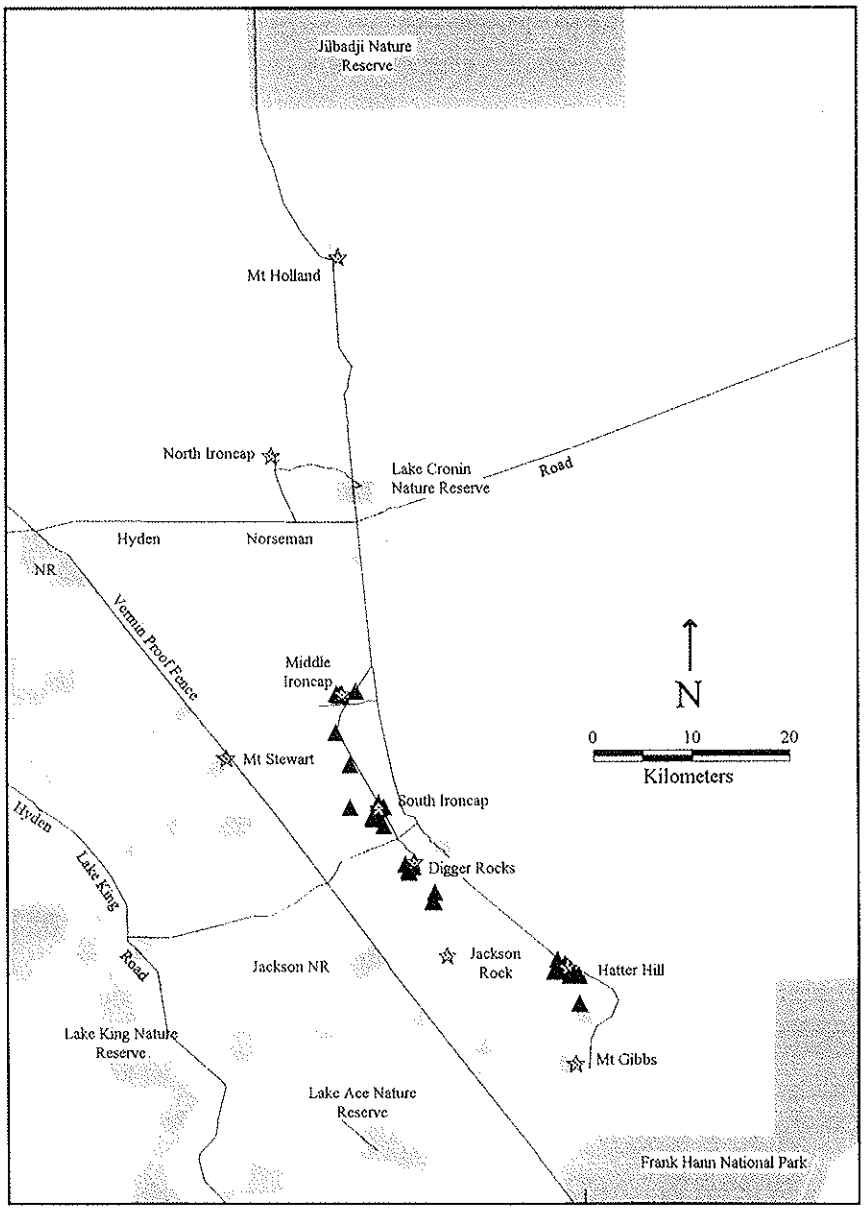
Floristic Survey of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the Eastern Goldfields of Western Australia

Neil Gibson and Michael N. Lyons



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by

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ABSTRACT

A study was undertaken of the flora and plant communities of the greenstone and banded ironstone belt stretching from Middle Ironcap south to Hatter Hill. Thirty eight quadrats were established along the range system and data from these sites were used to define five community types that were strongly correlated with soil type and underlying geology. A total flora of 234 taxa was recorded from the range, of which 232 were native and 2 were weeds. Two species of Declared Rare Flora and 16 taxa listed on CALM's priority flora list were found in the study area. A new species of *Stenanthemum* is recommended for immediate listing on the priority flora list. Further urgent survey is recommended for six taxa to determine if they should be gazetted as Declared Rare Flora.

Despite considerable mining and exploration activity in the area the flora and vegetation is still very poorly known. Very little of the Forrestania vegetation system is reserved in any National Park or Nature Reserve. Our results support recommendations for the establishment of a series of nature reserves to conserve this vegetation system.

INTRODUCTION

The Forrestania greenstone belt stretches from Mt Holland south to Hatter Hill, a distance of some 70 km, and lies 80 km east of Hyden. This narrow greenstone belt is composed of an undulating plain of mafic and ultramafic lithologies and abrupt ridges of banded ironstones with some Tertiary lateritic development.

Greenstone and banded ironstone ranges are one of the common landforms of the Eastern Goldfields and extend from the Highclere Hills in the west to the Roe Hills some 300 km further east and stretch north - south over 800 km. The Forrestania belt forms part of the western most greenstone series (Figure 1). Despite the greenstone and banded ironstone ranges being heavily exploited for minerals for over a hundred years a detailed knowledge of the vegetation and flora of the region is still lacking.

CLIMATE

The climate of the region is warm dry mediterranean with warm winters and hot summers. Mean annual rainfall at Hyden (100 km west) is 336 mm, with moderate seasonal variation. The driest year on record was 1972 with 159 mm and the wettest was 1942 with 572 mm. Most rain falls in winter generally associated with frontal activity from May through August. Summer falls (to 50 mm) are highly erratic and result from thunderstorms. Heaviest falls (to 160 mm) are associated with rain bearing depressions forming from tropical depressions (Newbey 1988, Bureau of Meteorology 1988).

The temperature data from Hyden shows mean maximum temperatures is highest in January (33.4°C) with December through April all recording mean annual temperatures above 30°C. Lowest mean minimum temperatures of below 5°C are recorded in July and August.

GEOLOGY AND LANDFORMS

The geology of the study area has been mapped and described in detail in the Hyden 1: 250000 sheets (Chin *et al.* 1984) and the geology and landforms have also been summarised by Newbey (1988). The study area has been tectonically stable since the Proterozoic (600 - 2500 million years (My) ago). The major landscape features are controlled by the Archaean (2500 -

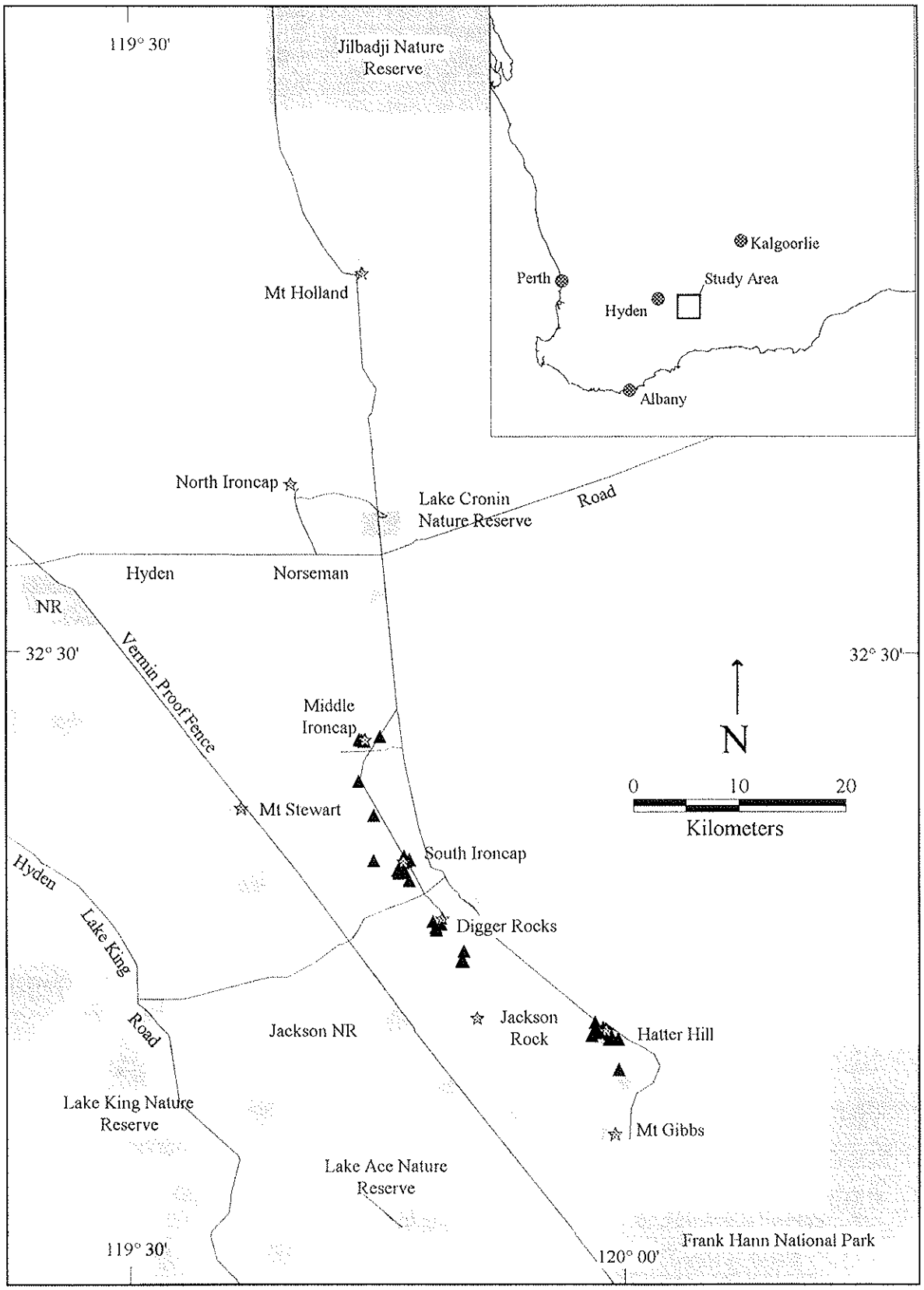


Figure 1. Location of the study area.

3700 My old) granites which underlie most of the study area and have weathered into gently undulating plains and broad valleys covered by Tertiary soils (< 65 My old). The narrow Forrestania greenstone (Archaean mafic and ultramafic lithologies) belt stretches from Mt Holland to Hatter Hill. This belt has several banded ironstone units (formed from lacustrine deposits of iron oxides and quartz sand) up to 30 m thick which form the abrupt ridges of North, Middle and South Ironcap (Chin *et al.* 1984). Some areas of Tertiary laterite were found associated with the greenstone belt.

Gold was first discovered in the Forrestania area in 1915 and there has been a long history of mineral exploration and mining along this belt. There are presently three large mines operating in the area, one at Forrestania, a second at Middle Ironcap and a third at Digger Rocks.

A large, extremely hot, wildfire swept through the northern section of the Forrestania belt in summer of 1993 consuming almost all vegetation between Mt Holland and Middle Ironcap. The current survey concentrated on the unburnt southern section from Middle Ironcap south to Hatter Hill.

VEGETATION

The Forrestania greenstone belt lies within the Roe Botanical District, an area characterised by mallee vegetation with some eucalypt woodland in lower valleys and scrub heath and *Allocasuarina* thicket on the residual plateau soils (Beard 1990).

Beard (1972) first described the major structural formations of this area which he grouped into vegetation systems. He defined the vegetation of the greenstone belt stretching from Mt Holland to Hatter Hill as the Forrestania system. This system also included granites, quartzites, and banded ironstones that formed prominent rocky ridges.

Beard described sclerophyll woodlands of *Eucalyptus salmonophloia* and *E. longicornis* but noted that these areas had been extensively cut and burnt over and were in poor condition. Very few areas of this vegetation type were encountered during the current survey. A peculiar feature of the Forrestania system was the ridges of banded ironstone (Beard 1972), with Mt Holland being covered by a dense thicket whose dominants included *Allocasuarina campestris, Calothamnus asper, Hakea* sp., *Dryandra* sp., and *Callitris preissii* subsp. *verrucosa*. Further south at South Ironcap the vegetation was a heath with occasional scattered *E. falcata*. Shrubs recorded included *Banksia sphaerocarpa, Allocasuarina ?dielsiana, Dryandra* sp., *Isopogon gardneri* (JSB 3731), *Melaleuca ?cardiophylla, Grevillea insignis, Adenanthos viridiflorus, Isopogon teretifolius, Callitris roei, Calothamnus quadrifidus, Lysinema ciliatum, Lasiopetalum* sp. and *Dryandra viscida*. (JSB 3735).

At Hatter Hill, a further 25 km south east, the rocky greenstone ridges were covered with thickets of *Allocasuarina ?dielsiana,* and *Eucalyptus loxophleba* with *Cassia chatelainiana, Dodonaea stenozyga, Melaleuca acuminata, Calothamnus quadrifidus, Boronia inornata* and *Westringia dampieri*.

Following Beards work in the area a series of regional surveys were undertaken across the eastern goldfields. In the cell report covering the Lake Johnson – Hyden area Newbey and Hnatiuk (1988) detail the regional vegetation patterns following a land system approach. They note that the three Ironcaps (North, Middle and South) vary slightly in their fine grain mosaic of vegetation structure and more so in species composition. They further note that the vegetation and flora of these ironstones differ widely from the nearest other banded ironstone formation. The major vegetation type of the greenstone belt from Hatters Hill to Mt Holland is

Eucalyptus flocktoniae low woodland which differs from the Parker Range and Highclere Hills to the north (Newbey and Hnatiuk 1988). Growing in the *E. flocktoniae* low woodlands were other low trees of *E. salubris*, and *E. annulata*, with tall shrubs of *Exocarpos aphyllus*, *Melaleuca cucullata* and *Melaleuca pauperiflora*. Breakaways, a common component of goldfield ranges, were only recorded once but mallees of *Eucalyptus livida (=E.* aff. *wandoo)* were usually present in small partially laterized areas.

The aim of the present work was to undertake a detailed floristic survey of the Forrestania greenstone belt form Middle Ironcap to Hatter Hill (Figure 1). This involved the compilation of a detailed flora list, and the description of the vegetation patterning of the area based on a series of permanently located quadrats.

METHODS

Thirty eight 20 m x 20 m quadrats were established on the southern half of the Forrestania greenstone belt from Middle Ironcap south to Hatter Hill (Figure 2). These sites attempted to cover the major geographical, geomorphological and floristic variation found in the study area. Care was taken to locate sites in the least disturbed vegetation available in the area being sampled.

Within each site all vascular plants were recorded. Sites were sampled in early September 1996. Data on topographical position, slope, aspect, percentage litter, percentage bare ground, percentage exposed rock, vegetation structure and condition were collected from each site. Topographical position was scored on a subjective six point scale. (Ridge tops = 1, upper slopes = 2, midslopes = 3, lower slopes = 4, valley flats =5, small rise in valley =6). Slope was scored on a one to three scale from flat to steep. Aspect was recorded as one of 16 cardinal directions. Vegetation structure was recorded using Muir's (1977) classification. All sites were permanently marked with four steel fence droppers and their positions fixed using a GPS unit.

Sites were classified according to similarities in species composition. In these analyses only perennial species were used to facilitate comparisons with classifications from other ranges in the area (Gibson & Lyons 1995, Gibson *et al.* 1997).

The site and species classifications undertaken used the Czekanowski coefficient and "unweighted pair-group mean average" fusion method (UPGMA, Sneath and Sokal 1973). Semi-strong hybrid (SSH) ordination of the sites data was undertaken to show spatial relationships between groups and to elucidate possible environmental correlates with the classification (Belbin 1991

Nomenclature follows Green (1985) and current usage at the Western Australian Herbarium (PERTH). Manuscript names are indicated by "ms" after the name. Selected voucher specimens will be lodged in the Western Australian Herbarium.

RESULTS

FLORA

A total of 234 taxa (species, subspecies, varieties and two hybrids) were recorded from the Forrestiana greenstone belt. The flora list was compiled from taxa found in the 38 plots or the adjacent area and from other opportunistic collections (Appendix 1). Of these 234 taxa, 232 are native and 2 are weeds.

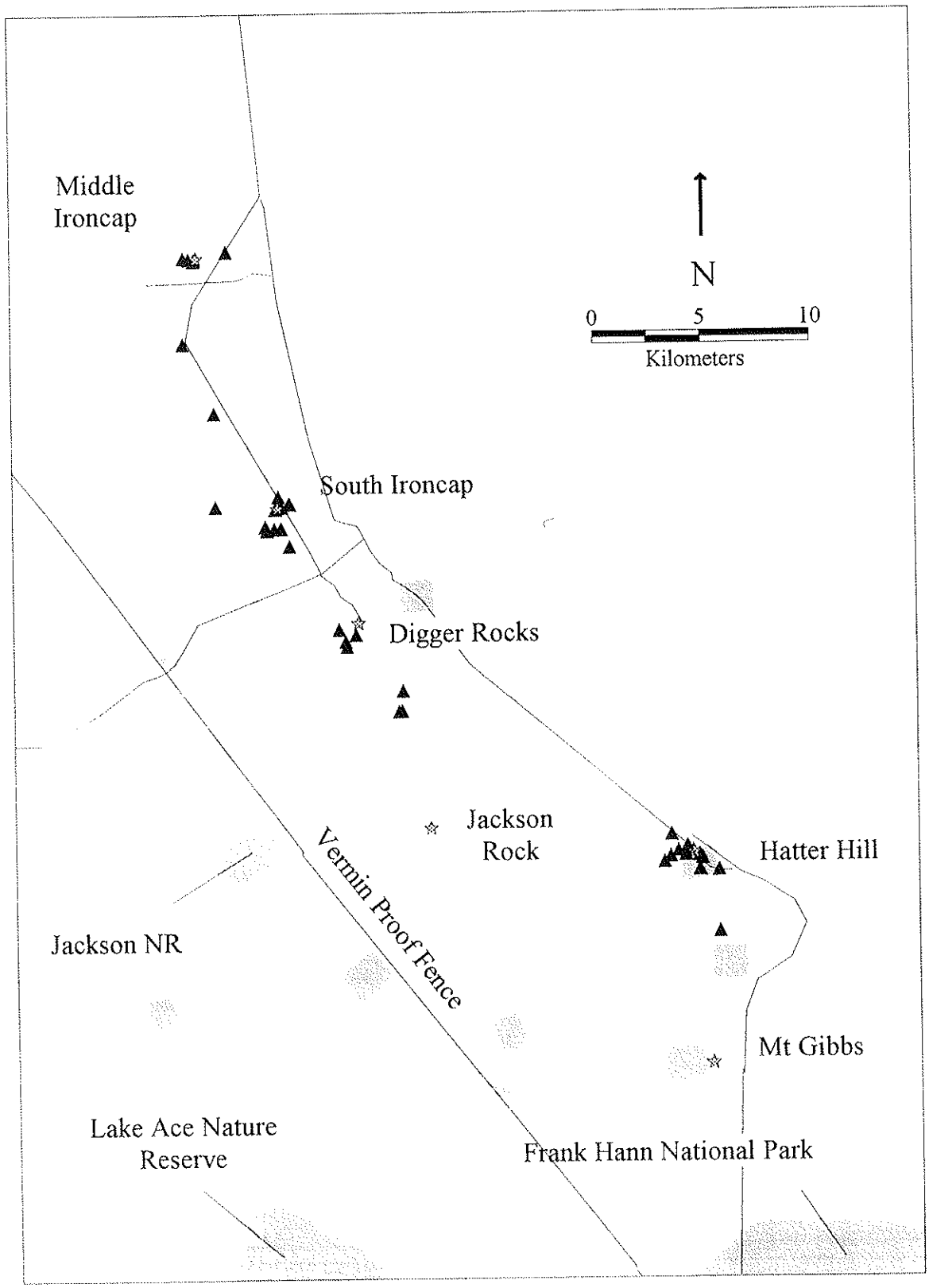


Figure 2. Location of survey sites within the study area.

The best represented families were the Myrtaceae (50 taxa), Proteaceae (25 taxa), Mimosaceae (16 taxa), Orchidaceae (15 taxa), and Asteraceae (13 native taxa and 1 weeds) (Appendix 1). This pattern is typical of the flora of the South Western Botanical Province (Beard 1990). The most common genera were *Eucalyptus* (23 taxa), *Melaleuca* (17 taxa) and *Acacia* (16 taxa).

During the survey two Declared Rare taxa and sixteen taxa listed on CALM's priority flora list (CALM 1996) were encountered (Table 1, Figure 3). One taxon (*Stenanthemum* sp. South Ironcap (NG 2518)) was collected for the first time (Figure 4). It is recommended that this taxon be immediately listed on CALM's priority flora list as priority one (CALM 1996) with further urgent survey to determine if listing as Declared Rare Flora (DRF) is required.

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

Table 1. Priority Flora encountered during the survey (CALM 1996).

Taxon	***Current priority listing***
Acacia castanostegia ms	2
Acacia heterochroa subsp. robertii	2
Acacia singula	3
Acrotriche patula	2
Banksia elegans	4
Banksia sphaerocarpa var. dolichostyla	R
Bentleya diminuta	2
Boronia revoluta	R
Cryptandra intonsa	1
Dryandra viscida	3
Grevillea insignis subsp. elliotii	3
Grevillea lullfitzii	1
Lasiopetalum sp. Ironcaps (PG Wilson 7024)	1
Melaleuca agathosmoides	1
Melaleuca cliffortioides	4
Phebalium brachycalyx	1
Stylidium sejunctus ms	1
Styphelia pulchella	1

The southern Forrestania belt is significantly richer in priority taxa than other goldfields ranges (Gibson & Lyons 1995, Gibson *et al.* 1997). Of the eighteen priority taxa and one new taxon, eight are endemics (*Banksia sphaerocarpa* var. *dolichostyla*, *Boronia revoluta, Cryptandra intonsa, Dryandra viscida, Grevillea insignis* subsp. *elliotii, Grevillea lullfitzii, Lasiopetalum* sp. Ironcaps (PG Wilson 7024), and *Stenanthemum* sp. South Ironcap (NG 2518)) to the laterites and banded ironstones of the Forrestania belt.

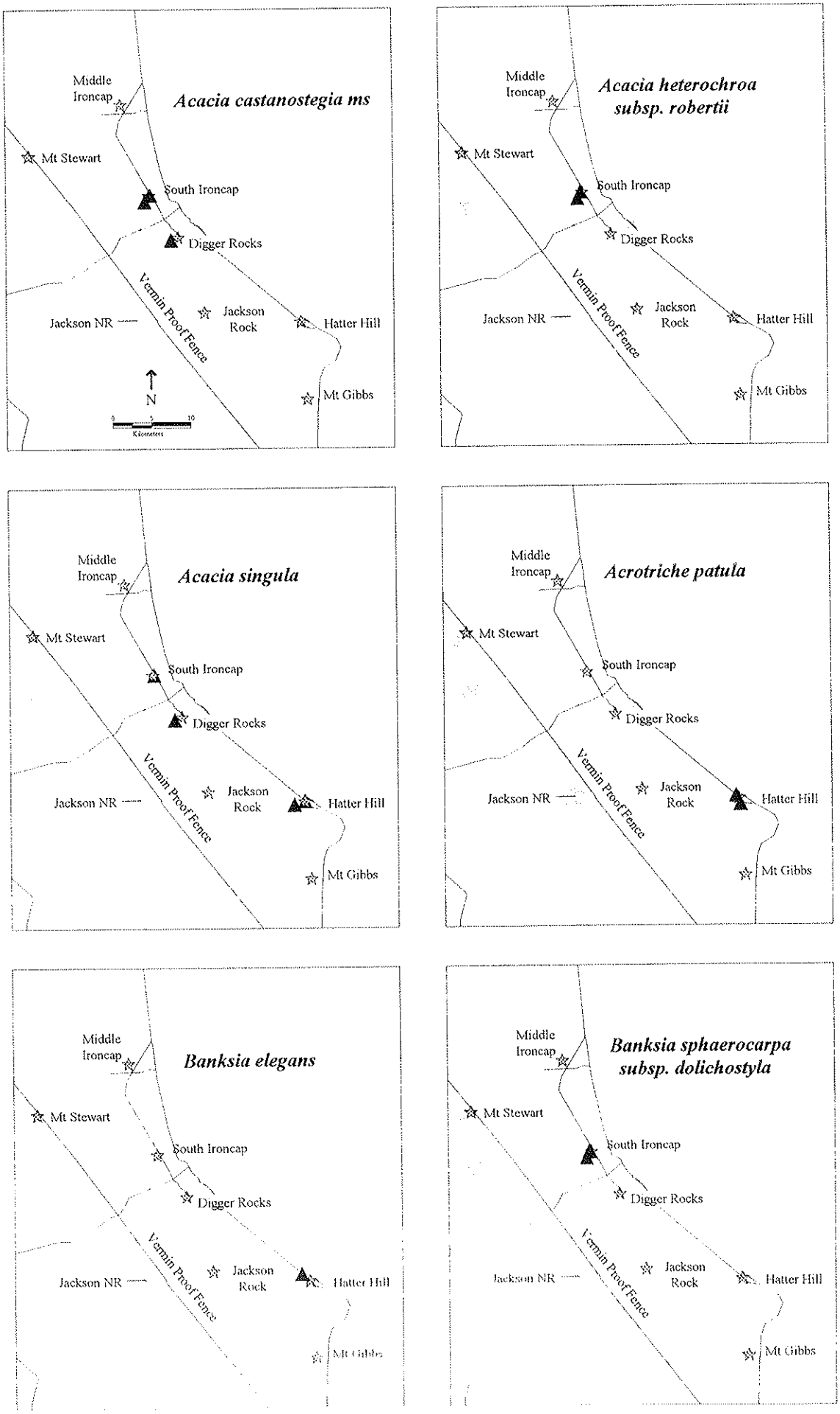


Figure 3. Populations of Declared Rare and Priority Flora recorded during the current survey.

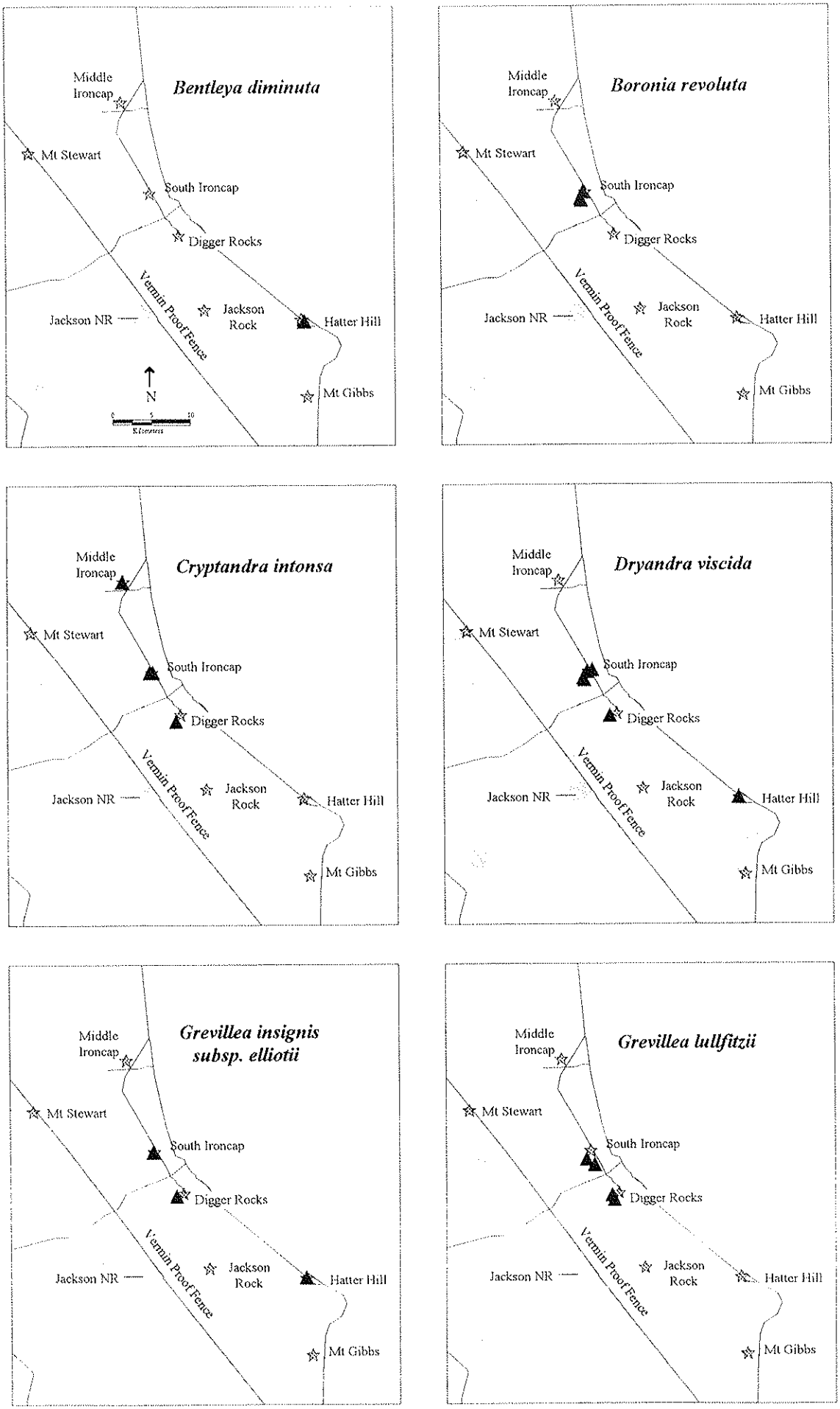
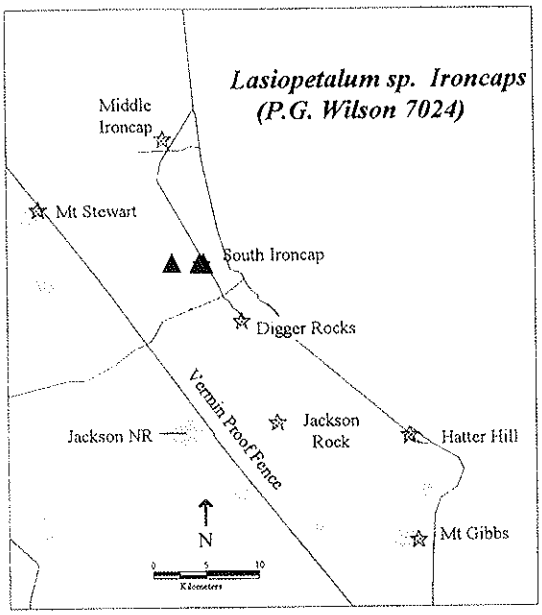
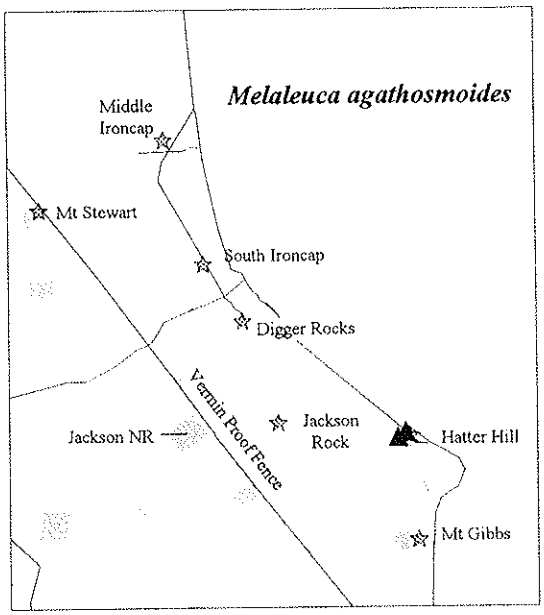
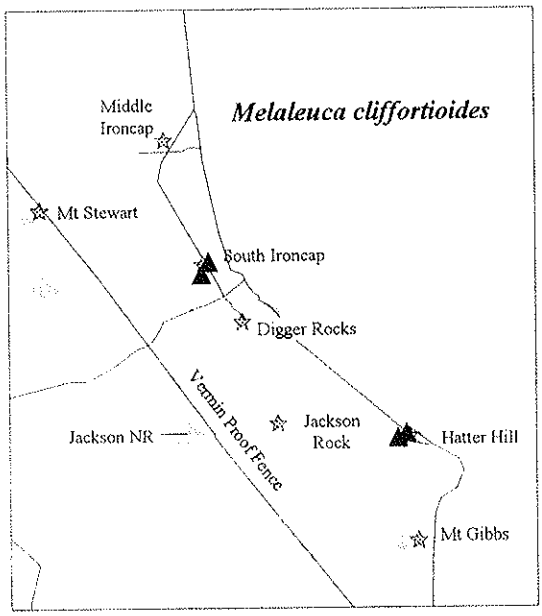
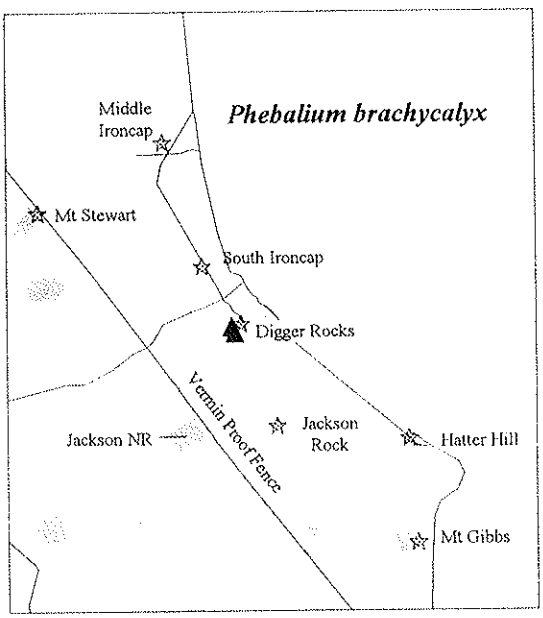


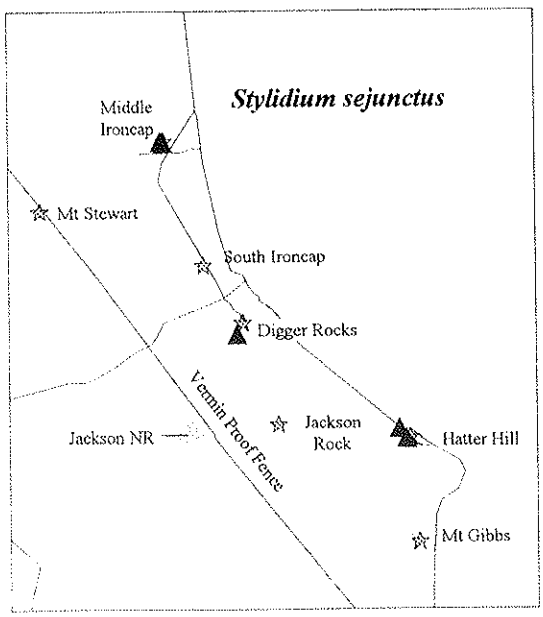
Figure 3. (cont'd) Populations of Declared Rare and Priority Flora recorded during the current survey.











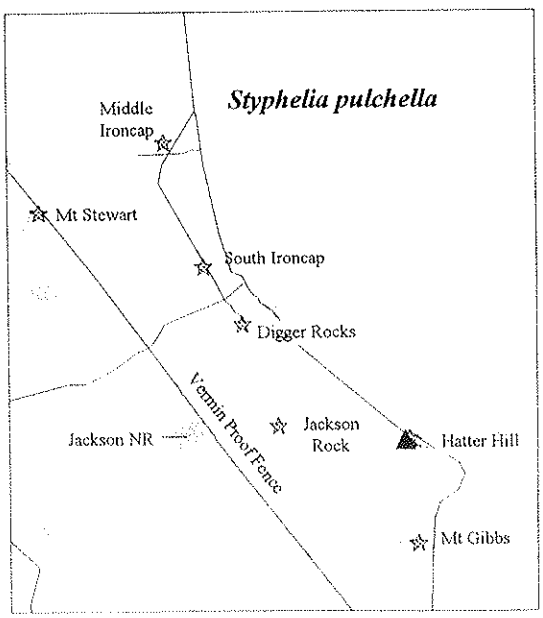


Figure 3. (cont'd) Populations of Declared Rare and Priority Flora recorded during the current survey.

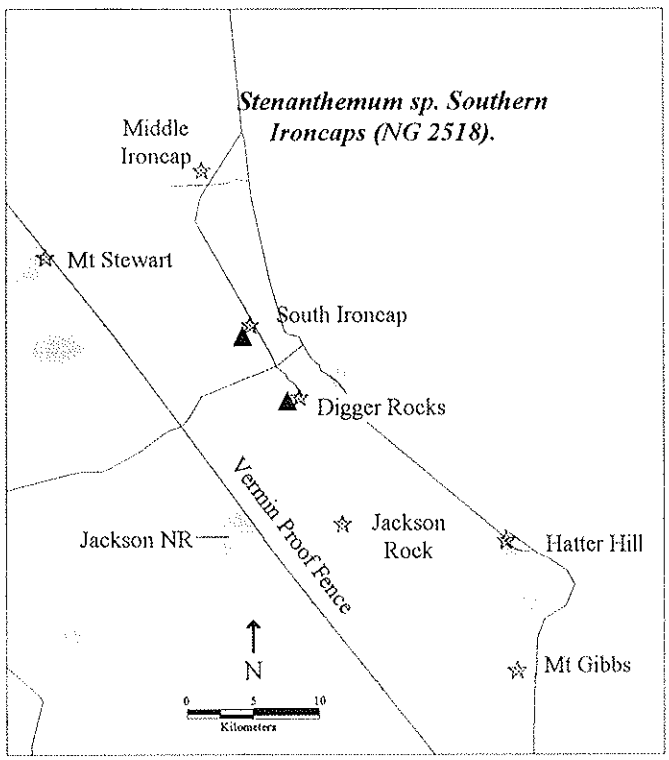


Figure 4. New taxon recorded during the current survey.

During the current survey new populations of *Boronia revoluta* and *Banksia sphaerocarpa* var. *dolichostyla* were located. This was somewhat surprising given the proximity to active mines and the botanical survey work undertaken associated with their commissioning.

Significant range extensions were recorded for *Phebalium brachycalyx* and *Bentleya diminuta*. *P. brachycalyx* major distribution is in the Wongan Hills area (some 350 km to the north west) although one isolated collection was made 33 miles east of Southern Cross (KRN 2544) in 1966. *Bentleya* is a very unusual tufted perennial herb (Pittosporaceae) which has small clusters of prostrate leaves connected by thick underground rhizomes. It has previously been recorded from the Cape Arid – Ravensthorpe area.

The study area was also rich in *Hibbertia* spp. with at least eight taxa being recorded. The taxonomy of this group requires revision before the conservation status and distribution of these taxa can be determined.

VEGETATION

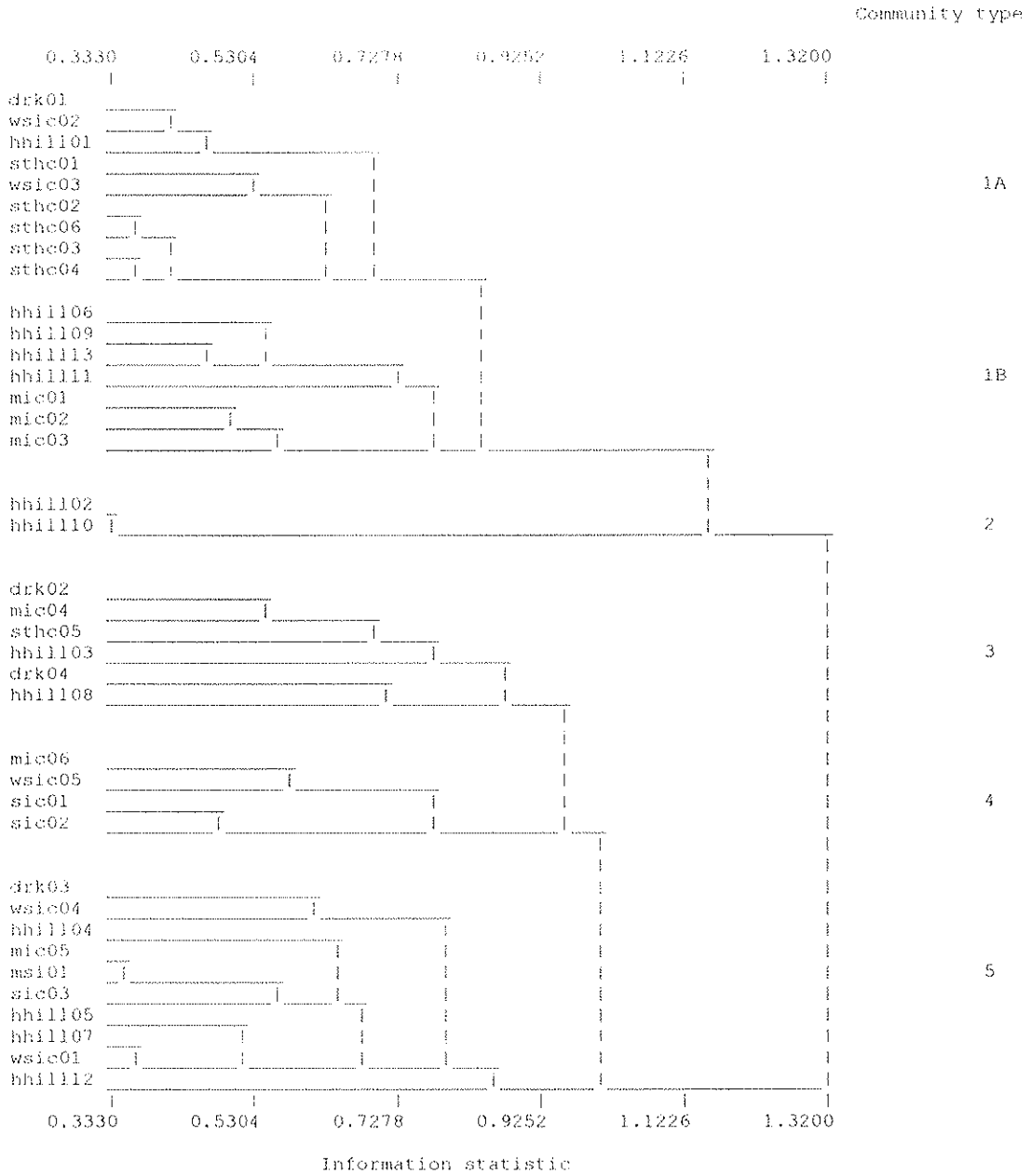
Only material that could be identified down to species level was included in the analysis (c. 99% of records). In the 38 quadrats established on the Forrestiana greenstone belt south of Middle Ironcap 226 taxa were recorded of which 179 were perennial (Appendix 2 & 3). Fifty one perennials occurred at only one site. Preliminary analyses showed these singletons had little effect on the community classification and therefore were excluded. As a result the final data set consisted of 128 perennial taxa in 38 sites. Species richness ranged from five to 34 taxa per site, with individual taxa occurring in between two and 17 of the 53 sites.

Multivariate analysis can assist in sorting both sites and species data such that patterns in species composition are more easily seen. The decision as to the number of site and species groups defined is subjective and related to the scale of pattern of interest (Kent and Coker 1992). In this analysis site groups are discussed at the five group level which best reflects the scale of patterning seen in the field.

The first major division in the dendrogram separates the sites on soils derived from banded ironstone and the massive laterites (community types 1 and 2) from sites on greenstone or decomposing laterites (community types 3, 4 and 5) (Figure 5, Table 2). Community type 1 are the species rich shrublands and thickets with scattered eucalypt emergents. Species in species group C characterise community type 1 with species in species groups B and D differentiating a species rich subgroup (type 1a). Average species richness of type 1a was 26.3 taxa / plot while type 1b had an average richness of 19.0 taxa / plot. In addition to entirely lacking species in species group B and having low frequency of species in species group D, more than half the typical species in species group B were absent or at very low frequency in community type 1b. Community type 1a was most common on South Ironcap while community type 1b was restricted to Hatter Hill and Middle Ironcap. Considerable structural diversity was encompassed in community type 1a on South Ironcap, where it was recorded on the ridge top to the lower slopes.

Community type 2 are species poor (mean richness 8 taxa / plot) dense *Allocasuarina* - *Melaleuca* thickets (to 3 m tall) on ridges and side slopes in the Hatter Hill area. This community type may represent a seral stage following fire. Much self thinning was evident within the thickets.

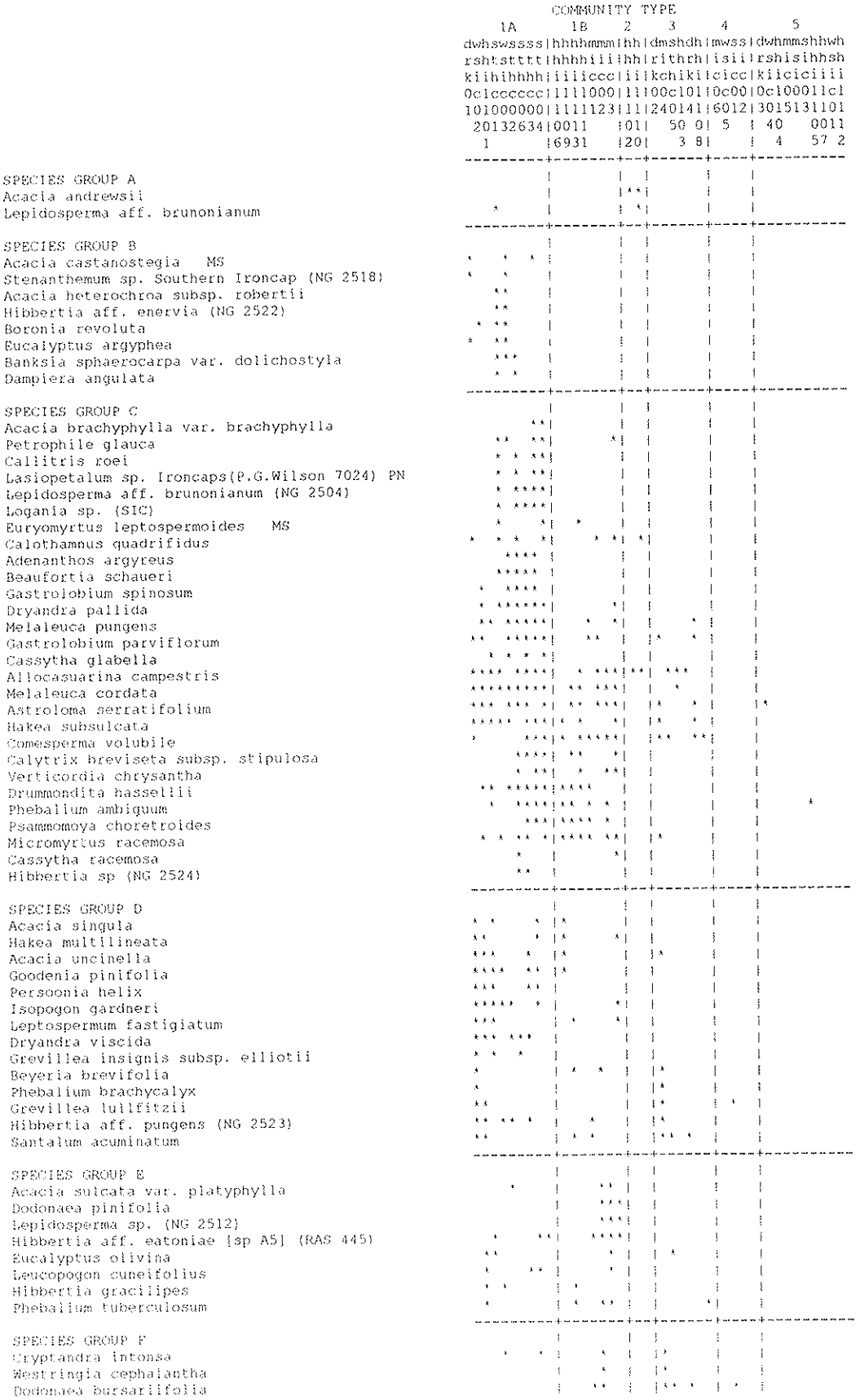
Figure 5. Dendrogram of the sites from the Forrestania greenstone belt south of Middle Ironcap showing the five group level classification.

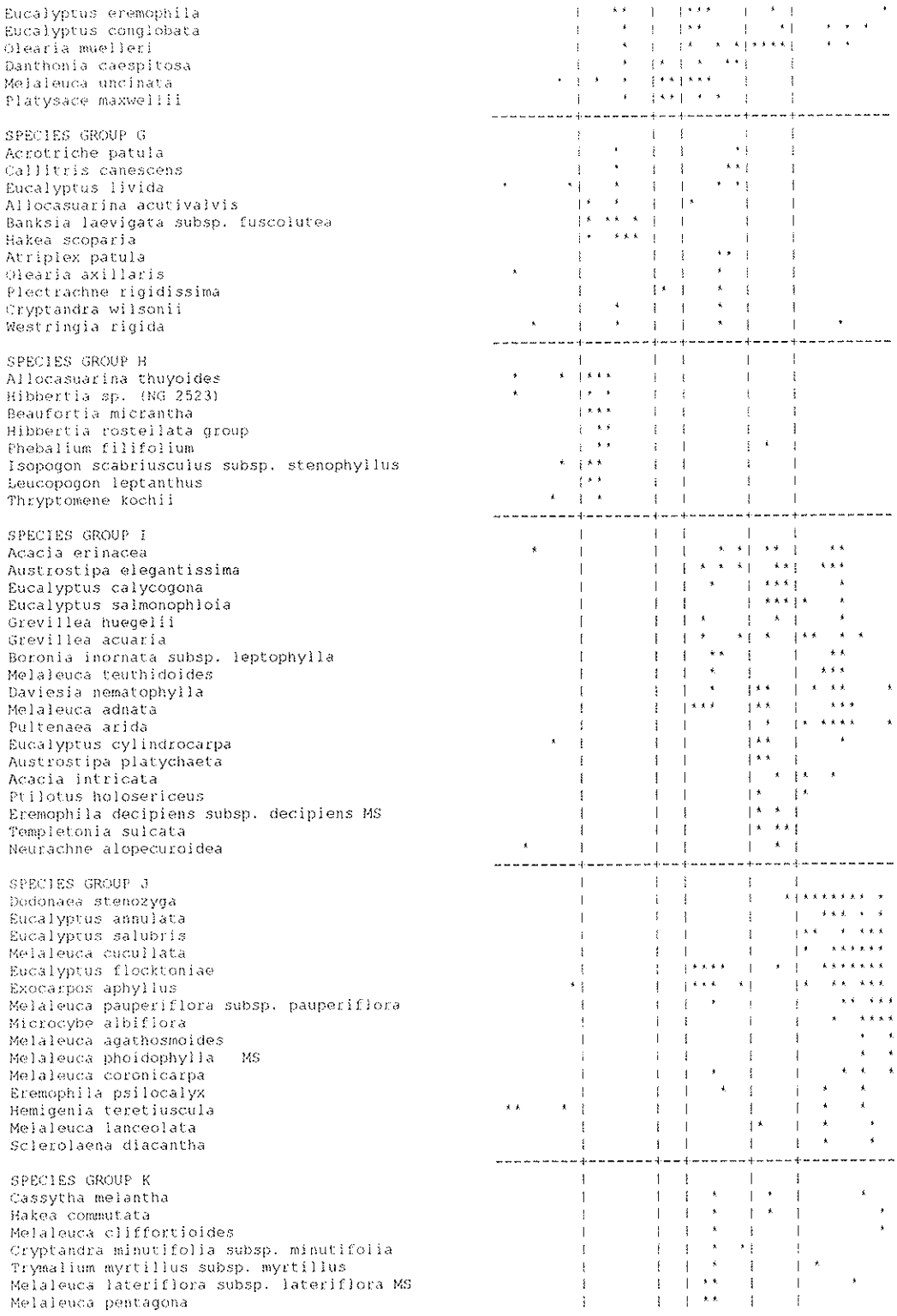


Community types 3, 4 and 5 represent eucalypt woodlands on more fertile soils but did include several sites on weathering laterites. Community type 3 was generally dominated or co dominated by *Eucalyptus flocktoniae* occurring on shallower greenstones soils across the study area. Other eucalypts recorded in community type 3 included *Eucalyptus eremophila, E. conglobata, E. livida* and *Eucalyptus densa* subsp. *densa.* Species in species group F were most faithful to this community type. Average species richness was 16.0 taxa / plot.

Community type 4 was a mallee community dominated by *Eucalyptus calycogona* (or rarely *E. cylindrocarpa*) on small colluvial flats. Occasional large emergent *Eucalyptus salmonophloia* were a feature of this community type. Species richness was low with an average 10.8 taxa / plot.

Table 2. Sorted two way table of the Forrestiana greenstone belt south of Middle Ironcap showing species occurrence by community type. Site codes appears as columns, species code as rows.





Species in species group I were typical of community type 4 and 5 while species in species group J were also common in community type 5 they were almost completely lacking in community type 4. This community type was recorded from areas near Middle and South Ironcap.

Eucalyptus flocktoniae, *E. salubris*, and *E. annulata* were the common dominants or co-dominants in community type 5, the latter two species not occurring in the other *E. flocktoniae*

community (type 3). The understorey was generally dominated by *Melaleuca* spp. (generally *Melaleuca cucullata* and / or *Melaleuca pauperiflora* subsp. *pauperiflora*, but also occasionally with *M. agathosmoides, M. phoidophylla* and *M. coronicarpa*). Species in species group J are largely restricted to this community type except for *E. flocktoniae* and *Exocarpos aphyllus* which are shared with community type 3. This community occurred on the deeper clay soils across the study area. Average species richness was low at 11.3 taxa / plot.

Physical Correlates

Topography was not a major controlling feature of the vegetation. The communities of the ironstone hills were widespread and uniform (at least in species composition) from the ridges to lower valley slopes. The undulating greenstone plain had little obvious relief and soil type and soil depth changed in a complex mosaic not related to major changes in topography (Table 3). The exceptions to this were the *Eucalyptus calycogona* mallee (type 4) that was restricted to small valleys and the species poor thickets of Middle Ironcap and Hatter Hill (type 1b) which tended to occur high in the landscape. Similarly neither slope or aspect was strongly correlated with community type.

Table 3. Topographic position by community type.

Community type	Ridge top	Upper slope	Mid slope	Lower slope	Valley	Small rise in valley
1a	2	2		5		
1b	3	1	2			1
2	1			1		
3	2	1	1	2		
4					4	
5	6	1		2	1	

Soil type and underlying geology were the major correlates with vegetation patterning. Community type 1 was entirely restricted to banded ironstone and massive laterites, while the other community types generally occurred on greenstone derived soils or weathered laterites (Table 4). The banded ironstones and massive laterites generally give rise to a yellow sandy loam almost all of community type 1 occurs on this soil type. Community types 3 and 4 are largely found on orange or brown loams while community types 2 and 5 generally occur on red clays, in the case of community type 2 these are very shallow over massive bedrock. Litter also tends to be more prevalent in community types 2 and 5, in contrast to *E. flocktoniae* woodlands of community type 3 which tended to have very low litter cover (Table 5).

Table 4. Soil class by community type

Community type	Red clay loams	Orange to brown sandy loams	Yellow sandy loam
1a			9
1b		2	5
2	2		
3		5	1
4		3	1
5	6	3	1

Table 5 Litter cover by community type.

Community type	< 30%	30% – 70%	> 70%
1a	5	4	
1b	1	5	1
2			2
3	4	2	
4	2		2
5		5	5

Ordination Results

Ordination of the site data was undertaken to show spatial relationships between groups and to better elucidate possible environmental correlates with the classification. The results of a three dimensional ordination (stress level 0.17) support the interpretation that a soil nutrient gradient is controlling the vegetation patterning. The first and second axes separate community type 2 from the rest while axes one and three reflect substrate and soil differences (Figure 6).

Community types 4 and 5 occur in the lower left quadrant of the ordination. These community types occur on richest soil with *Eucalyptus salmonophloia* and *E. salubris* being major components. (These two communities separate on a gradient running at ninety degrees). The sites on sandy yellow soils derived from banded ironstone or laterite occur in the upper right quadrant. The *E. flocktoniae* woodlands (type 3) and the *Allocasuarina – Melaleuca* thicket community (type 2) occupy an intermediate position (Figure 6).

DISCUSSION

The flora of 234 taxa was recorded from the southern Forrestania greenstone belt (Table 6). This flora included 2 Declared Rare taxa, 16 priority taxa and one species collected for the first time. The finding of a new *Stenanthemum* and significant new populations of two Declared Rare taxa was somewhat surprising given the biological survey undertaken prior to the commissioning of two active mines in the study area. Of the 18 taxa on the priority flora list and the one new species, eight are restricted to banded ironstone or soils developed on massive laterite of the Forrestania belt. These taxa all have a similar distribution in an area subject to intensive mining activity. Presently these taxa are listed as either DRF, P1 or P3 although all taxa face a similar level of threat. The six non DRF taxa should be considered for declaration as DRF but will require further survey to determine precise population numbers and boundaries. None of these species have been recorded from other banded ironstone ranges (Newbey & Hnatiuk 1988, Gibson & Lyons 1995, Gibson *et al.* 1997).

The southern Forrestania belt had a similar sized flora to that recorded for the Bremer and Parker Ranges, although annuals and geophytes were underestimated on those ranges due to a poor season (Gibson & Lyons 1995). The flora of the belt was typically south western in composition with low representation of genera common in the more arid Southwest Interzone (eg *Eremophila*). Occurrence of priority species was much higher than the nearby Bremer and Parker Ranges, perhaps reflecting the unusual combination of geology and climate (Table 7).

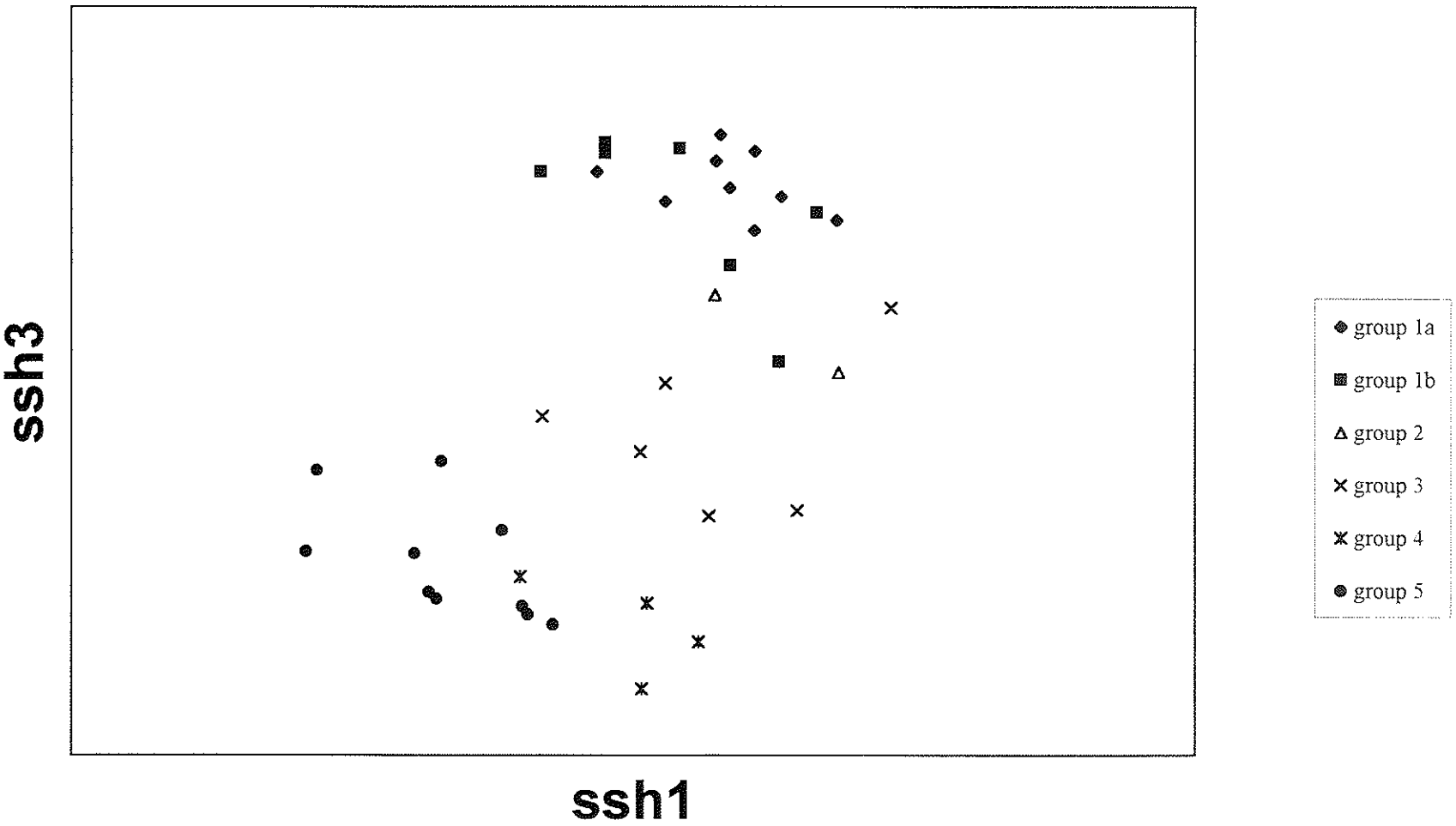


Figure 6 Ordination of 38 sites

Table 6. Taxa endemic to the Forrestania greenstone belt needing urgent further survey.

Taxon	Current priority listing
Banksia sphaerocarpa var. dolichostyla	R
Boronia revoluta	R
Cryptandra intonsa	1
Dryandra viscida	3
Grevillea insignis subsp. elliotii	3
Grevillea lullfitzii	1
Lasiopetalum sp. Ironcaps (PG Wilson 7024)	1
Stenanthemum sp. South Ironcap (NG 2518)	Not listed

Newbey and Hnatiuk (1988) noted that the flora and vegetation of the three Ironcaps (North, Middle and South varied significantly in terms of species composition. Analysis of plot data supports this observation. Of the two communities occurring on banded ironstone or laterites, type 1a is largely restricted to South Ironcap, while community type 1b was only found on Middle Ironcap and Hatters Hill (Table 4). Indeed within type 1b it is possible to separate Hatter Hill quadrats based on species group H.

Table 7. Comparison of the floras of the Forrestania greenstone belt between Middle Ironcap and Hatter Hill with the Bremer Range and the Parker Range.

	Southern Forrestania greenstone belt	Bremer Range	Parker Range
Total taxa	234	269	256
Declared Rare Flora	2	1	-
Priority taxa	16	6	8
Recommended listing	1	2	3
Eucalyptus spp.	23	30	29
Melaleuca spp.	17	19	14
Acacia spp.	16	17	20
Eremophila spp.	2	11	7

While community type 1a was recorded from the ridge crest of South Ironcap to the lower slopes, community structure and dominance changed dramatically and patterns of occurrence of annuals and geophytes could be expected to be quite different between these quadrats.

Elsewhere in the goldfields ranges lateritic breakaways are dominated by a species poor community dominated by *Eucalyptus livida* or *E. capillosa*. This landform was rare in the southern Forrestania belt (Newbey & Hnatiuk 1988) and where it did occur understorey species richness was high but variable and consequently these sites did not form a distinct community type. This difference again probably reflects the higher rainfall of the area compared with the more inland ranges.

Mining and exploration has been and continues to be extremely active in the study area and rehabilitation has generally been poor. There is an urgent need for the adoption of high standard environmental management of both exploration and mining operations.
Almost none of the Forrestania greenstone belt is currently in the conservation reserve system. Work outlined here and previously reported by Beard (1972) and Newbey and Hnatiuk (1988) indicate a number of plant communities and at least eight species are restricted to this area. The small Lake Cronin Nature Reserve (1016 ha) which lies between Middle Ironcap and Mt Holland is the only reserve covering the Forrestania vegetation system. None of the banded ironstone or associated lateritic areas are currently reserved. The work reported here strongly supports Henry – Hall's (1990) conclusion that there is an urgent need for a series of nature reserves along the Forrestania belt and supports the reserve recommendations he outlines.

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APPENDIX 1

Flora list for greenstone belt between Middle Ironcap and Hatter Hill.

This list includes all taxa from both the sampling quadrats and the opportunistic collections. Nomenclature follows Green (1975) and current usage at PERTH (ms denotes a manuscript name, * indicates a weed).

Family: Amaranthaceae
- Ptilotus holosericeus

Family: Anthericaceae
- Thysanotus patersonii

Family: Apiaceae
- Daucus glochidiatus
- Hydrocotyle rugulosa
- Platysace maxwellii
- Trachymene ornata

Family: Apocynaceae
- Alyxia buxifolia

Family: Asteraceae
- Asteridea athrixioides
- Blennospora drummondii
- Brachyscome perpusilla
- Hyalosperma demissum
- * Hypochaeris glabra
- Isoetopsis graminifolia
- Millotia tenuifolia
- Olearia axillaris
- Olearia muelleri
- Podolepis lessonii
- Podolepis tepperi
- Rhodanthe laevis
- Senecio glossanthus
- Senecio hispidulus

Family: Boraginaceae
- Halgania andromedifolia
- Halgania lavandulacea

Family: Caesalpiniaceae
- Labichea lanceolata

Family: Casuarinaceae
- Allocasuarina acutivalvis
- Allocasuarina campestris
- Allocasuarina thuyoides

Family: Celastraceae
- Psammomoya choretroides

Family: Centrolepidaceae
- Centrolepis cephaloformis subsp. cephaloformis

Family: Chenopodiaceae
- Atriplex patula
- Sclerolaena diacantha

Family: Chloanthaceae
- Cyanostegia lanceolata

Family: Crassulaceae
- Crassula colorata

Family: Cupressaceae
- Callitris canescens
- Callitris preissii subsp. verrucosa
- Callitris roei

Family: Cyperaceae
- Lepidosperma aff. brunonianum (NG 2504)
- Lepidosperma aff. brunonianum (NG 2062)
- Lepidosperma sp. (NG 2512)
- Schoenus nanus

Family: Dilleniaceae
- Hibbertia aff. eatoniae [sp A5] (RAS 445)
- Hibbertia aff. enervia (NG 2522)
- Hibbertia aff. pungens (NG 2523)
- Hibbertia gracilipes
- Hibbertia pungens
- Hibbertia rostellata complex
- Hibbertia sp. (NG 2524)
- Hibbertia sp. (NG 2523)

Family: Droseraceae
- Drosera browniana
- Drosera glanduligera
- Drosera lowriei
- Drosera macrantha

Family: Epacridaceae
- Acrotriche patula
- Astroloma serratifolium
- Leucopogon aff. hamulosus
- Leucopogon cuneifolius
- Leucopogon dielsianus

Leucopogon fimbriatus
Leucopogon leptanthus
Lysinema ciliatum
Styphelia pulchella

Family: Euphorbiaceae
Beyeria brevifolia

Family: Geraniaceae
Pelargonium havlasae

Family: Goodeniaceae
Dampiera angulata
Goodenia pinifolia
Scaevola spinescens

Family: Haemodoraceae
Conostylis argentea

Family: Juncaginaceae
Triglochin calcitrapum

Family: Lamiaceae
Hemigenia teretiuscula
Microcorys obovata
Westringia cephalantha
Westringia rigida

Family: Lauraceae
Cassytha aurea
Cassytha glabella
Cassytha melantha
Cassytha racemosa

Family: Loganiaceae
Logania perryana
Logania sp.

Family: Mimosaceae
Acacia andrewsii
Acacia binata
Acacia brachyphylla var. brachyphylla
Acacia castanostegia ms
Acacia deficiens ms
Acacia erinacea
Acacia evenulosa ms
Acacia hemiteles
Acacia heterochroa subsp. robertii
Acacia merrallii x poliochroa hybrid
Acacia intricata
Acacia merrallii
Acacia poliochroa
Acacia singula
Acacia sulcata var. platyphylla
Acacia uncinella

Family: Myoporaceae
Eremophila decipiens subsp. decipiens ms
Eremophila psilocalyx

Family: Myrtaceae
Astartea ambigua
Beaufortia micrantha
Beaufortia schaueri
Calothamnus quadrifidus
Calytrix breviseta subsp. stipulosa
Chamelaucium ciliatum
Eucalyptus aff oleosa (NG 2514)
Eucalyptus aff. calycogona
Eucalyptus annulata
Eucalyptus argyphea
Eucalyptus calycogona
Eucalyptus conglobata
Eucalyptus cylindriflora
Eucalyptus cylindrocarpa
Eucalyptus densa subsp. densa
Eucalyptus eremophila
Eucalyptus flocktoniae
Eucalyptus gratiae
Eucalyptus grossa
Eucalyptus livida
Eucalyptus longicornis
Eucalyptus loxophleba subsp. lissophloia
Eucalyptus olivina
Eucalyptus phaenophylla subsp. interjacens
Eucalyptus pileata
Eucalyptus salmonophloia
Eucalyptus salubris
Eucalyptus transcontinentalis
Eucalyptus yilgarnensis
Euryomyrtus leptospermoides ms
Leptospermum fastigiatum
Melaleuca acuminata subsp. acuminata ms
Melaleuca adnata
Melaleuca agathosmoides
Melaleuca cardiophylla
Melaleuca cliffortioides
Melaleuca cordata
Melaleuca coronicarpa
Melaleuca cucullata
Melaleuca lanceolata
Melaleuca lateriflora subsp. lateriflora ms
Melaleuca pauperiflora subsp. pauperiflora
Melaleuca pentagona
Melaleuca phoidophylla ms
Melaleuca pungens
Melaleuca sp. (NG 2516)
Melaleuca teuthidoides
Melaleuca uncinata
Micromyrtus racemosa
Thryptomene kochii
Verticordia chrysantha

Family: Orchidaceae
Caladenia flaccida ms

Caladenia microchila ms
Caladenia saccharata
Caladenia sigmoidea
Diuris laxiflora
Eriochilus dilatatus
Microtis media subsp. media
Pterostylis aff nana (Fawn Snail Orchid)
Pterostylis aff. aspera (Dwarf Shell Orchid)
Pterostylis aff. barbata (Dwarf Bird Orchid)
Pterostylis mutica
Pterostylis picta
Pterostylis recurva
Pterostylis sanguinea
Thelymitra aff. macrophyllum

Family: Papilionaceae
Daviesia benthamii subsp. acanthoclona
Daviesia euryloba ms
Daviesia nematophylla
Gastrolobium parviflorum
Gastrolobium spinosum
Pultenaea arida
Templetonia sulcata

Family: Pittosporaceae
Bentleya diminuta
Billardiera coriacea

Family: Plantaginaceae
Plantago aff. hispidula (NG & ML 1732)

Family: Poaceae
Austrostipa elegantissima
Austrostipa platychaeta
Danthonia caespitosa
Neurachne alopecuroidea
Plectrachne rigidissima

Family: Polygalaceae
Comesperma volubile

Family: Portulacaceae
Calandrinia corrigioloides

Family: Primulaceae
* Anagallis arvensis

Family: Proteaceae
Adenanthos argyreus
Banksia elegans
Banksia laevigata subsp. fuscolutea
Banksia sphaerocarpa var. dolichostyla
Dryandra pallida
Dryandra viscida
Grevillea acuaria
Grevillea cagiana
Grevillea huegelii
Grevillea insignis subsp. elliotii
Grevillea lullfitzii
Grevillea nematophylla
Grevillea paniculata
Hakea commutata
Hakea erecta
Hakea multilineata
Hakea scoparia
Hakea subsulcata
Isopogon gardneri
Isopogon scabriusculus subsp. stenophyllus
Persoonia helix
Petrophile circinata
Petrophile glauca
Petrophile stricta
Synaphea interioris

Family: Rhamnaceae
Cryptandra intonsa
Cryptandra minutifolia subsp. minutifolia
Cryptandra myriantha
Cryptandra wilsonii
Stenanthemum sp. Southern Ironcap (NG 2518)
Trymalium myrtillus subsp. myrtillus

Family: Rubiaceae
Opercularia hispidula

Family: Rutaceae
Boronia inornata subsp. leptophylla
Boronia revoluta
Drummondita hassellii
Microcybe albiflora
Phebalium ambiguum
Phebalium brachycalyx
Phebalium filifolium
Phebalium tuberculosum x canaliculatum intergrade
Phebalium tuberculosum

Family: Santalaceae
Exocarpos aphyllus
Santalum acuminatum

Family: Sapindaceae
Dodonaea bursariifolia
Dodonaea ceratocarpa
Dodonaea pinifolia
Dodonaea ptarmicaefolia
Dodonaea stenozyga
Dodonaea viscosa subsp. angustissima

Family: Stackhousiaceae
Stackhousia monogyna

Family: Sterculiaceae
Lasiopetalum sp. Ironcaps (P.G. Wilson 7024) pn

Family: Stylidiaceae
Stylidium breviscapum
Stylidium sejunctus ms

Family: Zygophyllaceae
Zygophyllum ovatum

APPENDIX 2

Floristic data for sites from Middle Ironcap to Hatter Hill.

The full data set (226 taxa x 38 quadrats) is provided in Cornell University Condensed Format. The species codes are derived from the first three letters of the genus and species names with a further two letters from intraspecific rank where applicable except where otherwise listed below.

Non standard species codes.

Eucalyptus salmonophloia	EUCSALm
Eucalyptus salubris	EUCSALu
Lepidosperma aff. brunonianum (NG 2504)	LEP2504
Lepidosperma aff. brunonianum (NG 2512)	LEP2512
Melaleuca cordata	MELCORd
Melaleuca coronicarpa	MELCORo

```
Forrestania greenstone middle ironcap to hatter hill 7-8-97
(13I6)                                                      5
     1     4    14    16    20    26    34    46    48    56    77    79    82
    88   107   109   113   114   118   120   125   134   141   156   177   182
   202   209   219
     2    16    19    26    34    43    48    56    59    70    79    90    93
    94   106   107   114   120   125   152   166   171   175   182   194   202
   217   219   224
     3    10    12    26    48    65    74   100   101   106   110   132   133
   158   172   198   199   200   214
     4    26    27    41    48    56    64    71    78    79    85    92   107
   120   131   132   164   170   172   186   189   198   204   217   219   221
     5    14    16    20    21    26    48    51    76    79    80    82    99
   109   113   120   122   123   126   134   141   156   164   174   177   181
   204   212
     6     1    20    48    64    69    76    79    95   166   187   188   197
   208
     7     6    20    27    33    37    43    48    62    69    70    73    84
    94    96    98   149   174   175   187   188   194   202   203   210   225
     8    25    74    84    87    94   122   133   159   165   169   194   200
   205   206   210   226
     9    52    74    84    87    94   101   106   110   122   153   157   158
   163   168   194   198
    10    14    16    19    21    29    31    48    56    79    80   109   118
   119   120   126   136   147   154   171   181   191   195   212   217
    11    90    94   101   106   158   159   161   168   195   205
    12     6    17    22    36    39    41    44    48    49    56    60    64
    69    75    85    96   106   110   131   132   135   172   175   184   186
   190   201   210   217   219   220
    13    21    26    31    34    40    67    80   111   117   121   127   129
   136   141   145   147   156   166   167   171   181   183   184   191   202
   212   215   218
    14     1    20    43    44    46    48    69    79    85   139   166   176
   187   204   208   213   214   217   219
    15    17    19    29    41    48    56    62    70    80    93    96   107
   119   123   125   164   171   181   185   191   202   212   225
    16     5    44    48    50    68    93   153   157   161   163   168   169
   195   200   217
    17    20    21    26    28    29    31    40    48    56    57    61    79
    80   105   115   120   126   129   156   171   183   191   196   212   214
   219   223
    18    15    20    26    34    35    43    46    48    56    59    64    70
    72    77    79    90    93   107   119   123   128   132   142   146   156
   166   175   184   187   192   194   198   214   217   224
    19    15    20    26    29    48    56    72    79    99   119   123   142
   144   156   171   181   184   191   193   196   212   214   217   223
    20    20    26    40    43    45    46    48    53    56    72    79    81
   118   120   123   134   141   142   156   164   169   171   179   212   214
   217   223
    21    20    24    43    48    54    56    64    66    70    77    79    90
    93    94    99   106   110   112   152   160   162   166   187   195   202
   204   210   217
    22     6    10    13    37    68    74    87    90    94   106   152   158
```

165	168	169	175	194	200	210						
23	8	11	23	42	44	48	58	68	83	91	97	103
152	159	175	199	206	207	211	216					
24	6	37	44	49	68	74	86	87	89	91	94	100
101	102	106	110	112	152	157	158	161	165	169	194	200
210	225											
25	6	10	48	83	89	93	94	100	112	173	175	210
216	217											
26	74	89	90	100	175	196	198	210	216			
27	74	90	94	152	158	160	161	169	175	181	200	
28	9	20	30	32	38	46	47	48	59	63	79	81
88	105	109	120	124	126	127	134	137	138	139	140	148
156	171	173	179	195	196	197	198	217				
29	18	20	26	30	32	40	46	47	48	53	63	79
80	81	82	104	107	108	113	130	138	140	143	148	156
164	171	181	212	223								
30	3	4	14	18	20	21	32	40	47	48	56	59
77	79	80	81	107	108	109	118	120	122	123	134	136
138	140	144	148	156	164	166	177	178	179	181	191	212
223												
31	3	20	26	40	46	47	48	51	56	79	80	81
96	105	106	107	120	123	138	140	148	150	156	164	171
179	181	191	223									
32	7	20	37	48	52	60	68	89	93	94	106	116
151	152	155	156	157	160	161	162	165	166	195	196	198
217	222											
33	16	18	20	26	32	40	48	51	56	77	79	80
81	82	91	107	108	109	120	125	130	140	144	148	156
164	171	177	180	181	191	212	218					
34	74	87	94	101	106	116	155	158	161	168	198	
35	16	20	26	38	48	79	80	81	82	96	99	107
108	109	114	118	120	122	125	127	134	141	144	156	164
171	177	184	196	202	212							
36	4	6	9	15	18	26	30	32	38	48	51	55
79	80	81	82	88	107	108	120	124	125	134	156	164
179	196	198	209	225								
37	2	68	74	101	110	198	219	222				
38	6	44	48	52	65	68	70	89	91	100	110	114
116	152	172	175	183	200	211	219					
0												

ACAAND	ACABIN	ACABRA	BRACACAS	ACADEF	ACAERI	ACAEVE	ACAHEM	ACAHETRO	ACAINT
ACAMER	ACAMXP	ACAPOL	ACASIN	ACASULPL	ACAUNC	ACRPAT	ADEARG	ALLACU	ALLCAM
ALLTHU	ALYBUX	ANAARV	ASTAMB	ASTATH	ASTSER	ATRPAT	BANELE	BANLAEFU	BANSPHDO
BEAMIC	BEASCH	BENDIM	BEYBRE	BILCOR	BLEDRU	BORINOLE	BORREV	BRAPER	CALBREST
CALCAN	CALCOR	CALFLA	CALMIC	CALPREVE	CALQUA	CALROE	CALSAC	CALSIG	CASAUR
CASGLA	CASMEL	CASRAC	CENCEPCE	CHACIL	COMVOL	CONARG	CRACOL	CRYINT	CRYMINMI
CRYMYR	CRYWIL	DAMANG	DANCAE	DAUGLO	DAVBENAC	DAVEUR	DAVNEM	DIULAX	DODBUR
DODCER	DODPIN	DODPTA	DODSTE	DODVISAN	DROBRO	DROGLA	DROLOW	DROMAC	DRUHAS
DRYPAL	DRYVIS	EREDECDE	EREPSI	ERIDIL	EUCAFFC	AEUCANN	EUCARG	EUCCAL	EUCCON
EUCCYL	EUCDENDE	EUCERE	EUCFLO	EUCGRA	EUCLIV	EUCLON	EUCLOXLI	EUCOLI	EUCSALm
EUCSALa	EUCTRA	EUCYIL	EUC_OL	EURLEP	EXOAPH	GASPAR	GASSPI	GOOPIN	GREACU
GRECAG	GREHUE	GREINSEL	GREUL	GRENEM	HAKCOM	HAKERE	HAKMUL	HAKSCO	HAKSUB
HALLAV	HEMTER	HIBAFFEA	HIBAFFEN	HIBAFFPU	HIBB_HH	HIBGRA	HIBPUN	HIBROS	HIB_HB
HYADEM	HYDRUG	HYPGLA	ISOGAR	ISOGRA	ISOSCAS	TLABLAN	LASSP.	LEP2062	LEP2504
LEPFAS	LEP_HH	LEUAFFH	ALEUCUN	LEUDIE	LEUFIM	LEULEP	LOGEXI	LOGPER	LYSCIL
MELACUAC	MELADN	MELAGA	MELCAR	MELCLI	MELCORd	MELCORo	MELCUC	MELLAN	MELLATLA
MELPAUPA	MELPEN	MELPHO	MELPUN	MELTEU	MELUNC	MEL_HH	MICALB	MICMEDME	MICOBO
MICRAC	MILTEN	NEUALO	OLEAXI	OLEMUE	OPEHIS	PERHEL	PETCIR	PETGLA	PETSTR
PHEAMB	PHEBRA	PHEFIL	PHETUB	PHETXC	PLAAFFHI	PLAMAX	PLERIG	PODLES	PODTEP
PSACHO	PTEAFFAS	PTEAFFB	APTEMUT	PTENANFS	PTEPIC	PTEREC	PTESAN	PTIHOL	PULARI
RHOLAE	SANACU	SCASPI	SCHNAN	SCLDIA	SENGLO	SENHIS	STAMON	STESIC	AUSELE
AUSPLA	STYBRE	STYPUL	STYSEJ	SYNINT	TEMSUL	THEAFFMA	THRKOC	THYPAT	TRAORN
TRICAL	TRYMYRM	YVERCHR	WESCEP	WESRIG	ZYGOVA				
drk01	drk02	drk03	drk04	hhill01	hhill02	hhill03	hhill04	hhill05	hhill06
hhill07	hhill08	hhill09	hhill10	hhill11	hhill12	hhill13	mic01	mic02	mic03
mic04	mic05	mic06	msi01	sic01	sic02	sic03	sthc01	sthc02	sthc03
sthc04	sthc05	sthc06	wsic01	wsic02	wsic03	wsic04	wsic05		

APPENDIX 3

Geographical location for the sites from Middle Ironcap to Hatter Hill.

Plot	Latitude	Longitude
DRK01	32.7310	119.8068
DRK02	32.7361	119.8100
DRK03	32.7383	119.8107
DRK04	32.7333	119.8151
HHILL01	32.8248	119.9809
HHILL02	32.8267	119.9839
HHILL03	32.8278	119.9855
HHILL04	32.8247	119.9737
HHILL05	32.8271	119.9699
HHILL06	32.8294	119.9668
HHILL07	32.8327	119.9935
HHILL08	32.8325	119.9842
HHILL09	32.8586	119.9938
HHILL10	32.8265	119.9771
HHILL11	32.8229	119.9785
HHILL12	32.8231	119.9778
HHILL13	32.8179	119.9702
MIC01	32.5753	119.7373
MIC02	32.5758	119.7370
MIC03	32.5749	119.7349
MIC04	32.5746	119.7321
MIC05	32.6104	119.7316
MIC06	32.5720	119.7532
MSI01	32.6396	119.7468
SIC01	32.7656	119.8360
SIC02	32.7654	119.8376
SIC03	32.7568	119.8381
STHC01	32.7460	119.7746
STHC02	32.6802	119.7759
STHC03	32.6794	119.7790
STHC04	32.6788	119.7470
STHC05	32.6780	119.7826
STHC06	32.6781	119.7830
WSIC01	32.6884	119.7756
WSIC02	32.6892	119.7720
WSIC03	32.6873	119.7711
WSIC04	32.6883	119.7787
WSIC05	32.6956	119.7828