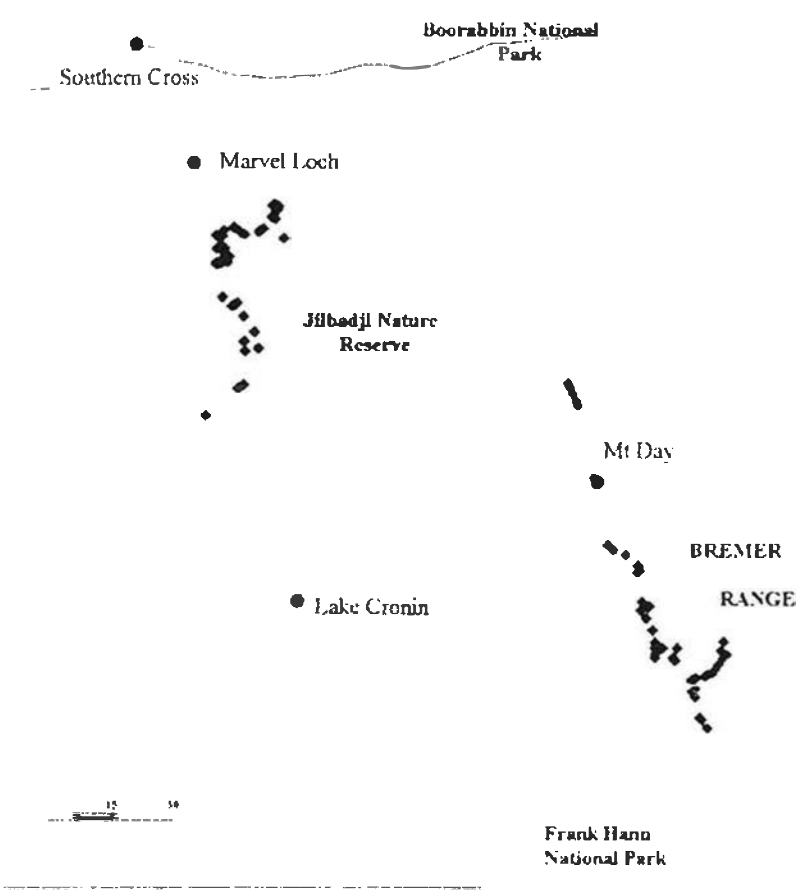
Floristic Survey of the Bremer and Parker Ranges of the Eastern Goldfields of Western Australia

Neil Gibson and Michael N. Lyons



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by

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ABSTRACT

A study was undertaken of the plant communities of the Bremer and Parker Ranges of the Eastern Goldfields of Western Australia. Both of these ranges are composed of ancient mafic and ultramafic rocks which are the focus for mineral exploration in the region.

One hundred and twenty five sampling sites (quadrats) were established and the floristic data from these sites were used to define major community types. A total of 396 flowering plant taxa (species, subspecies and varieties) were found in or adjacent to the 125 quadrats. Of these taxa 384 were native and 12 were weeds. The annual flora including weeds was probably underestimated since the spring of 1994 when the field work was undertaken was particularly poor for annuals.

Two new populations of the Declared Rare Flora species *Eucalyptus cerasiformis* were located during the survey as were new populations of 12 other priority species. Four apparently new taxa were found and these are recommended to be added to CALM's priority listing.

The Bremer and Parker Ranges were floristically distinct. Of the 397 taxa encountered during the survey, 141 were restricted to the Bremer Range, 127 were restricted to the Parker Range and 129 were common. Similarly, analysis of the perennial floristic dataset showed largely distinct community types between the two ranges. Six community types are described from the Bremer Range and another six from the Parker Range. The major environmental correlates with floristic communities were soil nutrient status and water holding capacity on both ranges.

The floristic community classification was in broad agreement with previous descriptions of the area but illustrated the much more complex nature of the vegetation patterning than previously documented. All six of the Bremer Range community types are unreserved as are three of the six Parker Range community types. Only one of the nine taxa endemic to these ranges is currently reserved.

There has been a significant impact on the vegetation of these ranges by mining and mineral exploration.

INTRODUCTION

Both the Bremer and Parker Ranges are composed primarily of Archaean mafic and ultramafic rocks, these formations are commonly termed greenstones. The greenstone ranges are one of the common landforms of the Eastern Goldfields and extend from the Parker Range in the west to the Roe Hills some 300 km further east and stretch north - south over 800 km. The Parker Range lies 15 km south east of Marvel Loch, with the Bremer Range some 100 km further south east, forming the second major greenstone belt in this region (Figure 1). Despite the greenstone ranges being heavily exploited for minerals for over a hundred years a detailed knowledge of the vegetation and flora of the region is still lacking.

CLIMATE

This region has cool winters and hot dry summers. There are few permanent climate stations in the area. Ravensthorpe lies south of the study area, Norseman to the east, Hyden to the west and Southern Cross to the north.

Table 1 Annual rainfall, evaporation, annual mean maximum temperature, annual mean minimum temperature for four centres surrounding the study area. Data from Bureau of Meteorology (1988).

	Rainfall (mm)	Raindays	Mean Max Temp (°C)	Mean Min Temp (°C)
Southern Cross	274	68	25.5	10.9
Hyden	336	75	24.5	9.7
Norseman	275	66	24.4	10.6
Ravensthorpe	419	107	22.7	10.3

Most rain falls between May to August, with average rainfall and reliability decreasing from the south and west to the north and east. This has a major effect on the vegetation of the Parker and Bremer Ranges which lie close to the boundary between the Southwest Botanical Province and the Southwest Interzone (Beard 1990). Both ranges occur below the 300 mm rainfall isohyte. Winter rainfall mainly comes from frontal activity, generally of about 10 mm but may reach 40 mm. Summer falls (to 50 mm) are highly erratic and result from thunderstorms. Heaviest falls are associated with rain bearing depressions forming from tropical cyclones and may exceed 160 mm (Newbey 1988).

Temperature follows a similar trend from highest in the north to lowest in the south, average annual evapotranspiration similarly varies between 2200 mm to 2700 mm (Newbey 1988, in press).

GEOLOGY AND LANDFORMS

The geology of the study area has been mapped and described in detail in Lake Johnson 1: 250000 sheet (Gower & Bunting 1976) , Boorabbin 1: 250000 sheet (Hunter 1991) (these two sheets cover the Bremer Range greenstones), and the Southern Cross 1: 250000 sheet (Gee 1982) (covering the Parker Range greenstones). Recently 1: 100000 mapping has become available for the Parker Range area which shows a more detailed geology (Cheritons Find sheet, Bagas 1991). The geology and landforms have also been summarised by Newbey (1988) and Newbey (in press) and are followed here.

The study area has been tectonically stable since the Proterozoic (600 - 2500 million years (My) ago). The major landscape features are controlled by the Archaean (2500 - 3700 My old) and Proterozoic 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). Secondly, two areas of Archaean greenstone (mafic and ultramafic lithologies), a north south belt from Southern Cross south to the Parker Range, and a second north south belt of the Mt Day - Bremer Range area, form the major relief features of the study area. The topography is none the less subdued given the long period of erosion this landscape has undergone. Two important features of the greenstone ranges are the banded ironstone formations found on both the Parker and Bremer Ranges and the massive gossanous cap (of concentrated iron minerals) on the Parker Range which develop shallow sandy soils.

Except for the low greenstone ranges the study area consists almost entirely of gentle undulating uplands dissected by broad valleys with chains of salt lakes. These salt lake systems are the remnants of an active drainage system at an earlier time of higher rainfall. Widespread laterization of the granites and greenstones is believed to have occurred during the Cainozoic (the last 65 My).

The soils of the greenstone ranges were described by Newbey (1988), he recognises four major units primarily controlled by the local bedrock. These are shown below.

Table 2. Major soil units of the greenstone ranges (After Newbey 1988).

Soil Group	A horizon	B horizon	Bedrock
Red sands	Loamy sands, 5-100 cm, pH 6.0-6.5	Rarely present	banded Ironstone
Deep Calcareous Earths	10-20 cm, pH 7.5-8.25	> 100 cm, pH 8.0-8.25, carbonate nodules usually present	mafic / ultramafic
Shallow Calcareous Earths	5-30 cm, pH 8.0-8.25	Rarely present	mafic / ultramafic
Cracking Red Clays	5-10 cm, pH 8.0-8.25	Medium clay, > 100 cm, pH 8.25	mafic

VEGETATION

Beard (1976, 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 describes the woodlands of the bottomlands 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. polyclada* subsp. *capillosa), Allocasuarina campestris, Calothamnus chrysantherus* and a number of other species.

The Bremer Range, Round Top Hill, Mt Day and unnamed hill to the north west of Mt Day form his Bremer Range vegetation system. He briefly describes broom bush Thickets of

Allocasuarina on the rocky knolls, footslopes of *Eucalyptus dundasii* and *E. longicornis*, with the lower slopes occupied by *E. salmonophloia* association.

Beard's pioneering work was followed up some years later with a major regional survey of the biota of the Eastern Goldfields. This was covered in 12 cell reports. The Lake Johnson - Hyden report (How *et al.* 1988) covered most of the Bremer Range area and the Boorabbin - Southern Cross report (Keighery *et al.* in press) covered the Parker Range area. These were regional surveys of flora, small mammals, birds, reptiles and amphibians. They adopted a land system approach, somewhat broader than Beard's vegetation systems.

Newbey and Hnatiuk (1988) describe the vegetation of the Bremer Range under two main headings, banded ironstone hills and undulating greenstone plains. The banded ironstone hills were dominated by *Eucalyptus* aff. *wandoo* (=*E. livida*) along with *Allocasuarina campestris*, *A. corniculata* and numerous shruby taxa. They note that at one location on the Honman Ridge the soil was supplemented by calcareous and sub saline material from a salt lake system. The undulating greenstone plain they describe as being covered by *Eucalyptus flocktoniae* woodland with an understorey of such species as *Exocarpus aphyllus*, *Melaleuca pauperiflora*, *Acacia pachyphylla*, *A. merrallii* etc.

In the Parker Range Newbey *et al.* (in press) split their undulating greenstone plain into colluvial flats and low rises and ridges. The colluvial flats are described as being 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*, *Exocarpus 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. Indeed, access to much of the Bremer Range was not possible at the time of these surveys. The only other report on the vegetation of the study area is that of Henry-Hall (1990). This report details reserve recommendations for the southern goldfields. In the section on the proposed Bremer Range Nature Reserve and the proposed Mt Day Nature Reserve he comments on the very diverse eucalypt woodlands of these areas and provides detailed descriptions of patterns in eucalypt distribution within the range as well as general vegetation descriptions of major features of the area.

PURPOSE OF THE STUDY

The aim of the present work was to undertake a detailed floristic survey of the individual ranges to better define the vegetation patterning. Both these ranges have and continue to undergo extensive mineral exploration with many small mines located in Parker Range and Toomey Hill, and an extensive open cut mine being developed at Harris Find. The Bremer Range has had considerable exploration activity since the 1960's and several areas have been very closely grided in recent years. Information contained in this report will allow better definition of the conservation significance of the study area.

METHODS

In all, one hundred and twenty five 20 m x 20 m quadrats were established, 64 in the Bremer Range area and 61 in the Parker Range area (Figure 1, 2, and 3). The 125 sites established attempted to cover the major geographical, geomorphological and floristic variation found in these greenstone belts. Care was taken to locate sites in the least disturbed vegetation available in the area being sampled. All sites were located in undulating greenstone plain and banded ironstone hills units of Newbey (1988, in press).

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 slope, aspect, vegetation structure, topographical position and condition were collected from each site. 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. Topographical position was scored on of a subjective five point scale from ridgetops (1) to broad flats (4) to dunes beside salt lakes (5). Vegetation condition was scored on a five point scale with a score of one indicating vegetation in near natural condition and five indicating highly disturbed sites with significant weed invasion (after Trudgen 1991). Geology was derived from Gower & Bunting (1976), Gee (1982), Bagas (1991) and Hunter (1991).

All sites were permanently marked with four steel fence droppers and their positions fixed using a GPS unit. Estimates of mean annual rainfall and mean annual temperature were derived from the BIOCLIM model of Busby (1986). Twenty four soil samples from the A horizon were collected from each site. These were bulked and analysed for electrical conductivity, pH, total N, total P, % sand, % silt, % clay, exchangeable Ca, exchangeable Mg, exchangeable K, exchangeable Al, and exchangeable Mn using standard ACL methods (Appendix 4).

Sites were classified according to similarities in species composition, however due to concern about data uniformity annuals and perennials such as orchids (annual geophytes) were excluded from the analysis. Initially all sites were analysed together but since the classification showed major geographical discontinuities, the dataset was split into the Parker Range area and the Bremer Range area and reanalysed.

The classification undertaken used the Czekanowski coefficient and "unweighted pair-group mean average" fusion method (UPGMA, Sneath and Sokal 1973). Species were classified into groups according to their occurrence at the same sites by using the TWOSTEP similarity algorithm (Austin and 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 sites data was undertaken to show spatial relationships between groups and to elucidate possible environmental correlates with the classification (Belbin 1991). Statistical relationship between site groups for such factors as species richness, soil parameters, slope, aspect etc, were tested using Kruskal - Wallis non parametric analysis of variance (Siegel 1956).

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

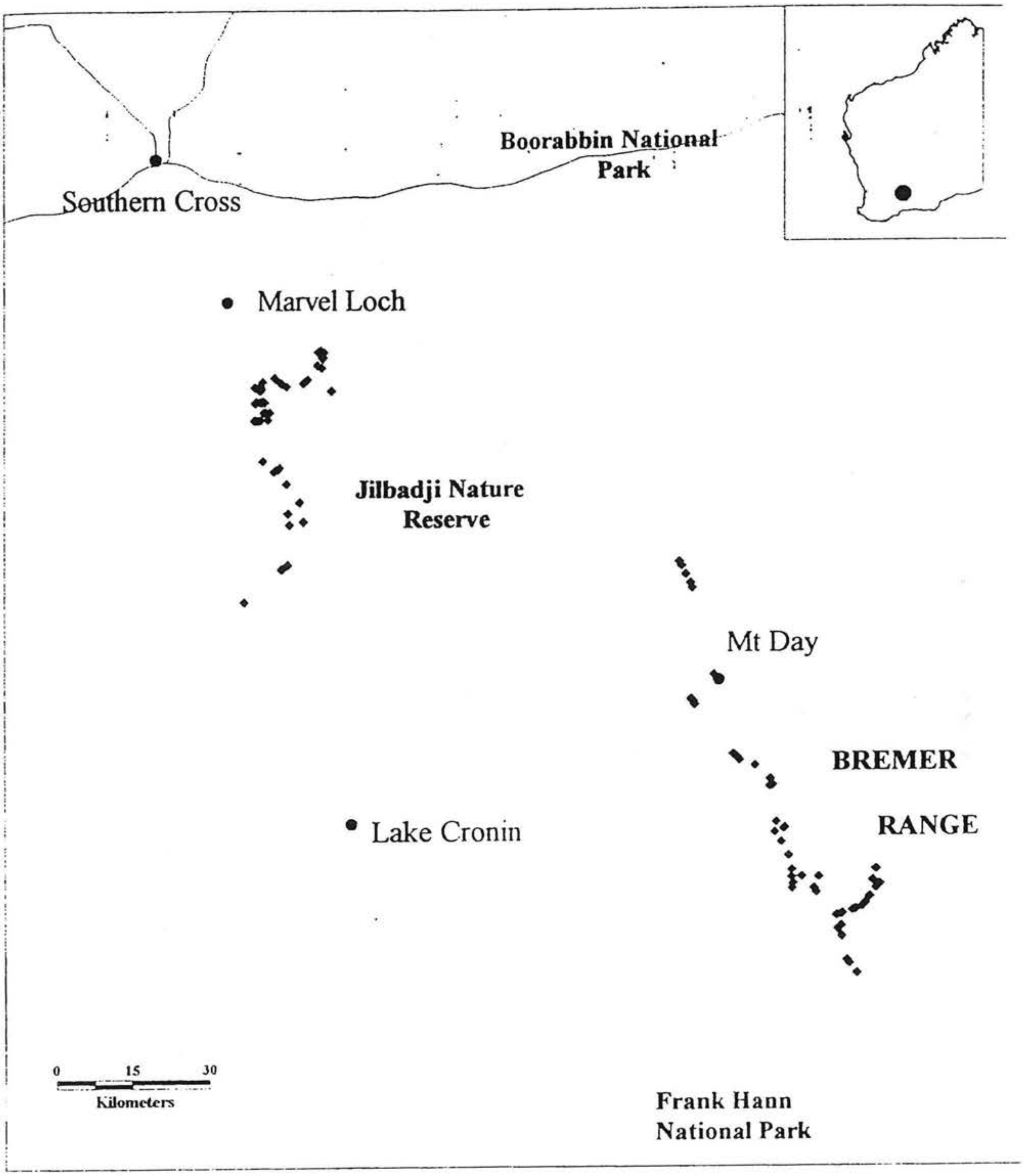


Figure 1. Location of study area showing sampling sites (diamonds).

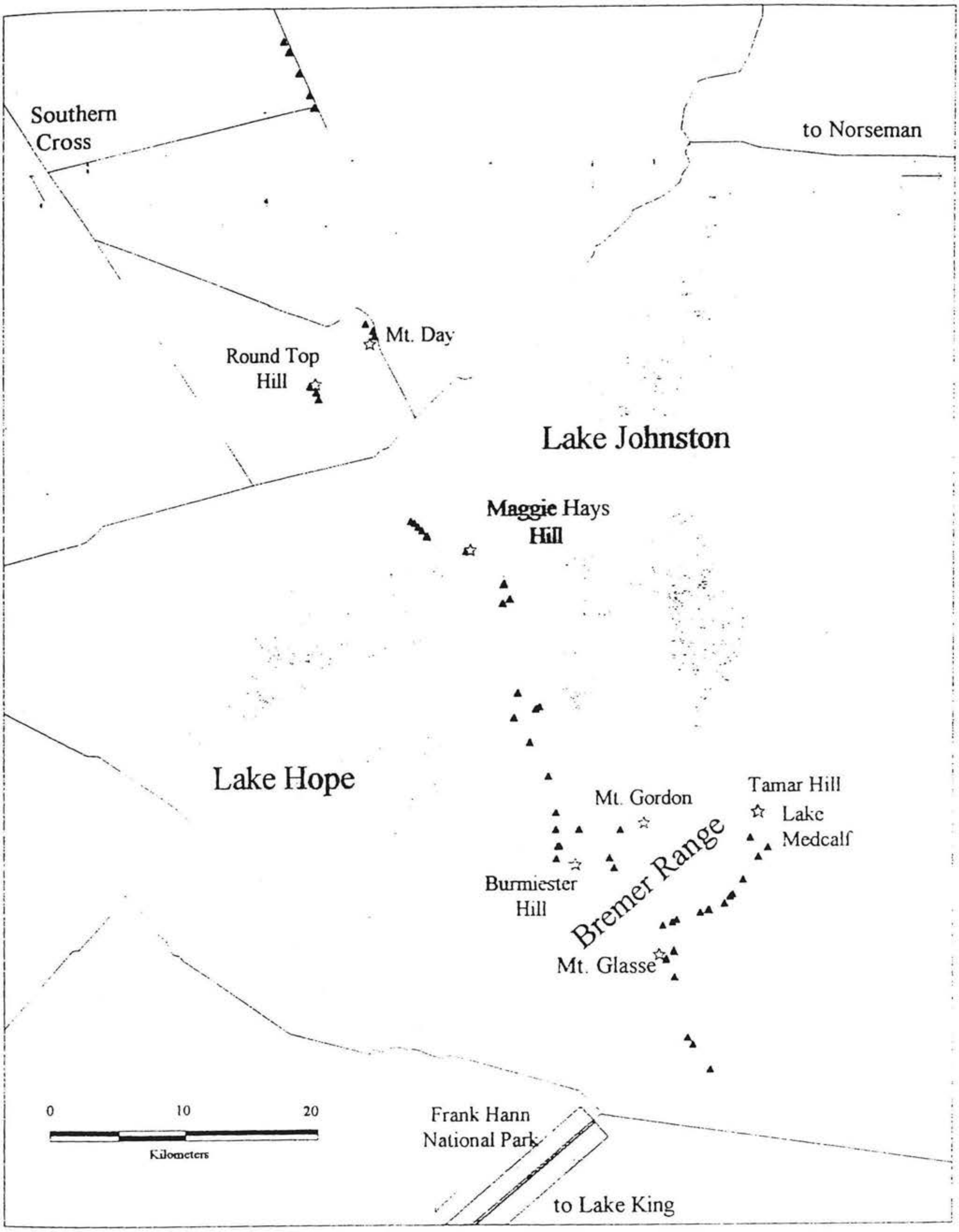


Figure 2. Bremer Range area showing location of floristic survey sites.

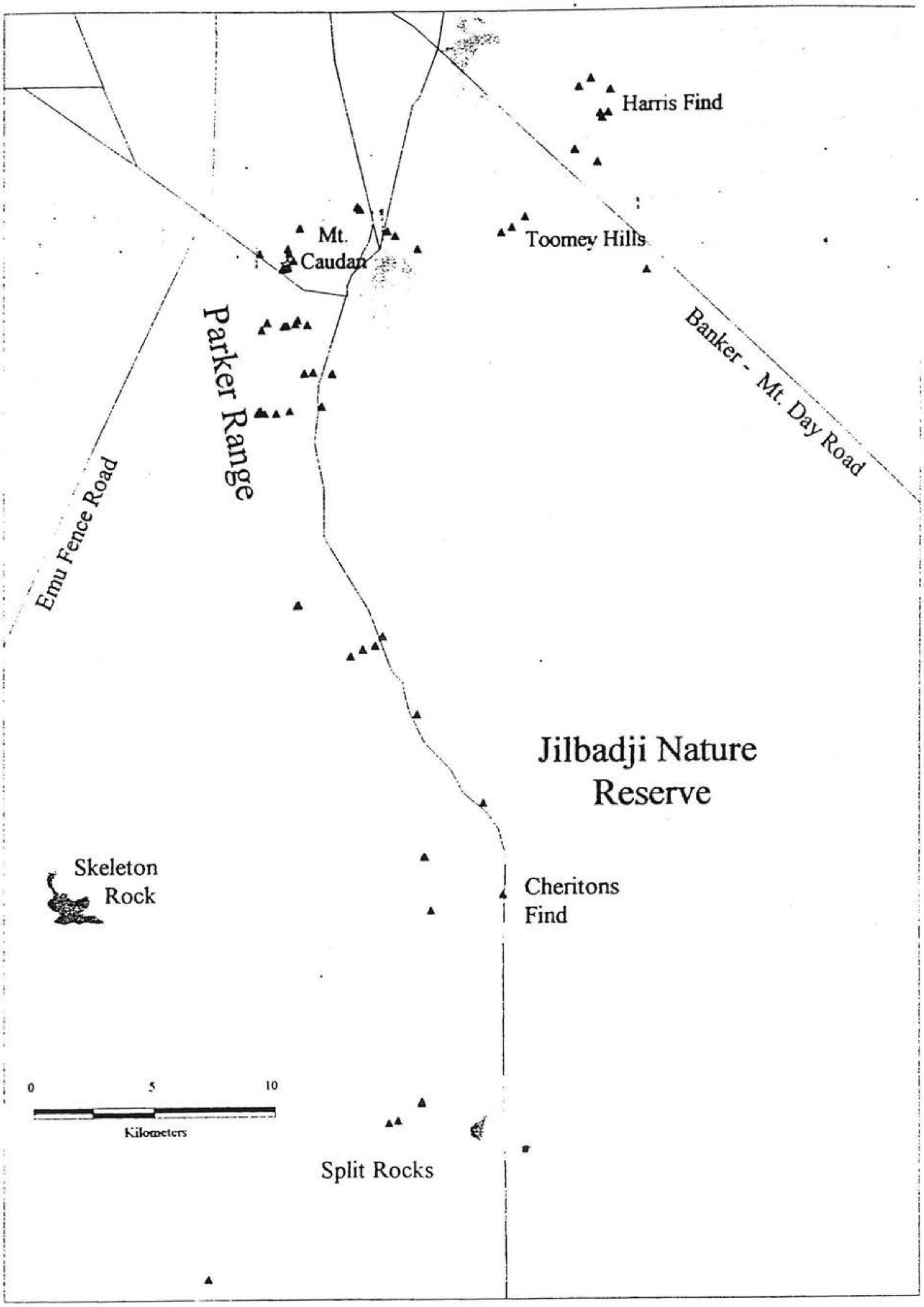


Figure 3. Parker Range area showing location of floristic survey sites.

RESULTS

FLORA

A total of 396 taxa (species, subspecies and varieties) were recorded from the 125 plots or the adjacent area. The commonest families were Myrtaceae (89 taxa), Asteraceae (36 taxa), Mimosaceae (29 taxa), Proteaceae (22 taxa), Poaceae (20 taxa), Chenopodiaceae (19 taxa), Myoporaceae (18 taxa), Orchidaceae (14 taxa) and Rutaceae (12 taxa). The patterns on both greenstone belts were very similar and typical of the flora of the South Western Interzone (Newbey & Hnatiuk 1988, Newbey *et al.* in press).

The most common genera were *Eucalyptus* (40 taxa), *Acacia* (29 taxa), *Melaleuca* (26 taxa), and *Eremophila* (16 taxa). Weed species were rarely encountered with only 12 being recorded. The 1994 spring was very poor for annual taxa except at a few water gaining sites. The reason for the lack of weed records was likely to be largely seasonal in nature.

During the survey one species of Declared Rare Flora (DRF) was recorded along with 14 taxa on CALM's priority flora list (CALM 1994). New populations of the DRF *Eucalyptus cerasiformis* were located, as were new populations of 12 priority taxa (Table 3, Figure 4 and 5).

Table 3. Declared Rare Flora and Priority Flora found during the survey indicating the number of new populations located (CALM 1994).

Taxon	*Current listing*	*Number of new populations*
Bremer Range		
Allocasuarina globosa	1	2
Acacia truculenta ms	3	3
Cryptandra polyclada	3	2
Eucalyptus cerasiformis	DRF	2
Eucalyptus georgei subsp. *georgei*	4	2
Eucalyptus rhomboidea ms	1	11
Halosarcia entrichoma	4	-
Parker Range		
Acacia asepala ms	2	4
Acacia concolorans ms	2	8
Acrotriche patula	2	3
Drummondita wilsonii	1	1
Gnephosis intonsa	1	2
Grevillea phillipsiana	1	4
Hakea pendens	2	15
Hemigenia obovata	1	1

The survey significantly extended the known range of *Eucalyptus rhomboidea* ms which was previously known only from near Mt Glasse (Henry-Hall 1990). This species also occurs on Mt Gordon to the east and north to Round Top Hill (Figure 4). Another significant range extension was recorded for *Hakea pendens* which was previously known only from the top of Mt Caudan and the nearby ridges with massive gossanous caps (Newbey *et al.* in press). This species was found to be much more widespread than previously thought, extending south to Cheriton's Find and north east to Harris Find (Figure 5). This species is not restricted to the

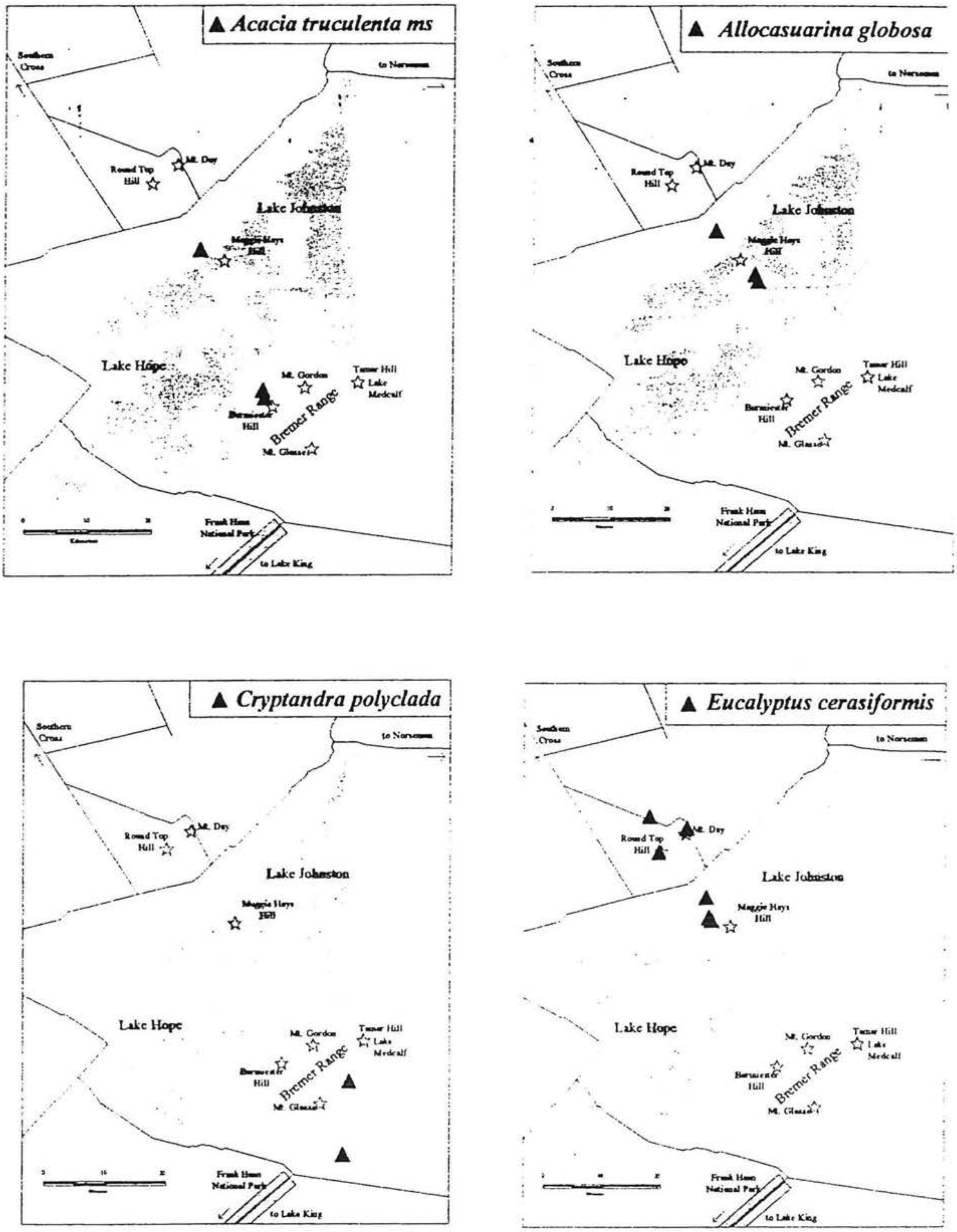
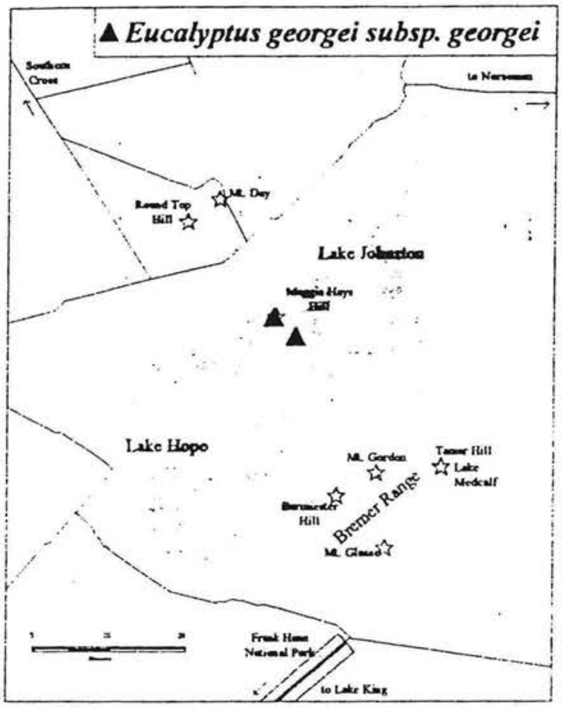


Figure 4. Declared rare and priority taxa from the Bremer Range area.



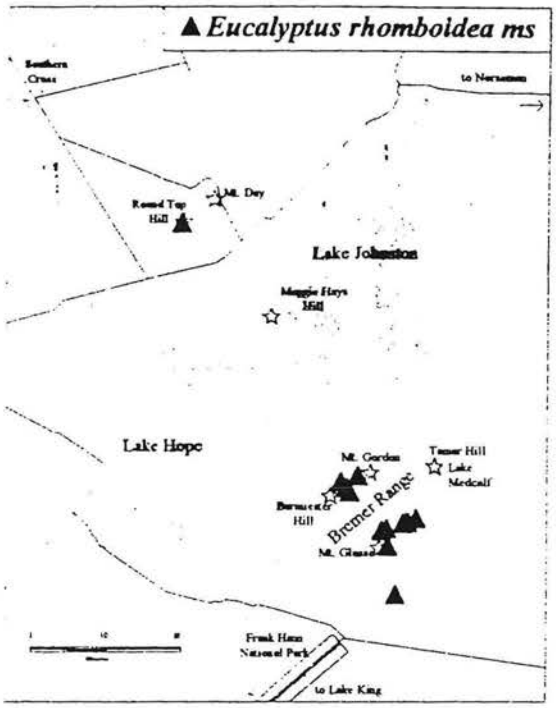


Figure 4 (cont.). Declared rare and priority taxa from the Bremer Range area.

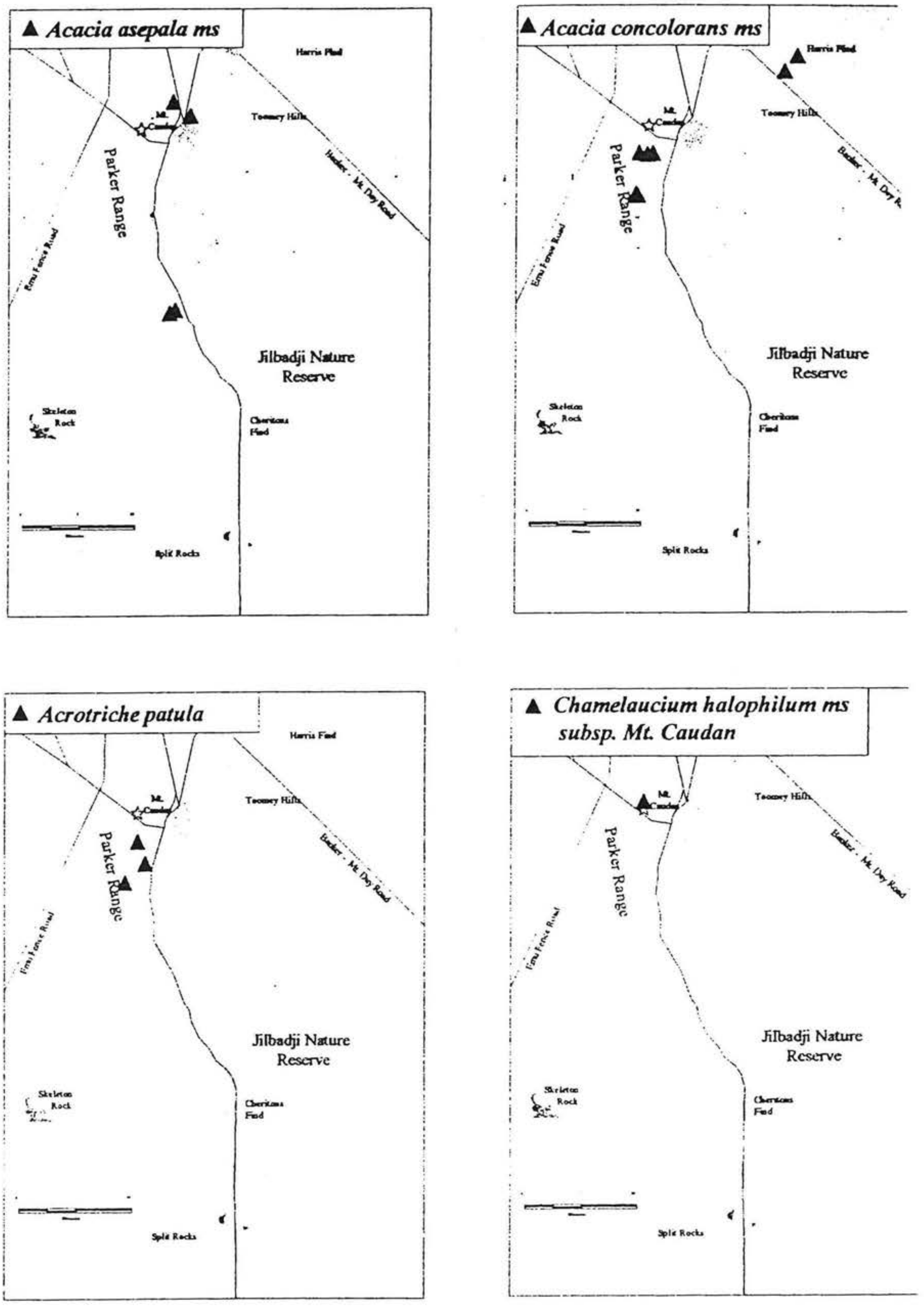


Figure 5. Priority and other significant taxa from the Parker Range area.

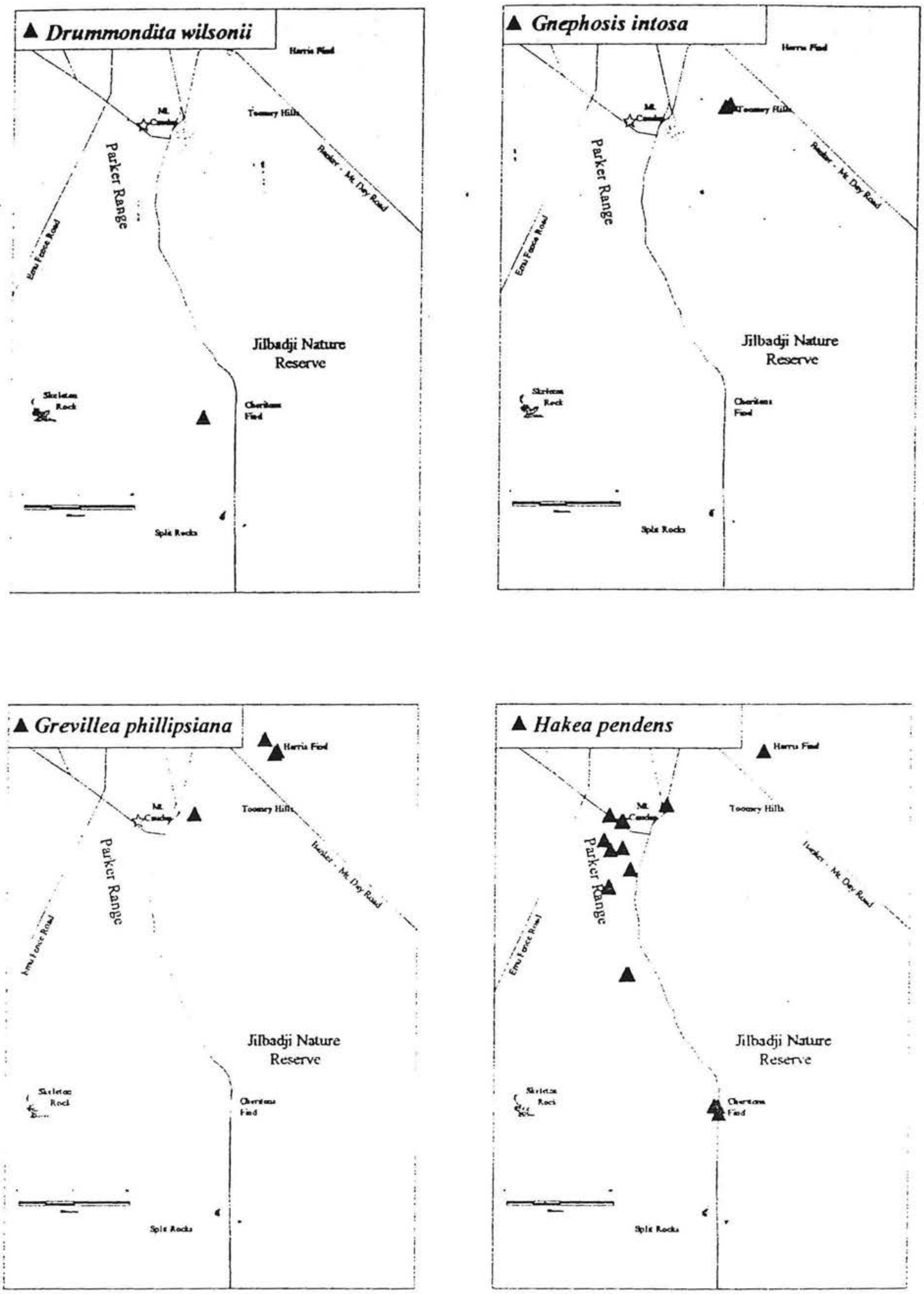


Figure 5 (cont.). Priority and other significant taxa from the Parker Range area.

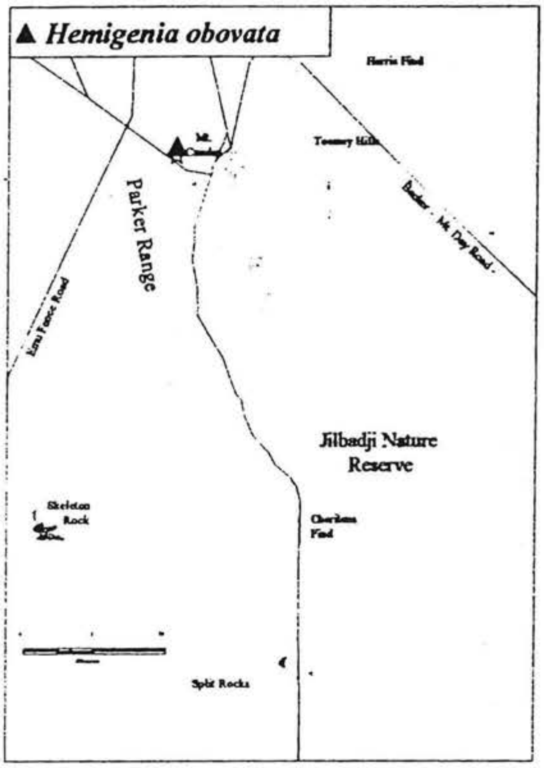


Figure 5 (cont.). Priority and other taxa of significance from the Parker Range area.

gossanous caps of the Mt Caudan area but is common on lateritic ridge tops of this greenstone belt.

Eucalyptus cerasiformis and *Eucalyptus rhomboidea* ms appear to be endemic to the Bremer Range - Mt Day greenstone belt. Similarly *Drummondita wilsonii* and *Hakea pendens* appear to be endemics to the Harris Find - Parker Range - Cheritons Find greenstone belt. In addition to these four taxa, four others are only known from a single population on these ranges and a fifth from three populations (Table 4, Figure 5 and 6).

An undescribed subspecies of *Chamelaucium halophilum* ms has been collected from Mt Caudan on three occasions, first by Basil Smith in 1989, and subsequently by Greg Keighery and during this survey. This deep pink flowered shrub is considered quite distinct from typical *Chamelaucium halophilum* ms (G.J. Keighery, personal communication).

Four other apparently undescribed taxa were located during the survey. *Euryomyrtus ciliata* ms (NG&ML 2037) was collected from three populations in the Parker Range area and is presently being described by M.E. Trudgen as part of his revision of the genus. Also in the Parker Range a large pink flowered *Isopogon* related to *Isopogon scabriusculus* was collected from a single population on sheet laterite only some 15 m off a major mining exploration track.

Table 4. New taxa from the study area showing recommended priority listing and the number of known populations

Taxon	*Recommended priority listing*	*Number of known populations*
Bremer Range		
Acacia sp (NG&ML 1959)	1	1
Billlardiera sp. Tamar Hill (NG&ML 1776)	1	1
Parker Range		
Chamelaucium halophilum ms subsp.		1
Mt Caudan (BH Smith 1255)	1	
Euryomyrtus ciliata ms (NG&ML 2037)	1	3
Isopogon sp. aff. *scabriusculus* (NG&ML 2077)	1	1

In the Bremer Range a new species of *Billardiera* was found on a greenstone ridge near Tamar Hill. This taxon was completely glabrous with large blue flowers. Eleanor Bennett who has previously revised this group, believes that this taxon is most closely related to *B. mollis* a DRF taxon which is found in the Ravensthorpe Ranges, 100 km to the south. Also in the Bremer Range, on heavy clay soils at the base of a greenstone ridge, an apparently undescribed *Acacia* sp. was found. This taxon is presently being studied by Bruce Maslin who is revising the genus.

It is recommended that these five taxa be listed on CALM's priority flora list as Priority 1, and that the other priority taxa listed maintain their current listings.

(Priority 1 taxa are defined as:- Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg. road verges, urban areas, farmland, active mineral lease, etc., or the plants are under threat, eg. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.).

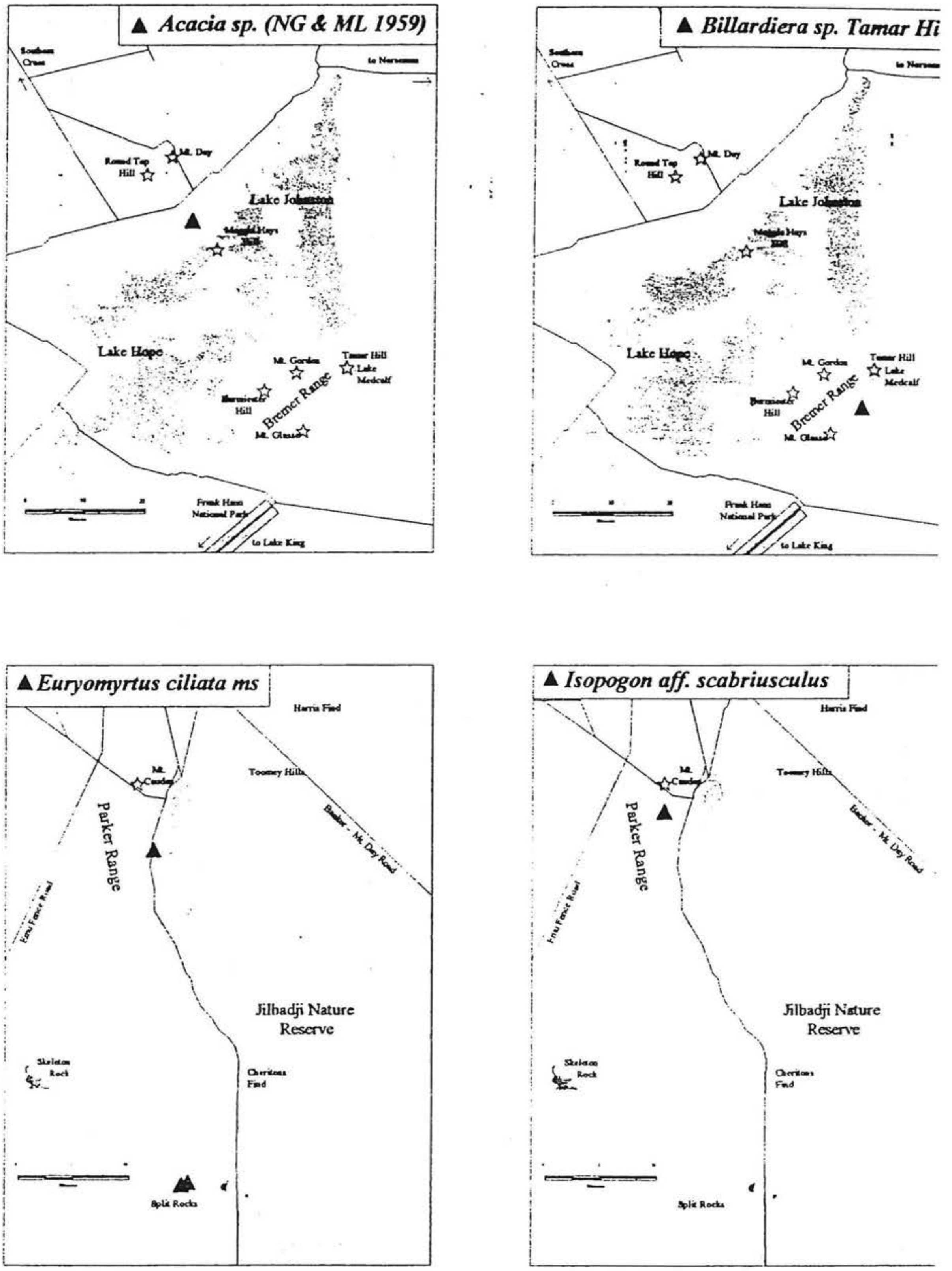


Figure 6. New taxa recorded during the current survey from the Bremer and Parker Ranges.

The present survey recorded 72 additional taxa from the Bremer Range area (cf. Newbey & Hnatiuk 1988) reflecting better access than was available a decade ago, and 49 additional taxa for the Parker Range area (cf. Newbey *et al.* in press) (Appendix 1). Some of these additions are a result of improvement in taxonomic knowledge.

A comparison of the flora between the Bremer and Parker greenstone belts show some remarkable discontinuities despite being separated by only 100 km. A major turn over in species is apparent between the two greenstone belts (Table 5). While the total flora of each belt is comparable (269 taxa for the Bremer greenstones and 256 taxa for the Parker greenstone) roughly half of the flora of each belt is unique to that belt.

Table 5. Comparison of the flora of the Bremer and Parker greenstone belts.

	Bremer greenstones	Parker greenstones	Shared taxa	Total taxa
Total flora	140	127	129	396
Eucalyptus spp.	11	10	19	40
Acacia spp.	9	12	8	29
Melaleuca spp.	10	5	9	26
Eremophila spp.	9	5	2	16

Analysis of the most common genera show similar patterns for *Eucalyptus* and *Acacia* species, but quite biased patterns for *Melaleuca* and *Eremophila* species (in favour of the Bremer greenstone belt).

VEGETATION

For the floristic analysis some species had to be amalgamated into complexes due to difficulty of differentiating between closely related taxa without good flowering material (eg *Hibbertia rostellata* complex, *Melaleuca pauperiflora* complex, see Appendix 3) Due to the poor season for annuals during the 1994 spring, annuals and perennials such as orchids were excluded from the analysis. Preliminary analysis of the perennial data set showed almost complete geographical separation of site groups from the Bremer Range area compared with the sites from the Parker Range area (as could be expected from major discontinuities in the flora (Table 5)). As a result the community analysis of the two greenstone belts was undertaken separately.

Bremer Range Plant Communities

Sixty four quadrats were established in the Bremer Range greenstone belt, 170 perennial taxa were recorded in these sites. Fifty eight species occurred at only one site. These singletons have little effect on the community classification and were excluded. As a result the final data set consisted of 112 taxa in 64 sites. Species richness ranged from three to 20 taxa per site, with individual taxa occurring in between two and 36 sites.

Multivariate analysis can assist in sorting both sites and species data such that patterns in species composition are more easily seen. The decision as to the number of site and species groups defined is subjective and related to the scale of pattern of interest (Kent and Coker

1992). In this analysis site groups are discussed at the six group level which best reflected the scale of patterning seen in the field.

The dendrogram shows the six community types recognised in the analysis (Figure 7). The primary division seen in the dendrogram between community types 1-4 and community types 5 and 6 separates the deeper more fertile soil types from the greenstone and lateritic ridges. This can also be clearly seen in the sorted two way table generated from the site and species classifications (Table 6). The first four community types are eucalypt woodlands.

Community type 1 generally occurs on the side slopes of low ridges and is typified by the high fidelity of species groups G and H (Table 6). This community type is typically dominated by *Eucalyptus rhomboidea* ms and *E. eremophila*. This community type was largely restricted to the Bremer Range proper but also occurred flanking Round Top Hill (Figure 2). *Melaleuca* species in the *M. pauperiflora* complex were common components of the understorey in this community and community types 2 and 3. *Eremophila clavata* ms was also common in community types 1 and 2, while *Acacia deficens* and *Grevillea acuaria* were largely restricted to this community type.

The second community type was the typical *Eucalyptus flocktoniae* woodlands of the area. Other eucalypts co-occurring in this community included *E. salubris*, *E. salmonophloia*, *E. dundasii* and *E. tenuis* (Figure 8). This community type largely lacked species in species group G and H, while species in group I occurred at moderate to high frequency and species group J was largely restricted to it (Table 6). It may be possible to further divide this community into a northern and a southern subgroup based on species in groups I, J, and K. Typical understorey species included *Daviesia argillacea*, *Dodonaea stenozyga* and *Acacia poliochroa*.

Generally *Eucalyptus flocktoniae* and / or *Eucalyptus longicornis* dominated community type 3. This community was typical of the more saline soils as indicated by the high fidelity of many species from species group K (eg. *Chenopodium curvispicatum*, *Maireana radiata*, *Sclerolaena diacantha* and *Zygophyllum apiculatum*). Again species in the *M. pauperiflora* complex were common in the understorey. This community was restricted to ridges and flats adjacent to the large salt lake systems (Figure 9).

Community type 4 is similar in species composition to type 3 but has a lower frequency of the saline tolerant species (Table 6, species group K). It was often dominated by *Eucalyptus longicornis* and / or *E. salmonophloia* but can also be dominated by *E. georgei* subsp. *georgei* or *E. dundasii*. This community generally had lowest species richness of any of the eucalypt woodlands (mean 8.9 taxa / plot cf. 14.4, 12.0 and 11.8, for types 1 to 3 respectively). *Olearia muelleri* was the most faithful of the understorey species (Figure 10).

The last two community types were common on the greenstone and / or lateritic ridge tops. Species from species groups A, B, E and F were typical of these communities (Table 6). These sites were generally dominated by either *Eucalyptus livida* Woodland (on the lateritic tops) or by *Allocasuarina* Thickets (on the greenstone ridges). Species typical of community type 5 include *Allocasuarina campestris*, *Eucalyptus livida*, *Lepidosperma* sp. A2 (Figure 11). Community type 6 occurred on the massive greenstone ridges with skeletal soils. Typical species from species group B included *Acacia duriuscula*, *Allocasuarina globosa*, *Eucalyptus georgei* subsp. *georgei* and *Eucalyptus oleosa* (Figure 12). Mean species richness dropped from 13.2 in community type 5 to 6.5 in community type 6. Community type 5 was widespread throughout the Bremer Range area mostly on lateritic breakaways. Community type 6 was only found on a greenstone ridge near Maggie Hay Hill (Figure 2).

Figure 7. Dendrogram of the sites from the Bremer Range area showing the six group level classification.

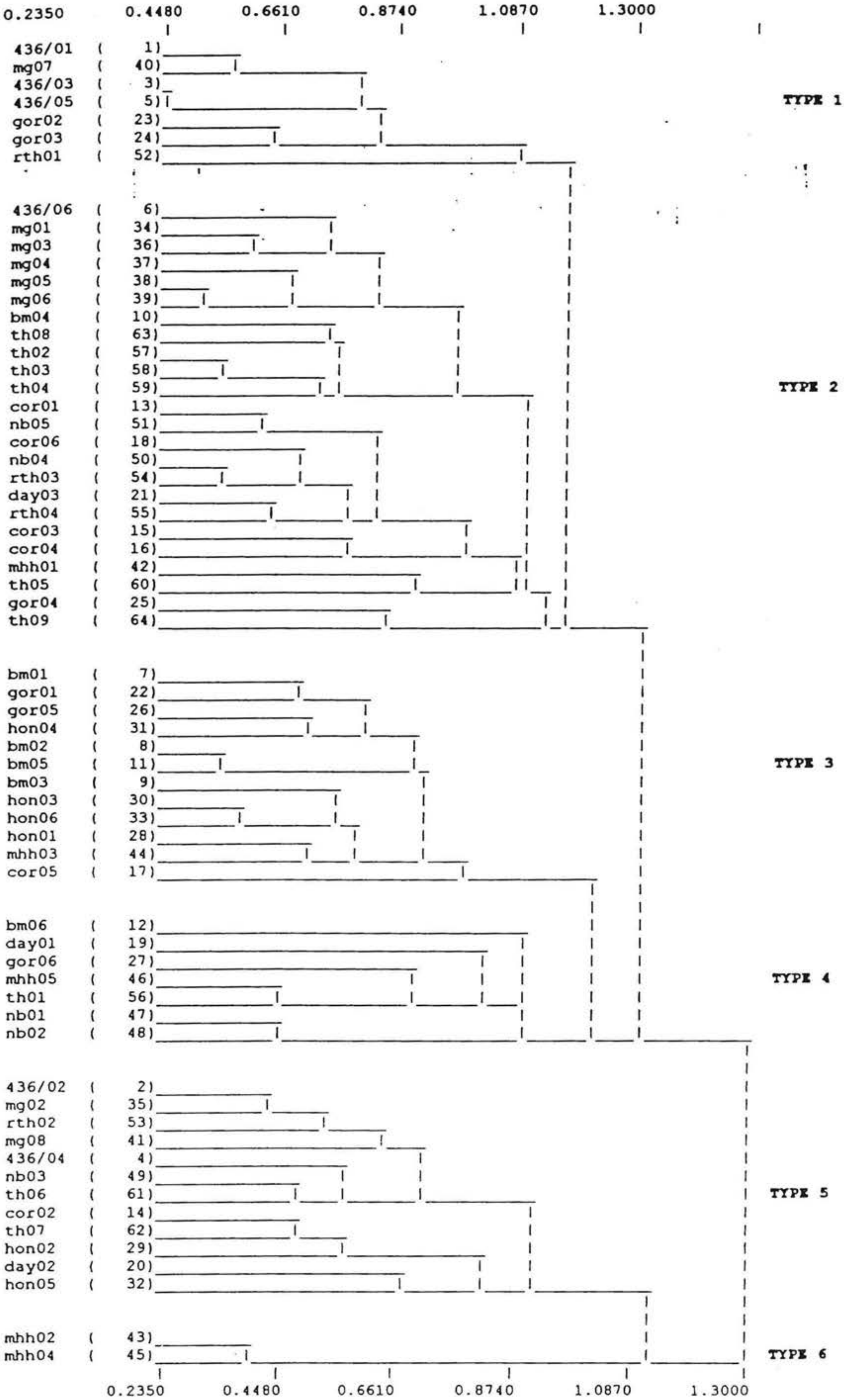


Table 6. Sorted two way table of the Bremer Range greenstone sites showing species occurrence by community type. Site codes appears as columns, species code as rows (see Appendix 1 for full species name).

```
                                       COMMUNITY TYPE
             1                 2                    3         4          5        6
                                                                                    SPECIES
                                                                                     GROUP
TAXA
          4m44ggr|4mmmmmbttttcncnrdrccmtgt|bgghbbbhhhmc|bdgmtnn|4mrm4ntcthdh|mm
          3g33oot|3gggggmhhhhobbbtatoohhoh|mooommmoooho|maohhbb|3gtg3bhohoao|hh
          6066rrh|60000000000r0r0hyhrrh0r0|0rrn000nnnhr|0yrh000|60h0600r0nyn|hh
          /7//000|/134564823405040000000509|100025300000|6000112|/208/3607000|00
          0 00231|0          1 6 334341 4 | 154   36135| 165   |0 2 0  2 225|24
          1 35   |6                       |            |       |2   4       |
                 |                        |            |       |            |
ACAACU           |                        |        *   |       |       * ** |
DODMICAC         |                        |      * *   |       |       * *  |
ALLACU           |                        |            |       |        *  *|     A
DIAREV          *|                        |            |       |          **|
DODLOB           |                        |            |       |          **|
PTIOBO           |                        |        *   |       |           *|
          -------+------------------------+------------+-------+------------+--
ACADUR           |                    *   |            |       |            |**
ALLGLO           |                        |            |       |            |**
EUCGEOGE         |                        |            |   *   |            |*
CHEAUS           |                        |            |       |       *  **|**   B
EUCOLE           |                        |            |       |         ** |**
EREDECDE         |                    *   |            |*      |            |
          -------+------------------------+------------+-------+------------+--
ACABLA           |                  *     |           *|       |            |
EUCCER           |                  *     |            |       |  *       * |
TRISCA          *|                        |            |       |  *         |     C
EUCTRA          *|             *     *    |            |       |  *         |
GREONC         **|             * *        |            |       |            |
          -------+------------------------+------------+-------+------------+--
ACAMER           |                   * *  |            |     * |            |
EUCCYLc          |                     *  |            |     * |            |
EUCLXO           |                     *  |*           |       |            |     D
GREPEC           |               *     *  |            |       |            |
          -------+------------------------+------------+-------+------------+--
ACAUNC           |                        |            |       |** **       |
HAKSCO           |                        |            |       |****        |
CHACIL           |                        |            |       | * *        |
HEMTER           |                        |            |       |*  *        |
MELCORd          |                        |            |       |**          |
BAECRI           |                        |            |       | **         |
CALQUA           |                        |            |       |***     *   | *    E
DAMTEN           |                        |            |       | *      *   |
CRYPOL           |                        |            |       | *    *     |
HIBROS           |                        |            |       | *   **     |
POMFOR           |       *                |            |       |*           |
          -------+------------------------+------------+-------+------------+--
ALLCAM           | *                **    |            |       |***** ** ** |
COMVOL           |             *          |           *|*      |*** *****   |
LEPIA2          *|                  *     |            |       |***  ** ** *|
EUCLIV           |                        |            |       |*   *****  *|
PHETUB      *    |           *   *   * *  |            |* *  * |**  *  ***  |
MELUNC    * **   |                        |            |       | *******    |
WESCEP    ****   |                  *     |   *     *  |      *| **** *     |
BEYBRE           | *   * *                |         *  |       |    **  **  |
HAKCOM           | **                     |            |       |       **   |     F
TRYMYR           |                  *     |            |       |       ***  |
PHEFIL           |*                       |            |       |     *   * *|
ALLHEL           |                        |            |       |     *      |*
THRKOC           |                        |            |       |   * *      |
DODBUR       *   |                        |            |       |    ***     |
RINSES           |                        |            |       |    **   *  |
          -------+------------------------+------------+-------+------------+--
ACACAM      **   |                        |            |     **|            |
ACAHYSHY  * **   |                        |            |    *  |            |
DAVBEN     ***   |           *            |            |       |            |
EUCERE    ****** |                        |            |       |    *       |     G
MELACU      **   | *                      |            |       |            |
MELLAT      **   |                        |            |       |            |
MELPEN      **   |                        |            |       |            |
          -------+------------------------+------------+-------+------------+--
```

```
ACADEF    ***  * | *             **     |           |       |           |
EUCRHO    *******|* *                   |           |       |*    *     |
GREACU      **** |*                *   *|           |       |   *       |
WILHUM     * * * |  **             *   *|           |       |           |
BORINOIN  *      |    *           *     |           |       |           |        H
CASMEL    **     |                      |           |       |           |
PULARI    **     |   ***                |          *|       |           |
MELELE    **    *|                      |           |       |  *        |
MELPHO     *     |* *                   |           |       |           |
          -------+----------------------+-----------+-------+-----------+--
ACAERI     *  ** |*    *      *  * **   |           |  *    |           |*
DAVARG     *   * |*** *     * *  ****** |           |       |   ** *    |
ERECLA    ****** |*    * ** **********  |          *|     * |      *    |
DODSTE     *   * |*** * ***** **** * * *|*       *  |       |           |
EUCFLO    *   *  |************ ******   | **   **** |       |           |
EXOAPH    ** *   |**** * **   **        |  ** **** *|  *    |   *      *|
MELPAU    *******| ****** **** ** * ****|******* ***|  *   *|           |
EUCSALu    *     |* ** *      ***   * **|      **   |       |           |
SANACU    ***    |*** ***   **      *   |  *  ***** |     * |* * **  *  |
MICMULMU    * *  |    *       *    * ** |    *      |       |           |        I
ACAPAC     *     |*          *      *   |          *|     **|      *    |
EUCSALm          |*            *      * |  **       |*    **|      *    |
EUCYIL           |*               *     |           |     * |  *        |
ACAPOL           |***       * *****  *  |* *        |       |           |
EUCDUN           |              **   *  |         **| *     |           |
EUCTEN           |           ******     |   *   *   |       |      * *  |
GREHUE           |            * * *     |           |  *  **|           |
SCASPI           |            *** *     |   *    *  |     **|      *    |
HALRIG           |            *   ***   |   *    * *|       |           |
EREALT           |                      |   *       |     **|           |
          -------+----------------------+-----------+-------+-----------+--
CASRAC           |    **                |           |       |           |
EREDENPU         | *  **                |           |       |           |
EREPSI    *   *  |    ** ** *           |    *      |       |           |
EUCANN           |**  * **              |  *        |       |           |        J
EUCPIL           |** ***** *            |     *     |       |           |
WESRIGBR  **     |********           *  |           |       |           |
EUCCAL           | *    *           *  *|           |       |           |
          -------+----------------------+-----------+-------+-----------+--
ACATRU           |     *      *         |      *    |       |           |
ATRACUKA         |                      |  * **     |       |           |
ENCTOM           |         *            |     **    |*      |           |
EREINT           |   *                  |      *    |       |           |
ATRVES           |                      |    ** **  |*  **  |           |
RHADRU           |                      |    * * *  |*  **  |          *|
ERERUG           |                      |       ** *|       |           |
CHECUR           |                      |  *******  |       |          *|
MAIRAD           |                      |****** *  *|       |           |
SCLDIA           |                      |***********|       |           |        K
ZYGAPI           |         *     **     |** ** *****|   *   |           |
CASNEM           |         *            |   *   *   |      *|         * |
CRACON           |               *      |*  *  *    |  * *  |           |
ERESCO           |*              **    *|****       | *  *  |           |
EUCLON           |     *                |    **  *  |  **  *|           |
PTIHOL           |       **             | *    *   *|  ***  |           |
ALYBUX           |     * ***          * |       *   |       |      *** *|
STEINT           | *     *              | *     *   |       |          *|*
OLEMUE      *   *|     **** ** * *      | * *       | ******|  * **    *|
STIELE        *  | ** * *****     *  *  |**  * ***  |   *** |  *   *  **|
EUCMEL           |       *           *  |           |    *  |           |
MELLAN           |      **              |           |    *  |           |
```

Figure 8. Community type 2, Eucalyptus tenuis - E. salmonophloia - E. salubris - E. flocktoniae *woodland at site NB04. Note tall* Melaleuca *shrub layer.* E. flocktoniae *in flower to right of observer.*

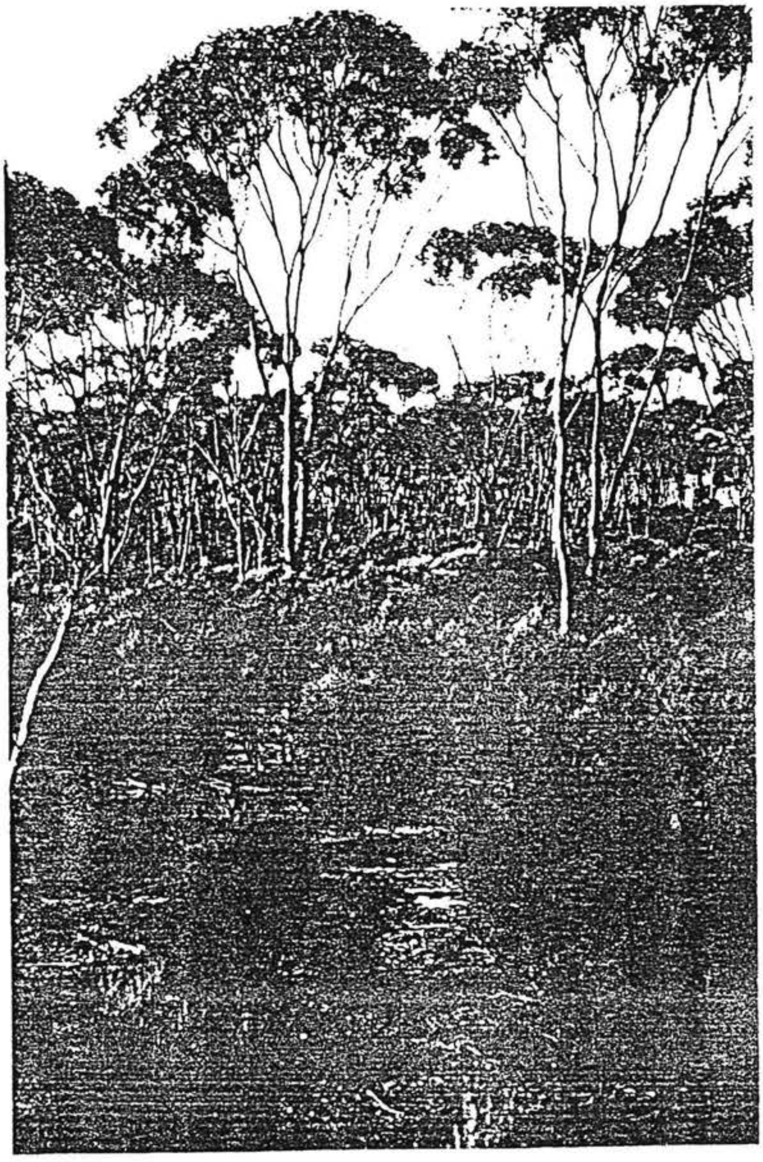


Figure 9. Community type 3, Eucalyptus dundasii - E. flocktoniae *woodland at site MHH03*

Figure 10. Community type 4. Eucalyptus longicornis *woodland at site NB02*

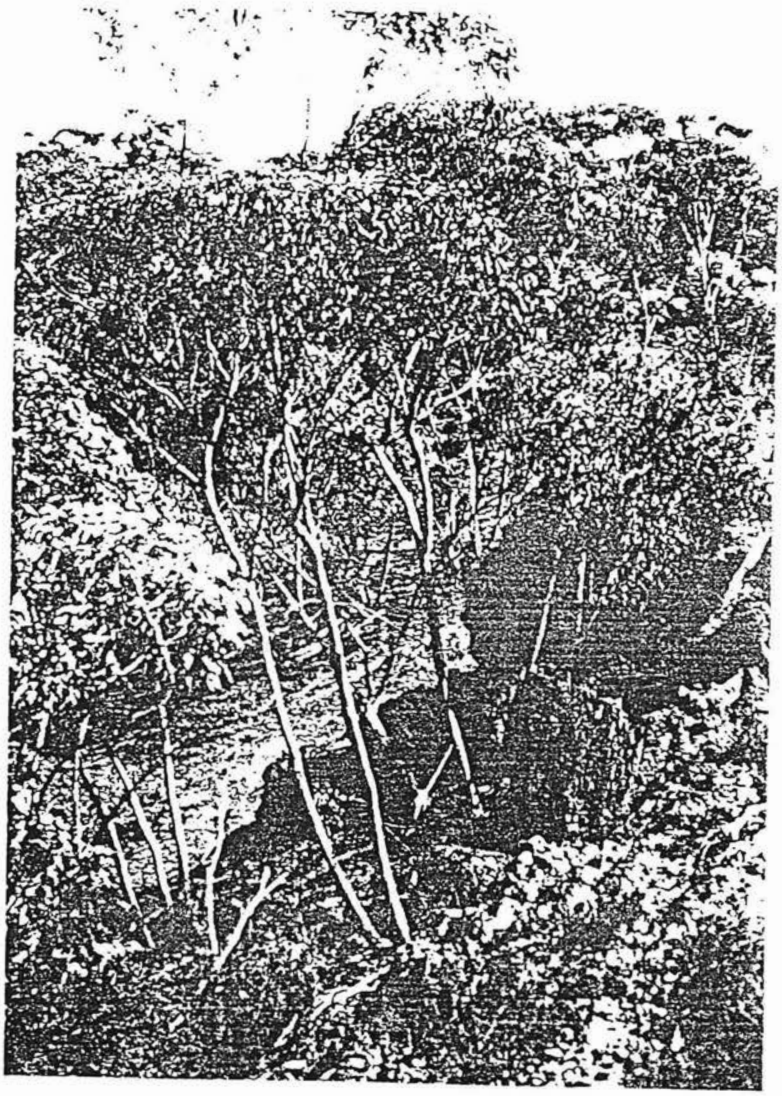


Figure 11. Community type 5 Eucalyptus livida *woodland on lateritic breakaway near site COR02*

Figure 12. Community type 6, Allocasuarina globosa - Calothamnus quadrifidus *Thicket on greenstone ridge at site MHH02.*

Environmental correlates

Comparison of floristic groups with geology

The geology of the study area has been mapped and described in Lake Johnson 1: 250000 sheet (Gower & Bunting 1976) , Boorabbin 1: 250000 sheet (Hunter 1991) no more detailed geological information has yet been published. Fourteen geological units were sampled during the present study, a brief description is given below.

Table 7. Geological units sampled during in the Bremer Range area (after Gower & Bunting 1976).

Age	Map Symbol	Description
Caniozoic Quaternary	Qrc	Colluvium - red-brown to buff silt, sand and gravel, rock fragments
	Qpk	Eolian desposits - kopi; gypsum and clay forming dunes and sheets; marginal to salt lakes
	Qpf	Alluvial and reworked eolian deposits - clay to sand, gypsiferous in part; marginal to salt lakes
	Qpl	Alluvium and colluvium - clay, loam and silt, calcareous in part; quartz, ironstone gravel,weathered rock float, gilgai
	Qqs	Clay, silt and sand, calcareous; contains sheet and nodular kankar
	Qqf	Clay, silt and sand with ironstone pebble veneer, calcareous; mantels low hills
Tertiary	Czl	Limonite deposits - cemented ironstone gravel and laterite
Archaean	Alb	Mafic extrusive rocks, fine to medium grain (Glasse formation)
	Ahw	Chert, ferruginous chert, banded ironstone formation (Honman formation)
	Amd	Mafic intrusive rocks, medium to coarse grain (Maggie Hays formation)
	Amb	Mafic extrusive rock, fine to medium grain (Maggie Hays formation)
	Amn	Mafic extrusive rock, fine to medium grain, porphyritic(Maggie Hays formation)
	Amh	Mafic hornfels, fine grained amphibolite
	As	Tuffaceous or clastic rocks

When the surfical geology is compared to the floristic classification of the perennial flora of the Bremer Range area little correlation is found (Table 8). Even in higher order classifications (eg. geological age) no degree of correlation is discernible. This lack of correlation is likely to arise from the different sampling scales between the floristics and the geological mapping. It is clearly apparent that geological mapping at this scale could not be used to predict floristic community types.

Table 8. Comparison of 1:250000 surfical geology with floristic classification of perennial plants from the Bremer Range area.

Geology Units	Community Type 1	Community Type 2	Community Type 3	Community Type 4	Community Type 5	Community Type 6
Qrc	2	1		1	2	
Qpk				1		
Qqf	1	2			1	
Qpl	1	1	1		1	
Qqs		2		1		
Qpf	1	2	1			
Czl	1	5	2		4	
Alb		4	4			
Ahw			1		1	
Amd		1				
Amb	1	4	3	3	3	1
Amn						1
Amh		2				
As				1		

Correlation with soil and geomorphological parameters

The soil parameters in particular showed high levels of intercorrelation (Table 9), making it difficult to suggest to which parameter (or parameters) the vegetation is responding. Significant differences between floristic group means were found for most of the soil parameters measured (Table 10).

Soils from community type 3 had the highest pH, total N, total P, and highest exchangeable Ca, Mg, Na, and K. Soils from community type 2 were the next most fertile but had lower mean values of total P and lower exchangeable Na. Soils of community type 4 also were much lower in exchangeable Na than community type 2 as well as having lower mean values for total P and N. Community type 1 tended to occur on sandier soils than the other lower slope woodlands reflected by lower mean % silt and its low mean total N and P values. The mean pH of the soils of lateritic and greenstone ridge tops sites (community types 5 and 6) were well below the other community types.

The highest fertility soils were those of community type 3. This community generally occurred on large flats adjacent to salt lakes. The saline nature of the soils can be seen from the high mean value of electrical conductivity and high mean values of exchangeable cations, in particular Na.

Ordination results

Ordination of the sites data was undertaken to show spatial relationships between groups and to better elucidate possible environmental correlates with the classification. A measure of how good the ordination fits the original association matrix is termed the stress value. This value decreases as the number of dimensions in the ordination increases and a compromise between minimizing stress values and number of dimensions in the solution has to be reached. In the present analysis stress values decreased from 0.34 in a two dimensional solution, to 0.23 in a three dimensional solution, to 0.19 in a four dimensional solution. Consequently the results of the three dimensional solution are reported below. Superimposed on the ordination output are best fit linear correlations of the environmental parameters measured using principal axis correlation (Belbin 1993). All parameters were range standardised prior to fitting.

Table 9. Matrix of spearman rank correlation coefficients between environmental parameters. Only correlations significant at P<0.01 shown (r≥0.3245). See Appendix 4 for method of measurement of soil parameters.

	ALTITUDE	ASPECT	CAEXCH	CLAY	EC15
ALTITUDE	1.000				
ASPECT		1.000			
CAEXCH			1.000		
CLAY				1.000	
EC15			0.662		1.000
KEXCH			0.712		0.649
MGEXCH			0.692	0.475	0.736
NAEXCH			0.491	0.434	0.829
NTOT			0.762		0.792
PH15			0.645		0.659
PTOT	-0.339				
SAND			-0.550	-0.822	-0.460
SILT			0.691		0.504
SLOPE		0.635			
TOPO					

	KEXCH	MGEXCH	NAEXCH	NTOT	PH15
KEXCH	1.000				
MGEXCH	0.617	1.000			
NAEXCH	0.524	0.799	1.000		
NTOT	0.544	0.544	0.512	1.000	
PH15	0.641	0.603	0.564	0.551	1.000
PTOT				0.497	
SAND	-0.552	-0.608	-0.499		-0.414
SILT	0.664	0.475	0.334	0.556	0.540
SLOPE					
TOPO					

	PTOT	SAND	SILT	SLOPE	TOPO
PTOT	1.000				
SAND		1.000			
SILT		-0.753	1.000		
SLOPE				1.000	
TOPO					1.000

NUMBER OF OBSERVATIONS: 64

Table 10. Wisker plots of soil parameters for which there was a significant difference between the means of the floristic community types, Bremer Range. (Community types are rows, soil parameters are columns)

KEY
L=lower limit.....1=1st Quartile.....M=mean
D=Median.....3=3rd quartile.....U=upper limit
*=more than one symbol at print position

Electrical conductivity (mS/m)   Kruskal-Wallis statistic: 30.110 df: 5 Probability < 0.001

```
   0.5000             17.38             34.25             51.13             68.00
 GRP +-----------------+-----------------+-----------------+-----------------+

   1    *=============D==M====3---------------------------------------U
   2        L--------1===D=====M========3---------------U
   3                 L----------1===========DM==============3-------------U
   4        L---1=====D===*-------------------------------------U
   5 L--*===M==3-----------------------U
   6     *==*==*
```

pH   Kruskal-Wallis statistic: 40.038 df: 5 Probability < 0.001

```
    5.000             5.950             6.900             7.850             8.800
 GRP +-----------------+-----------------+-----------------+-----------------+

   1                                L-------1==========M=D=========3---U
   2                                           L-----------------1=M=D3--U
   3                                                     L------------1MD=3--U
   4                                           L------1=======M===D===3-U
   5 L-----------------------1==MD===3--------------U
   6                                   *===*====*
```

N total (%)   Kruskal-Wallis statistic: 24.510 df: 5 Probability < 0.001

```
   0.3900E-01         0.1250            0.2110            0.2970            0.3830
 GRP +-----------------+-----------------+-----------------+-----------------+

   1 L1==D===M====3---------U
   2    L---------1====DM===3------------------------U
   3                  L--------1=======DM===3-----------------------------------U
   4       L-1====D===*-------------------------------U
   5  L1====D====M=====3-----------------------------U
   6          ***
```

P total (%)   Kruskal-Wallis statistic: 20.494 df: 5 Probability = 0.001

```
    43.00             102.3             161.5             220.8             280.0
 GRP +-----------------+-----------------+-----------------+-----------------+

   1     L----1====*=3----------U
   2 L--------1====*===3--------U
   3                  L---1=====D===M==3-------------------------------------U
   4          L----1==D=====M=======3-------------U
   5    L----1=======D=M=3-------------------------------------U
   6            **
```

% Silt Kruskal-Wallis statistic: 11.448 df: 5 Probability = 0.043

```
     4.000           9.250           14.50           19.75           25.00
GRP +----------------+---------------+---------------+----------------+

 1         L--------1==D=======M=========3--------------------U
 2 L----------------------------1============M====D=======3-----------U
 3                               L---1=====DM======3----------U
 4               L---------1=========M==D=======3---U
 5        L---1==========D==M=====3--------------------------U
 6                                                *==*=*
```

Exchangeable Ca (me%) Kruskal-Wallis statistic: 26.246 df: 5 Probability < 0.001

```
     2.900           11.17           19.45           27.72           36.00
GRP +----------------+---------------+---------------+----------------+

 1 L-1====D==M====3-----------U
 2      L----------------1======*=========3-------U
 3                      L--1==D====M====3--------------------------U
 4     L--------1=========M====D====3---U
 5 L1===D=====M=====3---------------------U
 6            *=======*=======*
```

Exchangeable Mg (me%) Kruskal-Wallis statistic: 30.407 df: 5 Probability < 0.001

```
     0.7100          4.032           7.355           10.68           14.00
GRP +----------------+---------------+---------------+----------------+

 1         L-1==D===M====3----------U
 2            L--------1===========DM=========3-----------------------U
 3                 L-----------1==D=M==3-------------------------U
 4     L-------------1=DM3---------------------U
 5 L--1==D===M=====3---------------U
 6           *====*====*
```

Exchangeable Na (me%) Kruskal-Wallis statistic: 26.579 df: 5 Probability < 0.001

```
     0.7000E-01      0.8525          1.635           2.418           3.200
GRP +----------------+---------------+---------------+----------------+

 1   L-------1====D===M=======3--------------U
 2   L------1=====D======M=======3-------------------------------------U
 3           L--1===================MD============3---------------U
 4     L1===D=M=====3------U
 5 *=D==M3---------------------U
 6   ***
```

Exchangeable K (me%) Kruskal-Wallis statistic: 37.149 df: 5 Probability < 0.001

```
     0.2000          0.8250          1.450           2.075           2.700
GRP +----------------+---------------+---------------+----------------+

 1     L-1========M==D===3--U
 2 L---------------------1=======MD======3----------------------------U
 3                 L-----------------1===DM==3-------------------------U
 4                   L-------1=====DM=====3----------U
 5 L-1==*=3-----U
 6           *
```

The ordination shows a major gradient related to soil fertility with community type 3 occupying the most fertile sites. At approximately 90 degrees to this gradient, a clear separation is seen between the ridge top communities (types 5 & 6) from the lower slope communities (Figure 13). Along with the significant correlation with % sand in this direction, it appears that soil moisture availability (or soil water holding capacity) is a secondary underlying gradient.

Parker Range Plant Communities

Sixty one quadrats were established in the Parker Range greenstone belt, 171 perennial taxa were recorded in these sites. Fifty eight species occurred at only one site. These singletons have little effect on the community classification and were excluded. As a result the final data set consisted of 113 taxa by 61 sites. Species richness ranged from six to 29 taxa per site, with individual taxa occurring in between two and 29 sites. Again a six group level classification best reflected the scale of pattern seen in the field.

The dendrogram shows the six community types recognised in the analysis (Figure 14). The primary division seen in the dendrogram between community types 1-3 and community types 4-6 again separates the deeper more fertile soil types from the greenstone and lateritic ridges. This can also be seen in the sorted two way table generated from the site and species classifications (Table 11). The first three community types are eucalypt woodlands while the last three include both woodland and thicket communities.

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 codominants. The most typical understorey species were *Davesia argillacea* and *Grevillea huegelii*. Species groups I and J were the most faithful to this community type. This community type also shared species in species group A with the three upland community types (types 4-6).

Eucalyptus longicorins generally dominated community type 2. Other eucalypts that occurred as codominants included *E. corrugata* and *E. salubris*. At one site this community was dominated by *E. myridena*. This community type occupied the broad flats. Species from species group G were the most typical of this community. Mean species richness was quite low at 10.0.

Another community of the broad flats within the greenstone belt was community type 3. It was generally dominated by *Eucalyptus salmonophloia* and *E. salubris*. Typical understorey species of this community include *Eremophila oppositifolia* subsp. *angustifolia* ms, *Acacia concolorans* ms, *Dodonaea stenozyga* and *Scaevola spinescens*. It had a higher mean species richness (12.9) compared to community type 2. Species patterning in species groups A and G suggests that further subdivision into a northern and a southern subgroup is possible (Table 11).

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 and 15.5) but quite low in type 6 (9.5).

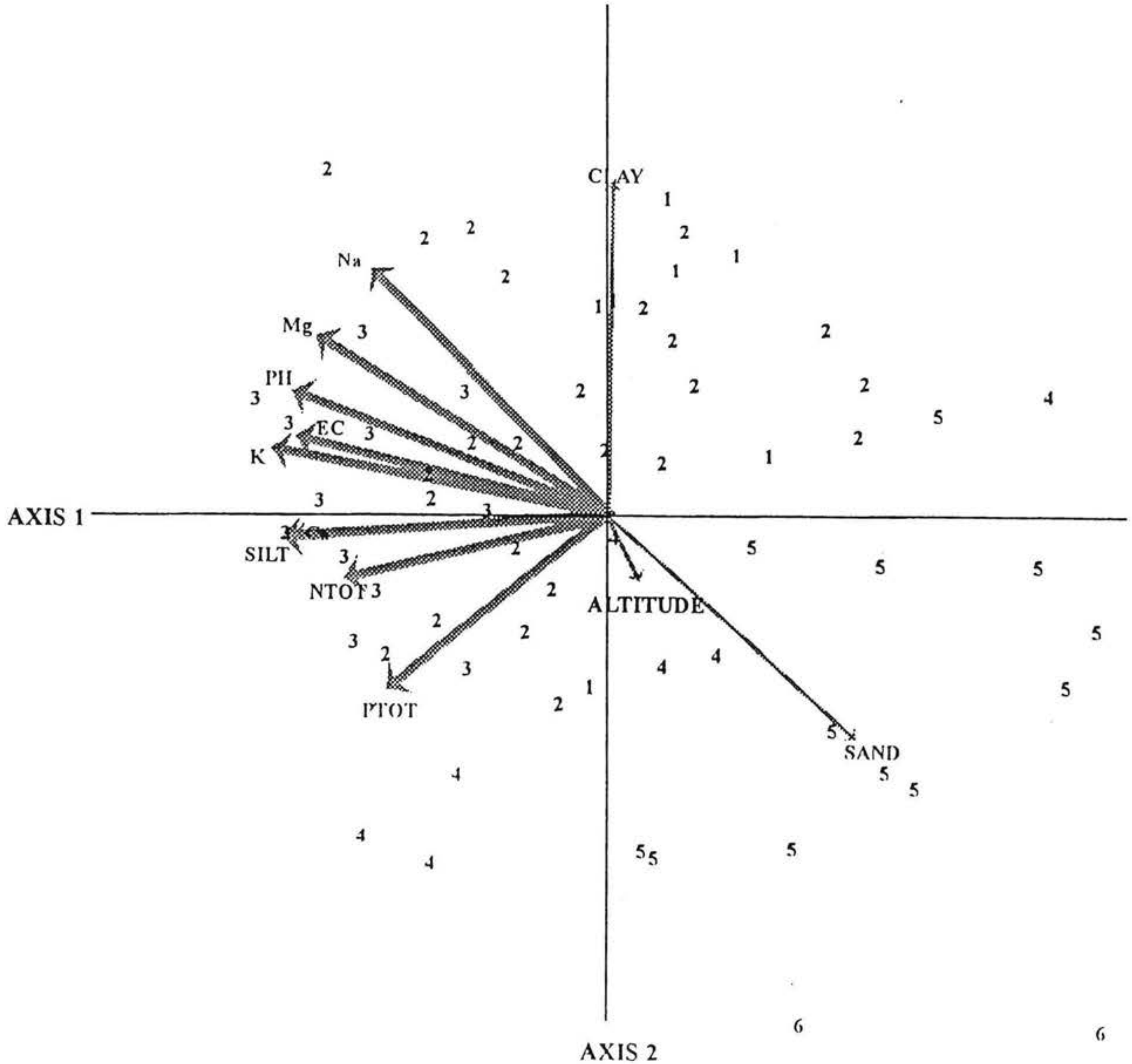


Figure 13: Ordination of Bremer Range sites with numbers corresponding to community types. Arrows show the direction of best fit linear correlations for environmental parameters. Narrow arrows are significant at less than or equal to 0.01 and broad arrows at less than or equal to 0.001, n= 64.

Figure 14. Dendrogram of the sites from the Parker Range area showing the six group level classification.

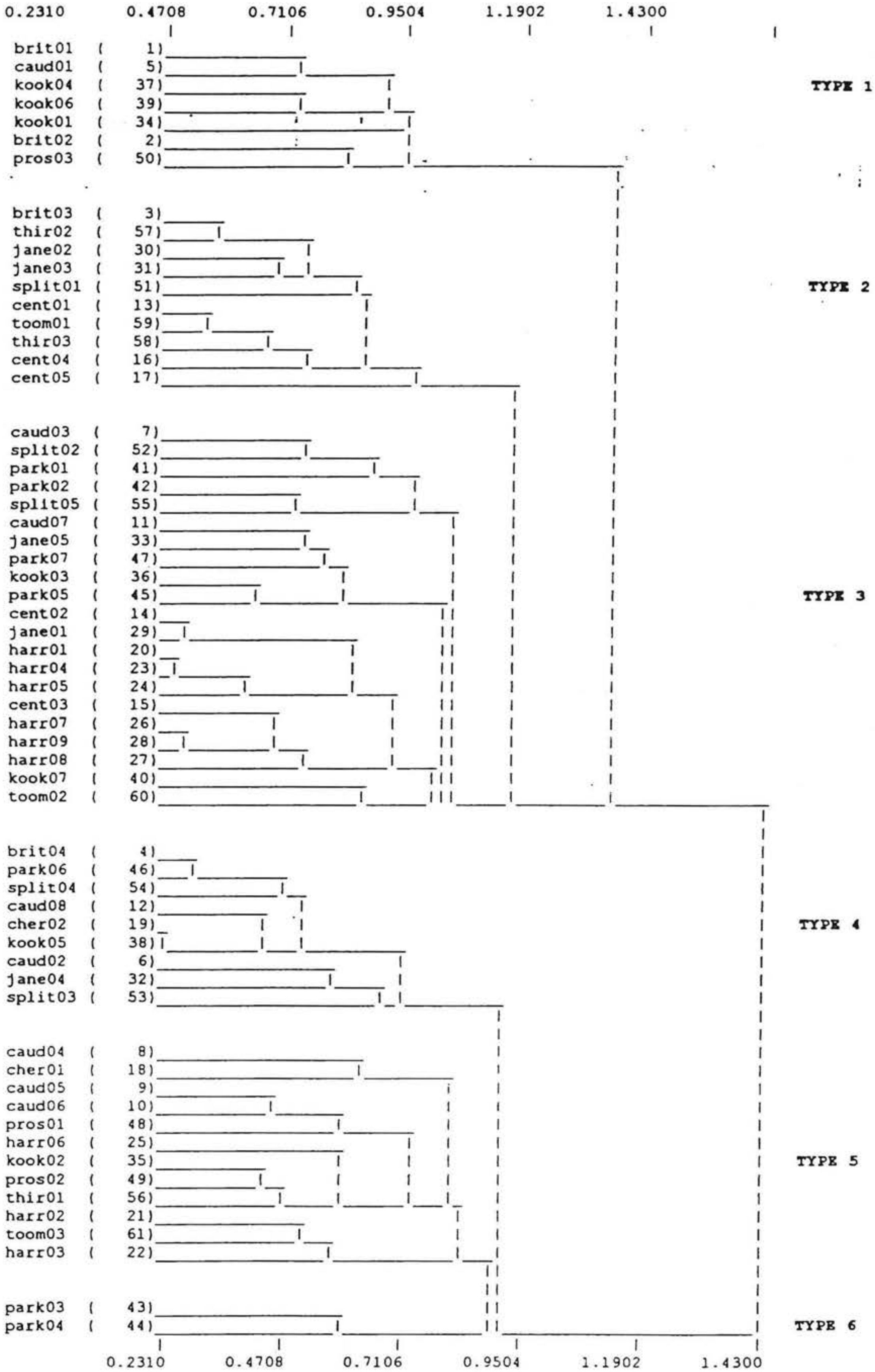


Table 11. Sorted two way table of the Parker Range greenstone sites showing species occurrence by community type. Site codes appears as columns, species code as rows (see Appendix 1 for full species name).

```
                                COMMUNITY TYPE
             1        2                3               4          5        6
                                                                                   SPECIES
                                                                                   GROUP
          bckkkbp|btjjscttcc|csppscjpkpcjhhhchhhkt|bpscckcjs|ccccphkpthth|pp
          raooorr|rhaapeohee|apaapaaaoaeaaaaeaaaoo|rapahoaap|ahaaraorhaoa|aa
          iuoooio|iinnlnoinn|ulrrlunrornnrrrnrrroo|irlueounl|ueuuorooiror|rr
          tdkkkts|treeitmrtt|dikkidekkkterrrtrrrkm|tkidrkdei|drddsrksrrmr|kk
          0000000|0000t00000|0t00t0000000000000000|00t00000t|000000000000|00
          1146123|3223011345|301207573521145379872|460825240|415616221233|34
                 |    1     | 2  5                |  4     3|            |
                 |          |                     |         |            |
                 |          |                     |         |            |
ACAACU     *     |          |                   * |   *** **|  * * ****  |
ALLACU     *  *  |          |        *            |**** ****| *   ** ** *|
EUCCAPPO   ** *  |          |        *            |**     * |  **  ***   |*
HAKPEN        * *|          |                     |   *     | **  ****   |
PHETUB        *  |          |* **                 |   *  ** |***   ***  *|*
COMVOL        *  |          |                     |  **     |      ***   |**
MICRAC           |          |   *                 | * *     |  **  * *   | *
ALLCAM           |          |                     |*        |*****     **|       A
TRYMYR           |          |   *                *|       * | **        *|*
HIBEXA     *     |          |                     |      *  |* *         |
ACAHEM     *    *|          |*  **                |        *|          * |
LEPIA2          *|          |                     |        *|*       * * |
MELELE        *  *|          |                     |        *|         ** |
EUCLOX          *|          |                     |       * |    *    ***|
MELUNC     **  **|          | *                   |   *   **|     **  ** |**
WESCEP    *** ***|          |        *            |        *|*     ** ***|
PHEFIL     **    |          |        *            |       * |      *  ***|
          -------+----------+---------------------+---------+------------+--
ACRPAT        *  |          |                     |         |        *   | *
BORCON           |          |   *                 |         |        *   | *
CHEAUS           |          |                     |         |  * *****   |
EREGRA           |          |                     |         |     *  *   |       B
PROINC           |          |*                    |       * |        *   |
CALGLA           |          |                     | *       |            |**
LEPISPf          |          |                     | *       |            | *
          -------+----------+---------------------+---------+------------+--
ACAFRA           |          |                     |         |  **        |
HAKSUB           |          |                     |      *  |  **     *  |
CASFIL           |          |                     |  *      |    *       |
ASTSER           |          |                     |      *  | *          |
ACANEU           |          |                     |*** *    |    *     * |
CALGIL           |          |                     |*** **   |* *** *   * |
GREOBL           |          |                     |* ****   |  *** ** ***|
HIBROS           |          |                     |*********| ******** **| *     C
ALLCOR           |          |                     |***** ***|         *  |
BAEELD           |          |                     |* *******|   *        |
GREPAR        *  |          |                     |*******  |   *     ***|
MELCORd       *  |          |                     |* *** * *| * **       |
CASGLA      *    |          |                     |    **** |            |
THRKOC      **   |          |                     |** ***   |            |
EUCBUR           |          |                     |*  *     |   *        |
EUCLEP           |          |                     |    **   |            |
MELCAR           |          |                     |**   *   |            |
MICMAI           |          |                     |   ***  *|            |
          -------+----------+---------------------+---------+------------+--
EUCLIV           |          |                     |  *     *| *          |
HAKFRA        *  |          |                     |  *     *|            |       D
EURCIL           |          |                   * |        *|            |
          -------+----------+---------------------+---------+------------+--
GREONC        *  |          |                     |      *  |            |       E
HIBPUN        *  |          |                     |         |      *     |
          -------+----------+---------------------+---------+------------+--
ACACOL           |          |*                    |         |           *|
DODBUR           |          |                     |         |          **|
DODMICAC         |          |                     |         |    ** *   *|
EUCCAPCA         |          |                     |         |     *     *|       F
EREDECDE         |    *    *|*                    |         |         *  |
OLEPIM     *     |          |*                    |         |     *   *  |
EUCCOR           |          |                  * *|         |         ** |
EUCOLE           |          |               *     |         |         * *|
          -------+----------+---------------------+---------+------------+--
```

```
ACAASE           |  ** *  * |                     |         |             |
EUCCON           | ***      |                     |         |             |
EUCCAL         * | *        |          **         |         |             |
ACAPAC           |      **  |                     |         |             |
ATRVES           |     **** |                **   |         |             |
EUCMEL           |      *   |                 *   |         |             |
ERESCO           |**   *****|     **       *****   |         |             |
SCLDIA           |    ***   |        *************|         |             |
TEMSUL           |* ******  |          *******   *|         |             |
EUCLON           |********* |               ****  |         |*            |
ZYGGLA           |   * **   |                  *  |         |             |      G
EUCYIL           |          |*           ***     *|         |             |
GREPHI           |         *|            ***      |         |             |
LYCAUS           |        **|             *       |         |             |
MAIRAD           |          |  *               *  |         |             |
ZYGAPI           |         *|                  *  |         |             |
MAITRI           |          |              *  **  |         |             |
RHADRU           |         *|              * *** *|         |             |
PTIHOL           |          | *         *    * *  |         |             |
ACAPOL           |          |  **                 |         |             |
CASNEM           |         *|                     |         |*            |
          -------+----------+---------------------+---------+-------------+--
ACACON      * *  |          |   *   ***    * *    |         |             |
EREOPPAN         |          |   * *****   * ***  *|         | *           |*
EUCSALm      *   |          |   ************      |         | *           |
ACAERI        * *| *        |***  *  **  ****  *  |       * |**     *     |
OLEMUE    *   ***|** *     *| * ** * **   *  *****|         |*      *     |*
EUCSALu      **  | *    * * |***  *  ***** ***  **|       * |             |
EXOAPH     *    *|       *  |** **     * **  ***  |         |             |
SCASPI     * *   |          |*  **   **  *** ***  |         |**           |
STIELE    **     |***  *** *|*****    **********  |         |    *** * *  |      H
ACAMER          *|***** * **|  * **     ***  *   *|        *| *           |
MELPAU    * *  **|*** ** ***| ** ********   *** * |         | *           |
EREION        *  |   * **   | *   *     ***  *    |         |             |
AMYMIQ     *     |     *  * |       *     * *  *  |         |           * |
DODSTE           | *        |  ***          ** * *|         |            *|
ALYBUX    **     |          |** * *  *   *  ****  |         |*** ** ***   |**
SANACU    *****  |** *     *|        *   **      *|**     **|**    **    *|
BEYBRE           | *        |                  ***|      ** |*     *      |
          -------+----------+---------------------+---------+-------------+--
ACACAM      **   |          |*                    |         |  *          |
MELLAT       * * |          |***                  |         |             |
PTIGAU         * |          |**                   |         |  *          |
DAVARG    *******|  *       |  *      *           |       * |             |
EUCSHE    ***** *|          |   *                 |         |*            |
MELACU      *** *|          |**      *            |       * |             |      I
EUCERE     *  ***|          |                     |         |             |
EREDRU      *    |          | *    *              |         |             |
GREHUE    * ** **|          |             *       |         |             |
GREACU      *   *|          | *  *                |     *   |             |
EUCTRA    ***    |  *    *  |     * *           * |         |             |
PHEMEG    ***    |          |                     |        *|             |*
          -------+----------+---------------------+---------+-------------+--
CASMEL      ***  |          |                     |         |             |
MELURE      **   |          |                     |         |             |      J
DIAREV      *    |          |                     |         |      *      |
          -------+----------+---------------------+---------+-------------+--
ERESAL          *|          |                     |         |       *     |
LOMEFF          *|         *|                     |         |       *     |
MELASP          *|    *     |                     |         |             |      K
PTIDRU          *|          |*                    |         |             |
MICMULMU        *|          |    *  * **          |         |             |
```

Community type 4 was generally dominated by *Allocasuarina acutivalvis* and *Allocasuarina corniculata*. At some sites *Eucalyptus capillosa* subsp. *polyclada* (an eastern form of *E. livida*) also occurred, but this species was more typical of community type 5. Other species typical of this community type included *Baeckea elderiana* and *Thrytomene kochii* further illustrating the sandy nature of these sites.

While closely related to type 4, community type 5 almost totally lacked *Allocasuarina corniculata*, 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 celphalantha* were common understorey elements. Figure 15 shows this community type in the foreground and community type 3 on the flats below.

The species-poor uplands on massive greenstone formed community type 6. These were dominated by low trees of *Callitris glaucophylla*. A large undescribed pink flowered *Isopogon* related to *I. scabriusculus* was found at one of these sites (Figure 16).

Figure 15. Community type 5 in the foreground (dominated by Eucalyptus capillosa *subsp.* polyclada) *with community type 3 on the flats in the background (dominated by* E. salmonophloia *and* E. salubris).

Figure 16. Community type 6, Callitris glaucophylla *Low Open Woodland on massive greenstone ridge.*

Environmental correlates

Comparison of floristic groups with geology

The geology of the study area has been mapped and described in Southern Cross 1: 250000 sheet (Gee 1982), and more detailed geological information is available on the Chertons Find 1: 100000 sheet (Bagas 1991). Eleven 1: 250000 and eleven 1: 100000 geological units were sampled during the present study a brief description is given below.

Table 12. The 1: 250000 geological units sampled during in the Parker Range area (after Gee 1982).

Age	Map Symbol	Description
Cainozoic Quaternary	Qa	Sandy loan; alluvial wash
	Qc	Clay, sitl, sand; buff or red, with quartz fragments and calcareous nodules; mainly colluvial deposits
Tertiary	Ts	Clean sand, yellow to white, containing scattered limonite nodules; remnants of extensive Tertiary sandplain.
	Tl	Laterite; limonite nodules in cemented matrix; grades upwards into Ts and downward into weathered bedrock.
Archaean	Alp	Pelitic metasediments containing quartz, biotite, muscovite, graphite, andalusite, felspar, garnet, cordierite, amphibole.
	Aap	Para-amphibolite, from mafic and ultramafic sedimentary material; generally finely laminated.
	Aad	. Amphibolite; medium-grained, with remnant igneous textures
	Aab	Amphibolite; fine-grained; derived from mafic volcanics.
	Aub	Chlorite-tremolite rock;derived from komatitic basalt
	Aux	Serpentine; includes talc carbonate schist

When the surfical geology is compared to the floristic classification of the perennial flora of the Parker Range area little correlation is found (Table 13). Although community type 3 was found primarily on the Alp unit, all the other five community types also occur on this unit.

Table13. Comparison of 1:250000 surfical geology with floristic classification of perennial plants from the Parker Range area.

Geology Units	Community Type 1	Community Type 2	Community Type 3	Community Type 4	Community Type 5	Community Type 6
Qa		1				
Qc		2	1			
Ts	2					
Tl	1	1	2	5	4	
Alp	4	3	12	4	7	1
Aap			2			
Aab		2				1
Aad		1				
Aub			1			
Aux			3		1	

Comparison of the 1: 250000 and 1: 100000 geology sheets shows the 1: 250000 units to be very broad. Given the lack of correlation with the 1: 250000 geology units a comparison of floristic community type and the 1: 100000 geology units was also undertaken. Eleven mapping units were sampled on the Chertons Find sheet (Table 14).

Again there was not a tight correlation between community type and geological unit, indicating that geological units by themselves are not a good surrogate for floristic community type (Table 15).

Table 14. The 1: 100000 geological units sampled during in the Parker Range area (after Bagas 1991).

Age	Map Symbol	Description
Cainozoic	Czl	Alluvial and eolian deposits adjacent to playa lakes; clay, silt and sand, gypsiferous in part.
	Czr	Poorly developed soil (clay, silt and sand) of alluvial, colluvial and eolian origin.
	Czc	Cooluvium - gravel, snad and silt as sheetwash, fann deposits and talus.
	Czs	Sandplain - yellow to white sand with ferricrete near base
Age uncertain	gs	gossan commonly developed over massive sulphides.
Archaean	Ash	Graphitic and sulphidic schist and phyllite; iron enriched.
	Aci	Banded ironstone formation.
	Aab	Amphibolite (basalt); fine-grained tremolite-chlorite rock.
	Aak	Amphibolite (basaltic komatite); fine- to medium-grained.
	Aad	Amphibolite (dolerite and grabbo); medium- to coarse-grained
	Aux	Ultramafic - Pyroxenite with talc-chlorite (carbonate)

Table15. Comparison of 1:100000 surfical geology with floristic classification of perennial plants from the Parker Range area.

Geology Units	Community Type 1	Community Type 2	Community Type 3	Community Type 4	Community Type 5	Community Type 6
Czl	1	1	1	5	5	
Czr	1	4	4			
Czc		1	2			
Czs	2					
gs					1	
Ash	3		8	4	6	2
Aci			2			
Aab		3	1			
Aak			1			
Aad		1	1			
Aux			1			

Correlation with soil and geomorphological parameters

Again soil parameters in particular showed high levels of intercorrelation (Table 16), making it difficult to determine possible causal factors for the observed vegetation patterning. As with the Bremer Range dataset there were significant differences between floristic group means for most of the soil parameters measured (Table 17).

The Parker Range (although still subdued) had more pronounced relief than the Bremer Range. This can be seen in significant differences between the community types in terms of both mean altitude and mean topographic position (scored subjectively from 1 indicating ridgetops to 4 broad flats). Community types 2 and 3 generally were found on broad flats at lower altitude. Community types 1, 4 and 6 generally occurred higher in the landscape while community type 5 occurred whereever laterite surfaces had formed.

The *Eucalyptus salmonophloia - E. salubris* flats (community type 3) were slightly more saline than the *E. longicornis* flats (community type 2). Both of these community types had the highest mean pH, and total N. Community type 1 had much sandier soils than either of the other two woodland communities although little salinity was evident (Table 17).

Of the three laterite and greenstone communities, community type 3 had the highest pH and highest mean N and P levels. Soil mechanical analysis did not separate communities 4 and 5, however soil tended to be deeper in community type 5. The skeletal soils of community type 6 were almost purely clay.

Ordination results

The Parker Range sites were also ordinated to show spatial relationships between groups and to better elucidate possible environmental correlates with the classification. In the ordination stress values decreased from 0.27 in a two dimensional solution, to 0.21 in a three dimensional solution, to 0.17 in a four dimensional solution. Consequently the results of the three dimensional solution are reported below (Figure 17). Superimposed on the ordination output are best fit linear correlations of the environmental parameters measured using principal axis correlation (Belbin 1993). All parameters were range standardised prior to fitting.

Table 16. Matrix of spearman rank correlation coefficients between environmental parameters. Only correlations significant at $P<0.01$ shown ($r \geq 0.3325$). See Appendix 4 for method of measurement of soil parameters.

	ALTITUDE	ASPECT	CAEXCH	CLAY	EC15
ALTITUDE	1.000				
ASPECT		1.000			
CAEXCH	-0.408		1.000		
CLAY			0.413	1.000	
EC15			0.714	0.551	1.000
KEXCH	-0.514		0.822		0.661
MGEXCH	-0.356		0.838	0.527	0.781
NAEXCH			0.632	0.601	0.929
NTOT			0.766	0.338	0.732
PH15	-0.495		0.840		0.593
PTOT	-0.354		0.475		
SAND			-0.674	-0.853	-0.772
SILT	-0.383		0.791	0.429	0.729
SLOPE		0.662			
TOPO	-0.365		0.410		
	KEXCH	**MGEXCH**	**NAEXCH**	**NTOT**	**PH15**
KEXCH	1.000				
MGEXCH	0.862	1.000			
NAEXCH	0.676	0.843	1.000		
NTOT	0.551	0.603	0.594	1.000	
PH15	0.904	0.816	0.576	0.514	1.000
PTOT	0.422			0.540	
SAND	-0.602	-0.748	-0.760	-0.618	-0.528
SILT	0.777	0.779	0.677	0.738	0.730
SLOPE					
TOPO	0.563	0.485	0.396		0.524
	PTOT	**SAND**	**SILT**	**SLOPE**	**TOPO**
PTOT	1.000				
SAND		1.000			
SILT	0.342	-0.800	1.000		
SLOPE				1.000	
TOPO			0.418		1.000

NUMBER OF OBSERVATIONS: 61

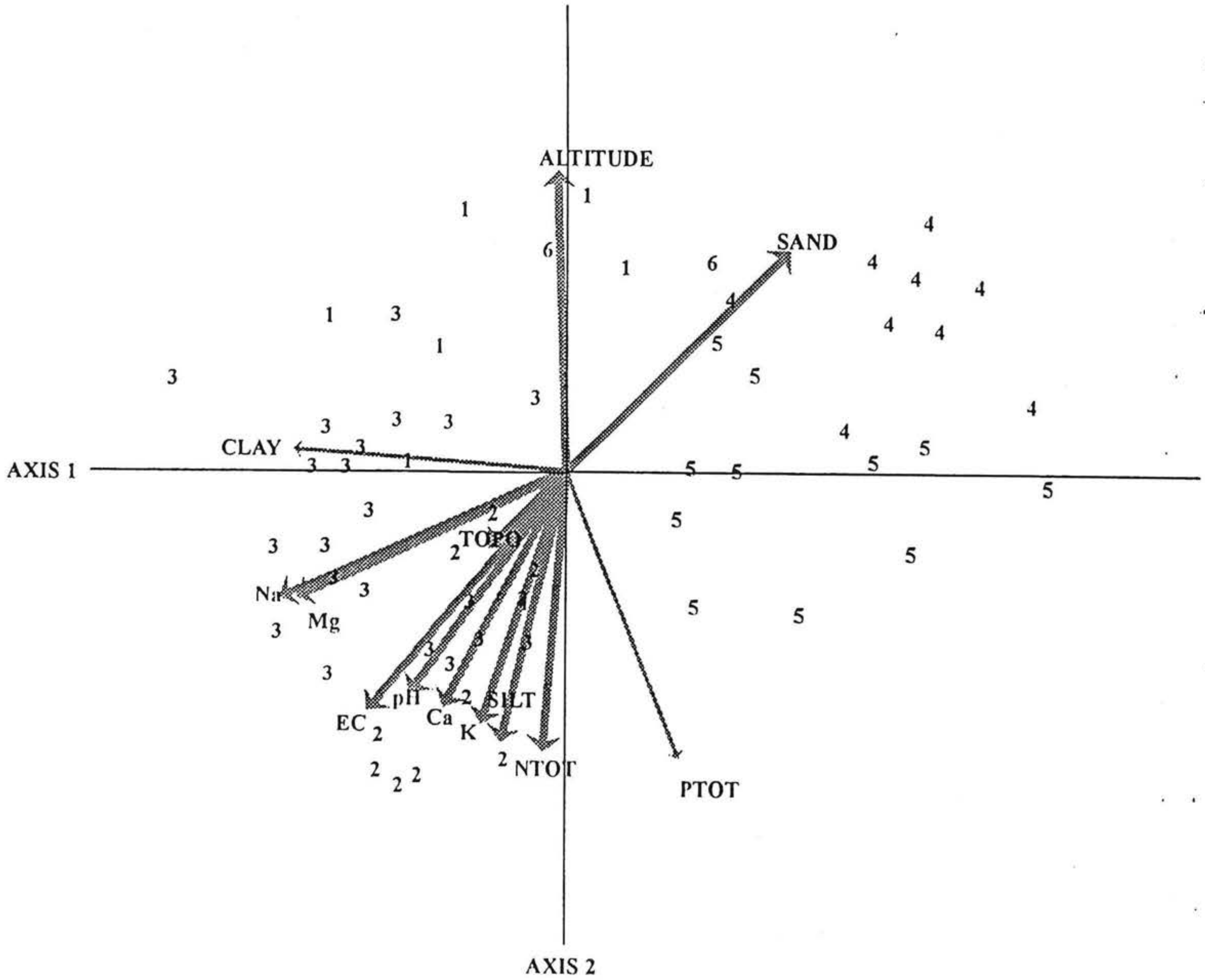


Figure 17. Ordination of Parker Range sites with numbers corresponding to community types. Arrows show the direction of best fit linear correlations for environmental parameters. Narrow arrows are significant at less than or equal to 0.01 and broad arrows at less than or equal to 0.001, n=61.

Table 17. Wisker plots of soil parameters for which there was a significant difference between the mean of the floristic community types, Parker Range. (Community types are rows, soil parameter are columns)

KEY

L=lower limit.....1=1st Quartile.....M=mean

D=Median.....3=3rd quartile.....U=upper limit

*=more than one symbol at print position

Altitude (m) Kruskal-Wallis statistic: 13.759 df: 5 Probability = 0.017

```
   380.0            395.0            410.0            425.0            440.0
GRP +----------------+----------------+----------------+----------------+

 1                          *==================M===D==========3----------U
 2  *=====D======M==========3----------------------U
 3  *=======================D==M===================3---------------------U
 4                          *================M=====*---------------------U
 5  L-----------1===========D===M=======3--------------------------------U
 6                                                 *
```

Topographic position Kruskal-Wallis statistic: 17.655 df: 5 Probability = 0.003

```
   1.000            1.750            2.500            3.250            4.000
GRP +----------------+----------------+----------------+----------------+

 1  L-----------------------1======================M=====================*
 2  L--------------------------------------------------------------M-----*
 3  L--------------------------------------------------------------M-----*
 4                          *===================M==D=====================*
 5                          *==================M===*---------------------U
 6                          *===========*==========*
```

Electrical conductivity (mS/m) Kruskal-Wallis statistic: 29.866 df: 5 Probability < 0.001

```
   2.000            31.50            61.00            90.50            120.0
GRP +----------------+----------------+----------------+----------------+

 1  L*M=3-U
 2    L-----1==D====3-M--------------------------------------------------U
 3  L--1=======DM====3---------------------U
 4  **--U
 5  *D3M---------------U
 6              *===*===*
```

pH Kruskal-Wallis statistic: 44.984 df: 5 Probability < 0.001

```
   4.200            5.325            6.450            7.575            8.700
GRP +----------------+----------------+----------------+----------------+

 1                             L-1=D===M==3----------U
 2                                                        L-----1==MD3--U
 3                                       L-------1=========M====D====3----U
 4        L----1=======DM=======3------------U
 5               L----------------1===M==D===3---U
 6  *=============*=============*
```

N total (%) Kruskal-Wallis statistic: 23.894 df: 5 Probability < 0.001

```
 0.2000E-01       0.6400E-01        0.1080           0.1520           0.1960
GRP +----------------+----------------+----------------+----------------+

 1  L---1==*3------------U
 2              L-------------------1==========M===D======3----U
 3     L-------------1====D======M======3----------------------------------U
 4        L1====M=*---------U
 5        L----1=========D===M=========3----------------------U
 6              *==========*==========*
```

P total (%) Kruskal-Wallis statistic: 32.965 df: 5 Probability < 0.001

```
   26.00             102.0             178.0             254.0             330.0
GRP +-----------------+-----------------+-----------------+-----------------+

  1 L--1====M===*------U
  2         L-----1====MD====3-U
  3       L---1====MD=3----U
  4    L-*M3----U
  5                L--1==D======M======3------------------------------------U
  6       *=*=*
```

% Sand Kruskal-Wallis statistic: 34.734 df: 5 Probability < 0.001

```
   48.00             58.88             69.75             80.63             91.50
GRP +-----------------+-----------------+-----------------+-----------------+

  1                                         L-----------1==D==M========3----U
  2              L-----------1D=M====3--------U
  3 L---------------1============*============3-----------U
  4                              L--------------1========M=====D3------U
  5                                        L----1=======*=======3----U
  6       *====*=====*
```

% Silt Kruskal-Wallis statistic: 41.881 df: 5 Probability < 0.001

```
   2.500             8.875             15.25             21.63             28.00
GRP +-----------------+-----------------+-----------------+-----------------+

  1 L---1===M=D3-U
  2                         L-----------1===========MD=====3---------------U
  3            L-----------1======*=========3------------U
  4       L1===DM===3--U
  5        L--1D==M====3----------U
  6                 *====*=====*
```

% Clay Kruskal-Wallis statistic: 21.622 df: 5 Probability < 0.001

```
   6.000             13.63             21.25             28.88             36.50
GRP +-----------------+-----------------+-----------------+-----------------+

  1 L-----1=======M==D=3---------------U
  2                 L----1*3------U
  3              L--------1============DM==========3-----------------------U
  4  L--1==D===========M===============3----------------U
  5  L-------1=======DM======3----------U
  6                                                                   *==*=*
```

Exchangeable Ca (me%) Kruskal-Wallis statistic: 36.974 df: 5 Probability < 0.001

```
   0.4300            8.323             16.22             24.11             32.00
GRP +-----------------+-----------------+-----------------+-----------------+

  1    L1DM3--U
  2                  L----------1===MD======*
  3      L------1====D=========M======3------------------------------------U
  4 L1*M--------------U
  5       L-1D=M3-------U
  6  *======*======*
```

Exchangeable Mg (me%) Kruskal-Wallis statistic: 44.751 df: 5 Probability < 0.001

```
   0.1200            3.340             6.560             9.780             13.00
GRP +-----------------+-----------------+-----------------+-----------------+

  1     L-1==DM==3-U
  2             L------1=========*=======3---------U
  3        L--------------1=========*========3----------------------------U
  4 L*3M--------------U
  5    L-1DM3--------U
  6     *======*=====*
```

Exchangeable Na (me%) Kruskal-Wallis statistic: 34.121 df: 5 Probability < 0.001

```
  0.1000E-01         0.9325            1.855             2.778           3.700
GRP +-----------------+-----------------+-----------------+-----------------+

  1   L1DM==3-U
  2    L---1==D=======M=3----------------------------------------------------U
  3   L------1======D====M============3-----------------------U
  4 L1*-U
  5  *D3M-----------------U
  6                *==*===*
```

Exchangeable K (me%) Kruskal-Wallis statistic: 45.592 df: 5 Probability < 0.001

```
  0.9000E-01        0.6675            1.245             1.823           2.400
GRP +-----------------+-----------------+-----------------+-----------------+

  1   L-1=DM=3----U
  2               L-----------------------1=======M==D====3--------------U
  3         L------1===D===M======3------------------------U
  4 *D=*---------------U
  5  L-1=DM3-----------U
  6   *
```

Again the ordination shows a clear separation between the ridge top communities (types 4, 5 & 6) from the lower slope communities (types 1,2 and 3). The least fertile, most sandy woodland community (type 1), is clearly most closely related to the upland thickets and woodlands (types 4, 5 and 6) (Figure 17). Soil nutrient status was again the most obvious environmental gradient. The plot also suggests altitude and perhaps % sand as being another significant gradient divergent from the soil nutrient axis. This could again be interpreted as a soil moisture or moisture availability gradient.

DISCUSSION

One of the striking features of this survey was the significant difference between the flora and vegetation of the Bremer and Parker greenstone belts. The ranges are only separated by 100 km and both belts lie along the boundary of the South West Botanical Province and the South Western Interzone. This suggests major climatic or edaphic differences between these belts or perhaps different historical influences.

A classification of the soil parameters of both belts failed to show any major geographical differences in patterns of soil parameters, although sandy, low total N and P soils with pH values of 6.0-6.5 were more common in the Parker Range belt than the Bremer. The best soils with high exchangeable cations, high total N and P and high pH were equally common in both areas.

Such dramatic turnover in species and communities may reflect significant regional climatic differences between these two areas. As was discussed above permanent meteorological stations are few in the study area. However Busby (1986) and others have developed a climatic model across Australia, based on all available long term meteorology stations. This program was used to estimate the annual rainfall and mean annual temperature of all 125 sites. These data were then split into the two greenstone belts and were tested to see if there were significant differences between the means (Table 18).

*Table 18. Mean BIOCLIM estimates for annual rainfall and mean annual temperature from 65 sites in the Bremer Range greenstone belt and 61 sites in Parker Range greenstone belt. (** indicates significant differences at P< 0.001 (Mann-Whitney U-test, standard deviation shown in brackets))*

	Estimated annual rainfall	Estimated mean annual temperature
Bremer Range area	278.7** (6.6)	16.8** (0.2)
Parker Range area	295.7** (3.5)	17.4** (0.2)

Both annual rainfall and mean annual temperature did show significant differences. The Parker Range area was on average both wetter and warmer than the Bremer Range area. Detailed autecological work would be needed to determine if these differences were sufficiently large to result in the different regional pattens in the flora and vegetation observed. Comparisons of the flora lists of the two belts show the drier Bremer Range area has more species of *Melaleuca* and *Eremophila* than the Parker Range area but similar numbers of eucalypts and acacias.

Four endemic taxa have been recorded from the Bremer Range greenstone belt and five endemic taxa have been recorded from the Parker Range area. Both areas are within Hopper's (1979) Transitional Rainfall Zone which has undergone major fluctuations in annual rainfall during the Tertiary. Hopper suggests these fluctuations have resulted in speciation centred on arid period refugia. This may explain the number of restricted endemics reported from these areas. These endemics are not related to ultramafic substrates which are rare in the study area. Ultramafic areas are generally rich in endemic taxa due to the very unbalanced soil chemistry (Brooks 1987). The ultramafic areas sampled in this study showed no soil chemistry imbalance, possibly due to the very ancient nature of these formations and the subsequent long period of soil weathering.

The differences in vegetation within these two greenstone belts appeared to be primarily controlled by edaphic factors with moisture holding capacity as a secondary gradient. The ridgetops of laterites and greenstones generally had much lower soil nutrient status than the colluvial deposits downslope and the alluvial and colluvial deposits of the valley bottoms. The soils with the highest nutrient status generally had the highest electrical conductivity and the highest exchangeable Na. They also occurred low in the landscape and their higher salinity probably reflects downslope leaching over most of the Tertiary. Interestingly % silt was more strongly correlated with levels of exchangeable cation than % clay in both data sets.

Consistent with similarity in major environmental gradients, the communities of both areas, although floristically distinct, tended to replace each other at similar places in the landscape (Table 19).

Table 19. Landscape position and occurrence of the floristic communities of the study area.

Position in landscape	Bremer Range area	Parker Range area
Ridgetop - massive greenstones	Type 6	Type 6
- skeletal soils	Type 5	Type 5
- deeper soils		Type 4
Side slope - sandy soils	Type 1	Type 1
Flats & broad ridge tops	Type 2	
Valley bottom	Type 3	Type 2
	Type 4	Type 3

This replacement is also apparent at the species level. *Eucalyptus livida* is a small mallee in the Wandoo group (series Reduncae) which occurs on the lateritic breakaways of the Bremer

Range. Further to the east this species is replaced in the same habitat in the Parker Range by *E. capillosa* subsp. *polyclada*. The only consistent difference between these taxa is the non glaucous branches of *E. livida*. Both species co-occur in the Parker Range area and they should both be considered subspecies of *E. capillosa*. *Eucalyptus capillosa* subsp. *capillosa* which is the tree form of this group also occurs in the Parker Range area (at Harris Find) in the same habitat.

The previous work undertaken in the study area described broad regional vegetation patterns (Beard 1976, 1979; Newbey & Hnatiuk 1988, Newbey *et al.* in press). Our results are consistent with those descriptions but show finer scale patterning. Indeed some of the vegetation units described above (Bremer 1-4 and Parker 1-3) which all occur on Newbey and Hnatiuks's (1988) Undulating Greenstone Plain unit are also described as occurring on their Broad Valley unit.

Our study also supports Beard's concepts of the Parker Range Vegetation System and the Bremer Range Vegetation System (Beard 1976, 1979). Two of our vegetation communities showed some north - south subdivision, another two were very localised and the remaining eight were spread throughout the different greenstone belts. The flora lists and our preliminary analysis showed the two vegetation systems to be largely independent.

Presently the vegetation communities and endemics of the Bremer Range greenstone belt are completely unreserved. Both past and present mineral exploration activity are having a significant impact on the vegetation of this area, especially within the smaller geomorphological units (Figure 18). Little effort was seen at rehabilitation of exploration tracks costines or drill sites.

Chertons Find lies just within Jilbadgi Nature Reserve and three of the six Parker vegetation types were recorded from this area as was *Hakea pendens* which appears to be endemic to this greenstone belt. The other three community types and the four endemic taxa are unreserved. The area of the Parker Vegetation System in reserves is much less than earlier suggested by Newbey *et al.* in press) 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 could be considered well reserved.

As in the Bremer Range, mining and exploration activity have significantly impacted on the vegetation of this area. The most obvious example of this is Mt Caudan where exploration griding has been extensive and where clean up has been minimal (Figure 19). Two taxa endemic to this greenstone belt occur in this area, one is restricted to it.

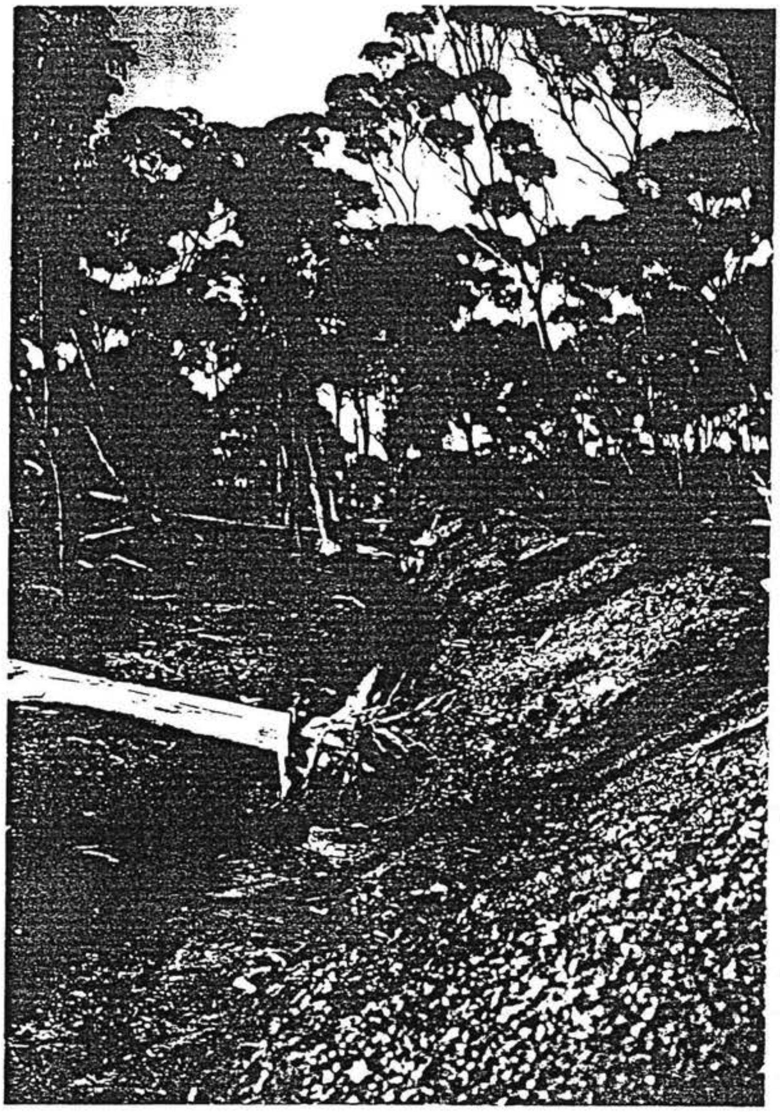


Figure 18. Abandoned costine in the Bremer Range

Figure 19. Gridding on Mt Caudan, Parker Range.

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APPENDIX 1

Flora List for the Bremer and Parker Ranges.

This list includes all taxa recorded from both sampling quadrats and non-plot collections. Species code corresponds to the code in the full data set (see Appendix 3). Solid dots denote taxa not recorded in either of the Goldfields Biological Survey reports. (see Newbey and Hnatiuk (1988) and Newbey *et al.* (in press)).

Family/Taxon	Parker Range	Bremer Range	Species Code
Adiantaceae			
Cheilanthes austrotenuifolia	+	+	CHEAUS
Aizoaceae			
Carpobrotus sp.		+	CARPSP
* *Mesembryanthemum nodiflorum*	+		MESNOD
Amaranthaceae			
Ptilotus drummondii	+		PTIDRU
Ptilotus exaltatus	+		PTIEXA
Ptilotus gaudichaudii	+		PTIGAU
Ptilotus holosericeus	+	+	PTIHOL
Ptilotus obovatus		+	PTIOBO
Anthericaceae			
Borya constricta	+	+	BORCON
Thysanotus patersonii	+	+	THYPAT
Apiaceae			
Daucus glochidiatus	+	+	DAUGLO
Homalosciadium homalocarpum		•	HOMHOM
Hydrocotyle pilifera var. *glabrata*		•	HYDPILGL
Hydrocotyle rugulosa		•	HYDRUG
Platysace maxwellii		+	PLAMAX
Trachymene cyanopetala	+	+	TRACYA
Trachymene ornata	+	+	TRAORN
Apocynaceae			
Alyxia buxifolia	+	+	ALYBUX
Asteraceae			
Actinobole uliginosum		+	ACTULI
Angianthus tomentosus	+		ANGTOM
* *Arctotheca calendula*	•		ARCCAL
Asteridea athrixioides	+	+	ASTATH
Asteridea pulverulenta		•	ASTPUL
Blennospora drummondii		+	BLEDRU
Brachyscome iberidifolia	+	+	BRAIBE
Calotis hispidula		+	CALHIS
Cratystylis conocephala		+	CRACON
Gnephosis intonsa	+		GNEINT
Hyalosperma demissum		+	HYADEM
Hyalosperma glutinosum subsp. *glutinosum* ms	•		HYAGLUGL
* *Hypochaeris glabra*	+	•	HYPGLA
Isoetopsis graminifolia		+	ISOGRA
Lawrencella rosea	•		LAWROS
Leucochrysum fitzgibbonii	+		LEUFIT
Millotia tenuifolia	+	+	MILTEN
Olearia dampieri subsp. *eremicola* ms		+	OLEDAMER
Olearia exiguifolia	+		OLEEXI

Family/Taxon	Parker Range	Bremer Range	Species Code
Olearia muelleri	+	+	OLEMUE
Olearia pimeleoides	+		OLEPIM
Podolepis capillaris	+	+	PODCAP
Podolepis lessonii		+	PODLES
Podolepis tepperi	+		PODTEP
Rhodanthe laevis		+	RHOLAE
Rhodanthe manglesii	:	•	RHOMAN
Rhodanthe oppositifolia subsp. *oppositifolia*	•	•	RHOOPPOP
Rhodanthe pygmaea		+	RHOPYG
Rhodanthe rubella	+		RHORUB
Senecio glossanthus	+	+	SENGLO
Senecio sp. (NG&ML 2323)		+	SENSP
* *Sonchus oleraceus*	+	•	SONOLE
* *Ursinia anthemoides*	+	+	URSANT
Vittadinia triloba			VITTRI
Waitzia acuminata		+	WAIACU
Waitzia citrina	+		WAICIT
Boraginaceae			
Halgania rigida		•	HALRIG
Halgania viscosa		+	HALVIS
Omphalolappula concava	+	•	OMPCON
Brassicaceae			
Stenopetalum lineare	+		STELIN
Stenopetalum robustum		+	STEROB
Caesalpiniaceae			
Cassia nemophila	+	+	CASNEM
Campanulaceae			
Wahlenbergia gracilenta		+	WAHGRA
Wahlenbergia preissii	•		WAHPRE
Caryophyllaceae			
Stellaria filiformis		+	STEFIL
Casuarinaceae			
Allocasuarina acutivalvis	+	+	ALLACU
Allocasuarina campestris	+	+	ALLCAM
Allocasuarina corniculata	+	+	ALLCOR
Allocasuarina globosa		•	ALLGLO
Allocasuarina helmsii	•	+	ALLHEL
Celastraceae			
Psammomoya choretroides		+	PSACHO
Chenopodiaceae			
Atriplex acutibractea subsp. *karoniensis*	+	+	ATRACUKA
Atriplex vesicaria	+	+	ATRVES
Chenopodium curvispicatum	•	•	CHECUR
Enchylaena tomentosa		+	ENCTOM

Family/Taxon	Parker Range	Bremer Range	Species Code
Eriochiton sclerolaenoides	+		ERISCL
Halosarcia entrichoma	+		HALENT
Halosarcia halocnemoides	+		HALHAL
Maireana erioclada		+	MAIERI
Maireana marginata	•		MAIMAR
Maireana pentagona	+		MAIPEN
Maireana radiata	•	•	MAIRAD
Maireana trichoptera	+	+	MAITRI
Rhagodia drummondii	+	+	RHADRU
Sclerolaena convexula	•		SCLCON
Sclerolaena diacantha	+	+	SCLDIA
Sclerolaena drummondii	+	•	SCLDRU
Sclerolaena eurotioides		+	SCLEUR
Sclerostegia disarticulata	+		SCLDIS
Threlkeldia diffusa		•	THRDIF
Convolvulaceae			
Wilsonia humilis	•	+	WILHUM
Crassulaceae			
Crassula colorata	+	+	CRACOL
Cupressaceae			
Callitris canescens	+		CALCAN
Callitris glaucophylla	+	•	CALGLA
Callitris preissii	+		CALPRE
Cyperaceae			
Gahnia lanigera		+	GAHLAN
Lepidosperma sp. (KN 7815)		•	LEPISP1
Lepidosperma sp. A2 (GJK 7000)	+	+	LEPIA2
Lepidosperma sp. (KN 7035)	+		LEPISP2
Lepidosperma sp. (NG&ML 2075)	+	+	LEPISPf
Schoenus nanus	+	+	SCHNAN
Tetraria capillaris	•		TETCAP
Dasypogonaceae			
Chamaexeros macranthera	+		CHAMAC
Lomandra effusa	+		LOMEFF
Dilleniaceae			
Hibbertia exasperata	+		HIBEXA
Hibbertia glomerosa	+		HIBGLO
Hibbertia pungens	+		HIBPUN
Hibbertia rostellata complex	+	+	HIBROS
Droseraceae			
Drosera macrantha subsp. *eremaea*	+		DROMACER
Drosera macrantha subsp. *macrantha*		+	DROMACMA
Epacridaceae			
Acrotriche patula	+		ACRPAT

Family/Taxon	Parker Range	Bremer Range	Species Code
Astroloma serratifolium	+	+	ASTSER
Coleanthera myrtoides		+	COLMYR
Leucopogon cuneifolius		+	LEUCUN
Styphelia pulchella		•	STYPUL
Euphorbiaceae			
Beyeria brevifolia	+	+	BEYBRE
Poranthera microphylla	+		PORMIC
Ricinocarpos stylosus		+	RICSTY
Frankeniaceae			
Frankenia sp. (NG&ML 2031)	+		FRANSP
Geraniaceae			
Erodium cygnorum	+	•	EROCYG
Goodeniaceae			
Dampiera tenuicaulis		+	DAMTEN
Goodenia dyeri		+	GOODYE
Goodenia havilandii	•		GOOHAV
Goodenia sp. (NG&ML 2370)	+		GOODSP1
Goodenia sp. (NG&ML 2250)	+		GOODSP2
Goodenia sp. (NG&ML 2371)	+		GOODSP3
Scaevola bursariifolia		+	SCABUR
Scaevola spinescens	+	+	SCASPI
Haloragaceae			
Glischrocaryon aureum	+		GLIAUR
Gonocarpus nodulosus		+	GONNOD
Juncaginaceae			
Triglochin centrocarpum	+		TRICEN
Lamiaceae			
Hemigenia obovata	+		HEMOBO
Hemigenia teretiuscula		•	HEMTER
Prostanthera grylloana		+	PROGRY
Prostanthera incurvata	+		PROINC
Teucrium sessiliflorum		•	TEUSES
Westringia cephalantha	+	+	WESCEP
Westringia rigida subsp. *brachyphylla* ms		+	WESRIGBR
Westringia rigida subsp. *rigida*		+	WESRIGRI
Lauraceae			
Cassytha filiformis	•		CASFIL
Cassytha glabella	+	+	CASGLA
Cassytha melantha	+	+	CASMEL
Cassytha racemosa		+	CASRAC
Lobeliaceae			
Lobelia gibbosa	+		LOBGIB

Family/Taxon	Parker Range	Bremer Range	Species Code
Loganiaceae			
Mitrasacme paradoxa	+	+	MITPAR
Loranthaceae			
Amyema miquelii	+	+	AMYMIQ
Mimosaceae			
Acacia acuminata	+	+	ACAACU
Acacia andrewsii		+	ACAAND
Acacia asepala ms	+		ACAASE
Acacia assimilis	•		ACAASS
Acacia blaxellii ms		•	ACABLA
Acacia camptoclada	+	+	ACACAM
Acacia colletioides	+		ACACOL
Acacia concolorans ms	•		ACACON
Acacia deficiens	+	•	ACADEF
Acacia duriuscula		•	ACADUR
Acacia enervia	+		ACAENE
Acacia erinacea	+	+	ACAERI
Acacia fragilis	+		ACAFRA
Acacia hadrophylla ms		•	ACAHAD
Acacia hemiteles	+		ACAHEM
Acacia hystrix subsp. *hystrix* ms		•	ACAHYSHY
Acacia lasiocalyx		+	ACALAS
Acacia longispinea	+		ACALON
Acacia merrallii	+	+	ACAMER
Acacia myrtifolia	•	•	ACAMYR
Acacia neurophylla		+	ACANEU
Acacia nigripilosa subsp. *nigripilosa* ms		+	ACANIGNI
Acacia nyssophylla		+	ACANYS
Acacia pachypoda	+	+	ACAPAC
Acacia poliochroa	+	+	ACAPOL
Acacia rendlei	+		ACAREN
Acacia sp. (NG&ML 1959)		•	ACASP
Acacia truculenta ms		•	ACATRU
Acacia uncinella		+	ACAUNC
Myoporaceae			
Diocirea microphylla ms		•	DIOMIC
Eremophila alternifolia		•	EREALT
Eremophila calorhabdos		+	ERECAL
Eremophila clavata ms		•	ERECLA
Eremophila decipiens subsp. *decipiens* ms	+	+	EREDECDE
Eremophila densifolia subsp. *pubiflora*		+	EREDENPU
Eremophila deserti		•	EREDES
Eremophila dichroantha		+	EREDIC
Eremophila drummondii	+		EREDRU
Eremophila granitica	+		EREGRA
Eremophila interstans		•	EREINT
Eremophila ionantha	+		EREION
Eremophila oppositifolia var. *angustifolia* ms	+		EREOPPAN
Eremophila psilocalyx		•	EREPSI

Family/Taxon	Parker Range	Bremer Range	Species Code
Eremophila rugosa ms		•	ERERUG
Eremophila saligna	•		ERESAL
Eremophila scoparia	+	+	ERESCO
Myoporum tetrandrum	•		MYOTET
Myrtaceae			
Astartea ambigua		+	ASTAMB
Baeckea crispiflora	+	+	BAECRI
Baeckea elderiana	+		BAEELD
Baeckea grandibracteata	+		BAEGRA
Beaufortia orbifolia	+		BEAORB
Calothamnus gilesii	+		CALGIL
Calothamnus quadrifidus		+	CALQUA
Calytrix breviseta subsp. *stipulosa*	•		CALBREST
Calytrix leschenaultii		+	CALLES
Chaemalaucium sp. (NG&ML 1963)		+	CHASP
Chamelaucium ciliatum		+	CHACIL
Chamelaucium halophilum ms subsp. Mt Caudan (B.H. Smith 1255)	+		CHAHALCA
Chamelaucium megalopetalum		+	CHAMEG
Eucalyptus annulata	+	+	EUCANN
Eucalyptus burracoppinensis	+		EUCBUR
Eucalyptus calycogona	+	+	EUCCAL
Eucalyptus capillosa subsp. *capillosa*	+		EUCCAPCA
Eucalyptus capillosa subsp. *polyclada*	•		EUCCAPPO
Eucalyptus cerasiformis		+	EUCCER
Eucalyptus conglobata	+		EUCCON
Eucalyptus corrugata	+		EUCCOR
Eucalyptus cylindriflora	•	+	EUCCYLf
Eucalyptus cylindrocarpa	+	+	EUCCYLc
Eucalyptus densa subsp. *densa*		•	EUCDENDE
Eucalyptus dundasii		+	EUCDUN
Eucalyptus eremophila	+	+	EUCERE
Eucalyptus flocktoniae	+	+	EUCFLO
Eucalyptus georgei subsp. *georgei*		+	EUCGEOGE
Eucalyptus gracilis	+		EUCGRA
Eucalyptus hypochlamydea subsp. *ecdysiastes* ms	+	•	EUCHYPEC
Eucalyptus incerata ms		•	EUCINC
Eucalyptus kondininensis	•		EUCKON
Eucalyptus leptopoda	+	•	EUCLEP
Eucalyptus livida	•	+	EUCLIV
Eucalyptus longicornis	+	+	EUCLON
Eucalyptus longicornis x *oleosa* (NG&ML 1755)		•	EUCLXO
Eucalyptus loxophleba	+	+	EUCLOX
Eucalyptus melanoxylon	+	+	EUCMEL
Eucalyptus myriadena	+		EUCMYR
Eucalyptus oleosa	+	+	EUCOLE
Eucalyptus pileata		+	EUCPIL
Eucalyptus platycorys	+	+	EUCPLA
Eucalyptus rhomboidea ms		•	EUCRHO
Eucalyptus rigidula	•		EUCRIG
Eucalyptus salicola		•	EUCSALi

Family/Taxon	Parker Range	Bremer Range	Species Code
Eucalyptus salmonophloia	+	+	EUCSALm
Eucalyptus salubris	+	+	EUCSALu
Eucalyptus sheathiana	+	+	EUCSHE
Eucalyptus spathulata subsp. *grandiflora*	+		EUCSPAGR
Eucalyptus tenuis		•	EUCTEN
Eucalyptus transcontinentalis	+	+	EUCTRA
Eucalyptus yilgarnensis	+	+	EUCYIL
Eucalyptus yilgarnensis x *gracilis* (NG&ML 2366)		•	EUCYXG
Euryomyrtus ciliata ms (NG&ML 2037)	•		EURCIL
Leptospermum fastigiatum		•	LEPFAS
Leptospermum roei	+		LEPROE
Melaleuca acuminata	+	+	MELACU
Melaleuca cardiophylla	•	+	MELCAR
Melaleuca cliffortioides		•	MELCLI
Melaleuca cordata	+	+	MELCORd
Melaleuca coroniocarpa ms		•	MELCORo
Melaleuca ctenoides	•		MELCTE
Melaleuca eleuterostachya	+	+	MELELE
Melaleuca fulgens subsp. *fulgens* ms		+	MELFULFU
Melaleuca hamulosa	+	+	MELHAM
Melaleuca lanceolata		•	MELLAN
Melaleuca lateriflora	+	+	MELLAT
Melaleuca laxiflora	+		MELLAX
Melaleuca pauperiflora complex	+	+	MELPAU
Melaleuca pauperiflora subsp. *fastigata* ms	+		MELPAUFA
Melaleuca pentagona		+	MELPEN
Melaleuca phoidophylla ms	•	•	MELPHO
Melaleuca podicarpa ms		•	MELPOD
Melaleuca quadrifaria		+	MELQUA
Melaleuca sheathiana		•	MELSHE
Melaleuca sp. (NG&ML 2335)	+		MELASP
Melaleuca sp. (NG&ML 2320)		+	MELSP
Melaleuca sparsiflora		+	MELSPA
Melaleuca teuthidoides		•	MELTEU
Melaleuca torquata		•	MELTOR
Melaleuca uncinata	+	+	MELUNC
Melaleuca ureolaris ms	•		MELURE
Micromyrtus maidenii	•		MICMAI
Micromyrtus obovata	+	+	MICOBO
Micromyrtus racemosa	+		MICRAC
Rinzia sessilis		+	RINSES
Thryptomene australis	+	+	THRAUS
Thryptomene kochii	+	+	THRKOC
Verticordia multiflora subsp. *solox*	+		VERMULSO
Orchidaceae			
Caladenia microchila ms		•	CALMIC
Caladenia saccharata		+	CALSAC
Caladenia sigmoidea		+	CALSIG
Cyanicula caerulea ms		•	CYACAE
Genoplesium nigricans ms		+	GENNIG
Pterostylis aff. *rufra*	+		PTEAFFRU

Family/Taxon	Parker Range	Bremer Range	Species Code
Pterostylis ciliata	•		PTECIL
Pterostylis mutica	•	+	PTEMUT
Pterostylis roensis	•		PTEROE
Pterostylis sanguinea		•	PTESAN
Pterostylis sargentii	+	+	PTESAR
Thelymitra aff. *pauciflora*	+	+	THEAFFPA
Thelymitra antennifera		+	THEANT
Thelymitra sargentii	•		THESAR
Papilionaceae			
Daviesia argillacea	•	+	DAVARG
Daviesia benthamii		+	DAVBEN
Eutaxia sp. (NG&ML 1997)	+		EUTASP
Gastrolobium crassifolium		+	GASCRA
Gastrolobium parviflorum	+		GASPAR
Gompolobium sp. (NG&ML 2292)	•		GOMSP
Mirbelia sp. (NG&ML 1881)		+	MIRBSP
Pultenaea arida		+	PULARI
Templetonia sulcata	+		TEMSUL
Phormiaceae			
Dianella revoluta	+	+	DIAREV
Pittosporaceae			
Billlardiera sp. Tamar Hill (NG&ML 1776)		•	BILTAM
Plantaginaceae			
Plantago aff. *hispidula* (NG&ML 1732)		•	PLAAFFHI
Plantago debilis	+	+	PLADEB
Poaceae			
* *Aira cupaniana*	+	+	AIRCUP
Amphipogon strictus	+		AMPSTR
Aristida contorta	+	+	ARICON
Bromus arenarius	•	•	BROARE
* *Bromus rubens*	+		BRORUB
Danthonia acerosa	•		DANACE
Danthonia caespitosa	+	+	DANCAE
Danthonia setacea	+		DANSET
Danthonia setacea var. *setacea*		+	DANSETSE
Neurachne alopecuroidea		+	NEUALO
* *Pentaschistis airoides*		+	PENAIR
Stipa elegantissima	+	+	STIELE
Stipa hemipogon	•		STIHEM
Stipa platychaeta		•	STIPLA
Stipa scabra subsp. scabra		•	STISCASC
Stipa sp. (NG&ML 2120)	+		STISP
Stipa trichophylla	+	+	STITRI
Triodia scariosa	+	+	TRISCA
* *Vulpia bromoides*	•	•	VULBRO
* *Vulpia myuros*	+	+	VULMYU

Family/Taxon	Parker Range	Bremer Range	Species Code
Polygalaceae			
Comesperma volubile	+	+	COMVOL
Portulacaceae			
Calandrinia eremaea	•	+	CALERE
Calandrinia granulifera	+		CALGRA
Primulaceae			
* *Anagallis arvensis*	+		ANAARV
Proteaceae			
Adenanthos argyreus	+		ADEARG
Grevillea acuaria	+	+	GREACU
Grevillea huegelii	+	+	GREHUE
Grevillea huegelii (glaucous form NG&ML	+		GREHUEg
Grevillea obliquistigma	+		GREOBL
Grevillea oncogyne	+	+	GREONC
Grevillea paradoxa	+	•	GREPAR
Grevillea pectinata		+	GREPEC
Grevillea phillipsiana	•		GREPHI
Grevillea teretifolia	+	+	GRETER
Hakea commutata		+	HAKCOM
Hakea cucullata		•	HAKCUC
Hakea falcata	•		HAKFAL
Hakea francisiana	+		HAKFRA
Hakea multilineata		+	HAKMUL
Hakea pendens	+		HAKPEN
Hakea scoparia		+	HAKSCO
Hakea subsulcata	+		HAKSUB
Isopogon sp. aff. *scabriusculus* (NG&ML 2077)	•		ISOAFFSC
Persoonia helix		•	PERHEL
Persoonia inconspiqua	+		PERINC
Persoonia trinervis	•		PERTRI
Petrophile seminuda	+		PETSEM
Rhamnaceae			
Cryptandra minutiflora subsp. *brevistylans* (NG&ML 2271)		•	CRYMINBR
Cryptandra myriantha	+		CRYMYR
Cryptandra polyclada		+	CRYPOL
Pomaderris forrestiana		•	POMFOR
Stenanthemum intricatum ms		•	STEINT
Stenanthemum pomaderroides		•	STEPOM
Stenanthemum stipulosum ms	•		STESTI
Trymalium myrtillus	+	+	TRYMYR
Rubiaceae			
Opercularia hispidula		+	OPEHIS
Rutaceae			
Boronia aff. *fabionoides* (NG&ML 2313)		+	BORSP
Boronia inornata subsp. *inornata*		+	BORINOIN

Family/Taxon	Parker Range	Bremer Range	Species Code
Boronia subsessilis	•		BORSUB
Boronia ternata var. *ternata*		+	BORTERTE
Drummondita wilsonii	+		DRUWIL
Eriostemon fitzgeraldii		+	ERIFIT
Eriostemon pachyphyllus		•	ERIPAC
Microcybe multiflora var. *multiflora*	+	+	MICMULMU
Phebalium filifolium	+	+	PHEFIL
Phebalium megaphyllum ms	+	+	PHEMEG
Phebalium tuberculosum	+	+	PHETUB
Phelbalium megaphyllum x *tuberculosum* (NG&ML 2374)	•		PHEMXT
Santalaceae			
Exocarpos aphyllus	+	+	EXOAPH
Exocarpos sparteus		+	EXOSPA
Santalum acuminatum	+	+	SANACU
Sapindaceae			
Dodonaea amblyophylla	+		DODAMB
Dodonaea bursariifolia	+	+	DODBUR
Dodonaea caespitosa	+	+	DODCAE
Dodonaea lobulata	+	•	DODLOB
Dodonaea microzyga var. *acrolobata*	+	+	DODMICAC
Dodonaea stenozyga	+	+	DODSTE
Dodonaea viscosa subsp. *angustissima*		•	DODVISAN
Solanaceae			
Anthocercis genistoides		+	ANTGEN
Lycium australe	+	+	LYCAUS
* *Solanum hystrix*		•	SOLHYS
Sterculiaceae			
Rulingia luteiflora		•	RULLUT
Stylidiaceae			
Levenhookia pusilla		+	LEVPUS
Stylidium limbatum	+		STYLIM
Urticaceae			
Parietaria debilis		+	PARDEB
Zygophyllaceae			
Tribulus astrocarpus	+		TRIAST
Zygophyllum apiculatum	+	+	ZYGAPI
Zygophyllum glaucum	+	+	ZYGGLA

APPENDIX 2

Plot location and floristic group.

Bremer Range communities prefixed with - b
Parker Range communities prefixed with - p

Site	Latitude (DMS)			Longitude (DMS)			Floristic Group
436/01	32	32	12.3	120	46	42.7	b1
436/02	32	32	13.1	120	46	39	b5
436/03	32	32	19.5	120	46	17.5	b1
436/04	32	32	36.7	120	45	5.7	b5
436/05	32	32	43.1	120	44	53	b1
436/06	32	32	51.3	120	44	24.4	b2
bm01	32	30	.8	120	38	59.2	b3
bm02	32	29	30.4	120	39	3.7	b3
bm03	32	29	28.2	120	39	9.2	b3
bm04	32	28	47.7	120	38	57.7	b2
bm05	32	28	4.5	120	38	57.7	b3
bm06	32	26	32.4	120	38	35.4	b4
brit01	31	50	14.6	119	36	44.7	p1
brit02	31	50	15.1	119	36	45.6	p1
brit03	31	49	4	119	38	16.3	p2
brit04	31	51	26.2	119	36	55.3	p4
caud01	31	36	55.5	119	33	15.8	p1
caud02	31	36	50	119	33	13.4	p4
caud03	31	36	22.7	119	33	31.9	p3
caud04	31	37	14.7	119	33	13.5	p5
caud05	31	37	16.2	119	33	9.9	p5
caud06	31	37	17.1	119	33	4.9	p5
caud07	31	37	6.1	119	33	22.7	p3
caud08	31	36	56.6	119	32	28.8	p4
cent01	31	35	55.3	119	35	2	p2
cent02	31	35	58.1	119	35	6.1	p3
cent03	31	36	27.6	119	35	48.6	p3
cent04	31	36	33.7	119	36	.4	p2
cent05	31	36	51	119	36	34.6	p2
cher01	31	51	26.7	119	38	52.6	p5
cher02	31	51	5.3	119	38	48	p4
cor01	32	16	23.4	120	32	30.5	b2
cor02	32	16	26.5	120	32	29.7	b5
cor03	32	16	10.9	120	32	15.5	b2
cor04	32	15	47	120	31	41.7	b2
cor05	32	15	52.3	120	31	53	b3
cor06	32	16	1.3	120	32	4.2	b2
day01	32	7	58.2	120	29	53.1	b4
day02	32	7	43.9	120	29	46.8	b5
day03	32	7	27.1	120	29	24.4	b2
gor01	32	28	48.4	120	42	13	b3
gor02	32	28	48.4	120	42	21	b1
gor03	32	30	.4	120	41	40.7	b1
gor04	32	30	25.1	120	41	55.1	b2
gor05	32	30	25.1	120	41	55.1	b3
gor06	32	28	46.4	120	40	8.9	b4
harr01	31	33	14.5	119	40	43.2	p3
harr02	31	33	3.3	119	41	1.9	p5
harr03	31	33	18.3	119	41	31.1	p5
harr04	31	33	48.7	119	41	27.9	p3
harr05	31	33	55.9	119	41	18.9	p3
harr06	31	33	49.5	119	41	15.9	p5

Site	Latitude (DMS)			Longitude (DMS)			Floristic Group
harr07	31	34	38.7	119	40	37.2	p3
harr08	31	37	19.1	119	42	27.5	p3
harr09	31	34	55.4	119	41	12.3	p3
hon01	32	23	35.7	120	38	9.2	b3
hon02	32	23	35.7	120	38	9.2	b5
hon03	32	23	41.9	120	37	57.7	b3
hon04	32	23	1.4	120	37	2.9	b3
hon05	32	24	4.7	120	36	52	b5
hon06	32	25	6.4	120	37	39.6	b3
jane01	31	47	6.6	119	36	34	p3
jane02	31	45	49.2	119	34	52.7	p2
jane03	31	45	40.7	119	35	10.5	p2
jane04	31	45	35.5	119	35	29.9	p4
jane05	31	45	23	119	35	40.8	p5
kook01	31	40	27.9	119	32	26.7	p1
kook02	31	40	25.3	119	32	27.5	p5
kook03	31	40	23.7	119	32	30.4	p3
kook04	31	40	28.2	119	32	37.1	p1
kook05	31	40	27.7	119	32	55.8	p4
kook06	31	40	25.1	119	33	16	p1
kook07	31	40	19	119	34	7	p3
mg01	32	37	52.5	120	45	55.4	b2
mg02	32	38	55.6	120	46	46.8	b5
mg03	32	37	34.4	120	45	40.8	b2
mg04	32	35	2.9	120	45	.6	b2
mg05	32	34	15	120	44	34.7	b2
mg06	32	34	17.8	120	44	33.9	b2
mg07	32	33	58.4	120	44	59.4	b1
mg08	32	33	54.6	120	44	57.4	b5
mhh01	32	18	25.6	120	36	22.8	b2
mhh02	32	18	27.3	120	36	20.7	b6
mhh03	32	19	15.3	120	36	18.1	b3
mhh04	32	19	4.3	120	36	39.5	b6
mhh05	32	17	2.7	120	34	27.5	b4
nb01	31	55	29.5	120	25	19.2	b4
nb02	31	55	56.9	120	25	35	b4
nb03	31	56	50.6	120	26	6	b5
nb04	31	57	46.4	120	26	37.6	b2
nb05	31	58	19.2	120	26	49.3	b2
park01	31	38	31	119	33	44.2	p3
park02	31	38	29.7	119	33	25.6	p3
park03	31	38	24.5	119	33	29.6	p6
park04	31	38	31.6	119	33	12.2	p6
park05	31	38	32.1	119	33	7.5	p3
park06	31	38	37.3	119	32	31.8	p4
park07	31	38	28	119	32	41.4	p3
pros01	31	44	42.1	119	33	28.6	p5
pros02	31	44	42.1	119	33	28.6	p5
pros03	31	44	41.3	119	33	30.5	p1
rth01	32	10	4.8	120	26	46.6	b1
rth02	32	10	3.2	120	26	38.2	b5
rth03	32	10	18.7	120	26	57	b2

Site	Latitude (DMS)			Longitude (DMS)			Floristic Group
rth04	32	10	37.6	120	27	3.6	b2
split01	31	59	33.7	119	31	7.7	p2
split02	31	56	7.4	119	35	50.3	p3
split03	31	56	4.2	119	36	3.8	p4
split04	31	55	37.8	119	36	40.6	p4
split05	31	55	41.4	119	36	39.9	p3
th01	32	29	34.7	120	49	33.4	b4
th02	32	29	9.9	120	48	42	b2
th03	32	29	9.9	120	48	42	b2
th04	32	27	58.8	120	49	6.4	b2
th05	32	29	59	120	49	5.7	b2
th06	32	31	57.1	120	47	26.7	b5
th07	32	31	38.7	120	47	43.6	b5
th08	32	31	32.6	120	47	51.4	b2
th09	32	30	55.5	120	48	21.7	b2
thir01	31	39	34.9	119	33	39.5	p5
thir02	31	39	34.3	119	33	53.4	p2
thir03	31	39	36.1	119	34	24	p2
toom01	31	36	8.7	119	39	21.8	p2
toom02	31	36	22.5	119	39	1.4	p3
toom03	31	36	30.1	119	38	44.5	p5

APPENDIX 3

Floristic data sets for the Bremer and Parker Range

The full data sets are provided in Cornel University Condensed Format. Within the condensed format species codes follow those listed in Appendix 1 and site codes follow those listed in Appendix 2. The taxa grouped below were amalgamated for the purposes of the floristic analysis.

Danthonia setacea
Danthonia setacea var. *setacea*

Drosea macrantha subsp. *eremaea*
Drosea macrantha subsp. *macrantha*

Melaleuca pauperiflora complex
Melaleuca pauperiflora subsp. *fastigata* ms
Melalueca sheathiana
Melaleuca sparsiflora
Melaleuca teuthioides

Stipa elegantissima
Stipa platycheata

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bremer range data set 235 species x 64 quadrats
(16i5)                                                               5
    1    5    9   25   33   45   74   80   93   94  104  111  151  155
    1  164  186  191  199  230  231
    2   14   18   41   52   56   98  104  126  129  138  149  177  183
    2  188  199  216  218
    3    4    5    9   62   74   93  104  118  147  152  154  156  161
    3  164  165  171  177  188  199  221  230
    4   14   18   29   42   51   52   53   61   65   91   93   99  111
    4  118  125  132  142  164  166  177  197  202  217  221  230
    5    4    8    9   62   65   74   93  104  111  118  147  154  156
    5  161  164  230  233
    6    7   11   12   61   69   74   82   86  103  104  106  107  110
    6  111  118  157  176  186  199  231
    7   12   54   69   82  100  145  155  211  234
    8   26   27   50   77   80   99  144  145  155  165  192  203  211
    8  234
    9   13   50   54   68   72   79  107  111  160  186  192  196  199
    9  203  221  234
   10    7   13   22   29   60   74   86   94   99  103  115  117  155
   10  171  199  200  211  214  226  231
   11   26   27   50   72   99  103  145  155  203
   12   27   43   52   72   75  106  177  192  204
   13   12   61   62   69   74   94  155  171  177  199
   14    1   18   22   32   49   52   58   68   71   84   98  123  139
   14  164  167  177  184  198  211  214  216  221  223  225  229
   15    3    7   18   61   69   74   88   94  118  127  138  165  214
   15  221  225  230  233
   16    7   10   11   18   61   74   87   94  107  109  127  177  199
   16  214
   17    3   11   52   64   74   92  111  127  145  155  189  191  203
   17  214
   18    7   12   13   52   61   69   74  107  108  109  111  119  120
   18  127  165  201  202
   19   82   92  171  186
   20    1   15   18   46   49   53   60   63   67   85   88  102  116
   20  132  133  135  166  168  170  174  182  193  202  211  215  222
   20  227  228  229
   21    5    7   12   54   61   69   74   82   92   94  108  171  234
   22   82   94  145  160  171  181  186  189  203  206  208  211  214
   22  234
   23    7   74   80   93   94  104  118  155  165  181  211  214
   24    5    7   61   69   74   93  104  118  120  150  155  233
   25   22   35  106  107  155  186  205  214  221
   26   12   26   50   82   86   94  106  111  145  155  199  203
   27    7   54   83   99  111  119  146  155  171  177  189  214  235
   28   29   69   94   99  111  127  128  155  186  199  201  203  211
   28  214  230  234
   29    1   18   22   29   68  102  108  138  176  177  197  199  214
   29  225
   30   27   50   81   94  107  111  145  186  189  199  203  211  214
   30  234
   31   46   50   54   73   82  106  108  111  127  145  155  171  201
   31  203  213  230  234
   32   17   22   35   36   38   49   50   53   59   60   63   67   70
   32   98  111  131  134  138  166  171  173  176  186  188  191  192
   32  193  195  205  206  208  210  211  214  216  221  223  226  228
   33    1   22   27   35   46   50   53   59   68   81   85   94  108
   33  111  135  136  143  190  192  194  195  199  203  206  208  211
   33  223  226  227  229  234
   34    5   12   18   24   29   61   69   76   86   87   94  103  111
   34  123  147  162  163  186  199  208  212  231
   35   14   18   28   39   41   44   48   52   55   57   71   96  126
   35  130  137  138  141  149  164  169  177  185  221  230
   36   12   24   61   69   78   94  104  107  111  123  157  158  162
   36  186  199  212  231  233
   37   53   79   94  103  107  111  134  162  176  186  187  191  205
   37  207  231  233
   38   33   47   76   80   86   94  103  155  159  165  186  191  199
   38  212  231
   39   47   61   69   76   80   94  103  107  111  148  155  191  199
   39  231
   40    5    7   11   45   61   62   69   74   93  104  107  111  151
   40  157  161  162  191  199  230  231  233
   41   14   18   42   48   61  110  115  126  129  164  175  188  199
   41  202  212  220  221  230
   42    6   12   61   69   75   92  155  165  186
   43    6    7   20   21   40   49   95  102  168  186  195  208  214
   43  216  221  223  228
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44   81   92   94  155  199  203  214  234
45    6   20   40   41   49  102  168  193  195  206  214  216  221
45  229
46   27   34   35   58   85   95   99  171  172  186  189  192  205
46  206  211  214  234
47    4   10   11   73   74   89  106  110  112  119  171  177  199
47  201  211
48    4   11   46   73   99  106  119  155  171  201  230
49   19   21   29   31   37   52   65   90   97   98  130  132  138
49  164  171  176  186  197  199  214  220  221
50   12   69   74   94  106  107  108  111  155  171  201
51   11   74   94  108  162  171  199  232
52   16   63  104  109  120  121  138  140  151  155  166  171  180
52  214  221  222  224  229
53    2   18   23   28   41   52   66   71   88  109  126  138  151
53  164  171  221  224  230
54   12   69   74   92   94  107  108  119  120  122  155  177  201
54  221
55    5   12   33   61   74   82   94  108  110  119  127  155  201
55  211  214  234
56    9   27   54   82  101  105  153  171  186  189  192  211  214
56  219  221
57   16   22   29   53   69   74   80   94  101  111  153  171  186
57  189  208  212
58   22   69   74   94  135  160  166  171  186  189  206  212  227
59   22   46   69   72   80   94  103  155  186  212  214  234
60   10   61   89  100  101  122  162  165  177  211  231
61   11   18   52   55   61   65   74   98  104  106  108  113  114
61  124  130  138  164  171  199  201  209  230
62   17   22   29   30   41   52   57   58   98  123  138  177  188
62  225
63   69   80   86   87   94  103  111  153  171  183  186  211  214
63  231
64   16   60   69   82   87  107  118  155  166  179  214  233
 0
ACAACU  ACAAND  ACABLA  ACACAM  ACADEF  ACADUR  ACAERI  ACAHAD  ACAHYSHYACAMER
ACAPAC  ACAPOL  ACATRU  ACAUNC  ACTULI  AIRCUP  ALLACU  ALLCAM  ALLCOR  ALLGLO
ALLHEL  ALYBUX  ARICON  ASTATH  ASTPUL  ATRACUKAATRVES  BAECRI  BEYBRE  BILTAM
BLEDRU  BORCON  BORINOINBRAIBE  BROARE  CALERE  CALGLA  CALHIS  CALLES  CALMIC
CALQUA  CALSAC  CARPSP  CASGLA  CASMEL  CASNEM  CASRAC  CHACIL  CHEAUS  CHECUR
COLMYR  COMVOL  CRACOL  CRACON  CRYPOL  CYACAE  DAMTEN  DANCAE  DANSETSEDAUGLO
DAVARG  DAVBEN  DIAREV  DIOMIC  DODBUR  DODCAE  DODLOB  DODMICACDODSTE  DROMAC
DROMACMAENCTOM  EREALT  ERECLA  EREDECDEEREDENPUEREDES  EREDIC  EREINT  EREPSI
ERERUG  ERESCO  ERIFIT  ERIPAC  EROCYG  EUCANN  EUCCAL  EUCCER  EUCCYLc EUCCYLf
EUCDENDEEUCDUN  EUCERE  EUCFLO  EUCGEOGEEUCHYPECEUCINC  EUCLIV  EUCLON  EUCLXO
EUCMEL  EUCOLE  EUCPIL  EUCRHO  EUCSALi EUCSALm EUCSALu EUCTEN  EUCTRA  EUCYIL
EXOAPH  EXOSPA  GAHLAN  GASCRA  GENNIG  GONNOD  GOODYE  GREACU  GREHUE  GREONC
GREPAR  GREPEC  HAKCOM  HAKCUC  HAKMUL  HAKSCO  HALRIG  HALVIS  HEMTER  HIBROS
HOMHOM  HYADEM  HYDPILGLHYDRUG  HYPGLA  ISOGRA  LEPFAS  LEPIA2  LEPISP1 LEPISPf
LEUCUN  LEVPUS  LYCAUS  MAIERI  MAIRAD  MAITRI  MELACU  MELCAR  MELCORd MELCORo
MELELE  MELHAM  MELLAN  MELLAT  MELPAU  MELPEN  MELPHO  MELPOD  MELQUA  MELSHE
MELSPA  MELTEU  MELTOR  MELUNC  MICMULMUMILTEN  MIRBSP  MITPAR  NEUALO  OLEDAMER
OLEMUE  OMPCON  PARDEB  PENAIR  PERHEL  PHEFIL  PHETUB  PLAAFFHIPLADEB  PLAMAX
PODCAP  PODLES  POMFOR  PROGRY  PSACHO  PTEMUT  PTESAN  PTESAR  PTIHOL  PTIOBO
PULARI  RHADRU  RHOLAE  RHOMAN  RHOQPPOPRICSTY  RINSES  RULLUT  SANACU  SCABUR
SCASPI  SCHNAN  SCLDIA  SCLEUR  SENGLO  SONOLE  STEFIL  STEINT  STEPOM  STEROB
STIELE  STIPLA  STISCASCSTITRI  TEUSES  THEAFFPATHEANT  THRAUS  THRDIF  THRKOC
THYPAT  TRACYA  TRAORN  TRISCA  TRYMYR  VULBRO  VULMYU  WAHGRA  WAIACU  WESCEP
WESRIGBRWESRIGRIWILHUM  ZYGAPI  ZYGGLA
436/01  436/02  436/03  436/04  436/05  436/06  bm01    bm02    bm03    bm04
bm05    bm06    cor01   cor02   cor03   cor04   cor05   cor06   day01   day02
day03   gor01   gor02   gor03   gor04   gor05   gor06   hon01   hon02   hon03
hon04   hon05   hon06   mg01    mg02    mg03    mg04    mg05    mg06    mg07
mg08    mhh01   mhh02   mhh03   mhh04   mhh05   nb01    nb02    nb03    nb04
nb05    rth01   rth02   rth03   rth04   th01    th02    th03    th04    th05
th06    th07    th08    th09
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parker range data set 232 species x 61 sites

(1615)

													5
1	26	63	65	106	107	120	157	170	176	196	207	208	217
1	227	229											
2	21	62	65	86	91	92	93	116	117	120	143	156	157
2	160	170	180	182	191	198	208	215	216	218	227	229	
3	13	81	98	157	170	196	207	209	210				
4	12	14	15	22	23	24	36	46	72	74	85	88	121
4	123	133	152	153	196	214							
5	1	11	22	26	28	65	88	93	106	107	111	130	160
5	171	175	176	180	196	197	207	227	229				
6	22	24	33	36	37	43	51	54	72	103	122	123	127
6	129	130	133	141	153	173	178						
7	4	5	9	11	26	62	75	105	108	111	150	156	171
7	178	183	189	191	197	207	209						
8	9	19	23	26	37	39	46	53	98	106	130	138	170
8	178	196	197	208	209	227	229						
9	1	4	10	21	23	26	30	46	56	69	88	121	126
9	127	130	133	135	165	167	178	191	209	212	215	221	222
9	225	227											
10	10	23	27	36	46	85	88	95	121	123	127	133	153
10	165	212	215										
11	9	13	26	78	79	81	104	105	107	157	209	215	
12	1	22	24	36	58	72	85	121	123	126	133	153	160
12	163	165	178	214									
13	2	28	29	32	35	78	81	82	98	157	180	199	203
13	204	207	209	210	230	232							
14	21	86	104	105	111	157	164	200	207	210	225		
15	9	26	28	71	79	81	98	102	105	128	139	157	200
15	207	210											
16	2	13	28	35	81	98	105	145	157	201			
17	13	16	53	75	81	101	124	144	145	146	147	157	170
17	193	196	207	209	231								
18	9	13	22	23	26	33	44	79	97	104	126	133	153
18	157	178	196	197	221	227							
19	1	14	24	36	46	51	72	96	121	123	133	153	163
19	214												
20	9	13	26	32	41	62	78	83	104	105	108	111	115
20	124	134	142	190	195	196	197	200	202	207	209	210	225
21	1	22	24	25	26	75	90	99	102	121	123	127	155
21	160	171	175	206	220	227	229						
22	5	22	23	67	70	71	87	99	102	121	123	133	175
22	178	196	221	229									
23	9	13	28	78	79	81	104	108	111	120	124	145	170
23	196	197	200	207	210								
24	6	9	21	81	104	105	108	124	149	180	193	197	200
24	207	210											
25	21	22	26	55	56	62	64	70	77	87	126	133	135
25	160	171	207	209	212	217							
26	6	13	26	35	62	71	78	79	81	98	105	111	157
26	170	180	192	193	197	200	207	210					
27	9	26	28	32	37	48	57	59	71	90	98	111	148
27	149	170	192	193	197	200	203	205	207	223	228	231	232
28	21	26	29	32	35	64	79	81	98	100	111	149	158
28	170	180	193	197	200	203	207	209					
29	13	32	34	78	86	94	104	105	157	162	172	180	192
29	200	207	210										
30	2	13	65	89	98	107	158	207	209	210			
31	2	13	78	83	89	98	170	196	210	225	232		
32	1	9	22	24	36	37	51	65	88	99	105	133	150
32	160	175	178	183	196	215	221	227					
33	76	79	81	104	157	170							
34	6	9	20	22	52	58	65	78	88	93	105	106	113
34	122	123	125	126	132	150	153	170	178	196	212	229	
35	1	21	22	37	46	56	58	63	66	68	88	121	126
35	132	133	160	165	175	178	196	207	215	227	229		
36	6	9	22	26	49	79	88	104	105	142	150	158	165
36	170	175	196	197	229								
37	4	6	51	52	65	66	76	88	106	107	119	120	150
37	157	160	161	175	176	196	214	215	229				
38	1	22	36	46	51	73	96	119	121	123	133	152	163
38	214												
39	4	8	52	65	104	105	106	120	150	155	156	161	196
39	197	214	227										
40	1	21	31	37	42	105	107	109	158	170	194	200	209
41	9	13	18	62	65	71	105	148	156	158	178	184	185
41	207												
42	6	11	18	21	26	29	38	62	64	71	79	104	106
42	111	165	166	167	170	172	178	179	181	197	198	207	221
42	224	226											

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43   26   47   58   60   79   88  160  170  176  177  178  211  221
44   20   21   26   38   47   58   72  133  136  140  160  165
45    6    7    9   21   65   79  104  105  110  157  164  170  180
45  197  200  207
46   14   22   24   46   47   72   88  123  133  140  152  165  196
46  214
47    6   28   79  104  107  158  164
48    1   14   23   26   46   50   56   70   72   99  118  121  133
48  153  207  209  212  215  228
49    1    9   21   26   45   56   58   59   63   64   70   80   88
49  121  126  133  135  144  167  170  178  196  203  209  215  217
49  225  228  229
50    9   11   13   21   65   80   93   99  106  111  119  120  126
50  137  138  144  150  151  155  157  160  164  169  170  180  189
50  209  212  227  229
51   13   75   84   98  151  158  186  200  203  210
52    9   26   63   76   78  105  111  118  119  135  143  150  156
52  157  160  166  170  186  191  192  198  207  212  215  216  219
52  227
53    1    3   11   13   22   24   32   36   97  109  125  133  138
53  153  154  155  160  163  174  176  196  213  227  229
54   14   22   24   36   46   50   58   72   97  121  123  125  133
54  153
55   11   13   71  104  111  119  158  159  164  170  185  197  207
55  215
56    1   20   21   22   26   38   56   58   61   72   77   88  126
56  133  134  135  138  165  178  181  183  207  212  216
57    9   13   37   71   81   86   89   98  105  157  170  187  196
57  207
58   17   29   35   81   98  107  111  112  157  203  207  210
59   13   17   32   35   78   81   98  100  105  200  207  209  210
59  232
60   13   32   37   40   41   62   71   79   90  105  108  114  116
60  170  193  194  195  196  200  209  210  221
61   11   14   23   28   46   67   90   99  114  121  123  131  133
61  138  155  160  175  207  209  229
 0
ACAACU  ACAASE  ACAASS  ACACAM  ACACOL  ACACON  ACADEF  ACAENE  ACAERI  ACAFRA
ACAHEM  ACALON  ACAMER  ACANEU  ACANIGNIACANYS  ACAPAC  ACAPOL  ACAREN  ACRPAT
AIRCUP  ALLACU  ALLCAM  ALLCOR  ALLHEL  ALYBUX  AMPSTR  AMYMIQ  ANGTOM  ARCCAL
ARICON  ASTATH  ASTSER  ATRACUKAATRVES  BAEELD  BEYBRE  BORCON  BORSUB  BRAIBE
BROARE  BRORUB  CALBRESTCALCAN  CALERE  CALGIL  CALGLA  CALGRA  CALPRE  CASFIL
CASGLA  CASMEL  CASNEM  CHAHALCACHAMAC  CHEAUS  CHECUR  COMVOL  CRACOL  CRYMYR
DANACE  DANCAE  DANSET  DAUGLO  DAVARG  DIAREV  DODBUR  DODCAE  DODLOB  DODMICAC
DODSTE  DROMAC  DROMACERDRUWIL  EREDECDEEREDRU  EREGRA  EREION  EREOPPANERESAL
ERESCO  ERISCL  EROCYG  EUCANN  EUCBUR  EUCCAL  EUCCAPCAEUCCAPPOEUCCON  EUCCOR
EUCCYLc EUCCYLf EUCERE  EUCFLO  EUCHYPECEUCLEP  EUCLIV  EUCLON  EUCLOX  EUCMEL
EUCMYR  EUCOLE  EUCRIG  EUCSALm EUCSALu EUCSHE  EUCTRA  EUCYIL  EURCIL  EUTASP
EXOAPH  FRANSP  GASPAR  GNEINT  GOODSP1 GOODSP2 GOODSP3 GOOHAV  GREACU  GREHUE
GREOBL  GREONC  GREPAR  GREPHI  HAKFRA  HAKPEN  HAKSUB  HALHAL  HEMOBO  HIBEXA
HIBGLO  HIBPUN  HIBROS  HYAGLUGLHYPGLA  ISOAFFSCLAWROS  LEPIA2  LEPISP2 LEPISPf
LEPROE  LEUFIT  LOBGIB  LOMEFF  LYCAUS  MAIMAR  MAIPEN  MAIRAD  MAITRI  MELACU
MELASP  MELCAR  MELCORd MELCTE  MELELE  MELLAT  MELPAU  MELPAUFAMELPHO  MELUNC
MELURE  MESNOD  MICMAI  MICMULMUMICRAC  MILTEN  MITPAR  MYOTET  OLEEXI  OLEMUE
OLEPIM  OMPCON  PERTRI  PETSEM  PHEFIL  PHEMEG  PHEMXT  PHETUB  PLADEB  PODCAP
PODTEP  PORMIC  PROINC  PTEAFFRUPTECIL. PTEMUT  PTEROE  PTESAR  PTIDRU  PTIEXA
PTIGAU  PTIHOL  RHADRU  RHOOPPOPRHORUB  SANACU  SCASPI  SCHNAN  SCLCON  SCLDIA
SCLDIS  SCLDRU  SENGLO  SONOLE  STELIN  STESTI  STIELE  STIHEM  STITRI  TEMSUL
TETCAP  THEAFFPATHRAUS  THRKOC  THYPAT  TRACYA  TRAORN  TRIAST  TRICEN  TRISCA
TRYMYR  URSANT  VITTRI  VULBRO  VULMYU  WAHPRE  WAIACU  WAICIT  WESCEP  WILHUM
ZYGAPI  ZYGGLA
brit01  brit02  brit03  brit04  caud01  caud02  caud03  caud04  caud05  caud06
caud07  caud08  cent01  cent02  cent03  cent04  cent05  cher01  cher02  harr01
harr02  harr03  harr04  harr05  harr06  harr07  harr08  harr09  jane01  jane02
jane03  jane04  jane05  kook01  kook02  kook03  kook04  kook05  kook06  kook07
park01  park02  park03  park04  park05  park06  park07  pros01  pros02  pros03
split01 split02 split03 split04 split05 thir01  thir02  thir03  toom01  toom02
toom03
```

APPENDIX 4

Soil Chemistry Data for the Bremer and Parker Ranges.

Methods Used For Chemical Analysis of Soil:

EC (1:5) Measured by conductivity meter at 25o C on a 1:5 extract of soil and deionised water. Rayment, G.E. & Higginson, F.R. (1992) Electrical Conductivity. In: Australian Laboratory Handbook of Soil and Water Chemical Methods. Inkata Press, Melbourne pp 15-16. (Method 3A1).

pH (1:5) Measured by pH meter on a 1:5 extract of soil and deionised water. Rayment, G.E. & Higginson, F.R. (1992) Soil pH. In: Australian Laboratory Handbook of Soil and Water Chemical Methods. Inkata Press, Melbourne pp 17-18. (Method 4A1).

Total N Measured by Kjeldahl digestion of soil. Rayment, G.E. & Higginson, F.R. (1992) Soil pH. In: Australian Laboratory Handbook of Soil and Water Chemical Methods. Inkata Press, Melbourne pp 41-43. (Method 7A2).

Total P Measured by colorimetry on the Kjeldahl digest for total N using a modification of the Murphy & Riley molybdenum blue procedure. Murphy, J. & Riley, J.P. (1962) Anal. Chim. Acta 27: 31-36.

Particle Sizing (% sand, silt, clay) Determined by modified "plummet" procedure. Soil dispersed with a solution of Calgon - sodium hydroxide, then silt (0.002 - 0.020 mm) and clay (<0.002 mm) was measured by density measurements using a plummet after standard settling times. Loveday, J. (ed) (1974) Methods for analysis of irrigated soils. Comm. Bureau of Soils, Technical Communication No 54.

Exchangeable Cations were measured by 3 procedures:

a) 1M NH_4Cl at pH 7.0 - Used for neutral soils (pH between 6.5 & 8.0).
Rayment, G.E. & Higginson, F.R. (1992) Ion-exchange Properties. In: Australian Laboratory Handbook of Soil and Water Chemical Methods. Inkata Press, Melbourne pp 138-145. (Method 15A1, 15A2).
Cations (Ca, Mg, Na, K) were measured by Inductively coupled plasma - atomic emission spectrometry (ICP-AES). Soluble salts were removed from soils with EC (1:5) >20 mS/m by washing with glycol-ethanol.

b) 0.1M $BaCl_2$ (unbuffered) - Used for acidic soils only (pH <6.5)
Unpublished WA Agricultural Chemistry Laboratory procedure.
Cations (Ca, Mg, Na, K, Al & Mg) were measured by ICP-AES. Soluble salts were removed from soils with EC (1:5) >20 mS/m by washing with glycol-ethanol.

c) 1M NH_4Cl at pH 8.5 - Used for calcareous soils
Modified method from Rayment, G.E. & Higginson, F.R. (1992) Ion-exchange Properties. In: Australian Laboratory Handbook of Soil and Water Chemical Methods. Inkata Press, Melbourne pp 148-154. (Method 15C1).
Cations (Ca, Mg, Na, K) were measured by flame atomic absorption spectrophotometry

Site	EC	pH	N total	P total	Sand	Silt	Clay	Cat	Ca	Mg	Na	K	Al	Mn
436/01	26	8.4	0.124	59	59.0	22.5	18.5	c	12	3.4	0.74	1.0		
436/02	<1	6.5	0.056	53	70.0	14.0	16.0	a	3.5	1.3	0.09	0.39		
436/03	3	7.1	0.039	87	80.0	10.0	10.0	a	3.1	2.7	0.66	0.43		
436/04	3	6.8	0.050	90	72.0	14.0	14.0	a	7.1	1.8	0.13	0.48		
436/05	3	7.0	0.041	92	78.0	10.5	11.5	a	3.4	3.1	0.41	0.44		
436/06	16	8.1	0.091	97	66.0	15.0	19.0	c	14	3.6	0.51	1.4		
bm01	31	8.4	0.170	100	75.5	14.0	10.5	c	17	4.3	0.66	1.5		
bm02	68	8.5	0.383	190	76.0	15.0	9.0	c	18	6.1	2.2	1.8		
bm03	24	8.6	0.150	120	55.0	18.5	26.5	c	25	8.1	1.3	1.7		
bm04	14	8.4	0.095	65	73.5	13.0	13.5	c	12	3.1	0.18	1.3		
bm05	48	8.5	0.221	160	73.5	16.5	10.0	c	17	6.9	1.6	1.6		
bm06	7	7.2	0.082	150	81.0	9.0	10.0	a	5.2	3.8	0.23	1.1		
brit01	9	7.4	0.040	44	80.5	6.0	13.5	a	4.9	2.8	0.43	0.53		
brit02	3	6.7	0.020	26	91.5	2.5	6.0	a	1.6	0.92	0.11	0.17		
brit03	23	8.3	0.160	94	64.0	21.5	14.5	c	18	6.8	0.78	1.7		
brit04	3	5.4	0.057	45	84.5	8.0	7.5	b	1.1	0.27	0.06	0.09	0.33	<0.02
caud01	4	6.2	0.027	34	90.0	3.0	7.0	b	2.7	0.76	0.16	0.16	0.02	0.03
caud02	2	5.9	0.036	62	88.5	5.0	6.5	b	1.1	0.27	0.03	0.11	0.03	0.02
caud03	2	6.8	0.028	65	74.5	8.5	17.0	a	3.2	1.6	0.11	0.43		
caud04	7	7.0	0.103	180	82.5	8.5	9.0	a	8.6	3.1	0.20	0.68		
caud05	4	6.4	0.159	330	74.0	13.0	13.0	b	9.2	1.5	0.12	0.34	0.02	0.12
caud06	3	6.8	0.042	120	87.0	6.5	6.5	a	3.8	0.77	0.06	0.28		
caud07	5	7.1	0.054	120	74.5	12.0	13.5	a	4.7	4.0	0.44	0.76		
caud08	5	4.6	0.046	37	74.0	5.0	21.0	b	0.54	0.29	0.11	0.12	0.69	<0.02
cent01	51	8.1	0.149	120	63.5	21.0	15.5	c	13	6.3	1.4	2.4		
cent02	29	8.0	0.065	92	48.0	18.5	33.5	a	26	9.7	1.3	1.2		
cent03	45	8.0	0.182	95	55.0	17.5	27.5	a	32	10	1.3	1.1		
cent04	25	8.6	0.155	140	56.0	28.0	16.0	c	16	8.6	1.0	1.9		
cent05	5	7.7	0.052	61	73.0	11.0	16.0	a	8.0	2.4	0.14	1.1		
cher01	3	6.5	0.051	88	76.5	6.0	17.5	a	3.8	1.5	0.13	0.20		
cher02	2	5.4	0.039	47	84.0	7.0	9.0	b	0.89	0.25	0.08	0.14	0.23	<0.02
cor01	29	8.3	0.148	69	69.0	13.5	17.5	c	14	8.5	1.1	1.3		

cor02	4	6.4	0.089	120	74.5	7.5	18.0	b	5.7	1.7	0.15	0.20	<0.02	0.05
cor03	8	7.7	0.054	100	76.5	4.0	19.5	a	9.3	4.6	0.80	0.24		
cor04	45	8.5	0.091	70	44.5	17.0	38.5	c	17	14	2.8	1.3		
cor05	44	8.8	0.198	99	68.0	16.0	16.0	c	15	13	2.9	0.83		
cor06	7	7.2	0.069	130	82.5	6.5	11.0	a	5.5	3.9	0.57	0.55		
day01	19	8.5	0.102	99	78.0	12.0	10.0	c	16	5.0	0.98	0.90		
day02	4	6.2	0.120	93	64.0	22.5	13.5	b	12	4.2	0.22	0.38	0.03	0.15
day03	19	8.4	0.139	94	55.0	20.5	24.5	c	25	9.3	1.1	1.7		
gor01	60	8.5	0.206	130	68.0	19.5	12.5	c	18	6.8	1.7	1.5		
gor02	63	8.2	0.149	100	64.0	21.0	15.0	c	16	4.6	1.1	1.1		
gor03	16	7.7	0.059	89	76.0	7.5	16.5	a	8.0	5.6	1.5	0.86		
gor04	23	8.5	0.130	120	59.0	24.0	17.0	c	21	6.1	0.93	2.3		
gor05	61	8.4	0.194	130	64.0	20.5	15.5	c	23	7.5	2.3	2.0		
gor06	16	8.5	0.108	93	62.0	20.0	18.0	c	20	4.6	0.62	1.6		
harr01	18	8.3	0.068	100	53.0	10.5	36.5	c	15	6.2	0.89	0.84		
harr02	2	6.9	0.035	110	84.5	5.0	10.5	a	3.8	0.95	0.09	0.30		
harr03	2	6.7	0.050	100	80.5	6.0	13.5	a	4.7	1.2	0.06	0.31		
harr04	27	8.3	0.067	110	67.0	10.5	22.5	c	6.7	4.2	1.4	1.1		
harr05	22	7.9	0.047	100	66.0	16.5	17.5	a	5.9	5.3	1.9	0.97		
harr06	5	5.5	0.106	170	71.5	7.5	21.0	b	3.2	1.2	0.19	0.18	0.21	0.09
harr07	44	8.5	0.130	97	57.5	21.5	21.0	c	17	7.6	1.8	1.7		
harr08	30	8.3	0.146	86	75.0	13.0	12.0	c	15	6.7	0.66	1.0		
harr09	69	8.7	0.196	110	68.5	17.0	14.5	c	15	6.4	3.0	1.9		
hon01	30	8.4	0.223	150	69.5	18.5	12.0	c	16	6.6	0.67	1.2		
hon02	13	7.5	0.127	96	58.0	18.5	23.5	a	21	6.8	0.35	0.40		
hon03	43	8.6	0.200	140	60.0	21.0	19.0	c	22	8.4	3.0	1.6		
hon04	19	8.2	0.119	120	58.5	23.5	18.0	c	16	6.9	0.72	2.7		
hon05	9	5.8	0.264	240	76.5	11.5	12.0	b	18	4.5	0.51	0.50	0.14	0.12
hon06	38	7.7	0.232	280	69.5	14.5	16.0	a	36	7.8	0.60	1.7		
jane01	36	8.2	0.105	85	50.5	17.5	32.0	c	15	7.8	1.9	1.4		
jane02	15	8.2	0.099	83	63.0	18.0	19.0	c	17	5.0	0.22	1.8		
jane03	28	8.4	0.133	98	72.0	15.0	13.0	c	18	3.6	0.60	1.6		
jane04	4	6.7	0.061	76	68.0	9.0	23.0	a	8.0	3.3	0.16	0.68		
jane05	6	7.0	0.084	92	73.0	11.5	15.5	a	7.4	4.9	0.55	0.99		

kook01	12	6.1	0.070	110	72.0	7.0	21.0	b	4.2	2.6	0.52	0.27	<0.02	0.14
kook02	5	6.1	0.095	140	74.5	6.0	19.5	b	5.9	1.3	0.17	0.17	0.02	0.08
kook03	7	6.6	0.084	120	71.0	8.0	21.0	a	7.0	3.8	0.34	0.43		
kook04	8	6.0	0.037	79	79.5	7.0	13.5	b	2.4	1.6	0.35	0.32	0.02	0.12
kook05	3	4.9	0.056	46	84.5	6.5	9.0	b	0.43	0.12	0.11	0.09	0.57	<0.02
kook06	3	5.9	0.036	82	79.0	6.0	15.0	b	2.0	2.2	0.21	0.29	0.04	0.05
kook07	27	8.0	0.107	69	64.5	13.0	22.5	a	25	7.8	0.84	0.56		
mg01	19	8.4	0.127	56	53.0	21.5	25.5	c	24	7.2	0.73	1.2		
mg02	3	6.5	0.046	70	82.5	8.0	9.5	a	3.0	0.97	0.08	0.32		
mg03	19	8.1	0.065	43	58.0	10.0	32.0	c	12	8.7	3.0	1.4		
mg04	36	8.4	0.122	96	44.0	24.0	32.0	c	19	11	2.6	1.9		
mg05	18	8.3	0.145	83	59.5	25.0	15.5	c	22	6.0	0.46	2.7		
mg06	19	8.4	0.175	83	64.0	22.0	14.0	c	23	7.1	0.60	1.8		
mg07	21	8.1	0.079	55	63.5	10.0	26.5	c	6.6	7.1	2.0	1.0		
mg08	3	6.5	0.054	71	83.0	9.5	7.5	a	2.9	0.71	0.10	0.40		
mhh01	48	8.4	0.208	86	74.0	15.5	10.5	c	23	7.6	1.9	0.85		
mhh02	10	7.4	0.096	79	65.5	17.5	17.0	a	16	4.6	0.24	0.56		
mhh03	29	8.6	0.148	100	71.0	16.5	12.5	c	18	8.5	1.7	1.4		
mhh04	4	6.9	0.085	82	72.0	19.0	9.0	a	8.6	2.8	0.17	0.58		
mhh05	56	8.2	0.269	190	73.0	17.5	9.5	c	19	8.9	1.1	1.7		
nb01	9	7.5	0.069	73	67.0	16.0	17.0	a	9.9	4.7	0.24	1.4		
nb02	12	7.6	0.068	87	74.0	12.0	14.0	a	8.6	4.6	0.29	1.3		
nb03	3	6.9	0.045	66	83.0	6.5	10.5	a	4.4	1.1	0.08	0.26		
nb04	44	7.9	0.106	75	54.0	19.5	26.5	a	16	10	1.8	1.7		
nb05	36	8.5	0.140	59	63.5	20.0	16.5	c	18	9.2	0.84	1.2		
park01	9	7.4	0.074	96	56.5	14.0	29.5	a	7.9	5.9	0.47	0.65		
park02	22	8.1	0.101	50	62.5	14.5	23.0	c	12	4.3	0.63	0.63		
park03	34	6.0	0.101	67	58.0	8.0	34.0	b	6.8	3.1	1.0	0.15	0.02	0.07
park04	21	4.2	0.049	53	51.5	12.0	36.5	b	0.81	0.85	0.66	0.14	0.93	<0.02
park05	19	7.0	0.062	66	65.0	11.0	24.0	a	5.8	6.4	1.8	0.75		
park06	8	4.7	0.057	54	65.5	6.5	28.0	b	1.2	0.48	0.21	0.17	0.57	<0.02
park07	16	7.5	0.072	60	64.5	9.5	26.0	a	5.3	13	2.0	0.66		
pros01	3	6.3	0.072	100	77.5	9.5	13.0	b	4.9	0.90	0.09	0.19	<0.02	0.04
pros02	34	5.0	0.151	170	80.0	6.0	14.0	b	5.3	1.5	1.1	0.20	0.76	0.07

pros03	2	6.5	0.030	79	85.5	4.5	10.0	a	2.4	1.7	0.12	0.44		
rth01	4	6.6	0.050	130	87.5	6.0	6.5	a	4.6	2.5	0.14	0.36		
rth02	2	6.5	0.047	95	84.5	7.5	8.0	a	4.2	1.6	0.07	0.27		
rth03	18	7.9	0.102	120	66.5	10.5	23.0	a	18	7.6	0.54	1.0		
rth04	13	8.6	0.111	85	62.0	19.5	18.5	c	17	5.1	0.28	1.4		
split01	15	8.5	0.139	140	67.5	14.5	18.0	c	18	3.6	0.37	1.4		
split02	3	7.2	0.036	62	78.5	6.5	15.0	a	3.1	2.4	0.15	0.42		
split03	2	6.5	0.038	47	88.0	4.5	7.5	a	2.4	0.49	<0.02	0.19		
split04	3	5.0	0.081	48	79.0	8.5	12.5	b	1.2	0.27	0.09	0.09	0.62	<0.02
split05	6	6.6	0.044	64	80.0	8.0	12.0	a	2.8	3.2	0.35	0.43		
th01	21	8.3	0.134	140	67.0	20.0	13.0	c	18	1.7	0.45	2.0		
th02	15	8.4	0.131	100	79.0	11.5	9.5	c	12	3.9	0.17	0.69		
th03	19	8.6	0.152	110	66.0	22.0	12.0	c	17	5.6	0.46	1.4		
th04	45	8.3	0.267	100	68.5	20.0	11.5	c	22	9.9	1.2	1.4		
th05	14	8.5	0.117	74	70.5	15.5	14.0	c	14	3.6	0.23	0.84		
th06	10	6.6	0.105	98	72.5	13.0	14.5	a	9.0	2.9	0.34	0.65		
th07	32	5.0	0.161	120	63.5	11.0	25.5	b	3.6	1.9	1.3	0.27	0.92	0.20
th08	29	8.3	0.185	93	72.0	17.0	11.0	c	19	5.3	0.66	1.1		
th09	29	8.3	0.111	88	37.0	19.5	43.5	c	15	13	3.2	1.5		
thir01	3	6.0	0.071	100	74.5	10.0	15.5	b	4.3	1.5	0.18	0.13	0.02	0.06
thir02	18	8.1	0.095	67	66.0	18.5	15.5	c	14	5.8	0.42	0.59		
thir03	120	8.4	0.166	130	63.0	22.0	15.0	c	12	7.8	3.7	1.9		
toom01	16	8.4	0.118	120	61.5	23.5	15.0	c	14	4.8	0.40	1.9		
toom02	12	8.6	0.117	83	65.5	16.0	18.5	c	18	5.3	0.28	0.62		
toom03	2	6.7	0.039	100	86.0	6.0	8.0	a	3.4	0.69	0.07	0.27		