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Flora and vegetation of banded iron formations of the Yilgarn Craton: the Lee Steere Range

WENDY A THOMPSON AND NIALL B SHEEHY

Science Division, Department of Environment and Conservation,
PO Box 51, Wanneroo, Western Australia, 6946.
Email: Wendyjo.Thompson@gmail.com

ABSTRACT

The Lee Steere Range is located on the northern edge of the Yilgarn Craton, adjacent to the Capricorn Orogeny, c. 200 km north-east of the township of Wiluna. Fifty permanent vegetation quadrats were established, with all vascular flora and a series of environmental attributes recorded. A total of 100 taxa were recorded, representing 27 families and 40 genera. A single taxon of conservation significance was identified, which also represented a c. 200 km range extension for this taxon. Two putative taxa were collected; further material is required for confirmation. Five floristic communities were identified from the survey; these communities were strongly associated with topographical position, local geology and edaphic factors. The Lee Steere Range is a relatively intact banded ironstone formation with little evidence of disturbance. Any future exploration or development should ensure that the important conservation values and condition of the range are retained.

Keywords: banded ironstone, Earaheedy, floristic communities, Gascoyne, Yilgarn.

INTRODUCTION

The Lee Steere range is located approximately 200 km northeast of Wiluna. The range is located on the north-east edge of the Yilgarn Craton and bordered by Capricorn Orogen. The range is the significant feature in the landscape, which is generally characterised by low relief (Commander et al. 1982). The Lee Steere Range represents erosional uplands with scree slopes and pediments transitioning to mixed alluvial deposits associated with extensive salt lakes to the south (Commander et al. 1982). The region is known as Kurrara–Kurrara by the Wiluna Aboriginal group within the Ngaanyatjarra Council. The first European explorers to venture near the Range were part of John Forrest's party (1874), who travelled via the Parker Ranges north of Lee Steere (Beard 1974). Other early explorers to the area include members of the LA Wells Expedition (1896–97; Commander et al. 1982).

STUDY SITE

Lee Steere Range is located in the south-eastern pocket of the Gascoyne Bioregion (Thackway & Creswell 1995) and trends west-north-west. The range is approximately 90 km in length and c. 6–8 km wide, occurring within 25° 26' S and 25° 39' S latitude and 121° 30' E and 122° 22' E longitude. The Range is c. 17 km north by road of the former Earaheedy homestead, which is now abandoned. The primary access is via the Sydney Heads Pass Road, which bisects the western portion of the Range, connecting the Earaheedy and Glen-Ayle leases.

Land Use History

Lee Steere Range extends across the northern portion of the former Earaheedy pastoral lease, with the remainder of the range located on unallocated crown land (UCL) and the neighbouring Carnegie Pastoral Lease. The Earaheedy pastoral lease, established in 1903, primarily stocked sheep, and Carnegie, established in 1921, stocked cattle (Commander et al. 1982). Following the acquisition of the Earaheedy pastoral lease by the Department of Environment and Conservation (DEC; then Conservation and Land Management in 2001), the property was destocked, the homestead removed and the artificial watering points closed. The property has been officially named Kurrara-Kurrara, in recognition of the Aboriginal heritage of the area, and nomination for inclusion in the conservation estate is pending. Active and pending exploration tenements are held over the Range (Department of Mines 2009).

Climate

Lee Steere Range falls into the portion of the Gascoyne bioregion defined as desert, with hot summers and cool winters, with the highest rainfall events associated with summer cyclonic activity. The closest weather station is the former Earaheedy homestead, which ceased operations in 2000 (Bureau of Meteorology 2009). The closest active weather station is at Carnegie, which is situated 140 km east of the homestead. Average annual rainfall at Earaheedy is 240.5 mm (based on records from 1946 to 2000), with the months of February and September having the highest (50.5 mm) and lowest (3.4 mm) mean monthly rainfall, respectively. The lowest annual rainfall was recorded in 1972 (78.1 mm) and the highest rainfall recorded in 1947 (529.7 mm). The single largest rainfall event occurred on 3 February 1980, with 202 mm rain recorded.

Temperatures were recorded at Earaheedy from 1952 to 1988. The average annual maximum is 29.9 °C and average annual minimum is 15.2 °C for the area. The hottest temperatures occur between October and April, with mean maximum temperatures exceeding 30 °C. January is the hottest month, with the mean maximum and mean minimum temperatures of 38.6 °C and 23.9 °C, respectively. The hottest daily maximum on record is 46 °C on 22 December 1972. The lowest daily minimum temperatures occur between June and August, where mean minimum temperatures are below 10 °C. The coolest month of the year is July, with the average maximum and minimum daily temperature of 20.4 °C and 5.6 °C, respectively. The coldest minimum temperature of -3.6 °C was recorded on 23 June 1981. Temperatures below 0 °C have been recorded between June and August, with July having a mean number of 1.5 days with temperatures <0 °C.

Geology

The geology of the Lee Steere Range has been described and mapped on the Stanley 1:250,000 map sheet (Commander et al. 1982) and the 1:100,000 Earaheedy (Hocking et al. 2001) and Lee Steere map sheets (Hocking & Pirajno 2004). The Lee Steere Range trends predominantly west-north-west, at the juncture of the Yilgarn Craton (c. 3.0 to 2.6 Ga; Myers 1993, Myers & Swagers 1997) and the Capricorn Orogen to the north and east. The Yilgarn Craton features a series of greenstone belts that have undergone low grade metamorphism (Myers & Swagers 1997). The majority of the Range is between c. 525 and 600 m above sea level, with the adjacent aeolian sands, colluvial and alluvial sediments sitting c. 500 m above sea level. The highest points in the Range are Mt Royal (625 m) and Mt Evelyn (631 m), which are associated with the Mudan Hills in the western extent of the Range.

At the juncture of the Yilgarn Craton and Capricorn Orogen is the Stanley Fold Belt, which includes the Lee Steere Range. The Stanley Fold Belt represents deformation resulting in tightly folded and faulted rocks (Myers 1990; Hocking et al. 2001; Abeysinghe 2005) of the Earaheedy Group (1.8–1.7 Ga; Myers 1993). The bedrock of the Lee Steere Range is Archaean granitoid, overlain by Early Proterozoic formations of the Earaheedy Group within the Nabberu Basin (Commander et al. 1982; Abeysinghe 2005). Degradational processes have exposed bedrock of the early Proterozoic period, which forms the majority of the Range, including the Mudan Hills of the western portion of the Range. The Sydney Heads Pass Road, adjacent to the Mudan Hills, bisects the Range. Sydney Heads Pass contains conglomerate and sandstone of undetermined age (Commander et al. 1982; Abeysinghe 2005).

The northern slopes of the Range are predominantly composed of the Yelma Formation, which is characterised by quartz-rich sandstone, arkose and shale (Commander et al. 1982). The central and southern slopes of the Range are composed of the younger Frere Formation, dominated by granular and laminar iron formations, hematite shale, chert, shale and minor carbonates (Commander et al. 1982). The Frere Formation in the Earaheedy Basin has been proposed as the greatest potential resource for iron in the region (Pirajno et al. 2002), with early assays of Mt. Ooloongathoo, in the far western portion of the Range, indicating 60% iron (Abeysinghe 2005). Quaternary aeolian sands border most of the northern slopes of the Range, while adjacent to the southern slopes are predominantly colluvial sediments transitioning to mixed alluvium and lake deposits.

General soil structure for uplands in the Yilgarn Craton is shallow stony soils on the crests, transitioning down slope to gravelly sandy loams, then finer sandy clay loams and light clays overlain by colluvium (Anand & Paine 2002). Breakaways, pediments and associated erosional plains are principally stony sandy loams to sandy clay loams with occasional underlying hardpans (Anand & Paine 2002). Beard (1990) described the prevailing soil types of the Gascoyne as shallow stony soils on the ranges, with red-brown hardpans overlain by earthy loams dominating the colluvial plains. Areas of lower relief are principally red loams with ironstone gravels and quartz pebbles overlying hardpan. Areas adjacent to and underlying salt lakes are associated with lime, gypsum and red clays (Beard 1974).

Vegetation

Lee Steere occurs within the Ashburton Botanical District (Beard 1990) of the Gascoyne bioregion, according to the current Interim Biogeographic Regionalisation of Australia (IBRA; Thackway & Creswell 1995; Department of the Environment and Water Resources 2004). Beard (1974) traversed the Gascoyne while mapping the 1:1,000,000 Great Victoria Desert map sheet. The Lee Steere Range was described as a shrub steppe flanked by *Acacia aneura* (mulga) to the north and south of the range within the Carnegie Salient (Beard 1974). The shrub steppe of the Carnegie Salient consists of scattered *Acacia* spp. shrubs over hummock grasslands of *Triodia pungens* (Beard 1974).

The Gascoyne region marks the transition from the shrublands of the Murchison to the hummock grasslands typical of the more arid environments (Beard 1990). Beard (1990) described the Lee Steere Range as dominated by spinifex, transitioning further south to mulga woodlands. Beard (1990) noted distinct vegetation changes approaching the Little Sandy Desert, north of the Carnegie Salient. In particular, within the Mudan Hills, Beard (1974) highlighted the presence of *Triodia melvillei* amongst *Acacia pruinocarpa* and *Eucalyptus setosa* with shrubs of *Ptilotus obovatus*, *Eremophila latrobei* and *Thryptomene maisonneuvei*. The low-lying flats adjacent to the ranges are predominantly low mulga woodlands interspersed with *A. pruinocarpa* and *Psydrax latifolia* (Beard 1990).

There have been no systematic flora surveys undertaken on the Lee Steere Range. Recent surveys on greenstone belts and associated ironstone formations in the Yilgarn Craton have found that distinct vegetation communities occur within (see Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c) and among these landscapes (Gibson et al. 2007). This study aimed to record the floristic diversity, describe vegetation patterns and examine environmental correlates on the Lee Steere Range.

METHODS

Fifty 20 x 20 m permanent quadrats were established in mid-September 2008. The quadrats were placed so as to capture the topographical, geological and geomorphological variation across the length and breadth of the range, including the Mudan Hills. Access was limited through the central portion of the Range due to few existing tracks. Survey methods followed those of previous surveys on Greenstone belts in the Yilgarn Craton (e.g. Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). Quadrats were located across a broad topological sequence from hill crests down slope to the colluvial deposits at the base of the range, in areas with minimal disturbance or modification. Thus, we avoided areas with heavy grazing, evidence of clearing or exploration-related disturbance.

The quadrats were marked by four steel fence droppers and their location recorded with a Garmin Map76 GPS. Photographs were taken at a set distance of 5 m from each corner. Site physical characteristics (landform, slope, aspect, litter and bare ground cover, size of coarse fragments, cover of surface rock fragments and bedrock, soil colour and texture) were recorded as a series of descriptive attributes and semi-quantitative scales as defined by McDonald et al. (1998). Landform description was based on topographical position (crest, upper slope, mid-slope, lower slope or flat) and landform element type (e.g. hillcrest, hillslope, breakaway; McDonald et al. 1998). Coarse fragments and rock outcrop data were recorded as rock type present and as percent cover. The seven cover classes were: zero % cover (0); <2% cover (1); 2–10% (2); 10–20% (3); 20–50% (4); 50–90% (5); >90% (6). Site disturbance was ranked between zero and three, with zero (0) representing no effective disturbance and three (3) being extensively cleared. Runoff was assigned to a scale of six classes (0 = no runoff, 1 = very slow, 2 = slow, 3 = moderately rapid, 4 = rapid, 5 = very rapid; McDonald et al. 1998).

Vegetation structure was determined by assigning dominant taxa to the relevant stratum, noting emergent taxa where appropriate (McDonald et al. 1998). All vascular plants were recorded from within the quadrat and assigned to a cover class (D >70%, M 30–70%, S 10–30%, V <10%, I isolated plants, or L isolated clumps); material was collected for verification and vouchering at the Western Australian Herbarium (WA Herbarium). Additional specimens were collected adjacent to the plots, contributing to the overall species list for the range. Representative material for all taxa was lodged at the WA Herbarium. Nomenclature generally follows Paczkowska and Chapman (2000).

Soil was collected from 20 regularly spaced intervals across the quadrat, bulked and sieved. The <2 mm fraction was analysed by an inductively coupled plasma – atomic emission spectrometer (ICP–AES) for B, Ca, Cd, Co, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, S and Zn using the Mehlich No. 3 procedure (Mehlich 1984). Soil pH was measured on 1:5 soil–water extracts in 0.01 M $CaCl_2$ (method S3; Rayment & Higginson 1992). Organic carbon content was determined using a modified Walkley–Black method (method 6A1), and soil nitrogen (N) was calculated using a modified Kjeldahl digest (method S10; Rayment & Higginson 1992).

The classification and ordination analyses were undertaken on a data matrix of the perennial species that were recorded in more than one quadrat, which is consistent with previous Greenstone belt studies (Gibson 2004a, 2004b). The dissimilarity between sites was determined using the Bray–Curtis measure and the Resemblance routine in PRIMER v6 (Clarke & Gorley 2006). The Bray–Curtis measure is a widely-used assessment of ecological distance, which reflects differences in relative abundance and compositional change (Legendre & Legendre 1998; Anderson & Robinson 2003), and provides quantitative output for similarity between samples (Faith et al. 1987). The species by site matrix was classified using flexible unweighted pair-group mean average (UPGMA, $\beta = -0.1$; Belbin 1989). The similarity profile (SIMPROF) routine in PRIMER v6 was used to determine, a priori, similarities in the structure of communities between samples ($p < 0.05$). Non-metric Multi-Dimensional Scaling (MDS) of the site similarity matrix was used to highlight groups determined through the SIMPROF procedure.

The degree of association between individual species with each community group, as determined by SIMPROF, was measured using indicator species analysis (Dufrêne & Legendre 1997). Indicator values examine information on constancy and fidelity of occurrence of each species. Statistical significance of the indicator values was determined by using the Monte Carlo randomization procedure performed with 1000 iterations in PC-ORD (McCune & Mefford 1999). The similarity percentages (SIMPER) analyses provided information on those species typically found within each community. The SIMPER routine in PRIMER determines those taxa that contribute most to the similarity within a community and dissimilarity between communities (Clarke & Warwick 2001). Those taxa contributing 10% or greater to the similarity within each community type are reported.

Relationships between environmental variables were examined using the nonparametric Spearman rank correlation routine in Statistix 7.1 (Analytical Software, Tallahassee, Florida). An environmental data matrix was created using soil chemical properties and site physical characteristics. The BIO-ENV routine within in PRIMER v6 was used to determine those environmental variables most highly correlated with the species resemblance matrix (Clarke & Gorley 2006). The environmental variables were log(1+x) transformed and normalised prior to performing the BIO-ENV routine. The resulting environmental variables identified through the BIO-ENV process were then analysed using Kruskal–Wallis nonparametric analysis of variance, with post-hoc significance testing at $\alpha = 0.05$ (Sokal & Rolf 1995).

RESULTS

A total of 100 species from 27 families and 40 genera were recorded in the 50 quadrats on the Lee Steere Range (Fig. 1). A further eight taxa were collected from areas adjacent to the quadrats. The dominant families were Mimosaceae (17 taxa), Malvaceae (12 taxa), Poaceae (12 taxa), Caesalpiniaceae (11 taxa), and Myoporaceae (9 taxa). The genera with the greatest representation were *Acacia* (17 species), *Senna* (11 species), *Eremophila* (9 species), and *Sida* (7 species). The majority of the taxa recorded were perennial shrubs. There were nine annuals, two geophytes and a single weed species identified.

Priority Taxon

A single priority-listed taxon was identified from the Lee Steere Range. *Baeckea* sp. Melita Station (H Pringle 2738; P3) was recorded from four quadrats, all located on the crest or upper slopes of the range. *Baeckea* sp. Melita Station (H Pringle 2738) is an upright shrub of up to 2.5 m height with a distinctive hooked apex on the leaf. The species is primarily distributed on ironstones throughout the Murchison bioregion, with the Lee Steere Range populations the second to be recorded within the Gascoyne bioregion. Furthermore, the populations recorded on Lee

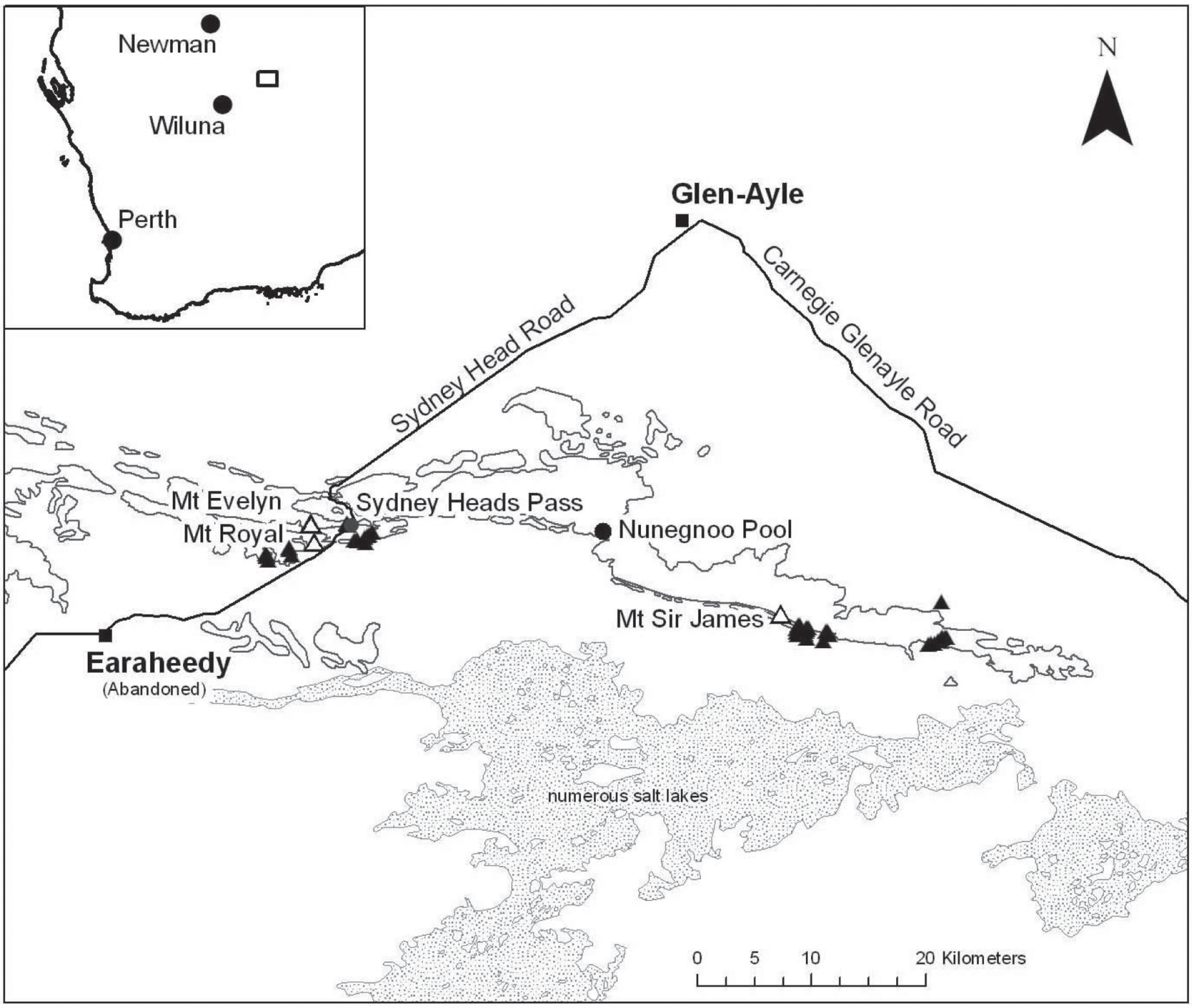

Figure 1. Map showing the location of the Lee Steere Range survey area, with major landforms and landmarks indicated. The locations of the 50 permanent quadrats are marked by triangles (▲).

Steere represent a range extension of approximately 200 km to the north-east. The nearest population of *B.* sp. Melita Station (H Pringle 2738) to Lee Steere occurs south-east of Wiluna.

Range Extensions

In addition to the priority taxon, a further five species recorded on the Lee Steere range had their known distributions extended by c. 100–200 km. This includes a c. 150 km range extension for *Hibiscus gardneri* AS Mitch. ms. *Lepidium oxytrichum* is widespread throughout large areas of the Eremaean botanical province, with the collections primarily occurring from the southern Pilbara to the Coolgardie bioregions. The single collection from the Lee Steere Range extends the distribution of this species c. 100 km east from the nearest locality at the edge of the Little Sandy Desert. Additional specimens have been collected c. 400 km east from Lee Steere in the Gibson and Great Victoria Deserts. *Sida ectogama* is a dioecious shrub primarily known from the Murchison bioregion. The collections from Lee Steere extend the distribution of this species c. 200 km east-north-east from the township of Wiluna. The geophyte *Cheilanthes brownii* has been widely recorded from the Murchison, Pilbara and Kimberley; the Lee Steere collection represents a c. 200 km range extension east. *Stenanthemum petraeum* is known from disjunct collections from the northern Murchison/Gascoyne and the Central Ranges. The collection of this species from the Lee Steere Range extends its known range by c. 200 km north-east from the nearest collection in the Joyner's Find Range south-west of Wiluna. The records from the edge of the Gibson Desert/ Central Ranges are c. 450 km east-south-east of the Lee Steere Range. The disjunct distribution and range extensions are likely a result of lack of sampling.

Possible New Variety/Species

A potentially new variety within the *Acacia aneura* complex (mulga) was identified during this survey. *Acacia aneura* aff. *argentea* was identified as a possible new variety due to resin differing from *A. aneura* var. *argentea*. *Acacia aneura* aff. *argentea* exhibits resin that is translucent aging to opaque on the branchlets (B Maslin pers. comm.[1]). The *A. aneura* complex is currently undergoing taxonomic revision and preliminary alliances based on characters such as pods, branchlet ribs and resin, phyllodes and new shoots have been identified. Typical *A. aneura* var. *argentea* occurs within the mulga alliance identified by winged pods and opaque resin (B Maslin pers. comm.). The specimens collected during the survey were sterile and pods were not located to aid in identification.

A single specimen identified from the genera *Trianthema*, collected from the salt flats south of the range, does not match any of the collections in the WA Herbarium. The specimen has been given the phrase name *Trianthema* sp. Lee Steere (WA Thompson and NB Sheehy 639). Insufficient material was present to provide additional information and further collections are needed.

Hybrids/Integrades

Interspecific hybrids of *Senna* and integrades of *A. aneura* were collected during the survey. All hybrids were matched with collections held at the WA Herbarium. Two interspecific hybrids of *Senna* were identified. A single integrade within the *A. aneura* complex was identified. At present, the revision of the *A. aneura* complex has identified a series of integrades between varieties within the complex. The survey recorded *A. aneura* var. *alata/ microcarpa*, which exhibits resin characteristics of both varieties (translucent and opaque) on the branchlets (B Maslin pers. comm.). Taxonomic work is underway to determine whether they are separate entities or gradations within a single variant.

Floristic Communities

Eight taxa of the 100 species identified from the survey were amalgamated into three species complexes. All annual, singletons and specimens identified only to genera level were removed before statistical analyses. The resulting species by site matrix analysed contained 70 species from 50 quadrats. The minimum and maximum species recorded per quadrat were seven and 27, respectively. The average species richness across all quadrats was 15.1 ± 3.7 SD.

The classification routine based on hierarchical clustering separated the taxa into six species groups (A–F; Table 1). The most widespread taxa occured in species

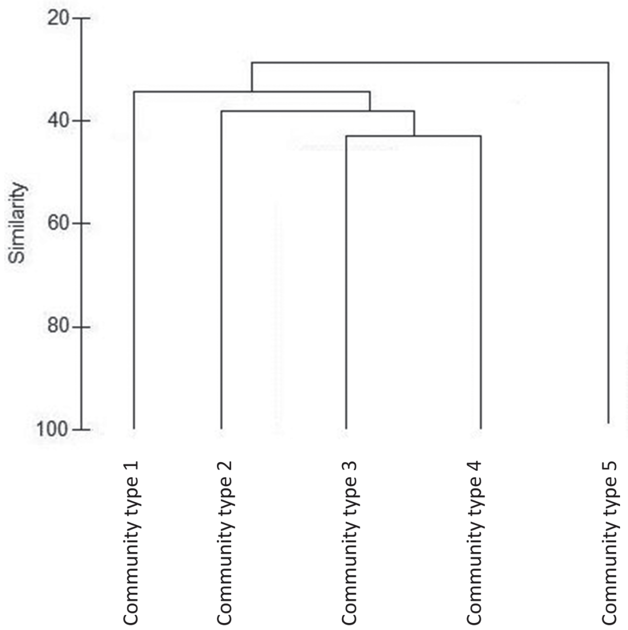

Figure 2. Summary dendrogram of community types for the Lee Steere Range based on the matrix of 70 species x 50 sites. The five community types displayed are derived from the SIMPROF routine.

[1] Bruce Maslin, Western Australian Herbarium, Department of Environment and Conservation, Perth.

group D, which was represented in all of the community types. The SIMPROF routine identified five community types (Fig. 2). The two-way table highlighted the relationship between the species and site groups (Table 1). The MDS routine displayed the interrelationship between the sites, based on the resemblance matrix (Fig. 3). The separation of community types was highlighted in multi-dimensional space, with quadrats with similar taxonomic composition occurring closer together. The resulting 3D stress value was 0.15.

Community type 1 was generally located on the mid-slopes of banded ironstone formation (BIF) with gentle to moderate gradients, and was recorded from four quadrats. Community structure was tall open *Acacia* shrubland, particularly *A. quadrimarginea*, over a sparse to open mid-stratum of *Eremophila margarethae* and *Senna glaucifolia* shrubs, with open hummock grasslands of *Triodia melvillei*. Indicator species analyses (Table 2) suggested that *A.quadrimarginea*, *A. rhodophloia*, *Eremophila margarethae*, *Keraudrenia velutina* subsp. *elliptica*, *Senna glaucifolia*, *Stenanthemum petraeum* and *Triodia melvillei* were typical taxa for this community. This community type was strongly allied with species group D, with minor representative taxa from species group F (Table 1). There were no taxa from species groups A, B or C in this community. This community type was relatively species poor, with seven to 13 taxa recorded per quadrat.

Soils from this community had low potassium (40–50 mg kg^{-1}, mean = 45.2 ± 4.6 SD) and phosphorus (4–5 mg kg^{-1}, mean= 4.5 ± 0.6 SD; Table 3) concentrations. Coarse fragments, primarily weathered banded ironstone, were a significant component of the bare ground, with some presence of exposed bedrock of weathered ironstone. Soils were strongly acidic (pH 3.9–4.1) sandy loams.

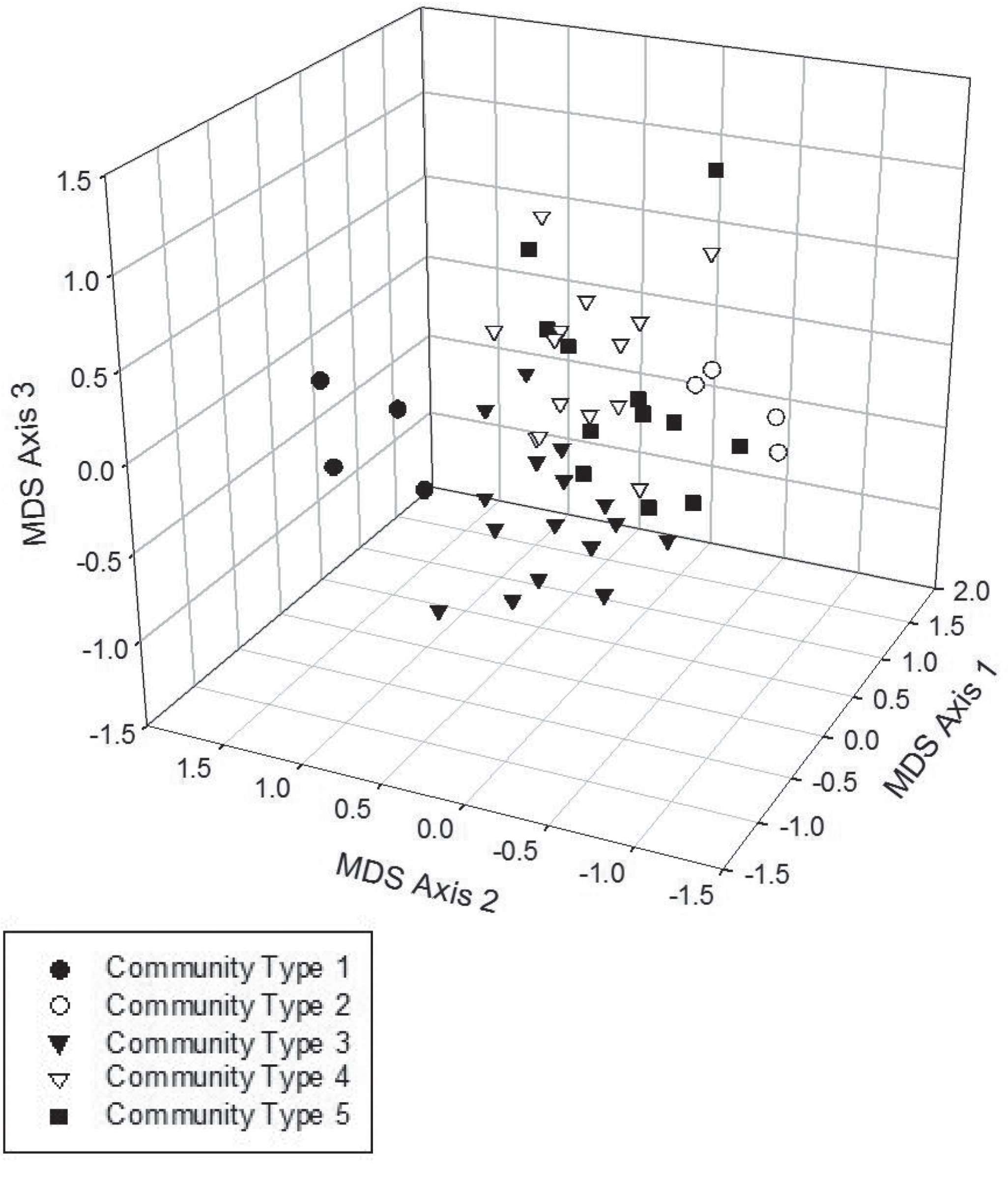

Figure 3. 3D graph of the first three axes of the MDS ordination of survey plots on the Lee Steere Range (stress level = 0.15). Data is a matrix of 70 species x 50 survey sites; taxa are perennial species occurring in more than a single quadrat.

Table 1

Two-way table of community types (columns) and species groups (rows) for the Lee Steere Range. Taxa are sorted within species groups. The squares represent the presence of the specific taxon in the corresponding quadrat.

Table 2

Taxa with indicator values ≥ 25 for the five community types of the Lee Steere Range. Significant taxa are shown at $p < 0.05$ (from Monte Carlo permutation test), levels of significance * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. Indicator values ≥ 25 are denoted by shading.

Indicator Species	Community Type 1	2	3	4	5
Acacia quadrimarginea ***	69	0	0	0	0
Keraudrenia velutina subsp. *elliptica**	43	0	0	0	1
*Stenanthemum petraeum***	40	0	18	1	0
Eremophila margarethae **	36	0	17	22	4
Acacia rhodophloia	32	0	2	0	4
Senna glaucifolia	27	12	0	12	5
Triodia melvillei	25	6	22	21	11
Senna glutinosa subsp. x *luerssenii* **	0	68	0	0	1
Tribulus suberosus **	0	55	0	23	2
*Solanum ellipticum**	0	43	0	0	1
*Ptilotus obovatus***	0	40	0	7	40
Sida sp. Golden calyces glabrous (HN Foote 32) **	0	40	3	0	0
Ptilotus schwartzii ***	0	33	22	20	6
Dodonaea petiolaris	3	31	10	0	6
Sida sp. Excedentifolia (JL Egan 1925)	0	27	12	9	8
Acacia aneura var. *microcarpa*	7	26	20	26	5
Acacia citrinoviridis ***	0	0	56	18	0
Eremophila granitica **	0	0	55	0	1
Cheilanthes brownii *	0	8	33	0	0
Baeckea sp. Melita Station (H Pringle 2738)	0	0	25	0	0
Eragrostis eriopoda complex **	0	11	4	38	11
Eriachne mucronata	0	4	21	27	0
Acacia tetragonophylla ***	0	4	0	3	58
Enchylaena tomentosa var. *tomentosa***	0	0	0	0	58
Rhagodia eremaea **	0	5	0	2	49
Hakea lorea **	0	0	0	0	42
Acacia aneura var. *alata* (narrow phyllode variant) *	0	0	0	9	39
Grevillea striata **	0	0	0	1	36
Acacia pruinocarpa *	4	0	0	20	34
Evolvulus alsinoides var. *villosicalyx* *	0	0	0	0	25
Number of quadrats	**4**	**4**	**16**	**14**	**12**

Community type 2 was a group of four quadrats with a high cover of coarse weathered ironstone fragments over strongly acidic (pH 4.1–4.6) sandy loams found from the mid-slopes to the crests (Table 3). The unifying characteristics of this community were the open shrubland of *A. aneura var. microcarpa* over *E. latrobei* subsp. *latrobei* with a sparse cover of *Ptilotus obovatus*, *P. schwartzii* and *Tribulus suberosus*. Typical species were tall shrubs of *A. aneura* var. *microcarpa*, a mid-stratum of *Dodonaea petiolaris*, *P. obovatus* and *Senna glutinosa* subsp. x *luerssenii* and a lower stratum of *P. schwartzii*, *Sida* sp. Excedentifolia (JL Egan 1925) and *S.* sp. golden calyces glabrous (HN Foote 32), *Solanum ellipticum*, and *T. suberosus* (Table 2). Taxa from this community type were strongly represented in species group D, with few species from groups A, B, C, and E (Table 1). There were no taxa from species group F found in this community type.

Species richness ranged from 10 to 23 taxa per quadrat (mean 15.3 ± 5.5 SD). Typical coarse fragments were composed of weathered iron enriched rock, quartz and associated metasediments with the presence of bedrock associated with those locations further upslope. Exposed bedrock included both laminar and granular weathered ironstone.

Community type 3 was the most wide spread of all the floristic communities. It occurred on the crests and upper slopes of ironstone formations in 16 quadrats. This community type was composed of sparse talls shrubs of *A. aneura* var. *microcarpa* and *A. citrinoviridis* over isolated to sparse shrubland of *E. latrobei* subsp. *latrobei*, *E. margarethae* with isolated *P. schwartzii*. Typical taxa in this community were *A. citrinoviridis*, *Baeckea* sp. Melita Station (H Pringle 2738), *E. granitica* and *Cheilanthes brownii* (Table 2). This community was primarily allied with species groups D and E, with no taxa from groups A and C (Table 1). Species richness ranged from 10 to 18 taxa per quadrat (mean 13.6 ± 2.4 SD; Table 3).

The upper portions of the range, adjacent to the crests, were typically moderately steep gradients. An abundance of coarse fragments, characteristic of upper slopes of degradational landscapes, was recorded in all quadrats in this community type. Coarse fragments were principally weathered laminar and granular ironstone, hematite, quartz and associated metasediments. Exposed bedrock of laminar and granular iron-enriched rock was present across the community, varying from very slightly rocky (<2%) to very rocky (20–50%). The underlying soils were strongly acidic (pH 3.9–4) sandy loams (Table 3).

Community type 4 was primarily located on the mid- to lower slopes and pediments, but was occasionally found further upslope. The community was recorded in 14 quadrats. Community structure was tall, sparse to open shrublands of *A. aneura* var. *microcarpa* with a sparse mid-stratum of *E. latrobei* subsp. *latrobei* over isolated hummock grassland of *Triodia melvillei* and isolated grasses of *Eragrostis eriopoda* complex. Indicator values identified *A. aneura* var. *microcarpa*, *E. eriopoda* complex and *Eriachne mucronata* as typical taxa for this community type (Table 2). This community type has the greatest representation of taxa from species group D, with few taxa from the remaining species groups. Species richness ranged from 11 to 22 taxa per quadrat, with a mean 16.1 ± 3.3 SD.

Coarse fragments were typically weathered laminar ironstones, hematite, quartz and associated metasediments, which were common to very abundant. Soils were highly acidic (pH 4–4.9) sandy loams to sandy clay loams (Table 3). The quadrat that had soil pH of 4.9 also had a higher calcium content (170 mg kg^{-1}), suggesting the presence of calcareous soils. Exposed bedrock, principally weathered laminar and granular ironstone, was minimal across the sites, typically <2%.

Community type 5 was generally found on the lower footslopes and adjacent colluvium, and was recorded in 12 quadrats. The community typically consisted of sparse shrubland of *A. tetragonophylla* with isolated shrubs of *Eremophila latrobei* subsp. *latrobei* and *P. obovatus*. Other taxa occurring in this community included sparse or open woodlands of *A. pruinocarpa* and isolated *Rhagodia eremaea*. Typical species associated with this community were *A. aneura* var. *alata* (narrow phyllode variant), *A. pruinocarpa*, *A. tetragonophylla*, *Enchylaena tomentosa* var. *tomentosa*, *Evolvulus alsinoides* var. *villosicalyx*, *Grevillea striata*, *Hakea lorea*, *P. obovatus*, and *R. eremaea* (Table 2). Taxa from this community type were primarily found in species groups B and D, with few taxa from the remaining groups (Table 1). Species richness ranged from 13 to 27 taxa per quadrat (mean 17.5 ± 3.3 SD).

The community occured on strongly acidic (pH 4.1–5.2) sandy loams to sandy clay loams (Table 3). Those locations with greater pH values were associated with higher calcium levels, which suggested the presence of calcareous soils. Quadrats in this community had slight to extremely abundant cover of weathered laminar and granular ironstone coarse fragments. There was almost no exposed bedrock associated with this community type.

Environmental Parameters

Soils were strongly acidic (mean pH 4.2 ± 0.3 SD) and typically shallow (2–50 cm) sandy loams or sandy clay loams (Table 3). A higher clay fraction in the soil matrix was associated with quadrats on the footslopes, pediments and colluvial plains. The majority of sites had >50% cover of coarse fragments, predominantly composed of weathered granular and laminar ironstones. Rock fragments were abundant at most survey sites, with an average cover category 4.42 (20–50% cover class; Table 3). The sites typically had a high proportion of bare ground (mean 90.7% ± 6.4 SD) and very sparse cover of leaf litter (mean 9% ± 5.7 SD).

There were significant intercorrelations between soil chemical properties (Table 3). Molybdenum was excluded from the analysis as it was below the level of detection. There were highly significant positive intercorrelations ($p < 0.01$) between Ca, Co, K, Mg, Mn, Ni, P and Zn. Sulphur, Fe and organic carbon were strongly positively intercorrelated ($p < 0.01$). Sulphur was highly negatively correlated with Ca, Co, K, Mg and Mn ($p < 0.01$). The strongest intercorrelation ($p < 0.0001$) was between N, Fe and organic carbon. Soil pH was highly positively correlated ($p < 0.001$) with Ca, Co, K, Mg, Mn and Ni, and strongly negatively correlated with Fe ($p < 0.0001$).

The strongest positive correlation between site physical characteristics was between slope and runoff ($p < 0.0001$; Table 3). There were two main intercorrelated groups, which in turn were primarily negatively correlated to one another. The first intercorrelated group was altitude, abundance of coarse fragment, abundance of rock outcrop, runoff and maximum coarse fragment size ($p < 0.01$). The second group contained soil depth, landform element (e.g. hillslope, plain) and topographical position (e.g. crest, upper slope). Species richness was positively correlated with landform element and morphology position ($p < 0.01$) and strongly intercorrelated with soil pH and Ca, Co, K, and Mg ($p < 0.01$).

All five community types were included in the analyses with post-hoc comparison of means ($\alpha = 0.05$; Table 3). Soils from community type 1 had the highest organic carbon content, the lowest concentrations of K and Mg ($p < 0.01$), and the least amount of bare ground present ($p < 0.05$). Community type 1 differed significantly from community type 5 for all of these parameters, except proportion of bare ground. Community type 1 had

Table 3

Summary statistics for environmental variables, separated by community type, for the Lee Steere Range. Mean values with standard deviation are listed for community types. Differences were determined using Kruskal–Wallis non-parametric analysis of variance. Significance values are indicated by * ($p < 0.01$ = **, $p < 0.001$ = ***, $p < 0.0001$ = ****); post-hoc differences were set at $\alpha = 0.05$. Units of measurements for the parameters are: soil chemicals = mg/kg; abundance of fragments and outcrop abundance = categorical maximum (0 = 0%, 1 = <2%, 2 = 2–10%, 3 = >10–20 %, 4 = >20–50 %, 5 = >50–90 %, 6 = >90%); topographical position: 1 = crest, 2 = upper slope, 3 = mid-slope, 4 = lower slope, 5 = flat; species richness = number of taxa per quadrat.

	Community Types				
Soil Parameters	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**
B ^{NS}	0.09 ± 0.08	0.14 ± 0.08	0.10 ± 0.09	0.12 ± 0.10	0.12 ± 0.11
Ca**	66.3 ± 21.9 ^{ab}	103.5 ± 20.9 ^{ab}	71.3 ± 35.6 ^{a}	83.4 ± 36.4 ^{ab}	183.1 ± 161.6 ^{b}
Cd ^{NS}	5.00E-03 ± 0	6.25E-03 ± 2.50E-03	6.25E-03 ± 3.87E-03	5.36E-03 ± 1.34E-03	7.50E-03 ± 4.52E-03
Co****	0.05 ± 5.00E-03 ^{ab}	0.08 ± 0.05 ^{ab}	0.05 ± 0.00 ^{a}	0.09 ± 0.09 ^{ab}	0.14 ± 0.11 ^{b}
Cu ^{NS}	0.43 ± 0.05	0.38 ± 0.05	0.43 ± 0.09	0.43 ± 0.06	0.42 ± 0.11
Fe***	44 ± 11.3 ^{ab}	52.8 ± 21.9 ^{ab}	48.5 ± 10.8 ^{a}	31.5 ± 4.1 ^{b}	35.1 ± 16.2 ^{b}
K***	45.3 ± 4.6 ^{a}	87 ± 11.0 ^{b}	55.1 ± 14.3 ^{a}	57.6 ± 14.8 ^{ab}	72.7 ± 14.8 ^{b}
Mg****	12.3 ± 4.2 ^{a}	24.5 ± 6.0 ^{ab}	15.6 ± 5.6 ^{a}	20.5 ± 7.9 ^{ab}	34 ± 13.0 ^{b}
Mn***	8 ± 3.6 ^{ab}	11 ± 2.9 ^{ab}	8.6 ± 3.1 ^{ab}	9.1 ± 9.9 ^{a}	17.3 ± 13.5 ^{b}
N (total)**	0.054 ± 0.02 ^{ab}	0.0573 ± 0.02 ^{ab}	0.05 ± 0.02 ^{a}	0.04 ± 7.19E-03 ^{b}	0.05 ± 0.04 ^{ab}
Na ^{NS}	0.63 ± 0.25	0.88 ± 0.25	1.2 ± 1.0	1.2 ± 0.8	1.4 ± 0.98
Ni ^{NS}	0.08 ± 0.03	0.1 ± 0.0	0.08 ± 0.03	0.09 ± 0.02	0.14 ± 0.09
Organic C (%)**	0.75 ± 0.23 ^{ab}	0.65 ± 0.22 ^{ab}	0.63 ± 0.23 ^{a}	0.37 ± 0.10 ^{b}	0.55 ± 0.42 ^{ab}
P***	4.5 ± 0.6 ^{a}	16.3 ± 7.8 ^{bc}	7.8 ± 3.0 ^{abcd}	5.1 ± 1.1 ^{bcd}	10.6 ± 9.5 ^{abc}
pH***	4 ± 0.1 ^{abcd}	4.3 ± 0.2 ^{abcde}	4.0 ± 0.1 ^{abcd}	4.2 ± 0.2 ^{abde}	4.5 ± 0.4 ^{bde}
S***	5 ± 1.2 ^{ab}	4 ± 0.8 ^{ab}	5.6 ± 1.0 ^{a}	4.6 ± 1.2 ^{a}	2.9 ± 1.0 ^{b}
Zn ^{NS}	0.9 ± 0.4	0.98 ± 0.3	0.76 ± 0.3	0.68 ± 0.2	1.44 ± 1.4
Site Physical Parameters					
Altitude (m)**	542 ± 15.2 ^{ab}	558 ± 14.8 ^{ab}	562 ± 18.9 ^{a}	536 ± 17.5 ^{b}	540 ± 16.1 ^{ab}
Bare ground (%) ^{NS}	79.5 ± 6.1	95.5 ± 1.0	93.1 ± 3.2	91.1 ± 5.9	89.1 ± 7.1
Abundance-fragments**	4.8 ± 0.5 ^{ab}	5.0 ± 0.0 ^{ab}	5.1 ± 0.3 ^{a}	4.6 ± 0.6 ^{ab}	4.1 ± 0.9 ^{b}
Leaf litter (%) ^{NS}	6.5 ± 5.9	10.3 ± 3.3	6.5 ± 2.7	9.2 ± 4.9	12.3 ± 8.4
Topographical position****	2.4 ± 0.9 ^{ab}	1.9 ± 0.9 ^{ab}	1.6 ± 0.5 ^{a}	3.4 ± 1.2 ^{b}	3.8 ± 0.9 ^{b}
Outcrop abundance***	1.3 ± 1.0 ^{ab}	1.3 ± 1.3 ^{ab}	2.4 ± 1.0 ^{a}	0.8 ± 0.8 ^{b}	0.3 ± 0.9 ^{b}
Slope ^{NS}	6.8 ± 7.8	11.8 ± 10.5	11.9 ± 10.2	5.1 ± 4.0	8.8 ± 8.8
Species Richness	10.3 ± 2.8	15.3 ± 5.5	13.6 ± 2.4	16.1 ± 3.3	17.5 ± 3.3
No. Quadrats	**4**	**4**	**16**	**14**	**12**

significantly less bare ground than both community types 2 and 3. Community type 2 had the greatest proportion of bare ground and the highest concentration of the cation K. The concentration of K in soils from community type 2 was significantly different from community types 1 and 3. Community type 3 was found in the highest positions in the landscape (i.e. low number for topographical position), and had the greatest abundance of coarse fragments and exposed bedrock, the highest concentrations of Fe and S, and lowest soil pH and concentration of Co (Table 3). There were significant differences between community types 3 and 5 for abundance of coarse fragments and exposed bedrock, topographical position, soil pH and Co, Fe, Mg, and S concentrations. Altitude, abundance of coarse fragments and exposed bedrock, topographical position and Fe concentration were significantly different between community types 3 and 4.

Community type 4, at the lowest mean altitude, had the lowest Mn and Zn concentrations, which were significantly different from means from community type 5. Community type 5 was significantly different from community type 3 for many of the site and soil characteristics (Table 3). Community type 5 had the highest mean species richness, soil pH, Ca, Co, Mg, Mn and Zn concentrations, and the lowest mean Fe and S concentrations. It also had the highest mean categorical value for morphology position and the lowest mean value for abundance of coarse fragments and exposed bedrock.

BIO-ENV

Five environmental variables, Mg, S, abundance of rock outcrop, bare ground and cardinal aspect (e.g. N, E, S, W), were highly correlated with the resemblance matrix (Rho statistic = 0.513). There was a strong intercorrelation amongst the trace elements Mg and S and abundance of rock outcrop ($p < 0.01$). The variation in rock outcrop abundance overlain on the MDS 3-dimensional graph was clearly delineated in the bubble plot, with sites with higher proportion of rock outcrop clustering together (Figure 4). Sites with high rock outcrop abundance also had a high proportion of bare ground, however, the separation of sites according to percent bare ground is less distinct. The bubble plots for Mg and S showed that sites that had low Mg values also had high concentrations of S; this is particularly evident for community types 1 and 5 (Figure 4).

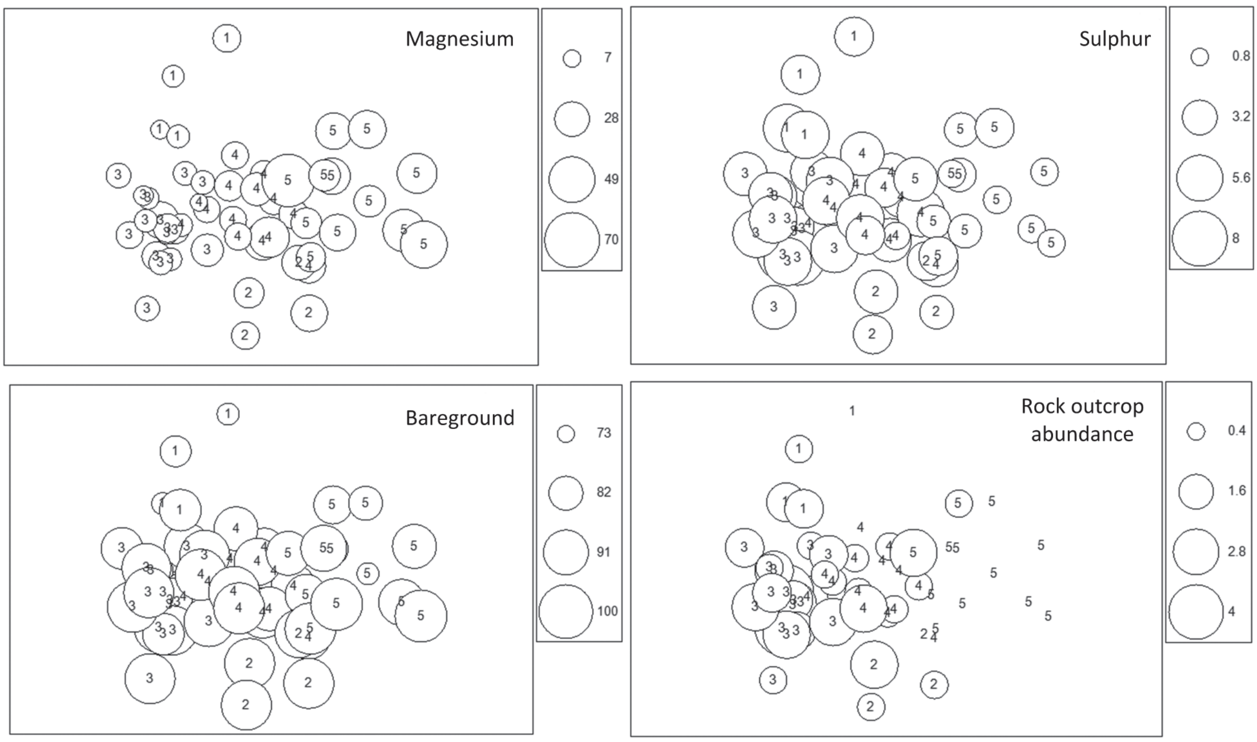

Figure 4. Bubble plots representing four of the highly correlated environmental parameters identified from the BIO-ENV routine (Rho = 0.513), overlayed on the MDS ordination output. Increase in the size of the bubble indicates increasing value of the variable. The numbers inside the bubbles represent the community types. The graphical output for cardinal aspect was not included as it was not as meaningful in two dimensions. The unit of measurements for the variables are as follows: Mg and S = mg/kg; bareground = %; rock outcrop abundance = categorical maximum (0 = 0%, 1 = <2%, 2 = 2–10%, 3 = >10–20 %, 4 = >20–50 %, 5 = >50–90 %, 6 = >90%).

DISCUSSION

No prior floristic surveys had been conducted on the Lee Steere Range, and records from the WA Herbarium are associated with sporadic opportunistic collections. There were 108 taxa recorded during this survey, which was lower than many of the other floristic surveys of the greenstone belts of the Yilgarn Craton (Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). Poor representation of annual taxa was associated with the low annual rainfall preceding the survey. The precipitation for the five months prior to the survey (April–August 2008) was 68.4 mm at Carnegie, where the mean rainfall during the same period is typically 89.2 mm (BOM 2009).

Prior floristic surveys of the greenstone belts of the Yilgarn have recorded taxa of conservation significance and range-specific endemics (see Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). This survey of the Lee Steere Range did not identify any taxa endemic to the range, and only a single priority-listed (P3) taxon, *Baeckea* sp. Melita Station (H Pringle 2738). The collections held at the WA Herbarium of *B.* sp. Melita Station (H Pringle 2738) suggest that the distribution of the taxon is widespread but restricted to ironstone related substrates. This is the second record of *B.* sp. Melita Station (H Pringle 2738) for the Gascoyne bioregion and a 200 km range extension. We suggest a review of the conservation status of this taxon with a view of removing its conservation status. This survey recorded range extensions and improved knowledge of the distribution of other taxa, including the geophyte *Cheilanthes brownii*. The survey also recorded a potential new variant within the *A. aneura* complex. Revision of the *A. aneura* complex is currently underway to clarify whether the putative new variant is a valid determination or whether it is an intergrade of known variants.

Previous flora and vegetation studies in the Yilgarn Craton have found topographical position highly indicative of particular vegetation communities (Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). The community types in this survey were associated with particular positions in the landscape, with the strongest separation seen between community 3 (typical of uplands) and communities 4 and 5 (both associated with footslopes, pediments and colluvial plains). Species richness generally increased with distance down slope and in areas with higher pH and higher concentrations of Ca, Co, K and Mg.

Environmental Characteristics

In general, the Lee Steere Range was characterised by highly acidic soils, primarily sandy loams, with sandy clay loams on the footslopes and colluvial plains. The strong acidic nature of the soils (mean pH 4.18) was indicative of regolith that has undergone extensive weathering (Slattery et al. 1999). The soil physical parameters of the Lee Steere Range were typical of regolith associated with the Yilgarn Craton (Anand & Paine 2002). The concentrations and variation in soil trace elements were similar to those from other greenstone and ironstone ranges in the Yilgarn Craton (Gibson 2004a, 2004b; Gibson & Lyons 1998a, 1998b, 2001a, 2001b; Gibson et al. 1997; Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c).

The weathering of the regolith has influenced the concentration of trace elements in the soils. Regolith studies have shown that sulphides and carbonates are readily leached from the profile (Butt et al. 2000; Anand 2005). Calcrete accumulation has been linked with lowland communities (Anand et al. 1997), thus higher calcium concentrations are associated with communities on the footslopes, pediments and colluival plains. The prevalence of Mg in the soil is also associated with the presence of ultra-mafic rocks (LeBas 2000) and concentrations of Fe are indicative of weathered soils and the underlying regolith (Gray & Murphy 2002). These patterns were evident at Lee Steere. In particular, community type 5 (lowland community with high species richness) had the greatest soil pH and concentrations of the trace elements Ca, Co, Mg, Mn and Zn.

Conservation Significance

This survey was limited by access to the range. However where the range was traversed, condition on the southern flanks was considered good, despite the below average rainfall. There was no evidence of grazing by goats, as seen on many of the other greenstone belts of the Yilgarn. Disturbance to vegetation appeared to be from kangaroos and camels; the Earaheedy lease was destocked in 2001 and cattle were not sighted while on the Carnegie lease on the eastern portion of the range. There are active and pending exploration tenements covering the Range and adjacent pediments, but no evidence of exploration was seen during the survey. While the majority of the Range occurs on land now managed by the Department of Environment and Conservation, it is not incorporated into the secure conservation estate. The Range represents an intact example of the northern margin of the Yilgarn Craton.

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APPENDIX A

Flora list for the Lee Steere Range, including opportunistic collections adjacent to the survey plots. Nomenclature follows Packowska and Chapman (2000). * indicates a weed species.

Acanthaceae
Harnieria kempeana subsp. *muelleri*

Adiantaceae
Cheilanthes brownii
Cheilanthes sieberi subsp. *sieberi*

Aizoaceae
Trianthema sp. Lee Steere Range (WA Thompson & NB Sheehy WAT 639)

Amaranthaceae
Ptilotus obovatus
Ptilotus schwartzii

Asclepiadaceae
Rhyncharrhena linearis
Sarcostemma viminale subsp. *australe*

Asteraceae
Calotis hispidula
Calotis plumulifera
Podolepis canescens
Vittadinia eremaea

Brassicaceae
Lepidium oxytrichum
Stenopetalum anfractum

Caesalpiniaceae
Senna artemisioides subsp. *filifolia*
Senna artemisioides subsp. *helmsii*
Senna artemisioides subsp. *oligophylla* x sp. Meekathera
Senna artemisioides subsp. x *artemisioides*
Senna artemisioides subsp. x *helmsii* x *glaucifolia*
Senna artemisioides subsp. x *sturtii*
Senna glaucifolia
Senna glutinosa subsp. *glutinosa*
Senna glutinosa subsp. x *luerssenii*
Senna sp. Austin (A Strid 20210)
Senna sp. Meekatharra (E Bailey 1–26)

Chenopodiaceae
Dysphania cristata
Enchylaena tomentosa var. *tomentosa*
Maireana georgei
Maireana glomerifolia
Maireana planifolia
Maireana villosa
Rhagodia eremaea
Sclerolaena convexula
Sclerolaena cornishiana

Convolvulaceae
Evolvulus alsinoides var. *villosicalyx*

Frankeniaceae
Frankenia laxiflora

Goodeniaceae
Goodenia macroplectra
Goodenia tenuiloba
Goodenia triodiophila
Scaevola spinescens

Gyrostemonaceae
Gyrostemon ramulosus

Haloragaceae
Haloragis gossei var. *gossei*

Lamiaceae
Spartothamnella teucriiflora

Loranthaceae
Amyema gibberula var. *gibberula*
Amyema hilliana
Lysiana murrayi

Malvaceae
Abutilon fraseri
Hibiscus burtonii
Hibiscus cf. *gardneri*
Hibiscus sturtii
Sida ectogama
Sida fibulifera
Sida sp. dark green fruits (S van Leeuwen 2260)
Sida sp. Excedentifolia (JL Egan 1925)
Sida sp. Golden calyces glabrous (HN Foote 32)
Sida sp. verrucose glands (FH Mollemans 2423)

Mimosaceae
Acacia aneura aff. *argentea* (translucent aging to opaque resin)
Acacia aneura GOK – BRM
Acacia aneura var. *alata* (narrow phyllode variant) BRM 9058
Acacia aneura var. *alata/microcarpa* BRM 9083
Acacia aneura var. *argentea*
Acacia aneura var. *argentea* (narrow phyllode variant) BRM 9745
Acacia aneura var. *argentea* (short phyllode variant) BRM 9300
Acacia aneura var. *conifera*
Acacia aneura var. *microcarpa*
Acacia aneura var. *microcarpa* (broad, incurved phyllode variant) BRM 9929
Acacia citrinoviridis
Acacia cuthbertsonii subsp. *cuthbertsonii*
Acacia pachyacra
Acacia pruinocarpa
Acacia quadrimarginea
Acacia ramulosa var. *linophylla*
Acacia rhodophloia
Acacia tetragonophylla

Moraceae
Ficus brachypoda

Myoporaceae
Eremophila eriocalyx
Eremophila exilifolia
Eremophila foliosissima
Eremophila granitica
Eremophila latrobei subsp. *latrobei*
Eremophila linearis
Eremophila malacoides
Eremophila margarethae
Eremophila platycalyx subsp. *platycalyx*
Eremophila punctata
Eremophila spectabilis

Appendix A (cont.)

Myrtaceae
- *Aluta maisonneuvei subsp. auriculata*
- *Baeckea* sp. Melita Station (H Pringle 2738) P3
- *Corymbia deserticola* subsp. *deserticola*
- *Eucalyptus oldfieldii*
- *Eucalyptus socialis*
- *Lamarchea sulcata*
- *Thryptomene decussata*

Papilionaceae
- *Swainsona affinis*

Poaceae
- *Aristida holathera*
- *Enneapogon caerulescens*
- *Eragrostis eriopoda* complex
- *Eriachne mucronata*
- *Eriachne pulchella* subsp. *pulchella*
- *Monachather paradoxus*
- *Thyridolepis xerophila*
- *Triodia basedowii*
- *Triodia melvillei*

Portulacaceae
- **Portulaca oleracea*

Proteaceae
- *Grevillea berryana*
- *Grevillea striata*
- *Hakea lorea*

Rhamnaceae
- *Stenanthemum petraeum*

Rubiaceae
- *Psydrax latifolia*
- *Psydrax rigidula*
- *Psydrax suaveolens*

Santalaceae
- *Anthobolus leptomerioides*
- *Santalum lanceolatum*
- *Santalum spicatum*

Sapindaceae
- *Dodonaea petiolaris*

Solanaceae
- *Solanum ashbyae/lasiophyllum* complex
- *Solanum ellipticum*
- *Solanum orbiculatum* subsp. *orbiculatum*

Sterculiaceae
- *Keraudrenia velutina* subsp. *elliptica*

Zygophyllaceae
- *Tribulus suberosus*