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Flora and vegetation of banded iron formations of the Yilgarn Craton: Koolanooka and Perenjori Hills

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ABSTRACT

A study of the flora and plant communities of Koolanooka and Perenjori Hills, east of Morawa, recorded 238 taxa, with 217 native and 21 weeds. Nine priority taxa were found and five new species were identified and are considered endemic to the hills. Fifty quadrats were established to cover the major geographical, geomorphologic and floristic variation across the hills. Data from 48 of these quadrats were used to define five community types, with two subtypes in one community. Differences in communities were strongly correlated with landform and soil fertility. Patterns of high plant endemicity and restricted communities are similar to those found on other ranges within the Yilgarn Craton. None of the plant communities found on the Koolanooka and Perenjori Hills is reserved in the conservation estate.

INTRODUCTION

Banded iron formation ranges within the Yilgarn Craton are highly prospective for iron ore exploration and mining. Previous studies on greenstone and banded ironstone ranges in the Goldfields have found high plant endemicity and restricted vegetation types (Gibson et al. 1997; Gibson & Lyons 1998a,b; Gibson & Lyons 2001a,b; Gibson 2004a,b). It is hypothesised that similar patterns would also be found on the ironstone ranges in the Yilgarn Craton. The current knowledge of the vegetation and flora that occur on these ranges is poor and based on Beard's pioneering vegetation mapping (Beard 1976).

The Koolanooka Hills, Aboriginal for hill of wild turkeys (Rogers 1996), is located approximately 20 km east of Morawa. Perenjori Hills is located 10 km southeast of Koolanooka and 12 km to the northeast of Perenjori (Figure 1). Both hills are located near the boundary of the agricultural and pastoral zones in Western Australia, which roughly correlates with the boundary of the Eremaean and Southwest IBRA provences (Figure1).

The Koolanooka and Perenjori Hills are part of the Koolanooka synform, one of several Archaen belts within the Yilgarn Craton. The hills strike NNW–SSE and N–S respectively. The banded iron formation within the Koolanooka synform is part of the middle sedimentary association. The association contains siltstones, sandstones, conglomerates interbedded with banded iron formation and shale. This in turn is intruded by granitoids and bounded by upper and lower volcanic associations (Baxter & Lipple 1985). Historically, iron ore was mined in the northern part of Koolanooka Hills between 1966 and 1975 (Baxter & Lipple 1985). Currently, there is interest in further exploiting the iron ore resources of Koolanooka Hills.

The climate of the region is dry warm mediterranean (Beard 1990) with a mild wet winters and hot dry summers. Mean annual rainfall recorded at Morawa is 333.8 mm, but not as variable in more arid regions (227.8 mm 1st decile; 453.7 mm 9th decile; recorded 1911 to 2004). Rain primarily falls in winter, derived mainly from cold fronts moving in an easterly direction over the Indian Ocean. Summer rains are unpredictable and tend to occur later in the season. Summer rains originate from troughs and depressions and sometimes tropical cyclones off the northwest coast of Western Australia (Rogers 1996).

The highest maximum temperatures occur during summer, with the January as hottest month (mean maximum temperature 36.7 °C with mean of 7.4 days above 40 °C). Winters are mild with lowest mean maximum temperatures recorded for July of 18.1 °C. Temperatures rarely fall below 0 °C in winter (a mean of 0.2 days below 0 °C), with a mean minimum of 6.2 °C in July.

The Koolanooka and Perenjori Hills were described by Beard (1976) as a single vegetation system, the Koolanooka system, consisting of *Allocasuarina huegeliana*, *Eucalyptus ebbanoensis*, *Acacia acuminata*, *Dodonaea inaequifolia* interspersed with communities of *Allocasuarina campestris*, *Acacia acuminata*, *Grevillea paradoxa*, *Melaleuca cordata*, *Melaleuca nematophylla* and *Melaleuca radula*. The footslopes grade into *Eucalyptus loxophleba* woodlands interspersed with the thickets.

Koolanooka vegetation system was endorsed by the Minister for Environment as a Threatened Ecological Community (TEC) in 2001. The TEC, plant assemblages of the Koolanooka system, is based upon Beard's (1976) vegetation system described above, covering the entire extent of both hills, approximately 4500ha. It is currently ranked vulnerable following English and Blythe (1999).

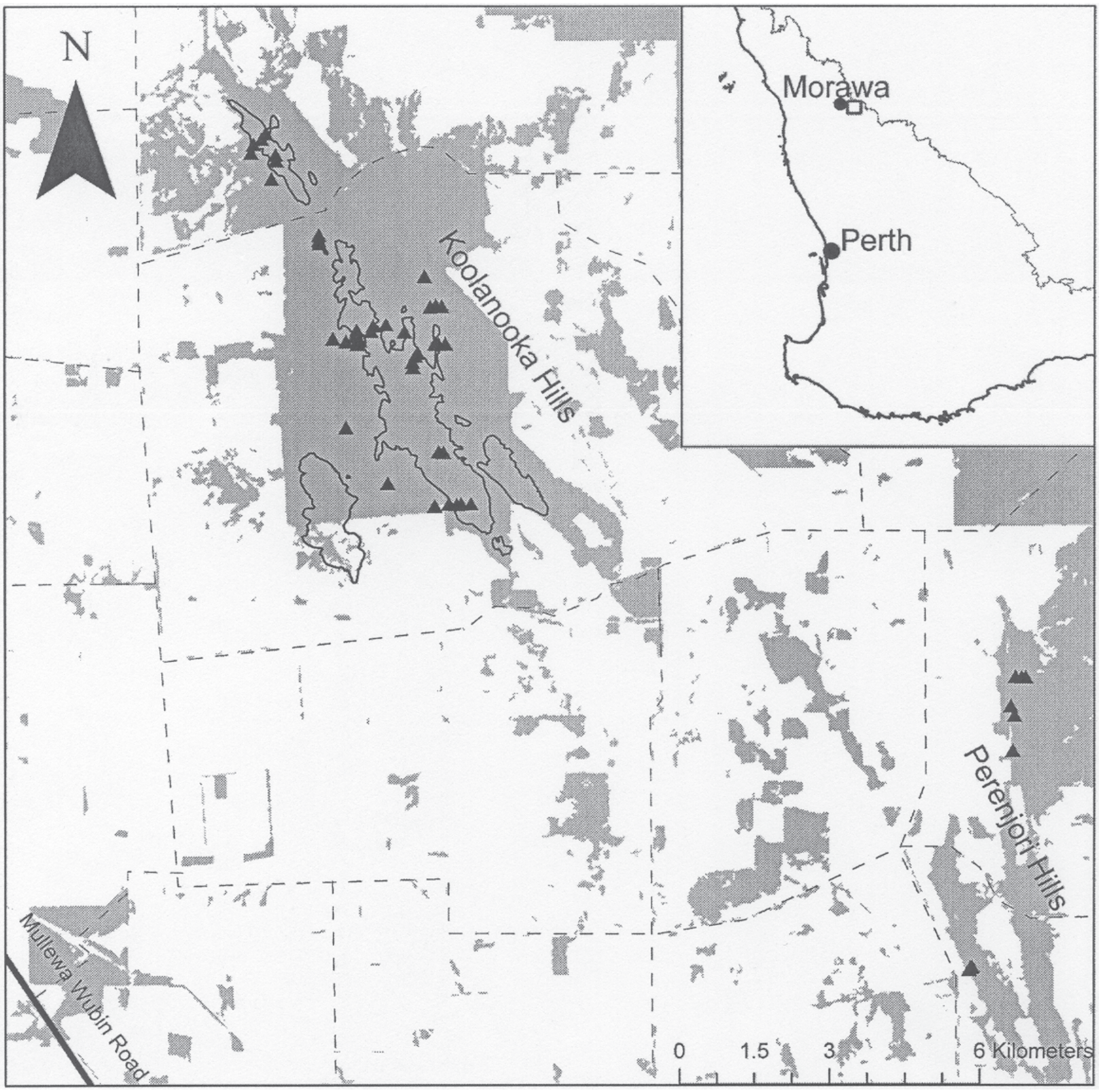

Figure 1. Location of survey and distribution of quadrats (▲) on Koolanooka and Perenjori Hills. The 340 m contour is shown, with remnant vegetation represented by shaded areas represent, dashed lines represent roads. In the inset, the grey line represents the zone between the Southwest and Eremaean provinces.

The aim of the present work was to undertake a detailed floristic survey of the Koolanooka and Perenjori Hills and to identify the plant communities that occur on the ranges. This was achieved by detailed flora lists, and description of plant communities based on a series of permanently established quadrats. Ultimately, the aim is to place these communities in a regional context with other banded ironstone ranges throughout the Yilgarn Craton.

METHODS

Fifty 20 x 20 m quadrats were established on the crests, slopes and foot slopes of Koolanooka and Perenjori Hills in October 2005 (Figure 1). These quadrats were established to cover the major geographical, geomorphologic and floristic variation found in the study area. Each quadrat was permanently marked with four steel fence droppers and their positions determined using a GPS unit. All vascular plants within the quadrat were recorded and collected for later identification at the Western Australian Herbarium.

Data on topographical position, disturbance, abundance, size and shape of coarse fragments on the surface, the amount of exposed bedrock, cover of leaf litter and bare ground were recorded following McDonald et al. (1990). Additionally, growth form, height and cover were recorded for dominant taxa in each stratum (tallest, mid- and lower).

Twenty soil samples were collected from the upper 10 cm of the soil profile within each quadrat. The soil was bulked and the 2 mm fraction analysed for B, Ca, Cd, Co, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S and Zn using the Mehlich No. 3 procedure (Mehlich 1984). The extracted samples were then analysed using Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP-

AES). This procedure is an effective and cost efficient alternative to traditional methods for evaluating soil fertility and has been calibrated for Western Australian soils (Walton & Allen 2004). pH was measured in 0.01M $CaCl_2$ at soil to solution ratio of 1:5. Effective cation exchange capacity (eCEC) was calculated from the sum of exchangeable Ca, Mg, Na and K (Rengasamy & Churchman 1999). Exchangeable Ca, Mg, Na and K were obtained by multiplying the values of Ca, Mg, Na and K obtained from ICP-AES by a standard constant.

Quadrats were classified on the basis of similarity in species composition on perennial species only, to be consistent with other analyses of banded ironstone ranges (Gibson 2004 a, b). Perennials were also more consistent across season and amount of pre-survey rainfall. Life form followed Paczknowska and Chapman (2000), where perennial is defined as a plant whose life span extends over 2 or more growing seasons. The quadrat and species classifications were undertaken using the Bray and Curtis coefficient and Flexible UPGMA (Unweighted pair-group mean average; â = -0.1; Belbin 1989). Indicator species and species assemblages characterising each community were determined following Dufrene and Legendre (1997) using the INDVAL routine in PC-ORD (McCune & Mefford 1999). Quadrats were ordinated using SSH (semi-strong hybrid multidimensional scaling), correlations of environmental variables were determined using the PCC (Principal Component Correlation) routine and significance determined by the MCAO (monte-carlo attributes in ordination) permutation test in PATN (Belbin 1989).

Statistical relationships between quadrat groups were tested using Kruskall-Wallis non parametric analysis of variance (Siegel 1956), followed by non-parametric comparison (Zar 1999). Correlations between environmental parameters were analysed using Spearman Rank correlation coefficient.

Nomenclature generally follows Paczkowska and Chapman (2000).

RESULTS

Flora

A total of 237 taxa from 53 families were recorded from the 50 established quadrats and adjacent areas. Of these 237 taxa, 216 were native and 21 weeds. The dominant families in order were Asteraceae (39 species, 3 weeds), Myrtaceae (21), Poaceae (21 species, 11 weeds), Mimosaceae (19) and Chenopodiaceae (11).

Rare and Priority Flora

Nine priority taxa (designated P1, P2, P3) were found during the survey of Koolanooka and Perenjori Hills.

- *Acacia acanthoclada* subsp. *glaucescens* (P3) is an intricately branched shrub to 2 m with pungent branchlets and glaucous phyllodes. It was found growing in open forests and mallee woodlands and of *E. ebbanoensis* or *E. loxophleba* subsp. *supralaevis.* It has been previously found on Koolanooka Hills.
- *Baeckea* sp. Perenjori (J.W. Green 1516) (P2) is a small myrtaceous shrub to 1.5 m with pink flowers. This taxon is restricted to the Morawa and Perenjori region. In this survey, it was found growing on the crests and slopes of Perenjori and Koolanooka Hills.
- *Gunniopsis rubra* (P3) is a small succulent herb to 10 cm growing on water gaining sites in sandy loam. A single collection was made of this taxon from a colluvial outwash site, growing under mallee woodlands of *Eucalyptus subangusta subsp. pusilla* and *Eucalyptus ebbanoensis* subsp. *ebbanoensis.*
- *Melaleuca barlowii* (P1) is a myrtaceous shrub to 1.8 m known mainly from the Mullewa and Morawa area growing on roadside reserves. It has been collected previously from Koolanooka Hills. In this survey, it was collected from two sites on Koolanooka Hills, growing in shrublands of *Allocasuarina acutivalvis* on a lower and mid slope.
- *Millotia dimorpha* (P1) is a small yellow flowered daisy characteristically with two rows of glandular involucral bracts. This species is poorly collected, and originally known only from Koolanooka Hills and Kadji Kadji Station. It has recently been found growing on the slopes of Mount Karara, east of Kadji Kadji (Markey and Dillon, 2008).
- *Mribelia sp.* Helena and Aurora (B.J. Lepschi 2003) (P3) is a perennial, leaf less but pungent shrub to 3m. Originally found only on the Helena and Aurora Ranges in the western Goldfields, it was found growing on the mid to upper slopes of Koolanooka Hills with *A. acutivalvis* and *E. ebbanoensis.* This is a new record for Koolanooka Hills and a range extension of over 400km for the species.
- *Persoonia pentasticha* (P2) is a proteaceous shrub to 2 m with pungent five ribbed leaves. In this survey, it was found at two sites on crests of Koolanooka Hills, growing in open forests of *A. acutivalvis* and *E. ebbanoensis.*
- *Rhodanthe collina* (P1) is an annual daisy with small delicate flowers. It is known mainly from the pastoral stations near Paynes Find on flats and water gaining sites. A single specimen was found on Koolanooka Hills on a rocky midslope. This is a new record, range extension and population for the area.
- *Stenanthemum poicilum* (P2) is small shrub to 50 cm that was found growing on the crests and upper slopes of Koolanooka Hills in open mallee forests and woodlands of *E. ebbanoensis* and *A. acutivalvis.* It has been previously collected from rocky sites in the Morawa area. This a new record for Koolanooka Hills.

New Species

During the survey, six new species were identified. These taxa are apparently endemic to the Koolanooka and

Perenjori Hills. Further surveys are required to determine the distribution and population size of each taxon. Further taxonomic work is also required to determine taxonomic rank of several of the taxa.

- *Acacia muriculata* is a shrub to 2 m found growing only on the slopes and crests of Koolanooka Hills in open mallee forests and woodlands of *E. ebbanoensis* and *A. acutivalvis*. It characterised by hairy verruculose-ribbed branchlets and falcate phyllodes with solitary globular flowers (Maslin & Buscomb 2007). It has recently been listed as Priority One species and is known only from Koolanooka Hills.
- *Acacia graciliformis* is an openly branched shrub to 2 m with slender stems and short pungent phyllodes. It was found at four sites growing in *Eucalyptus* woodlands crests and slopes of Koolanooka Hills. This species is closely allied to *Acacia mackeyana* and *A. dissona* which differ significantly from the species in their phyllode nervature (Maslin & Buscomb 2007). It has been listed as a Priority One species due to its restricted habitat and location.
- *Caesia* sp. Koolanooka Hills (R.Meissner & Y.Caruso 78) is a geophyte to 30 cm with pale yellow flowers growing on crests and slopes of Koolanooka and Perenjori Hills. The species is closely related to *Caesia* sp. Wongan (K.F. Kenneally 8820) but with smaller, pallid flowers and spreading anthers. It may belong to a sub-group of the genus that is endemic to ironstone ranges, including such species as *Caesia* sp. Ennuin (N.Gibson & M.N.Lyons 2737) (G. Keighery[1] , pers. comm.). The occurrence on the ranges is unusual as most *Caesia* spp. grow in deep clay soils on flats and plains.
- *Dodonaea scurra* is a dioecious shrub to 1 m with verticillate leaves and solitary flowers. It is closely allied to *Dodonaea caespitosa* but is distinguished by relatively more clustered leaves per node and distinctly rounded capsules with simple scattered hairs (Shepherd et al. 2007). It was found only on the slopes and crests of Koolanooka Hills in several different communities. There was one previous collection in the Western Australian Herbarium of this taxon, which was misidentified, from the Koolanooka Hills. It is has recently been listed as Priority One due to its limited distribution to Koolanooka Hills.
- *Drummondita rubroviridis* is a spindly shrub to 1.5 m with glandular clavate leaves, held recurved to horizontal, and subsessile, solitary flowers that possess red petals with green tips (Meissner & Markey 2007). It is closely related to *D. wilsonii* and *D. ericoides*, both taxa with restricted distributions (Mollemans 1993). This species was only found on the slopes and crests of Koolanooka Hills, growing mainly in open mallee forests and woodlands of *E. ebbanoensis* and *A. acutivalvis*.
- *Lepidosperma* sp. Koolanooka (K. Newbey 9336) is a sedge to 50 cm found growing on the slopes of Koolanooka and Perenjori Hills in open forests and shrublands of *A. acutivalvis* or *A. campestris*. Although previously collected from Koolanooka, it was not recognised as a new species until the current survey collected sufficient material for the status to be determined with confidence. It is closely related to another newly discovered granite endemic, *Lepidosperma* sp. Karara (H.Pringle 3865) found growing on granite outcrops on Karara Station.

Flora of taxonomic interest

- *Hibbertia* aff. *exasperata* belongs to a complex, including *Hibbertia rostellata*, *Hibbertia nutans* and *Hibbertia uncinata*, of unresolved taxonomy (Wheeler 2004). Further work needs to be undertaken to elucidate the taxonomic relationships within this complex. The species was collected only from the slopes and crests of Koolanooka Hills, mainly from mallee woodlands of *E. ebbanoensis* and *A. acutivalvis*.
- *Eucalyptus ebbanoensis* subsp. *glauciramula* is a mallee to 3 to 6m and was collected from both ranges. It was commonly the dominant *Eucalyptus* and was found across the landscape, from crests to lower slopes and plains. It has previously been collected from the range. The nearest populations are nearly 400 km to the east in the Goldfields.
- *Labichea lanceolata* subsp. *brevifolia* is a shrub to 3m. It was found growing at single site on a midlsope of Koolanooka Hills, in an open forest of *A. acutivalvis*. The taxon is found in three discreet areas; around Esperance, York and an outlying northern population. The specimen collected in this survey belongs to the northern variant of the taxon, found in scattered populations between Geraldton and Morawa. These collections have narrow leaves and look superficially more like *Labichea eremaea* than *L. lanceolata*, but differ from the former as they have 4 rather than 5 sepals. Revision of this taxon is required.
- *Tetraria* aff. *capillaris* is a sedge with curly leaves growing to 50 cm. It was found growing at a single site on Koolanooka Hills in *Allocasuarina acutivalvis* subsp. *acutivalvis* woodland with *M. nematophylla*, *H.* aff. *exasperata* and *L.* sp. Koolanooka (K.Newbey 9336). It is closely allied to *Tetraria capillaris* and this complex is in need of taxonomic revision (R. Barrett[2] , pers. comm.).

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[2] Science Directorate, Botanic Gardens & Parks Authority, Kings Park and Botanic Garden, Western Australia

Plant Communities

Initial analysis of the data with all species excluding singletons (species which occurred in only one plot) compared to an analysis of data with only perennial species revealed little difference in the groupings and ordination. Ninety eight perennial taxa were included in the final analysis. Subspecies of *E. ebbanoensis* and *A. acutivalvis* were reduced to species level for the analysis, due to the difficulty in differentiating between subspecies without sufficient flowering or fruiting material.

Forty eight quadrats out of the fifty established on the ranges were used in the final analysis. In the initial analysis, two quadrats were outliers and subsequent removal improved the ordination stress. Quadrat KOOL26 was a species poor *Eucalyptus salmonophloia* woodland occurring over limestone and KOOL36 was an open shrubland of *Acacia tetragonophylla* and *Calycopeplus paucifolius* and had a high percentage of weeds present, probably due to high levels of disturbance. Both sites had high levels of calcium, magnesium and high pH.

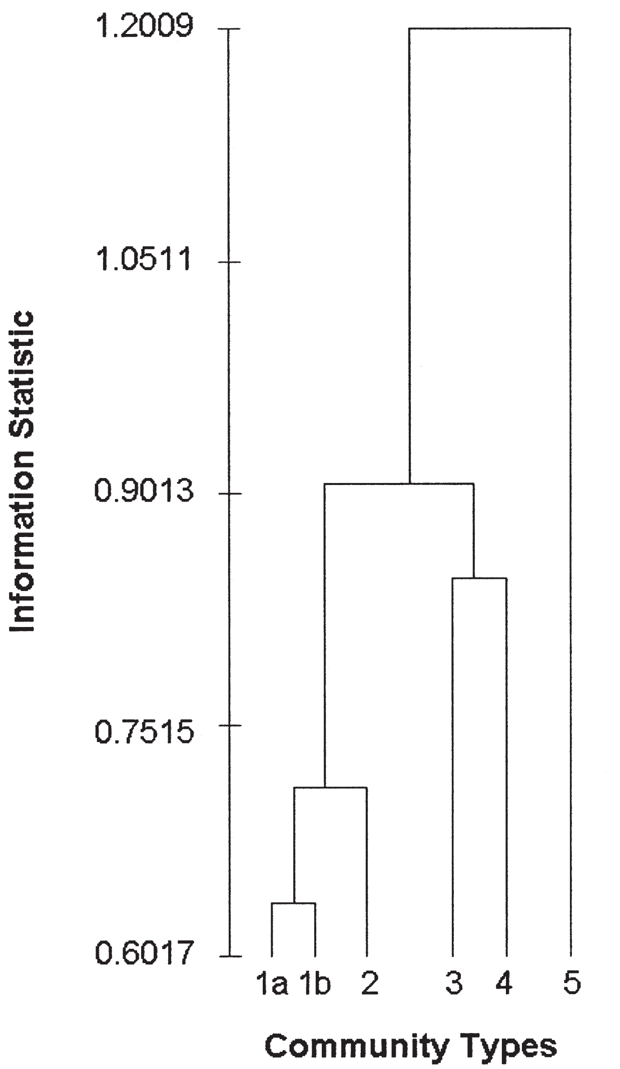

Figure 2. Dendrogram of 6 group level classification of 48 quadrats established at Koolanooka and Perenjori Hills.

Community groups were separated into 5 groups, based upon clear pattern in the final dendrogram. This pattern was also the first division separates the *Allocasuarina* shrublands and thickets (Communities 1-4) from the more fertile woodland sites (Community 5; Figure 2). The second division separates communities restricted mainly to the crests, upper and mid slopes of Koolanooka Hills (Communities 1 and 2) from communities common between Perenjori and Koolanooka Hills (Community 3) and communities found on the lower slopes of Koolanooka (Community 4). These divisions can also be clearly seen in the sorted two-way table of the sites and species classification (Table 1).

In total, five community types, one with two subtypes, were recognised.

Community 1 – Woodlands, mallee shrublands and shrublands of *A. acutivalvis*, *E. ebbanoensis* over shrublands of *Acacia* spp. and Myrtaceae spp. The community occurs only on crests and slopes of Koolanooka Hills and can be further divided into 2 subtypes.

Community type 1a – This community is found only on Koolanooka Hills on all landforms except colluvial outwashes. It is described as mallee shrublands, shrublands and woodlands of *A. acutivalvis*, *E. ebbanoensis* and *Melaleuca* spp. over shrublands with *Micromyrtus racemosa*, *G. paradoxa* and *M. sp.* Helena and Aurora (B.J. Lepschi 2003) present. The community had the lowest mean species richness (annuals and perennials) of all communities (mean 32.3 ± 0.6 species per quadrat). The best indicator species are *Acacia neurophylla* subsp. *neurophylla*, *Cheiranthera filifolia* var. *simplicifolia*, *D. rubroviridis*, *E. ebbanoensis*, *G. paradoxa*, *Micromyrtus racemosa* subsp. *racemosa*, *Melaleuca atroviridis*, *M. sp.* Helena and Aurora (B.J. Lepschi 2003) and *Thysanotus manglesianus* (Table 1).

Community type 1b – This community is only found on the slopes of Koolanooka Hills. It is best described as woodlands and shrublands of *A. acutivalvis* with an understorey of *L.* sp. Koolanooka (K.Newbey 9336), *Pimelea avonensis,* and *Acacia nigripilosa* subsp. *nigripilosa*. Mean species richness was 34.0 ± 0.5 species per quadrat. Indicator species were *A. nigripilosa* subsp. *nigripilosa, Austrostipa hemipogon*, *C.* sp. Koolanooka Hills (R.Meissner & Y.Caruso 78), *L.* sp. Koolanooka (K. Newbey 9336), *M. nematophylla, P. avonensis* and *Tricoryne elatior*. This community is characterised by taxa from Species groups D and G (Table 1).

Community type 2 – This community occurs only on Koolanooka Hills, mainly on crests and upper slopes and contains taxa from Species group A (Table 1). It can be described as mallee woodlands and shrublands of *E. ebbanoensis* and *A. acutivalvis.* This community had the second highest species richness with a mean of 38.6 ± 1.3 species per quadrat. Indicator species were *S. poicilum*, *H.* aff. *exasperata*, *A. acutivalvis* and *Ptilotus obovatus* subsp. *obovatus.*

Community type 3 – This community occurs on midslopes and crests of Koolanooka and Perenjori Hills. It can be described as open woodlands, shrublands and open shrublands of *Allocasuarina* spp., *M. nematophylla,* and

C. paucifolius over a mixed shrubland of *D. inaequifolia* and *Philotheca brucei* subsp. *brucei*. The community had the highest species richness with a mean of 39.4 ± 0.6 species per quadrat. Indicator species for this community are *Acacia exocarpoides*, *C. paucifolius*, *D. inaequifolia* and *P. brucei* subsp. *brucei*. Taxa in the community are mainly from species groups A, D, F and G (Table 1).

Community type 4 – This community was found mainly on low fertility lower slopes of Koolanooka Hills. The vegetation is shrublands and open shrublands of *Allocasuarina* spp., *M. cordata*, *Hemigenia* sp. Paynes Find (A.C. Beauglehole 49138) and *Mirbelia microphylla*. This community had a mean species richness of 34.4 ± 1.6 species per quadrat and is comprised of taxa from species group D, I and J (Table 1). The Best indicator species are *Acacia stereophylla* var. *stereophylla*, *A. campestris*, *Drosera macrantha* subsp. *macrantha*, *Grevillea obliquistigma* subsp. *obliquistigma*, *H.* sp. Paynes Find (A.C. Beauglehole 39138), *Hibbertia arcuata*, *M. cordata*, *M. microphylla*, *Monachather paradoxus* and *Stypandra glauca*.

Community type 5 – This community was found on both ranges. It occurs on colluvial outwash soils from the ranges, and sites occurring in pockets of fertile soil within community type 1. The vegetation is woodlands and mallee woodlands of *Eucalyptus* spp. (*E. loxophleba*, *E. ebbanoenisis* or *E. salmonophloia*) over *Acacia* spp. and chenopods. The community had a mean species richness of 34.2 ± 0.8 species per quadrat. The best indicator species are *Acacia andrewsii*, *Acacia erinacea*, *Austrodanthonia caespitosa*, *Austrostipa trichophylla*, *Enchylaena lanata*, *Maireana carnosa*, *Maireana georgei*, *Rhagodia drummondii*, *Scaevola spinescens*, *Sclerolaena diacantha* and *Senna charlesiana*. The community is characterised by taxa from species groups A and C (Table 1), which are typical of soils of high pH.

Physical parameters

The soil chemistry showed significant intercorrelations with other soil parameters. Iron had the most correlations with physical site parameters. It was positively correlated with slope, aspect, maximum surface rock fragment size and rock outcrop abundance, but negatively with leaf litter cover (Table 2).

There were few correlations between physical site characters. Slope, rock outcrop abundance, maximum surface rock size and run off were positively intercorrelated (Table 2).

Phosphorus, pH, magnesium and cobalt were all high in Community 5, indicating sites of higher fertility. Low phosphorus and magnesium separated Communities 1 and 4 from the other communities (Table 3).

Communities 2 and 5 showed similar values in phosphorus, cobalt, magnesium and pH. Community 3 differed from the latter with the highest phosphorus values but significantly lower pH (Table 3).

Community 3 had significantly greater coarse fragment size and abundance than Community 5, which occurred on the colluvial outwashes and deeper fertile soils (Table 4). The remaining communities did not differ from Communities 3 and 5 in these site characters. Community 4 occurred on lower slopes and differed only from Community 3, which occurred predominantly on crests and midslopes. The cover of surficial rock (rock outcrop abundance) was greatest in Community 2, followed by Community 3 (Table 4).

The three dimensional ordination (stress = 0.17) clearly separated the majority of the communities (Figure 3). The most common community type found on Koolanooka Hills (Community 1a) is on the left side of the ordination, characterised by lower fertility (low phosphorous and potassium). Community 1b occurred in the upper left quadrant with lower pH and an increase in coarse fragment abundance. The woodlands on colluvial soils and on the slopes of the hills (Community 5) also clearly separated out from the other communities. This community was found in the lower right quadrant and was characterised by higher pH and Co and occurrences on predominantly lower slopes and flats. Community 3, common between Koolanooka and Perenjori Hills, occurred in the upper right quadrant. This community can be characterised by the higher abundance of rocky outcrops and steeper slopes, and high phosphorus. Community 2 and 4 occur in the centre of the ordination but separate in the third dimension (not shown). The soil of Community 4 has characteristically lower fertility and is found on gently inclined slopes, while Community 2 was on soils of intermediate fertility.

DISCUSSION

Flora

The total of 238 taxa and the pattern of dominant families recorded for Koolanooka Hills are similar to other ironstone and greenstone ranges surveyed in the Eastern goldfields (see Gibson 2004a). Six endemic species were identified during the survey, similar to the number of endemics found on other ironstone ranges (Gibson 2004b).

The patterns of endemism and priority species on ironstone ranges are high. A concurrent survey in the Central Tallering found 15 priority species and 9 endemic taxa (*cf.* 8 species and 6 taxa, respectively, in this survey) (Markey & Dillon, 2008). The Central Tallering survey covered a greater area and sampled twice the number of quadrats, making it even more significant the high number of endemic species found in this survey.

Three of the endemic species, *A. muriculata*, *C.* sp. Koolanooka (R. Meissner & Y. Caruso 78) and *D. rubroviridis* (R. Meissner & Y. Caruso 69), were collected for the first time. *Acacia muriculata*, *A. graciliformis*, *D. scurra* and *D. rubroviridis* appear to be restricted to Koolanooka Hills and were not found on Perenjori Hills, while *Caesia* sp. Koolanooka (R. Meissner & Y. Caruso 78) and *L.* sp. Koolanooka (K. Newbey 9336) occur on both.

Recent taxonomic work has discovered several

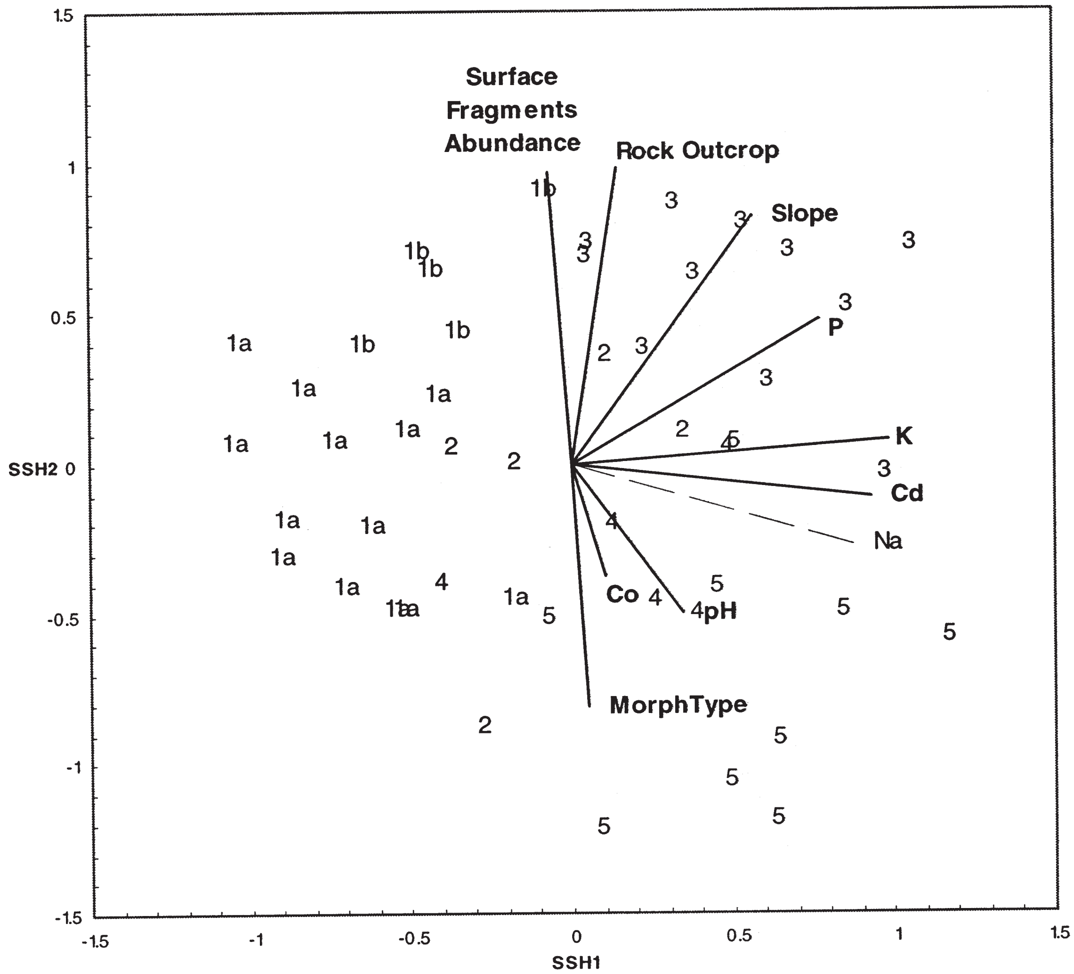

Figure 3. Two dimensional representation of a three dimensional ordination showing only axis 1 and 2 of the 48 quadrats established on Koolanooka and Perenjori Hills and represented by community type. Lines represent the strength and direction of the best fit linear correlated variables. Unbroken and dashed lines represent significance at $P < 0.01$ and $P < 0.05$ respectively. Abbreviations as in Table 4.

additional taxa of *Lepidosperma* that are endemic to banded ironstone ranges, such as *Lepidosperma gibsonii*, *L. ferricola* and *Lepidosperma* sp Karara (Markey and Dillon 3468) (R. Barrett[3], pers. comm., Barrett 2007). This group is currently undergoing a much needed revision.

Koolanooka and Perenjori Hills occurs close to the boundary between two provinces, Southwest and Eremaean (Beard 1990). The flora found within this survey showed a greater affinity to the Southwest flora (e.g. *Ptilotus drummondii*, *Alyxia buxifolia*, *Hibbertia* spp. and *Allocasuarina* spp.) than Eremaean. Those Eremaean taxa present at Koolanooka and Perenjori Hills showed considerable range extensions, especially *Eucalyptus ebbanoenis* subsp. *glauciramula* and *Mirbelia* sp. Helena & Aurora (B.J. Lepschi 2003), found in the eastern goldfields.

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Communities

Vegetation on Koolanooka and Perenjori Hills is described by Beard (1976) as the same system; however, there were differences in communities between Koolanooka and Perenjori Hills. Three of the communities, 1, 2 and 4 were found only on Koolanooka Hills while Communities 3 and 5 were found on both Koolanooka and Perenjori Hills. Perenjori Hills is smaller in extent than Koolanooka, and in some places the vegetation has been cleared up to the lower slopes. In addition, there is a history of sheep grazing in Perenjori Hills, but only feral goat grazing is known at Koolanooka.

Community types were found to be correlated with soil fertility, landscape position, soil depth and surface rockiness. Low phosphorus and potassium separate Communities 1 and 4, restricted to Koolanooka Hills, from the more fertile sites. The two communities occur on very different landforms with Community 1 occurring on skeletal soils on crests and slopes, while Community 4 is found on the lower slopes of the ranges. In contrast, Community 2, which is also restricted to Koolanooka Hills, shows higher levels of phosphorus. It is found on a similar landform to Community 1 but mainly on sites with laterised banded ironstone and with higher cover of surficial rocks.

Community 3 is found on both Perenjori and Koolanooka Hills and showed highest phosphorus levels, but had lower pH. It was commonly found on steeper slopes and crests and often with a higher cover of surficial rocks, some weakly metamorphosed banded ironstone but no tertiary laterites.

Community 5 is typical of the woodlands surrounding many of the greenstone and ironstone ranges in the Yilgarn Craton (see Gibson 2004b). At Koolanooka it occurred on the colluvial flats at the bases of both hills and also on pockets of fertile soils on slopes and small valleys between hills. The communities are likely to be responding to the higher nutrients and pH, and possibly deeper soils required for larger trees to survive.

Gradients in the floristics and associated environmental variables occur in the study area. Communities 1b and 3 occurred on rockier sites which were always associated with a higher position in the landscape. The soils in these areas are often shallower with higher phosphorus, a characteristic of soils derived from the ironstone (Gray & Murphy 2002). In contrast, the lower colluvial and lower slope communities (4 and 5) the soils were relatively higher in nutrients, and in the case of the woodlands, possessing deeper soil. This is the likely result of the enrichment by leachates and colluvium from the surrounding ridges.

Beard (1976) mapped Koolanooka and Perenjori Hills as a single vegetation system, the Koolonooka system. A vegetation system encompasses a series of plant communities recurring in a catenary sequence or mosaic pattern linked to topographic, pedological and or/ geological features (Beard 1981). This present study shows the broad vegetation system as comprised of five plant communities. The current definition of the Koolanooka TEC should be re-evaluated and incorporate these communities.

In Beard's (1976) description of the Koolanooka system, he notes *Allocasuarina huegeliana* as the dominant taxon (*cf. A. acutivalvis* in this survey). There is no record of *A. huegeliana* from Koolanooka or Perenjori Hills in the Western Australian Herbarium, and is probably a misidentification. Furthermore, within the vegetation system he also mapped two structural units that largely correspond to Communities 1 and 5.

The plant communities on Koolanooka and Perenjori Hills, especially the three restricted to Koolanooka, are currently under increasing threat from mining and none of the area is currently reserved.

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Table 1

Sorted two-way table of quadrats established Koolanooka and Perenjori Hills showing species by community type. Taxa shaded grey within a community are indicator species identified by INDVAL > 17 (Dufrene & Legendre 1997) at the 6 group level (* indicates P< 0.05; ** indicates P<0.01; statistical significance tested by randomisation procedures).

		Community Types					
		1a	1b	2	3	4	5
	SPECIES GROUP A						
	Acacia acanthoclada subsp. *glaucescens*			••			• ••
**	*Scaevola spinescens*	•			• • •		(shaded) •• •••••
*	*Senna charlesiana*			•	•		(shaded) • • ••
	Acacia acuminata	•••• •• •• •		•• •••	• • ••••	•	•• ••••
*	*Austrostipa trichophylla*	••• •		•	• ••	• •	(shaded) •••••• •
	Austrostipa elegantissima	• ••••• ••	•	•••••	•••	•••	•••••• ••
**	*Acacia andrewsii*	•		(shaded) ••••	• •		(shaded) •••••••••
**	*Rhagodia drummondii*			(shaded) • ••	•		(shaded) ••• ••••
	Austrostipa scabra			• ••••	• • •• ••	•	••• •
	Ptilotus obovatus var. *obovatus*	••		•••	•• •• ••		•• ••• •
	Acacia anthochaera	•		• • •			• • •
	Austrodanthonia sp. Goomalling (A.G. Gunness et al. OAKP 10/63)	•			•		•
	SPECIES GROUP B						
*	*Bulbine semibarbata*			(shaded) ••			
	Senna artemisioides subsp. *filifolia*	•		•			
	Maireana planifolia			•			• • •
	Olearia humilis	•		•	• •		•
	SPECIES GROUP C						
	Acacia graciliformis			• •			••
**	*Acacia erinacea*						(shaded) •• ••
	Maireana marginata						••
**	*Austrodanthonia caespitosa*						(shaded) •• • •
	Sclerolaena fusiformis						• •
**	*Sclerolaena diacantha*						(shaded) • ••• •
**	*Maireana carnosa*						(shaded) •••• •
**	*Maireana georgei*						(shaded) •••• •
*	*Enchylaena lanata*						(shaded) •• •
	Olearia muelleri						••
	Eucalyptus subangusta subsp. *pusilla*			•			••
	SPECIES GROUP D						
	Acacia assimilis subsp. *assimilis*	••• •••• • •	••••	••	• • •	•••••	
	Amphipogon caricinus var. *caricinus*	••• •••••• •	••••••	• •	• •• •	•• •••	•
*	*Allocasuarina acutivalvis*	(shaded) •••• ••••••••	(shaded) ••••	(shaded) •••••	••••••••	•	• •
	Arthropodium dyeri	•••••••••••	•••••	•••••	•• •• •• •	•• • •	•••• •
*	*Eucalyptus ebbanoensis*	(shaded) •••••••••••••	(shaded) •••	(shaded) ••••••	• ••	•	•••••
**	*Grevillea paradoxa*	(shaded) •••••••••••••	(shaded) •••••	•••	(shaded) ••••••••••••	••	
*	*Thysanotus manglesianus*	(shaded) •••••••••••••	(shaded) •••••	• •	• •• •	(shaded) •• •••	•
	Astroloma serratifolium	•• • • ••••	•• • •	••••	••	•••	
**	*Hibbertia* aff. *exasperata*	• •••• •••	• • •	(shaded) •••••	•		
	Dianella revoluta var. *divaricata*	••••• •••	••• •	••••	• • •	•	•
*	*Melaleuca nematophylla*	••• ••	(shaded) •••••	(shaded) ••••	(shaded) ••••••••••• •	•	
**	*Acacia nigripilosa* subsp. *nigripilosa*	•• ••••••	(shaded) ••• •	•			
	Dodonaea scurra	•••• • •••	•	•••			•
**	*Micromyrtus racemosa* var. *racemosa*	(shaded) •••• •••• •••	•	•			
	Aluta aspera subsp. *hesperia*	• •••••••	•		•	• •	
	Stylidium confluens	•• ••••••• •	•• •	• •	• •	•	
*	*Hibbertia arcuata*	• • •••	•		••	(shaded) •••	
	Acacia coolgardiensis subsp. *coolgardiensis*	•• • •			••	• • •	
**	*Melaleuca atroviridis*	(shaded) ••••• ••					• •
*	*Melaleuca cordata*	•••••• •				(shaded) •• •	
	Schoenus nanus	• ••	•			••	•
	Melaleuca eleuterostachya	••		• •			• •
**	*Stenanthemum poicilum*	••• •	•	(shaded) •••••	••		

Table 1 (cont.)

	1a	1b	2	3	4	5
SPECIES GROUP E						
Acacia daviesioides	••					
Acacia muriculata	••••		•			
* *Drummondita rubroviridis*	••••					
* *Mirbelia* sp. Helena & Aurora (B.J. Lepschi 2003)	•••••			•		
* *Acacia neurophylla* subsp. *erugata*	•••••					
* *Cheiranthera filifolia* var. *simplicifolia*	••••					
Westringia cephalantha	•					•
Malleostemon tuberculatus		•			•	
Santalum acuminatum	•	•				
SPECIES GROUP F						
** *Acacia exocarpoides*				•••••		
Allocasuarina dielsiana				•••		
Acacia tetragonophylla			•	•••		••
Eremophila latrobei subsp. *latrobei*				••		
Solanum ellipticum				•	•	
Hakea recurva			••	••		
Persoonia pentasticha		•	•			
SPECIES GROUP G						
** *Austrostipa hemipogon*	•	•••••	•••	•		
** *Lepidosperma* sp. Koolanooka (K.Newbey 9336)		•••••		•••		
* *Tricoryne elatior*	•	•••	•	•••		
** *Pimelea avonensis*	•	•••				
Baeckea sp. Perenjori (J.W. Green 1516)		••		•••	•	
Comesperma integerrimum	•••••	••••	•	••••••••	•••	
Xanthosia bungei	•	•••		••••••••	•••	
Caesia sp. Koolanooka Hills (R.Meissner & Y.Caruso 78)	•	••		••••••	•	
** *Calycopeplus paucifolius*				••••		
Melaleuca radula	••••	••		••		
Chamaexeros macranthera			•	•••••		••
** *Dodonaea inaequifolia*		•	••	••••••••••	•	••••
** *Philotheca brucei* subsp. *brucei*			••	••••••••••	•	••
Eremophila clarkei	•••		•••	••••••••	•	••••
Daviesia hakeoides subsp. *hakeoides*		•	•	••••	•••	
Dioscorea hastifolia	•	••	••	••••••	•	
* *Mirbelia microphylla*	•	••	••	••••••	•••••	
Sida atrovirens	••	•	•••	•••••	•	
SPECIES GROUP H						
* *Caesia* sp. Wheatbelt (AJM Hopkins 353)		••				
Eucalyptus loxophleba subsp. *supralaevis*	•	•	•			•••
Melaleuca hamata	•	•		•		
SPECIES GROUP I						
* *Acacia stereophylla* var. *stereophylla*	•			•	••	
Thysanotus pyramidalis					••	••
* *Grevillea obliquistigma* subsp. *obliquistigma*					••	
Alyxia buxifolia				•		••
Arthropodium curvipes			•	•		
SPECIES GROUP J						
** *Allocasuarina campestris*	•••	•			••••	
** *Drosera macrantha* subsp. *macrantha*	•••	•••			•••••	
** *Hemigenia* sp. Sticky Terete (B.H. Smith 449)	•				•••	
* *Monachather paradoxus*	•			••	•••	••
Melaleuca barlowii		•			•	
* *Stypandra glauca*					••	

Table 2
Spearman's rank correlation of soil chemistry parameter and physical site characters. Cells with numbers present represent significant correlation at P < 0.05.

	eCEC	pH	B	Ca	Cd	Co	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Zn	Aspect	Slope	Disturbance	Surface Rock Abundance	Surface CF Size
eCEC																							
pH																							
B	0.20	0.41																					
Ca	0.99	0.58																					
Cd																							
Co	0.31	0.39			0.48																		
Cu					0.34	0.53																	
Fe	0.51			0.54																			
K	0.63	0.33		0.57	0.31	0.30	0.39																
Mg	0.90	0.60	0.31	0.85		0.34	0.31	0.45	0.58														
Mn	0.39	0.42		0.37	0.52	0.68	0.30			0.29													
Mo			0.57																				
Na	0.42		0.30	0.34			0.50		0.69	0.50													
Ni	0.74	0.41		0.71	0.41	0.47	0.30	0.45	0.52	0.71	0.51												
P							0.34		0.33				0.33	0.08									
Pb		-0.30			0.33		0.33						0.29										
S		-0.56											0.41			0.45							
Zn					0.41		0.52		0.47		0.31		0.40		0.35	0.51	0.29						
Aspect								0.30															
Slope								0.31		0.29				0.38				0.34	0.41				
Disturbance																							
Surface Rock Abundance							-0.37																
Surface CF Size								0.38					0.32				0.34			0.42			
Rock Outcrop Abundance								0.50												0.45			0.61
Runoff														0.31						0.73		0.41	0.29
%Litter					0.39	0.43	0.33	-0.39			0.35												
%Bare															-0.43								

Table 3

Plant community mean values for soil chemistry parameters (measured in mg/kg except eCEC and pH). Differences between ranked values tested using Kruskall-Wallis non-parametric analysis of variance. Standard error in parentheses. Parameters in bold indicate significance at P<0.01. a, b and c represent significant differences between community types at P < 0.05 (n = number of quadrats, P = probability, ns = not significant).

			Community Type			
	1	**2**	**3**	**4**	**5**	**P**
eCEC	4.7 (0.5)	4.9 (0.9)	4.3 (0.7)	2.6 (0.3)	5.5 (0.9)	ns
pH	**4.9 (0.0)[b]**	**5.0 (0.1)[ab]**	**4.8 (0.1)[b]**	**4.7 (0.1)[b]**	**5.3 (0.1)[a]**	**0.01**
P	**4.3 (0.2)[a]**	**7.2 (1.0)[bc]**	**9.1 (1.5)[b]**	**3.4 (0.4)[a]**	**7.0 (0.6)[c]**	**<0.01**
Ca	636.7 (60.5)	660.0 (148.0)	565.5 (112.7)	336.0 (57.3)	658.9 (112.5)	ns
K	116.4 (6.3)	132.0 (17.4)	139.4 (13.2)	112.8 (11.9)	144.4 (9.9)	ns
Mg	**140.0 (20.3)[a]**	**144.0 (21.6)[a]**	**115.9 (17.4)[ab]**	**69.8 (7.6)[b]**	**199.7 (36.2)[a]**	**<0.01**
B	**0.6 (0.0)**	**0.7 (0.1)**	**0.8 (0.1)**	**0.5 (0.0)**	**0.9 (0.2)**	**0.05**
Cd	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)	0.02 (0.01)	ns
Co	**0.4 (0.1)[ab]**	**0.8 (0.3)[ab]**	**0.3 (0.1)[b]**	**0.2 (0.1)[b]**	**0.8 (0.2)[a]**	**<0.01**
Cu	**1.7 (0.3)**	**3.2 (0.4)**	**1.6 (0.2)**	**1.3 (0.3)**	**2.8 (0.7)**	**0.01**
Fe	**77.3 (3.7)**	**73.2 (5.0)**	**69.5 (7.2)**	**53.6 (3.4)**	**66.9 (9.6)**	**0.04**
Mn	121.1 (17.1)	170.8 (40.0)	94.8 (16.7)	90.6 (29.1)	147.0 (27.8)	ns
Mo	**0.01 (0.00)**	**0.01(0.00)**	**0.01(0.00)**	**0.01(0.00)**	**0.01(0.00)**	**0.05**
Na	**20.3 (2.1)**	**28.4 (4.2)**	**40.6 (8.4)**	**16.0 (1.9)**	**47.1 (15.4)**	**0.03**
Ni	0.3 (0.1)	0.4 (0.1)	0.3 (0.0)	0.2 (0.0)	0.3 (0.0)	ns
Pb	1.4 (0.5)	1.7 (0.7)	1.7 (0.4)	5.9 (2.9)	1.7 (0.4)	ns
S	9.8 (0.8)	10.4 (1.0)	14.5 (2.4)	11.0 (2.2)	8.0 (1.1)	ns
Zn	2.3 (0.9)	2.4 (0.5)	2.2 (0.3)	2.3 (0.7)	2.9 (1.2)	ns
n	18	5	11	5	9	

Table 4

Plant community mean values for physical site parameters; aspect (16 cardinal directions), slope (degrees), coarse fragment (CF) abundance (0 – no coarse fragments to 6 very abundant coarse fragments), Maximum size of coarse fragments (CF) (1 – fine gravelly to 7 – large boulders), Morph type (landscape morphology; 1 – crest, 2 – midslope, 3 – simple slope, 4 – flat, 5 – lowerslope), rock outcrop (RO) abundance (0 – no bedrock exposed to 5 – rockland), runoff (0 – no runoff to 5 – very rapid), % leaf litter and bare ground (1 – >70% to 4 – <10%). Differences between ranks tested using Kruskall –Wallis non-parametric analysis of variance. Standard error in parentheses. Parameters in bold indicate significance, a and b represent significant differences between community types at P < 0.05 (n = number of quadrats, P = probability, ns = not significant).

			Community Type			
	1	**2**	**3**	**4**	**5**	**P**
Aspect	5.4 (1.1)	6.4 (2.1)	6.5 (1.7)	9.0 (2.7)	8.2 (2.0)	ns
Slope	5.0 (1.1)	1.2 (2.5)	9.4 (2.4)	17.0 (4.1)	6.6 (1.8)	ns
CF Abundance	**3.6 (0.3)[ab]**	**4.2 (0.4)[ab]**	**3.8 (0.4)[a]**	**4.4 (0.2)[ab]**	**2.6 (0.5)[b]**	**0.01**
CF Max. Size	**3.8 (0.4)[ab]**	**3.6 (1.1)[ab]**	**4.2 (0.6)[a]**	**5.0 (0.3)[ab]**	**3.4 (0.5)[b]**	**0.02**
MorphType	**2.2(0.31)[ab]**	**1.8 (0.6) [ab]**	**1.5 (0.2)[b]**	**4.4 (0.6)[a]**	**2.9 (0.4) [ab]**	**<0.01**
RO Abundance	**1.0 (0.3)**	**2.4 (0.9)**	**1.5 (0.6)**	**1.6 (0.7)**	**0.4 (0.3)**	**0.01**
Runoff	1.4 (0.2)	2.0 (0.3)	1.5 (0.3)	2.6 (0.4)	1.6 (0.3)	ns
%Leaf Litter	**2.3 (0.3)**	**2.6 (0.4)**	**3.0 (0.2)**	**3.0 (0.3)**	**3.1 (0.3)**	**0.05**
% Bare Ground	**1.6 (0.2)**	**1.0 (0.0)**	**1.4 (0.2)**	**1.6 (0.6)**	**1.1 (0.1)**	**0.02**
n=	18	5	11	5	0	

APPENDIX 1

Flora list for Koolanooka and Perenjori Hills, including all taxa from the sampling quadrats and adjacent areas. Nomenclature follows Paczkowska and Chapman (2000), * indicates introduced taxon.

Adiantaceae

Cheilanthes adiantoides

Aizoaceae

* *Cleretum papulosum*
Gunniopsis rubra
* *Mesembryanthemum nodiflorum*

Amaranthaceae

Ptilotus drummondii
Ptilotus exaltatus var. *exaltatus*
Ptilotus gaudichaudii var. *gaudichaudii*
Ptilotus gaudichaudii var. *parviflorus*
Ptilotus grandiflorus var. *grandiflorus*
Ptilotus holosericeus
Ptilotus obovatus var. *obovatus*
Ptilotus polystachyus var. *polystachyus*

Anthericaceae

Arthropodium curvipes
Arthropodium dyeri
Caesia sp. Koolanooka Hills (R.Meissner and Y. Caruso 78)
Thysanotus manglesianus
Thysanotus pyramidalis
Tricoryne elatior

Apiaceae

Daucus glochidiatus
Platysace cirrosa
Trachymene cyanopetala
Trachymene ornata
Trachymene pilosa
Xanthosia bungei

Apocynaceae

Alyxia buxifolia

Asphodelaceae

Bulbine semibarbata

Asteraceae

Actinobole uliginosum
* *Arctotheca calendula*
Bellida graminea
Blennospora drummondii
Brachyscome ciliocarpa
Brachyscome perpusilla
Calocephalus multiflorus
Calotis hispidula
Calotis multicaulis
Cephalipterum drummondii
Ceratogyne obionoides
Erymophyllum ramosum subsp. *ramosum*
Gilberta tenuifolia
Gilruthia osbornei
Hyalosperma demissum
Hyalosperma glutinosum subsp. *glutinosum*
* *Hypochaeris glabra*
Lawrencella davenportii
Lawrencella rosea
Millotia dimorpha
Millotia myosotidifolia
Myriocephalus guerinae
Olearia dampieri subsp. *eremicola*
Olearia humilis
Olearia muelleri
Podolepis canescens
Podolepis lessonii
Podotheca gnaphalioides
Rhodanthe battii
Rhodanthe chlorocephala subsp. *rosea*
Rhodanthe collina
Rhodanthe laevis
Rhodanthe maryonii
Rhodanthe polycephala
Schoenia cassiniana
Senecio pinnatifolius var. *pinnatifolius*
* *Sonchus oleraceus*
* *Urospermum picroides*
Waitzia acuminata var. *acuminata*

Brassicaceae

* *Brassica tournefortii*
Lepidium oxytrichum
* *Sisymbrium erysimoides*
Stenopetalum filifolium
Stenopetalum lineare
Stenopetalum salicola

Caesalpiniaceae

Labichea lanceolata subsp. *brevifolia*
Senna artemisioides subsp. *filifolia*
Senna charlesiana
Senna sp. Austin (A. Strid 20210)

Campanulaceae

Wahlenbergia gracilenta
Wahlenbergia tumidifructa

Caryophyllaceae

* *Petrorhagia dubia*
* *Silene nocturna*
Spergularia sp.

Casuarinaceae

Allocasuarina acutivalvis subsp. *acutivalvis*
Allocasuarina acutivalvis subsp. *prinsepiana*
Allocasuarina campestris
Allocasuarina dielsiana

Chenopodiaceae

Enchylaena lanata
Maireana carnosa
Maireana georgei
Maireana marginata
Maireana planifolia
Maireana planifolia x *villosa*
Maireana thesioides
Rhagodia drummondii
Rhagodia preissii subsp. *preissii*
Sclerolaena diacantha
Sclerolaena fusiformis
Sclerolaena sp. Koolanooka Hills (R. Meissner & Y. Caruso 437)

Crassulaceae

Crassula closiana
Crassula colorata var. *acuminata*
Crassula colorata var. *colorata*
Crassula tetramera

Cuscutaceae

* *Cuscuta epithymum*

Cyperaceae

Lepidosperma sp. Koolanooka (Newbey 9336)
Schoenus nanus
Tetraria aff. *capillaris* (R.Meissner & Y.Caruso 51)

Dasypogonacea

Chamaexeros macranthera

Dilleniaceae

Hibbertia aff. *exasperata* (R.Meissner & Y.Caruso 56)
Hibbertia arcuata

Dioscoreaceae

Dioscorea hastifolia

Droseraceae

Drosera macrantha subsp. *macrantha*

Epacridaceae

Astroloma serratifolium

Euphorbiaceae

Calycopeplus paucifolius
Euphorbia boophthona
Poranthera microphylla
Ricinocarpos muricatus

Geraniaceae

Erodium cygnorum

Goodeniaceae

Brunonia australis
Goodenia berardiana
Goodenia mimuloides
Goodenia occidentalis
Goodenia pinnatifida
Scaevola spinescens
Velleia cycnopotamica
Velleia hispida
Velleia rosea

Haloragaceae

Gonocarpus nodulosus
Haloragis trigonocarpa

Lamiaceae

Hemigenia sp. Sticky Terete (B.H. Smith 449)
Westringia cephalantha

Lauraceae

Cassytha nodiflora

Lobeliaceae

Lobelia winfridae

Loganiaceae

Phyllangium sulcatum

Malvaceae

Sida atrovirens

Mimosaceae

Acacia acanthoclada subsp. *glaucescens*
Acacia acuminata
Acacia acuminata (narrow phyllode variant)
Acacia andrewsii
Acacia anthochaera
Acacia assimilis subsp. *assimilis*
Acacia cf. *coolgardiensis*
Acacia coolgardiensis subsp. *coolgardiensis*
Acacia daviesioides
Acacia erinacea
Acacia exocarpoides
Acacia graciliformis
Acacia lineolata subsp. *lineolata*
Acacia muriculata
Acacia neurophylla subsp. *erugata*
Acacia nigripilosa subsp. *nigripilosa*
Acacia ramulosa var. *ramulosa*
Acacia stereophylla var. *stereophylla*
Acacia tetragonophylla

Myoporaceae

Eremophila clarkei
Eremophila deserti
Eremophila latrobei subsp. *latrobei*
Eremophila oldfieldii subsp. *oldfieldii*
Eremophila oppositifolia subsp. *angustifolia*

Myrtaceae

Aluta aspera subsp. *hesperia*
Baeckea sp. Perenjori (J.W. Green 1516)
Calothamnus gilesii
Chamelaucium micranthum
Eucalyptus ebbanoensis subsp. *ebbanoensis*
Eucalyptus ebbanoensis subsp. *glauciramula*

Eucalyptus subangusta subsp. pusilla
Eucalyptus kochii subsp. *borealis*
Eucalyptus loxophleba subsp. *supralaevis*
Eucalyptus wubinensis
Eucalyptus oldfieldii
Eucalyptus salmonophloia
Malleostemon tuberculatus
Melaleuca atroviridis
Melaleuca barlowii
Melaleuca cordata
Melaleuca eleuterostachya
Melaleuca hamata
Melaleuca nematophylla
Melaleuca radula
Micromyrtus racemosa var. *racemosa*

Orchidaceae

Diuris porrifolia

Papilionaceae

Daviesia benthamii subsp. *benthamii*
Daviesia hakeoides subsp. *hakeoides*
Mirbelia microphylla
Mirbelia sp. Helena & Aurora (B.J. Lepschi 2003)

Phormiaceae

Dianella revoluta var. *divaricata*
Stypandra glauca

Pittosporaceae

Cheiranthera filifolia var. *simplicifolia*

Plantaginaceae

Plantago aff. *hispida* (R.Meissner & Y.Caruso 512)

Poaceae

Amphipogon caricinus var. *caricinus*
Aristida contorta
Austrodanthonia caespitosa
Austrodanthonia sp. Goomalling (A.G. Gunness et al. OAKP 10/63)
Austrostipa elegantissima
Austrostipa eremophila
Austrostipa hemipogon
Austrostipa scabra
Austrostipa trichophylla
* *Avena fatua*
* *Bromus madritensis*
* *Bromus rubens*
* *Ehrharta longiflora*
* *Lamarckia aurea*
* *Lolium perenne* x *rigidum*
Monachather paradoxus
* *Pentaschistis airoides* subsp. *airoides*
* *Rostraria pumila*
* *Elymus* sp.
* *Vulpia muralis*
* *Vulpia myuros*

Polygalaceae

Comesperma integerrimum

Polygonaceae

* *Acetosa vesicaria*

Portulacaceae

Calandrinia aff. *eremaea* (R.Meissner & Y.Caruso 533)
Calandrinia calyptrata
Calandrinia eremaea complex
Calandrinia sp. Blackberry (D.M. Porter 171)
Calandrinia sp. Bungalbin (G.J. Keighery & N. Gibson 1656)

Proteaceae

Grevillea levis
Grevillea obliquistigma subsp. *obliquistigma*
Grevillea paradoxa
Hakea minyma
Hakea recurva
Persoonia pentasticha

Rhamnaceae

Stenanthemum poicilum

Rutaceae

Drummondita rubroviridis
Phebalium tuberculosum
Philotheca brucei subsp. *brucei*

Santalaceae

Santalum acuminatum

Sapindaceae

Dodonaea adenophora
Dodonaea inaequifolia
Dodonaea scurra

Solanaceae

Nicotiana rosulata subsp. *rosulata*
Solanum ellipticum
Solanum sp.

Stylidiaceae

Levenhookia stipitata
Stylidium confluens

Thymelaeaceae

Pimelea avonensis

Urticaceae

Parietaria cardiostegia

Zygophyllaceae

Zygophyllum apiculatum
Zygophyllum eremaeum