III Vegetation and Flora

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Background

In the Norseman-Balladonia Study Area, Woodlands (15-20 m high) occurred on Calcareous Plains, Broad Valleys and Hills (Greenstone). Low Woodlands (<15 m) were the dominant vegetation type in the Study Area, particularly on Calcareous Plains, Undulating Plains and Broad Valleys. Mallees (3-6 m) were common on Calcareous Plains and Salt Lake Features, and present on Sandplain, Undulating Plains and Granite Exposures. Tall Shrublands (>1 m) occurred on Granite Exposures, Salt Lake Features, Sandplain, Undulating Plains (Basic Granulite) and Calcareous Plains. Low Shrublands (<1 m) dominated Salt Lake Features with scattered occurrences on Calcareous Plains. Complexes were common on Granite Exposures.

The structural formations have been described and mapped at a scale of 1:1,000,000 (Beard 1975). During the survey 162 sites were sampled using the plotless releve technique. This technique, the selection of sites and the parameters recorded, are detailed by the Biological Surveys Committee of Western Australia (1984). The sites are broadly classified on vegetation structure and plant species composition of the upper stratum, into vegetation types. Two of the types (Granite and Lake Margin) are referred to as vegetation complexes, where vegetation structure and species composition changed markedly over a few metres. A typical site for each vegetation type is described in Appendix I, together with relevant data on geology, landforms and soils.

Appendix I provides data on the detailed composition of 49 sites in the Norseman-Balladonia Study Area (see Figure 2 for locations). Table 1 summarises the relationship between landforms, lithology, soils, vegetation structure and floristic composition. Some examples of the range in vegetation types present within the Study Area are shown in Plates 1-15. Vegetation descriptions are listed below by landform unit. Only a few of the species occurring in the Norseman-Balladonia Study Area have accepted common names; they are listed where the species first occurs in the text. Plant taxonomy follows Green (1986) except for eucalypts (Brooker & Kleinig 1990; Johnson & Hill 1990) and orchids (Hoffman & Brown 1992).

Vegetation Descriptions

Granite Exposure (G): *Inner and outer aprons*: Aprons in the south-eastern and south-western corners of the Norseman-Balladonia Study Area were similar in composition to those in more northern sections. Shrub density, however, was much greater and individual plants were larger and more luxuriant in the southern areas. This was particularly obvious for the sedgelands of *Lepidosperma drummondii* and hummock grasslands of *Triodia scariosa*.

In some areas the bunch grasses (e.g. *Danthonia setacea, Stipa* spp.) became dominant forming large open glades in the mallee formations. These areas of *Lepidosperma* sedgelands and *Triodia* hummock grasslands were only found in the south-eastern margins of the Study Area.

Some differences were also noted in the shrub flora. For example, Ponier Rock has a shrubland of *Acacia saligna* and scattered trees of *Allocasuarina huegeliana*, neither of which has been recorded north of this rock.

The herbaceous flora increases in species richness from the northern areas to the south-eastern margins of the Study Area. For example, a comparison of the orchids recorded on a number of granite exposures provides an indication of the differences in herb floras throughout the Study Area.

In the north-west of the Study Area, two species were recorded at Buldania Rocks (*Diuris* aff. *corymbosa, Pterostylis* aff. *nana*). At Boingaring Rocks and Afghan Rock in the north-east, an additional four orchid species were recorded (*Caladenia microchila, Pterostylis* aff. *rufa, Prasophyllum ringens, Thelymitra* aff. *nuda*). In the central section, 10 species were recorded on a series of granite exposures in the vicinity of Mt. Andrew. These granites supported the above plus an additional four orchids (*Caladenia flava, C. marginata, Microtis unifolia, Pterostylis allantoidea*).

In the south-eastern corner of the Study Area, 14 additional orchid species — that were not recorded on granites to the north — occurred on Ponier Rock, Mt. Newmont and granite exposures on the margins of salt lakes. These included Declared Rare Flora *Caladenia voigtii, C. latifolia* and *Pterostylis* aff. *scabra*. Mt. Newmont (10km west of site NB43) supported an impressive orchid flora of 22 taxa that included an additional 11 orchids (*Caladenia attingens* ssp. *gracillima, C. brevisura, C. saccharata, C. sigmoidea, Cyanicula caerula* ssp. *apertala, Cyrtostylis robusta, Pterostylis mutica, P. recurva, P.* aff. *rufa, P. sargentii, P. vittata, Thelymitra antennifera*).

Jyndabinbin Rocks (Ag) in the north-western section of the Study Area, supported a Granite Complex that comprised a rich assemblage of herbs with no particular dominance shown (composites, mainly, but with numerous bulbous perennials).

The apron surrounding Jyndabinbin Rocks supported Low Woodlands of *Acacia acuminata* (Jam) over scattered shrubs and herbs including *Gnephosis pusilla, Gonocarpus nodulosus, Rutidosis multiflora* and *Waitzia acuminata*. The outer apron (Ag) of a small granite exposure in the north-western portion supported an *Acacia* Tall Shrubland that included *A. acuminata* over *Lepidosperma drummondii, Prostanthera incurvata* and the bunch grass, *Amphipogon debilis*.

The Granite Complex present on Boingaring Rocks (Py), in the north-eastern section of the Study Area, contained a similar assemblage of herbs as found on Jyndabinbin Rocks, but with a reduced species diversity.

The granite endemic *Eucalyptus histophylla* surrounded Boingaring Rocks, while the peripheral apron supported Tall Shrublands of *Thryptomene australis* with *Dodonaea lobulata, Eremophila alternifolia* var. *latifolia* over *Melaleuca elliptica* and a selection of herbs from the Granite Complex.

In the south-eastern section of the Study Area, Ponier Rock (Pm) supported a Granite Complex on deeper soil than both Jyndabinbin and Boingaring Rocks, and hence supported *Dodonaea lobulata* and *Bossiaea walkeri* with *Beyeria lechenaultii* over herbs rather than a herbfield.

Rises of Calcareous Loams at Ponier Rock supported *Eucalyptus melanoxylon* Low Woodlands over *Atriplex vesicaria* (Bladder Saltbush), *Carpobrotus rossii, Disphyma crassifolium, Enchylaena tomentosa, Geijera linearifolia, Olearia revoluta, Sclerolaena diacantha* and *Threlkeldia diffusa.* Small clumps of *Acacia saligna, Allocasuarina heugeliana, Melaleuca elliptica, Muehlenbeckia adpressa* and *Polygonum prostratum* occurred on slopes and in rills around the granite exposures.

Granite exposures were also common on the margins of salt lakes in the Norseman-Balladonia Study Area. An exposure (Pc) in the north-eastern section supported a Granite Complex similar to the outer aprons of Ponier or Boingaring Rocks, being a shrubland of *Dodonaea lobulata* and *Eremophila alternifolia* var. *latifolia* over herbs.

The peripheral apron of a granite (Pl) in the south-eastern corner, supported a Hummock Grassland of *Lepidosperma drummondii* with bunch grasses of *Danthonia setacea* and *Stipa* aff. *trichophylla* over scattered annuals.

Hill, Greenstone (HN): *Slopes and summits*: In the north-western section of the Norseman-Balladonia Study Area, greenstone slopes and summits with a variety of lithological surfaces (Aeo, Awb, Abd) supported Woodlands of *Eucalyptus brockwayi* (Dundas Mahogany), and Low Woodlands of *E. lesouefii* (Goldfield's Blackbutt) and mixed *Eucalyptus* species. On the margins of Lake Dundas, the summit of a greenstone hill (Apz) was mantled with Shallow Calcareous Earths. This surface supported *Eucalyptus torquata* (Coral Gum) with occasional *E. dundasii* (Dundas Blackbutt) over *Atriplex vesicaria, Eremophila scoparia* and *Pittosporum phylliraeoides* (Weeping Pittosporum).

In the Dundas Hills north-west of Norseman, Jimberlana Hill (Pd) supported a Low Woodland of *Eucalyptus oleosa* (Red Mallee), which included Declared Rare Flora *Eucalyptus* aff. *diversifolia* (KRN 6754), with *Allocasuarina campestris* ssp. *grossa* over shrubs of *Cryptandra pungens* and *Melaleuca elliptica.* The recently described *Eucalyptus jimberlanica* is known only from Jimberlana Hill (Johnson & Hill 1990).

Hill, Basic Granulite (HR): *Slopes and summits*: The slopes and summit of a Basic Granulite hill (Px), near Mt Pleasant in the Fraser Range, supported a unique Granite Complex. Trees of *Allocasuarina huegeliana* and *Pittosporum phylliraeoides* occurred with shrubs of *Beyeria lechenaultii* and *Dodonaea microzyga* over bunch grasses of *Aristida contorta.* This element extends north into the adjacent Study Area (Newbey & Hnatiuk 1984).

Salt Lake Features (L): *Lake floors:* The species composition of salt lake floors (Qra) did not change markedly across the Study Area. A lake floor in the south-eastern section supported *Atriplex vesicaria, Disphyma crassifolium, Halosarcia halocnemoides, H. indica* var. *bidens, H. peltata* and *H. syncarpa.* Lake floors in the north-western portion supported *Halosarcia* Low Shrublands comprised of *Disphyma crassifolium, Halosarcia halocnemoides, H. indica* var. *bidens, H. lylei, Hemichroa diandra, Frankenia pauciflora* and *Maireana glomerifolia.* Small playas of the Esperance salt

lake chains on the south-western periphery of the Study Area were relatively poor in species; only three species were recorded on one lake.

Lake slopes: In the north-western portion of the Study Area, margins of the extensive Lake Dundas (Qps) support Low Woodlands of *Eucalyptus lesouefii* over *Bossiaea walkeri* with sedges of *Dianella revoluta* and *Lepidosperma brunonianum.* Calcareous Earths on the margin of a small salt lake (Qpf) in the north-western section supported Low Woodlands of *Eucalyptus oleosa* with *E. kumarlensis* over shrubs of *Cratystylis conocephala* (Grey Bush), *Geijera linearifolia, Melaleuca lanceolata* and *M. quadrifaria. Eucalyptus kumarlensis* has a distribution associated with salt lakes (Brooker & Kleinig 1990).

In the north-eastern portion of the Study Area, lake slopes of Aeolian Sands (Qo) supported Lake Margin Complex and *Eucalyptus* Mixed Mallee. These formations comprised the mallees *Eucalyptus gracilis* (Yorrell), *E. leptocalyx* and *E. transcontinentalis* (Redwood) over shrubs of *Bossiaea leptacantha, Callitris columellaris, Grevillea pauciflora, Melaleuca uncinata* (Broombush) with sedges of *Lepidosperma drummondii.* The margin of a salt lake (Qpl, Qre, TQo) in the north-east supported a Low Woodland of *Eucalyptus fraseri* (Blackbutt) with *E. longicornis* (Red Morrel) and *Melaleuca quadrifaria.* In the south-eastern section, a lake slope (Qpl, Pl) supported *Callitris canescens* Tall Shrubland comprised of *Boronia caerulescens, Melaleuca uncinata* and *Thryptomene australis* with sedges of *Lepidosperma drummondii.*

Raised Aeolian flats: Between salt pans in the north-western section (Campsite 1), raised Aeolian flats (Qpf) of Calcareous Earths supported *Eucalyptus oleosa* Low Woodlands comprised of *Cratystylis conocephala, Geijera linearifolia* and *Melaleuca pauperiflora* (Boree). In central areas, near Campsite 4, these raised flats between playas supported sparse *Myoporum platycarpum* (Sugarwood) over *Atriplex vesicaria.* This formation was not seen further west (see Calcareous Plain).

Peripheral lake dunes: In the north-eastern section, a lake dune of Aeolian Sands (Qo) supported *Eucalyptus gracilis* Mallee with *Callitris columellaris, Melaleuca* aff. *cuticularis* (KRN 7247) and *Darwinia diosmoides* over hummock grass *Triodia scariosa.* In the south-eastern portion, a marginal dune of Aeolian Sands (Qpl) supported *Eucalyptus eremophila* (Tall Sand Mallee) Low Woodland comprised of *E. uncinata* (Hook-leaved Mallee) with *Callitris preissii, Melaleuca* sp. (KRN 7340) and *Microcybe multiflora.*

Aeolian gypsum dunes are intermittent along playa chains throughout the Study Area. They are included in Qro (Balladonia Geological map sheet) but are equivalent to Qpk (Norseman). A typical site, sampled for vegetation in the south-east, supported *Eucalyptus fraseri* Low Woodland over *E. celastroides, E. eremophila, Casuarina cristata* and *Melaleuca quadrifaria.* The shrub layer, comprising elements seen on the Calcareous Plains, was very sparse and species poor.

Aeolian sheet deposits: Sand dunes and sheet deposits adjacent to playas in the south-eastern and south-western corners of the Study Area supported thicker versions of their more northern counterparts, as well as certain species more typical of south-western heaths. For example, species of *Conostephium, Leucopogon, Boronia, Allocasuarina* and *Adenanthos forrestii* were noted in this situation in the south-east. Noted on Aeolian deposits on the south-west periphery were *Adenanthos ileticos, Banksia media, Beyeria lechenaultii, Boronia albiflora, Conostephium* sp. nov. (KRN 7325), *Eucalyptus conglobata* (Port Lincoln Mallee), *E. falcata* (Silver Mallee), *E. fraseri* and *Stylidium* sp. nov. (GK 12676).

Low Woodlands of *Eucalyptus lesouefii* were noted only in the western end of the Study Area; *E. oleosa* Mallee was the canopy dominant in eastern areas. In drier areas, mainly central and north-eastern sections, *Lepidosperma* was less frequent and *Triodia* more prominent in this formation than in the north-west and southern areas. In the communities of the central and more eastern parts, where the *Triodia* dominated, understorey species composition did not differ markedly across the Study Area.

In the north-western part of the Study Area, flat and gently sloping Aeolian sand deposits marginal to playas (Qps) supported *Eucalyptus gracilis* Mallee with *Astartea clavulata, Callitris preissii, Darwinia diosmoides, Grevillea pauciflora, Melaleuca uncinata, M. quadrifaria* and *Westringia cephalantha.* In central parts of the Study Area, sheet deposits of Aeolian Sands (Qpf) supported richer mallee assemblages. Stands of *Callitris* were noted in fire-protected areas around the edge of the lakes (see site NB45).

Calcareous Plain (P): *Flat and gentle undulating plain*: Calcareous Earths (Qqs, Qpl Norseman; Qpl Balladonia) in the north-western section of the Study Area supported mixed *Eucalyptus* Low Woodlands of *Eucalyptus flocktoniae* (Merrit), *E. lesouefii, E. oleosa* and *E. transcontinentalis.* Where soil was deeper in colluvial deposits, *E. diptera* (Two-winged Gimlet) and *E. salubris* (Gimlet) Low Woodlands occurred. Understorey elements included *Atriplex vesicaria, Eremophila scoparia* and *Melaleuca pauperiflora* with *Acacia hemiteles* more common to the east. Within the undulating calcareous plains *Eucalyptus flocktoniae* was more common on ridges while sandier areas had some *E. eremophila.*

Shallow Loamy Sands in this area (Qqs) supported *Eucalyptus oleosa* Low Woodland comprised of *Beyeria brevifolia, Daviesia benthamii* ssp. *benthamii, Eremophila paisleyi, Exocarpos aphyllus, Melaleuca lanceolata* ssp. *lanceolata, Olearia muelleri* and *Santalum acuminatum* (Quondong).

Scattered areas of Calcareous Earths superficially mantled by reddish-brown Clay Loams in the north-west (Qqs) supported mallee formations of *Eucalyptus cylindrocarpa* (Woodline Mallee) over *Triodia scariosa.* Other species included *Eucalyptus gracilis, Daviesia benthamii, Eremophila scoparia* and *Westringia rigida.*

Shallow Loamy Sands over Sandy Clay (Qqs) in the central portion of the Study Area supported *Eucalyptus transcontinentalis* Woodland comprised of *E. diptera, E. eremophila, E. gracilis* and *E. longicornis* over *Acacia ancistrophylla, A. saxatilis,*

Melaleuca uncinata and *M. lanceolata.* Low Woodlands of *Eucalyptus oleosa* in this area included *E. angulosa* (Ridge-fruited Mallee) and *E. flocktoniae* over *Atriplex vesicaria* and *Melaleuca pauperiflora.*

In the north-eastern section of the Study Area (Qpl, Balladonia) Woodlands of *Eucalyptus transcontinentalis* contained a dense cover of the low shrub *Wilsonia humilis.* Other shrubs included *Atriplex nummularia, Eremophila scoparia* and *Melaleuca pauperiflora.*

On the south-west periphery of the Study Area (Qqs), near Campsite 5, shrub densities were again much higher than in more northern parts, with a markedly richer *Melaleuca* component. Generally, species composition reflected the proximity of the south coast. Species such as *Eucalyptus falcata, E. indurata* (Ironbark) and *E. tumida* were near their northern and eastern distributional limits (Brooker & Kleinig 1990).

Valleys of Calcareous Earths (Qpv) within the undulating plains (Qqs) supported *Eucalyptus salmonophloia* (Salmon Gum) Woodland with scattered *E. salubris* over *Cratystylis conocephala* and *Santalum acuminatum.*

In the north-western section of the Study Area Calcareous Earths (Qpl) supported *Eucalyptus oleosa* over *Atriplex vesicaria, Cratystylis conocephala, Melaleuca pauperiflora* and *Santalum acuminatum.* Near where quartzite outcrops on slopes in this unit, *Eucalyptus dundasii* was present. Occurring in the understorey were *Beyeria brevifolia, Eremophila caerulea* and *Santalum acuminatum.* The *Eucalyptus dundasii* formation was confined to the north-west.

In central and eastern areas, Calcareous Plain (Qpl) supported *Eucalyptus oleosa* Low Woodlands that were more open. *Eucalyptus oleosa* occurred with *Atriplex vesicaria, Melaleuca eleuterostachya, M. uncinata* and *Triodia scariosa.* To the east, *Eucalyptus fraseri* appeared with *E. oleosa,* but not as a dominant. *Myoporum platycarpum* appeared in the *Eucalyptus oleosa* Low Woodland formation in the north-eastern corner (glades of *Myoporum* were noted from 3.5 km east of site NB65), which is the approximate boundary of the Eucla Basin (see McKenzie & Robinson 1987). The eastern end of the Dundas Nature Reserve included *Eucalyptus oleosa* communities structurally typical of the south-west Nullarbor margins except for *Acacia papyrocarpa.* Overall, however, this formation shows little change in species composition across the Study Area.

In south-east and south-west corners of the Study Area, formations on this surface (Qpl) were similar in species composition to their more northern counterparts. The eucalypts appeared uniformly lower and the *Melaleuca* understorey thicker and proportionally higher. On the south-west periphery of the Study Area the *Melaleuca* component was much richer, and included over ten species: *Melaleuca bromelioides, M. cliffortioides, M. cucullata, M. eleuterostachya, M. glaberrima, M. lateriflora , M. leptospermoides, M. uncinata, M. quadrifaria, M. scabra* and *M. teuthidoides.*

Generally, the species composition at sites on the Qpl surface-type in the south-western parts, reflected the proximity of the south coast. For example, species such as *Eucalyptus* aff. *conglobata* (GK 12668), *E. creta, E. falcata, E. indurata, E. spathulata*

ssp. *grandiflora* (Swamp Mallet), *E. tumida, Darwinia luehmannii, Melaleuca acuminata, M. cardiophylla* and *Nematolepis phebalioides* were recorded.

Further east, as a scattered unit of the Balladonia map sheet (Qpc), Sandy Clay surfaces supported Mixed Mallee comprised of *Eucalyptus* aff. *oleosa, E. extensa, E. calycogona* and *E. conglobata* with *Westringia* aff. *cephalantha* (GK 12662). In the south-eastern corner (near site NB46), the record of *Eucalyptus ovularis* (Small-fruited Mallee) represented a large eastern range extension (Brooker & Kleinig 1990).

Flat and gentle undulating plain adjacent to granite exposure: Calcareous Earths thinly mantled with Sandy Loams (Qpl, Pa) in the north-western section supported *Eucalyptus cylindrocarpa* Mallee with *E. gracilis* over *Acacia enervia, A. hemiteles, Boronia inornata, Bossiaea leptacantha, Eremophila ionantha* and *Westringia cephalantha.* Similar soils on outwash below a granite exposure supported mallees of *Eucalyptus cylindrocarpa* and *E. gracilis* over a sparse understorey dominated by *Wilsonia humilis.* Other mallees growing in *Eucalyptus cylindrocarpa* Mallee were *E. brachycorys* and *E. transcontinentalis* over *Jacksonia* sp. (KRN 7420) and *Triodia scariosa.*

Adjacent to exposed granite in the north-west (Qpl, Ag) Loamy Sands with granite fragments in profile supported *Eucalyptus gracilis* Mallee over *Acacia acuminata, Lepidosperma brunonianum, Leptospermum roei, Melaleuca uncinata* and *Triodia scariosa.* The understorey was similar to site NB117, a granite outer apron (see Granite Exposure).

Similar structures in the north-eastern section (Qpl, Pc) supported *Melaleuca uncinata* Tall Shrubland including *Acacia eremophila, Eremophila paisleyi, Microcybe multiflora, Phebalium filifolium* and *Trymalium ledifolium.* The presence of *Eucalyptus histophylla*, a granite endemic, reflects the influence of adjacent granite. On Loamy Clays over kankar surrounding the outer apron of granite exposures, *Eucalyptus diptera* stands were noted, particularly in south-eastern parts.

Soils adjacent to exposed granite (Qpl, Pc) in the south-eastern portion, also supported *Melaleuca uncinata* Tall Shrubland with *Actinobole uliginosum, Calytrix tetragona, Lepidosperma drummondii, Leptospermum erubescens* and *Pimelea thesioides* over *Triodia scariosa.* Surrounding Ponier Rock in the south-east (Qpl, Pm) were *Eucalyptus oleosa* Low Woodlands (see Granite Exposure).

Flat and gentle undulating plain superficial to Tertiary deposits: Loamy Sands adjacent to, or mantling, Tertiary deposits (Qqs, ?Ttf) occured in substantial areas through the central parts of the Study Area. Soil profiles included pale brown Loamy Sands mantling a Sandy Clay hardpan with hard clay below 40 cm. These sheet deposits supported mixed Mallee formations, which are substantially lower than their more westerly counterparts, mixed *Eucalyptus* Low Woodland (Qqs) and *E. oleosa* Low Woodland (Tox, Ttl, Tog). Mallees recorded include *Eucalyptus cylindrocarpa, E. eremophila, E. flocktoniae* and *E. gracilis* over a shrub layer of *Acacia enervia, Daviesia benthamii, Helichrysum blackallii, Grevillea pauciflora, G. pectinata, Melaleuca uncinata, M. eleuterostachya, Pultenaea conferta* and *Westringia cephalantha.*

Eucalyptus oleosa Low Woodland occurred on a variety of surfaces (Qro, Tep, TQr, Tmn) in the eastern sections of the Study Area. Scattered areas in the south-east (Qro) also supported *Cratystylis conocephala* Low Shrubland with *Asteridea athrixioides, Eremophila decipiens* and *Olearia revoluta.*

Small scattered areas of Clay Sands (Ttf) in central parts of the Study Area supported *Eucalyptus calycogona* Mallee over *Triodia scariosa* grading into *Acacia acuminata* Tall Shrubland. Fine Loamy Sands supported *Eucalyptus transcontinentalis* Mallee comprised of *E. cylindrocarpa* and *E. gracilis* over *Acacia hemiteles, A. merrallii, Daviesia benthamii, Grevillea pectinata, Halgania lavandulacea, Melaleuca uncinata* and *Triodia scariosa.*

Aeolian dunes: In the central portion of the Study Area, Aeolian dunes of Shallow Loamy Sands (Qpl Norseman) supported *Eucalyptus oleosa* Mallee with *Atriplex vesicaria* and *Melaleuca uncinata* over *Triodia scariosa.*

Aeolian sheet deposits: In the north-western section of the Study Area (Qqs Norseman; Qpl Balladonia), Aeolian sheet deposits supported a mixed *Eucalyptus* Low Woodland of *E. eremophila, E. flocktoniae, E. transcontinentalis* over *Grevillea pectinata.* Occurring with *Eucalyptus oleosa* Mallee were *Eucalyptus* cf. *incrassata, Acacia hemiteles, Bossiaea leptacantha, Lomandra effusa* and *Melaleuca uncinata* with *Triodia scariosa.*

Sandplain (S): *Plains*: This unit (Ttf) of sandy and gravelly upland plains was more extensive in the western section of the Study Area and is dealt with in more detail by Newbey & Hnatiuk (1988). No sites are included in Appendix I. In this text, sandplain uplands of the western section are included in Broad Valley (V).

In central parts of the Study Area, such sandplain surfaces (Ttf and other unmapped units that were not associated with playas) are relatively small and scattered, and have been included in Calcareous Plain (P).

Undulating Plain, Greenstone (UN): *Raised colluvial flats and slight ridges*: Greenstones were virtually confined to the north-western corner of the Study Area. Vegetation on the slopes and summit of hills within the Greenstone are described in Hill (HN).

On the north-west shore of Lake Dundas, a slight ridge (Qqs) with Shallow Calcareous Earths supported a mixed Low Woodland of *Eucalyptus lesouefii, E. oleosa, E. dundasii* over *Melaleuca pauperiflora* and *Eremophila scoparia.* Soils were heavier approaching the valley floors, and this understorey graded into areas of *Atriplex vesicaria* with scattered clumps of *Eucalyptus salubris* over *Cratystylis conocephala.*

Raised colluvial flats and slight ridges (Pd) in the Dundas Hills supported *Allocasuarina helmsii* Tall Shrubland and *Eucalyptus griffithsii* (Griffith's Grey Gum) Mallee. Occurring with *E. griffithsii* were *Acacia erinacea, A. graffiana, A. pachypoda, Cassia helmsii, Melaleuca eleuterostachya, M. uncinata, Scaevola spinescens, Triodia scariosa* and *Westringia dampieri.*

The Brockway Timber Reserve, between Lake Cowan and Lake Dundas, supported a variety of Greenstone communities that have been described by Sandiford (1989). Other

vegetation types present on undulating plains (Qqs) include Low Woodlands of *Eucalyptus lesouefii* and *E. torquata.*

Undulating Plain, Basic Granulite (UR): *Colluvial flats and undulating plains*: In the Fraser Range, colluvial flats with Loamy Clay Sands (Qpl) supported *Eucalyptus effusa* Mallee. This formation comprised *Eucalyptus* aff. *uncinata* (KRN 7854) over *Cassia helmsii, Cryptandra miliaris, Dodonaea boroniifolia, D. stenozyga* and *Triodia scariosa.* In the same range, uplands with Shallow Loamy Sands (Pxa) supported *Acacia acuminata* Tall Shrubland dominated by *Melaleuca uncinata* and *Triodia scariosa. Eucalyptus effusa* (Rough-barked Gimlet) and *E. fraseri* ssp. 'blackbutt' are restricted to the Fraser Range (Brooker & Kleinig 1990).

Broad Valley (V): *Flat and gentle undulating plains:* Flat and gentle undulating plains were confined to the western margin of the Study Area, west of Lake Cowan and Lake Dundas. Gentle undulating plains with Deep Calcareous Earths (Qqs), to the west of Lake Dundas, supported mixed Low Woodlands of *Eucalyptus dundasii, E. flocktoniae, E. lesouefii, E. longicornis* and *E. oleosa* in various combinations over *Acacia hemiteles, Eremophila scoparia, Exocarpos aphyllus, Melaleuca pauperiflora* and *Olearia muelleri.* Gentle undulating plains with Deep Calcareous Earths (Qpl) supported Low Woodlands of *Eucalyptus salubris* and *E. cylindriflora.*

Extensive areas of sand and gravel plain (Ttf) west of Lake Dundas, as uplands in the western section of the Study Area, supported *Eucalyptus transcontinentalis* Mallee and Tall Shrublands of *Allocasuarina acutivalvis* and *Melaleuca uncinata.* Low Woodlands of *Eucalyptus diptera, E. ovularis* and *E. transcontinentalis* occurred on undulating plains of this surface.

Woodlands were present where alluvial deposits occurred in valleys. For instance, in the far south-west corner of the Study Area, *Eucalyptus salmonophloia* Woodlands comprised *Acacia colletioides, Santalum acuminatum* and *Scaevola bursariifolia.*

These surfaces were extensively sampled in the Lake Johnston-Hyden Study Area and are discussed in detail by Newbey & Hnatiuk (1988).

Discussion

The Norseman-Balladonia Study Area is located at the boundary between the Roe Botanical District of the South-West Botanical Province and the Coolgardie Botanical District (South-Western Interzone) of the Eremaen Botanical Province (Beard 1980). Major transitions of vegetation communities occurred from west to east and north to south. A transitional zone was also present along the southern margins of the Study Area.

The survey of the Norseman-Balladonia Study Area confirmed the general vegetation communities defined by Beard (1975). The Study Area contained the eastern-most examples of Goldfields *Eucalyptus* Woodlands (on the margins of Lake Dundas) which were more extensive on the adjacent Study Areas to the west (Lake Johnston-Hyden: Newbey & Hnatiuk 1988; Boorabbin-Southern Cross: McKenzie & Hall in prep.).

Across the Study Area, from west to east, these Woodlands merge into the low open *Eucalyptus oleosa* Woodlands of the Eucla Basin. These were described in detail by Keighery *et al.* (1987) during the biological survey of the Nullarbor.

As noted earlier (see Granite Exposures), a floristic change occurs between the southern and northern granite orchid floras. The number of orchid taxa recorded increased from north to south (4 to 24). A number of other species were not recorded on granites north of Coragina and Ponier Rocks.

The other major transitional communities are the Mallee and *Banksia* heaths on the south-eastern and south-western margins of the Norseman-Balladonia Study Area. The heaths recorded in the south-western corner (NB158-161) are typical of the coastal heaths of the Esperance region in structure and species composition (Beard 1973).

These south-western heaths included inland populations of *Adenanthos ileticos, Banksia media, Darwinia luehmanii, Hybanthus epacroides, Persoonia teretifolia* and *Pimelea erecta.* The Mallee Shrublands of the south-west contained inland populations of *Eucalyptus creta, E. falcata, E. indurata* and *E. tumida*, and also many of the understory *Melaleuca* (e.g., *M. bromelioides, M. teuthidoides, M. leptospermoides*).

The south-eastern heaths are dominated by mallees and contain elements of the Roe Plains and the Cape Arid area (Keighery & Alford unpubl.). These Mallee heaths contained the western-most populations of *Adenanthos forrestii* and *Conostephium drummondii* (Roe Plains); and a major inland range extension to the east for *Eucalyptus ovularis.*

Thus, the Norseman-Balladonia Study Area contains major transition zones of the South-Western flora, running in both an east-west and north-south direction. The boundary of the South-West Botanical Province runs through the Study Area (Beard 1980). Goldfields Woodlands extend to the west and north of the Study Area, and merge into the Low Woodlands of the Eucla Basin in the east.

The flora of the Norseman-Balladonia Study Area had not previously been systematically recorded and documented. During our survey 705 taxa were recorded from the Study Area including four taxa of Declared Rare Flora (Government Gazette 1990): *Adenanthos ileticos, Caladenia voigtii, Daviesia* sp. (Norseman) M.D. Crisp 5943 and *Eucalyptus* aff. *diversifolia* (KRN 6754).

The Norseman-Balladonia Study Area contains several geographically restricted species. These are included on CALM's Reserve Flora List for priority taxa which have been or are being considered for gazettal as Declared Rare Flora (Hopper *et al.* 1990). *Allocasuarina globosa, Eucalyptus brockwayi* and *E. pterocarpa* are restricted to the Undulating Plains of greenstone, which are confined to the north-western corner of the Study Area (Henry-Hall 1990). The recently described *Eucalyptus jimberlanica* is known only from Jimberlana Hill north-west of Norseman (Johnson & Hill 1990). *Eucalyptus effusa* and *E. fraseri* ssp. 'blackbutt' are endemic to the Fraser Range (Brooker & Kleinig 1990).

New undescribed species collected during the 1980 field survey include *Chamelaucium* sp. nov (KRN 7325), *Eucalyptus* aff. *diversifolia* (KRN 6754) and *Spyridium* spp. nov.

(KRN 6108 & 6718). During re-sampling in 1990, *Stylidium* sp. nov. (GK 12676) was first collected. The continual discovery of previously unknown taxa indicates how poorly known the flora of this region was before the survey, and the need for further studies (see below).

During the survey 7 species of fern and 698 taxa (248 genera, 70 families) of flowering plants were recorded. Families with the largest numbers of species were Myrtaceae (105 taxa), Asteraceae (78 taxa), Leguminosae (broad sense) (69 taxa) and Chenopodiaceae (53 taxa). Genera with numerous species were *Eucalyptus* (57 taxa), *Acacia* (40 taxa) and *Melaleuca* (28 taxa).

Comparisons with the Eucla Basin and Nullarbor to the east (Keighery *et al.* 1987), the Widgiemooltha-Zanthus Study Area to the north (Newbey & Hnatiuk 1984) and the Lake Johnston-Hyden Study Area to the west (Newbey & Hnatiuk 1988), highlight the transitional nature of the Norseman-Balladonia Study Area.

To the east of the Norseman-Balladonia Study Area, the whole Eucla Basin (in W.A. and S.A.) has 674 species recorded from its boundaries, with 287 species recorded from the central Nullarbor (Keighery *et al.* 1987). This low species richness, due to the area's aridity, calcium rich soils and low relief, is reflected in the major families here: the Asteraceae (117 spp.), Chenopodiaceae (74 spp.) and Poaceae (60 spp.). Typical south-western families (Proteaceae and Orchidaceae) are virtually absent.

The adjacent Study Area to the north (Widgiemooltha-Zanthus), with 536 taxa recorded, is removed from the influence of the transitional vegetation zones intersected by the Norseman-Balladonia Study Area. This is demonstrated by the lower numbers of Myrtaceae (57-105 taxa), Orchidaceae (8-31 taxa) and Leguminosae (49-69 taxa).

The Lake Johnston-Hyden Study Area abutting the western side of the Norseman-Balladonia Study Area is almost entirely south-western in nature, and shows an increased species richness (1076 taxa). This is caused mainly by a large increase in south-western centred families: Myrtaceae (173-105 taxa), Proteaceae (101-19 taxa) and Leguminosae (151-69 taxa).

The flora of the Norseman-Balladonia Study Area is still incompletely known. In particular, three areas urgently require further investigation: the Fraser Range, the transition zone along the southern margins, and the scattered Tertiary surfaces.

More thorough work is needed on the Fraser Range communities as these were not extensively sampled during the present survey, or in the adjacent Widgiemooltha-Zanthus Study Area (Newbey & Hnatiuk 1984). The poorly studied Fraser Range forms a unique vegetation complex (Beard 1975), lacking representation in the conservation estate.

The Sandplains and Calcareous Plains of the southern margin of the Study Area show major differences from east to west. This area also forms a transition zone with the South-West. Further sampling of these areas in the spring and in the central-southern region (which was inaccessible during the survey period) should reveal additional species with south-western affinities.

The numerous Tertiary land surfaces scattered throughout the Study Area contain unique vegetation communities. These areas were not adequately sampled during the survey due to their small size and disjunct distribution in this largely trackless area.

Existing conservation reserves in the Norseman-Balladonia Study Area are listed below. Those marked with an asterisk are not vested in the National Parks and Nature Conservation Authority (N.P.N.C.A.).

Reserve No.	Location (°S °E)	Area (ha)
197/25*	32°20′ 121°50′	3724
26965*	32°25′ 123°40′	1620
6043*	32°10′ 121°50′	994
4508*	32°25′ 121°45′	728
17402*	32°10′ 122°05′	405
17403*	32°05′ 122°40′	405
8762*	32°05′ 123°10′	405
36957	(see Figure 2)	780883
33113	32°50′ 121°55′	8859
36608	32°55′ 121°35′	205
33501	32°50′ 121°55′	80

Dundas Nature Reserve (No. 36957) covers a substantial portion of the Norseman-Balladonia Study Area. This large conservation reserve (780,883 ha) includes extensive areas of three landform units (Calcareous Plain, Salt Lake Feature and Granite Exposure) and supports vegetation types dominated by *Eucalyptus* Low Woodlands.

The existing Dundas Nature Reserve however, does not encompass the original area recommended by the Conservation Through Reserves Committee (1974). The area of land delineated by the Environmental Protection Authority (1975) for biological survey extended south to 33°05′. Only the northern half of this area was gazetted in 1981, with the southern boundary of the reserve being truncated at 32°45′ (see Figure 2).

The original area would have incorporated the important southern transitional zone reported here, and the series of granite rocks in the south-eastern corner. The original proposal should be re-considered as this would form a conservation corridor linking Dundas Nature Reserve with the Cape Arid and Nuytsland conservation reserves.

A review and update of the nature conservation reserves in the Eastern Goldfields (Henry-Hall 1990) makes recommendations for reservation of a series of small areas in the north-western corner of the Norseman-Balladonia Study Area.

From Table 1 a general assessment of conservation status, or extent and rarity of vegetation types, can be made by comparing the distribution of lithological units on the relevant geological 1:250 000 maps (Norseman and Balladonia) with one another and with the boundaries of existing and proposed conservation reserves.

References

Beard J.S. (1973). *The vegetation of the Esperance and Malcolm Areas*, W. A. Vegmap Publications, Perth.

Beard J.S. (1975). The vegetation of the Nullarbor area. Vegetation Survey of Western Australia, 1:1 000 000 Series, sheet 4 and explanatory notes. University of Western Australia Press, Perth.

Beard, J.S. (1980). A new phytogeograhic map of Western Australia. *West. Aust. Herb. Res. Notes* 3:37-58.

Biological Surveys Committee of Western Australia (1984). The Biological Survey of the Eastern Goldfields. Part I: Introduction and Methods. *Rec. West. Aust. Mus.* Supplement No. **18**, 1-19.

Brooker, M.I.H. and Kleinig, D.A. (1990). *Field guide to Eucalypts. Vol 2: South-western and Southern Australia.* Inkata Press: Melbourne.

Conservation Through Reserves Committee (1974). Conservation Reserves in Western Australia (Systems 1-5,8-12). Report to the Environmental Protection Authority.

Environmental Protection Authority (1975). Conservation reserves for Western Australia (Systems 4,8,9,10-12).

Government Gazette, (1990). Schedule of Declared Rare Flora. No. 52, 1 June.

Green, J.W. (1986). Census of the vascular plants of Western Australia. Western Australian Herbarium, Perth.

Henry-Hall, N.J. (1990). Nature Conservation Reserves in the Eastern Goldfields, Western Australia (Southern two-thirds of CTRC System 11). Unpublished Report submitted to the EPA Red Book Task Force. Environmental Protection Authority, Perth.

Hoffman, N. and Brown, A. (1992). *Orchids of South-west Australia* (second edition). University of Western Australia Press, Perth.

Hopper, S.D., van Leeuwen, S., Brown, A. and Patrick, S. (1990). *Endangered flora of Western Australia.* Dept. of Conservation and Land Management Public Affairs Branch, Perth.

Johnson, L.A.S. and Hill, K.D. (1990). Systematic studies in the eucalypts-2. A revision of the gimlets and related species: *Eucalyptus* extracodical series Salubres and Annulatae (Myrtaceae). *Telopea* **4(2)**,201-222.

Keighery, G.J., Robinson, A.C. and Downing, B.H. (1987). Vegetation. In: *A Biological Survey of the Nullarbor Region of South and Western Australia* (Eds: N.L. McKenzie & A.C. Robinson) pp. 39-102. South Aust. Dept. Envir. and Planning, Adelaide.

McKenzie, N.L. and Robinson, A.C. (Eds) (1987). *A Biological Survey of the Nullarbor Region of South and Western Australia in 1984.* 413pp. South Aust. Dept. Envir. and Planning, Adelaide.

Muir, B.G. (1977). Biological survey of the Western Australian wheatbelt. Part 2: Vegetation and habitat of Bendering Reserve. *Rec. West. Aust. Mus.* Supplement No. **3**, 9-15.

Newbey, K.R. and Hnatiuk, R.J. (1984). Vegetation and Flora. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 2: Widgiemooltha-Zanthus Study Area. *Rec. West. Aust. Mus.* Supplement No. **18**, 41-56.

Newbey, K.R. and Hnatiuk, R.J. (1988). Vegetation and Flora. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 4: Lake Johnston-Hyden Study Area. *Rec. West. Aust. Mus.* Supplement No. **30**, 17-43.

Sandiford, E.M. (1989). Distribution and conservation status of *Eucalyptus brockwayi* with particular reference to Brockway Timber Reserve. Unpublished report to the Department of Conservation and Land Management, Western Australia.