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Flora and vegetation of banded iron formations of the Yilgarn Craton: the Montague Range Zone of the Gum Creek Greenstone Belt

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ABSTRACT

The Montague Range of the Gum Creek Greenstone Belt is located in the central portion of the Yilgarn Craton, c. 70 km north of the township of Sandstone. Fifty permanent vegetation quadrats were established, within which all vascular flora and a series of environmental attributes were recorded. A total of 91 taxa were recorded, representing 28 families and 43 genera. Five taxa of conservation significance were identified, including *Acacia burrowsiana* (P1), *Stenanthemum mediale* (P1), *Calytrix praecipua* (P3), *Sauropus ramosissimus* (P3), and *Baeckea* sp. Melita Station (H Pringle 2738; P3). A single putative variant of the *Acacia aneura* complex was identified; further material of *A. aneura* aff. *argentea* is required for confirmation. Three taxa (*A. aneura* aff. *argentea*, *A. aneura* var. *conifera*, *A. cockertoniana*) represented significant range extensions. No weeds or regional endemics were collected during the survey. Six floristic communities were identified from the survey, which were related to topographical position, geology and edaphic factors. The Montague Range represents an important repository of significant taxa and floristic communities associated with banded ironstone formations. Any future exploration or development should ensure that the important conservation values and condition of the range are retained.

Keywords: banded ironstone, floristic communities, mulga, Murchison, Yilgarn.

INTRODUCTION

The Montague Range is a distinct landform within the Gum Creek Greenstone belt in the Yilgarn Craton. The Gum Creek Greenstone belt is separated into two zones trending north-west, the Montague Range Zone and the Lake Mason Zone. The Montague Range Zone is located north and east of the Lake Mason Zone. Erosional processes have exposed the underlying Archaean regolith that forms the Montague Range. The result is a highly dissected landscape with widespread lateritic breakaways (Kimseed Environmental 1998). In addition to the exposed bedrock, the range contains alluvial drainage systems and scree slopes formed by the weathering of regolith, which contribute to the pediments and adjacent colluvial plains (Tingey 1985).

STUDY SITE

The Montague Range is situated in the centre of the Murchision bioregion (Interim Biogeographic Regionalisation of Australia—IBRA; Thackway & Cresswell 1995), approximately 70 km north of Sandstone and 100 km southwest of Wiluna, within the Wiluna and Sandstone Shires (Fig. 1). The greenstone belt trends north-west, covering c. 55 km from north to south, with a width c. 6–7 km. The latitudinal and longitudinal boundaries of the Range are roughly 27° 00” S, 27° 30” S and 119° 20” E and 119° 35” E, respectively. The land tenure for the Range includes Gidgee pastoral lease and the former Kaluwiri and Lake Mason pastoral leases, which are both now owned by the Department of Environment and Conservation (DEC) and managed for conservation.

Land Use History

The Murchison Region has a long history of pastoralism and mineral exploration, particularly gold mining. The Montague Range bears the evidence of both activities, including cattle grazing, gridlines, drill holes and mining pits. Access to the Range is facilitated by mineral exploration and gridline tracks. The potential for gold deposits in the Gum Creek Belt was identified by government geologists, including T Blatchford in 1898 (Blatchford 1899) and CG Gibson in 1908 (Gibson 1908). The Gidgee pastoral lease covers the majority of the central and north-west portion of the Range. Gidgee has a mixed history of stocking sheep, cattle and horses, as well as mining activities (Senior 1995).

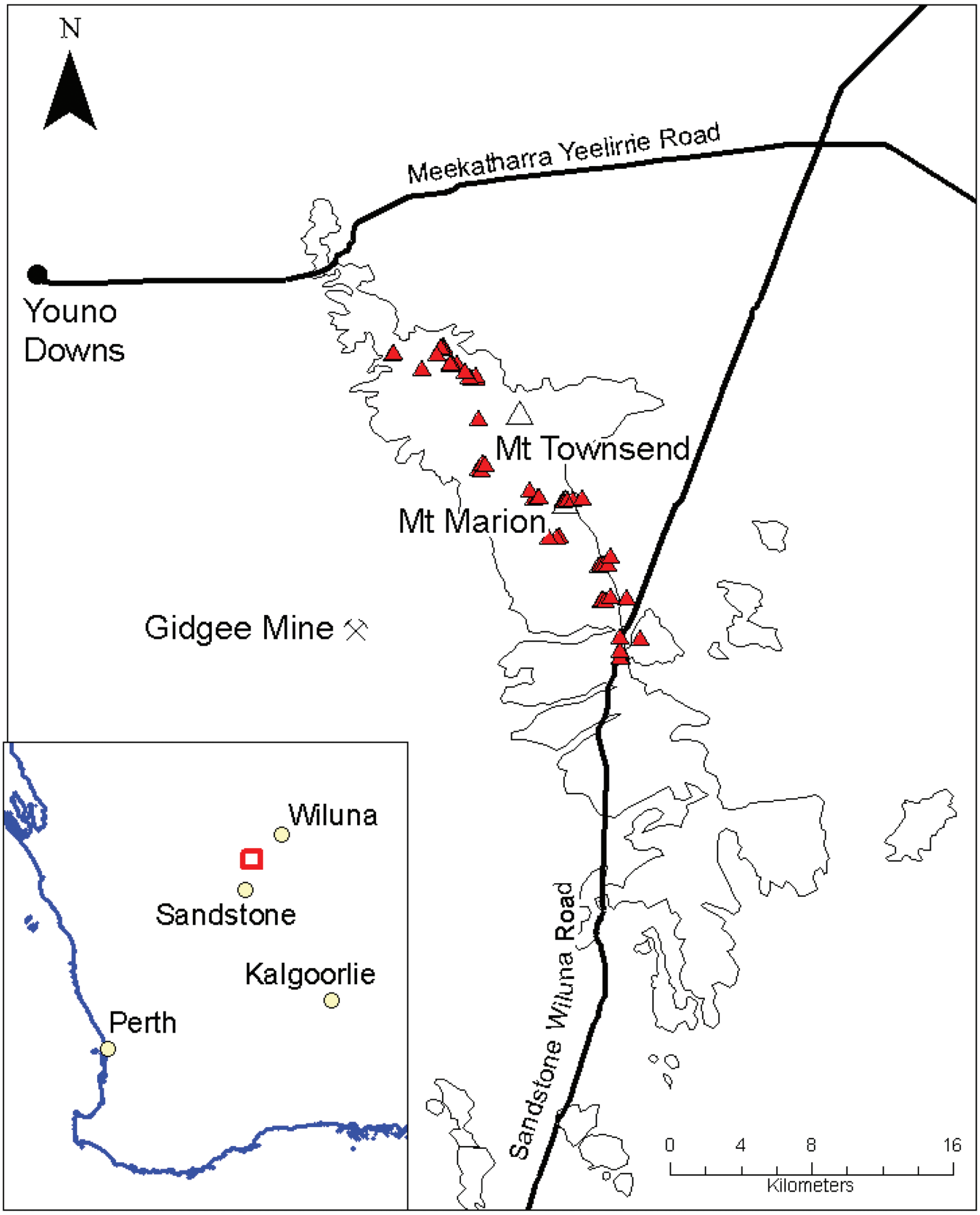


Figure 1. Map showing the location of the Montague Range survey area, with major landforms and landmarks indicated. The locations of the 50 permanent quadrats are marked by solid triangles (▲).

Lake Mason is named for the surveyor and leaseholder Henry GB Mason, who passed through the region in 1900 (Senior 1995). The Lake Mason station initially stocked cattle and later focused on sheep (Senior 1995) until the property was purchased by the Department of Conservation and Land Management (CALM, now DEC) in 2000. Rangeland condition of the former Lake Mason pastoral lease varies, with more than 50% considered in poor to fair condition (Department of Conservation and Land Management 2001). At the time of purchase, evaluation of the lease suggested that condition on the lease was improving following low stocking rates and limiting water availability (Department of Conservation and Land Management 2001).

The Gum Creek Greenstone Belt has the largest recorded gold production for the region, at 39 t, which is primarily associated with mafic rocks (Wyche et al. 2004). There are active mining and exploration leases on the Range at present (Department of Mines and Petroleum 2009). Open pit gold mining operated by Arminco Mining Pty Ltd occurred two kilometres west of Mt. Townsend, in the northern portion of the range, during the late 1990s. Legend Mining still operates a gold mine at Gidgee, which is currently under 'care and maintenance' (Wyche et al. 2004).

Climate

The Montague Range sits in the central portion of the Murchison bioregion, which has an arid climate with hot summers and cool winters. Rainfall is highly variable and occurs sporadically throughout the year (Leighton 1998; Bureau of Meteorology 2009). There is a slight increase in mean rainfall during summer, generally associated with cyclonic activity.

The closest weather station to Montague Range is Yeelirie, located c. 55 km east of the Range. Average annual rainfall at Yeelirie is 238 mm, based on records from 1928 to 2009. March and September have the highest (31.5 mm) and lowest (4.2 mm) mean monthly rainfall, respectively. The highest annual rainfall was recorded in 1975 (506.8 mm) and the lowest rainfall recorded in 1950 (42.8 mm). The single highest rainfall event occurred on 30 March 1931, with 99.1 mm of rain recorded.

Temperatures have been recorded at Yeelirie from 1973 to 2009. The average annual maximum is 28.7 °C and average annual minimum is 12.7 °C. The highest temperatures occur between November and March, with mean maximum temperatures exceeding 30 °C. January is the hottest month, with the record for mean maximum and mean minimum temperatures at 37.9 °C and 31.6 °C, respectively. The highest daily maximum on record is 46 °C recorded on 11 February 1991. The lowest daily minimum temperatures occur between May and September, where mean minimum temperatures are below 10° C. The coldest month of the year is July, with the average maximum and minimum daily temperature of 28.6 °C and 3.5° C, respectively. The coldest minimum temperature of –5.1 ° C was recorded on 27 July 2000.

Geology

The Montague Range has been mapped and described on the Sandstone 1:250,000 geological sheet (SG/50-16; Tingey 1985) and straddles the Montagu (Wyche & Doyle 2006) and Youno Downs (Chen et al. 2006) 1:100,000 map sheets. The Montague Range Zone of the Gum Creek Belt lies entirely in the northern portion of the Youanmi Terrane within the Southern Cross Domain in the Yilgarn Craton (Cassidy et al. 2006). The Yilgarn Craton is composed of crustal rocks primarily formed during the Late Archaean (3.0–2.6 Ga; Myers 1993; Myers & Swagers 1997). The Yilgarn Craton occurs as a series of greenstone belts that have undergone low grade metamorphism (Myers & Swagers 1997) and are primarily surrounded by granitoid (Anand & Paine 2002).

The Range is part of the larger Gum Creek Greenstone Belt, occupying the north-east portion of the belt. Elevations are between c. 550 and 600 m above sea level (see Tingey 1985). The Montague Range features the highest point on the Sandstone map sheet (SG/50-16), Mt. Townsend (660 m), and another noted peak, Mt. Marion (646 m; Tingey 1985). The Cenozoic deposits of the lower slopes, flats and outwash, are situated at c. 550 m or below.

The Montague Range trends north-north-west, the typical orientation of the greenstone belts of the Southern Cross Domain (Griffin 1990). The predominant geology of the Range includes metabasalts, interspaced with irregular sequences of banded iron formations (BIF), metamorphosed ultramafic rocks and minor occurrences of metasediments (Tingey 1985). The northern portion of the greenstone belt is largely overlain by deeply weathered profiles of ferruginised duricrust (Tingey 1985). The central and southern section of the Range is principally composed of metabasalt with metamorphosed mafic complexes and minor occurrences of quartzite and slate (Tingey 1985). The ferruginous material from Mt. Townsend and Mt. Marion has an iron ore content of 30.1% and 33.6%, respectively (Connolly 1959).

Adjacent to the eastern periphery of the Range are significant areas of granite, including deeply weathered profiles and sandplains composed of residual and aeolian sands (Wyche & Doyle 2006). The lower slopes, particularly along the western boundary, are composed of ferruginous gravel and grit with colluvial material derived from reworked ferruginous duricrust and gravel. The lower slopes and the adjacent outwash, which incorporates alluvial drainage lines linked to surrounding floodplains, are allied to Cenozoic depositional activities (Wyche & Doyle 2006).

Murchison Region soils are typically red-brown hard pans overlain by shallow earthy loams, with the hills primarily shallow stony loams (Beard 1990). The soils of the greenstone belts of the Sandstone region are derived from weathering and erosional processes, and are characteristically skeletal to shallow, poorly developed and acidic in nature (Churchward 1977; Hennig 1998). Soil texture of the greenstone belts is typically loam to clay loam overlain by sandy loam and loams. Dominant soil types of the Montague Range are stony soils on the hills (Beard 1976; Churchward 1977), with shallow calcareous loams interspersed with shallow red earths and shallow calcareous red clayey sands associated with breakaways (Hennig 1998). The Jundee land system, prevalent beyond the western flanks of the range, is predominantly composed of shallow hardpans with minor occurrences of deeper red earths (Hennig 1998).

Vegetation

Montague Range is situated within the Wiluna sub-Region of the Austin Botanical District in the Eremaean Province (Beard 1976). The vegetation of the Murchison Region is dominated by *Acacia aneura* (mulga; Beard 1990). Beard (1976) classified the Montague Range as low mulga woodland with adjacent areas of mulga and minor occurrences of marble gum (*Eucalyptus gonglyocarpa*) and shrub steppe sandplains. Structurally, the community is dominated by tall *Acacia* shrubs (>3 m), over sparse cover of low shrubs (1–2 m) with ephemeral herbs present under favourable conditions (Beard 1990). Other than *A. aneura*, all other species are predominantly non-dominant when defining community composition (Beard 1990).

The mulga communities on the rocky slopes are generally composed of tall shrubs of *A. aneura*, *A. quadrimarginea*, *A. grasbyi* and *Hakea lorea* over a mid-stratum of *Senna* sp. (formerly *Cassia*), *Eremophila clarkei*, *E. latrobei* and *Ptilotus obovatus* with an annual understorey (Beard 1976). Beard (1976) did not differentiate between the vegetation communities growing on granites and greenstones. The surrounding sandplains predominantly contain scattered trees, typically *Eucalyptus kingsmillii*, *E. lucasii* and *E. ebbanoensis*, and shrubs over hummock grasslands of *Triodia basedowii*, *T. pungens*, and *T. melvillei* (Beard 1976).

The Montague Range is predominantly the Bevon land system, with gently undulating low rises, irregular hills and stony plains with breakaways and occasional ridges of BIF (Pringle & van Vreeswyk 1994; Payne et al. 1998). There are also elements of the Brooking (ridges of BIF), Felix (gently undulating stony plains and low rises) Gabinantha (ridges and hills of greenstone), Sherwood (granite overlain by stony plains and breakaways) and Violet (gently inclined stony or gravelly plains) land systems on the Range, with the Jundee (outwash composed of ironstone gravels over hardpans) land system abutting the western flanks and the Yanganoo (gently inclined hardpans) and Bullimore (sandplains) land systems dominating the eastern plains adjacent to the Range (Payne et al. 1998).

The Bevon land system supports eight vegetation communities, principally mulga shrublands, *Acacia* shrublands or *Acacia* and *Eremophila* shrublands on stony plains, with occasional cover of stony plains of bluebush mixed shrubland (Pringle 1998a, 1998b). Common tall shrubs include *A. burkittii*, *A. quadrimarginea*, *A. ramulosa* and *A. tetragonophylla* (Pringle 1998a, 1998b). Other widespread taxa in these communities are *Eremophila* sp. (e.g. *E. forrestii* and *E. latrobei*), *Ptilotus obovatus*, *Senna* sp., *Solanum lasiophyllum* (Kimseed Environmental 1998), *Sida* sp. and *Scaevola spinescens* (Pringle 1998a, 1998b). Additional taxa, frequently occurring in the bluebush shrublands, are low chenopods shrubs such as *Maireana georgei*, *M. glomerifolia*, and *M. triptera* (Pringle 1998a, 1998b).

Previous regional mapping (i.e. Beard 1976; Payne et al. 1998) has provided an overview of vegetation structure and composition associated with the greenstone belts and granites of the Yilgarn Craton. However, recent surveys on greenstone belts and associated BIF 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 associated with the Montague Range in the Gum Creek Greenstone belt.

METHODS

In early October 2008, fifty 20 x 20 m permanent quadrats were established across the Montague Range so that the topographical, geological and geomorphological variation across the length and breadth of the range was represented. Survey sampling took place within 551–651 m range of elevation. Quadrats were located so that the vegetation communities associated with the greenstone belt, particularly the occurrence of BIF and associated geology, were captured. 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 below the range, in areas with minimal disturbance or modification. Thus, we avoided placing quadrats where heavy grazing, evidence of clearing or exploration-related disturbance was obvious.

The quadrats were marked by four steel fence droppers and their locations 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 recorded as one 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 present (McDonald et al. 1998). The cover of all vascular plants within each quadrat was recorded using the cover classes (D >70%, M 30–70%, S 10–30%, V <10%, I isolated plants, or L isolated clumps). Plant material was collected for verification and vouchering at the Western Australian Herbarium (WA Herbarium). Additional specimens were collected from areas adjacent to the plots, which contributed to the overall species list for the range. Where sufficient representative plant material was available, it 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). Molybdenum was excluded from the analyses as it was below the level of detection. 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) determined using a modified Kjeldahl digest (method S10; Rayment & Higginson 1992).

The classification and ordination analyses were undertaken on a presence/absence data matrix of the 86 perennial taxa recorded in more than one quadrat, which is consistent with previous greenstone belt studies (Gibson 2004a, 2004b). The dissimilarity between quadrats 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 compositional change (Legendre & Legendre 1998; Anderson & Robinson 2003), providing quantitative output for similarity between samples (Faith et al. 1987). The species by site matrix was then classified using flexible unweighted pair-group mean average (UPGMA, β = –0.1) in PATN v3.11 (Belbin 1989). The similarity profile (SIMPROF) routine in PRIMER v6 (Clarke & Gorley 2006) was used to determine, a priori, similarities in the structure of communities between quadrats. A two-way table was created based on these classification routines. Non-metric Multi-Dimensional Scaling (MDS) was used to highlight groups determined through the SIMPROF procedure.

The degree of association of 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 each species. Statistical significance of the indicator values were determined by the Monte Carlo randomization procedure performed with 1000 iterations using 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 contributing the greatest similarity within a community and dissimilarity amongst communities (Clarke & Warwick 2001). Those taxa contributing ≥10% 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). The environmental variables were analysed using Kruskal–Wallis nonparametric analysis of variance and post-hoc significance testing of means α = 0.05 (Sokal & Rolf 1995), using groups determined by the SIMPROF routing. An environmental data matrix was created that included soil chemical properties and site physical characteristics. The BIO-ENV routine within the BEST analyses procedure in PRIMER v. 6 was used to determine which environmental variables had the highest correlation with the site resemblance matrix (Clarke & Gorley 2006). For the BIO-ENV routine, the environmental variables were transformed [log(1+x)] and normalised prior to analyses.

RESULTS

A total of 91 taxa from 28 families and 43 genera were recorded across 50 quadrats on the Montague Range (Fig. 1). A further 13 species were collected from areas adjacent to the quadrats. The dominant families represented on the range were Mimosaceae (23 taxa), Myoporaceae (10 taxa), Chenopodiaceae (9 taxa) and Caesalpiniaceae (6 taxa). The genera with the greatest representation were *Acacia* (23 species), *Eremophila* (10 species) and *Senna* (6 species). The majority of the taxa found on the range were perennial shrubs. There were two annuals, two geophytes and no weed species recorded from the quadrats.

Species richness ranged between six and 21 taxa per quadrat, with an average richness per quadrat of 11.9 + 3.4 SD. Nine taxa were amalgamated into four species complexes during analyses. All annuals, singletons and specimens unidentifiable beyond genus were removed from the original species matrix, which resulted in a matrix of 86 taxa x 50 sites.

Priority Taxa

Five priority-listed taxa were collected during the survey (Table 1). All of these taxa have been previously recorded

Table 1

Priority taxa recorded from the Montague Range. Bioregion abbreviations: Mur = Murchison, Gas = Gascoyne, Yal = Yalgoo, GD = Gibson Desert, GVD = Great Victoria Desert, LSD = Little Sandy Desert.

Family	Taxon	Status for Montague	Status	Bioregion
Mimosaceae	*Acacia burrowsiana*	New record	P1	Mur, Gas
Rhamnaceae	*Stenanthemum mediale*	New record	P1	Mur
Myrtaceae	*Baeckea* sp. Melita Station (H Pringle 2738)	New record	P3	Mur, Gas, Yal
Myrtaceae	*Calytrix praecipua*	New record	P3	Mur, Gas, GVD, LSD
Euphorbiaceae	*Sauropus ramosissimus*	New record	P3	Mur, Gas, GD, GVD

in the Murchison IBRA region, but represent new records for the Montague Range. There were nine new populations of *Stenanthemum mediale* (P1) identified during the survey. Prior to the survey, there were only nine records on the WA Herbarium database, Florabase (Western Australian Herbarium 1998–) for this species. Taxa of conservation significance recorded include a new population of *A. burrowsiana* (P1) and three new populations of each of the following taxa: *Baeckea* sp. Melita Station (H Pringle 2738; P3), *Calytrix praecipua* (P3) and *Sauropus ramosissimus* (P3).

Possible New Variety in the Mulga Complex

A potential new variety within the *Acacia aneura* complex (mulga) was identified during this survey. This putative new variety was first collected during a flora survey on the BIF of Lee Steere Range in the Gascoyne IBRA Region (Thompson & Sheehy 2011b). *Acacia aneura* aff. *argentea* (translucent aging to opaque) was identified as a possible new variety due to resin differing from *A. aneura* var. *argentea* (B Maslin pers. comm.[1]). Typical *A. aneura* var. *argentea* occurs within the mulga alliance identified by winged pods and opaque resin (B Maslin pers. comm.). A single specimen collected during the survey was sterile and pods were not located to aid in identification. Further collections are necessary to verify the putative new variety.

Range Extensions

Range extensions for three taxa were recorded during the survey. The putative new variety of *A. aneura* aff. *argentea* (translucent aging to opaque) was previously identified from the Lee Steere Range in the south-east portion of the Gascoyne IBRA Region. The Montague Range population is a range extension of c. 250 km south-west of its only other known locality. *Acacia aneura* var. *conifera* has a scattered distribution in the Eremaean botanical region. The collection from Montague Range represents a range extension of c. 200 km to the south-west of the closest population on the northern boundary of the Murchison IBRA Region. The *A. cockertoniana* collected on the Montague Range is an extension of c. 200 km north-east from the closest population. *Acacia cockertoniana* is known primarily from the southern and south-western portion of the Murchison IBRA Region.

Hybrids/Integrades

A single hybrid and two interspecific hybrids were recorded during the survey. All hybrids were known from collections held at the WA Herbarium. The hybrid collected was *Maireana georgei* x *Enchylaena tomentosa*. The interspecific hybrids were *Prostanthera althoferi* subsp. *althoferi* x *campbellii* and *Senna glaucifolia* x *artemisioides* subsp. x *sturtii*.

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

Floristic Communities

The classification routine based on hierarchical clustering separated the taxa into six species groups (A–F; Table 2). The most widespread species group, C, was composed of taxa considered ubiquitous across the Range. Six community types were identified, based on the clustering of samples and the SIMPROF routine (Fig. 2). Three of the vegetation communities recognized were recorded in two or fewer quadrats. The relationship between species groups and community types are discussed below. The MDS routine showed the interrelationship between the sites, based on the resemblance matrix. Quadrats with a similar suite of taxa clustered together, which corresponded to community type; represented on the 3D graph as the least distance between points. The resulting stress value was 0.15 (Fig. 3).

Community type 1 was recorded in two quadrats, MNTG 14 and MNTG 23, both located in the upper portion of the landscape where soils had relatively high pH values (5.2 and 7.4, respectively; Table 3). High Ca concentrations from both quadrats suggested the presence of calcareous soils. Sites were sandy loam soils overlain by a moderate cover of weathered iron-enriched coarse fragments.

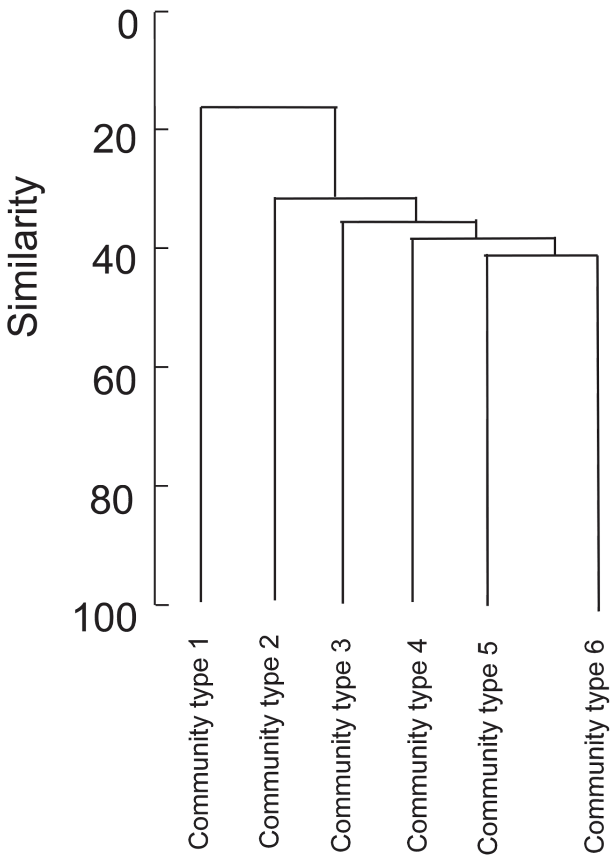


Figure 2. Summary dendrogram, derived from the classification analyses of the 86 taxa by 50 site matrix, for the Montague Range Zone of the Gum Creek Greenstone Belt. The six community types displayed were determined by the SIMPROF routine.

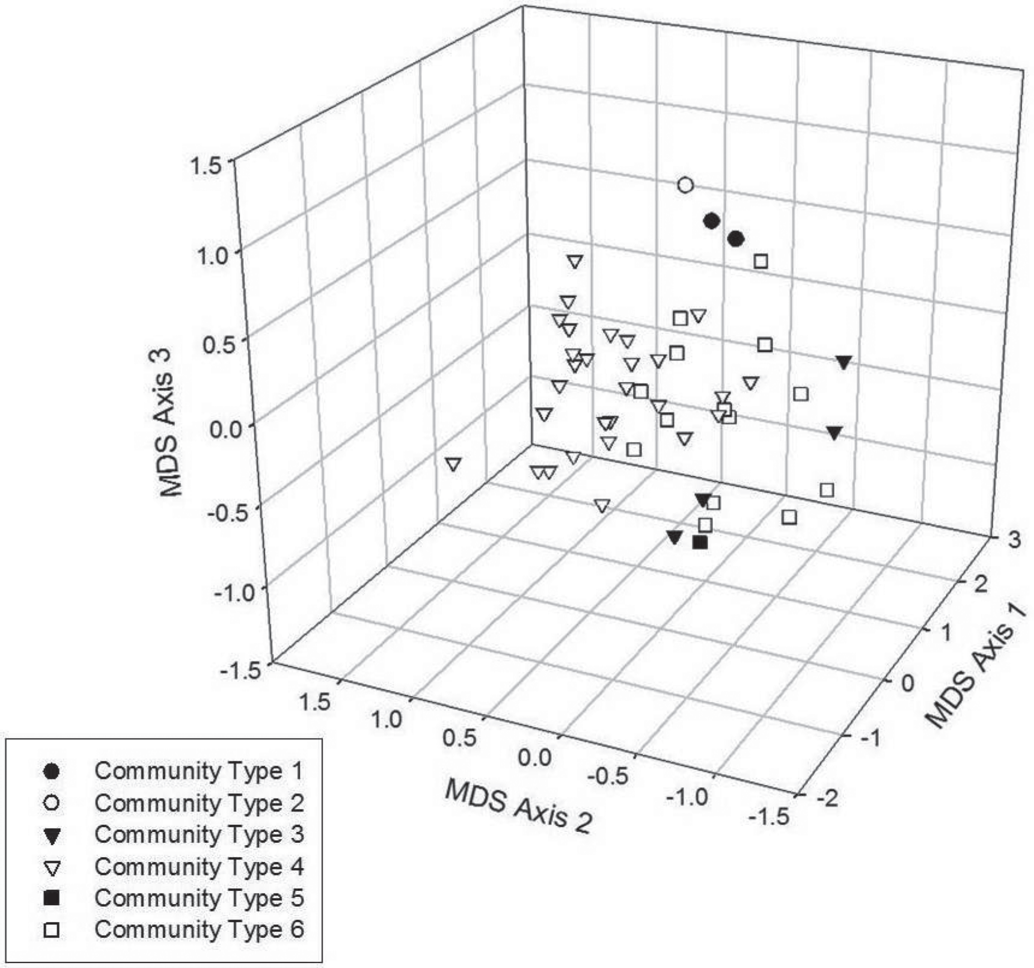


Figure 3. 3D representation of the first three axes of the MDS ordination of survey plots on the Montague Range (stress 0.15). Data were the matrix of 86 perennial species from 50 survey sites.

The community consisted of tall open shrubland of *A. aneura* over sparse shrubs of *Ptilotus obovatus*, *Scaevola spinescens*, *Lepidium platypetalum* and *M. triptera*. Indicator values (IV, Table 4) suggested that typical species include *A. sibirica*, *Eremophila longifolia*, *Enchylaena tomentosa* var. *tomentosa*, *L. platypetalum*, *M. triptera*, *P. obovatus*, *Santalum spicatum* and *Scaevola spinescens*. This community type was weakly allied with species groups B, C, and F, with no taxa from the remaining species groups (Table 2). The sites were relatively species poor, with 13 and 11 taxa recorded, respectively.

Community type 2 was recorded in a single quadrat, located in the middle of the range on a south-south-east facing crest. The quadrat had strongly acidic (pH 4) sandy loam soils with coarse fragments of weathered iron-enriched rock and associated metasediments and no exposed bedrock (Table 3). Comparatively, the quadrat was species poor, with only 10 taxa recorded during the survey. The community was described as an open shrubland of *A. aneura* and *A. rhodophloia* over sparse shrubs of *Eremophila forrestii* and *E. punctata* with isolated *E. jucunda*. This community type was associated with species groups C and D (Table 2).

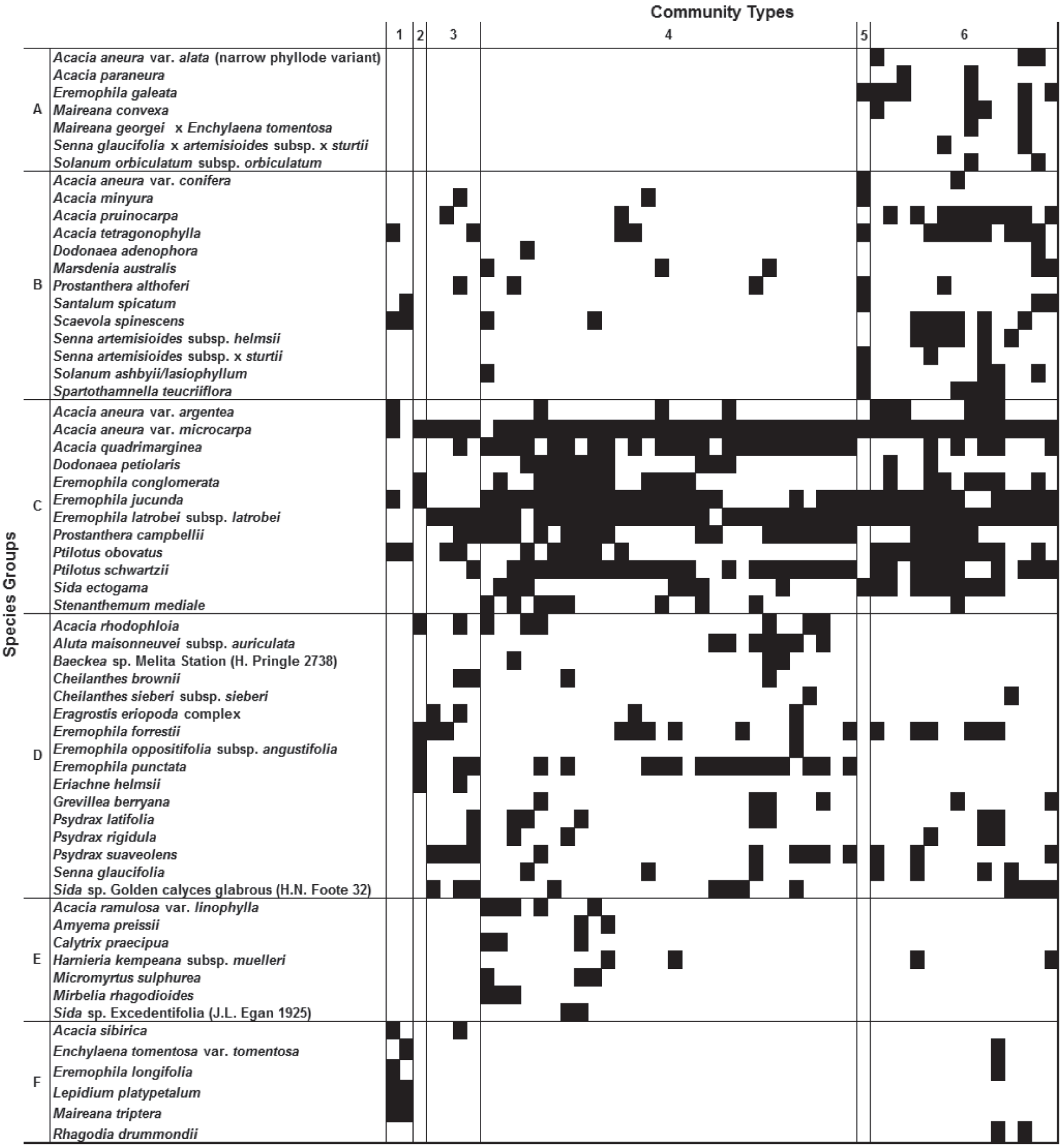
Community type 3 was composed of sparse to open shrubland of *A. aneura* var. *microcarpa* over isolated *E. latrobei* subsp. *latrobei* and *Psydrax suaveolens*, with isolated *Sida* sp. golden calyces glabrous (HN Foote 32). Typical species were *A. aneura* var. *microcarpa*, *E. latrobei* subsp. *latrobei*, *P. suaveolens*, *S.* sp. golden calyces glabrous (HN Foote 32), *Eragrostis eriopoda* complex, *Eriachne helmsii* and the geophyte *Cheilanthes brownii* (Table 4). The taxa from this community type were predominantly from species groups C and D (Table 2).

The community type was identified from four quadrats located on the steeper upper slopes to the pediments at the base of the range. All the quadrats were characterised by strongly acidic soils (pH 3.8–4.1) with relatively low concentrations of sulphur and a moderate to abundant covering of coarse fragments composed of BIF (Table 3). The quadrats had varying species richness, ranging from six to 18 taxa per quadrat. The classification routine indicated that community types 3 and 4 were closely allied (Fig. 2).

Community type 4 was the most widespread of all the community types identified, recorded from 28 quadrats. This community was not restricted to a particular

Table 2

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



topographical position or landform, as it occurred from the crests to the lower slopes of the range. Community structure was characteristically tall shrubs of *A. aneura* var. *microcarpa* and *A. quadrimarginea*, mid-stratum shrubs *Eremophila latrobei* subsp. *latrobei*, *E. jucunda* and sparse *Ptilotus schwartzii*. Indicator species of this community were *A. aneura* var. *microcarpa*, *A. quadrimarginea*, *Dodonaea petiolaris*, *E. jucunda*, *E. longifolia*, *E. punctata*, *Aluta maisonneuvei* subsp. *auriculata*, *Prostanthera campbellii*, and *Ptilotus schwartzii* (Table 4).

This community type was represented by species in group C, composed of taxa generally not restricted by gradients in the landscape, with some association with species group D (Table 2). The similarity with species group D appeared to be associated with quadrats in the northern portion of the Range. There were six to 16 taxa per quadrat. The community occurs on strongly acidic soils (pH 3.8–4.3; Table 3).

Table 3

Summary statistics for environmental variables, separated by community type, for the Montague Range Zone of the Gum Creek Greenstone Belt. Mean values with standard deviation are listed for community types recorded in more than one quadrat. Differences were determined using Kruskal–Wallis non-parametric analysis of variance. Only community types with >2 representative sites were included in the analyses. Significance values are indicated by * ($p < 0.05$ = *, $p < 0.01$ = **, $p < 0.001$ = ***, $p < 0.0001$ = ****); 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**	**Type 6**
B ^{NS}	0.45 ± 0.07	0.3	0.14 ± 0.18	0.11 ± 0.12	0.05	0.09 ± 0.07
Ca****	2200 ± 2687	31.0	160.0 ± 94.9 ^{ab}	83.7 ± 59.1 ^{a}	200.0	210.0 ± 88.7 ^{b}
Cd^{NS}	7.50E-03 ± 0.0	5.00E-03	5.00E-03 ± 0.0	0.01 ± 0.0	5.00E-03	6.79E-03 ± 0.0
Co****	0.87 ± 0.42	0.05	0.073 ± 0.04 ^{ab}	0.06 ± 0.02 ^{a}	0.42	0.30 ± 0.24 ^{b}
Cu^{NS}	1.8 ± 0.6	0.7	0.63 ± 0.10	0.71 ± 0.14	1.2	0.81 ± 0.20
Fe*	27.5 ± 7.8	29.0	62.8 ± 38.1 ^{ab}	49.6 ± 16.7 ^{a}	35.0	36.5 ± 5.3 ^{b}
K****	69.0 ± 33.9	21.0	49.5 ± 16.3 ^{ab}	36.9 ± 14.8 ^{a}	64.0	96.1 ± 38.2 ^{b}
Mg****	270.0 ± 56.6	7.0	29.8 ± 14.7 ^{ab}	18.0 ± 9.4 ^{a}	58.0	48.6 ± 19.4 ^{b}
Mn****	28.0 ± 12.7	5.0	10.5 ± 1.91 ^{ab}	7.6 ± 3.7 ^{a}	25.0	21.5 ± 9.2 ^{b}
N (total)^{NS}	0.04 ± 0.0	0.03	0.073 ± 0.04	0.05 ± 0.01	0.05	0.05 ± 0.01
Na**	75.0 ± 19.8	0.5	1.5 ± 1.68 ^{ab}	1.23 ± 1.38 ^{a}	2.0	3.1 ± 2.3 ^{b}
Ni***	0.50 ± 0.14	0.1	0.23 ± 0.13 ^{ab}	0.12 ± 0.06 ^{a}	0.3	0.24 ± 0.09 ^{b}
Organic C (%)^{NS}	0.46 ± 0.13	0.4	1.1 ± 0.85	0.62 ± 0.2	0.42	0.57 ± 0.15
P^{NS}	6.5 ± 0.7	4.0	11.5 ± 8.74	8.0 ± 7.7	5.0	5.9 ± 1.6
pH****	6.3 ± 1.6	4.0	4.0 ± 0.13 ^{ab}	4.0 ± 0.2 ^{a}	4.3	4.4 ± 0.3 ^{b}
S***	140.0 ± 155.6	19.0	10.5 ± 2.08 ^{ab}	12.4 ± 2.7 ^{a}	5.0	7.4 ± 3.1 ^{b}
Zn***	1.6 ± 0.6	0.4	1.1 ± 0.25 ^{a}	0.78 ± 0.5 ^{b}	1.1	1.2 ± 0.4 ^{a}
Site Physical Parameters						
Altitude (m)^{NS}	580.5 ± 14.8	611.0	585.8 ± 45.4	589.8 ± 19.0	575.0	580.6 ± 13.3
Bare ground (%)^{NS}	97.5 ± 0.7	88.0	94.5 ± 4.5	96.3 ± 2.4	97.0	96.1 ± 2.2
Abundance-fragments^{NS}	5.0 ± 0.0	4.0	4.5 ± 0.6	4.8 ± 0.6	4.0	4.5 ± 0.7
Leaf litter (%)^{NS}	5.0 ± 1.4	20.0	11.0 ± 7.8	9.3 ± 5.6	6.0	11.8 ± 10.3
Topographical position**	1.5 ± 0.7	1.0	3.3 ± 1.5 ^{ab}	2.3 ± 1.2 ^{a}	5.0	3.7 ± 0.9 ^{b}
Outcrop abundance*	0.5 ± 0.7	0.0	1.8 ± 2.1 ^{ab}	1.5 ± 1.3 ^{a}	0.0	0.4 ± 0.6 ^{b}
Slope^{NS}	5.5 ± 0.7	2.0	15.5 ± 15.1	9.9 ± 8.8	2.0	5.4 ± 3.7
Species Richness	12.0 ± 1.4	10.0	10.8 ± 5.5	10.8 ± 2.6	17.0	14.3 ± 3.3
Number of Quadrats	**2**	**1**	**4**	**28**	**1**	**14**

Community type 5 was identified from one quadrat and was closely allied with community type 6 and species groups B and C (Figure 2; Table 2). The community was found on an east-north-east flat with a moderate cover of coarse fragments of weathered iron-enriched rock and strongly acidic sandy clay loam soils (pH 4.3; Table 3). The quadrat was relatively species rich compared with the majority of other quadrats, with 17 taxa recorded. The community was described as an open tall shrubland of *A. aneura* with isolated mallees of *Eucalyptus lucasii* over isolated shrubland of *Eremophila galeata*, *E. jucunda* and *S. ectogama*.

Community type 6 was generally found on the mid- to lower-slopes, pediments and colluvial plains adjacent to the range; recorded in 14 quadrats. The community was described as sparse to open tall shrubland of *A. aneura* var. *microcarpa* over open shrubland of *E. latrobei* subsp. *latrobei* and *E. jucunda*. Other species contributing to this community included sparse cover of *A. pruinocarpa* trees and mid- to lower-stratum shrubs including *P. obovatus*, *P. schwartzii* and *S. ectogama*. Indicator values identified the following species as typical of the community: *A. aneura* var. *microcarpa*, *A. pruinocarpa*, *E. conglomerata*, *E. galetea*, *E. jucunda*, *E. latrobei* subsp. *latrobei*, *M. convexa*, *P. obovatus*, *P. schwartzii*, *Senna artemisioides* subsp. *helmsii*, *Sida ectogama* and *Spartothamnella teucriiflora* (Table 4). This community had representatives from all species groups, however, the closest relationships are with species groups B and C (Table 2).

The community was characterised by shallow acidic sandy loam and sandy clay loam soils (pH 4.0–5.1). The quadrats typically were covered by moderate to abundant coarse fragments of weathered BIF, iron-enriched rock, quartz and associated metasediments, with the presence of exposed bed rock associated with quadrats further upslope from the base of the range. The mean species richness was 14.3 ± 3.3 SD, ranging from eight to 21 taxa per quadrat (Table 3).

Environmental Variables

The soils of the Montague Range were typically strongly acidic, with a mean pH of 4.17 ± 0.56 SD and a range of 3.8 to 7.4 (Table 3). There were only three quadrats where soil pH was >5 and only a single quadrat with soil pH of 7.4. The quadrats with higher pH values concomitantly had high soil Ca concentrations (>300 mg kg^{-1}). The soils collected on the Range were skeletal to shallow red-brown sandy loams and sandy clay loams. The high clay fraction in the soil matrix was typically associated with quadrats on the footslopes, pediments and colluvial plains. The majority of sites had >50% cover of coarse fragments, predominantly composed of weathered laminar ironstones and iron enriched rock. Rock fragments were abundant at most survey sites, with an average cover category 4.6, which approaches 50–90% cover category (Table 3). The quadrats typically had a high proportion of bare ground (mean 96% ± 2.7 SD) and very sparse cover of leaf litter (mean 10.1% ± 7.3 SD).

Table 4

Taxa with indicator values ≥ 25 for three of the six community types of the Montague Range Zone. Communities with ≤ 3 representative sites were excluded from the analysis. Significant taxa are shown at $p < 0.05$ (from Monte Carlo permutation test), levels of significance are indicated as: * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$. Indicator values ≥ 25 are indicated by shading.

Indicator Species	Community Types 3	4	6
*Psydrax suaveolens***	70	3	3
Sida sp. golden calyces glabrous (HN Foote 32) *	46	3	7
*Cheilanthes brownii**	44	1	0
Eragrostis eriopoda complex *	44	1	0
Acacia aneura var. *microcarpa*	34	31	34
Eremophila latrobei subsp. *latrobei*	34	29	34
Acacia sibirica	25	0	0
Eriachne helmsii	25	0	0
Acacia quadrimarginea *	4	47	9
*Eremophila jucunda**	0	38	45
Ptilotus schwartzii	3	38	29
Eremophila punctata	24	28	0
Dodonaea petiolaris	0	26	4
Prostanthera campbellii	17	25	9
Aluta maisonneuvei subsp. *auriculata*	0	25	0
*Acacia pruinocarpa***	6	0	51
*Sida ectogama**	0	7	46
*Eremophila galeata***	0	0	43
Senna artemisioides subsp. *helmsii***	0	0	43
*Ptilotus obovatus**	17	3	41
*Acacia tetragonophylla**	7	1	37
*Scaevola spinescens**	0	1	37
Acacia aneura var. *argentea**	0	2	34
*Maireana convexa**	0	0	29
*Spartothamnella teucriiflora**	0	0	29
Eremophila conglomerata	0	17	28
Number of quadrats	**4**	**28**	**14**

There were strong intercorrelations between soil chemical properties ($p < 0.01$; Table 3). Soil pH and the elements Ca, Co, K, Mg, Mn, Na, Ni and Zn were all positively intercorrelated ($p < 0.01$). All soil chemical properties were negatively correlated with sulphur ($p < 0.01$), except Na and Ni ($p > 0.05$). Species richness was positively related to Ca, K, Mg and Na content ($p < 0.01$). Iron content, soil nitrogen and organic carbon were highly intercorrelated ($p < 0.001$), with the strongest relationship among all soil chemical properties between soil nitrogen and organic carbon ($r_s = 0.91$, $p < 0.0001$).

Abundance of coarse fragments and exposed bedrock, soil depth, runoff and slope were all highly intercorrelated ($p < 0.01$), with the strongest relationship of all site physical characteristics between runoff and slope ($r_s = 0.82$, $p < 0.0001$; Table 3). Other strong relationships existed between topographical position (e.g. 1 = crest to 5 = outwash) and abundance of exposed bedrock ($r_s = -0.61$, $p < 0.0001$). There were no significant correlations between species richness and site physical parameters ($p > 0.01$).

Community types recorded in two or fewer quadrats (types 1, 2 and 5) were excluded from the analyses comparing environmental variables between communities. There were significant differences ($p < 0.05$) between community types 4 and 6 for Ca, Co, Fe, Mg, Mn, Na, Ni, S, soil pH, and topographical position and rock outcrop abundance (Table 3). There were significant differences between community type 4 and types 3 and 6 for Zn ($p < 0.001$). Community type 4 had the lowest mean values for soil pH and the trace elements Ca, Co, Mg, Mn, Na and Ni, and the highest concentrations of Fe and S.

BIO-ENV

The PRIMER BIO-ENV routine examined which environmental variables best correlated with the patterns in the site resemblance matrix. Mg, Ni, S, altitude and abundance of rock outcrop had the highest correlation with the patterns within the site resemblance matrix (Rho = 0518). Magnesium was strongly correlated with Ni ($r_s = 0.77$, $p < 0.0001$) and S ($r_s = -0.49$, $p < 0.001$). Altitude and abundance of exposed bedrock were positively correlated ($r_s = 0.38$, $p < 0.01$). The high values for altitude and abundance of exposed bedrock were almost in complete opposition to the those of the soil trace elements (Fig. 4). In particular, community type 2, with high values for all three trace elements, was clearly separated from the other sites (Fig. 4).

DISCUSSION

Flora and Vegetation Communities

There were 104 taxa recorded during the survey (91 of which were from quadrats). This was markedly lower than many of the flora surveys in the greenstone belt flora of the Yilgarn Craton (e.g. Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c), and lower than flora surveys carried out in association with the Mt. Townsend Project, which identified 131 taxa (Kimseed Environmental 1998). However, prior to this survey there were only 72 species lodged at the WA Herbarium from the vicinity of the Montague Range. Poor representation of annual taxa and lower absolute numbers of taxa collected during the survey was associated with the low annual rainfall preceding the survey.

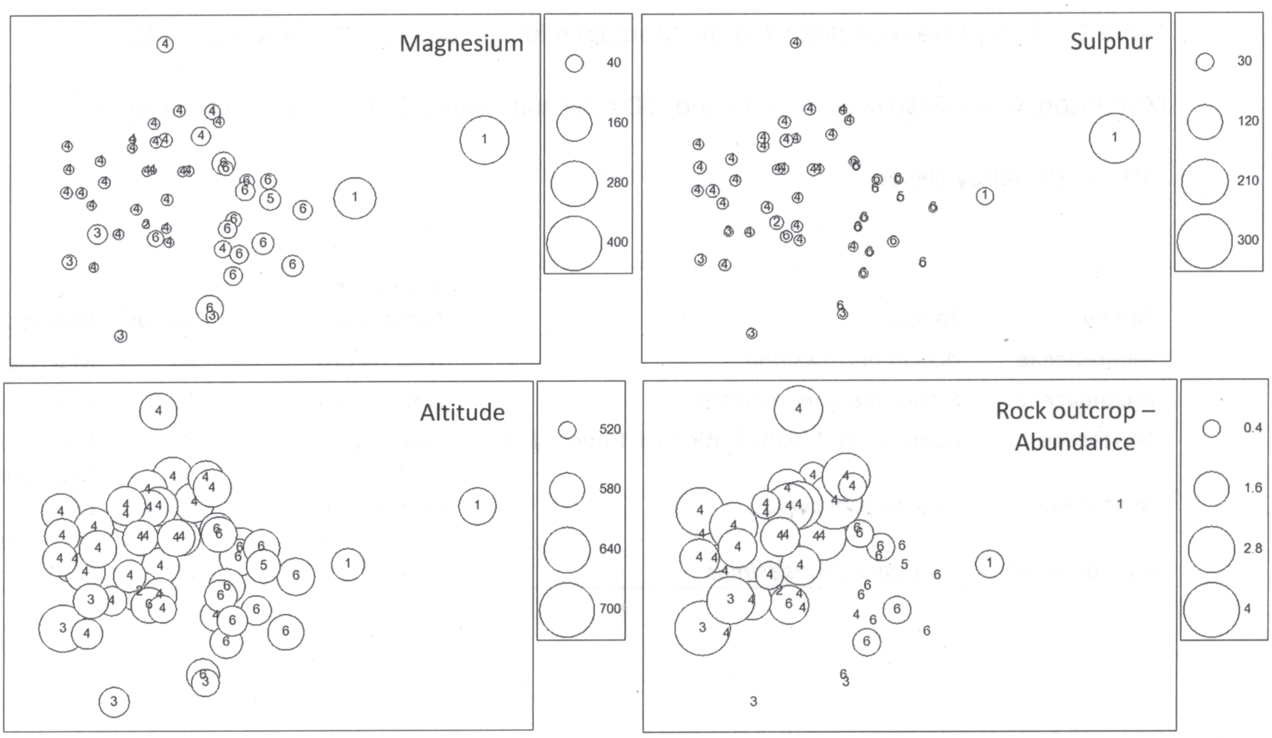


Figure 4. Bubble plots of the four most highly correlated environmental parameters identified from the BIO-ENV routine (Rho = 0.518) overlaid on the MDS ordination. The plot for nickel was excluded as the trace element was highly positively correlated with magnesium (p < 0.0001). Increase in the size of the bubble correlates with increasing value of the variable. The numbers inside the circles correspond to the community types.

Previous flora surveys of the greenstone belts of the Yilgarn Craton have identified taxa endemic to specific upland formations and taxa of conservation significance (Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). The flora survey of the Montague Range Zone of the Gum Creek Greenstone belt identified no endemic taxa and five priority listed taxa, which was lower than the seven priority tax recorded from the Lake Mason Zone of the Gum Creek Greenstone belt (Thompson & Sheehy 2011a). *Stenanthemum mediale* (P1) is regionally restricted and known from populations at Jack Hills (c. 100 km west of Meekatharra) and Youno Downs and Yeelirie, which are both adjacent to Montague Range. This taxon has been recorded as occurring on Montague Range (Kimseed Environmental 1998), but vouchered specimens were not lodged with the WA Herbarium. It is recommended that *S. mediale* is downlisted from P1 to P2, as nine new populations were recorded on the Montague Range and a single population was recorded in the Lake Mason Zone, south of Montague (Thompson & Sheehy 2011a). A further three taxa collected during the survey represent range extensions of 200 km or greater, including the putative new variety of *Acacia aneura* aff. *argentea*.

Six distinct vegetation communities were identified following classification of the site resemblance matrix. This is similar to other greenstone belt studies (Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). The communities generally were not restricted to a specific topographical position in the landscape, the exception being those communities identified from a single quadrat. The community types found on Montague Range had a more general distribution with regards to topography and landscape element. The BIO-ENV routine showed that altitude was highly correlated with the site resemblance matrix, however, there are inherently more complex relationships influencing the vegetation patterns than simple topographical position in the landscape.

Acacia aneura dominated all vegetation communities, generally as the tallest stratum. This is typical for the Murchison Region (Beard 1976; Beard 1990; Payne et al. 1998), and of flora surveys undertaken in the immediate vicinity (Kimseed Environmental 1998). Furthermore, taxa ubiquitous to other greenstone belts in the region were found across the Montague Range (e.g. *Eremophila jucunda*, *E. latrobei* subsp. *latrobei*). The primary source of similarity was the presence of some ubiquitous taxa within community types. For example, *A. aneura* over *E. latrobei* subsp. *latrobei* with sparse *Ptilotus schwartzii* were indicator taxa in both community type 4 on Montague Range Zone and community type 2 at Lake Mason Zone (Thompson & Sheehy 2011a).

Environmental correlates

Most of the soils on the Montague Range were highly acidic, as is typical of weathered regolith (Slattery et al. 1999). Where soil pH approached neutral or alkaline values, there were concomitant higher calcium concentrations, suggesting the presence of calcareous soils. Soil textures were generally sandy loam, with sandy clay loams occurring only at mid- to lower slopes and on adjacent colluvial plains where deeper soil profiles routinely form. The soil physical parameters of the Montague Range are typical of regolith associated with the Yilgarn Craton (Anand & Paine 2002). The variability in soil trace element concentrations were similar to those from other greenstone and ironstone ranges in the Yilgarn Craton (Gibson 2004a, 2004b; Gibson et al. 1997; Gibson & Lyons 1998a, 1998b, 2001a, 2001b; Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c).

The Gum Creek Greenstone Belt is composed of both metabasalt and ultramafic rocks (Tingey 1985), which are known to have high to very high concentrations of Mg (LeBas 2000; Gray & Murphy 2002). Sulphides and carbonates are readily leached from the profile, mobilising elements such as S, Na, Ca, Mg, Mn, Co, Cu, Ni and Zn (Butt et al. 2000; Britt et al. 2001; Anand 2005). Calcrete accumulation has been linked with lowland communities (Anand et al. 1997); in this study, higher calcium concentrations were recorded in communities on the footslopes, pediments and colluvial plains.

Altitude, abundance of exposed bedrock and concentrations of soil trace elements (Mg, Ni, and S) were correlated with 51.8% of the site resemblance matrix. This suggested that the position, underlying regolith and weathering of the profile has influenced the floristic composition. Weathering of the regolith mobilises elements, leaching some and retaining others in varying concentrations (Britt et al. 2001; Anand 2005). Those elements with higher concentrations (e.g. Mg, K) are most likely not leached to the same extent as others, whereas higher Fe concentrations are likely attributed to the weathering of iron-enriched rock (Gray & Murphy 2002).

Community type 1 had soil physical characteristics typical of mafic sites (e.g. higher Mg, Mn, Ni) as well as a higher Ca level attributed to the presence of calcareous soils. The other communities exhibited more moderate concentrations of trace elements. The most noticeable significant environmental differences occurred between community type 4 (widespread locations with ubiquitous taxa—*A. aneura*, *E. latrobei* and *P. schwartzii*) and community type 6 (mid- to lower slopes with ubiquitous taxa). Higher concentrations of chemical elements, except Fe and S, were linked to community type 6.

Conservation Significance

The Montague Range has a long history of grazing, mineral exploration and mining. Evidence of the impact of these activities was apparent on the range, in particular the presence of livestock, extensive gridline tracks, drill holes and open cut mining. The history of land disturbance combined with the low rainfall preceding the survey were likely contributing factors to the poor representation of annuals and generally low species richness.

While the range had lower levels of species richness than other BIF ranges in the Yilgarn, the range is still an important repository of taxa of conservation significance and taxonomic uncertainty. This is similar to other areas on the BIF ranges of the Yilgarn (Gibson 2004 a, 2004b; Gibson & Lyons 1998a, 1998b, 2001a, 2001b; Gibson et al. 1997; Markey & Dillon 2008a, 2008b; Meissner & Caruso 2008a, 2008b, 2008c). The south-east portion of the range occurs on land managed by the Department of Environment and Conservation, but remains unclassified within the conservation estate. At present, there are no BIF ranges designated within Class A Nature Reserves.

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APPENDIX A

Flora list for the Montague Range Zone of the Gum Creek Greenstone Belt, including collections made outside of the survey quadrat boundaries. Nomenclature follows Packowska and Chapman (2000).

Acanthaceae
- *Harnieria kempeana* subsp. *muelleri*

Adiantaceae
- *Cheilanthes brownii*
- *Cheilanthes sieberi* subsp. *sieberi*

Amaranthaceae
- *Ptilotus obovatus*
- *Ptilotus roei*
- *Ptilotus schwartzii*

Asclepiadaceae
- *Marsdenia australis*
- *Sarcostemma viminale* subsp. *australe*

Asteraceae
- *Olearia humilis*

Brassicaceae
- *Lepidium platypetalum*

Caesalpiniaceae
- *Senna artemisioides* subsp. *filifolia*
- *Senna artemisioides* subsp. *helmsii*
- *Senna artemisioides* subsp. *petiolaris*
- *Senna artemisioides* subsp. x *artemisioides*
- *Senna artemisioides* subsp. x *sturtii*
- *Senna glaucifolia*
- *Senna glaucifolia* x *artemisioides* subsp. x *sturtii*
- *Senna* sp. Meekatharra (E Bailey 1–26)

Chenopodiaceae
- *Enchylaena tomentosa* var. *tomentosa*
- *Maireana convexa*
- *Maireana georgei*
- *Maireana georgei* x *Enchylaena tomentosa*
- *Maireana thesioides*
- *Maireana triptera*
- *Rhagodia drummondii*
- *Sclerolaena fusiformis*

Convolvulaceae
- *Duperreya sericea*

Cupressaceae
- *Callitris columellaris*

Dilleniaceae
- *Hibbertia arcuata*

Euphorbiaceae
- *Sauropus ramosissimus* P3

Frankeniaceae
- *Frankenia pauciflora*

Goodeniaceae
- *Goodenia macroplectra*
- *Scaevola spinescens*

Lamiaceae
- *Prostanthera althoferi* subsp. *althoferi*
- *Prostanthera althoferi* subsp. *althoferi* x *campbellii*
- *Prostanthera campbellii*
- *Spartothamnella teucriiflora*

Loranthaceae
- *Amyema preissii*

Malvaceae
- *Sida ectogama*
- *Sida* sp. Excedentifolia (JL Egan 1925)
- *Sida* sp. golden calyces glabrous (HN Foote 32)
- *Sida* sp. verrucose glands (FH Mollemans 2423)

Mimosaceae
- *Acacia* aff. *coolgardiensis*
- *Acacia aneura* aff. *argentea* (transluscent aging to opaque resin)
- *Acacia aneura* var. *alata* (narrow phyllode variant) BRM 9058
- *Acacia aneura* var. *argentea*
- *Acacia aneura* var. *argentea* (narrow phyllode variant) BRM 9745
- *Acacia aneura* var. *conifera*
- *Acacia aneura* var. *microcarpa*
- *Acacia aneura* var. *microcarpa* (broad, incurved phyllode variant) BRM 9929
- *Acacia aneura* var. *tenuis* (grey) BRM 9191C
- *Acacia burrowsiana* P1
- *Acacia cockertoniana*
- *Acacia craspedocarpa*
- *Acacia effusifolia*
- *Acacia masliniana*
- *Acacia minyura*
- *Acacia paraneura*
- *Acacia pruinocarpa*
- *Acacia quadrimarginea*
- *Acacia ramulosa* var. *linophylla*
- *Acacia rhodophloia*
- *Acacia sibirica*
- *Acacia tetragonophylla*
- *Acacia xanthocarpa*

Myoporaceae
- *Eremophila conglomerata*
- *Eremophila exilifolia*
- *Eremophila forrestii*
- *Eremophila galeata*
- *Eremophila jucunda*
- *Eremophila latrobei* subsp. *latrobei*
- *Eremophila longifolia*
- *Eremophila oppositifolia* subsp. *angustifolia*
- *Eremophila pantonii*
- *Eremophila punctata*

Myrtaceae
- *Aluta maisonneuvei* subsp. *auriculata*
- *Baeckea* sp. Melita Station (H Pringle 2738) P3
- *Calytrix desolata*
- *Calytrix praecipua* P3
- *Eucalyptus carnei*
- *Eucalyptus kingsmillii* subsp. *kingsmillii*
- *Eucalyptus lucasii*
- *Micromyrtus sulphurea*

Papilionaceae
- *Mirbelia rhagodioides*

Poaceae
- *Eragrostis eriopoda/xerophila/setifolia* complex
- *Eriachne helmsii*
- *Eriachne mucronata*
- *Eriachne pulchella* subsp. *pulchella*
- *Paspalidium basicladum*

Proteaceae
- *Grevillea berryana*
- *Hakea preissii*

Rhamnaceae
- *Stenanthemum mediale* P1

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

Santalaceae
- *Exocarpos aphyllus*
- *Santalum spicatum*

Sapindaceae
- *Dodonaea adenophora*
- *Dodonaea petiolaris*
- *Dodonaea rigida*

Solanaceae
- *Solanum ashbyii*/*lasiophyllum* complex
- *Solanum orbiculatum* subsp. *orbiculatum*

Sterculiaceae
- *Brachychiton gregorii*

Stylidiaceae
- *Stylidium induratum*