Flora and vegetation of the Eastern Goldfields ranges: Part 5. Hunt Range, Yendilberin and Watt Hills

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Abstract

A study was undertaken of the flora and plant communities of the Watt and Yendilberin Hills and the Hunt Range on Jaurdi Station. The area has a complex geology which includes Archaean mafics, ultramafics and banded ironstones, and Tertiary laterites. A total flora of 287 taxa and one hybrid was recorded from the uplands, of which 273 were native and 15 were weeds. Fifty three quadrats were established along the range system and used to define seven community types, which were most highly correlated with soil chemistry and an inferred soil moisture gradient. None of the Bungalbin vegetation system is presently in any National Park or Nature Reserve, although the northern section of the Hunt Range has been recommended for inclusion into the Mt Manning Range Nature Reserve. Mining activity in the study area has the potential to severely impact on the restricted breakaway community type. Impacts of past wood harvesting for mining operations and for the water pipeline boilers are still evident decades after these operations ceased.

Keywords: flora, vegetation, Goldfields, Hunt Range, Yendilberin Hills, Watt Hills

Introduction

Greenstone and banded ironstone ranges are 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. These ranges systems have been heavily exploited for minerals for over a hundred years although a detailed knowledge of their vegetation and flora is far from complete. Earlier botanical work has concentrated on broad scale structural vegetation mapping (*e.g.* Beard 1972, 1978) and regional vegetation surveys (*e.g.* Newbey & Hnatiuk 1985), and few detailed botanical surveys have been undertaken on individual range systems.

The aim of this series is to report on detailed floristic studies on individual ranges to address this deficiency (Gibson *et al.* 1997; Gibson & Lyons 1998a,b; Gibson & Lyons 2000). This work has shown high beta-diversity in species composition between adjacent ranges, highly localized distribution patterns for some elements of the flora and a number of new taxa not previously known. This paper extends these detailed studies and reports recent survey work undertaken on the greenstone plain north of Jaurdi homestead, the Watt and Yendilberin Hills and the Hunt Range (collectively referred to as the uplands of Jaurdi Station).

Study Locality

The study area occurs on Jaurdi Station some 60 km east of Koolyanobbing and 135 km west of Kalgoorlie. Running north-northwest from the homestead are a series of uplands of contrasting geologies which include mafic and ultramafic ridges (these formations are commonly termed greenstones), banded ironstones and extensive Tertiary laterites. The uplands of Jaurdi Station form part of the western most greenstone belts (Fig 1).

Jaurdi was purchased by the Department of Conservation and Land Management in 1989 using Sandalwood Conservation and Regeneration Project funding. In the Goldfields region management plan (CALM 1994) it is proposed that the northern section of Jaurdi station (covering the Hunt Range) be incorporated into the Mt Manning Range Nature Reserve, while the southern section (including the Yendilberin and Watt Hills and associated greenstones) be vested as State Forest for sandalwood and flora and fauna conservation. None of the station is grazed. Much of the southern section of Jaurdi has been cut over for timber to feed the pumping stations supplying water to the goldfields earlier last century.

The climate of the region is semi-arid mediterranean with warm winters and hot summers. Mean annual rainfall at Southern Cross (100 km south-west) is 288 mm although seasonal variation is high. The driest year on record was 1940 with 117 mm and the wettest was 1943 with 542 mm. Most rain falls in winter generally associated with frontal activity from May through August. Summer falls (to 100 mm) are highly erratic and result from thunderstorms. Heaviest falls are associated with rain bearing depressions forming from tropical cyclones (Newbey 1985; Anon 1988).

The temperature data from Southern Cross shows mean maximum temperatures are highest in January

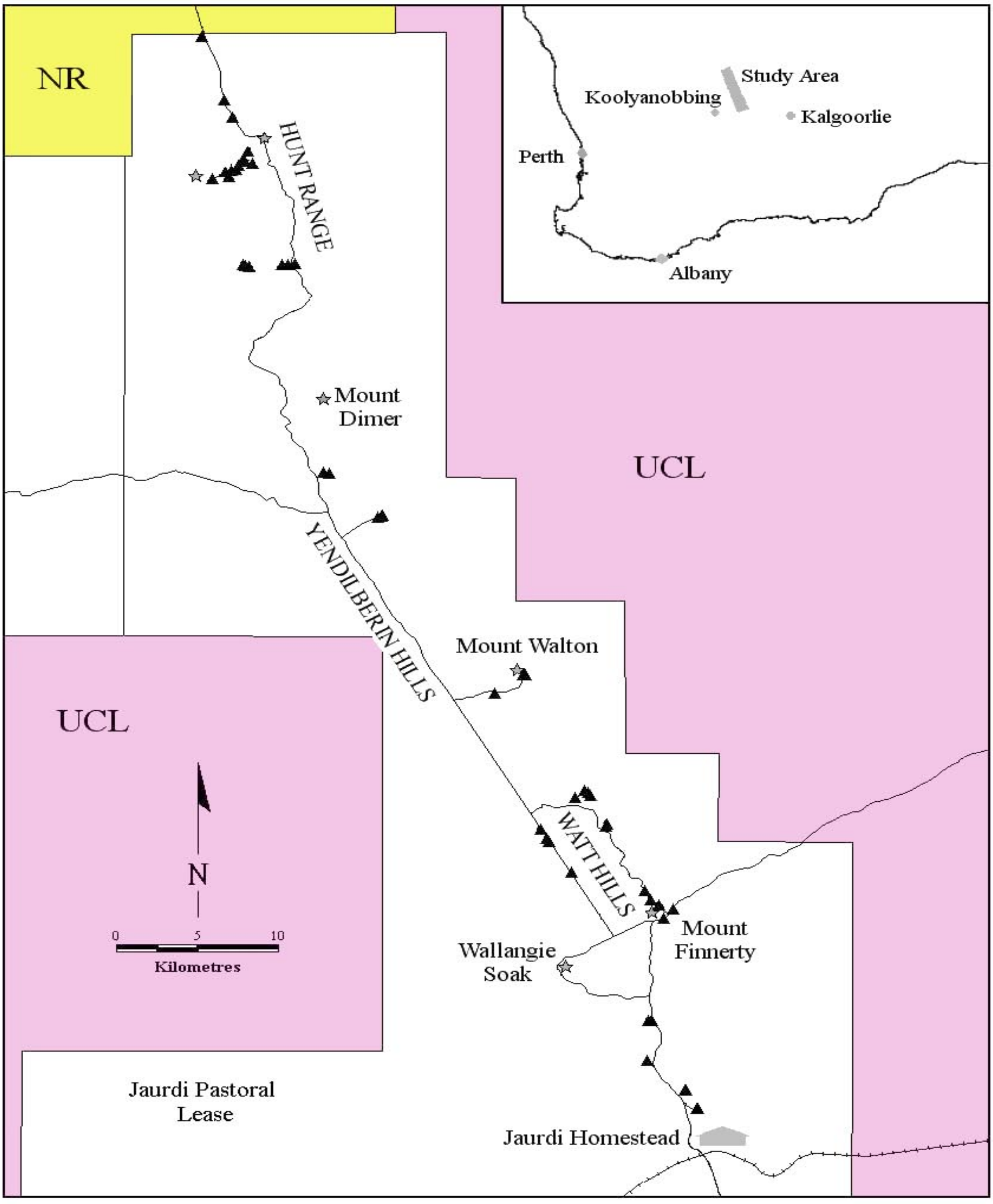

Figure 1. Location survey sites (solid triangle) within the study area. (UCL, Unallocated Crown Land; NR, Nature Reserve)

(34.5 °C) with December through March all recording mean annual temperatures above 30 °C and the highest daily temperature on record of 45.6 °C. Lowest mean minimum temperatures of below 5 °C are recorded in July and August. Lowest daily minimum temperature on record was –3.8 °C.

The geology of the study area has been mapped and described in detail in Jackson and Kalgoorlie 1: 250000 sheets (Chin & Smith 1983; Wyche 1993) and the geology and landforms have been summarized by Newbey (1985). The study area has been tectonically stable since the Proterozoic (600 - 2500 MY old). 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). Immediately north of the Jaurdi homestead are a series of Archaean mafic and ultramafic ridges. These give way to the Watt and Yendilberin Hills which have a core of resistant Archaean banded ironstones (formed from lacustrine deposits of iron oxides and quartz sand) and chert surrounded by Tertiary laterites. Further to the north, the Hunt Range is largely greenstone and a narrow band of banded ironstone. The upland areas and around the base of the range have been extensively laterised. The net result is a subdued landscape set in extensive outwash plains of Tertiary colluvium.

Jaurdi Station lies in the Coolgardie interzone, which is generally dominated by eucalypt woodlands and shrublands on yellow sandplains. The interzone marks the transition in vegetation from the species-rich southwest to the more arid communities of the desert regions (Beard 1990). Beard (1972, 1978) first described the major structural formations of this area, which he grouped into vegetation systems. He defined the vegetation of the Watt and Yendilberin Hills and the Hunt Range as forming part of the Bungalbin System. This system also encompasses the ironstone and greenstone areas of the Helena and Aurora Range, the Koolyanobbing Range and Mt Jackson area. The undulating greenstone plain north of Jaurdi homestead is described as part of the very widespread Jackson system.

The Bungalbin system is most well developed on the massive banded ironstone ranges (Helena and Aurora, Mt Jackson and Koolyanobbing Ranges). The system is a low thicket composed of *Acacia quadrimarginea*, *A. tetragonophylla*, *Allocasuarina acutivalvis* with trees of *Brachychiton gregorii* and on massive outcrops *Dryandra arborea*. This system typically has an understorey of *Dodonaea* spp, *Eremophila clarkei*, *Eriostemon brucei*, *Grevillea paradoxa* and a range of annual species (Beard 1972). On Mt Finnerty *Allocasuarina acutivalvis* dominates rather than *Acacia quadrimarginea*. On the lower slopes *Eucalyptus corrugata* and *Brachychiton gregorii* are present merging below with woodlands of *E. corrugata*, *E. longicornis*, *E. loxophleba* and *Casuarina pauper* (= *C. cristata*) (Beard 1978).

The Jackson system around Jaurdi homestead is described (Beard 1978) as woodlands principally composed of *E. sheathiana*, *E. salubris*, *E. transcontinentalis* and *Casuarina pauper* with an understorey of either broombush (*Eremophila*) or saltbush (*Atriplex*). Elsewhere on the Jackson sheet Beard describes *Acacia* shrublands and breakaways in this vegetation system (Beard 1972).

Beard's pioneering work was followed up some years later with a major regional survey of the biota of the Eastern Goldfields (Dell *et al.* 1985). Newbey & Hnatiuk's (1985) description of the vegetation of the study area was essentially similar to that provided by Beard. 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 extensively.

The aim of the present work was to undertake a detailed flora and vegetation survey of the greenstone areas north of Jaurdi homestead and the Watt and Yendilberin Hills and the Hunt Range (Fig 1).

Methods

Fifty three 20 m x 20 m quadrats were established on the greenstone areas north of Jaurdi homestead, and on the foot slopes and the outwash plains of the Hunt Range and the Yendilberin and Watt Hills (Fig 1). These quadrats attempted to cover the major geographical, geomorphological and floristic variation found in the study area. Care was taken to locate quadrats in the least disturbed vegetation available in the area being sampled. Additional records from the Hunt Range and the Yendilberin and Watt Hills were compiled from collections held in the Western Australian Herbarium.

All vascular plants within each quadrat were recorded and data on topographical position, slope, aspect, percentage litter, percentage bare ground, percentage exposed rock, and vegetation structure were collected from each quadrat. Most of the Hunt Range quadrats were established in July 1995 and all quadrats were scored in September 1995. Topographical position was scored on a subjective seven point scale (ridge tops (1); upper slopes (2); midslopes (3); lower slopes (4); valley flats (5); small rises in valley (6); washlines (7)). 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 quadrats were permanently marked with four steel fence droppers and their positions determined using a GPS unit. Twenty four soil samples from the upper 10 cm were collected from each quadrat. These were bulked and analyzed for electrical conductivity, pH, total N, total P, percentage sand, silt and clay, exchangeable Ca, exchangeable Mg, exchangeable Na, and exchangeable K (McArthur 1991).

Quadrats were classified according to similarities in species composition of perennial taxa to facilitate comparisons with classifications from other ranges in the area (Gibson *et al.* 1997; Gibson & Lyons 1998a,b; Gibson & Lyons 2000). The quadrat and species classifications were undertaken used the Czekanowski coefficient and followed by "unweighted pair-group mean average" fusion method (UPGMA; Sneath & Sokal 1973). Semi-strong hybrid (SSH) ordination of the quadrat data was undertaken to show spatial relationships between groups and to elucidate possible environmental correlates with the classification (Belbin 1991).

Climate estimates (mean annual temperature, annual temperature range, mean annual rainfall, rainfall coefficient of variation) were obtained from BIOCLIM (Busby 1986), a prediction system that uses mathematical surfaces fitted to long term climate data. Relationships among and between soil and physical site parameters and climate estimates were examined using Spearman rank correlation coefficient. Vectors for soil, physical site parameters, and climatic estimates were fitted to the ordination along axes of highest correlation using the principal axis correlation routine in the PATN package (Belbin 1993) (also known as rotational correlation analysis). Statistical significance of these vectors was determined using random permutations of the values of the variable among sites (Faith & Norris 1989). Statistical relationships between quadrat groups for factors such as soil and physical site parameters and climate estimates were tested using Kruskal-Wallis non-parametric analysis of variance (Siegel 1956). To reduce the probability of type I errors given the number of intercorrelations and cross comparisons made, significance differences were reported at a level of $P<0.01$.

Nomenclature generally follows Paczkowska & Chapman (2000). Manuscript names are indicated by "ms", introduced weeds by "*". Selected voucher specimens have been lodged in the Western Australian Herbarium.

Results

Flora

A total of 287 taxa (species, subspecies and varieties) and one hybrid were recorded from the Jaurdi greenstones, Watt Hills, the Yendilberin Hills and the Hunt Range. The flora list was compiled from taxa found in the 53 plots or the adjacent area, from other opportunistic collections and collections held in Western Australian Herbarium (Appendix 1). Of these 288 taxa, 273 are native and 15 are weeds.

The best represented families were the Asteraceae (41 native taxa and 3 weeds), Myrtaceae (32 taxa), Poaceae (12 native taxa and 6 weeds), Chenopodiaceae (16 taxa), Myoporaceae (16 taxa), Mimosaceae (17 taxa), and Proteaceae (13 taxa). This pattern is typical of the flora of the South Western Interzone (Newbey & Hnatiuk 1985). Good rains were experienced in the winter and early spring of 1995, reflected by the large numbers of annuals and geophytes on the flora list (Appendix 1). The most common genera were *Eucalyptus* (20 taxa), *Acacia* (17 taxa) and *Eremophila* (16 taxa).

Six taxa (*Acacia acanthoclada* subsp *glaucescens, Elachanthus pusillus, Eremophila caerulea* subsp *merrallii* ms, *Grevillea erectiloba, Grevillea georgeana, Trymalium urceolare*) were recorded during the survey that are under consideration for listing as threatened flora (K Atkins, CALM, personal communication). *Grevillea georgeana* was widespread on banded ironstone along the entire range from near Jaurdi homestead to close to the Mt Manning Range Nature Reserve boundary (Fig 1). *Acacia acanthoclada* subsp *glaucescens*, *Elachanthus pusillus, Eremophila caerulea* subsp *merrallii* ms, *Grevillea erectiloba* and *Trymalium urceolare* were all located near the northern end of the Hunt Range (Fig 1). The *Acacia* and *Elachanthus* were growing on greenstone soils near the base of the range.

Elachanthus pusillus is a small annual daisy that has been poorly collected. Only four other collections are lodged in Western Australian Herbarium, one collected by Spencer Moore in the WA goldfields in 1895, another by WV Fitzgerald from Kalgoorlie in 1898, and a third by GJ Keighery 16 km east of Cocklebiddy in 1981. The fourth collection lacks locality details. Further work is required to determine the extent of this species north of the Hunt Range.

Grevillea erectiloba was found on yellow sands over laterite, a similar habitat to where it has been located at the Helena and Aurora Ranges and the Mt Manning Range (Gibson *et al.* 1997; Gibson & Lyons, unpublished data). The *Trymalium* was located on a yellow sand sheet in the saddle of the Hunt Range between Pittosporum and Kurrajong Rock Holes. This represents a range extension of some 350 km from the Bindoon – Calinigiri area.

A large new population of *Eremophila caerulea* subsp *merrallii* ms was located on red clay flats over decomposing granite at the base of the Hunt Range. This taxon is also known from a number of populations from the Hunt Range and south to Southern Cross area and west to Bruce Rock.

Three other taxa were recorded that have been very poorly collected. *Leucopogon* sp Marvel Loch (RJ Cranfield & P J Spencer 7790) was collected on the top of a breakaway in the Watt Hills; this taxon had only previously been recorded from a breakaway about 50 km SSW of the study area. Further collections of this taxon have subsequently been made in similar habitats at the southern end of the Watt Hills (M Hislop 2092 & 2093).

A *Gnephosis* sp related to *G. brevifolia* was collected from *Eucalyptus salubris* woodland near Jaurdi homestead. This collection matches *Gnephosis* sp Norseman (KR Newbey 8096), which was collected 12 km north-east of Norseman.

Austrostipa blackii was collected twice, once below the Watt Hills and again below the Hunt Range. This taxon is widespread in South Australia, New South Wales and Victoria, but had only been collected three times previously in Western Australia, most recently in 1959 (Vickery *et al.* 1986). It has recently been relocated in the nearby Highclere Hills (NG & ML 2504) and in the Dalwallinu town reserve, some 300 km east of the study area (M Hislop 1815 & 1852).

Vegetation

Only material that could be identified to species level was included in the analysis (*ca* 99% of records). In the 53 quadrats established on the greenstones north of Jaurdi homestead, Watt and Yendilberin Hills, and Hunt Range, 236 taxa were recorded of which 148 were perennial (Appendix 1). Forty three perennials occurred at only one quadrat. 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 105 perennial taxa in 53 quadrats. Species richness ranged from one to 24 taxa per quadrat, with individual taxa occurring in between two and 37 of the 53 quadrats.

The dendrogram shows the 53 sites divide into two primary groups, based on soil type with the eucalypt

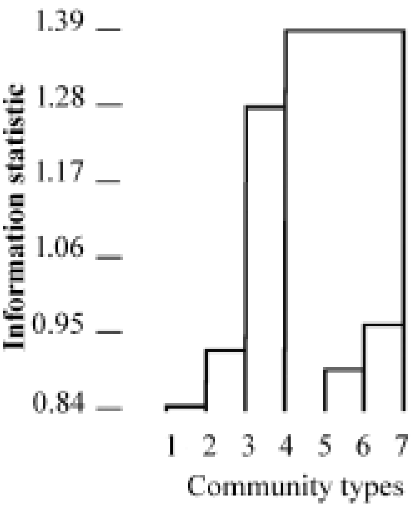

Figure 2. Dendrogram of the floristic quadrats from the uplands of Jaurdi Station showing the seven group level classification.

woodlands (community type 1, 2, 3 & 4) of the deeper more fertile soils separating from the *Acacia* and *Allocasuarina* shrublands (community types 5, 6 & 7) of the less fertile sites (Fig 2). This division can also be clearly seen in the sorted two-way table of the sites and species classification (Table 1).

- **Community type 1** is generally dominated by *Eucalyptus clelandii, E. griffithsii* or *E. longicornis*. Species in species group B are typical of this community as is the lack of species in species group J (Table 1). Common species in the understorey include *Olearia muelleri, Acacia erinacea* and *Maireana georgei*. Community type 1 can be split into two subgroups. Type 1a typically includes taxa such as *Acacia acuminata, Ptilotus obovatus, Dodonaea lobulata, Eremophila oldfieldii, Sclerolaena densiflora* and other taxa in species group C, while type 1b is well represented by species in species group D including *Eucalyptus salmonophloia, E. salubris* and *Melaleuca pauperiflora* subsp *fastigiata*. Community type 1b represents deeper and or more fertile soils lower in the landscape. Average species richness was similar (18.3 *cf* 14.4 perennial taxa per plot) between subgroups.
- **Community type 2** shared many species in species group B but also had high representation of species in the chenopod-rich species group C. Sites in this type were typically low in the landscape and dominated by *Eucalyptus ravida* or *E. longicornis*. Average species richness was 13.0 taxa per plot.
- **Community type 3** was dominated or co-dominated by *Eucalyptus transcontinentalis* and *E. clelandii*. Both sites in this group were species poor (average richness of 8.5 taxa per plot) and both sites had been extensively cut over for timber.
- **Community type 4** was also species poor with an average species richness of only 3.3 taxa per plot. This community type occurred on breakaways and was dominated by *Eucalyptus capillosa* subsp *capillosa* or *E. capillosa* subsp *polyclada*. The difference between the subspecies was that the first was a tree and the second a mallee. The understorey was typically *Ptilotus helichrysoides* (species group F) but on one site on the Hunt Range it was totally lacking. It is not clear if the growth form of the eucalypt is genetically fixed or if the tree habit develops with old age.
- **Community type 5** occurs on sandy soils developed over laterites or banded ironstone. This community type is characterized by species in species group J, some of which are shared with community type 6. Those largely restricted to and generally co-dominant in community type 5 include *Allocasuarina campestris, Baeckea elderiana, Grevillea obliquistigma, Acacia ?sibina,* and *Grevillea paradoxa*. This community was found in the north of the study area on Hunt Range and on the Yendilberin Hills. On the Hunt Range it occurred as a dense thicket on the top of the range on sands developed on a laterite sheet and on laterites on change in slope at the base of the range. On the Yendilberin Hills the community was more open and occurred on north and north-northwest facing slopes. Average species richness was 13.8 taxa per plot.
- **Community type 6** generally occurred on shallower soils than community type 5 and was more widespread occurring from the Hunt Range to near Jaurdi homestead. Species groups J and B were typical of this community type, but as noted above some taxa in species group J were absent or occurred at low frequency. This community type was generally dominated or co-dominated by *Acacia acuminata*, with or without a variable eucalypt component. *Eriostemon brucei, Eremophila clarkei*, the rock fern *Cheilanthes austrotenuifolia* and *Allocasuarina acutivalvis* were common understorey components. On massive banded ironstone the *Acacia acuminata* was replaced by *Acacia hemiteles*. Average species richness in community type 6 is high at 16.5 taxa per plot.
- **Community type 7** comprised a single site occurring on deep yellow sands in the saddle on the Hunt Range between Pittosporum and Kurrajong Rock Holes. These sands are presumed colluvial deposits derived from weathered laterites higher in the landscape. This community type was considerably different from all other sites sampled with 10 shared taxa and a further nine recorded only from this one site.

Physical correlates

Soil parameters showed generally high levels of intercorrelation (Table 2) except for total P and percentage clay. The highest levels of intercorrelation were seen between pH and exchangeable Ca and exchangeable K. Similarly the climate estimates and latitude were all highly intercorrelated, while physical site parameters (*e.g.* topographic position, slope, aspect, etc) were more independent (Table 2). Soil parameters showed significant differences in mean values of electrical conductivity, exchangeable Na, pH, exchangeable Ca, exchangeable K, exchangeable Mg, total N and percentage sand between floristic groups (Table 3).

Soils of community types 1, 2 and 3 had a higher pH and higher levels of exchangeable Ca and K than the other four community types. A similar pattern is seen for exchangeable Mg but community type 4 also had elevated levels compared with the remaining community types. Community types 2 and 3 were found on the most

Table 1

Sorted two-way table of Jaurdi greenstone, Yendilberin and Watt Hills, and the Hunt Range sites showing species occurrence by community type. Sites appears as columns, species as rows.

	COMMUNITY TYPE							
	1A	1B	2	3	4	5	6	7
SPECIES GROUP A								
Acacia acanthoclada subsp *glaucescens*	+ +							
Eucalyptus corrugata	++++							
Eucalyptus transcontinentalis	+		+	++				
Maireana radiata	++		++					
Acacia hemiteles	++	+					+++ +++	
Eremophila caperata ms	+	+ +						
Halgania andromedifolia	+ +	+						
Bossiaea walkeri	+ +		+					
Dodonaea stenozyga	+ +	+	++	+				
Eucalyptus ravida			+++					
SPECIES GROUP B								
Acacia acuminata	++ +++					++++	+++++++++++++	
Scaevola spinescens	++++ +++++	++++++	+			+	+ +++ + + +	
Austrostipa elegantissima	+++++++++++	+ ++	+++++ ++			++++	+ ++++++++ ++++	+
Acacia tetragonophylla	+++	++		+		+	++ + ++ ++ +	
Alyxia buxifolia	+ +++++	+ +			+		++ ++++++++++	
Santalum spicatum	+ + ++++	+					+ + +++	+
Dodonaea lobulata	+ +++ +					+	+ + +	
Eremophila oldfieldii subsp *angustifolia* ms	++ +++ +						+++++ + +	
Ptilotus obovatus	++ +++++++						+++ +	
Eucalyptus griffithsii	++ + +		+ +				++ +++	
Senna artemisioides subsp *filifolia*	++++++	+	++	+		+	+++	
Austrostipa trichophylla	++++	++ +	++	++			++ +++++ + +++	
Acacia erinacea	++ +++	+ +++++	++ ++		+			
Eremophila scoparia	+ ++++	+++	+ +++++	+				
Maireana trichoptera	+++++++ ++	++ + +	+++++++					
Sclerolaena diacantha	+++++++ +	+ +++ +	+++++++					
Eucalyptus clelandii	++++ +++	++ ++	++	+				
Maireana georgei	+++++ +	+++ + +	+				++	
Olearia muelleri	+++++++ ++	+++++++	+++ +++	++			++++	
Eremophila oppositifolia var *angustifolia* ms	+ +	++++++	+	+		+ +	+ ++ +	
Grevillea acuaria	++	+++++	+		++		+ +	
Exocarpos aphyllus	+	+	+ +	+			+ +	
Eucalyptus yilgarnensis	++	+ +						
Solanum orbiculatum	+ +		+			+	+	
SPECIES GROUP C								
Acacia pachypoda	+		++					
Sida spodochroma			++					
Atriplex nummularia	++ +		++ ++ +					
Atriplex vesicaria	+ +		++++ ++	+				
Eremophila ionantha		++	++++++				+	
Eremophila interstans	++	+	+					
Eucalyptus longicornis	++		+++ +					
Sclerolaena densiflora	++ ++	+	++++					
Austrostipa platychaeta	+++		+					
Atriplex paludosa	+		+					
Maireana pentatropis	+ +		++++					
Maireana triptera	+		+++ +					
Beyeria brevifolia			+ +					
Enchylaena tomentosa	+ +							
Pittosporum phylliraeoides	+ +							
Rhagodia drummondii	+ +							
Eremophila glabra subsp *glabra*	+ + +							
SPECIES GROUP D								
Eucalyptus salmonophloia		++++	+ +					
Lawrencia repens		+ +	+					
Santalum acuminatum	+	+++ +						+

Table 1 (continued)

	COMMUNITY TYPE							
	1A	1B	2	3	4	5	6	7
Sclerolaena fusiformis	++++	++++						
Eucalyptus sheathiana		++						
Melaleuca pauperiflora subsp *fastigiata*		+++		+				
Templetonia sulcata		+++						
Eucalyptus salubris		++	+					
SPECIES GROUP E								
Acacia andrewsii	+	+			+		++	
Eucalyptus capillosa subsp *polyclada*					+		+	
Eremophila granitica							++	
Melaleuca leiocarpa							++++	
Xerolirion divaricata							+++	
SPECIES GROUP F								
Eucalyptus capillosa subsp *capillosa*					++			
Ptilotus helichrysoides					++			
SPECIES GROUP G								
Eucalyptus ewartiana							++	
Austrostipa blackii							++	
SPECIES GROUP H								
Acacia quadrimarginea							++	
Eucalyptus oleosa							++	
Dodonaea microzyga var *acrolobata*						+	+++++	
Olearia pimeleoides						+	+++++	
Eucalyptus loxophleba subsp *lissophloia*				+		+	++++	
SPECIES GROUP I								
Acacia ramulosa		+				+		+
Phebalium canaliculatum		+		+			+	+
Acacia resinimarginea							+	+
Phebalium tuberculosum							+	+
Amphipogon strictus						+++	++	+
Lepidosperma sp (NG & ML 2056)							++	
Prostanthera campbellii						+	+++	
Rinzia carnosa						+	+	
SPECIES GROUP J								
Acacia ?sibina						++++++		
Baeckea elderiana						++++++	++	
Grevillea obliquistigma						+++++	+++	
Allocasuarina campestris						++++	+++	
Grevillea paradoxa						++++	+++	
Hibbertia rostellata complex						+++++	+++	
Prostanthera grylloana						+++	++++++	
Allocasuarina acutivalvis						+++	++++++++++++	+
Leucopogon breviflorus						+++++	+++++++++	
Cheilanthes austrotenuifolia						++	+++++++++++++	
Philotheca brucei	+					++++	+++++++++++++++	
Eremophila clarkei						++	+++++++++++	
Calycopeplus paucifolius						+	+	
Melaleuca nematophylla						+++	+++	
Brachychiton gregorii						+	++	
Dryandra arborea						+	+	
Rhyncharrhena linearis		+				+		
Dianella revoluta						++	++++	
Sida atrovirens ms						+	++	
Olearia stuartii							++++	
Grevillea georgeana							+++	
Hibbertia eatoniae							+++	
Westringia cephalantha							++	
Hibbertia exasperata							++++	+

Table 2

Matrix of Spearman rank correlation coefficents between soil and physical site parameters and climate estimates. Only correlations significant at P < 0.01 shown (r > 0.351). See methods for parameter codes.

	EC	pH	N	P	Sand	Silt	Clay	Ca	Mg	Na	K	Topog	Slope	Aspect	%rock	%litter	%bare	Lat	Tann	Trange	Rann	Rcv
Soil parameters																						
EC	1.000																					
pH	.484	1.000																				
Total N	.626	.530	1.000																			
Total P	.	.	.	1.000																		
% Sand	-.462	-.434	.	.	1.000																	
% Silt	.558	.544	.559	.	-.760	1.000																
% Clay	.	.	.	.	-.806	.	1.000															
Ca	.535	.916	.674	.	-.532	.625	.	1.000														
Mg	.738	.692	.542	.	-.604	.621	.355	.733	1.000													
Na	.771	.	.356	.	-.526	.470	.379	.	.692	1.000												
K	.519	.915	.607	.	-.469	.591	.	.884	.731		1.000											
Physical site parameters																						
Topography	.	.	.	.	.	.	.	.	.	.	.416	1.000										
Slope	.	-.503	.	.	.	.	.	.	.	.	-.508	.	1.000									
Aspect	-.398	-.399	.	.	.	-.391	.	.	-.362	.	-.423	.	.	1.000								
%Rock	.	-.524	.	.	.	.	.	.	.	.	-.538	-.533	.459	.	1.000							
%Litter	.	.365	.	.	.	.	.	.352	.	.	.377	.	.	.	-.497	1.000						
%Bare	.	.366	.	.	.	.	.	.	.	.	.	.416	-.421	.	-.758	.	1.000					
Latitude																		1.000				
Climate estimates																						
Tann	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.375	.	.389	.916	1.000			
Trange	.	.	.	.	.	.	.	.	.	-.363	.	.	.	.	.	.	.	.989	.917	1.000		
Rann	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.371	-.363	-.401	-.932	-.982	-.926	1.000	
Rcv	.	.	.	.	.	.	.	.	.	.394	.	.	.	.	.	.	.	-.753	-.603	-.749	.629	1.000

alkaline soils (pH > 8.2) with community type 2 also having high levels of exchangeable K. While communities types 1, 2 and 3 all tended to occur on low slopes, they were not restricted to positions low in the landscape; community types 1 and 2 were recorded from most topographic positions, implying that these sites were not simple colluvial deposits low in the landscape or that calcrete accumulation occurs only in erosional regimes (*cf* Anand *et al.* 1997). The breakaway community (type 4) shows greatly elevated levels of exchangeable Na and electrical conductivity than the other communities, probably resulting from the release of salts from the pallid zone clays.

Of the major elements, total N was higher in the soils of the eucalypt woodlands (especially community type 3) and lower in the soils of the units on laterites, banded ironstone and sands (community types 5, 6 and 7) although total N in soils of community type 6 were quite variable (Table 3). Soils of community types 4 to 7 were acidic ranging from pH 4 to pH 6.7 with the breakaway soils being the most acidic. Total P levels were largely uniform across all soils but were elevated in soils of community type 4 (eroding breakaway) and lower in the sands of community type 7. Insufficient number of plots were available to allow tests of significance of this trend. Community types 1, 2 and 3 tended to occur low in the landscape with community type 3 in washlines. Soils of community types 1 and 2 showed significantly lower percentage sand.

Of the site parameters only percentage surface rock and litter cover showed significant differences between the mean of the floristic groups with community types typical of steeper slopes (types 5 and 6) having significantly higher surface rock cover. Conversely litter cover was generally low in these sites. Some geographic segregation in distribution of floristic groups was seen, with significant differences in mean latitude, temperature range and annual rainfall estimates (Table 3).

Both the three (stress 0.18) and four dimensional (stress 0.14) ordinations of the data-set showed essentially the same patterns, except for an increase level of correlations with climatic variables on the fourth axis. The simpler three dimensional solution is depicted in Fig 3. Abiotic vectors were fitted to the ordination, with the most highly correlated soil, physical site parameters and climatic estimates being superimposed on the ordination (Fig 3A,B). Correlations could not be improved by standard data transformations, implying no simple non-linear responses in the data.

Table 3

Jaurdi upland community type means for soil and physical site parameters and climate estimates. Differences between means for community types 1, 2, 5 and 6 (in bold) tested using Kruskal-Wallis non-parametric analysis of variance (ns indicates not significant, ** indicates P < 0.01, *** indicates P < 0.001, **** indicates P < 0.0001).

	Type 1	**Type 2**	Type 3	Type 4	**Type 5**	**Type 6**	Type 7
Soil parameters							
EC (mS m^{-1}) ****	**12.23**	**15.75**	24.00	116.33	**2.33**	**3.50**	2.00
pH ****	**7.80**	**8.63**	8.35	4.57	**5.53**	**5.92**	5.80
Total N (%) **	**.083**	**.101**	.142	.087	**.039**	**.066**	.0270
Total P (%) NS	**126.6**	**128.9**	125.5	273.0	**138.3**	**145.2**	64.0
% Sand **	**71.8**	**66.8**	80.3	75.8	**80.5**	**74.2**	93.5
% Silt **	**12.1**	**15.9**	11.5	10.7	**8.4**	**10.1**	1.5
% clay NS	**16.1**	**17.3**	8.3	13.5	**11.1**	**15.7**	5.0
exch Ca (me%) ****	**12.7**	**18.3**	13.2	1.1	**1.6**	**4.0**	1.0
exch Mg (me%) ****	**3.92**	**4.15**	6.07	2.77	**0.39**	**1.16**	0.16
exch Na (me%) **	**0.28**	**0.38**	0.28	3.60	**0.03**	**0.07**	0.02
exch K (me%) ****	**0.74**	**1.18**	0.95	0.16	**0.19**	**0.31**	0.11
Physical site parameters							
Topography NS	**3.2**	**3.9**	4.0	2.0	**2.8**	**2.4**	1.0
Slope NS	**1.7**	**1.6**	1.5	2.7	**2.2**	**2.1**	2.0
Aspect NS	**3.3**	**2.1**	2.0	3.3	**4.7**	**4.6**	6.0
% rock **	**51.8**	**28.8**	27.5	93.3	**76.7**	**75.0**	0.0
% litter **	**35.6**	**32.5**	35.0	31.7	**27.5**	**13.8**	50.0
% bare NS	**16.5**	**22.5**	35.0	0.0	**10.0**	**6.9**	50.0
Latitude NS	**-30.439**	**-30.383**	-30.645	-30.533	**-30.325**	**-30.583**	-30.200
Climate estimates							
Mean annual temp (°C) **	**18.7**	**18.8**	18.5	18.5	**18.7**	**18.5**	18.8
Annual temp range (°C) NS	**29.7**	**29.8**	29.5	29.6	**29.9**	**29.6**	30.0
Mean annual rainfall (mm) **	**261**	**260**	266	266	**260**	**266**	258
Rainfall coefficient of variation (%) NS	**31.9**	**31.7**	32.0	31.9	**31.7**	**31.7**	31.6
Number of quadrats	**17**	**8**	2	3	**6**	**16**	1

While none of the abiotic vectors paralleled the primary ordination axis, the eucalypt woodlands (types 1 to 4, top left quadrant) clearly separate from the shrublands (types 5 to 7, bottom right quadrant). Strong correlations with soil pH, exchangeable Ca, exchangeable K and exchangeable Mg are consistent with this separation (Fig 3A). These parameters were highly intercorrelated as noted above. Gradients in exchangeable Na and electrical conductivity (both highly intercorrelated) and percentage rock cover are consistent with the separation of the breakaway community (type 4) on axis 3 (Fig 3B, Table 3). Significant correlations with estimated climatic parameters (mean annual temperature and mean annual rainfall) result from the restriction of community types 3 and most occurrences of type 6 to the southern part of the study area while types 5 and 7 occur in the north. These regional gradients become more obvious in the four dimensional solution (not shown).

Discussion

The Jaurdi greenstones, the Watt and Yendilberin Hills and the Hunt Range have a rich flora, with 287 taxa and one hybrid having been recorded. This includes six taxa under consideration for listing as threatened flora. In addition three further poorly-surveyed taxa were identified, which should also be considered for listing.

The flora is comparable with that of the Helena and Aurora Range (50 km to the west, Gibson *et al.* 1997) and the Highclere Hill (100 km west-southwest, Gibson & Lyons 2000) (Table 4). The uplands of Jaurdi station (which include the Jaurdi greenstones, the Watt Hills, the Yendilberin Hills and the Hunt Range) are less extensive

Table 4.

Comparison of the floras of the uplands of Jaurdi station with the Helena and Aurora Range, and the Highclere Hills.

	Upland of Jaurdi Station	**Helena and Aurora Range**	**Highclere Hills**
Total flora	288	325	242
Weeds	15	21	25
Endemic taxa	-	4	-
Eucalyptus spp	20	19	12
Eremophila spp	16	14	8
Acacia spp	15	17	9
Melaleuca spp	4	5	2

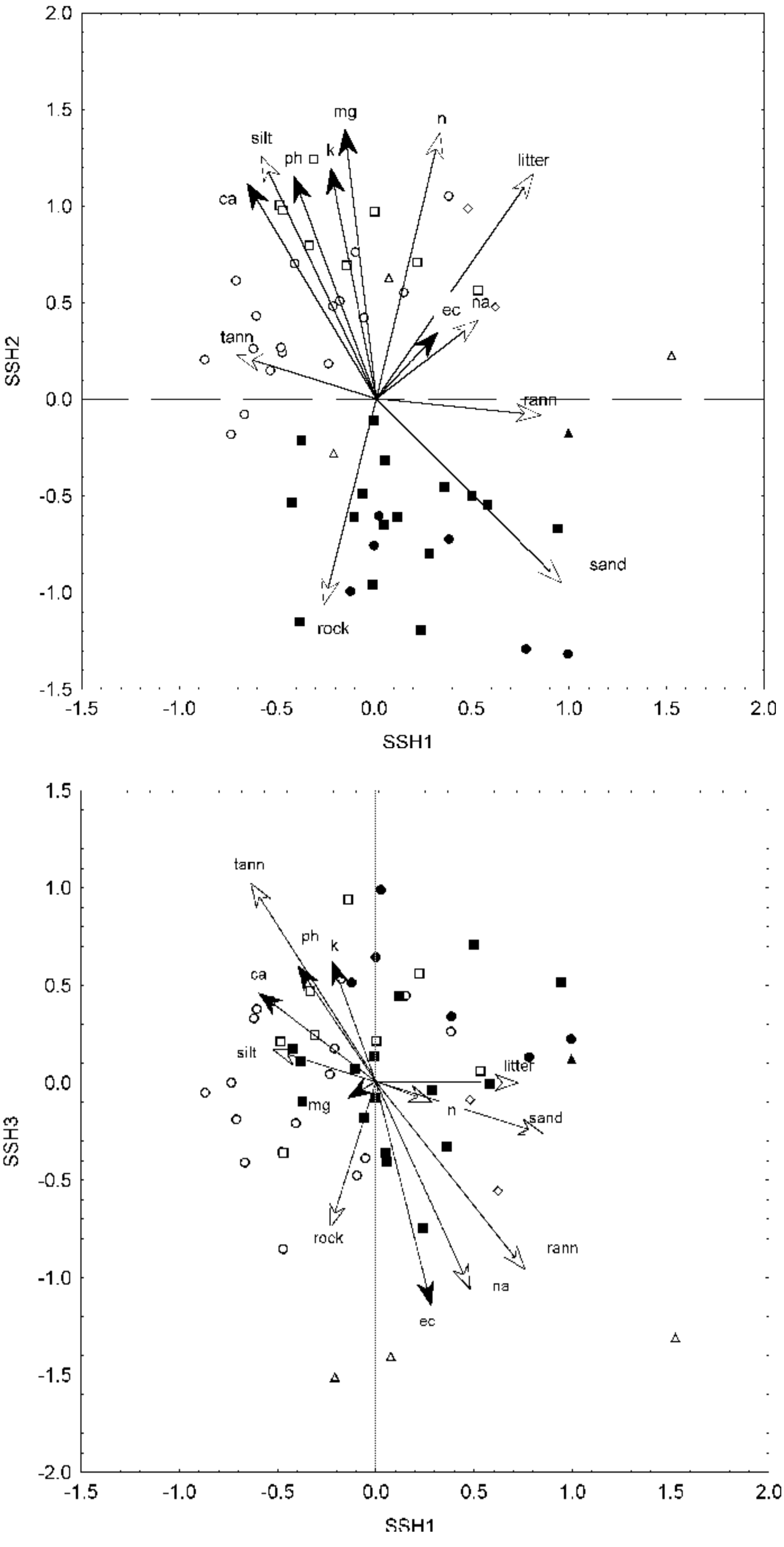

Figure 3. Ordination of Jaurdi Station uplands floristic quadrats coded by community type (1 open circles, 2 open squares, 3 open diamonds, 4 open triangles, 5 solid circles, 6 solid squares, 7, solid triangles). Arrows show the direction of the best fit linear correlation for the most significant (solid arrows, P< 0.001; open arrows P< 0.01) soil and site parameters. The longer the lines the less projection into other dimensions. **A:** Ordination axes 1 versus 2. **B:** Ordination axes 1 versus 3.

in area than the Helena and Aurora Range, and this is likely to contribute to the lower number of taxa recorded, with the reverse being true in the comparison with the Highclere Hills. Both the Helena and Aurora Range and the uplands of Jaurdi station have similar numbers of the eucalypts, *Acacia* spp, and *Eremophila* spp. However, there is a significant changeover of species between the range systems. Five of the 20 eucalypts, five of the 16 *Eremophila* spp and seven of the 15 *Acacia* spp recorded in the present study were not recorded on the Helena and Aurora Range.

While none of the measured soil, physical site parameters or climate estimates corresponded closely with the primary axis of the ordination, the site descriptions are strongly suggestive of a soil moisture gradient running from the eucalypt woodlands on deep more clayey soils on the left of the ordination to the shrublands on skeletal sandier soil to the right, with the single site on deep yellow sand lying in the middle of the ordination. Very strong correlations were found between the site ordination scores and some of the soil parameters. The eucalypt woodlands (types 1 to 3) occurred on more alkaline sites with higher levels of total N, while the breakaways produced highly acidic soil with higher levels of exchangeable Na, electrical conductivity and total P than other habitats. These differences presumably related to the mobilization of elements associated with the active erosion of these areas. Differences between soil parameters between community types within the major floristic division tended to be gradational.

The primary split between community types 1, 2, 3, and 4 from community types 5, 6 and 7 also largely conforms with the division between Beard's Jackson and Bungalbin systems (Beard 1972, 1978). Species typical of the Bungalbin system are found in species groups E, G, H, I and J. Our data show that the Bungalbin system on Jaurdi Station can be subdivided into three community types. Beard (1972, 1978) although recognizing variation within the Bungalbin system did not describe the patterns reported here.

The Bungalbin system is typical of the outcrops of banded ironstone (Beard 1972,1978). What is clear from the present survey is that this system also encompasses vegetation of decomposing laterites and that these laterites occur both on the tops of ranges and also at the change in slope at the base of the ranges. What is not clear is if these laterites are solely derived from banded ironstones or were derived from a several different lithologies.

The banded ironstones on Jaurdi station are much smaller and less extensive outcrops than on the Helena and Aurora Ranges or the Koolyanobbing Range to the west. Consequently somewhat different plant associations are recorded. Gibson *et al.* (1997) record three floristic communities on the banded ironstones of the Helena and Aurora Ranges. One was an upland community on massive ironstone variously dominated or co-dominated by *Dryandra arborea*, *Calycopeplus paucifolius*, *Acacia quadrimarginea*, *Grevillea zygoloba*, *Melaleuca nematophylla* (=*M. filifolia*) and *Allocasuarina acutivalvis*. The second community that occurred on the upper slopes and breakaways was dominated by *Eucalyptus ebbanoensis* or *E. capillosa* subsp *capillosa*. The third community occurred on the mid slopes and was generally dominated by *Eucalyptus ebbanoensis* over *Neurachne* sp Helena & Aurora (KRN 8972). With the possible exception of the breakaway community type, direct analogues of these three communities do not occur on Jaurdi ironstones. *Dryandra arborea* and *Calycopeplus paucifolius* (common and widespread on the Helena and Aurora Range) were rarely recorded on Jaurdi and *Eucalyptus ebbanoensis* and *Neurachne* sp Helena & Aurora (KRN 8972) were entirely lacking.

There are however some similarities in species composition between the ironstone floras of the two range systems. Species group J from the current analysis shares many taxa in common with species group H from the Helena and Aurora analysis. The smaller size of the outcrops and the more extensive development of laterite on the Jaurdi uplands are the most likely explanations of the shift in floristic composition although a climatic gradient and Tertiary climatic history (Hopper 1979) may also be involved.

These data imply that while broad agreement exists between Beard's vegetation systems (based on structural mapping, dominant species and geology) and the floristic classification presented here (based on perennial species presence / absence), significant variation does occur within a vegetation system and not all components of this variation are present on all ranges. None of the Bungalbin vegetation system is presently in any National Park or Nature Reserve, although the northern section of the Hunt Range and the Helena and Aurora Range have been recommended for inclusion into the Mt Manning Range Nature Reserve (CALM 1994). Our results support these recommendations.

Small scale mining has and continues to occur on Jaurdi station. While the greenstone community types appear to be widespread, mining activity is also impacting on the much more restricted breakaway community (type 4). Any future expansion into this community type will need to be very carefully assessed. Jaurdi was also extensively cut over to supply wood for mines and the boilers of the pumping stations for the goldfields water pipeline. The most severely impacted areas were avoided in the present study although community type 3 may be a result of this cutting.

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References

Anand R R, Phang C, Wildman J E, & Lintern M J (1997) Genesis of some calcretes in the southern Yilgarn Craton, Western Australia: implications for mineral exploration. Australian Journal of Earth Sciences 44:87-103.

Anon 1988 Bureau of Meteorology - Climatic Averages Australia. AGPS, Canberra.

Beard J S 1972 The Vegetation of the Jackson Area, Western Australia. Vegmap, Perth.

Beard J S 1978 The Vegetation of the Kalgoorlie Area, 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.

Belbin L 1993 Principal Axis Correlation In: PATN Users Manual. CSIRO, Canberra, 219-220.

Busby J R 1986 A biogeoclimatic analysis of *Nothofagus cunninghamii* (Hook.) Oerst, in southeastern Australia. Australian Journal of Ecology 11:1-7.

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

Dell J 1985 Introduction. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 3 Jackson - Kalgoorlie Study Area. Records of the Western Australian Museum Supplement 23:1-4.

Faith D P & Norris R H 1989 Correlation of environmental variables with patterns of distribution and abundance of common and rare freshwater macroinvertebrates. Biological Conservation 50:77-98.

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.

Gibson N & Lyons M N 1998a Flora and vegetation of the eastern goldfields ranges: Part 2. Bremer Range. Journal of the Royal Society of Western Australia 81:107-117.

Gibson N & Lyons M N 1998b Flora and vegetation of the eastern goldfields ranges: Part 3. Parker Range. Journal of the Royal Society of Western Australia 81:119-129.

Gibson N & Lyons M N 2000 Flora and vegetation of the eastern goldfields ranges: Part 4. Highclere Hills. Journal of the Royal Society of Western Australia 84:71-81.

Hopper S D 1979 Biogeographical aspects of speciation in the south west Australian flora. Annual Review of Ecology and Systematics 10:399-422.

McArthur W M 1991. Reference Soils of South-western Australia. Department of Agriculture, Perth.

Muir B G 1977 Biological Survey of the Western Australian Wheatbelt. Part II. Records of the Western Australian Museum Supplement 3:11.

Newbey K R 1985 Physical Environment. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 3 Jackson - Kalgoorlie Study Area. Records of the Western Australian Museum Supplement 23: 5-10.

Newbey K R & Hnatiuk R J 1985 Vegetation and Flora In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 3 Jackson - Kalgoorlie Study Area. Records of the Western Australian Museum Supplement 23:11-38.

Paczkowska G & Chapman A R 2000 The Western Australian Flora: A Descriptive Catalogue. Wildflower Society of Western Australia, Western Australian Herbarium, CALM & Botanic Gardens and Parks Authority, Perth.

Sneath P H A & Sokal R R 1973 Numerical taxonomy: The Principles and Practice of Numerical Classification. Freeman, San Francisco.

Siegel S 1956 Non-Parametric Statistics for Behavioral Sciences. McGraw-Hill, New York.

Vickery J W, Jacobs S W L & Everitt J 1986 Taxonomic studies in *Stipa* (Poaceae) in Australia. Teleopa 3:1-132.

Wyche S 1993 Kalgoolie, Western Australia. 1: 250 000 geological map - second edition. Geological Survey of Western Australia, Perth.

Appendix 1

Flora List for the Jaurdi greenstones, the Yendilberin and Watt Hills, and the Hunt Range. Nomenclature follows Paczkowska & Chapman (2000); ms denotes a manuscript name, * an introduced taxon.

Adiantaceae
- *Cheilanthes austrotenuifolia*
- *Cheilanthes lasiophylla*
- *Cheilanthes sieberi* subsp *sieberi*

Aizoaceae
- * *Mesembryanthemum nodiflorum*

Amaranthaceae
- *Ptilotus aervoides*
- *Ptilotus carlsonii*
- *Ptilotus exaltatus*
- *Ptilotus gaudichaudii*
- *Ptilotus helichrysoides*
- *Ptilotus holosericeus*
- *Ptilotus obovatus*

Anthericaceae
- *Thysanotus manglesianus*
- *Thysanotus patersonii*

Apiaceae
- *Daucus glochidiatus*
- *Hydrocotyle rugulosa*
- *Trachymene cyanopetala*
- *Trachymene ornata*
- *Uldinia ceratocarpa*

Apocynaceae
- *Alyxia buxifolia*

Asclepiadaceae
- *Rhyncharrhena linearis*

Asteraceae
- *Actinobole uliginosum*
- *Angianthus tomentosus*
- * *Arctotheca calendula*
- *Asteridea athrixioides*
- *Blennospora drummondii*
- *Brachyscome ciliaris*
- *Calotis hispidula*
- *Cephalipterum drummondii*
- * *Centaurea melitensis*
- *Ceratogyne obionoides*
- *Chthonocephalus pseudevax*
- *Elachanthus pusillus*
- *Erymophyllum ramosum* subsp *ramosum*
- *Gilruthia osbornei*
- *Gnephosis* sp Norseman (KRN 8096)
- *Gnephosis tenuissima*
- *Hyalosperma demissum*
- *Hyalosperma zacchaeus*
- * *Hypochaeris glabra*
- *Isoetopsis graminifolia*
- *Lawrencella rosea*
- *Leucochrysum fitzgibbonii*
- *Millotia myosotidifolia*
- *Millotia tenuifolia*
- *Olearia exiguifolia*
- *Olearia muelleri*
- *Olearia pimeleoides*
- *Olearia stuartii*
- *Podolepis canescens*
- *Podolepis capillaris*
- *Podolepis lessonii*
- *Podotheca angustifolia*
- *Pogonolepis stricta*
- *Rhodanthe laevis*
- *Rhodanthe oppositifolia*
- *Rhodanthe rubella*
- *Rhodanthe stricta*
- *Schoenia cassiniana*
- *Senecio glossanthus*
- *Streptoglossa liatroides*
- *Trichanthodium skirrophorum*
- *Triptilodiscus pygmaeus*
- *Waitzia acuminata*

Boraginaceae
- * *Echium plantagineum*
- *Halgania andromedifolia*

Brassicaceae
- * *Brassica tournefortii*
- *Harmsiodoxa brevipes*
- *Lepidium muelleri-ferdinandii*
- *Lepidium rotundum*
- *Stenopetalum filifolium*

Caesalpiniaceae
- *Senna artemisioides* subsp *filifolia*
- *Senna cardiosperma* subsp *cardiosperma*

Campanulaceae
- *Wahlenbergia tumidifructa*

Casuarinaceae
- *Allocasuarina acutivalvis*
- *Allocasuarina campestris*
- *Allocasuarina corniculata*
- *Casuarina pauper*

Centrolepidaceae
- *Centrolepis pilosa*

Chenopodiaceae
- *Atriplex nummularia*
- *Atriplex paludosa*
- *Atriplex vesicaria*
- *Enchylaena tomentosa*
- *Maireana carnosa*
- *Maireana georgei*
- *Maireana pentatropis*
- *Maireana radiata*
- *Maireana trichoptera*
- *Maireana triptera*
- *Rhagodia drummondii*
- *Sclerolaena densiflora*
- *Sclerolaena diacantha*
- *Sclerolaena fusiformis*
- *Sclerolaena parviflora*
- *Threlkeldia diffusa*

Chloanthaceae
- *Lachnostachys coolgardiensis*

Colchicaceae
- *Wurmbea tenella*

Crassulaceae
- *Crassula colorata*

Cupressaceae
- *Callitris glaucophylla*
- *Callitris tuberculata*

Cyperaceae
- *Isolepis cernua*
- *Lepidosperma* aff *angustatum*
- *Lepidosperma* sp (NG & ML 2056)
- *Schoenus nanus*

Dasypogonaceae
- *Lomandra effusa*
- *Xerolirion divaricata*

Dilleniaceae
- *Hibbertia eatoniae*
- *Hibbertia exasperata*
- *Hibbertia rostellata* complex

Droseraceae
- *Drosera macrantha* subsp *macrantha*

Epacridaceae
- *Leucopogon* sp Marvel Loch (RJC & PJS 7790)
- *Leucopogon breviflorus*

Euphorbiaceae
- *Beyeria brevifolia*
- *Calycopeplus paucifolius*
- *Euphorbia drummondii*
- *Monotaxis occidentalis*
- *Poranthera microphylla*

Frankeniaceae
- *Frankenia* sp

Geraniaceae
- * *Erodium cicutarium*
- *Erodium cygnorum*

Goodeniaceae
- *Brunonia australis*
- *Dampiera eriocephala*
- *Dampiera stenostachya*
- *Goodenia berardiana*
- *Goodenia krauseana*
- *Goodenia mimuloides*
- *Goodenia occidentalis*
- *Scaevola spinescens*
- *Velleia rosea*

Haloragaceae
- *Gonocarpus nodulosus*
- *Haloragis gossei*

Juncaceae
- *Juncus aridicola*

Juncaginaceae
- *Triglochin calcitrapum*

Lamiaceae
- *Prostanthera althoferi* subsp *althoferi*
- *Prostanthera campbellii*
- *Prostanthera grylloana*
- *Prostanthera incurva*
- *Westringia cephalantha*
- *Westringia rigida*

Lobeliaceae
- *Isotoma petraea*

Appendix 1 (continued)

Loganiaceae
Phyllangium paradoxa

Loranthaceae
Amyema benthamii
Amyema preissii
Lysiana casuarinae

Malvaceae
Lawrencia repens
Sida atrovirens ms
Sida spodochroma

Mimosaceae
Acacia acanthoclada subsp *glaucescens*
Acacia acuminata
Acacia andrewsii
Acacia assimilis subsp *assimilis*
Acacia colletioides
Acacia daviesioides
Acacia erinacea
Acacia hemiteles
Acacia merrallii
Acacia pachypoda
Acacia quadrimarginea
Acacia ramulosa
Acacia resinimarginea
Acacia rhodophloia
Acacia ?sibina
Acacia steedmanii
Acacia tetragonophylla

Myoporaceae
Eremophila caerulea subsp *merrallii* ms
Eremophila ?caperata ms
Eremophila clarkei
Eremophila decipiens subsp *decipiens* ms
Eremophila drummondii
Eremophila glabra subsp *glabra*
Eremophila granitica
Eremophila interstans
Eremophila ionantha
Eremophila latrobei subsp *latrobei* ms
Eremophila maculata
Eremophila oldfieldii subsp *angustifolia* ms
Eremophila oppositifolia var *angustifolia* ms
Eremophila rugosa ms
Eremophila scoparia
Eremophila serrulata

Myrtaceae
Baeckea elderiana
Eucalyptus brachycorys
Eucalyptus capillosa subsp *capillosa*
Eucalyptus capillosa subsp *polyclada*
Eucalyptus celastroides subsp *celastroides*
Eucalyptus clelandii
Eucalyptus corrugata
Eucalyptus cylindrocarpa
Eucalyptus ewartiana
Eucalyptus griffithsii
Eucalyptus hypochlamydea subsp *hypochlamydea*
Eucalyptus leptopoda subsp *subluta*
Eucalyptus longicornis
Eucalyptus loxophleba subsp *lissophloia*
Eucalyptus oleosa
Eucalyptus ravida
Eucalyptus salmonophloia
Eucalyptus salubris
Eucalyptus sheathiana
Eucalyptus transcontinentalis subsp *transcontinentalis*
Eucalyptus yilgarnensis
Euryomyrtus maidenii ms
Leptospermum roei
Malleostemon roseus
Malleostemon tuberculatus
Melaleuca nematophylla
Melaleuca leiocarpa
Melaleuca pauperiflora subsp *fastigiata*
Melaleuca uncinata
Micromyrtus imbricata
Rinzia carnosa
Thryptomene urceolaris

Ophioglossaceae
Ophioglossum lusitanicum

Orchidaceae
Pterostylis aff *nana*
Pterostylis aff *picta* (NG & ML 3690)
Thelymitra aff *macrophyllum*

Orobanchaceae
* *Orobanche minor*

Papilionaceae
Bossiaea walkeri
Mirbelia aff *densiflora* (NG & ML 3560)
Mirbelia sp (NG & ML 2055)
Templetonia sulcata

Phormiaceae
Dianella revoluta

Pittosporaceae
Pittosporum phylliraeoides

Plantaginaceae
Plantago aff *hispidula* (NG & ML 1732)
Plantago drummondii

Poaceae
* *Aira caryophyllea*
Amphipogon strictus
Aristida holathera
Austrodanthonia caespitosa
Austrostipa blackii
Austrostipa elegantissima
Austrostipa platychaeta
Austrostipa trichophylla
* *Bromus rubens*
Elymus scaber
Eragrostis dielsii
Eragrostis eriopoda
Eriachne flaccida
* *Hordeum leporinum*
Monachather paradoxus
* *Pentaschistis airoides*
* *Rostraria pumila*
* *Vulpia myuros*

Polygalaceae
Comesperma volubile

Portulacaceae
Calandrinia corrigioloides
Calandrinia eremaea
Calandrinia ptychosperma

Primulaceae
* *Anagallis arvensis* var *caerulea*

Proteaceae
Dryandra arborea
Grevillea acuaria
Grevillea erectiloba
Grevillea georgeana
Grevillea haplantha subsp *haplantha*
Grevillea huegelii
Grevillea obliquistigma subsp *obliquistigma*
Grevillea paradoxa
Grevillea zygoloba
Hakea minyma
Hakea preissii
Hakea recurva subsp *recurva*
Persoonia sp

Rhamnaceae
Stenanthemum stipulosum
Trymalium myrtillus subsp *myrtillus*
Trymalium urceolare

Rutaceae
Phebalium canaliculatum
Phebalium canaliculatum x megaphyllum (NG & ML 3685)
Phebalium megaphyllum
Phebalium tuberculosum
Philotheca brucei subsp *brucei*

Santalaceae
Exocarpos aphyllus
Leptomeria preissiana
Santalum acuminatum
Santalum spicatum

Sapindaceae
Dodonaea lobulata
Dodonaea microzyga var *acrolobata*
Dodonaea stenozyga
Dodonaea viscosa subsp *angustissima*

Solanaceae
Nicotiana occidentalis
Solanum lasiophyllum
Solanum orbiculatum

Stackhousiaceae
Tripterococcus brunonis

Sterculiaceae
Brachychiton gregorii

Stylidiaceae
Levenhookia leptantha
Stylidium induratum

Zygophyllaceae
Zygophyllum aff *tesquorum*
Zygophyllum apiculatum
Zygophyllum eremaeum
Zygophyllum glaucum
Zygophyllum ovatum