two adjacent Study Areas. In addition, Goongarrie National Park provides for the conservation of small areas of Salt Lake Features and Broad Valleys, as well as Granite Exposures and Sandplains which are well-covered by conservation areas in this regional context.

Mt Manning Range Nature Reserve and Mt Manning Range

Background

The Mt Manning Range Nature Reserve (No. 36208) is situated around the Mount Manning Range. A Mining Act Ministerial Temporary Reserve (1971H) encompasses the entire Range and effectively excludes the Mount Manning Range itself from the Mt Manning Range Nature Reserve. The following discussion of the Mount Manning Range area includes both the Mt Manning Range Nature Reserve and the Mt Manning Range.

The Nature Reserve (153 293 ha) straddles the southern border of the Barlee–Menzies Study Area and extends into the Jackson–Kalgoorlie Study Area immediately to the south. It includes extensive plains in the surrounding area, embracing substantial examples of the vegetation types of the region, but excludes the entire Mt Manning Range. The area supports

varied vegetation types including restricted but well-known species such as *Dryandra arborea* and *Eucalyptus formanii*. It also contains a number of vegetation types found in the Barlee–Menzies and the adjacent Jackson–Kalgoorlie Study Areas (Newbey & Hnatiuk 1985). Most of the vegetation types in the Nature Reserve and those on the Mt Manning Range itself are shared between these two Study Areas. However, a notable exception is *Eucalyptus formanii* Low Woodland, which barely penetrates the Jackson–Kalgoorlie Study Area.

A unique feature of the banded ironstone Hills in the Mt Manning Range and adjacent parts of the Jackson–Kalgoorlie Study Area (e.g. Die Hardy Range, Yokradine Hills, Mount Jackson and Bungalbin Hill) is that geographically restricted species are particularly common components of the vegetation types in which they occur. The best example is *Eucalyptus formanii* but the same applies *to Neurachne* sp. nov. (GJK/J. Alford 1951), *Calycopeplus ephedroides, Grevillea georgiana, Grevillea* aff. *paradoxa* (KRN 9646) and *Dryandra arborea*. The Mt Manning Range area thus contains a substantial proportion of both the total area of these vegetation types and the total population of these species.

Vegetation Descriptions

The vegetation of the Mt Manning Range area extends from the hills of the Mt Manning Range onto the surrounding plains that constitute the Mt Manning Range Nature Reserve. The following descriptions discuss the vegetation types from the hills down to the plains.

Hills (ridges, rocky slopes and crests)

Five vegetation types were distinguished on the hills of the Mt Manning Range: *Acacia aneura* Tall Shrubland, *Eucalyptus ebbanoensis* Mallee, *Acacia quadrimarginea* Tall Shrubland, *Dryandra arborea* Tall Shrubland and *Allocasuarina acutivalvis* Tall Shrubland.

Eucalyptus ebbanoensis Mallee was a stunted version of the general vegetation type of the lower slopes of the Mt Manning Range (see below). *Acacia quadrimarginea* Tall Shrubland was essentially similar in habitat and species composition to *Acacia aneura* Tall Shrubland, but local dominance shifted to *A. quadrimarginea* owing possibly to the nature of the bedrock. *Dryandra arborea* Tall Shrubland occupied lateritic patches, particularly on the ridge crest (see BM7 in Appendix 1).

Acacia aneura Tall Shrubland was the vegetation of the rocky slopes and crest of the Mt Manning Range, a relatively dense form of Tall Shrubland with composition shared between members of the Leguminosae (Mimosoideae), Proteaceae, Myrtaceae, Euphorbiaceae, Casuarinaceae, Sapindaceae, Myoporaceae, Rutaceae, Goodeniaceae, Epacridaceae, Dilleniaceae and Amaranthaceae. Most areas had a ground cover of perennial grass (Poaceae). Dispersed among the angular stones were a few species of ephemerals with a seasonal canopy cover totalling 0.5–1%, and composed of Apiaceae, Goodeniaceae and Asteraceae. The soil was dark reddish brown loam referable to the type Red Sands which characterised outcrops of banded ironstone, including these Hills, in the Eastern Goldfields (see Soils in Physical Environment).

Most of the shrub species coexisted with roughly equitable contributions to canopy cover. However, *Acacia aneura* was weakly dominant in the upper stratum. *Neurachne* sp. nov. (GJK/J. Alford 1951) characteristically dominated the ground stratum as small grass tussocks of soft spinifex. *Trachymene ornata* dominated the ephemerals.

Medium-tall shrubs were composed of at least three species of *Acacia, Santalum spicatum, Allocasuarina acutivalvis* and a few other species. Medium-low shrubs formed the most important stratum, in terms of cover if not biomass, and comprised *Grevillea paradoxa, G.* aff. *paradoxa* (KRN 9646), *Calycopeplus ephedroides, Eriostemon brucei* and relatively small proportions of more than five other species including *Scaevola spinescens* and two species of *Baeckea.* Chenopodiaceae were virtually absent. Ground plants included scattered individuals of rhizomatous ferns (*Cheilanthes* spp.).

Ephemerals were present in small populations of interesting composition on the ridgetop of the Mt Manning Range. The ephemerals, particularly *Waitzia acuminata,* were not noticeably clumped under shrubs as was true in most other vegetation types in the study area. *Waitzia acuminata,* sprinkled throughout the shallow rocky soils from ridgetop to bottom, was a species shared with Sandplains where it was generally restricted to patches of litter under relatively large shrubs. Likewise, *Trachymene ornata* extended on to even the rockiest, shallowest soils irrespective of the availability of shrub cover. However, shade or shelter appeared to remain important for *Helichrysum davenportii* and *Bellida graminea,* which were locally common even on the ridgetop.

Other ephemerals which were uncommon but definite components of this community included *Crassula sieberi, Brunonia australis, Helipterum verecundum, Waitzia citrina, Stenopetalum filifolium, Chthonocephalus pseudevax* and possibly *Actinobole uliginosum.* Patches of *Calocephalus drummondii* were found on the main crest. Small areas of the rocky ridge and slopes had a shallow calcareous coating over the bedrock marked by the growth of *Helipterum oppositifolium* and *Vittadinia* sp. Surprisingly, *Helipterum fitzgibbonii* was absent.

Lower slopes (colluvial soils)

Eucalyptus ebbanoensis Low Woodland consisted of an open stand of trees, or tree mallee, of *Eucalyptus ebbanoensis* over tall shrubs of *Acacia ramulosa* over the tussock grass *Plectrachne* sp. (as above). A sprinkling of ephemerals consisted of *Waitzia acuminata, Helipterum fitzgibbonii, Stenopetalum filifolium* and *Schoenia cassiniana.* The soil was shallow, stony, dark red loam and sandy loam on the lower slopes of the Hills of banded ironstone. At the base of the Hills, similar substrate and vegetation occurred as small patches referable to Undulating Plains (banded ironstone), not Hills. A thin hardpan of calcium carbonate separated soil from bedrock.

Acacia aneura Low Woodland occurred in small patches on relatively deep, colluvial soils on Undulating Plains forming the lower slopes of the Mt Manning Range (see BM18 in Appendix 1). On some gently sloping pediments, the soil was gravelly and loamy on lateritic sites free of rock. *Eucalyptus ewartiana* was present, and *Acacia* spp. and several low shrubs of small-leafed Myrtaceae entered, providing a floristic link to Sandplains.

Valleys (loams)

Casuarina cristata Low Woodland (Undulating Plains) dominated restricted areas of gently sloping ground at the base of the Mt Manning Range. The local Undulating Plains over greenstone supported *Casuarina cristata* Low Woodland on the rises formed over amphibolite bedrock, and the following type (*Eucalyptus salubris* Low Woodland) in the dips formed over serpentinite bedrock. Rises and dips did not necessarily lie adjacent to each other since

Undulating Plains occurred as small enclaves at the junction of Hills and Broad Valleys.

The low shrub *Ptilotus obovatus* was characteristic. However, the tussock grass (*Plectrachne*), typical of the footslopes of banded ironstone, was present here too in small populations. The ephemerals were generally dominated by *Gnephosis skirrophora*, although *Cephalipterum drummondii* extended well into this type from the *Eucalyptus salubris* Low Woodland described below. However, saltbush (*Atriplex*) was absent. Some areas had well-grown trees of *Eucalyptus* as well as the dominant *Casuarina cristata*.

Eucalyptus salubris Low Woodland consisted of a well-stocked stand of the single-boled tree *Eucalyptus salubris* over low shrubs of the semi-succulent *Atriplex vesicaria*. There was generally only a sparse contribution by intermediate strata. *Casuarina cristata* was present as low trees and *Eremophila scoparia* and other species occurred as tall shrubs. There was a seasonally dense cover of tall ephemerals of *Cephalipterum drummondii* and a diversity of low annuals and ephemerals including several small grasses. The habitat occurred as oblong depressions in Undulating Plains at the base of the Mt Manning Range. Such patches generally ran about 100 m wide along poorly defined creeklines with some development of crabholes (gilgai). The soil was relatively heavy and nutrient-rich, referable to Deep Calcareous Earths, gravelly in some places or with a tendency to crack at the surface in others.

Eucalyptus salubris Low Woodland was distinctive in both composition and habitat and did not occur extensively in the Mt Manning Range area. The ephemeral community differed from those of the other landforms including those generally abutting this type, i.e. *Eucalyptus formanii* Low Woodland. In some areas, *E. salubris* gave way to *Eucalyptus salmonophloia* or a mixed stand of several other species of *Eucalyptus* and *Casuarina cristata*.

Eucalyptus salmonophloia Woodland consisted of relatively tall, scattered trees of *Eucalyptus salmonophloia* with an open understorey and very few ephemerals. It occupied only small areas, in gentle basins on Broad Valleys. The ground surface in these basins included slight rises. Presumably a friable, penetrable calcareous subsoil was characteristic (also see *Eucalyptus salubris* Low Woodland).

Acacia aneura Low Woodland had several prominent constituents of which *Acacia aneura* was the most important. *Eucalyptus* spp. were common and formed the tallest plants, so that the type was similar to *Eucalyptus oleosa* Low Woodland and *Eucalyptus transcontinentalis* Low Woodland (see Table 1). *Eucalyptus formanii* was generally absent. The habitat was dark reddish brown sandy loam on Broad Valleys which formed a large part of the plain surrounding the Mt Manning Range. A subsoil hardpan occurred and, where exposed, appeared to be at least partly calcareous.

Low trees of *Casuarina cristata* and a definite sub-stratum of tall shrubs of *Acacia ramulosa* were generally present. The ground was characteristically open with a seasonally prominent ephemeral stratum. However, ephemeral cover even in good seasons varied from near-complete, on relatively low-lying sites with comparatively heavy (though still sandy) soils, to very sparse on some other sites. The ephemerals typically consisted of dense but patchy populations of *Velleia rosea*, and thin but widespread populations of *Waitzia acuminata*. *Podolepis lessonii* was also present, although *Cephalipterum drummondii* appeared in some places with relatively firm or stony soils. There were occasional trees of *Brachychiton gregorii* or *Eucalyptus salmonophloia*. Some areas had a recognisable structural component of tree mallee (*Eucalyptus* spp.) and broombush (*Eremophila* spp.).

Plains (sands/loams)

Eucalyptus formanii Low Woodland consisted of 10 m high trees of *Eucalyptus formanii* with an understorey of hummock grass of *Plectrachne rigidissima.* However, composition was fairly complex with several intermediate strata of tall and low shrubs. *Eucalyptus formanii* trees resembled mallees in that they branched low down and lacked long single boles. The shrub stratum consisted of e.g *Grevillea acuaria, Bossiaea walkeri* and *Eremophila* spp. The soil was dark reddish brown to yellowish red sandy loam. It was an unusually coarse and nutrient-poor soil for Broad Valleys. Generally the soil was deep although a lime hardpan was apparent in places. *Eucalyptus formanii* Low Woodland occupied the nearly flat plain immediately surrounding the Mt Manning Range.

A variant of the type was dominated by mallee of *Eucalyptus transcontinentalis* over relatively low shrubs of *Acacia* over hummock grasses (see below). The ephemeral *Cephalipterum drummondii* was generally absent except in the beds of a few diffuse creeklines at the boundary between this type and the footslopes of the Mt Manning Range. The creeklines were marked by particularly well-grown eucalypts (see BM20 Appendix 1). Where the soil was a firm loam at the transition to *Acacia aneura* Low Woodland or Undulating Plains, hummock grasses became rare. Where the soil on flat ground was shallow over sub-surface banded ironstone, the composition was of open tree mallees including *Eucalyptus ebbanoensis* over *Acacia ramulosa*, providing the transition to *Eucalyptus ebbanoensis* Low Woodland on Undulating Plains.

Eucalyptus leptopoda Mallee, in contrast to most other vegetation in the Mt Manning Range area, was shrub- rather than tree-dominated. Plants taller than 7.5 m were absent. It consisted of mallee of *Eucalyptus leptopoda* and a few congeners, together with tall shrubs of *Acacia* spp. The understorey consisted of small-leafed shrubs of various species, and a sparse admixture of hummock grasses (*Triodia scariosa* and *Plectrachne rigidissima*). The soil was a pale loamy sand with a lateritic gravel subsoil on flat sites on Sandplains. It was referable to yellowish red to dark yellowish brown Deep Sands. *Eucalyptus leptopoda* Mallee occupied extensive areas on the level ground surrounding the Mt Manning Range, particularly to the west and south. In some places of past aeolian activity, marked by *Callitris preissii* ssp. *verrucosa* and *Melaleuca uncinata*, there was a slight ridge-swale topography too subdued to be referable to the landform Dunefields.

On especially pale, reddish yellow, gravelly Sandplains (Gravelly Sands) the vegetation was *Acacia* spp. Tall Shrubland (2 m high). It consisted of a dense stand of *Acacia* spp. over an open stand of small hummocks of *Triodia scariosa.* However, the community was mixed, with a wide variety of other Sandplains perennials uniformly scattered among the above components. Examples included tall shrubs of *Banksia*, the grass tree *Xanthorrhoea*, and Myrtaceae and other taxa which formed moderately tall, low or dwarf, small-leafed shrubs. *Eremophila* was absent. On Sandplains sites transitional to the sandy flats found on Broad Valleys there were patches of *Eucalyptus formanii* stunted to mallee form over shrubs of *Acacia.* This vegetation was distinguished from *Eucalyptus formanii* Low Woodland of Broad Valleys by the lack of trees but did not warrant the recognition of a separate vegetation type (see Table 1).

Acacia quadrimarginea Tall Shrubland consisted of tall shrubs of *Acacia quadrimarginea* and a wide variety of other species (*Acacia burkittii, A. tetragonophylla, A. ramulosa,*

Pittosporum phylliraeoides, Eremophila longifolia, Santalum spicatum) with a dense and diverse seasonal cover of ephemerals. Together with *Eucalyptus leptopoda* Mallee, *Acacia quadrimarginea* Tall Shrubland was one of the few vegetation types in the Mt Manning Range area lacking substantial trees. The only trees present were stunted and not much higher than the *Acacia* shrubs e.g. *Brachychiton gregorii*. The herbaceous cover consisted of *Velleia rosea, Cephalipterum drummondii, Schoenia cassiniana, Helichrysum davenportii, Podolepis canescens* and *Stenopetalum filifolium. Podolepis lessonii* was commonly found clumped under shrubs. Where the soil was relatively deep and siliceous, *Waitzia acuminata* occurred and where the soil was relatively shallow and calcareous, *Angianthus tomentosus* occurred with occasional populations of *Podotheca gnaphalioides*.

Granite Exposures

On the plains surrounding the Mt Manning Range, Granite Exposures generally consisted of nearly level aprons with mainly subsurface granite with shallow and dark reddish brown soil. However, the vegetation was complex and no species clearly dominated over any large area. Seven associated vegetation types were distinguished as patches on Granite Exposures and the few Breakaways present in the Mt Manning Range Nature Reserve. These were *Casuarina cristata* Low Woodland, *Acacia aneura* Tall Shrubland, *Acacia tetragonophylla* Tall Shrubland, *Acacia burkittii* Tall Shrubland, *Eucalyptus ewartiana* Mallee, *Eucalyptus loxophleba* Mallee and Granite Exposures Complex.

Casuarina cristata Low Woodland occupied stony rises on extensive Granite Exposures. *Cephalipterum drummondii* was generally the most conspicuous ephemeral. *Acacia aneura* Tall Shrubland occupied small, relatively low-lying flats of base-rich, saline soils associated with Granite Exposures together with low shrubs of Chenopodiaceae including samphires (*Halosarcia* spp.). *Acacia tetragonophylla* Tall Shrubland was poorly defined and consisted of several species of *Acacia* and other tall shrubs of near-equal contribution (including *Acacia burkittii*). It occupied some aprons on nearly flat Granite Exposures with shallow soils.

Eucalyptus ewartiana Mallee co-occurred in small patches where *E. ewartiana* or *E. loxophleba* locally joined the dominant *Acacia burkittii* on stony plains constituting a variant of the aprons of Granite Exposures. Scattered tussock grasses of *Plectrachne* were present. At the transition from Granite Exposures to the closely related landform Broad Valleys, the vegetation contained trees of Acacia aneura, shrubs of *Acacia* spp., low shrubs of *Eremophila leucophylla*, and ephemerals of *Helipterum manglesii, Schoenia cassiniana, Waitzia acuminata, Podolepis canescens* and *Cephalipterum drummondii*.

Granite Exposures Complex occupied expanses of the bare rock itself, but such areas were limited in extent and no exposed rocks higher than 3 m were seen in the area.

Salt Lake Features

Vegetation types that occurred over small areas on Salt Lake Features in the Mt Manning Range Nature Reserve included *Casuarina cristata* Low Woodland, *Eremophila miniata* Tall Shrubland, *Cratystylis subspinescens* Low Shrubland, *Maireana* spp. Low Shrubland, *Atriplex* spp. Low Shrubland, *Frankenia* spp. Low Shrubland and *Halosarcia* spp. Low Shrubland.

Casuarina cristata Low Woodland was part of a complex group of vegetation types, in which dominance was ill-defined and patches varied according to microtopography and the soil catena. On the base-rich soils of Salt Lake Features in the Nature Reserve, *Casuarina*

cristata occurred as trees taller than 7 m on slightly raised, relatively sandy ground (red sandy loam). There were scattered groups of *Eucalyptus clelandii* or *E. lesouefii*, and shrubs of *Scaevola spinescens, Acacia hemiteles, Dodonaea angustissima, Bossiaea walkeri, Olearia* sp. and, in some areas, *Callitris* sp. Ephemerals were found mainly in patches of leaf litter and included *Waitzia acuminata* (common), *Podolepis canescens, Schoenia cassiniana* and *Velleia rosea.*

Where the sand was relatively pale and piled into distinct small dunes, *Eucalyptus* spp. and *Callitris columellaris* tended to replace *C. cristata, Triodia scariosa* occurred, and the ephemeral *Helipterum manglesii* was conspicuous. On extensive flats of dusky red sandy loam, there was an evenly spaced stand of *C. cristata* 8–12 m in height. The sclerophyllous shrub *Bossiaea walkeri* was common while ephemerals and soft grasses were relatively sparse. *Waitzia* and a few other species remained obvious and there was a sprinkling of *Stipa trichophylla.*

Eremophila miniata Tall Shrubland was found upslope of *Frankenia* spp. Low Shrubland (see below). Patchy tall shrubs of *Eremophila miniata, Acacia ramulosa, Eremophila scoparia* and *Dodonaea angustissima* were characteristic. However, *Acacia ramulosa* Tall Shrubland and *Dodonaea angustissima* Tall Shrubland could be distinguished as separate types. The fine-scale mosaic of vegetation resulted from the dunefield microrelief. *Eremophila miniata* Tall Shrubland gave way upslope or on the most substantial of the small dunes of *Casuarina cristata* Low Woodland as described above.

Cratystylis subspinescens Low Shrubland consisted of an open stand of the 1 m high shrub *Cratystylis subspinescens*. Plants taller than 1.5 m were mainly tall shrubs rather than trees, and were largely restricted to groves. The type occupied relatively nutrient-rich Sub-saline Soils on flats and in slight depressions.

Maireana spp. Low Shrubland was a form of succulent steppe (Beard 1976). Semi-succulent shrubs weakly dominated relatively dense stands of 0.5–1 m high shrubs with scattered groves of trees or tall shrubs. *Podotheca gnaphalioides* was the dominant ephemeral. It was common on pale, sandy soils irrespective of whether the perennial stratum was referable to *Atriplex* spp. Low Shrubland *Frankenia* spp. Low Shrubland, or *Halosarcia* spp. Low Shrubland (see below).

Atriplex spp. Low Shrubland occupied small areas of sub-saline Soils containing some gypsum and occurred in the northern part of the Mt Manning Range Nature Reserve. Associated with the 0.5–1 m high, semi-succulent shrubs of *Atriplex* was a seasonally continuous cover of ephemerals including some grasses and introduced species (e.g. *Bromus*). One variant was low, dense *Atriplex* with very scattered groves of shrubs or low trees such as *Pittosporum phylliraeoides* on open flats.

Frankenia spp. Low Shrubland consisted of low, soft shrubs of *Frankenia* and *Gunniopsis*, occurring over small areas generally between *Atriplex* spp. Low Shrubland (see above) and *Halosarcia* spp. Low Shrubland (see below). The best examples fringed narrow salt lakes with bare, white floors. However, small patches occurred on a few abrupt, bare pans, including claypans, punctuating Salt Lake Features away from these salinas.

Halosarcia spp. Low Shrubland occupied the inner fringes of salt lakes or, in some areas, floors of the small pans described above. The soil was seasonally inundated, saline and occurred in flat lake bottoms.

Discussion

From the present survey, 30 major vegetation types were distinguished in the Mt Manning Range area.

Beard mapped the southern part of the Reserve at a scale of 1:250 000 (Beard 1972) and the northern part at 1:1 000 000 (Beard 1976). On the range itself, *Acacia* thicket of *Acacia quadrimarginea* and *A. aneura*. On the plains at the base, Sclerophyll woodland of *Eucalyptus salmonophloia* and *E. loxophleba*. Also on the surrounding plains, large patches of *Acacia* thicket (punctuated by Granite Exposures). In the general vicinity, several other types including scrub or low woodland of *Acacia* spp.

Beard's description of the vegetation of what is now the Mt Manning Range Nature Reserve is thus apt, if general. The main deficiency is that he does not recognise the restricted but important type characterised by *Eucalyptus formanii* in the Mt Manning Range area.

Although not stated, the implication of Beard's maps is that the vegetation changes from south-west to north-east within the Mt Manning Range Nature Reserve. On Hills, *Acacia quadrimarginea* in the south-west shifts to *A. aneura* and *A. quadrimarginea* in the north-east. On Sandplains, *Acacia resinomarginea, A. neurophylla* and/or *A. beauverdiana* lose their dominance in the *Acacia* thicket.

On the deep soils on Broad Valleys and parts of Salt Lake Features, sclerophyll woodland shifts to mixed *Acacia aneura* with *Casuarina cristata* and eucalypts. On the relatively shallow soils on Broad Valleys, wattle scrub of *Acacia brachystachya* and congeners shifts to scrub of *Acacia ramulosa* with scattered trees of *Casuarina cristata* (Beard's *Acacia brachystachya* is now regarded as a form of *A. aneura*, B.R. Maslin, pers. comm.). Patches of mulga low woodland of *A. aneura* appear in the north, presumably on Granite Exposures and Broad Valleys. On Salt Lake Features, dotted with claypans, wattle and saltbush shifts to mulga and wattles with saltbush.

These changes aptly emphasise the gradually fading dominance of *Acacia* on the Sandplains, and the gradually increasing dominance of *Casuarina cristata* and *Acacia aneura* on other landforms, both as a regional phenomenon and specifically within the Nature Reserve, in a northward direction.

Beard's (1972) brief description of the Die Hardy System applies well to the Mt Manning area. We therefore propose that the Mt Manning Range and the associated Broad Valleys, Sandplains and Salt Lake Features in its vicinity should henceforth be regarded as part of the Die Hardy System. Such an assignment would extend the at present unrealistically restricted Die Hardy system, and emphasise the occurrence of a vegetation type dominated by *Eucalyptus formanii* on the plains as a fundamental distinction between the Die Hardy System and the other ridges of banded ironstone to the south, which form the Bungalbin System as islands in the extensive Jackson Vegetation System.

South-western elements are associated with the nutrient-poor tall Hills of banded ironstone and yellow Sandplains while Eremaean elements are associated with other soil types, relatively rich in calcium and in some cases other nutrients. The Sandplains in the Mt Manning Range area may be compared with those in Goongarrie National Park and nearby (Comet Vale), which constitute another noteworthy outlier of South-western elements lying at similar latitude but slightly east of the Barlee–Menzies Study Area, in the adjacent Edjudina–Menzies Study Area (Milewski & Keighery 1988).

Sandplains in the Mt Manning Range Nature Reserve have slightly stronger South-western affinities than those in the Goongarrie reserve, and other details of species-composition differ. For example, several species of Cyperaceae, Epacridaceae and Stylidiaceae, found in the Nature Reserve and in the Mt Manning Range, fail to reach the sites sampled in and near Goongarrie National Park (see Milewski & Keighery 1988).

Most of the 30 vegetation types of the Mt Manning Range area are shared between the southern fringe of the Barlee–Menzies Study Area and the northern part of the Jackson–Kalgoorlie Study Area but are rare elsewhere in the Eastern Goldfields.

The vegetation of the Mt Manning Range itself, the central feature of the area, is intermediate between mulga vegetation and south-western Australian thicket. It contains elements specific to the scrub of Granite Exposures under a wide variety of climatic regimes in southern Western Australia. It also contains elements of Sandplains of the south-west of the State, particularly in the low shrub stratum (e.g. *Leucopogon, Hibbertia, Melaleuca*). The controlling factors appear to be the intermediate climate of the area and the siliceous rock type with its chemical similarity to granite but poverty of nutrients which allies it with senile, lateritic podsols. Further exploration may show that the crest of the Mt Manning Range provides a refuge for other south-western elements, such as Orchidaceae, depending on moist or shady microhabitats. Similar comments apply to Breakaways which have not been adequately explored in the Mt Manning Range Nature Reserve.

By virtue of its position on the mulga-eucalypt line at the northern edge of the South-western Interzone, the Mt Manning Range Nature Reserve contains vegetation types widespread in the northern part of the Eastern Goldfields, and others widespread in the southern part. However, both groups have local distinctive features. For example, *Eucalyptus salubris* Low Woodland found here is essentially an outlier of similar vegetation widespread on Calcareous Plains in the southern part of the Eastern Goldfields. *Atriplex* in the northern portions of the Eastern Goldfields generally has an overstorey of *Acacia aneura* (instead of *Eucalyptus*). *Eucalyptus gracilis* and *Eucalyptus campaspe* in the Mt Manning Range area are at the northern extremes of their distributions.

This survey recorded 293 taxa of vascular plants from the Mt Manning Range area (see Appendix 2), 50% of the flora recorded for the Study Area. This list probably represents 70% of the total flora expected to occur in the area.

Species richness in the Nature Reserve is enhanced by its geographic position, e.g.: *Ptilotus carlsonii*, at the northern extreme of its range, meets *Ptilotus aervoides* and *Ptilotus chamaecladus*, at the southern edge of their ranges. The ephemerals replace southern features of *Eucalyptus salubris* Low Woodland such as a tall shrub stratum of *Melaleuca* and a low shrub stratum of *Cratystylis conocephala*. This replacement also occurs in the tall shrubs, e.g.: *Myoporum* and *Geijera* found in the southern type are replaced by *Eremophila* spp. and *Atriplex nummularia* in the reserve.

The conclusion from the present survey is that the Mt Manning Range Nature Reserve is an important conservation reserve representative of a substantial area in the northern part of the Jackson–Kalgoorlie Study Area and the southern margin of the Barlee–Menzies Study Area. It is also a noteworthy area of interaction in phytogeographical terms.

The Reserve unfortunately excludes the entire Mt Manning Range with its distinctive vegetation types that include several potentially threatened species, by virtue of their restricted

geographical distributions. The Mt Manning Range is a scenically unique range of Hills with marked topographic relief adding to the aesthetic value of the area and setting it apart from examples of similar geology and vegetation nearby. The entire Mt Manning Range area is also in excellent condition, the vegetation having hardly been affected by mining or pastoral use, and is surrounded by extensive tracts of land in similar condition.

Proposed extensions to the Mt Manning Range Nature Reserve are detailed in Henry-Hall (1990). These seek to incorporate the Mt Manning Range into the nature conservation reserve and also to extend the reserve to the west and to the south.

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