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Flora and vegetation of the eastern goldfields ranges, Part I: Helena and Aurora Range

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SUMMARY

A study was undertaken of the flora and plant communities of the Helena and Aurora Range within the Coolgardie Bioregion of Western Australia. The range is formed from banded ironstone and basalts and is surrounded by an outwash plain derived from these units. Fifty-five quadrats were established and data from these were used to define six community types that were highly correlated with topographic position and slope. A total flora of 324 taxa was recorded from the range, of which 303 were native and 21 were introduced.

One species of Declared Rare Flora and 10 taxa listed on CALM's priority flora list were found on the range. Four taxa appear to be endemic to the Helena and Aurora Range, one of which had not previously been collected. None of these taxa are currently reserved. A further five taxa are restricted to banded ironstone ranges or associated soils within 100 km of the Helena and Aurora Range and two of these are not reserved.

The floristic classification is in broad agreement with previous descriptions of the range but documents finer scale patterning than has previously been reported. A key to the major community types is provided. Data are not yet available to determine the conservation status of the community types identified. Only a small proportion of the Bungalbin vegetation system is presently managed for conservation.

INTRODUCTION

While the ranges of the eastern goldfields of Western Australia have had a long history of geological exploration owing to their highly prospective nature, comparatively little detailed information is available on the flora and fauna of these ranges. A regional survey has been undertaken of the flora and fauna of the region and results have been published in 12 cell reports (see Dell *et al.* 1985); these reports do not, however, provide detailed information on individual ranges. Botanical survey work has been undertaken in recent years to gather detailed floristic information from a number of the ranges in the goldfields. The work reported here describes the flora and vegetation of the Helena and Aurora Range.

The Helena and Aurora Range is located 180 km west-north-west of Kalgoorlie and 50 km north-north-east of Koolyanobbing (Fig. 1). It lies within the Coolgardie Bioregion which is dominated by eucalypt woodland (Beard 1990; Thackway and Creswell 1995). The climate is semi-arid mediterranean with an annual rainfall of 200-300 mm (Beard 1990). The lower slopes and valleys around the range are dissected by numerous exploration gridlines.

The range itself is composed of Archaean banded ironstones in two stratigraphic units separated by a basalt layer. The range is surrounded by an outwash plain derived from these units (Chin and Smith 1983), and is one of the most spectacular in the eastern goldfields, reaching 702 m.

Beard (1972) first described the major structural vegetation formations in the study area. He grouped his structural units into vegetation systems and defined the vegetation of the banded ironstones of the Helena and Aurora Range as forming part of the Bungalbin System. Beard included in this system the ironstone areas of the Hunt Range, the Watt and Yendilberin Hills to the east, the Mt Jackson Range to the west, a small unnamed range of hills to the north and the Koolyannobbing Range to the south. He described the vegetation of these ranges as thickets dominated by *Acacia quadrimarginea, Acacia tetragonophylla*, *Dryandra arborea* (on rocky outcrops) and *Allocasuarina acutivalvis* with understoreys of such shrubs as *Dodonaea* spp., *Eriostemon brucei, Eremophila* spp., *Enchylaena tomentosa*, and *Grevillea paradoxa*. The lower slopes of the Helena and Aurora Range and valley systems would fall into the *Eucalyptus salmonophloia - E. salubris* association of his very broad Jackson system. Keighery (1980) confirmed the occurrence of *Dryandra arborea* shrublands in the Die Hardy Ranges, Mt Jackson, Koolyanobbing Range, Mt Dimer, the Hunt Range and the Helena and Aurora Range.

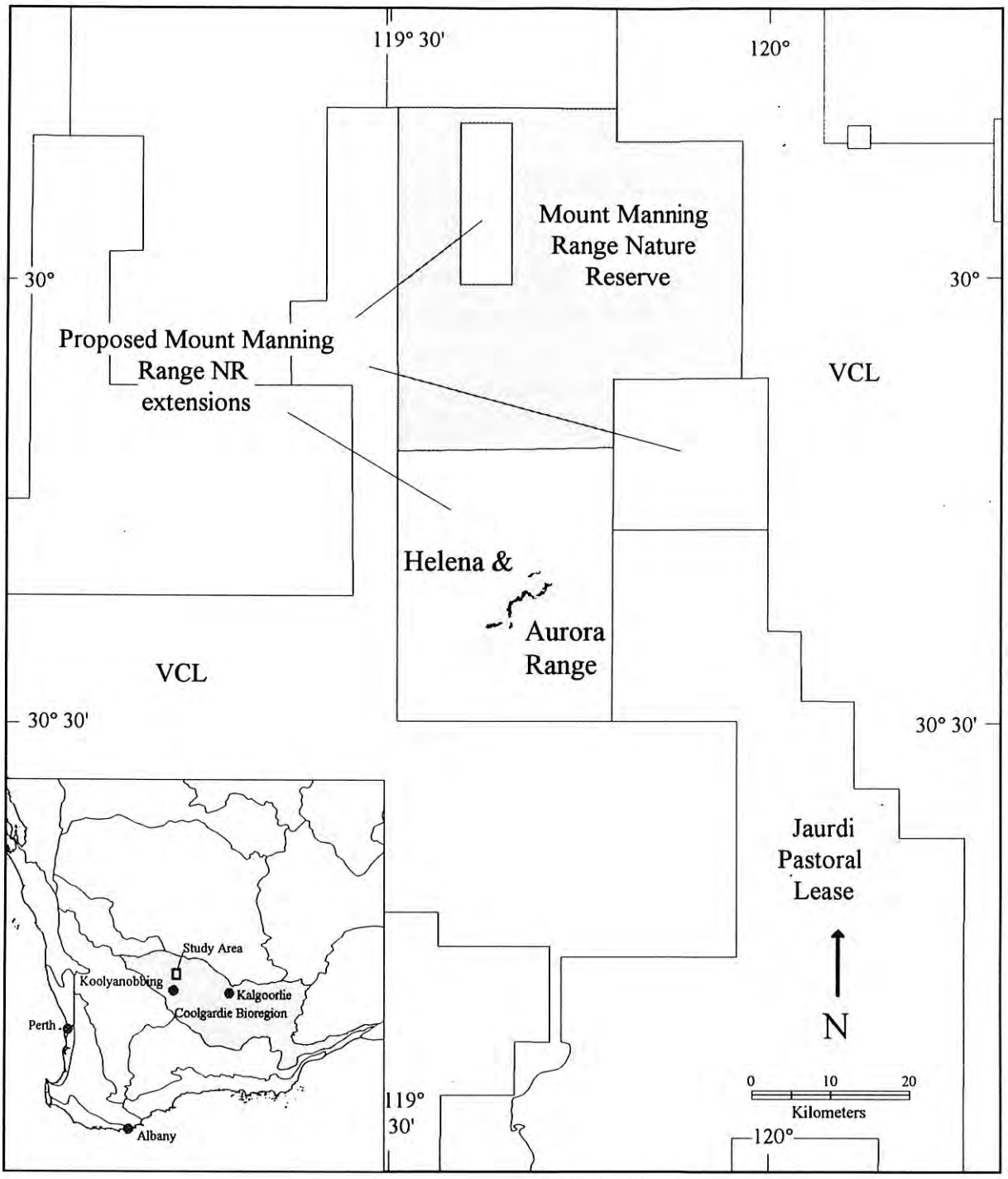


Figure 1. Location of study area and position within the Coolgardie Bioregion.

In a broad regional survey Newbey and Hnatiuk (1985) describe the vegetation of the Helena and Aurora Range under the heading, 'Hills (banded ironstone formation)'. They briefly describe the major structural units seen on the Helena and Aurora Range and note the *Dryandra arborea* shrublands on the steep upper slopes with *Eucalyptus ebbanoensis* mallee on the upper and lower slopes and *Acacia aneura* low woodland on the pediment. They also note small areas of *Eucalyptus wandoo (=E. capillosa* ssp. *capillosa)* near the crest of the range.

Both Beard's survey and the later biological survey of the eastern goldfields were undertaken to provide regional overviews. Consequently the individual ranges were not sampled intensively. Indeed, only two sites from the Helena and Aurora Range are described in detail (Newbey and Hnatiuk 1985). The only other report on the vegetation of the study area is that of Henry-Hall (1990), which details reserve recommendations for the southern goldfields. In the section on the proposed Bungalbin Hill extension to the Mt Manning Nature Reserve, Henry-Hall describes the diverse nature of the vegetation of the range and provides detailed descriptions of some of the structural units.

The aim of the present work was to undertake a detailed floristic survey of the range to compile a detailed flora list for the range and the surrounding outwash areas, and to describe the vegetation patterning of this area.

METHODS

Fifty-five 20 m x 20 m quadrats were established on the range, its lower slopes and the outwash plain (Fig. 2). These sites were selected with the aim to cover the major geographical, geomorphological and floristic variation found in the area. Care was taken to locate sites in the least disturbed vegetation available in the area being sampled. Some difficulty was experienced in reaching the uplands of the western half of the Aurora Range owing to lack of vehicle access, but several traverses carried out on foot indicated that an adequate sampling of the major vegetation types of the tops and upper slopes was achieved. No attempt was made to sample the Tertiary sand plain that surrounds the Helena and Aurora Range (Chin and Smith 1983).

Within each site all vascular plants were recorded. Twenty-seven primarily upland sites were established in the last week of July 1995. These sites were revisited and a further 28 sites were established in the last week of September 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 three-point scale from ridge tops and upper slopes (1), to midslopes (2), and to lower slopes and broad flats (3). Slope was scored on a

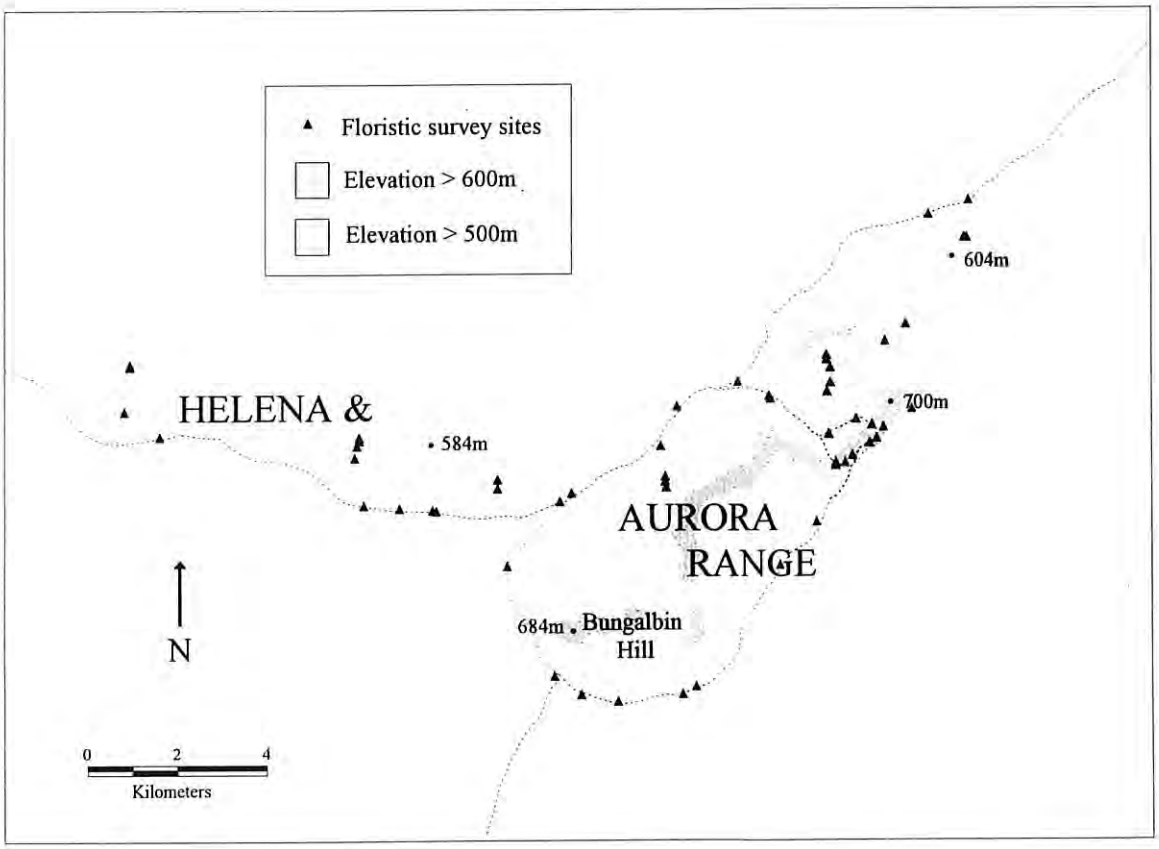


Figure 2. Study area showing location of floristic survey sites.

one to three scale from flat (<5°) to steep (>20°). 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 global positioning system (GPS) unit.

Sites were classified according to similarities in species composition based on presence/absence data. In these analyses only perennial species were used to facilitate comparisons with classifications from other ranges in the area (Gibson and Lyons 1995).

The site and species classifications undertaken used the Czekanowski coefficient and 'unweighted pair-group mean average' fusion method (UPGMA, Sneath and Sokal 1973) using the PATN software package (Belbin 1993). Statistical relationships between site groups for such factors as species richness, slope, aspect, were tested using Kruskal-Wallis non parametric analysis of variance and Mann Whitney U-tests (Siegel 1956). In a preliminary analysis ordination of the sites showed essentially the same pattern as the classification and will not be discussed further.

Nomenclature follows Green (1985) and current usage at the Western Australian Herbarium (PERTH). Selected voucher specimens will be lodged in PERTH.

RESULTS

Flora

A total of 324 taxa (species, subspecies and varieties) were recorded from the Helena and Aurora Range. The flora list was compiled from taxa found within the 55 plots or the adjacent area, from opportunistic collections and from confirmed records held in PERTH (Appendix 1). Of these 324 taxa, 303 are native and 21 are introduced. The largest families represented were the Asteraceae (50 native taxa and 6 introduced), Myrtaceae (30 taxa), Poaceae (12 native taxa and 8 introduced), Mimosaceae (17 taxa), Chenopodiaceae (14 taxa), Myoporaceae (14 taxa), Goodeniaceae (11 taxa), Fabaceae (10 taxa), and Proteaceae (10 taxa). This pattern is typical of the flora of the South Western Interzone (Newbey and Hnatiuk 1985). Good rains were experienced in the winter and early spring of 1995, reflected by the large numbers of annuals and geophytes recorded (Table 1; Appendix 1).

The most common genera were *Eucalyptus* (19 taxa), *Acacia* (17 taxa), and *Eremophila* (14 taxa). Introduced species were generally not a major component of the vegetation.

During the survey one species of Declared Rare Flora (DRF) was recorded along with 10 other taxa on CALM's priority flora list (CALM 1996). Two new populations of the DRF *Tetratheca aphylla* were located, as were new populations of some of the 10 priority taxa (Table 2). Previously one species of DRF and five priority taxa were known from the range (CALM 1994).

Acacia adinophylla ms appears to be endemic to the Helena and Aurora Range. The understorey of the side slopes of the range is dominated by another range endemic, the undescribed grass *Neurachne* sp. Helena & Aurora (K.R. Newbey 8972). This taxon is extremely widespread but as yet has not been collected from any other range in the area. *Tetratheca aphylla* also appears to be endemic to the massive ironstones of the range. (One collection in PERTH indicating a population 10 km to the north of Bungalbin Hill is likely to be in error and should read 10 km NE of Bungalbin Hill.) *Stenanthemum newbeyi* was previously believed to be restricted to Helena and Aurora Range and nearby hills (Rye 1995), however, recent field work has recorded this species on banded ironstones at Ennuin Station some 80 km to the south-west (Gibson and Lyons *unpublished data*).

TABLE 1

Lifeform spectrum of the flora of the Helena and Aurora Range.

LIFEFORM	PERCENTAGE
Annual grasses	5.2
Annual herbs	33.3
Annual sedges	0.6
Geophytes	5.9
SUBTOTAL	45.1
Perennial grasses	0.9
Perennial herbs	4.0
Perennial sedges	0.6
Shrubs	41.0
Mallee	3.7
Trees	4.6
SUBTOTAL	54.8

TABLE 2

Declared Rare Flora and Priority Flora found during the survey indicating the number of new populations located (CALM 1996).

TAXON	CURRENT PRIORITY LISTING	NUMBER OF NEW POPULATIONS
Acacia adinophylla ms	1	2
Acacia cylindrica	3	1
Daviesia purpurascens	4	3
Gnephosis intonsa	1	1
Grevillea erectiloba	4	3
Grevillea georgeana	3	1
Leucopogon breviflorus	2	6
Phlegmatospermum eremaeum	2	1
Prostanthera magnifica	4	1
Stenanthemum newbeyi	1	5
Tetratheca aphylla	R	2

Several other species (*A. cylindrica, Grevillea erectiloba* and *G. georgeana*) appear to be restricted to the banded ironstone ranges (or associated soils) within 100 km of Bungalbin Hill.

An undescribed species of *Leucopogon* was collected from a cliff line approximately 3 km east of Bungalbin Hill. This taxon (*Leucopogon* sp. Helena & Aurora BJL 2077) was locally abundant, growing in association with *Tetratheca aphylla,* but was not encountered elsewhere on the range. Another undescribed taxon, *Mirbelia* sp. Helena & Aurora (BJL 2003), was also collected on the range. This species has previously been collected from two locations, one north of the Hunt Range and the second in the Watt Hills. Both locations lie some 60 km from Bungalbin Hill. It is recommended that both these taxa be listed on CALM's priority flora list as Priority 1 and Priority 2 respectively (Table 3).

Daviesia purpurascens has recently been delisted from DRF to Priority 4. Data from this survey support this reassessment. This species was found to be very widespread on the range, occupying both the massive ironstone tops as well as the side and midslopes.

Echinopogon ovatus was collected at the base of the same cliff line at which *Leucopogon* sp. Helena & Aurora (BJL 2077) was found. This grass is known from only six collections in Western Australia, one from near Onslow and the rest in the Margaret River-Nannup area. It is recommended that this species also be listed on CALM's priority flora list as Priority 2 (Table 3). The range is also the eastern limit of *Conostylis argentea* and represents the furthest inland record of any *Conostylis* (Hopper *et al.* 1987).

TABLE 3

Taxa from the study area requiring priority listing and the number of known populations.

TAXON	RECOMMENDED PRIORITY LISTING	NUMBER OF KNOWN POPULATIONS
Leucopogon sp. Helena & Aurora (BJL 2077)	1	1
Mirbelia sp. Helena & Aurora (BJL 2003)	2	3
Echinopogon ovatus	2	5

Vegetation

For the floristic analysis two species had to be amalgamated into a species complex owing to the difficulty of differentiating between them (*Vulpia myuros* and *V. muralis*). Only material that could be identified down to at least species level was included in the analysis (*c.*99 per cent of records). In the 55 quadrats established on the Helena and Aurora Range, 233 taxa were recorded, 117 of which were perennials. Twenty-seven perennials occurred at only one site. These singletons have little effect on the community classification and were excluded from the analysis. As a result the final data set consisted of 90 taxa in 55 sites. Species richness ranged from three to 20 taxa per site, with individual taxa occurring in two to 36 of the 55 sites.

Multivariate analysis can assist in sorting both site 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 six group level and species groups at the nine group level, which best reflected the scale of patterning seen in the field.

The dendrogram shows the six community types recognized in the analysis (Fig. 3). The primary division seen in the dendrogram separates skeletal and weathered soils of the uplands and slopes (community types 1 to 4) from the deeper calcareous fertile soils of the valley bottoms (community types 5 and 6). This can also be clearly seen in the sorted two-way table generated from the site and species classifications (Table 4). These data are consistent with the patterning reported by Newbey and Hnatiuk (1985).

Community types 1 and 2 are largely confined to the ridge tops and upper slopes of the Helena and Aurora Range. Both community types develop on skeletal yellow or red soils. Taxa in species group H are typical species of community type 1; these include *Acacia quadrimarginea, Grevillea zygoloba, Allocasuarina acutivalvis, Melaleuca nematophylla, Dryandra arborea* and *Calycopeplus paucifolius* (Table 4). This community is generally dominated or codominated by the species listed above. Average species richness was 14.7 taxa per plot.

Community type 2 was entirely restricted to the massive ironstone tops, the upper slopes and breakaways of the range. This community was generally dominated by either *Eucalyptus ebbanoensis* or, below the small breakaways, by *Eucalyptus capillosa* ssp. *capillosa.* Taxa from species group B, H and I are most consistently present, but with a lower representation of taxa from species group H compared with community type 1. Average species richness was 13.6 taxa per plot.

The open side slopes of the Helena and Aurora Range are primarily occupied by community type 3. This community is generally dominated or codominated by *Eucalyptus ebbanoensis* and/or *E. corrugata*, with an understorey dominated by the *Neurachne* sp. Helena & Aurora (KRN 8972). Occasionally this community may be dominated by *Acacia* spp. rather than the eucalypt species. Species richness was lower with an average of 10.5 taxa per plot. Typical species of this community are taxa in species groups A and B. Taxa in species groups D, F, G, H and I are completely or almost completely lacking from this community type (Table 4).

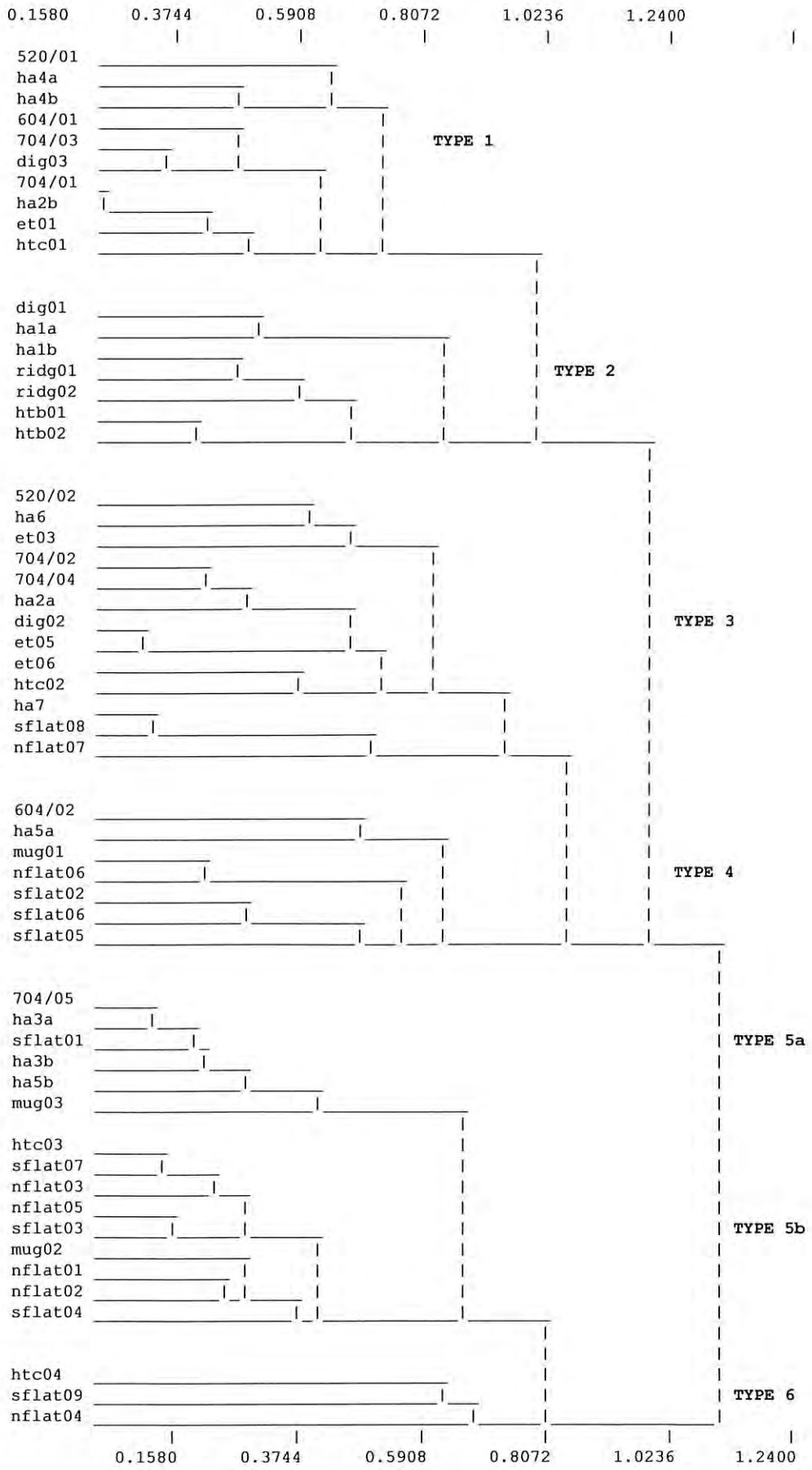


Figure 3. Dendrogram of the sites from the Helena and Aurora Range area showing the six group level classification.

TABLE 4

Sorted two way table of the Helena and Aurora Range sites showing species occurrence (rows) by community type (site codes appears as columns).

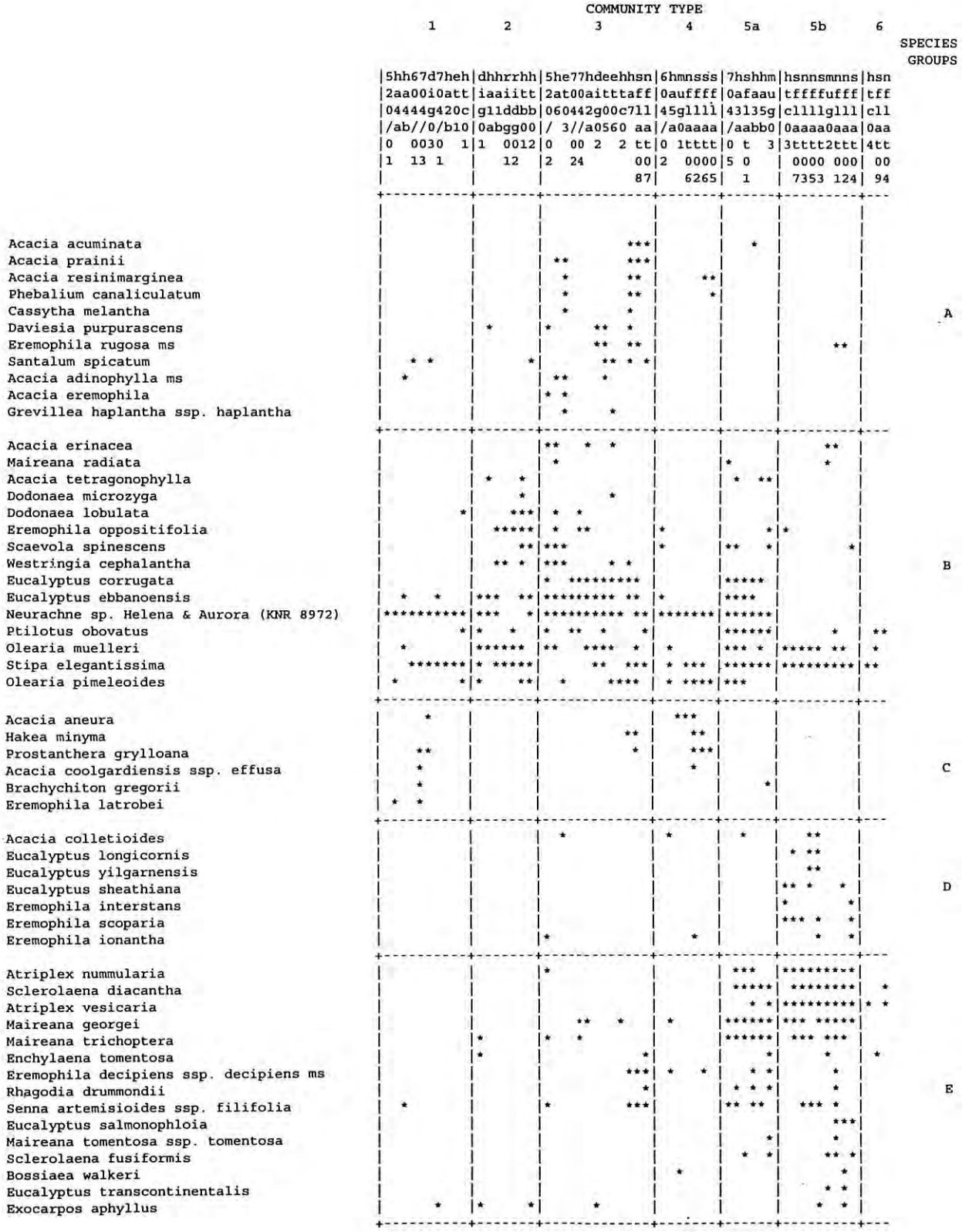
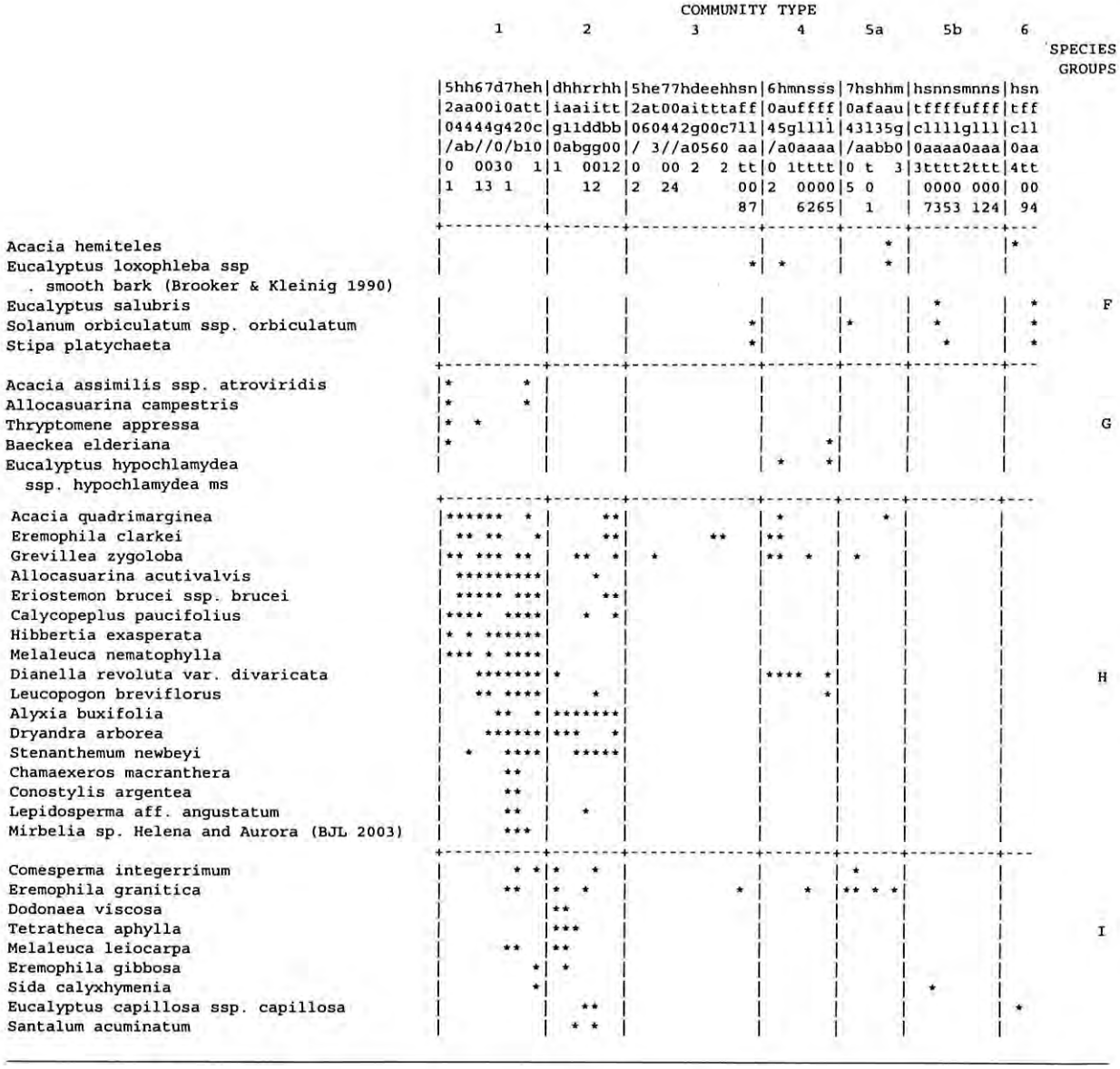


Table 4 (continued)



Community type 4 was restricted to the lower slopes and flats below the range. It was a species-poor community (in terms of perennials) with an average species richness of 7.9 taxa per plot. This community was variously dominated by *Acacia aneura, A. resinimarginea* or *A. acuminata*, or occasionally by *Eucalyptus ebbanoensis* and/or *E. hypochlamydea* ssp. *hypochlamydea* ms. Where eucalypts dominated, the understorey included taxa such as *Grevillea zygoloba* and *Eremophila clarkei,* species more typical of upland areas. The only understorey species that were largely constant to this group were *Neurachne* sp. Helena & Aurora (KRN 8972), *Austrostipa elegantissima, Olearia pimeleoides* and *Dianella revoluta* (Table 4). It differed from community type 5, which also occurs on the flats below the range, by the almost complete lack of chenopod species.

Community type 5 consisted of the eucalypt woodlands on the flats below the range with a diverse chenopod understorey. No single eucalypt species consistently dominated this community type, with species such as *Eucalyptus salmonophloia, E. salubris, E. longicornis, E. sheathiana, E. transcontinentalis, E. ebbanoensis* and *E. corrugata* dominating at different sites. Taxa in species group E (mainly chenopods) largely defines this group (Table 4). This group was quite species-rich with an average of 13.1 taxa per plot. This group can be further subdivided into two subgroups. Type 5a are those woodlands close to the change in slope where *E. ebbanoensis* and *E. corrugata* form an overstorey over chenopods and *Neurachne* sp. Helena & Aurora (KRN 8972). Type 5b is more typical of the extensive flats between the ranges where these slope species decline.

Indeed type 5a can be considered transitional between community type 3 and type 5b.

The final community type consists of three heterogenous species-poor quadrats (average species richness 4.7 taxa per plot). One quadrat appears to be related to the *Eucalyptus capillosa* ssp. *capillosa* stands classified into community type 2 and the other two quadrats appear to be species-poor examples of community type 5. The numerical techniques used in this analysis are known to be sensitive to species richness (Sneath and Sokal 1973).

PHYSICAL CORRELATES

It is clear from the above community descriptions that one of the primary correlates with community type is topographic position and slope class. Significant differences were found between community means for these parameters (Table 5). Community type 2 was entirely restricted to massive ironstone tops and upper slopes, while community type 1 extended down to the midslopes where suitable outcropping of banded ironstone occurred. Both community types were restricted to the steeper slope classes (Table 5). Community type 3 occurred at an intermediate position in the landscape and consequently occurred across a broader range of slope classes. Community types 4 and 5 occurred low in the landscape, generally on gentle slopes.

There were also significant differences between the community types in percentage exposed rock and percentage litter cover (Table 5). Percentage exposed rock showed a similar pattern to slope, with highest degree of rock exposure in those community types on the steepest slopes while percentage litter cover showed the inverse pattern.

Significant differences in species richness were found between different community types (Table 5). The species-poor community type 6 had significantly fewer species than all other community types except for type 4. The shrublands on the massive tops (community type 1) were significantly richer than community types 3 (side slopes) and 4 (lower slopes) but had a similar richness to eucalypt-chenopod woodlands (type 5) of the valley flats. The other upland community type (type 2) had a lower richness than community type 1 and was again significantly richer than community type 4.

It is interesting to find the highest species richness of perennial taxa at both ends of a presumed productivity gradient. Community types 1 and 2 occur on skeletal soils on massive banded ironstones while community type 5 occurs on deep clay rich soils of the outwash plain.

DISCUSSION

Little detailed survey work has been carried out on the individual ranges of the eastern goldfields, but some recent work has been completed on the Bremer Range (*c.* 240 km to the south-east) and the Parker Range (some 130 km to the south) (Table 6) (Gibson and Lyons 1995).

The higher number of taxa recorded at the Helena and Aurora Range compared with the other two ranges most likely reflects a seasonal effect (Table 1). Good rains prior to the 1995 season led to a profusion of annual taxa compared with that of the 1994 season (when the other ranges were sampled), which was very poor for annual species and geophytes.

Similar numbers of priority taxa have been recorded from the ranges indicating the poor state of knowledge of a significant number of taxa from these range systems. This is further borne out by the first collection of one or two taxa on each range for a limited survey effort, generally less than 10 days per range.

The data also show significant biogeographical differences in the most species rich genera between the Helena and Aurora Range and the ranges to the south. *Eucalyptus* and *Melaleuca* numbers decline toward the

TABLE 5

Mean values by community type for topographic position (1 = upland and upper slopes, 2 = midslopes, 3 = lower slopes and valley bottom), slope class (1 = flat to 3 = steep), degree of rock outcrop in plot (1 = < 25 percent outcrop, 2 = 25-50 per cent outcrop 3 = > 50 per cent outcrop), degree of litter cover in plot (using same classes as rock exposure) and species richness. Means which are not significantly different ($P > 0.05$ Mann Whitney U-test) are indicated by superscript of same letter.

	TOPOGRAPHIC POSITION	SLOPE CLASS	DEGREE OF ROCK OUTCROP	DEGREE OF LITTER COVER	SPECIES RICHNESS
Type 1	1.10^{a}	2.70^{a}	2.80^{ab}	1.40^{ab}	14.70^{a}
Type 2	1.00^{a}	2.57^{ab}	3.00^{a}	1.00^{a}	13.57^{ab}
Type 3	1.85^{b}	2.08^{bc}	2.31^{ac}	1.31^{ab}	10.54^{bc}
Type 4	2.71^{c}	1.74^{c}	1.71^{cd}	1.43^{ac}	7.86^{cd}
Type 5	2.53^{c}	1.73^{c}	1.53^{d}	2.00^{c}	13.13^{ab}
Type 6	2.33^{bc}	1.67^{ac}	1.67^{bcd}	2.33^{bc}	4.67^{d}

TABLE 6
Comparison of the floras of the Helena and Aurora Range, the Bremer Range and the Parker Range.

	HELENA & AURORA RANGE	BREMER RANGE	PARKER RANGE
Flora	324	268	256
Declared Rare Flora	1	1	-
Priority taxa	10	6	8
Taxa - first collections	1	2	2
Eucalyptus spp.	19	30	29
Acacia spp.	17	17	20
Eremophila spp.	14	11	7
Melaleuca spp.	5	19	14

north, while *Acacia* numbers stay roughly constant and numbers of *Eremophila* spp. increase northward.

The current survey has identified three taxa that should be listed on the CALM priority list. Two taxa (*Leucopogon* sp. Helena & Aurora (BJL 2077) and *Mirbelia* sp. Helena & Aurora (BJL 2003)) have very limited distributions while the third (*Echinopogon ovatus*) has an outlying population in the Helena and Aurora Range (main distribution in Margaret River-Nannup area, but also with a record from Onslow). The taxonomy of *Echinopogon ovatus* clearly needs expert review.

Our data and records from the WA Herbarium show that four species appear to be endemic to the Helena and Aurora and a further five taxa are regional endemics (found within 100 km) of the banded ironstone ranges and associated soils of this area (Table 7). The majority of these taxa are unreserved.

The vegetation patterning encountered on the range was highly correlated with topographic position and substrate (as in Gibson and Lyons 1995). Two community types were restricted to upper slopes, there was a broad midslope community type and two community types were found on the lower slopes and flats. This classification, although based only on presence/absence data, accords well with the structural descriptions of Beard (1972), Newbey and Hnatiuk (1985) and Henry-Hall (1990), but provides more detail, allows recognition of more community types, and shows the relationships between these community groups.

Given the strong correlations with substrate and topographic position it was possible to generate a key to the major floristic units found on the range (Table 8), it should also be possible to map the floristic units from good quality aerial photography.

Some of the floristic units showed some degree of internal heterogeneity and with further sampling it may be possible to describe further subtypes. For example, community type 2 contains two sites dominated by *Eucalyptus capillosa* ssp. *capillosa* which are structurally distinct from the other quadrats in this group. One quadrat in community type 6 also appears to be a depauperate example of this subunit.

Similarly, community type 4 has potential for subdivision into an *Acacia aneura* subgroup, an *Acacia resinimarginea* subgroup and a eucalypt subgroup. More data would need to be collected from these communities to determine subgroup structure.

Community type 6 does not appear to be a natural group. One quadrat appears to be related to community type 2 while the other two quadrats appear to be related to community type 5. In a classification of the full data set (perennials, geophytes and annuals) the *E. capillosa* ssp. *capillosa* quadrat falls with the other quadrats dominated by this species (community type 2), but the remaining two quadrats form the centre of a small group of species-poor sites restricted to the flats. Further sampling of this community type is needed to clarify its relationships with other communities of the flats.

TABLE 7
Local and regional endemic taxa.

TAXON	ENDEMIC STATUS	RESERVATION STATUS
Acacia adinophylla	Endemic to Helena & Aurora Range	Not reserved
Leucopogon sp. Helena & Aurora (BJL 2077)	Endemic to Helena & Aurora Range	Not reserved
Neurachne sp. Helena & Aurora (KRN 8972)	Endemic to Helena & Aurora Range	Not reserved
Tetratheca aphylla	Endemic to Helena & Aurora Range	Not reserved
Acacia cylindrica	Regional endemic	Known from 1 reserve
Grevillea erectiloba	Regional endemic	Known from 2 reserves
Grevillea georgeana	Regional endemic	Known from 1 reserve
Mirbelia sp. Helena & Aurora (BJL 2003)	Regional endemic	Not reserved
Stenanthemum newbeyi	Regional endemic	Not reserved

TABLE 8

Key to the major floristic community types found on the Helena and Aurora Range.

1. Upland or midslope sites on massive banded ironstone.
   2. Shrublands or woodlands not dominated by eucalypt species. ..... *Community type 1*
   2. Woodlands dominated by *Eucalyptus ebbanoensis* and/or *E. corrugata* or *E. capillosa* ssp. *capillosa* with *Alyxia buxifolia* and/or *Stenanthemum newbeyi* in understorey. ..... *Community type 2*
1. Midslope or valley bottoms not on massive banded ironstones.
   3. Midslope community dominated by *Eucalyptus ebbanoensis* and/or *E. corrugata* over *Neurachne* sp. Helena & Aurora (KRN 8972), chenopods absent. ..... *Community type 3*
   3. Lower slope or valley.
      4. Community type generally dominated by *Acacia* spp. or if dominated by eucalypts then with *Eremophila clarkei* and *Grevillea zygoloba* present. ..... *Community type 4*
      4. Community dominated by eucalypts over chenopod shrublands ..... *Community type 5*

The endemics and near endemics of the Helena and Aurora Range are completely unreserved. Beard (1972) places the vegetation of the range into his Bungalbin system, a small part of which occurs on Jaurdi Station to the east. CALM holds the lease to this station and has recommended the northern area become a Nature Reserve and the southern area become State forest (CALM 1994; Fig. 1). As yet it is not possible to determine whether the community types found on the Helena and Aurora Range also occur on the banded ironstone areas on Jaurdi Station. The bulk of Beard's Bungalbin vegetation system occurs from the Helena and Aurora Range west to the Mt Jackson area. None of this area is in the current reserve system.

It is regrettable that past exploration activity in the area was not rehabilitated. Tracks and gridlines left in this environment take many years to recover owing to the slow growth rates found in these areas. Some of the tracks left on steeper slopes show significant erosion.

The results of this study support the recommendations of Keighery (1980), Henry-Hall (1990) and CALM (1994) that the Helena and Aurora Range should be declared a Nature Reserve for the protection of flora and the conservation of the banded ironstone vegetation communities.

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APPENDIX 1

Flora List for the Helena and Aurora Range.

This list includes all taxa from both the sampling quadrats and the opportunistic collections and confirmed records from PERTH. Nomenclature follows Green (1985) and current usage at PERTH (ms denotes a manuscript name,
* indicates an introduced taxa).

Family: Adiantaceae
- *Cheilanthes austrotenuifolia*
- *Cheilanthes brownii*
- *Cheilanthes lasiophylla*
- *Cheilanthes sieberi* ssp. *sieberi*

Family: Aizoaceae
- *Gunniopsis quadrifida*
- * *Mesembryanthemum nodiflorum*
- *Tetragonia* sp.

Family: Amaranthaceae
- *Ptilotus aervoides*
- *Ptilotus carlsonii*
- *Ptilotus drummondii* var. *drummondii*
- *Ptilotus exaltatus*
- *Ptilotus gaudichaudii*
- *Ptilotus holosericeus*
- *Ptilotus obovatus*

Family: Anthericaceae
- *Arthropodium curvipes*
- *Thysanotus patersonii*

Family: Apiaceae
- *Daucus glochidiatus*
- *Hydrocotyle rugulosa*
- *Trachymene ornata*
- *Trachymene pilosa*
- *Uldinia ceratocarpa*

Family: Apocynaceae
- *Alyxia buxifolia*

Family: Asclepiadaceae
- *Rhyncharrhena linearis*

Family: Asphodelaceae
- *Bulbine semibarbata*

Family: Aspleniaceae
- *Pleurosorus rutifolius*

Family: Asteraceae
- *Actinobole uliginosum*
- *Angianthus tomentosus*
- *Bellida graminea*
- *Blennospora drummondii*
- *Brachyscome ciliaris*
- *Brachyscome iberidifolia*
- *Brachyscome perpusilla*
- *Calotis hispidula*
- * *Centaurea melitensis*
- *Cephalipterum drummondii*
- *Ceratogyne obionoides*
- *Chrysocephalum semicalvum*
- *Chthonocephalus pseudevax*
- *Euchiton sphaericus*
- *Gilberta tenuifolia*
- *Gilruthia osbornei*
- *Gnephosis intonsa*
- *Hyalosperma demissum*
- *Hyalosperma glutinosum* ssp. *glutinosum*
- * *Hypochaeris glabra*
- *Isoetopsis graminifolia*
- *Lawrencella davenportii*
- *Lawrencella rosea*
- *Lemooria burkittii*
- *Leucochrysum fitzgibbonii*
- *Millotia myosotidifolia*
- *Minuria cunninghamii*
- *Olearia decurrens*
- *Olearia exiguifolia*
- *Olearia humilis*
- *Olearia muelleri*
- *Olearia pimeleoides*
- * *Osteospermum clandestinum*
- *Podolepis canescens*
- *Podolepis capillaris*
- *Podolepis lessonii*
- *Podotheca gnaphalioides*
- *Pogonolepis stricta*
- * *Pseudognaphalium luteoalbum*
- *Rhodanthe laevis*
- *Rhodanthe manglesii*
- *Rhodanthe oppositifolia*
- *Rhodanthe pygmaea*
- *Rhodanthe rubella*
- *Rhodanthe stricta*
- *Schoenia cassiniana*
- *Senecio glossanthus*
- *Senecio picridioides*
- *Senecio quadridentatus*
- * *Sonchus oleraceus*
- * *Sonchus tenerrimus*
- *Streptoglossa liatroides*
- *Trichanthodium skirrophorum*
- *Triptilodiscus pygmaeus*
- *Waitzia acuminata*
- *Waitzia citrina*

Family: Boraginaceae
- *Halgania* sp. 1 (BJL 2049)
- *Halgania* sp. 2 (BJL 2082)

Family: Brassicaceae
- *Arabidella* sp. Goldfields (P.G. Wilson 7183)
- *Lepidium oxytrichum*
- *Lepidium phlebopetalum*
- *Phlegmatospermum eremaeum*
- * *Sisymbrium irio*
- *Stenopetalum filifolium*
- *Stenopetalum robustum*

Family: Caesalpiniaceae
- *Senna artemisioides* ssp. *filifolia*
- *Senna cardiosperma* ssp. *cardiosperma*
- *Senna pleurocarpa* var. *pleurocarpa*

Family: Campanulaceae
- *Wahlenbergia tumidifructa*

Family: Caryophyllaceae
- * *Cerastium glomeratum*
- *Stellaria filiformis*

Appendix 1 (continued)

Family: Casuarinaceae
Allocasuarina acutivalvis
Allocasuarina campestris

Family: Chenopodiaceae
Atriplex nummularia
Atriplex vesicaria
Enchylaena tomentosa
Halosarcia halocnemoides
Maireana georgei
Maireana radiata
Maireana tomentosa ssp. *tomentosa*
Maireana trichoptera
Rhagodia drummondii
Rhagodia preissii ssp. *preissii*
Sclerolaena diacantha
Sclerolaena drummondii
Sclerolaena fusiformis
Sclerolaena obliquicuspis

Family: Chloanthaceae
Newcastelia viscida

Family: Colchicaceae
Wurmbea tenella

Family: Convolvulaceae
Convolvulus erubescens

Family: Crassulaceae
Crassula colorata

Family: Cupressaceae
Callitris glaucophylla

Family: Cyperaceae
Isolepis congrua
Lepidosperma aff. *tenue* (KRN 9197)
Lepidosperma aff. *angustatum*
Schoenus nanus

Family: Dasypogonaceae
Chamaexeros macranthera
Lomandra effusa

Family: Dilleniaceae
Hibbertia exasperata

Family: Droseraceae
Drosera macrantha ssp. *macrantha*

Family: Epacridaceae
Leucopogon breviflorus
Leucopogon sp. Helena & Aurora (BJL 2077)

Family: Euphorbiaceae
Calycopeplus paucifolius
Monotaxis occidentalis
Poranthera microphylla

Family: Fabaceae
Bossiaea walkeri
Daviesia benthamii ssp. *acanthoclona*
Daviesia purpurascens
Mirbelia depressa
Mirbelia microphylla
Mirbelia sp. Helena and Aurora (BJL 2003)
Swainsona canescens
Swainsona kingii
Swainsona oliveri
Templetonia sulcata

Family: Geraniaceae
* *Erodium cicutarium*
Erodium crinitum
Erodium cygnorum ssp. *cygnorum*

Family: Goodeniaceae
Brunonia australis
Dampiera lavandulacea
Dampiera spicigera
Goodenia berardiana
Goodenia havilandii
Goodenia mimuloides
Goodenia occidentalis
Goodenia peacockiana
Goodenia pinnatifida
Scaevola spinescens
Velleia rosea

Family: Haemodoraceae
Conostylis argentea

Family: Haloragaceae
Gonocarpus nodulosus
Haloragis gossei
Haloragis trigonocarpa

Family: Juncaginaceae
Triglochin sp.

Family: Lamiaceae
Prostanthera campbellii
Prostanthera grylloana
Prostanthera magnifica
Westringia cephalantha
Westringia rigida

Family: Lauraceae
Cassytha melantha

Family: Lobeliaceae
Lobelia gibbosa

Family: Loganiaceae
Phyllangium paradoxum

Family: Loranthaceae
Amyema miquelii
Amyema preissii
Lysiana casuarinae

Family: Malvaceae
Lavatera plebeia
Lawrencia repens
Sida aff. *spodochroma*
Sida calyxhymenia
Sida excedentifolia ms

Family: Mimosaceae
Acacia acuminata
Acacia adinophylla ms
Acacia aneura
Acacia assimilis ssp. *atroviridis*
Acacia colletioides

Appendix 1 (continued)

Acacia coolgardiensis ssp. *effusa*
Acacia cylindrica
Acacia eremophila
Acacia erinacea
Acacia hemiteles
Acacia hystrix ssp. *hystrix* ms
Acacia aff. *multispicata*
Acacia prainii
Acacia quadrimarginea
Acacia resinimarginea
Acacia steedmanii
Acacia tetragonophylla

Family: Myoporaceae
Eremophila alternifolia
Eremophila clarkei
Eremophila decipiens ssp. *decipiens*
Eremophila gibbosa
Eremophila granitica
Eremophila interstans
Eremophila ionantha
Eremophila latrobei
Eremophila maculata ssp. *brevifolia* ms
Eremophila oldfieldii
Eremophila oppositifolia
Eremophila rugosa ms
Eremophila saligna
Eremophila scoparia

Family: Myrtaceae
Baeckea elderiana
Calothamnus gilesii
Eucalyptus aff. *oleosa*
Eucalyptus calycogona
Eucalyptus capillosa ssp. *capillosa*
Eucalyptus celastroides
Eucalyptus clelandii
Eucalyptus corrugata
Eucalyptus cylindrocarpa
Eucalyptus drummondii
Eucalyptus ebbanoensis
Eucalyptus ewartiana
Eucalyptus hypochlamydea ssp. *hypochlamydea* ms
Eucalyptus longicornis
Eucalyptus loxophleba ssp. smooth bark (Brooker & Kleinig 1990)
Eucalyptus ravida
Eucalyptus salmonophloia
Eucalyptus salubris
Eucalyptus sheathiana
Eucalyptus transcontinentalis
Eucalyptus yilgarnensis
Homalocalyx thryptomenoides
Leptospermum roei
Melaleuca eleuterostachya
Melaleuca leiocarpa
Melaleuca nematophylla
Melaleuca radula
Melaleuca uncinata
Rinzia carnosa
Thryptomene appressa

Family: Ophioglossaceae
Ophioglossum lusitanicum

Family: Orchidaceae
Caladenia incensa ms
Caladenia incrassata ms
Caladenia microchila ms
Caladenia saccharata
Cyanicula amplexans ms
Pterostylis aff. *nana*
Pterostylis picta
Thelymitra aff. *macrophyllum*

Family: Orobanchaceae
* *Orobanche minor*

Family: Oxalidaceae
Oxalis perennans

Family: Phormiaceae
Dianella revoluta var. *divaricata*

Family: Pittosporaceae
Cheiranthera filifolia
Pittosporum phylliraeoides

Family: Plantaginaceae
Plantago aff. *hispidula* (N. Gibson & M. Lyons 1732)
Plantago drummondii
Plantago turrifera

Family: Poaceae
* *Aira caryophyllea*
Amphipogon caricinus var. *caricinus*
Austrostipa elegantissima
Austrostipa platychaeta
Austrostipa trichophylla
Bromus arenarius
* *Bromus diandrus*
* *Bromus rubens*
Danthonia caespitosa
Danthonia setacea
Echinopogon ovatus var. *pubiglumis*
Elymus scaber
Eragrostis dielsii
Eragrostis eriopoda
* *Hordeum glaucum*
Neurachne sp Helena & Aurora (KRN 8972)
* *Pentaschistis airoides*
* *Rostraria pumila*
* *Vulpia bromoides*
* *Vulpia myuros - muralis* complex

Family: Polygalaceae
Comesperma integerrimum

Family: Polygonaceae
Muehlenbeckia adpressa
Muehlenbeckia cunninghamii

Family: Portulacaceae
Calandrinia corrigioloides
Calandrinia eremaea

Family: Proteaceae
Dryandra arborea
Grevillea acuaria
Grevillea erectiloba
Grevillea georgeana
Grevillea haplantha ssp. *haplantha*

Appendix 1 (continued)

Grevillea nematophylla
Grevillea paradoxa
Grevillea zygoloba
Hakea minyma
Hakea preissii

Family: Rhamnaceae
Stenanthemum intricatum
Stenanthemum newbeyi

Family: Rubiaceae
* *Galium aparine*
* *Galium murale*

Family: Rutaceae
Eriostemon brucei ssp. *brucei*
Eriostemon tomentellus
Phebalium canaliculatum
Phebalium tuberculosum

Family: Santalaceae
Exocarpos aphyllus
Santalum acuminatum
Santalum lanceolatum
Santalum spicatum

Family: Sapindaceae
Dodonaea inaequifolia
Dodonaea lobulata
Dodonaea microzyga
Dodonaea rigida
Dodonaea stenozyga
Dodonaea viscosa

Family: Solanaceae
Nicotiana occidentalis
Nicotiana rotundifolia
Solanum hoplopetalum
Solanum lasiophyllum
Solanum orbiculatum ssp. *orbiculatum*
Solanum plicatile

Family: Sterculiaceae
Brachychiton gregorii
Keraudrenia integrifolia
Rulingia cuneata
Rulingia luteiflora
Rulingia magniflora

Family: Thymelaeaceae
Pimelea microcephala

Family: Tremandraceae
Tetratheca aphylla

Family: Urticaceae
Parietaria cardiostegia

Family: Zygophyllaceae
Zygophyllum apiculatum
Zygophyllum eremaeum
Zygophyllum fruticulosum
Zygophyllum ovatum