Floristic Survey of the Mt Manning Range of the Eastern Goldfields of Western Australia

by

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ABSTRACT

A study was undertaken of the flora and plant communities of the Mt Manning Range which lies some 100 km north of Koolyanobbing and 150 km north west of Coolgardie. The range is formed by a central spine of banded ironstones running north – south, with lower areas of greenstone to the east. It is surrounded by an outwash plain derived from these units and extensive Tertiary sand sheets. Fifty four quadrats were established and data from these sites were used to define eight community types that were strongly correlated with topographic position and substrate type. A total flora of 217 taxa was recorded from the range, of which 213 were native and 4 were weeds. Six taxa listed on CALM's priority flora list were found on the range, one of which is not currently reserved. A further two taxa are recommended for listing as priority 2.

The floristic classification is in broad agreement with previous descriptions of the range detailing topographic position and soil type correlations. One vegetation type previously reported as occurring on the range could not be relocated. None of the Die Hardy vegetation system is presently in any conservation reserve.

INTRODUCTION

The Mt Manning Range is composed primarily of Archaean banded ironstones which reach altitudes of 210 m above the surrounding plain. The range itself is surrounded by the Mt Manning Nature Reserve but does not form part of this reserve. It was originally covered by a Mining Act Ministerial Temporary Reserve (TR 1971H) but this has now lapsed and the area is again Vacant Crown Land although it is now occupied by an exploration lease (CALM 1994).

Banded ironstone and greenstone (Archaean mafic and ultramafic lithologies) ranges are one of the common landforms of the Eastern Goldfields and extend from the Highclere Hills in the west to the Roe Hills some 300 km further east and stretch north - south over 800 km. The Mt Manning Range lies some 100 km north of Koolyanobbing and 150 km north west of Coolgardie (Figure 1). Despite the ranges being heavily exploited for minerals for over a hundred years a detailed knowledge of the vegetation and flora of the region is still lacking.

CLIMATE

The climate of the region is semi arid mediterranean with warm winters and hot summers. Mean annual rainfall at Diemals (45 km north west of the Mt Manning Range) is 282 mm although seasonal variation is high. The driest year on record had rainfall of 146 mm and the wettest was 514 mm (records available from 1970, Milewski & Hall 1995). Most rain falls in winter and is generally associated with frontal activity from May through August. Summer falls (to 150 mm) are highly erratic and result from thunderstorms or cyclones (Milewski & Hall 1995).

The closest meteorological stations for which long term temperature data are available are Southern Cross (150 km to the south south west) and Menzies (140 km to the east north east). Mean maximum temperatures at these stations is highest in January (34° – 35°C) with December through March all recording mean annual temperatures above 30°C. Lowest mean minimum temperatures of below 5°C are recorded in July. Recorded extreme temperatures from Diemals range from 46.5°C to –4.6°C.

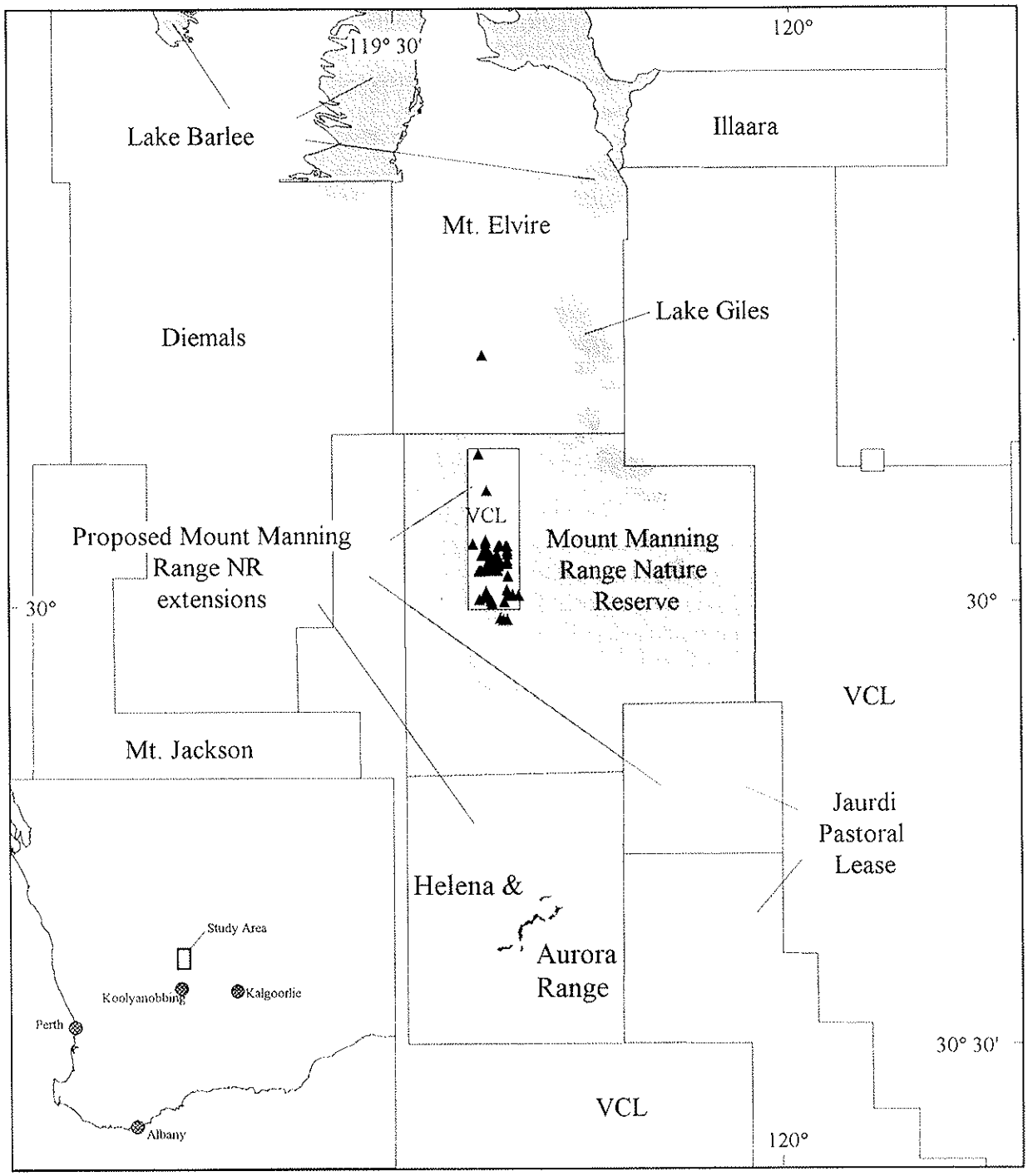


Figure 1. Location of study area.

GEOLOGY AND LANDFORMS

The geology of the study area has been mapped and described in detail in the Barlee 1: 250000 sheet (Walker & Blight 1983) and the geology and landforms have been summarised by Milewski and Hall (1995). The study area has been tectonically stable since the Proterozoic (600 - 2500 million years (My) ago). The major landscape features are controlled by the Archaean (2500 - 3700 My old) granites which underlie most of the study area and have weathered into gently undulating plains and broad valleys covered by Tertiary soils (< 65 My old). Trending roughly north - south are linear bands of Archaean banded ironstone formations (which were formed from of lacustrine deposits of iron oxides and quartz sand) and Archaean greenstone formations (mafic and ultramafic lithologies). Widespread laterization is believed to have occurred during the Cainozoic (the last 65 My). The net result is a very subdued landscape except for the highly resistant ironstone sediments which form a series of abrupt rocky ranges (eg Mt Manning Range, Mt Jackson, Helena and Aurora Range) (Milewski and Hall 1995).

VEGETATION

The Mt Manning Range lies in the Coolgardie interzone close to the border with the Murchison botanical region (Beard 1990). The interzone is generally dominated by eucalypt woodlands and shrublands on yellow sandplains and it marks the transition in vegetation from the species rich south west to the more arid communities of the desert regions. The Murchison region is dominated by mulga (*Acacia aneura)* low woodlands.

Beard (1972) described the major structural formations of the Jackson 1 :250 000 sheet which lies immediately south of the Mt Manning Range. In that publication he describes the Die Hardy vegetation system on the northern edge of that map sheet considering it similar to that occurring on the banded ironstones of Mt Jackson and Koolyanobbing Range but slightly different due to its lower rainfall. *Brachychiton gregorii* and *Dryandra arborea* are occasional trees on the range crest with the northern slopes dominated by open scrubs of *Acacia aneura, A. linophylla, A. acuminata, A. tetragonophylla* and *Dodonaea* sp. The southern slopes support dense thickets of *Allocasuarina acutivalvis* and *A. campestris* with some acacias and eucalypts.

Keighery *et al.* (1995) ascribe the vegetation of the Mt Manning Range to this vegetation system. They identify 30 major structural vegetation units as occurring along the range. The ridges of the range support five structural units: *Acacia aneura* tall shrubland, *Eucalyptus ebbanoensis* mallee, *Acacia quadrimarginea* tall shrubland, *Dryandra arborea* tall shrubland and *Allocasuarina acutivalvis* tall shrubland. The *E. ebbanoensis* mallee is a stunted version of the vegetation of the lower slopes. The two acacia shrublands have similar composition but differing dominance and the *Dryandra* shrubland occupies lateritic patches on the ridge crests. Pure *Acacia aneura* low woodlands occur on lower slopes on deep colluvial soils while the valleys are dominated by *Eucalyptus salubris* and / or *E. salmonophloia* woodland or by *Casuarina pauper (=C. cristata)* low woodland around the base of the Mt Manning Range and on small rises of greenstone on the plain. The surrounding sandplain is dominated by *Eucalyptus formanii* over *Plectrachne rigidissima.*

The aim of the present work was to extend the work of Keighery *et. al.* (1995) by undertaking further survey work on the Mt Manning Range (Figure 2). This involved the compilation of a detailed flora list for the range and the associated outwash areas, and a description of the vegetation patterning of this area based on a series of permanently located quadrats.

METHODS

Fifty four 20 m x 20 m quadrats were established on the range, its foot slopes and the outwash plain (Figure 2). These sites attempted to cover the major geographical, geomorphological and floristic variation found in the study area. Care was taken to locate sites in the least disturbed vegetation available in the area being sampled. No attempt was made to undertake detailed sampling of the Tertiary sandplain that surrounds the range, although one was established on the sandplain to allow comparisons with previous work done in the area.

Within each site all vascular plants were recorded. Quadrats were sampled in early November 1995. Data on topographical position, slope, aspect, percentage litter, percentage bare ground, percentage exposed rock, vegetation structure and condition were collected from each site. Topographical position was scored on a subjective six point scale. (Ridge tops - 1, upper slopes - 2, midslopes - 3, lower slopes - 4, valley flats - 5, small ridges in the valleys - 6). Slope was scored on a one to three scale from flat to steep. Aspect was recorded as one of 16 cardinal directions. Vegetation structure was recorded using Muir's (1977) classification.

All sites were permanently marked with four steel fence droppers and their positions fixed using a GPS unit. Twenty four soil samples from the A horizon were collected and bulked from each site. These soil samples are presently being analysed.

Sites were classified according to similarities in species composition. In these analyses only perennial species were used to facilitate comparisons with classifications from other ranges in the area (Gibson & Lyons 1995, Gibson *et al.* 1997).

The site and species classifications undertaken used the Czekanowski coefficient and "unweighted pair-group mean average" fusion method (UPGMA, Sneath and Sokal 1973). Semi-strong hybrid (SSH) ordination of the sites data was undertaken to show spatial relationships between groups and to elucidate possible environmental correlates with the classification (Belbin 1991).

Nomenclature follows Green (1985) and current usage at the Western Australian Herbarium (PERTH). Manuscript names are indicated by "ms" after the name. Selected voucher specimens will be lodged in the Western Australian Herbarium.

RESULTS

FLORA

A total of 217 taxa (species, subspecies and varieties) were recorded from the Mt Manning Range. The flora list was compiled from taxa found in the 54 plots or the adjacent area and from other opportunistic collections (Appendix 1). Of these 217 taxa, 213 are native and 4 are weeds.

The best represented families were the Asteraceae (34 native taxa and 2 weeds), Myrtaceae (26 taxa), Chenopodiaceae (13 taxa), Poaceae (10 native taxa and 2 weeds), Myoporaceae (11 taxa) and Mimosaceae (10 taxa). Sampling was undertaken in the first week of November 1995 and although good rains had fallen in winter and spring of 1995, the annuals and geophytes were largely finished and further additions could be expected to the flora list. (Appendix 1).

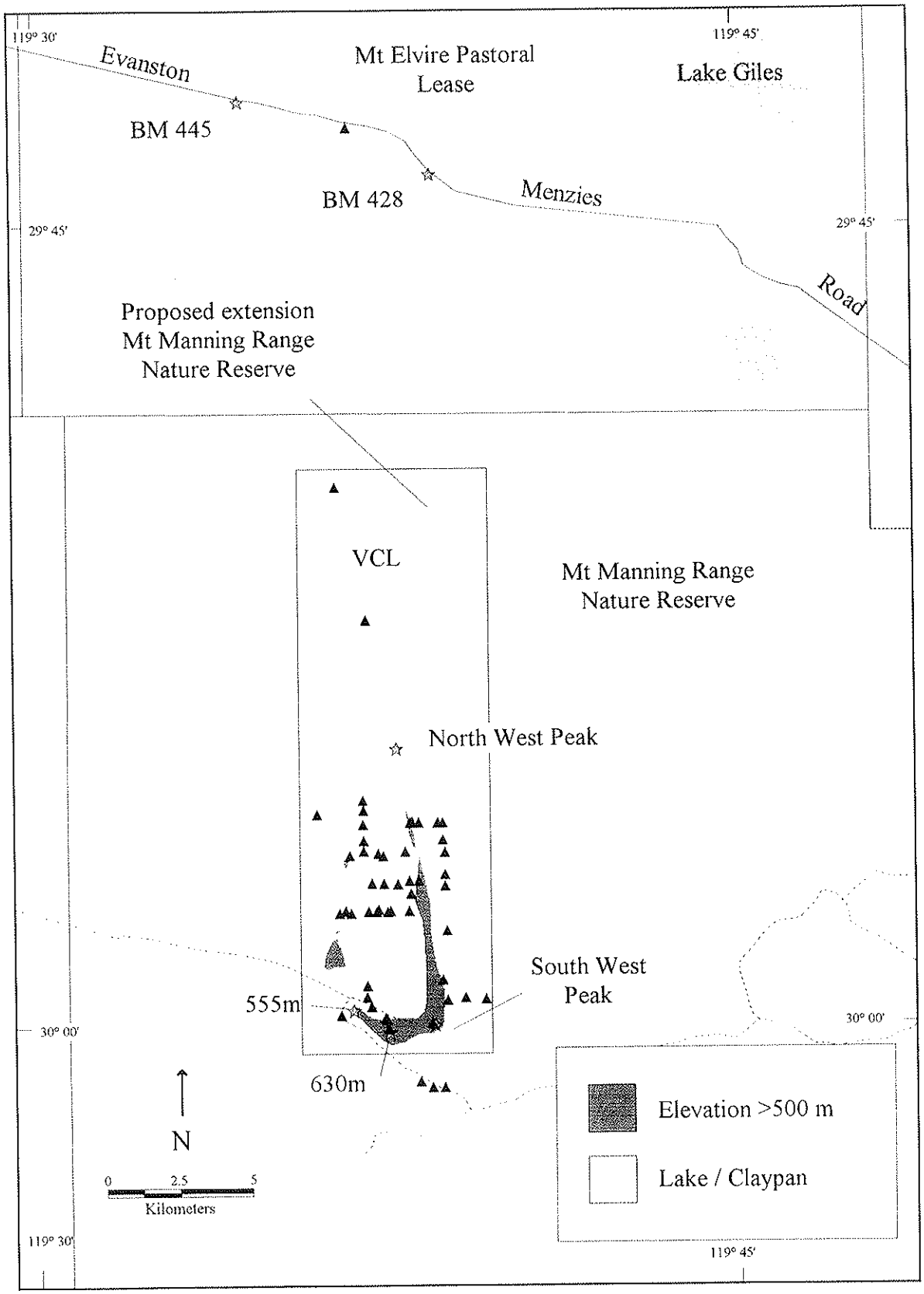


Figure 2. Location of survey sites within the study area.

The most common genera were *Eucalyptus* (14 taxa), *Eremophila* (11 taxa), *Acacia* (10 taxa) and *Ptilotus* (7 taxa). Very few weeds were encountered on the Mt Manning Range. During the survey six taxa listed on CALM's priority flora list (CALM 1996) were encountered (Table 1, Figure 3).

Calytrix creswellii is not known from any conservation reserve however its typical habitat is deep yellow sands and it is likely to occur in Mt Manning Range Nature Reserve. *Daviesia purpurascens* has recently been delisted from DRF to Priority 4. Data from this survey and previous surveys (Gibson *et al.* 1997) supports this reassessment. *Eucalyptus formanii* has a very restricted distribution in the Mt Manning – Die Hardy Range area, however within this area it the locally dominant eucalypt of the Tertiary sand sheet. *Grevillea erectiloba* and *Grevillea georgeana* are taxa restricted to the banded ironstone formations of the central goldfields, on these ironstones they can be locally common. *Leucopogon breviflorus* has a similar distribution to the grevilleas.

Table 1. Priority Flora (CALM 1996) encountered during the survey .

Taxon	***Current priority listing***
Calytrix creswellii	1
Daviesia purpurascens	4
Eucalyptus formanii	4
Grevillea erectiloba	4
Grevillea georgeana	3
Leucopogon breviflorus	2

Mirbelia sp. Helena & Aurora (BJL 2003) was encountered at one site (Figure 4). This species has previously been recorded from the Helena and Aurora Range, the Hunt Range and the Watt Hills. Given its limited distribution it has been recommended for listing on CALM's priority flora list as a priority 2 taxon (Gibson *et al.* 1997). This recommendation is supported here.

Another taxon that has only been recorded from a few locations in the Mt Manning Range area is *Eremophila* aff. *paisleyi* (GJK 4327). There are two collections in PERTH of this taxon - one from Diemals (from open woodland) and the other from Mt Jackson (from a Salmon gum woodland). Two populations of this taxa were located on the Mt Manning Range (Figure 4) both from small rises on the flats below the range, one dominated by *Eucalyptus longicornis* and the other by *Casuarina pauper*. From the available data this taxon has a range of 50 km. It is recommended that it be added to CALM's priority flora list as a priority 2 taxon.

(Priority 2 taxa are defined as:- Taxa which are known from one or a few (generally < 5) populations, at least some of which are not believed to be under immediate threat (ie not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.)

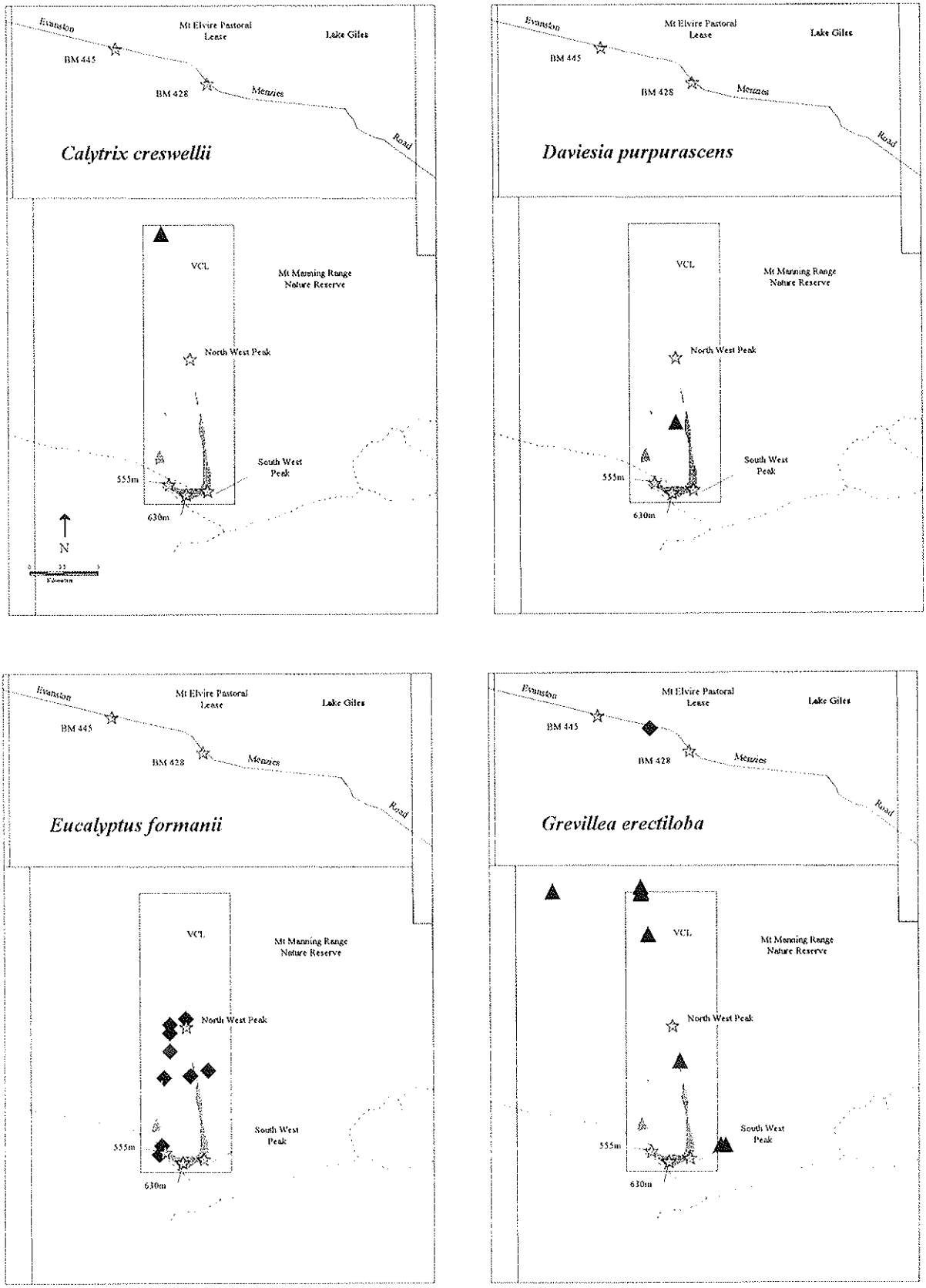


Figure 3. Populations of priority flora (triangles - new populations, diamonds - known populations) recorded during the current survey.

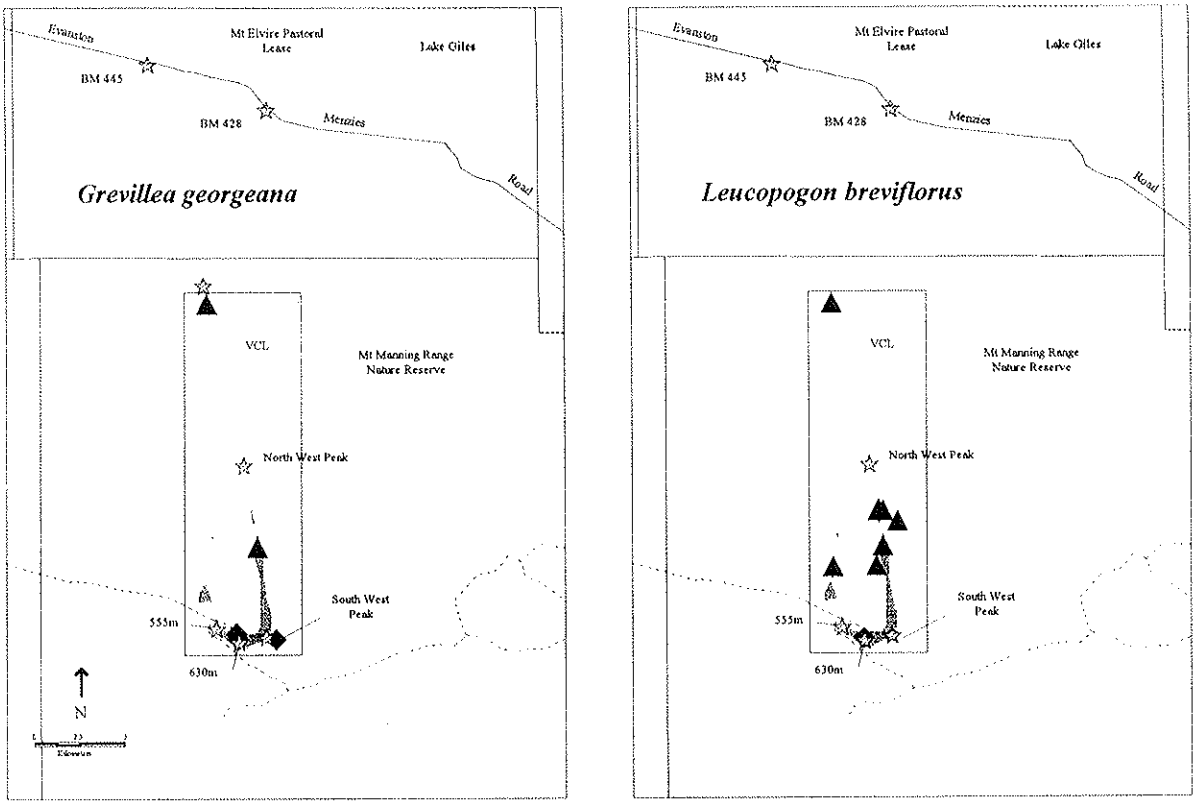


Figure 3. (cont'd.) Populations of priority flora (triangles - new populations, diamonds - known populations) recorded during the current survey.

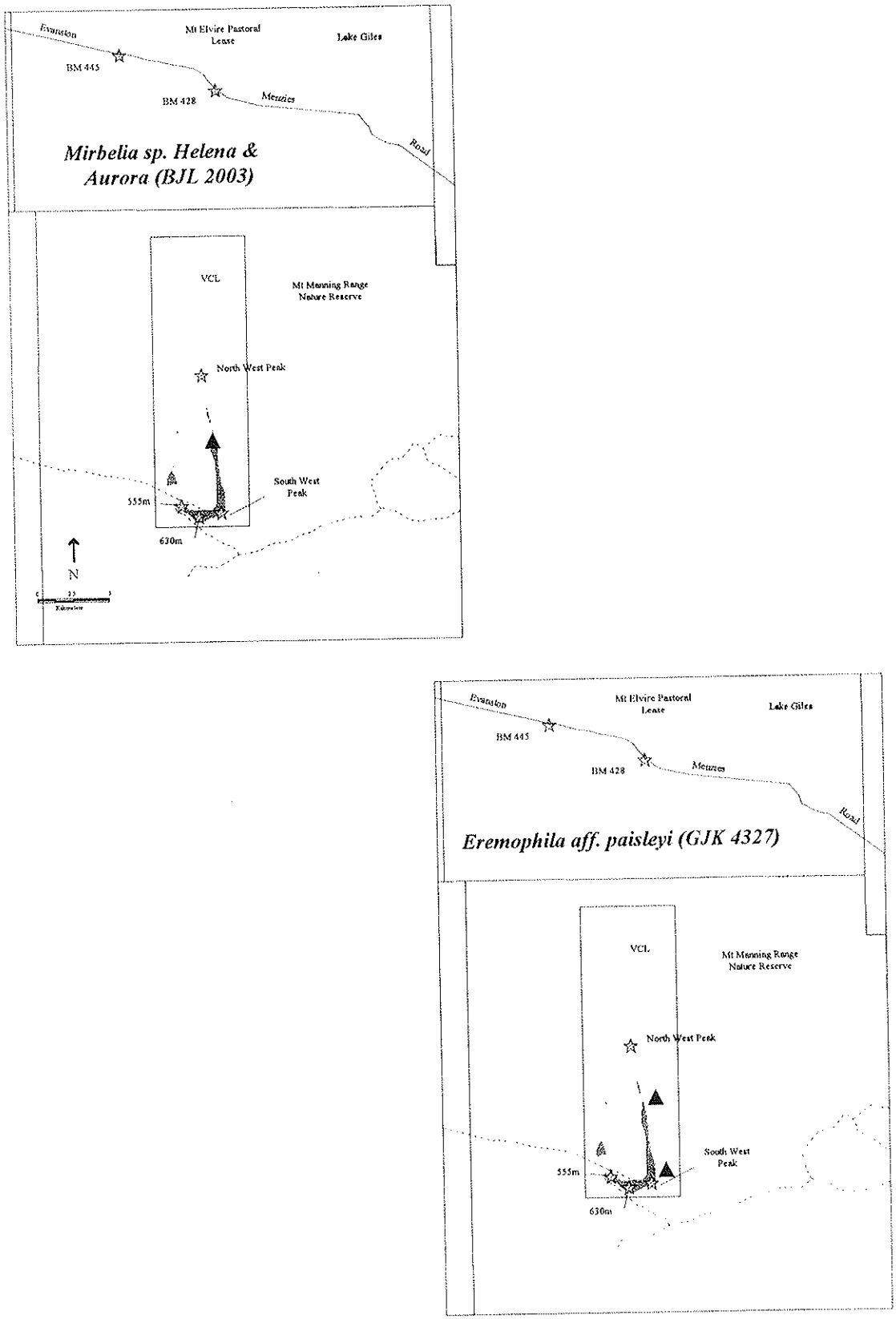


Figure 4. Populations of taxa proposed as priority flora recorded during the current survey.

VEGETATION

Only material that could be identified down to species level was included in the analysis (c.99% of records). In the 54 quadrats established on the Mt Manning Range 195 taxa were recorded of which 122 were perennial (Appendix 2 & 3). Forty five perennials occurred at only one site. Preliminary analyses showed these singletons had little effect on the community classification and therefore were excluded. As a result the final data set consisted of 77 perennial taxa in 54 sites. Species richness ranged from four to 20 taxa per site, with individual taxa occurring in between two and 38 of the 54 sites.

Multivariate analysis can assist in sorting both sites and species data such that patterns in species composition are more easily seen. The decision as to the number of site and species groups defined is subjective and related to the scale of pattern of interest (Kent and Coker 1992). In this analysis site groups are discussed at the eight group level which best reflects the scale of patterning seen in the field.

The dendrogram shows the 54 sites divide into two primary groups, the first group containing sites with skeletal soils over banded ironstone or weathered yellow sand on banded ironstone or laterite, the second group containing sites on greenstone or colluvial soils (Figure 5, Table 2). Both of these groups can be further subdivided with a total of eight communities being recognised.

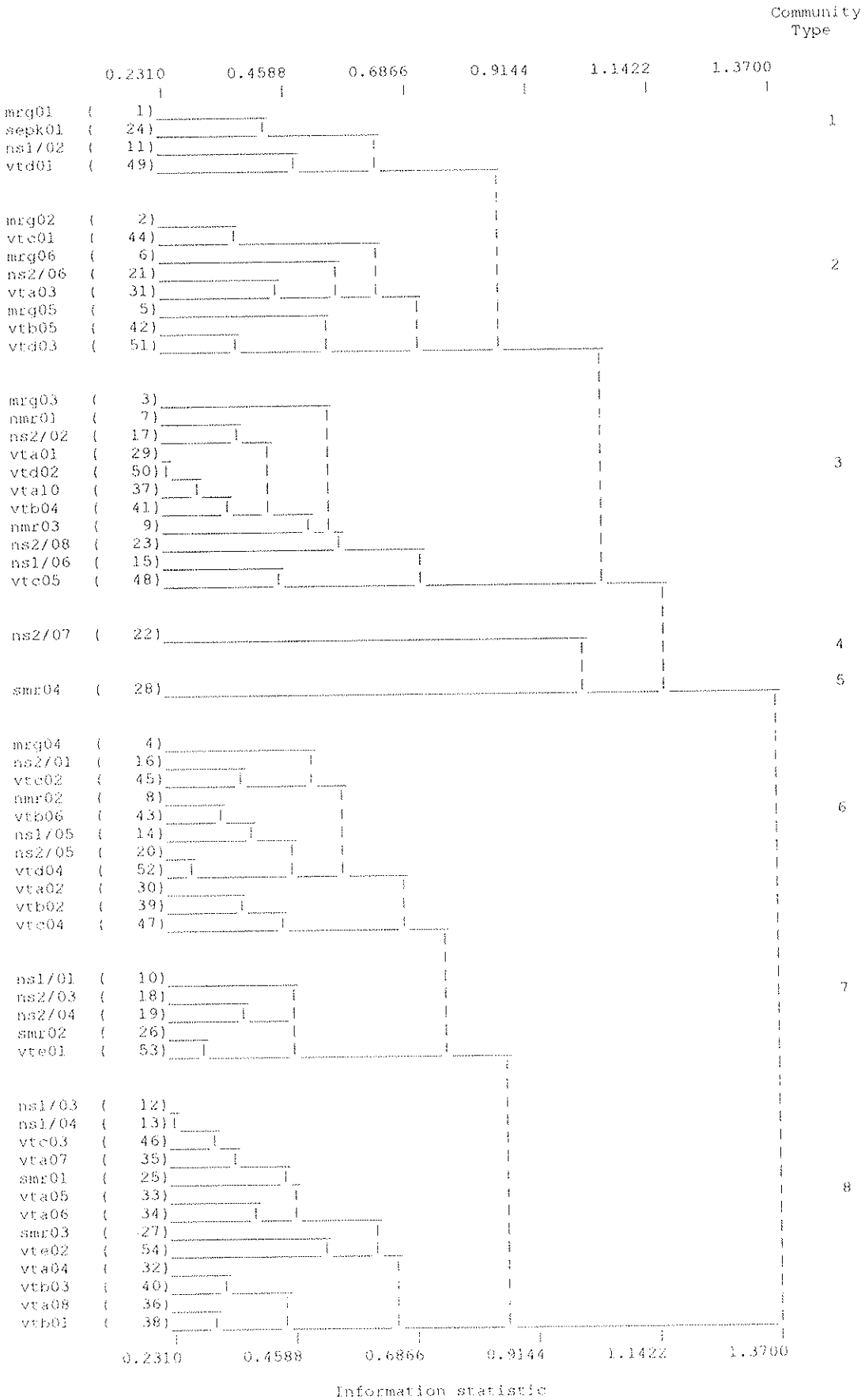
Community type 1 were species poor sites that generally occurred on massive banded ironstone near the crest of the range. Species richness was low (mean 9.75 taxa / plot) with only some taxa in species groups A and F (Table 2) being consistently represented. Dominance was variable with *Calycopeplus paucifolius* being the most consistent. One site in this group occurred on massive greenstone on a small rise near the base of the range. Constant species to this group included the perennial grasses *Amphipogon strictus* and *Austrostipa trichophylla* and the fern *Cheilanthes austrotenuifolia;* none were faithful to this group.

Community type 2 occurs on the lower flanks of the ranges on somewhat deeper soils. This community type is generally dominated or co dominated by *Eucalyptus ebbanoensis, Acacia ramulosa, A. aneura, A. quadrimarginea* and /or at the foot of the range *Callitris glaucophylla*. Species groups G and H are largely restricted to this community type but at low constancy levels (Table 2). Species group A is also well represented as are two *Acacia* spp. and *Eremophila latrobei* subsp. *latrobei.* Average species richness was 11.0 taxa / plot.

Around the base of the range and on some upland units a characteristic yellow sand unit develops over laterite. Community type 3 occurs on this unit and is characterised by high constancy of taxa in species group F. Common co-dominants include *Acacia quadrimarginea, Allocasuarina acutivalvis, Melaleuca filifolia,* and *Calycopeplus paucifolius.* Typical shrubs include *Baeckea elderiana, Grevillea paradoxa, Grevillea obliquistigma* and *Phebalium canaliculatum.* Average species richness is high at 13.27 taxa / plot. This community is most common around the base of the range but does occur where ever the laterite sheet remains.

Community types 4 and 5 are represented by single quadrats. Community type 4 occurs on eroding breakaways which are dominated by *Eucalyptus capillosa* subsp. *capillosa.* This landform is very restricted at the Mt Manning Range, it is more common on the banded ironstones of the Helena and Aurora Range and the Yendilberin Hills to the south (Gibson *et al.* 1997, Gibson, unpublished data).

Figure 5. Dendrogram of the sites from the Mt Manning Range showing the eight group level classification.



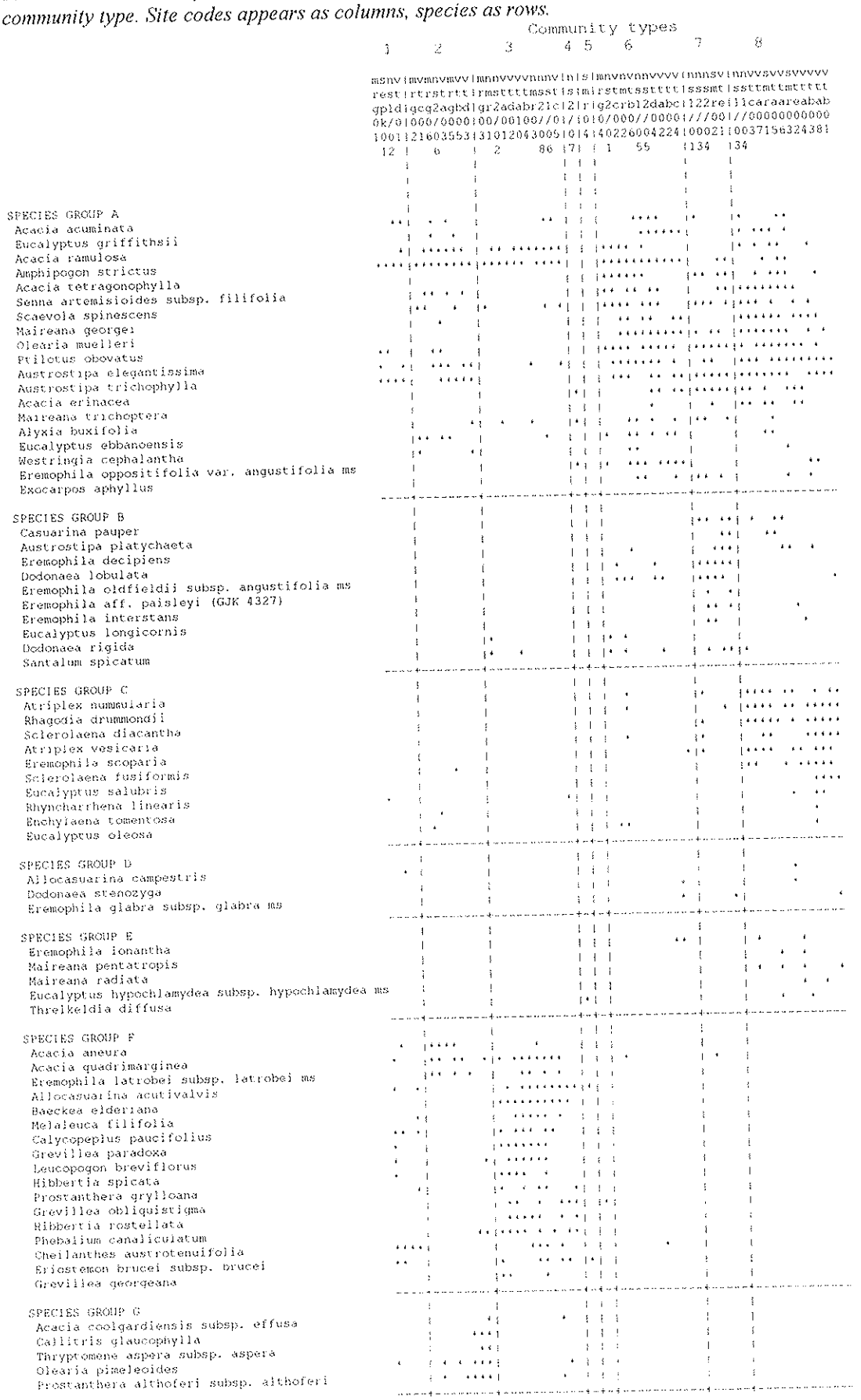
A single quadrat was established on the sandy plain at the base of the range. This site was dominated by *Eucalyptus formanii* and had previously been part of the regional survey undertaken in the area, being more representative of the surrounding sandplain (Keighery *et al.* 1995). Species richness was low with only eight perennial species being recorded, four of which were only recorded at this site.

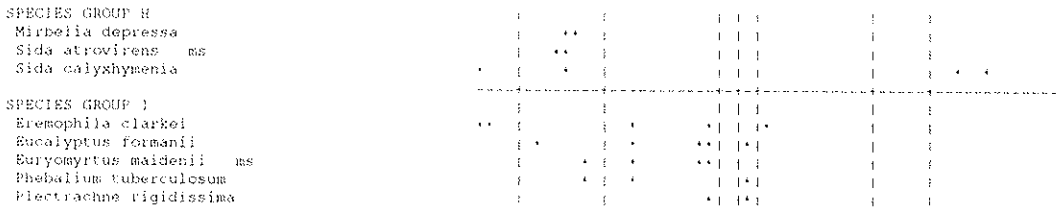
Community types 6, 7 and 8 appear to represent communities on the more fertile soils lower in the landscape (Figure 5, Table 2). Taxa in species group A are most faithful to these three communities. These species *Olearia muelleri, Ptilotus obovatus, Scaevola spinescens* and *Maireana georgei* (except community type 7). Community type 6 are eucalypt woodlands which are found on the slopes, valley and small rises in the valleys. These sites are generally dominated by *Eucalyptus ebbanoensis* and / or *E. griffithsii,* and occasionally by *Eucalyptus oleosa.* This community differs from community type 7 by general lack of taxa in species group B and from community type 8 by the general lack of taxa from the chenopod rich species group C (Table 2). Average species richness was 12.55 taxa / plot.

The *Casuarina pauper* and / or *Eucalyptus longicornis* dominated woodlands of community type 7 are restricted to small greenstone rises on the plain at the base of Mt Manning Range. Species groups A and B are well represented in this community type, however some individual species of these groups are entirely lacking (eg. *Eucalyptus ebbanoensis, Maireana georgei, Dodonaea rigida*). Species richness of these sites was high with an average of 15.0 taxa / plot.

The final community type (type 8) is the chenopod rich eucalypt woodlands of the valleys and small rises. Common dominants include *Eucalyptus griffithsii, E. salubris* and occasionally *Casuarina pauper*. Species group C (largely chenopods) was characteristic of this community type (Table 2). Average species richness was high at 15.31 taxa / plot. Some differentiation of *E. salubris* sites can be seen in the two way table with some sites lacking *E. griffithsii, Acacia erinacea* and *Maireana trichoptera.*

Table 2. Sorted two way table of the Mt Manning Range sites showing species occurrence by community type. Site codes appears as columns, species as rows.





Physical Correlates

The community types showed very strong correlations with topographic position, soil type and to a lesser degree slope (Tables 3, 4 & 5) all of which are strongly intercorrelated. Community type 1 is largely restricted to upland and upper slopes on skeletal soils over massive ironstone (rarely massive greenstone) on steep to gentle slopes.

Table 3. Community types by topographic position

Community type	Upland	Upper slope	Mid slope	Lower slope	Valley	Low rise in valley
1	2	1				1
2			1	1	6	
3	3	2	2	1	1	2
4				1		
5					1	
6	1		2	1	2	5
7						5
8					9	4

Table 4. Community type by soil type.

Community type	Skeletal soil on massive ironstone	Skeletal soil over massive greenstone	Sandy loam over laterite	Deep sands, loams and clays
1	3	1		
2	1			7
3	2		8	1
4			1	
5				1
6	1		3	7
7				5
8		1		12

Community type 2 generally occurs around the base of the range on deeper sandy soils on gentle or flat slopes. Community type 3 can occur in all places in the landscape but is restricted to yellow sandy soils over laterites. These soils are found on gentle or flat slopes.

Community type 4 is restricted to the single large eroding breakaway located in the study area, a landform not common in northern goldfields (Milewski & Hall 1995). Community type 5

occurred on gentle sloping sites with deep sandy soils which are more typical of the sandplain surrounding the range.

Table 5. Community type by slope.

Community type	flat	gentle	steep
1		3	1
2	4	4	
3	7	4	
4		1	
5		1	
6	4	7	
7		5	
8	8	5	

Community type 7 was restricted to gentle slopes on small greenstone rises in the valleys that had developed deeper soil profiles, while community type 8 occurred on similar positions as well as the valleys.

When the soil chemistry analyses are available (these are presently with the WA Chemistry Centre) a more detailed analysis of soil differences between the eight community types will be possible.

Ordination Results

Ordination of the site data was undertaken to show spatial relationships between groups and to better elucidate possible environmental correlates with the classification. The results of a three dimensional ordination (stress level 0.176) shows good separation of most of the classificatory groups. The first and second axes separated community types 4 and 5 from all other sites, further indicating the very different nature of these community types. The first and the third axes show what appears to be a major soil fertility gradient from the yellow sands over laterites of community type 3 in the upper right quadrant to the chenopod rich loams of community type 8 in the lower left quadrant (Figure 6).

Along this gradient community type 1 is most similar to community type 3 followed by community type 2 with community types 6 and 7 (although these separate on the orthogonal axis) being most similar to community type 8. Further elucidation of these gradients will be possible when the results of the soil chemical and mechanical analyses are available.

DISCUSSION

The total of 217 taxa recorded on the Mt Manning Range compares with 293 taxa recorded by Keighery *et al.* (1995) for the Mt Manning Range area which included both the range and the surrounding sandplain in the Mt Manning Range Nature Reserve. The total for the range is low compared with the list for the Helena and Aurora Range (324 taxa) this probably reflects in part the sampling of the Mt Manning Range later in the season when many of the annuals and geophytes were finished (Gibson *et al.* 1997). However the flora list for the range is also lower than those for the Bremer Range (268 taxa) and the Parker Range (256 taxa) which were sampled in very poor years (for annuals and geophytes) (Gibson & Lyons 1995). This

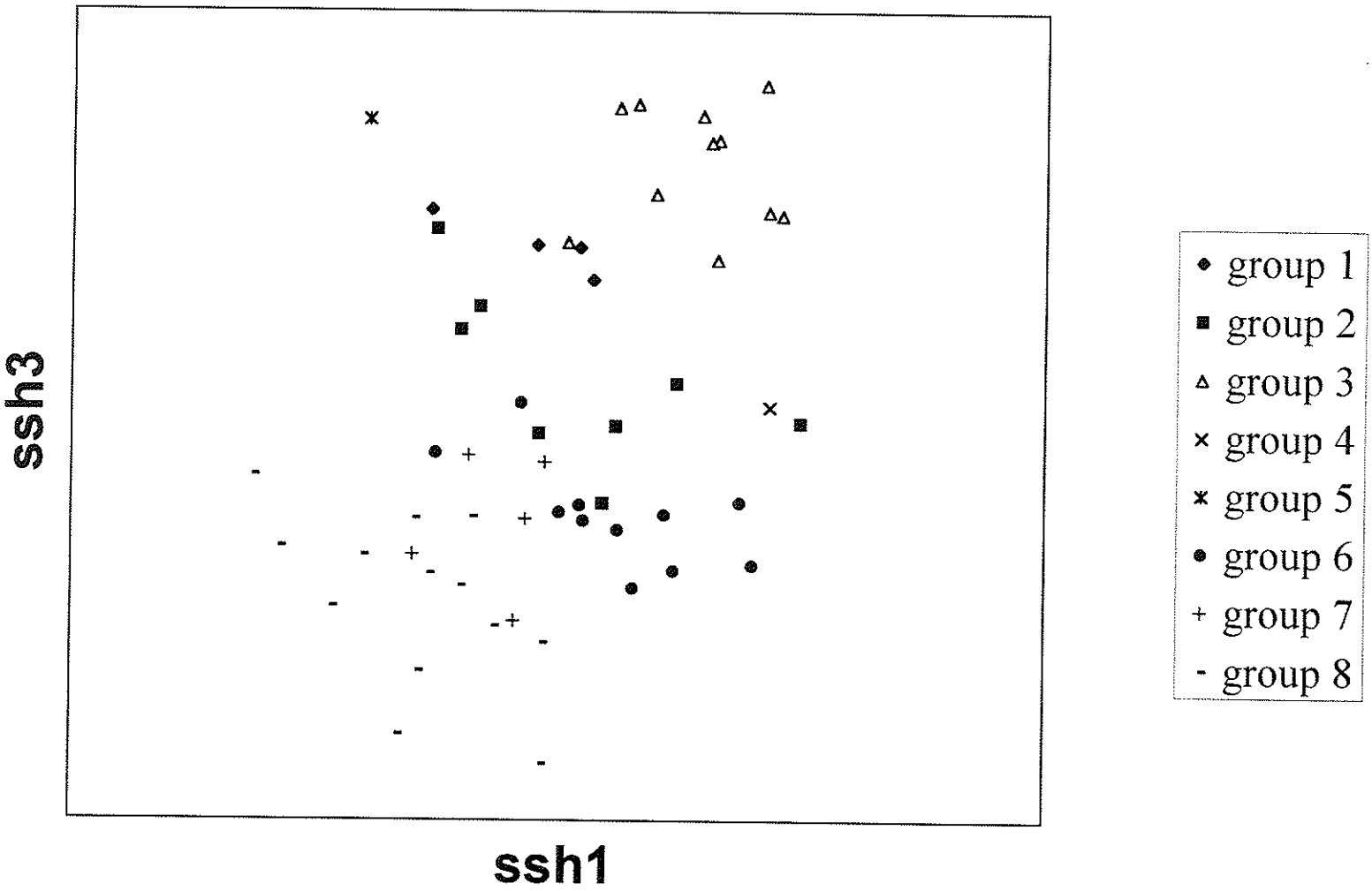


Figure 6 Ordination of Mt Manning Range sites

reduction in total species richness is consistent with a decline in species richness along an increasing aridity gradient (Beard 1972). The Mt Manning Range lies just south of the boundary between the Coolgardie botanical region and the Murchison region. The Coolgardie region is the change over zone between the species rich south west and the more arid eremaean zone.

Our results are consistent with the view of Keighery *et al.* (1995) that the vegetation of the Mt Manning Range area should be considered part of Beard's Die Hardy vegetation system. Our data suggest that the floristic variation across the range is considerably less than the structural variation described by Keighery *et al.* (1995). The present classification allow the placement of the structural units described earlier to be set in a topography – soil context.

We were not able to relocate the *Dryandra arborea* shrubland on the top of the Mt Manning Range described by Keighery *et al.* (1995) despite extensive searches in the region of South East Peak, the ridge to the west and the more extensive ridge to the north. This community type, which is common on the massive ironstone tops of the Helena & Aurora Range (70 km to the south), must be localised in small patches on the Mt Manning Range. This decrease in the occurrence of this community type is likely to be associated with the decreasing rainfall (Beard 1972). Off the range *Dryandra arborea* was encountered twice, once on skeletal soils over decomposing granites and also on deep yellow sands. Both populations occur on the gridline between North West Peak and the Diemals – Menzies road. These populations represent the northern limits of this species.

Keighery *et al.* (1995) listed *Neurachne* sp. Nov. (GJK / JA 1951) as a common perennial grass of the *Eucalyptus ebbanoensis* woodlands of the lower slopes. This taxon was not recorded during the current survey. Common perennial grasses recorded included *Amphipogon strictus, Austrostipa trichophylla,* and *Austrostipa elegantissima.* The *Neurachne* may have been missed due to lateness of the survey. The distribution of this species on the range needs clarification.

Significant populations of the priority taxa *Grevillea erectiloba, Grevillea georgeana* and *Leucopogon breviflorus* were located during the present survey. *Grevillea georgeana* generally occurs on massive banded ironstone while *G. erectiloba* generally occurs on yellow sands over laterites around the base of the range. Of the five regional endemics of the banded ironstones and associated soils of the Helena and Aurora 70 km to the south (Gibson *et al.* 1997), only *Grevillea erectiloba* and *Grevillea georgeana* and *Mirbelia* sp. Helena & Aurora (BJL 2003) occur as far north as the Mt Manning Range.

The *Mirbelia* has previously been recommended for listing as a priority taxon given its limited distribution on soils associated with banded ironstone (Gibson *et al.* 1997). That recommendation is supported here. Another taxon with very restricted distribution was identified during the current survey. This taxon (*Eremophila* aff. *paisleyi* (GJK 4327)) is only known from four populations spread over 50 km from Mt Manning Range to Diemals and south to Mt Jackson. It is recommended that this taxon also be listed as a priority 2 taxon.

The present survey clearly shows that the ridge and slope communities are fundamentally different from those reported for the Helena and Aurora Range (Gibson *et al.* 1997). The Helena and Aurora Range is also composed of massive banded ironstones of the same age (Chin & Smith 1983). The differences in vegetation therefore most likely reflect differences in climate. None of the Die Hardy vegetation system is presently reserved. Our work supports the recommendations of Henry-Hall (1990) CALM (1994) and Keighery *et al.* (1995) that the Mt Manning Range should become part of the Mt Manning Range Nature Reserve.

REFERENCES

Beard J.S. (1972) *The vegetation of the Jackson areas, Western Australia.* Vegmap, Perth.

Beard J.S. (1990) *Plant life of Western Australia.* Kangaroo Press, Kenthurst.

Belbin L. (1991) Semi-strong hybrid scaling, a new ordination algorithm. *Journal of Vegetation Science* **2:491-496.**

Bureau of Meteorology (1988). *Climatic averages Australia.* AGPS, Canberra

CALM (1994) *Goldfields region. Regional management plan 1994 – 2004. Management plan No. 27.* CALM, Perth.

CALM (1996) *Declared Rare and Priority flora list* - 21/10/1996. Unpublished Report, CALM.

Chin, R.J. & Smith R.A. (1983) Jackson, Western Australia. 1: 250 000 geological series - explanatory notes. Geological Survey of Western Australia, Perth.

Gibson N. & Lyons M.N. (1995) *Floristic survey of the Bremer and Parker Ranges of the Eastern Goldfields of Western Australia.* Unpublished report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management.

Gibson N., Lyons M.N, & Lepschi B.J. (1997) Flora and vegetation of the eastern goldfields ranges, 1. Helena and Aurora Range. *CALMScience* **2: 231-246.**

Green J.W. (1985) *Census of the Vascular Plants of Western Australia.* Department of Agriculture, Perth.

Henry-Hall N.J. (1990) *Nature conservation reserves in the Eastern Goldfields, Western Australia. (Southern two thirds of CTRC System 11).* Unpublished Report to EPA Red Book Task Force.

Keighery G.J., Milewski A.V. & Hall N.J. (1995). Vegetation and flora. In: The biological survey of the Eastern Goldfields of Western Australia. Part 12. Barlee Menzies study area. *Records of the Western Australian Museum Supplement* **49: 183-207.**

Kent M. & Coker P. (1992) *Vegetation description and analysis: A practical approach.* Belhaven Press, London.

Muir B.G. (1977) Biological survey of the Western Australian wheatbelt. Part II. *Records of the Western Australian Museum Supplement* **3.**

Milewski A.V. & Hall N.J. (1995). Physical Environment. In: The biological survey of the Eastern Goldfields of Western Australia. Part 12. Barlee Menzies study area. *Records of the Western Australian Museum Supplement* **49: 174-182.**

Sneath P.H.A. & Sokal R.R. (1973) *Numerical taxonomy: The principles and practice of numerical classification.* Freeman, San Francisco.

Walker I.W. & Blight D.F. (1983) Barlee, Western Australia. 1: 250 000 geological series - explanatory notes. Geological Survey of Western Australia, Perth.

APPENDIX 1

Flora List for the Mt Manning Range.

This list includes all taxa from both the sampling quadrats and the opportunistic collections. Nomenclature follows Green (1975) and current usage at PERTH (ms denotes a manuscript name, pn denotes a phrase name, * indicates a weed).

Family: Adiantaceae

Cheilanthes austrotenuifolia
Cheilanthes lasiophylla

Family: Amaranthaceae
Ptilotus aervoides
Ptilotus divaricatus
Ptilotus drummondii
Ptilotus exaltatus
Ptilotus gaudichaudii
Ptilotus holosericeus
Ptilotus leucocoma
Ptilotus obovatus

Family: Anthericaceae
Thysanotus patersonii

Family: Apiaceae
Daucus glochidiatus
Trachymene ornata

Family: Apocynaceae
Alyxia buxifolia

Family: Asclepiadaceae
Marsdenia australis
Rhyncharrhena linearis

Family: Asteraceae
Actinobole uliginosum
Asteridea athrixioides
Blennospora drummondii
Calotis hispidula
Calotis multicaulis
Cephalipterum drummondii
Chthonocephalus pseudevax
Erymophyllum ramosum subsp. ramosum
Gilberta tenuifolia
Gilruthia osbornei
Gnephosis tenuissima
* Hypochaeris glabra
Lawrencella rosea
Leucochrysum fitzgibbonii
Olearia exiguifolia
Olearia humilis
Olearia muelleri
Olearia pimeleoides
Olearia subspicata
Podolepis canescens
Podolepis capillaris
Podolepis lessonii
Podotheca angustifolia
Rhodanthe laevis
Rhodanthe manglesii
Rhodanthe oppositifolia
Rhodanthe rubella
Rhodanthe stricta
Schoenia cassiniana
Senecio glossanthus
* Sonchus oleraceus
Streptoglossa liatroides
Trichanthodium skirrophorum
Vittadinia humerata
Waitzia acuminata
Waitzia citrina

Family: Boraginaceae
Halgania viscosa

Family: Brassicaceae
Stenopetalum filifolium
Stenopetalum pedicellare

Family: Caesalpiniaceae
Senna artemisioides subsp. filifolia
Senna pleurocarpa var. pleurocarpa

Family: Campanulaceae
Wahlenbergia tumidifructa

Family: Casuarinaceae
Allocasuarina acutivalvis
Allocasuarina campestris
Allocasuarina corniculata
Allocasuarina helmsii
Casuarina pauper

Family: Chenopodiaceae
Atriplex nummularia
Atriplex vesicaria
Enchylaena tomentosa
Maireana georgei
Maireana pentatropis
Maireana radiata
Maireana trichoptera

Maireana triptera
Rhagodia drummondii
Sclerolaena densiflora
Sclerolaena diacantha
Sclerolaena fusiformis
Threlkeldia diffusa

Family: Chloanthaceae
Lachnostachys coolgardiensis
Physopsis viscida

Family: Crassulaceae
Crassula colorata

Family: Cupressaceae
Callitris columellaris
Callitris glaucophylla

Family: Cyperaceae
Lepidosperma sp.

Family: Dasypogonaceae
Xerolirion divaricata

Family: Dilleniaceae
Hibbertia rostellata complex
Hibbertia spicata

Family: Droseraceae
Drosera menziesii

Family: Epacridaceae
Leucopogon breviflorus

Family: Euphorbiaceae
Calycopeplus paucifolius
Poranthera microphylla

Family: Frankeniaceae
Frankenia desertorum

Family: Geraniaceae
Erodium cygnorum

Family: Goodeniaceae
Brunonia australis
Dampiera juncea
Dampiera roycei
Goodenia berardiana
Goodenia occidentalis
Scaevola spinescens
Velleia rosea

Family: Haloragaceae
Glischrocaryon flavescens
Gonocarpus nodulosus
Haloragis gossei

Family: Lamiaceae
Prostanthera althoferi subsp. althoferi
Prostanthera grylloana
Westringia cephalantha

Family: Lobeliaceae
Lobelia heterophylla

Family: Loganiaceae
Mitrasacme paradoxa

Family: Loranthaceae
Amyema miquelii

Family: Malvaceae
Abutilon otocarpum
Abutilon oxycarpum
Sida atrovirens ms
Sida calyxhymenia
Sida sp.golden calyces (H.N.Foote 32) pn

Family: Mimosaceae
Acacia acuminata
Acacia andrewsii
Acacia aneura
Acacia coolgardiensis subsp. effusa
Acacia erinacea
Acacia kempeana
Acacia neurophylla
Acacia quadrimarginea
Acacia ramulosa
Acacia tetragonophylla

Family: Myoporaceae
Eremophila aff. paisleyi (GJK 4327)
Eremophila alternifolia
Eremophila clarkei
Eremophila decipiens
Eremophila glabra subsp. glabra ms
Eremophila interstans
Eremophila ionantha
Eremophila latrobei subsp. latrobei ms
Eremophila oldfieldii subsp. angustifolia ms
Eremophila oppositifolia var. angustifolia ms
Eremophila scoparia

Family: Myrtaceae
Baeckea elderiana
Calytrix creswellii
Eucalyptus capillosa subsp. capillosa
Eucalyptus ebbanoensis
Eucalyptus formanii
Eucalyptus griffithsii
Eucalyptus hypochlamydea subsp. hypochlamydea ms
Eucalyptus leptopoda subsp. leptopoda

Eucalyptus longicornis
Eucalyptus loxophleba subsp. lissophloia
Eucalyptus oldfieldii
Eucalyptus oleosa
Eucalyptus salubris
Eucalyptus subangusta subsp. subangusta
Eucalyptus transcontinentalis
Eucalyptus yilgarnensis
Euryomyrtus maidenii ms
Homalocalyx thryptomenoides
Malleostemon roseus
Melaleuca acuminata
Melaleuca filifolia
Melaleuca fulgens
Melaleuca uncinata
Thryptomene aspera subsp. aspera
Thryptomene kochii
Verticordia helmsii

Family: Orchidaceae
Pterostylis picta
Thelymitra aff. macrophyllum

Family: Papilionaceae
Daviesia purpurascens
Mirbelia depressa
Mirbelia ramulosa
Mirbelia sp.Helena & Aurora(B.J.Lepschi 2003) pn

Family: Phormiaceae
Dianella revoluta

Family: Pittosporaceae
Bursaria occidentalis
Cheiranthera filifolia var. filifolia

Family: Plantaginaceae
Plantago aff. hispidula (NG & ML 1732)

Family: Poaceae
Amphipogon strictus
Aristida holathera
Austrostipa elegantissima
Austrostipa platychaeta
Austrostipa trichophylla
Bromus arenarius
Danthonia caespitosa
Eragrostis dielsii
Monachather paradoxus
Plectrachne rigidissima
* Pentaschistis airoides
* Vulpia myuros

Family: Portulacaceae
Calandrinia eremaea

Family: Proteaceae
Dryandra arborea
Grevillea acuaria
Grevillea erectiloba
Grevillea georgeana
Grevillea nematophylla
Grevillea obliquistigma
Grevillea paradoxa
Hakea minyma

Family: Rhamnaceae
Stenanthemum stipulosum

Family: Rubiaceae
Canthium lineare

Family: Rutaceae
Eriostemon brucei subsp. brucei
Eriostemon tomentellus
Phebalium canaliculatum
Phebalium tuberculosum

Family: Santalaceae
Exocarpos aphyllus
Santalum acuminatum
Santalum spicatum

Family: Sapindaceae
Dodonaea divaricata
Dodonaea lobulata
Dodonaea rigida
Dodonaea stenozyga
Dodonaea viscosa

Family: Solanaceae
Nicotiana occidentalis
Solanum cleistogamum
Solanum lasiophyllum
Solanum orbiculatum
Solanum plicatile

Family: Sterculiaceae
Brachychiton gregorii
Keraudrenia integrifolia

Family: Stylidiaceae
Stylidium dichotomum
Stylidium limbatum
Stylidium repens

Family: Zygophyllaceae
Zygophyllum apiculatum
Zygophyllum eremaeum
Zygophyllum ovatum

APPENDIX 2

Floristic data set for the Mt Manning Range.

The full data set (195 taxa x 54 quadrats) is provided in Cornell University Condensed Format. The species codes are derived from the first three letters of the genus and species names with a further two letters from intraspecific rank where applicable except where otherwise listed below. *Aira caryophyllea* and *Pentaschistis airoides* proved difficult to consistently differentiate and have been treated as a species complex in the full data set.

Non standard species codes.

Maireana trichoptera	MAITRIc
Maireana triptera	MAITRIp

```
mt manning range dataset 24-7-97
(13I6)                                                                5
     1    10    14    18    33    37    41    44    55    64    94    98    99
   100   101   102   113   115   125   127   146   148   153   165   167   169
   172   174   183   185   187   189
     2     5    10    18    27    60    69   122   123   141   156   185   189
   191
     3    10    18    24    27    33    48    64    91    94    98   128   138
   155   156   189
     4    11    12    18    31    48    55    62    69   100   120   142   146
   155   156   161   183   185   189   194   195
     5    11    18    27    30    32    34    60    71    84    95   100   116
   120   125   130   133   137   139   143   145   156   171   174   182   185
   189   194
     6     3     5    11    18    27    51    71    92   142   146   157   161
   162   170   172   182   189   194
     7     9    11    14    18    24    27    28    91    93    94    97    98
   102   120   128   148   182   189
     8     4    11    12    17    18    43    56    61    62    69   103   105
   124   133   142   143   146   148   156   161   172   174   182   189   191
     9    10    11    14    18    24    27    33    90   120   128   143   148
   183   189
    10     3     7    12    17    22    23    31    35    36    43    47    61
    63    67    82    95   124   140   146   156   159   174   182   195
    11     3    15    18    21    37    50    88    95    96   100   114   133
   143   148   150   170   174   182   186   189   195
    12     3     7    11    20    22    36    43    63    66    71    80    88
   100   105   108   120   124   130   133   134   142   143   146   147   155
   156   157   159   160   161   170   172   174   182   185   189   194
    13     7    22    35    43    52    59    63   105   107   108   110   124
   140   142   147   156   159   160   161   172   174   194   195
    14     3    11    12    18    62    71    79    82   105   124   134   142
   143   146   156   172   182   189
    15     3    11    14    18    24    27    64    70    81    93   100   104
   111   125   128   184   185   188   189   190
    16    10    11    12    18    47    61    76   103   146   156   161   172
   174   182   185   189   194   195
    17    10    11    16    17    18    24    27    33    43    46    55    70
    81    93    94    95    97    98   100   102   112   128   129   133   177
   182   184   189
    18     7    10    12    17    35    47    53    58    61    74    82   109
   146   155   156   172   174   195
    19     7    47    56    58    61    74   108   124   146   156   172   174
   195
    20     3     7    17    18    27    37    43    47    61    67    69    71
   103   105   108   124   135   141   143   146   149   156   161   170   172
   174   185   189   194   195
    21     5    10    11    18    60    69    83    88   100   105   125   130
   143   146   148   157   164   170   172   174   185   189
    22     7    14    17    62    64    67    68   127   139   180   183   192
    23     3     6    10    11    14    18    24    27    31    37    45    60
    64    69    84    93    97   100   112   119   137   148   156   182   189
    24     1     5    18    29    33    37    39    55    64    66   100   127
   146   150   166   174   189
    25    11    12    17    35    43    54    69    71   105   106   107   108
   124   142   143   146   156   159   161   168   172   173   174   180   189
   195
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26 7 12 18 35 43 47 56 61 82 124 142 146
147 155 161 173 174 195
27 7 58 59 63 72 105 106 107 108 146 156 160
161 172 195
28 27 42 70 93 100 126 129 131 134 141 157 163
188
29 10 14 18 24 27 33 60 94 97 98 100 102
112 128 138 182 185 189
30 18 59 62 69 71 124 146
31 3 10 11 18 44 69 87 115 116 121 133 137
157 160 161 164 165 170 172 174 182 185 189
32 2 11 22 23 36 43 51 56 62 63 67 76
77 82 95 105 124 127 130 140 141 142 147 153 156
158 159 160 170 172 174 194 195
33 3 8 11 12 18 22 35 36 43 56 83 88
105 124 146 147 160 161 165 172 174 182 194
34 3 7 12 15 18 22 36 43 49 56 63 71
82 89 95 124 142 146 147 153 159 161 170 172 174
191 195
35 7 18 22 23 43 63 69 71 105 108 124 142
146 147 154 159 161 173 174 194
36 22 23 26 36 52 63 67 77 86 124 130 133
142 144 147 150 151 159 160 162 172 174 175 194 195
37 5 10 11 14 18 24 27 37 64 93 94 97
102 112 128 138 148 184 185 189
38 22 23 41 43 57 61 77 88 107 127 134 140
142 147 152 159 170 172 174 194
39 7 17 18 43 49 57 59 62 69 71 82 95
103 105 124 140 143 146 170 172 174 195
40 12 23 62 63 72 77 105 142 146 147 153 159
160 170 172 174 182
41 10 11 14 17 24 27 33 37 60 64 91 94
98 100 102 112 118 138 148 172 176 178 182 185 189
190
42 11 18 27 30 65 73 81 84 85 100 120 125
128 129 137 145 161 172 174 179 185 189
43 3 12 17 18 19 43 62 69 82 124 133 143
161 172 182 189 191
44 5 10 11 18 27 60 69 70 76 100 125 137
148 156 161 176 184 185 189
45 11 12 18 22 23 48 61 76 103 105 115 124
133 142 143 146 147 155 156 172 174 189 194
46 11 12 22 23 29 41 63 71 105 124 143 146
147 156 159 161 165 170 172 174 182 183 185 194 195
47 7 18 27 62 63 71 78 100 103 105 124 140
143 170 174 183 189 195
48 11 14 18 25 27 55 70 81 87 93 97 100
115 120 128 131 132 133 138 148 153 156 172 183 189
49 3 11 14 18 27 33 37 100 112 117 136 138
148 172 174 182 183 189
50 10 11 14 18 24 27 33 37 60 75 94 97
100 102 112 148 155 176 182 189
51 6 10 17 18 27 30 31 38 84 100 102 120
125 128 133 137 157 170 172 174 179 181 182 184 185
189 191
52 3 7 13 18 27 40 43 61 62 71 83 103
124 146 155 156 161 172 174 184 189 193 194
53 7 12 17 18 35 43 47 53 56 57 58 130
146 148 155 156 161 173 174 184 189 195
54 7 23 74 105 108 142 146 147 159 160 172 180
195
0

ABUOTO ABUOXY ACAACU ACAAND ACAANE ACACOOE FACAERI ACAKEM ACANEU ACAQUA
ACARAM ACATET ACTULI ALLACU ALLCAM ALLCOR ALYBUX AMPSTR AMYMIQ ARIHOL
ASTATH ATRNUM ATRVES BAEELD BLEDRU BROARE BRUAUS CALCRE CALERE CALGLA
CALHIS CALMUL CALPAU CANLIN CASPAU CEPDRU CHEAUS CHEFILFICHELAS CHTPSE
CRACOL DAMROY DANCAE DAUGLO DIAREV DODDIV DODLOB DODRIG DODSTE DROMEN
ENCTOM ERADIE EREAFFPAEREALT ERECLA EREDEC EREGLAGLEREINT EREION ERELATLA
EREOLDANEREOPPANERESCO ERIBRUBRERITOM EROCYG ERYRAMRAEUCCAPCAEUCEBB EUCFOR
EUCGRI EUCHYPHYEUCLEPLEEUCLON EUCOLD EUCOLE EUCSAL EUCSUBSUEUCTRA EUCYIL
EURMAI EXOAPH GILOSB GILTEN GNETEN GONNOD GOOBER GOOOCC GREACU GREERE
GREGEO GRENEM GREOBL GREPAR HALGOS HALVIS HIBROS HIBSPI HYPGLA LAWROS
LEPIDSP LEUBRE LEUFIT LOBHET MAIGEO MAIPEN MAIRAD MAITRIc MAITRIp MARAUS
MELACU MELFIL MELFUL MELUNC MILLSP MIRDEP MIRRAM MIRSP. MITPAR MONPAR
NICOCC OLEEXI OLEHUM OLEMUE OLEPIM OLESUB PENAIR PHECAN PHETUB PLAAFFHI
PLERIG PODANG PODCAN PODCAP PODLES PORMIC PROALTALPROGRY PTEPIC PTIAER
PTIDIV PTIEXA PTIGAU PTIHOL PTILEU PTIOBO RHADRU RHOLAE RHOMAN RHOOPP
RHORUB RHOSTR RHYLIN SANACU SANSPI SCASPI SCHCAS SCLDEN SCLDIA SCLFUS
SENARTFISENGLO SENPLEPLSIDATR SIDCAL SOLCLE SOLLAS SOLORB SONOLE STEFIL
STEPED AUSELE AUSPLA AUSTRI STRLIA STYLIM STYREP THEAFFMATHRASPASTHRDIF

THRKOC	THYPAT	TRAORN	TRISKI	VELROS	VITHUM	VULMYU	WAHTUM	WAIACU	WAICIT
WESCEP	XERDIV	ZYGAPI	ZYGERE	ZYGOVA					
mrg01	mrg02	mrg03	mrg04	mrg05	mrg06	nmr01	nmr02	nmr03	ns1/01
ns1/02	ns1/03	ns1/04	ns1/05	ns1/06	ns2/01	ns2/02	ns2/03	ns2/04	ns2/05
ns2/06	ns2/07	ns2/08	sepk01	smr01	smr02	smr03	smr04	vta01	vta02
vta03	vta04	vta05	vta06	vta07	vta08	vta10	vtb01	vtb02	vtb03
vtb04	vtb05	vtb06	vtc01	vtc02	vtc03	vtc04	vtc05	vtd01	vtd02
vtd03	vtd04	vte01	vte02						

APPENDIX 3

Geographical location for the sites from the Mt Manning Range.

Plot	Latitude	Longitude
mrg01	30.0003	119.6251
mrg02	29.9969	119.6239
mrg03	29.9973	119.6245
mrg04	29.9933	119.6189
mrg05	29.9904	119.6173
mrg06	29.9869	119.6175
nmr01	29.8317	119.6075
nmr02	29.8731	119.6181
nmr03	29.7197	119.6128
ns1/01	29.9335	119.6001
ns1/02	29.9450	119.6167
ns1/03	29.9417	119.6167
ns1/04	29.9367	119.6164
ns1/05	29.9322	119.6167
ns1/06	29.9292	119.6164
ns2/01	29.9361	119.6447
ns2/02	29.9414	119.6447
ns2/03	29.9453	119.6453
ns2/04	29.9522	119.6453
ns2/05	29.9558	119.6453
ns2/06	29.9697	119.6458
ns2/07	29.9851	119.6443
ns2/08	29.9914	119.6458
sepk01	29.9985	119.6406
smr01	30.0186	119.6447
smr02	30.0186	119.6403
smr03	30.0167	119.6361
smr04	29.9961	119.6081
vta01	29.9643	119.6079
vta02	29.9636	119.6100
vta03	29.9644	119.6121
vta04	29.9638	119.6183
vta05	29.9639	119.6211
vta06	29.9631	119.6217
vta07	29.9639	119.6249
vta08	29.9636	119.6261
vta10	29.9636	119.6326
vtb01	29.9582	119.6333
vtb02	29.955	119.6195
vtb03	29.9552	119.6237
vtb04	29.954	119.6361
vtb05	29.9542	119.6328
vtb06	29.9553	119.6286
vtc01	29.9452	119.6313
vtc02	29.9466	119.6236
vtc03	29.9458	119.6217

vtc04	29.9464	119.6117
vtc05	29.9464	119.6117
vtd01	29.9361	119.6331
vtd02	29.9358	119.6339
vtd03	29.9361	119.6361
vtd04	29.9361	119.6428
vte01	29.9906	119.6522
vte02	29.9911	119.6595