Journal of the Royal Society of Western Australia, 81:119-129, 1998

Flora and Vegetation of the Eastern Goldfields Ranges: Part 3. Parker Range

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Manuscript received march 1997; accepted November 1997

Abstract

A study of the flora and plant communities of the Parker Range greenstone belt recorded 254 taxa in the spring of 1994. Only 10 weed species were recorded but this number is likely to increase if further work is carried out in a better season. The flora list included new populations of eight rare or poorly known taxa. Of the five species apparently endemic to the Parker Range greenstone belt, two were collected for the first time.

Six community types were defined from 61 sites spread across the range. The distribution of these community types appears to be primarily controlled by edaphic factors including water holding capacity. Three of the floristic communities have some representation in conservation reserves but four of the endemic taxa and three of the community types are presently unreserved. The flora and community types of the Parker Range are significantly different from the Bremer Range (100 km to south east) although the local underlying ecological gradients appear to be similar. It is suggested that the differences between the range systems is related to regional climatic gradients. There has been significant impact on the vegetation of this range by mining and mineral exploration.

Introduction

The Parker Range greenstone belt lies some 15 km south east of Marvel Loch and is composed primarily of Archaean (2500 - 3700 My old) mafic and ultramafic rocks (generally termed greenstone) which has undergone some degree of metamorphosis. This belt includes the Parker Range proper stretching south some 30 km to Cheritons Find and includes the areas of the Toomey Hills to the east and Harris Find to the north east. This highly-prospected area has several active mines and a high level of exploration activity. While there has been a long history of detailed geological exploration in the area our knowledge of the flora and vegetation of the area is still poor. This series of papers is aimed at providing detailed floristic information on individual ranges (Gibson *et al.* 1997; Gibson & Lyons 1998). This paper reports recent survey work in the Parker Range greenstone belt.

Study Locality

The geology of the study area has been mapped and described by Gee (1982) and Bagas (1991). The Parker Range proper consists of a broad band of mafic rock with narrow band of banded ironstone on the eastern side, to the west is area of schist and phylite with some significant areas of laterization. A narrow band of massive gossan (concentrated iron minerals) runs north - south through Mt Caudan at the interface between the laterites and the schists (Bagas 1991). The Toomey Hills and Harris Find have similar geologies without occurrence of banded ironstone or gossan. Further away from the uplands outwash plains or sand plains occur. Overall the topography is subdued reflecting the great age of this landscape.

This region has cool winters and hot dry summers. The nearest climatic station is Southern Cross, some 50 km to the north west, which has a mean annual rainfall of 274 mm with temperature extremes from 47.2 °C to -5.0 °C (Newbey 1995).

Beard (1979) first described the major structural formations in the area. He grouped his structural units into vegetation systems and defined the vegetation of the Parker Range, Toomey Hill and Harris Find as forming the Parker Range System. From this system he described the woodlands of the bottom lands being commonly dominated by *Eucalyptus longicornis, E. salmonophloia*, and *E. salubris* with three types of understorey: *Atriplex, Melaleuca* or a mixed understorey of *Eremophila, Acacia,* and *Olearia muelleri.* On rising ground there are mallee or thicket communities primarily of *Acacia* spp and *Allocasuarina* spp, with ridge tops being dominated by thickets of *Eucalyptus redunca (= E. capillosa* subsp *polyclada), Allocasuarina campestris, Calothamnus chrysantherus* and a number of other species.

In the Boorabbin-Southern Cross report of the eastern goldfields regional survey, Newbey *et al.* (1995) described the undulating greenstone plain of the Parker Range. The colluvial flats of this unit are dominated by *Eucalyptus salubris* low woodland, with more basic soils dominated by *E. longicornis* low woodland. The understorey shrubs in these woodlands were normally *Melaleuca pauperiflora,*

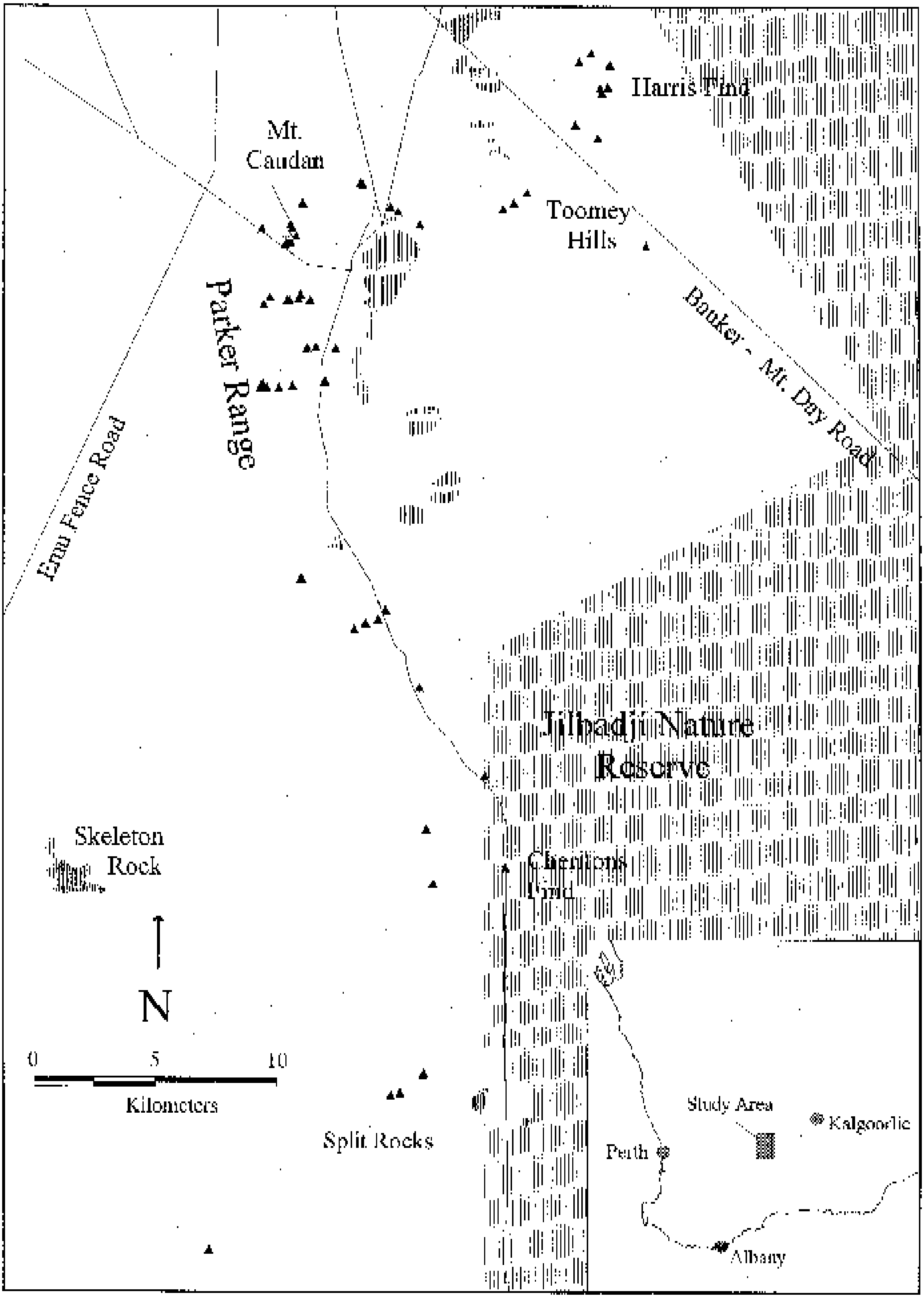

Figure 1. Location of study area. Individual sampling sites shown by solid triangles.

Exocarpos aphyllus, *Acacia merrallii* and *Templetonia sulcata*. On the low rises and ridges *E. longicornis* low woodland dominated on the shallow calcareous earths, with *E. corrugata* low woodland on stony rises and *E. conglobata* low woodland on the upper slopes. Growing with the *E. longicornis* were *Melaleuca pauperiflora*, and *Atriplex vesicaria*. They note that the gossanous cap (massive ironstone) of Mt Caudan and nearby ridges in the Parker Range supported a distinctive *Hakea pendens* tall shrubland. Both Beard's survey and the later biological survey of the eastern goldfields were undertaken to provide regional overviews. Consequently the individual greenstone ranges were not sampled extensively.

Methods

Sixty one 20 m x 20 m quadrats were established in the Parker Range area (Fig 1). The sites attempted to cover the major geographical, geomorphological and floristic variation. Care was taken to locate sites in the least disturbed vegetation available in the area being sampled. All sites were located in the undulating greenstone plain and banded ironstone hills units of Newbey (1995).

Within each site all vascular plants were recorded. The sites were only visited once during the spring of 1994. This was a poor year for annuals and it could be expected that the species richness of most sites would increase significantly if revisited during a good season. Data on topographical position, slope, aspect, vegetation structure and condition were collected from each site. Topographical position was scored on a subjective five point scale from ridge tops (1) to broad flats (4) to dunes beside salt lakes (5). Slope was scored on a one to three scale from flat (1) to steep (3). 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 determined using a GPS unit. Twenty four soil samples from the upper 10 cm were collected from each site. These were bulked and analysed for electrical conductivity, pH, total N, total P, percentage sand, silt and clay, exchangeable Ca, exchangeable Mg, and exchangeable K (Gibson *et al.* 1997).

Sites were classified according to similarities in species composition of perennial taxa. The 1994 season was quite poor and annuals and geophytes had a very patchy distribution. The classification undertaken used the Czekanowski coefficient and "unweighted pair-group mean average" fusion method (UPGMA; Sneath & Sokal 1973). Species were classified into groups according to their occurrence at the same sites by using the TWOSTEP similarity algorithm (Austin & Belbin 1982) followed by UPGMA fusion. Alternate classifications were tried using the ALOC algorithm (Belbin 1987). The resulting classifications were largely similar and only the former will be discussed in detail.

Semi-strong hybrid (SSH) ordination of the site data was undertaken to show spatial relationships between groups and to elucidate possible environmental correlates with the classification (Belbin 1991). Statistical relationships between site groups for such factors as species richness, soil parameters, slope, aspect, *etc*, were tested using Kruskal-Wallis non parametric analysis of variance and Mann Whitney U-tests (Siegel 1956).

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

Results

Flora

A total of 253 taxa (species, subspecies and varieties) and 1 hybrid were recorded from the 61 plots or the adjacent area. The best represented families were Myrtaceae (57 taxa), Asteraceae (23 taxa), Mimosaceae (20 taxa), Proteaceae (17 taxa), Poaceae (15 taxa) and the Chenopodiaceae (14 taxa). The composition of the flora on the range was very similar to, and typical of, the flora of the South Western Interzone (Newbey *et al.* 1995).

The most common genera were *Eucalyptus* (29 taxa), *Acacia* (20 taxa), *Melaleuca* (13 taxa), and *Grevillea* (8 taxa). Annual weed species were rarely encountered (only 10 recorded) resulting from the below average rainfall of the 1994 season. During the survey new populations of eight rare or poorly known taxa being considered for gazettal as Declared Rare Flora were located (K Atkins, CALM, *pers comm*; Table 1).

Table 1

The number of new populations of species being considered for gazettal as Declared Rare Flora found during the survey (K Atkins, CALM, pers comm).

Taxon	Number of new populations
Acacia asepala ms	4
Acacia concolorans ms	8
Acrotriche patula	3
Drummondita wilsonii	1
Gnephosis intonsa	2
Grevillea phillipsiana	4
Hakea pendens	15
Hemigenia obovata	1

The survey significantly extended the known range of *Hakea pendens* which was previously known only from the top of Mt Caudan and the nearby ridges with massive gossanous caps (Newbey *et al.* 1995). It was found to be much more widespread than previously thought, being common on lateritic ridge tops of this greenstone belt extending south to Cheriton's Find and north east to Harris Find.

An undescribed subspecies of *Chamelaucium halophilum* ms has been collected from Mt Caudan on three occasions, first by B Smith in 1989, and subsequently by G Keighery and during this survey. This deep pink flowered shrub is considered quite distinct from typical *Chamelaucium halophilum* ms and awaits formal description as a subspecies. (GJ Keighery, CALM, *pers comm*).

Two other undescribed taxa were collected for the first time. *Euryomyrtus ciliata* ms was collected from three populations in the Parker Range and will be described in the forthcoming revision (M Trudgen, DEP, *pers comm*). Also in the Parker Range the large pink flowered

Isopogon robusta ms related to *Isopogon scabriusculus* was collected from a single population on sheet laterite only some 15 m off a major mining exploration track.

Chamelaucium halophilum subsp nov, *Drummondita wilsonii*, *Euryomyrtus ciliata* ms, *Hakea pendens*, and *Isopogon robusta* ms appear to be endemic to the Harris Find-Parker Range-Cheritons Find greenstone belt. The present survey recorded 49 additional taxa for the Parker Range area (*cf* Newbey *et al.* 1995). Some of these additions are a result of improvement in taxonomic knowledge.

Vegetation

Some species had to be amalgamated into complexes for the floristic analysis due to difficulty of differentiating between closely related taxa without good flowering material (e.g. *Hibbertia rostellata* complex and the *Melaleuca pauperiflora* complex). One hundred and seventy one perennial taxa were recorded from the 61 quadrats located in the Parker Range greenstone belt. Fifty eight taxa occurred at only one site. These singletons have little effect on the community classification and were excluded, so the final data set consisted of 113 taxa by 61 sites. Species richness ranged from 6 to 29 taxa per site, with individual taxa occurring in between 2 and 29 sites. Site groups are discussed at the six group level which best reflected the scale of patterning seen in the field.

The primary division seen in the dendrogram (Fig 2) separates the sites occurring on the deeper more fertile soils (types 1 to 3) from sites occurring on greenstone and lateritic ridges (types 4 to 6). This can also be seen in the sorted two way table of the site and species classifications (Table 2). The first three community types are eucalypt woodlands while the last three include both woodland and thicket communities.

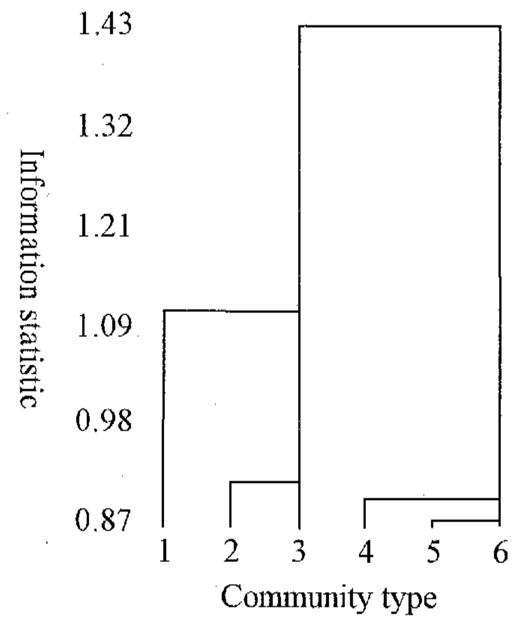

Figure 2. Dendrogram of the floristic sites from the Parker Range area showing the six group level classification.

- **Community type 1** occupies the sandy soils at the base of ridges and low rises. It had the highest mean species richness of 17.4 taxa / plot. It is generally dominated by *Eucalyptus sheathiana* with *E. transcontinentalis* and / or *E. eremophila* as co-dominants. The most typical understorey species were *Daviesia argillacea* and *Grevillea huegelii*. Species groups I and J were the most faithful to this community type. It also shared species of group A with the three upland community types (types 4 to 6).
- **Community type 2** was generally dominated *Eucalyptus longicornis*. Other eucalypts that occurred as co-dominants included *E. corrugata* and *E. salubris*. At one site this community was dominated by *E. myriadena*. This community occupied the broad flats with species from group G being the most typical. Mean species richness was quite low at 10.0 taxa / plot.
- **Community type 3** also occurred on the broad flats within the greenstone belt. It was usually dominated by *Eucalyptus salmonophloia* and *E. salubris*. Typical understorey species of this community include *Eremophila oppositifolia*, *Acacia concolorans* ms, *Dodonaea stenozyga* and *Scaevola spinescens*. It had a higher mean species richness (12.9) than type 2 (10.0). Species patterning in groups A and G suggests that further subdivision into a northern and a southern subgroup is possible (Table 2).

The three remaining community types are those typical of the lateritic and greenstone ridges. Differences in species frequency in species groups A, B, C, D and F differentiate between them. Community type 4 tends to occur on the deeper sandy soils, type 5 on somewhat more skeletal soils and type 6 on massive greenstone. Mean species richness was similar in community types 4 and 5 (14.8 & 15.5) but quite low in type 6 (9.5 taxa / plot).

- **Community type 4** was generally dominated by *Allocasuarina acutivalvis* and *Allocasuarina corniculata*. At some sites *Eucalyptus capillosa* subsp *polyclada* also occurred, but this species was more typical of community type 5. Other species typical of this community type included *Baeckea elderiana* and *Thryptomene kochii*, further illustrating the sandy nature of these sites.
- **Community type 5** almost totally lacked *Allocasuarina corniculata* (*cf* type 4), being replaced by *A. campestris*, while *Allocasuarina acutivalvis* was still a common element. *Eucalyptus capillosa* subsp *polyclada* and / or *Eucalyptus loxophleba* tended to dominate these sites while *Hakea pendens*, *Phebalium tuberculosum*, and *Westringia cephalantha* were common understorey elements. This community type was associated with laterites, breakaways and the massive gossanous caps of the Mt Caudan area.
- **Community type 6** was restricted to a small area of a massive decomposing laterite and granite in the Parker Range. The area was dominated by low trees of *Callitris glaucophylla* and the previously unknown *Isopogon robusta* ms.

Environmental correlates

Correlation with soil and geomorphological parameters. Soil parameters in particular showed high levels of intercorrelation (Table 3). Some care needs to be taken in interpreting comparisons with community type 6 since only two quadrats of this community were sampled. Altitude

Table 2

Sorted two way table of the Parker Range greenstone sites showing species occurrence by community type.
Site appear as columns, species as rows

	COMMUNITY TYPE					
	1	2	3	4	5	6
TAXA						
Species Group A						
Acacia acuminata	*		*	*** **	* * ****	
Allocasuarina acutivalvis	* *		*	**** ****	* ** * * *	
Eucalyptus capillosa subsp *polyclada*	** *		*	** *	** ***	*
Hakea pendens	* *			*	** ****	
Phebalium tuberculosum	*		* **	* **	*** *** *	*
Comesperma volubile	*			**	***	**
Micromyrtus racemosa			*	* *	** * *	*
Allocasuarina campestris				*	***** **	
Trymalium myrtillus			* *	*	** *	*
Hibbertia exasperata	*			*	* *	
Acacia hemiteles	* *		* **	*	*	
Lepidosperma sp (GJK 7000)	*			*	* * *	
Melaleuca eleuterostachya	* *			*	**	
Eucalyptus loxophleba	*			*	* ***	
Melaleuca uncinata	** **		*	* **	** **	**
Westringia cephalantha	*** ***		*	*	* ** ***	
Phebalium filifolium	**		*	*	* ***	
Species Group B						
Acrotriche patula	*				*	*
Borya constricta			*		*	*
Cheilanthes austrotenuifolia					* *****	
Eremophila granitica					* *	
Prostanthera incurvata			*	*	*	
Callitris glaucophylla				*		**
Lepidosperma sp				*		*
Species Group C						
Acacia fragilis					**	
Hakea subsulcata				*	** *	
Cassytha filiformis				*	*	
Astroloma serratifolium				*	*	
Acacia neurophylla				*** *	* *	
Calothamnus gilesii				*** **	* *** * *	
Grevillea obliquistigma				* ****	*** ** ***	
Hibbertia rostellata				*********	******** **	*
Allocasuarina corniculata				***** ***	*	
Baeckea elderiana				* *******	*	
Grevillea paradoxa	*			*******	* ***	
Melaleuca cordata	*			* *** * *	* **	
Cassytha glabella	*			****		
Thryptomene kochii	**			** ***		
Eucalyptus burracoppinensis				* *	*	
Eucalyptus leptopoda				**		
Melaleuca cardiophylla				** *		
Micromyrtus maidenii				*** *		
Species Group D						
Eucalyptus livida				* *	*	
Hakea francisiana	*			* *		
Euryomyrtus ciliata ms			*	*		
Species Group E						
Grevillea oncogyne	*			*		
Hibbertia pungens	*				*	
Species Group F						
Acacia colletioides			*		*	
Dodonaea bursariifolia					**	
Dodonaea microzyga var *acrolobata*					** * *	
Eucalyptus capillosa subsp *capillosa*					* *	
Eremophila decipiens		* *	*		*	
Olearia pimeleoides	*		*		* *	
Eucalyptus corrugata			* *		**	
Eucalyptus oleosa			*		* *	

Table 2 (continued)

	COMMUNITY TYPE 1	2	3	4	5	6
Species Group G						
Acacia asepala ms		** * *				
Eucalyptus conglobata		***				
Eucalyptus calycogona	*	*	**			
Acacia pachypoda		**				
Atriplex vesicaria		****	**			
Eucalyptus melanoxylon		*	*			
Eremophila scoparia		** *****	** *****			
Sclerolaena diacantha		***	************			
Templetonia sulcata		* ******	******* *			
Eucalyptus longicornis		*********	****		*	
Zygophyllum glaucum		* **	*			
Eucalyptus yilgarnensis			* *** *			
Grevillea phillipsiana		*	***			
Lycium australe		**	*			
Maireana radiata			* *			
Zygophyllum apiculatum		*	*			
Maireana trichoptera			* **			
Rhagodia drummondii		*	* *** *			
Ptilotus holosericeus			* * * *			
Acacia poliochroa			**			
Cassia nemophila		*			*	
Species Group H						
Acacia concolorans ms	* *		* *** * *			
Eremophila oppositifolia			* ***** * *** *		*	*
Eucalyptus salmonophloia	*		*************		*	
Acacia erinacea	* *	*	*** * ** **** *	*	** *	
Olearia muelleri	* ***	** * *	* ** * ** * *****		* *	*
Eucalyptus salubris	**	* * *	*** * ****** **** **	*		
Exocarpos aphyllus	* *	*	** ** * ** ***			
Scaevola spinescens	* *		* ** ** *** ***		**	
Austrostipa elegantissima	**	*** *** *	***** **********		*** * *	
Acacia merrallii	*	****** * **	* ** *** * *	*	*	
Melaleuca pauperiflora	* * **	*** ** ***	** ******** *** *		*	
Eremophila ionantha	*	* **	* * *** *			
Amyema miquelii	*	* *	* * * *		*	
Dodonaea stenozyga		*	*** ** * *		*	
Alyxia buxifolia	**		** * * * * ****		*** ** ***	**
Santalum acuminatum	*****	** * *	* ** *	** **	** ** *	
Beyeria brevifolia		*	***	**	* *	
Species Group I						
Acacia camptoclada	**		*		*	
Melaleuca lateriflora	* *		***			
Ptilotus gaudichaudii	*		**		*	
Daviesia argillacea	*******	*	* *	*		
Eucalyptus sheathiana	***** *		*		*	
Melaleuca acuminata	*** *		** *	*		
Eucalyptus eremophila	* ***					
Eremophila drummondii	*		* *			
Grevillea huegelii	* ** **		*			
Grevillea acuaria	* *		* *	*		
Eucalyptus transcontinentalis	***	* *	* * *			
Phebalium megaphyllum ms	***			*		*
Species Group J						
Cassytha melantha	***					
Melaleuca ureolaris ms	**					
Dianella revoluta	*				*	
Species Group K						
Eremophila saligna	*				*	
Lomandra effusa	*	*			*	
Melaleuca sp (NG & ML 2335)	*	*				
Ptilotus drummondii	*		*			
Microcybe multiflora var *multiflora*	*		* * **			

Table 3

Matrix of Spearman rank correlation coefficients between environmental parameters. Only correlations significant at P < 0.01 shown (r > 0.3325). See methods for soil parameter codes.

	Altitude	Aspect	Ca	Clay	Conduct	K	Mg	Na	Total N	pH	Total P	Sand	Silt	Slope	Topog
Altitude	1.000														
Aspect		1.000													
Ca	-0.408		1.000												
Clay			0.413	1.000											
Conduct			0.714	0.551	1.000										
K	-0.514		0.822		0.661	1.000									
Mg	-0.356		0.838	0.527	0.781	0.862	1.000								
Na			0.632	0.601	0.929	0.676	0.843	1.000							
Total N			0.766	0.338	0.732	0.551	0.603	0.594	1.000						
PH	-0.495		0.840		0.593	0.904	0.816	0.576	0.514	1.000					
Total P	-0.354		0.475			0.422			0.540		1.000				
Sand			-0.674	-0.853	-0.772	-0.602	-0.748	-0.760	-0.618	-0.528		1.000			
Silt	-0.383		0.791	0.429	0.729	0.777	0.779	0.677	0.738	0.730	0.342	-0.800	1.000		
Slope		0.662												1.000	
Topog	-0.365		0.410			0.563	0.485	0.396		0.524			0.418		1.000

Table 4.

Parker Range community type means for altitude, topographic position (1-ridge top to 4-valley flat), slope class (1-flat to 3-steep), aspect (16 cardinal directions) and species richness. Non significant differences between means indicated by same superscript (P>0.05, Mann-Whitney U-test).

Community Type	Altitude (m)	Topography	Slope	Aspect	Species richness
1	417.1^{ab}	3.0^{ab}	1.6^{a}	1.6^{a}	17.4^{abc}
2	391.0	3.7^{bc}	1.5^{a}	2.2^{a}	10.0^{b}
3	401.9^{ab}	3.7^{bc}	1.8^{a}	3.5^{a}	12.9^{ce}
4	415.6^{b}	2.9^{a}	1.8^{a}	3.3^{a}	14.8^{cd}
5	403.3^{ab}	2.8^{a}	2.0^{b}	4.0^{a}	15.5^{d}
6	420.0^{b}	2.5^{a}	2.0^{b}	4.8^{a}	9.5^{abe}

Table 5.

Parker Range community type means for soil parameters. Non significant differences between means indicated by same superscript (P>0.05, Mann-Whitney U-test).

Community Type	Electrical Conductivity (mS m^{-1})	pH	N total (%)	P total (%)	% Sand	% Silt	% Clay	Exchangeable Ca (me %)	Exchangeable Mg (me %)	Exchangeable Na (me %)	Exchangeable K (me %)
1	5.9^{a}	6.40^{a}	0.038^{a}	64.9^{ac}	82.6^{a}	5.1^{a}	12.3^{a}	2.9^{a}	1.80^{a}	0.27^{a}	0.31^{a}
2	31.6^{b}	8.27	0.127^{b}	105.3^{bd}	65.0^{b}	19.3^{b}	15.8^{a}	14.8^{b}	5.47^{b}	0.90^{b}	1.63
3	21.6^{c}	7.72	0.089^{c}	86.8^{ab}	65.3^{b}	13.1^{c}	21.6	11.9^{bc}	6.02^{b}	1.05^{b}	0.88
4	3.6^{a}	5.46^{b}	0.052^{d}	51.3^{ce}	79.6^{a}	6.7^{ad}	13.8^{a}	1.9^{d}	0.64^{c}	0.10^{c}	0.19^{b}
5	6.1^{ad}	6.33^{a}	0.081^{cd}	142.3^{d}	79.1^{a}	7.5^{ad}	13.4^{a}	5.1^{e}	1.34^{a}	0.21^{acd}	0.27^{ac}
6	27.5^{bcd}	5.10^{ab}	0.075^{abcd}	60.0^{abe}	54.8^{b}	10.0^{bcd}	35.3	3.8^{acde}	1.98^{abc}	0.83^{bd}	0.15^{bc}

and topographic class were found to be significantly correlated with six of the soil parameters and with each other (Table 3). Percentage silt was more highly correlated with soil nutrient parameters than was percentage clay. There were significant differences between floristic group means for some of the geomorphical parameters (Table 4) and for most of the soil parameters measured (Table 5).

Topographic position clearly separated the upland community types (types 4 to 6) from the other vegetation types. Differences in mean altitude were not as clear, while community types 5 and 6 occurred on steeper slopes than community type 4 (Table 4). Within the lowland communities, community type 2 occurred at a significant lower altitude than types 1 and 3 (Table 4).

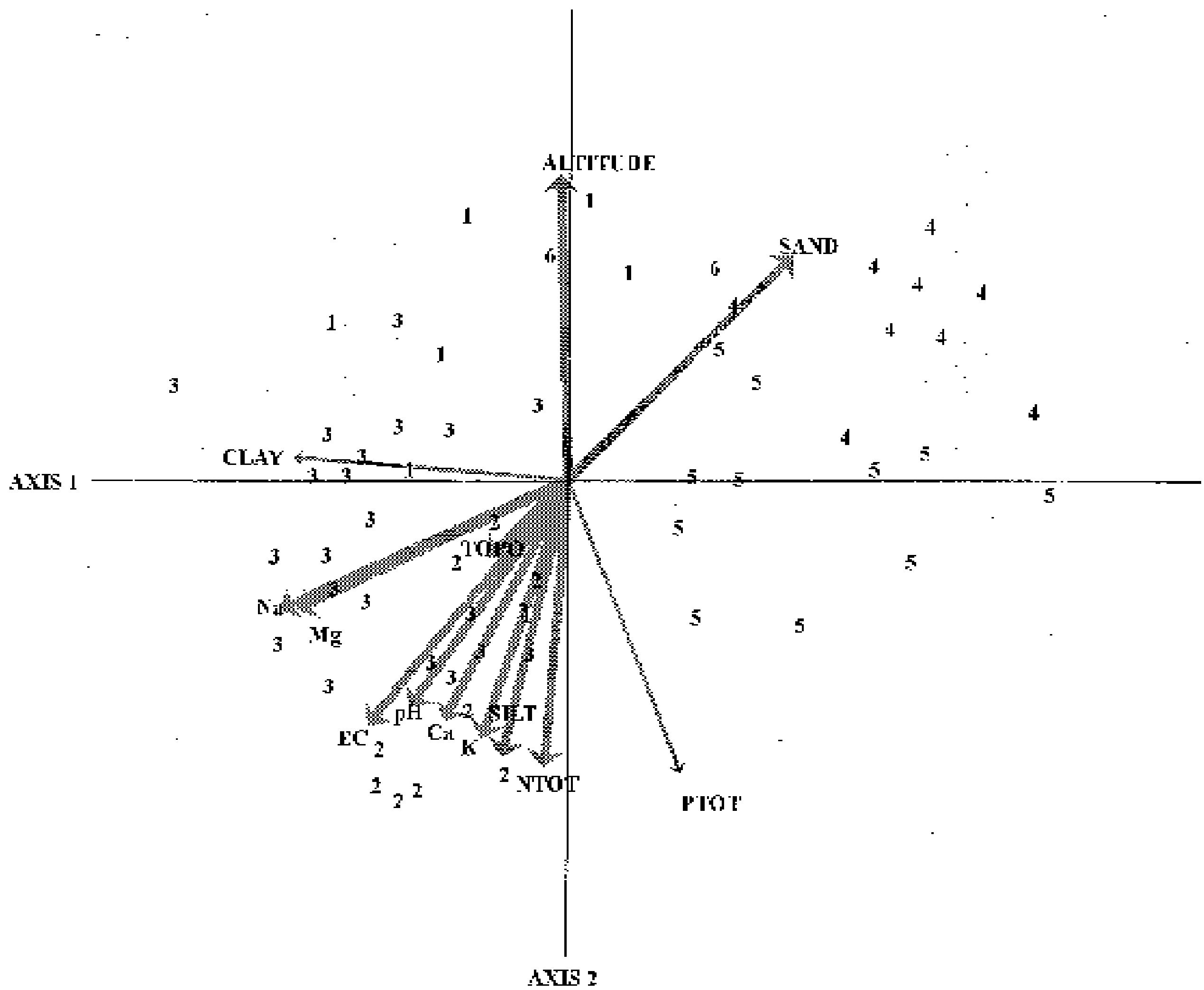

Figure 3. Ordination of Parker Range floristic sites with numbers corresponding to community types. Arrows show the direction of the best fit linear correlation for environmental parameters. Narrow arrows are significant at P < 0.05, and broad arrows at P < 0.01, n = 61.

Of the lowland community types the *Eucalyptus sheathiana-E. eremophila* community (type 1) occurred on soils with significantly higher percentage sand and lower pH than the other two types. These soils were also significantly lower in total N, and exchangeable Ca, Mg, Na, and K and had very low electrical conductivity compared to community types 2 and 3. Total P was also lower lower than community type 3 (Table 4).

The soils of the *Eucalyptus salmonophloia-E. salubris* flats (type 3) and the *E. longicornis* flats (type 2) had high electrical conductivity, and significantly higher pH than any other community type. Both community types had high levels of all soil nutrient parameters measured. The *E. longicornis* flats (type 2) had significantly higher pH (8.27) than the *Eucalyptus salmonophloia - E. salubris* flats (type 3) (7.72) while this latter community type occurred on soils with significantly greater clay content (22% *cf* 16%) (Table 4).

Comparisons of community type 6 with the other two upland community types is difficult due to the small number (two) of quadrats sampled. Community type 6 was found only in a very localised area on the Parker Range. The soils at these site were skeletal over massive laterite and decomposing granite and showed very high clay content (Table 4).

The other two upland community types show radically different soil chemistry. Soils of community type 5 showed significantly higher pH, total P, exchangeable Ca, Mg, and K than community type 4. Soil mechanical analysis, however, showed a similar breakdown of sand, silt and clay. Community type 4 tended to occur on deep yellow soils compared to the shallower brown soils of community type 5.

Ordination results. The Parker Range sites were ordinated to show spatial relationships between groups and to better elucidate possible environmental correlates with the classification. A three dimensional solution with a stress level of 0.21 was used. Superimposed on the ordination output (Fig 3) are best fit linear correlations of the environmental parameters measured using principal axis correlation (Belbin 1993). All parameters were range standardised prior to fitting.

The ordination shows a clear separation between the ridge top communities (types 4, 5 & 6) and the lower slope communities (types 1, 2 & 3). The least fertile, most sandy woodland community (type 1), is clearly most closely related to the upland thickets and woodlands (types 4, 5 & 6) (Figure 3). Soil nutrient status was again the most obvious environmental gradient. The plot also suggests altitude and perhaps percentage sand as being another significant gradient divergent from the soil nutrient axis. This could be interpreted as a soil moisture or moisture availability gradient. The stronger correlation of percentage silt (*cf* percentage clay) with soil nutrient parameters can be clearly seen (Fig 3).

Discussion

Our present poor knowledge of the flora and vegetation patterning of the Parker Range greenstone belt is highlighted by the discovery of two previously unknown taxa (*Euryomyrtus ciliata* ms & *Isopogon robusta* ms), the large range extension documented for *Hakea pendens*, and the location of new populations of eight rare or poorly known taxa (K Atkins, CALM, *pers comm*; Table 1) during a 10 day period.

Five taxa appear to be endemic to the Parker Range. Similar levels of endemism have been reported for the Helena and Aurora Range and the Bremer Range (Gibson *et al.* 1997). This endemism is not related to ultramafic substrates which are often associated with high levels of endemism elsewhere (Brooks 1987). The ranges may have acted as refugia during the waves of aridity of the Tertiary which is now reflected by patterns of local endemism (Hopper 1979).

There is a marked change over in the flora between the Bremer Range and the Parker Range even though these ranges are only 100 km apart. Of the combined flora list of 396 taxa, 141 were recorded only on the Bremer Range and 127 were recorded only on the Parker Range. Within the major genera a similar pattern is seen. A total of 40 eucalypt species were recorded from the two range systems, 19 were shared, 11 were recorded only from the Bremer Range and 10 were recorded only from the Parker Range.

Six community types were described for the Parker Range greenstone belt. The distribution of these communities appears to be primarily controlled by edaphic factors and soil water capacity. Soil development is strongly correlated to altitude and topographic position. These relationships were not as pronounced in the Bremer Range (Gibson & Lyons 1998) where topography is much more subdued. The ridge tops of laterites, schists and greenstones generally had a much lower soil nutrient status than the alluvial and colluvial deposits of the valley bottoms.

A similar cantena of vegetation types has been reported from the Bremer Range (Gibson & Lyons 1998) however the species composition of the two cantenas is significantly different, as could be expected from the change over in the flora described above. Soil chemistry between the two range systems is similar (as shown by a classification of site soil data) and cannot account for the major differences in flora and community types. It is likely that the flora is changing in relation to regional scale climatic gradients.

The previous work undertaken in the study area described broad regional vegetation patterns (Beard 1979; Newbey *et al.* 1995). Our results are consistent with those descriptions but suggest a much more complex mosaic of vegetation patterning and support Beard's concepts of the Parker Range Vegetation System (Beard 1979). One of the vegetation communities showed some north - south subdivision, another one was very localised while the remaining four were spread throughout the different greenstone belts.

The Cheritons Find area lies just within Jilbadgi Nature Reserve and three of the six Parker Range vegetation types were recorded from this area as was *Hakea pendens*. The other three community types and the four endemic taxa are unreserved. The area of the Parker Vegetation System in reserves (106 km^2 in reserves out of a total of 800 km^2) is much less than earlier suggested by Newbey *et al.*(1995) since much of area mapped as this vegetation system in Jilbadgi Nature Reserve is in fact Tertiary sandplain (Bagas 1991). None of the three communities occurring in Jilbadgi Nature Reserve could be considered well reserved.

Mining and exploration activity have significantly impacted on the vegetation of this area. The most obvious example of this is Mt Caudan where exploration gridding has been extensive and where clean up (including capping of drill holes) has been minimal. Two taxa endemic to this greenstone belt occur in this area and one is restricted to it.

Acknowledgements: This project was partially funded by the National Estate Program, a Commonwealth-financed grants scheme administered by the Australian Heritage Commission (Federal Government) and the Heritage Council of WA (State Government). The following people are thanked for assistance with identifications in their particular field of expertise; S Hopper, G Keighery, B Lepschi, B Maslin, B Rye, M Trudgen, and P Wilson. D Allen's advice on soil chemistry analysis is acknowledged. The soil analyses were undertaken by the WA Chemistry Centre.

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Appendix 1

Flora list for the Parker Range greenstone belt (* indicates introduced taxa).

Adiantaceae
- *Cheilanthes austrotenuifolia*

Aizoaceae
- * *Mesembryanthemum nodiflorum*

Amaranthaceae
- *Ptilotus drummondii*
- *Ptilotus exaltatus*
- *Ptilotus gaudichaudii*
- *Ptilotus holosericeus*

Anthericaceae
- *Borya constricta*
- *Thysanotus patersonii*

Apiaceae
- *Daucus glochidiatus*
- *Trachymene cyanopetala*
- *Trachymene ornata*

Apocynaceae
- *Alyxia buxifolia*

Asteraceae
- *Angianthus tomentosus*
- * *Arctotheca calendula*
- *Asteridea athrixioides*
- *Brachyscome iberidifolia*
- *Gnephosis intonsa*
- *Hyalosperma glutinosum* subsp *glutinosum*
- * *Hypochaeris glabra*
- *Lawrencella rosea*
- *Leucochrysum fitzgibbonii*
- *Millotia tenuifolia*
- *Olearia exiguifolia*
- *Olearia muelleri*
- *Olearia pimeleoides*
- *Podolepis capillaris*
- *Podolepis tepperi*
- *Rhodanthe oppositifolia subsp oppositifolia*
- *Rhodanthe rubella*
- *Senecio glossanthus*
- * *Sonchus oleraceus*
- * *Ursinia anthemoides*
- *Vittadinia triloba*
- *Waitzia acuminata*
- *Waitzia citrina*

Boraginaceae
- *Omphalolappula concava*

Brassicaceae
- *Stenopetalum lineare*

Caesalpiniaceae
- *Cassia nemophila*

Campanulaceae
- *Wahlenbergia preissii*

Casuarinaceae
- *Allocasuarina acutivalvis*
- *Allocasuarina campestris*
- *Allocasuarina corniculata*
- *Allocasuarina helmsii*

Chenopodiaceae
- *Atriplex acutibractea* subsp *karoniensis*
- *Atriplex vesicaria*
- *Chenopodium curvispicatum*
- *Eriochiton sclerolaenoides*
- *Halosarcia halocnemoides*
- *Maireana marginata*
- *Maireana pentagona*
- *Maireana radiata*
- *Maireana trichoptera*
- *Rhagodia drummondii*
- *Sclerolaena convexula*
- *Sclerolaena diacantha*
- *Sclerolaena drummondii*
- *Sclerostegia disarticulata*

Convolvulaceae
- *Wilsonia humilis*

Crassulaceae
- *Crassula colorata*

Cupressaceae
- *Callitris canescens*
- *Callitris glaucophylla*
- *Callitris preissii*

Cyperaceae
- *Lepidosperma* sp (GJK 7000)
- *Lepidosperma* sp (KRN 7035)
- *Lepidosperma* sp (NG & ML 2075)
- *Schoenus nanus*
- *Tetraria capillaris*

Dasypogonaceae
- *Chamaexeros macranthera*
- *Lomandra effusa*

Dilleniaceae
- *Hibbertia exasperata*
- *Hibbertia glomerosa*
- *Hibbertia pungens*
- *Hibbertia rostellata*

Droseraceae
- *Drosera macrantha* subsp *eremaea*

Epacridaceae
- *Acrotriche patula*
- *Astroloma serratifolium*

Euphorbiaceae
- *Beyeria brevifolia*
- *Poranthera microphylla*

Fabaceae
- *Daviesia argillacea*
- *Eutaxia* sp (NG & ML 1997)
- *Gastrolobium parviflorum*
- *Gompholobium* sp (NG & ML 2292)
- *Templetonia sulcata*

Frankeniaceae
- *Frankenia* sp (NG & ML 2031)

Geraniaceae
- *Erodium cygnorum*

Goodeniaceae
- *Goodenia havilandii*
- *Goodenia* sp (NG & ML 2250)
- *Goodenia* sp (NG & ML 2370)
- *Goodenia* sp (NG & ML 2371)
- *Scaevola spinescens*

Haloragaceae
- *Glischrocaryon aureum*

Juncaginaceae
- *Triglochin centrocarpum*

Lamiaceae
- *Hemigenia obovata*
- *Prostanthera incurvata*
- *Westringia cephalantha*

Lauraceae
- *Cassytha filiformis*
- *Cassytha glabella*
- *Cassytha melantha*

Lobeliaceae
- *Lobelia gibbosa*

Loganiaceae
- *Mitrasacme paradoxa*

Loranthaceae
- *Amyema miquelii*

Mimosaceae
- *Acacia acuminata*
- *Acacia asepala* ms
- *Acacia assimilis*
- *Acacia camptoclada*
- *Acacia colletioides*
- *Acacia concolorans* ms
- *Acacia deficiens* ms
- *Acacia enervia*
- *Acacia erinacea*
- *Acacia fragilis*
- *Acacia hemiteles*
- *Acacia longispinea*
- *Acacia merrallii*
- *Acacia myrtifolia*
- *Acacia neurophylla*
- *Acacia nigripilosa*
- *Acacia nyssophylla*
- *Acacia pachypoda*
- *Acacia poliochroa*
- *Acacia rendlei*

Myoporaceae
- *Eremophila decipiens*
- *Eremophila drummondii*
- *Eremophila granitica*
- *Eremophila ionantha*
- *Eremophila oppositifolia*
- *Eremophila saligna*
- *Eremophila scoparia*
- *Myoporum tetrandrum*

Myrtaceae
- *Baeckea crispiflora*
- *Baeckea elderiana*
- *Baeckea grandibracteata*
- *Beaufortia orbifolia*
- *Calothamnus gilesii*
- *Calytrix breviseta* subsp *stipulosa*
- *Chamelaucium halophilum* subsp nov
- *Eucalyptus annulata*
- *Eucalyptus burracoppinensis*
- *Eucalyptus calycogona*
- *Eucalyptus capillosa* subsp *capillosa*
- *Eucalyptus capillosa* subsp *polyclada*
- *Eucalyptus conglobata*
- *Eucalyptus corrugata*
- *Eucalyptus cylindriflora*
- *Eucalyptus cylindrocarpa*
- *Eucalyptus eremophila*
- *Eucalyptus flocktoniae*
- *Eucalyptus gracilis*
- *Eucalyptus hypochlamydea* subsp *ecdysiastes* ms
- *Eucalyptus kondininensis*
- *Eucalyptus leptopoda*
- *Eucalyptus livida*
- *Eucalyptus longicornis*
- *Eucalyptus loxophleba*
- *Eucalyptus melanoxylon*
- *Eucalyptus myriadena*
- *Eucalyptus oleosa*
- *Eucalyptus platycorys*
- *Eucalyptus rigidula*
- *Eucalyptus salmonophloia*
- *Eucalyptus salubris*
- *Eucalyptus sheathiana*
- *Eucalyptus spathulata* subsp *grandiflora*
- *Eucalyptus transcontinentalis*
- *Eucalyptus yilgarnensis*
- *Euryomyrtus ciliata* ms
- *Leptospermum roei*
- *Melaleuca acuminata*
- *Melaleuca cardiophylla*
- *Melaleuca cordata*
- *Melaleuca ctenoides*
- *Melaleuca eleuterostachya*
- *Melaleuca hamulosa*
- *Melaleuca lateriflora*
- *Melaleuca laxiflora*
- *Melaleuca pauperiflora* subsp nov (NG 10)
- *Melaleuca phoidophlla* ms
- *Melaleuca* sp (NG & ML 2335)
- *Melaleuca uncinata*
- *Melaleuca ureolaris* ms
- *Micromyrtus maidenii*
- *Micromyrtus obovata*
- *Micromyrtus racemosa*
- *Thryptomene australis*
- *Thryptomene kochii*
- *Verticordia multiflora* subsp *solox*

Orchidaceae
- *Pterostylis* aff. *rufa*
- *Pterostylis ciliata*
- *Pterostylis mutica*
- *Pterostylis roensis*
- *Pterostylis sargentii*
- *Thelymitra* aff. *pauciflora*
- *Thelymitra sargentii*

Phormiaceae
- *Dianella revoluta*

Plantaginaceae
- *Plantago debilis*

Poaceae
- * *Aira cupaniana*
- *Amphipogon strictus*
- *Aristida contorta*
- *Austrostipa elegantissima*
- *Austrostipa hemipogon*
- *Austrostipa* sp (NG & ML 2120)
- *Austrostipa trichophylla*
- *Bromus arenarius*
- * *Bromus rubens*
- *Danthonia acerosa*
- *Danthonia caespitosa*
- *Danthonia setacea*
- *Triodia scariosa*
- * *Vulpia bromoides*
- * *Vulpia myuros*

Polygalaceae
- *Comesperma volubile*

Portulacaceae
- *Calandrinia eremaea*
- *Calandrinia granulifera*

Primulaceae
- * *Anagallis arvensis*

Proteaceae
- *Adenanthos argyreus*
- *Grevillea acuaria*
- *Grevillea huegelii*
- *Grevillea huegelii* (glaucous form)
- *Grevillea obliquistigma*
- *Grevillea oncogyne*
- *Grevillea paradoxa*
- *Grevillea phillipsiana*
- *Grevillea teretifolia*

Proteaceae
- *Hakea falcata*
- *Hakea francisiana*
- *Hakea pendens*
- *Hakea subsulcata*
- *Isopogon robusta* ms
- *Persoonia inconspicua*
- *Persoonia trinervis*
- *Petrophile seminuda*

Rhamnaceae
- *Cryptandra myriantha*
- *Stenanthemum stipulosum*
- *Trymalium myrtillus*

Rutaceae
- *Boronia subsessilis*
- *Drummondita wilsonii*
- *Microcybe multiflora* var *multiflora*
- *Phebalium filifolium*
- *Phebalium megaphyllum* ms
- *Phebalium tuberculosum*
- *Phebalium tuberculosum x Phebalium megaphyllum* ms

Santalaceae
- *Exocarpos aphyllus*
- *Santalum acuminatum*

Sapindaceae
- *Dodonaea amblyophylla*
- *Dodonaea bursariifolia*
- *Dodonaea caespitosa*
- *Dodonaea lobulata*
- *Dodonaea microzyga* var *acrolobata*
- *Dodonaea stenozyga*

Solanaceae
- *Lycium australe*

Stylidiaceae
- *Stylidium limbatum*

Zygophyllaceae
- *Tribulus astrocarpus*
- *Zygophyllum apiculatum*
- *Zygophyllum glaucum*