Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney

David Keith

Keith, David, (NSW National Parks and Wildlife Service, PO Box 1967, Hurstville NSW Australia 2220) 1994. Floristics, structure and diversity of natural vegetation in the O'Hares Creek catchment, south of Sydney. Cunninghamia *3(3): 543–594.* Fifteen plant communities were described and mapped at 1:25 000 scale in O'Hares Creek catchment. Cluster analysis and ordination were used to elucidate relationships between the vegetation and environmental variables. Three forest communities and one scrub community occurred on relatively fertile, well-drained soils; three woodland and three heath communities occurred on less fertile, well-drained to damp soils; and five swamp communities occurred on periodically waterlogged soils of varying fertility. Floristic composition and vegetation structure were related to a complex of factors reflecting soil fertility and moisture status, as well as a regional rainfall gradient related to elevation and distance from the coast.

Of 510 vascular plant taxa recorded, 17 are listed as rare or threatened nationally and a further 24 are of regional conservation significance. The exotic flora is small (34 taxa recorded) and locally restricted to disturbed sites. While most of the plant communities have analogues in other parts of the Sydney sandstone area, their floristic composition is particular to the Nepean ramp, an area not well sampled by existing conservation reserves. The O'Hares Creek area and other water catchment areas, which cover much of the Nepean ramp, are therefore an important augmentation to the formal reserve system.

Introduction

Emerging from pastoral country around Appin on 21 October 1818, Allan Cunningham, then King's Botanist, remarked, 'we arrived at once upon an entire change of country, of a rugged sandstony character, alternated by extensive tracts of spongy bogs' (Lee 1925). Cunningham's sketch aptly captures a landscape that subsequently attracted numerous botanists to the area. Among them were Joseph Henry Maiden, a former Director of the Royal Botanic Gardens in the early 1900s, and Consett Davis, one of Australia's early students in classical plant ecology. Their publications, notes and collections contributed to early knowledge of the flora.

In recent years, the O'Hares Creek catchment is increasingly the focus of competing land-uses including nature conservation, mining, military activities, water supply and recreation. Conflicts between these land-uses are unlikely to be resolved rationally without a more thorough inventory of the biota than that provided by early work. This information, together with an evaluation of the regional significance of the biota, is required as a basis for ongoing management and conservation planning in the expanding southern Sydney–Wollongong–Campbelltown region.

This paper aims to describe the floristics, structure, diversity and habitat of plant communities, map their distribution, identify major environmental factors influencing vegetation patterns and evaluate the regional conservation significance of vegetation in the O'Hares Creek catchment.

Study area

The O'Hares Creek catchment, an area of 9 000 ha, is centred on latitude 34° 14' S and longitude 150° 52' E, 45 km south-west of Sydney centre (Figure 1). The area comprises part of the Nepean Ramp, which is in turn, part of the Sydney Basin. The 'ramp' is a dissected plateau dipping gently north-west away from the Illawarra escarpment toward the Cumberland Plain. The major watercourses, O'Hares and Stokes Creeks, both flow from elevated, low-relief terrain in the south-east to more dissected terrain in the north-west. Elevation varies from 100 to 450 m above sea level.

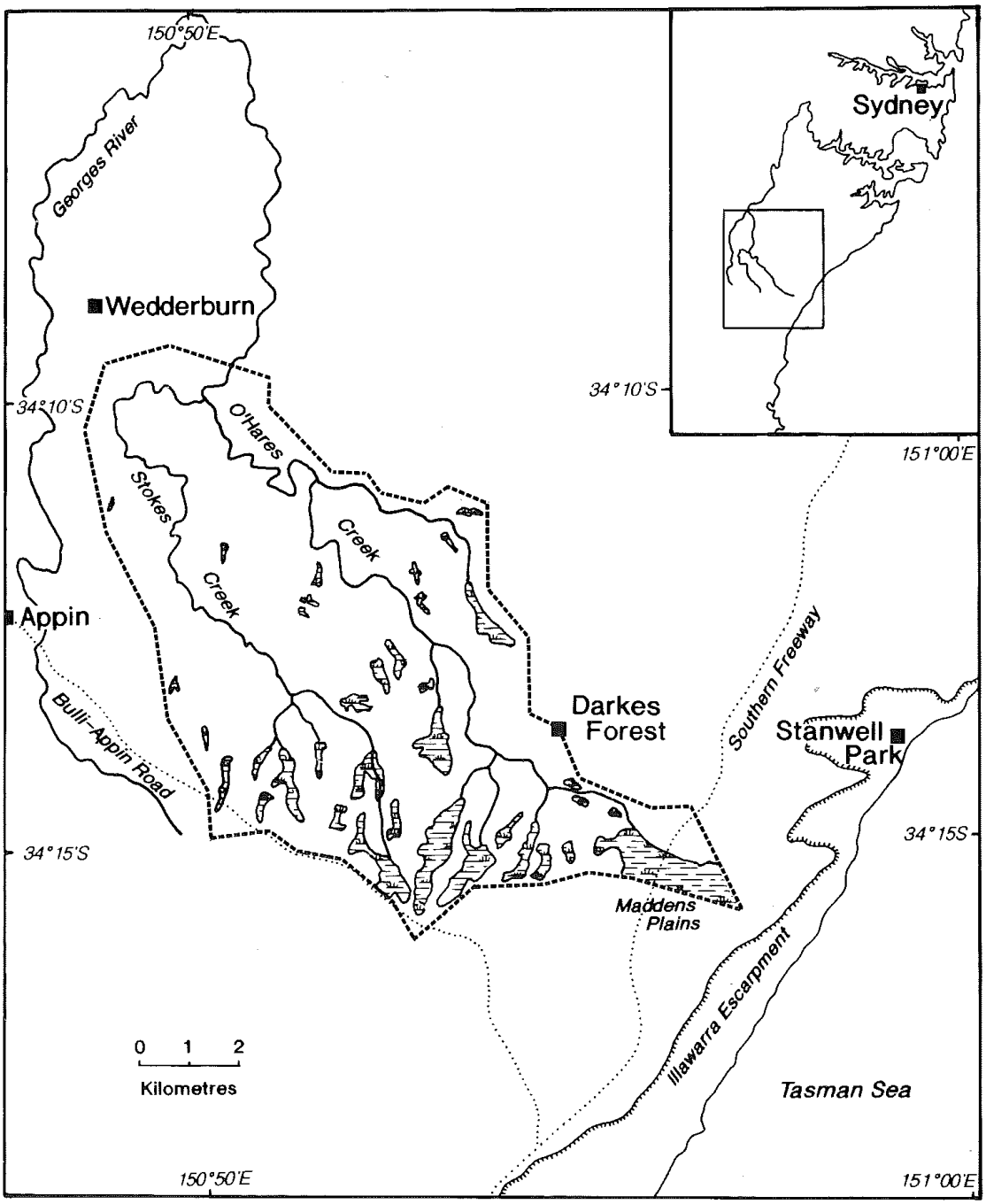

Figure 1. Location of O'Hares Creek catchment (from Keith & Myerscough 1993).

The Triassic Hawkesbury Sandstone Formation, the major geological unit of the plateau, is composed primarily of quartzose sandstone, but also includes lensoidal shale strata that outcrop in the eastern part of the catchment (Bowman et al. 1986). Thick ironstone mantles are present in some areas and may be the remnants of heavily weathered shale lenses (Sherwin et al. 1986). Deposits of swamp alluvium have accumulated in low-relief headwater valleys on the plateau (Young 1986a). The Hawkesbury Sandstone is underlain by the Triassic Narrabeen Group and the Permian Illawarra Coal Measures, respectively, which are exposed on the Illawarra escarpment. The Triassic Wianamatta Group overlies the Hawkesbury Formation and outcrops on the Cumberland Plain to the west.

The local climate is dominated by the influence of the Illawarra escarpment and the close proximity of the sea. There is a marked gradient in mean annual rainfall and seasonality from 1550 mm at Maddens Plains in the east to 850 mm at Wedderburn on the western edge of the catchment. An average annual evaporation rate of 800 mm at nearby Cataract Dam suggests a considerable moisture surplus in the east (unpubl. data, Bureau of Meteorology). At Maddens Plains, the wettest months are February and March, while September is the driest. Wedderburn has no obvious seasonal trend in rainfall. Rainfall also varies considerably from year to year, the range at Maddens Plains being 960–2550 mm. Temperatures vary from an average daily maximum of 25.9°C (January) to a minimum of 6.6°C (July) at Lucas Heights, 15 km north of the study area.

A major land-use on the Woronora Plateau is water catchment and supply, with the Sydney Water Board controlling five major dams. O'Hares Creek was set aside in the 1920s for this purpose but, unlike adjacent catchments, plans for impoundment of the creek were abandoned. The Water Board currently manages the area to maintain water quality by limiting development and restricting access. O'Hares Creek maintains a reliable supply of clean water to the Georges River, a major recreational waterway in southern Sydney. Coal is mined from the Bulli seam, 450–500 m below ground surface. Major coal processing plants and stock piles are located just to the west of the study area on the upper Georges River. Ventilation shafts and seismic survey lines have been constructed within the study area, resulting in localised disturbance. Other extractive industries within the catchment include small quarries for clay and sand, but these are now largely abandoned. O'Hares Creek catchment is used as a training area by the Australian Army as a supplement to Holsworthy Military Area which lies adjacent to the north. Orchards and hobby farms occupy shale-capped ridges at Darkes Forest and Wedderburn on the eastern and western watersheds of the catchment, respectively. These rural settlements were established in the late nineteenth century.

Methods

Remote sensing

Aerial photographs flown in May–July 1982 (Wollongong 1:16 000 Colour, Misc. 1320) were interpreted to categorise variation in vegetation structure across the catchment. The following structural types were mapped onto a 1:25 000 scale topographic map base: forest (single-stemmed trees ≥ 5 m tall and ≥ 20% cover); woodland (single-stemmed trees ≥ 5 m tall and < 20% cover); mallee (multi-stemmed trees); heath (shrubs < 5 m tall).

Sampling strategy and data collection

Samples were stratified among categories of parent material, topography and vegetation structure (Table 1). Only eleven of 32 possible combinations of parent material, topography and structure were represented within the study area. Three of these sampling categories (forest on shale slopes, forest on sandstone plateau tops and heath on ironstone plateau tops) had very restricted occurrence and could only be allocated a small number of samples. The remaining eight categories were allocated at least four samples or more, depending on their geographic extent.

For all sampling categories except plateau alluvium dominated by shrubs, vegetation was sampled in 20 x 20 m quadrats, a standard size used by the National Parks and Wildlife Service and the National Herbarium in surveys of the coast and tablelands of New South Wales (e.g. Keith & Sanders 1990). All vascular plant species were allocated cover-abundance estimates on the Blaun-Blanquet scale (Poore 1955). Height and projective foliage cover were estimated for tall tree, small tree, shrub and ground-cover strata whenever present. Aspect, slope, parent material type and exposed rock (% cover) were recorded and scores were estimated for soil texture (clay/clay–loam/loam/sandy–loam/sand), drainage (waterlogged/damp/moist/dry) and depth (skeletal/shallow/deep). Disturbance history was recorded if evident. Soil samples

Table 1. Stratification of 56 quadrats among parent material (Shale, Sandstone, Ironstone, Alluvium), topography (Sl - slopes and gullies, Pl - plateau) and vegetation structure (of dominant stratum).

– indicates combinations of parent material, topography and structure that do not exist within the study area.

* indicates 60 transect samples as described in Keith & Myerscough (1993).

Parent Material:	Shale		Sandstone		Ironstone		Alluvium	
Topography:	Sl	Pl	Sl	Pl	Sl	Pl	Sl	Pl
Structure:								
forest	1	2,3, 4,5, 6,7, 8	18,23, 24,25, 26,27, 28,29, 30,31, 32,33, 34,35, 36	9,10, 11	–	–	–	–
woodland	–	–	–	37,38, 39,40, 41,42, 43	–	12,13, 14,15, 44,45, 46	–	–
mallee	–	–	–	47,48, 49,50, 51,52	–	–	–	–
heath	–	–	–	53,54, 55,56	–	16,17 21,22	19,20,	*

were collected for chemical analysis from selected sites. Soils were analysed for exchangeable cations, pH and electrical conductivity (methods in Keith 1991).

Plateau alluvium (upland swamps) supported a fine-scale mosaic of wet heath that varied greatly in floristics, structure and soil characteristics over short distances. This variation could not be sampled satisfactorily by 20 x 20 m quadrats and was the subject of a related study (Keith & Myerscough 1993), in which 60 belt transects were stratified by categories of soil moisture and shrub dominance. Each transect consisted of sixty 0.5 m x 0.5 m quadrats, in which the presence of each vascular plant species was scored and summed over the whole transect. Structural and environmental data were gathered in a manner similar to the other sampling categories. Data were archived in a data base and geographic information system held by the NSW National Parks and Wildlife Service.

Data analysis

Matrices of dissimilarity between samples were calculated using the Kulzcynski and Bray-Curtis association measures. These measures are 'non-linear' — species are weighted more highly in the calculation of similarity between two sites when they have higher abundances — and robust to variations in the response curves of species to environmental gradients (Faith et al. 1987). Each measure was applied both to raw data and data standardised by adjusting species to equal maxima, giving a total of four association matrices.

Cluster analysis was carried out using an unweighted pair-group arithmetic averaging procedure (UPGMA) with ß=-0.1 to achieve space conserving behaviour (i.e. relationships between groups stay the same as clustering proceeds, Lance & Williams 1967). Belbin & McDonald (1993) found this strategy was more likely to retrieve natural clusters than two-way indicator species analysis (TWINSPAN, Hill 1978). Classifications based on the four association matrices were compared using homogeneity analysis (Bedward et al. 1992). The classification with the most homogeneous groups was interpreted by attempting to match floristic groups with the sampling categories in Table 1.

Floristic groups were mapped using their correspondence with the sampling categories which were based on mappable features of parent material, topography and vegetation structure. Additional aerial photograph interpretation and field reconnaissance were undertaken to refine vegetation boundaries, particularly on plateau alluvium. Map boundaries were digitised and exported as a postscript file from the geographic information system into desktop publishing software (Aldus Pagemaker) for preparation of the layout and legend. The map was printed directly from this system without manual cartographic preparation.

Relationships between floristic composition and environmental variables were examined using global non-metric multidimensional scaling (NMDS), a method that is more robust to variations in species response to environmental gradients than alternative ordination techniques (Minchin 1987). NMDS maximises the rank-order agreement between values in the association matrix and inter-point distances in ordination space of a specified number of dimensions. Ordinations were fitted from 10 random starting configurations in each of 2, 3 and 4 dimensions. For each number of dimensions, the solution with the lowest stress (i.e. best rank order agreement with the association matrix) was selected for analysis of environmental and structural data.

Nine environmental variables (slope, aspect, elevation, distance from coast, parent material, soil texture, soil moisture, soil depth and rock cover) and six structural

variables (height and cover for each of tree, shrub and ground strata) were standardised to a range of 0–1. The four categories of parent material were arranged in a sequence that reflected their relative nutrient status as indicated by the soil analyses (shale-alluvium-ironstone-sandstone). Aspect was coded as an index that reflected a sequence of increasing exposure (1: 120–210°; 2: 30–120° and 210–300°; 3: 0–30° and 300–360°). A vector for each variable was fitted to each of the three ordinations. Correlations between the vectors (indicating floristic composition) and their respective environmental and structural variables were tested using a Monte Carlo procedure (Minchin 1991).

The regional conservation significance of the vegetation was evaluated by: compiling a list of rare, threatened or biogeographically significant plant species; comparing levels of species richness with that in other areas; and attempting a comparison with vegetation elsewhere on Sydney sandstone using data from previous surveys and Pidgeon's (1941) regional classification.

Results

Native and introduced flora

Five hundred and ten vascular plant taxa were recorded in the O'Hares Creek catchment (list on reverse side of map). Of these, 382 were recorded in the 20 x 20 m quadrats, 165 were recorded in the swamp transects and 452 were recorded in either. Major plant families include Fabaceae (55 taxa), Myrtaceae (53), Proteaceae (44) and Cyperaceae (39).

A number of informal taxa were recognised where morphotypes or ecotypes could be distinguished repeatably in the field. These include two forms of *Hakea dactyloides* (one lignotuberous with broad leaves and large fruits, the other single-stemmed with narrower leaves and smaller fruits, Hovenden 1989), two forms of *H. teretifolia* (one multi-stemmed up to 1.5 m tall, the other single-stemmed up to 5 m tall), two forms of *Lepidosperma viscidum* (one with colourless resin and narrow biconvex leaves, the other with red resin and broader flat leaves), two forms of *Leptospermum trinervium* (one with broad leaves, the other with narrower leaves, Krauss 1994), two forms of *Pultenaea elliptica* (one with red flowers and a short growth form, the other with yellow flowers and a tall growth form) and two forms of *Xanthosia pilosa* (one with densely hairy entire dentate leaves, the other with sparsely hairy narrow lobed leaves).

Seventeen taxa are listed as rare or threatened in Australia (Briggs & Leigh 1988, Table 2), some of which have distributions that are essentially restricted to the Nepean ramp. An additional 17 taxa are uncommon either generally or in the Sydney region, three taxa are represented by atypically coastal populations, including one with a population disjunct from other occurrences of the species. Eleven taxa reach the southern limit of their known distribution in the O'Hares Creek catchment.

Fifty non-indigenous taxa, mainly in the families Asteraceae, Fabaceae and Poaceae, were recorded within the study area (reverse side of map). Sixteen of these are native to Australia, but were considered unlikely to be indigenous to part or all of the study area. Introduced taxa were largely confined to disturbed areas, including abandoned quarries, the interface between farmland and bushland, and along major roads and tracks. Weeds were most abundant at sites exposed to heavy vehicular traffic (e.g. along Bulli–Appin Road, North Cliff mine access road, Lysaghts Road) and/or nutrient-enriched runoff from developed sites such as farmland, mine sites and major

Table 2. Vascular plant taxa of conservation significance in the O'Hares Creek catchment

Significance codes in upper case follow Briggs & Leigh (1988): 2- geographic range < 100 km; 3- geographic range >100 km; V- vulnerable; R -rare; K- poorly known but may be rare or threatened; C- represented within a conservation reserve (a- >1000 plants, i- < 1000 plants, -unknown number). Significance codes in lower case: cl- coastal locality of typically inland taxon; dp- disjunct population; sl- southern limit of distribution; uc- uncommon; ucs- uncommon in Sydney region. Refer to Appendix 1 for explanation of community abbreviations.

Taxon	Significance	Community/Distribution
Acacia bynoeana	3VC-	SW & RH south of Wedderburn. Northern Sydney-Berrima.
Acacia stricta	ucs	SF near Darkes Forest. Coast & tablelands Qld–Tas.
Allocasuarina nana	cl	MH north of O'Hares Ck. Mainly tablelands Blue Mtns-East Gippsland.
Allocasuarina paludosa	ucs	RH scattered in eastern part of catchment. Northern Sydney–Tas.
Angophora hispida	sl	IH & MH in centre of catchment. Gosford–O'Hares Ck.
Banksia cunninghamii	cl	EGF scattered along O'Hares Ck gully. Scattered mainly along NSW tablelands and coastal East Gippsland.
Blandfordia cunninghamii	3RC-	WGF along Pheasant Ck, Wedderburn. Blue Mtns & Nepean ramp.
Blechnum ambiguum	uc	EGF restricted to sandstone overhangs throughout gullies. Mainly Sydney sandstone, also Qld.
Boronia serrulata	uc,sl	SW near Northcliff mine. Wondabyne–Manly & Loftus–O'Hares. Uncommon south of Sydney.
Callitris endlicheri	cl,dp	RPH south of Darkes Forest. Widespread in dry and semi-arid woodlands on the tablelands, western slopes and plains.
Corybas fordhamii	ucs	CH, SL & RH scattered in eastern part of catchment. Scattered on coast and tablelands.
Darwinia diminuta	3RCi,sl	MH near Northcliff mine. Manly-Ingleside & Loftus-O'Hares Ck.
Darwinia grandiflora	2RC-	WH & RH scattered in eastern part of catchment. Endemic to Nepean ramp.
Doryanthes excelsa	sl	SF & EGF throughout eastern part of catchment. Scattered localities from far north coast to Bulli-Appin Rd.
Epacris coriacea	3RC-	EGF near confluence of O'Hares & Cobbong Cks. O'Hares Ck–Macquarie Pass & Rhylstone.
Eriachne glabrata	sl	RH scattered in eastern part of catchment. Along coast Qld-O'Hares Ck.
Eucalyptus apiculata	2R	RH, MH & RPH in eastern part of catchment. Berrima, Nepean ramp & Linden. Intergrades with E. stricta.
Eucalyptus ligustrina	uc	SW west of Darkes Forest. Nepean ramp, Blue Mtns & Gibraltar Range.

Eucalyptus luehmanniana	2RCa,sl	MH scattered in eastern part of catchment. Gosford-O'Hares Ck.
Eucalyptus multicaulis	uc	SW & WGF mainly near Wedderburn. Hornsby Plateau, Nepean ramp, Blue Mtns, Jervis Bay & Budawang Range.
Eucalyptus squamosa	uc	WGF near Wedderburn. Hornsby Plateau & Nepean ramp.
Gonocarpus salsoloides	3RCa,sl	CH & SL scattered in eastern part of catchment. Port Macquarie–O'Hares Ck.
Grevillea diffusa var. *diffusa*	uc	SW & EGF throughout catchment. Menai–Cordeaux Dam. Form restricted to Bulli–Appin.
Grevillea longifolia	2RC-	EGF along O'Hares & Stokes Cks. Waterfall–Cataract Dam & Lawson–Springwood.
Hibbertia nitida	2RC-	EGF along O'Hares & Stokes Cks. Thornleigh–Manly & Oatley–Nepean Dam.
Leucopogon amplexicaulis	uc	EGF along O'Hares & Stokes Cks. Gosford–Pigeon House Mtn.
Leucopogon exolasius	2VC-,sl	EGF scattered along O'Hares & Stokes Cks. Woronora–Georges Rivers & Grose River.
Lomandra fluviatilis	3RC-	RS along O'Hares & Stokes Cks. Colo River–Cataract Dam.
Melaleuca deanei	3RC-	SW at Wedderburn. Hornsby Plateau & Nepean ramp.
Melaleuca squamea	ucs	CH scattered in eastern part of catchment. Scattered along tablelands & coast northern NSW-Tasmania.
Melichrus urceolatus	ucs	SW in western part of catchment. Widespread on coast, tablelands, slopes & plains of NSW, Qld & Vic, but only 2 localities in Sydney region.
Monotoca ledifolia	3RC-	RPH scattered in south-eastern part of catchment. Blue Mtns & Nepean ramp.
Persoonia mollis subsp. *nectans*	uc	EGF east of Darkes Forest. Restricted to Nepean ramp.
Prasophyllum nublingii	2KC-,sl	SW in southern part of catchment. Royal NP–O'Hares Ck.
Pseudanthus orientalis	ucs,sl	BT & MH scattered in eastern part of catchment. Qld–O'Hares Ck, usually on coastal sand dunes.
Pultenaea aristata	2VC-	BT, RH & MH mainly in eastern part of catchment. Helens burgh–Mt Kiera & Budawang Range.
Pultenaea divaricata	ucs	TT & CH scattered in larger swamps. Blue Mtns–Corang.
Pultenaea hispidula	ucs	SF scattered in eastern part of catchment. Hornsby Plateau–East Gippsland.
Tetratheca neglecta	3RC-	SW, IW & MH throughout catchment. Sutherland–Robertson.
Tetratheca shiressii	sl	SW near Northcliff mine. Watagan Mtns–Hawkesbury River & Sutherland–O'Hares Ck
Thelymitra circumsepta	ucs	RH & IW in eastern part of catchment. Northern NSW coast–East Gippsland.

roads. The most abundant introduced species along roads was *Andropogon virginicus*. Localised infestations of *Ageratina adenophora* occur south of Darkes Forest coal mine, where treated sewerage effluent was sprayed upon native vegetation. Native vegetation away from developed sites is remarkably free of weeds. Only three out of the 56 samples included introduced taxa. The three taxa recorded (*Hypochoeris radicata, Conyza albida* and *Rubus ?discolor*) had cover-abundance scores of 1 (uncommon and < 5% cover). Watercourses were apparently free of weeds, with no introduced taxa recorded in any of the riparian samples.

Classification and mapping

Classifications based on raw data grouped samples into more homogeneous groups than those based on standardised data (Figure 2). The two classifications based on raw data were similar, but the Kulzcynski classification (Figure 3) corresponded more closely with the sampling categories (Table 1) than the Bray-Curtis classification.

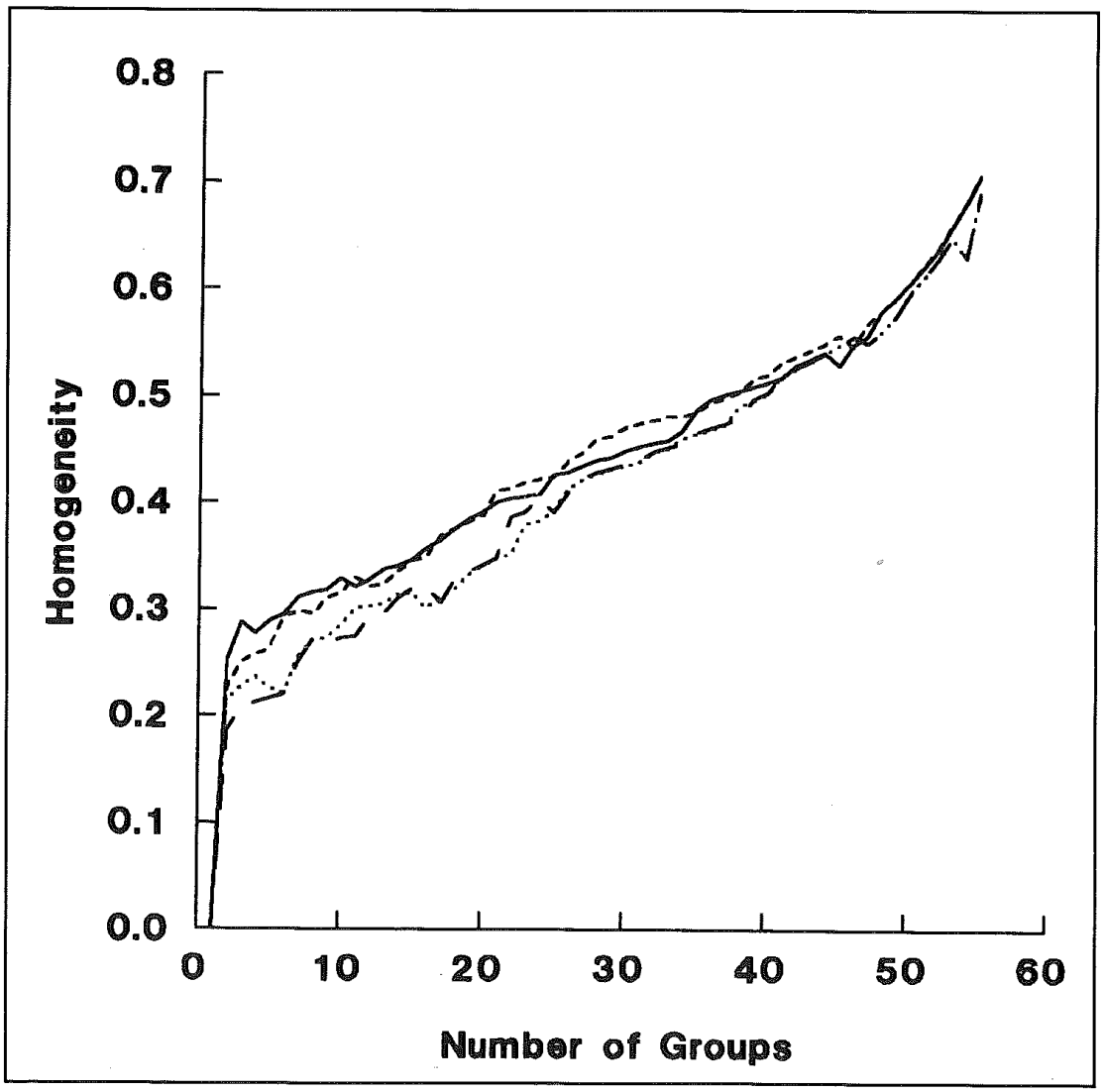

Figure 2. Homogeneity curves for site classifications based on raw data and Kulzcynski coefficient (-----), raw data and Bray-Curtis coefficient (——), standardised Kulzcynski coefficient (····) and standardised Bray-Curtis coefficient (- - -).

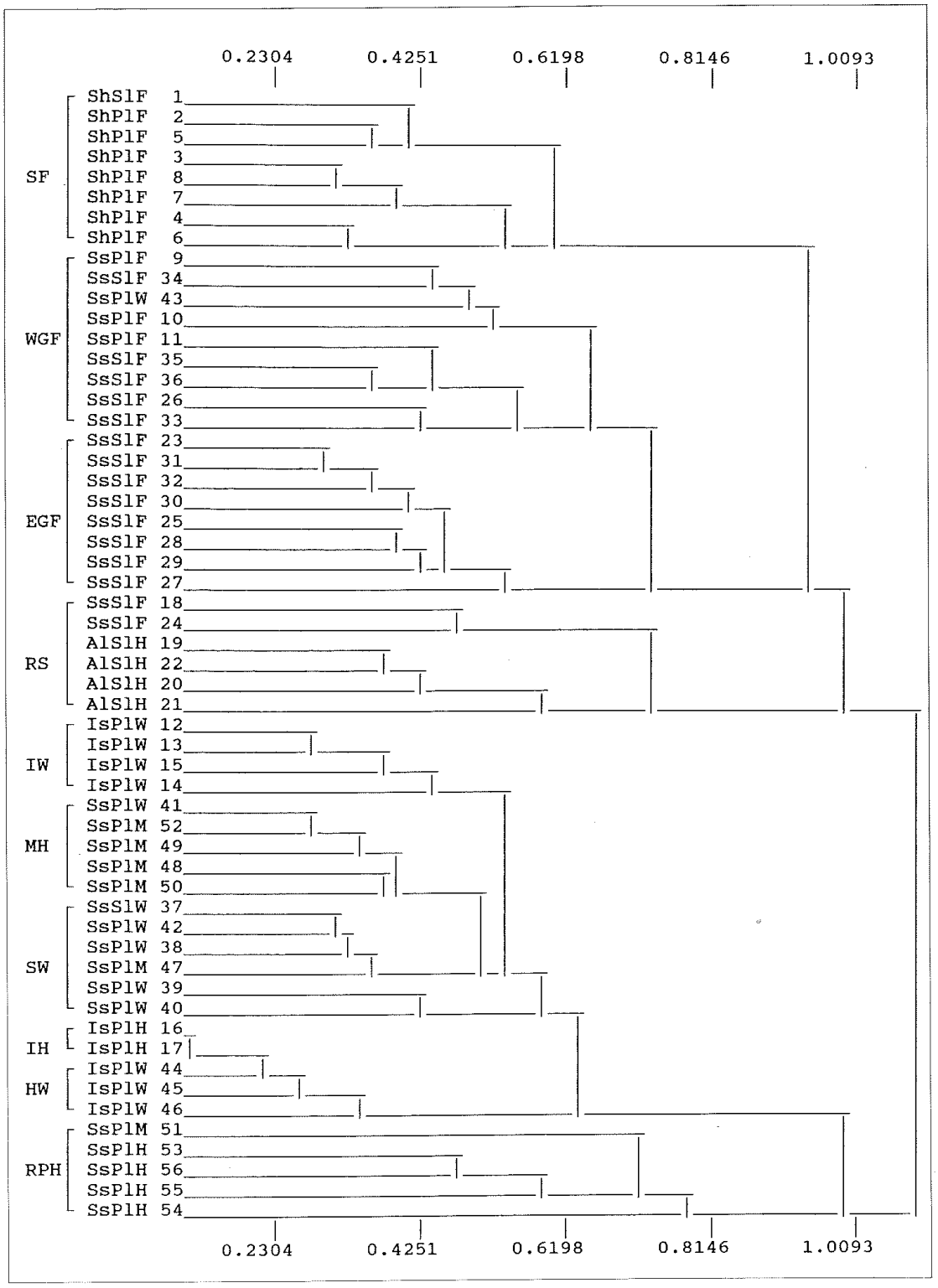

Figure 3. Classification of non-swamp sites based on raw data and Kulzcynski coefficient with UPGMA clustering. See Appendix 1 or vegetation map for abbreviations of plant community names. Sample labels indicate sampling cell to which sample belongs (Table 1): Sh – shale; Ss – sandstone; Is – ironstone; Al – creek alluvium; Pl – plateau top; Sl – slopes and gullies; F – forest; W – woodland; M – mallee; H – heath.

Five major groups can be identified from Figure 2 and correspond to groups of sampling categories defined in Table 1: forest on shale (eight sites); forest on sandstone gully slopes (17 sites); scrub on alluvium in gullies (six sites); woodland, mallee and heath on the sandstone/ironstone plateau (20 sites); and heath on the sandstone plateau (five sites).

The first major group was made up of seven forested shale sites on the plateau and one on gully slopes and was recognised as a single community, 'Shale Forest'. The second major group included 13 forested sites on sandstone gully slopes and four on the plateau. It was split into two communities (Figure 3): one confined to the western side of the catchment, 'Western Gully Forest'; the other confined to the eastern side of the catchment, 'Eastern Gully Forest'. The third major group included four heath sites on alluvium in gullies and two forested sites in sandstone gullies and was recognised as a single community, 'Riparian Scrub'.

The fourth major group was a complex of sites from five different sampling categories (Figure 3). Within this complex, three woodland groups could be distinguished from one another on floristic grounds: 'Ironstone Woodland' (sites 12, 13, 14, 15); 'Sandstone Woodland' (sites 37, 42, 38, 47, 39, 40); and 'Heath Woodland' (sites 44, 45, 46). Map boundaries were determined by field traverse because their structure and parent materials were difficult to separate on aerial photographs. A group of mallee sites (41, 52, 49, 48, 50) was closely related in floristics to Sandstone Woodland, but was distinct in structural characteristics and mapped as 'Mallee Heath'.

Table 3. Correlations of environmental and structural variables with floristic ordination vectors in 2, 3 and 4 dimensions

	Number of Ordination Dimensions		
	4	**3**	**2**
Slope	0.6528***	0.5367***	0.3576*
Aspect Index	0.3482ns	0.2204ns	0.1737ns
Elevation	0.6811***	0.6756***	0.3524*
Distance from Coast	0.7169***	0.7056***	0.0439ns
Parent Material	0.8329***	0.6602***	0.5888***
Soil Depth	0.8343***	0.8365***	0.7890***
Soil Quartz	0.7274***	0.6937***	0.6292***
Soil Moisture	0.8108***	0.7422***	0.6516***
Rock cover	0.7222***	0.7208***	0.6763***
Tree height	0.8888***	0.8296***	0.7757***
Tree cover	0.8173***	0.8100***	0.7913***
Shrub height	0.7473***	0.7401***	0.7087***
Shrub cover	0.4474*	0.4422*	0.3901*
Ground height	0.5432***	0.5257***	0.4377***
Ground cover	0.7252***	0.6455***	0.4364***

*** = significant at $P < 0.001$
* = significant at $P < 0.05$
ns = not significant $P > 0.05$

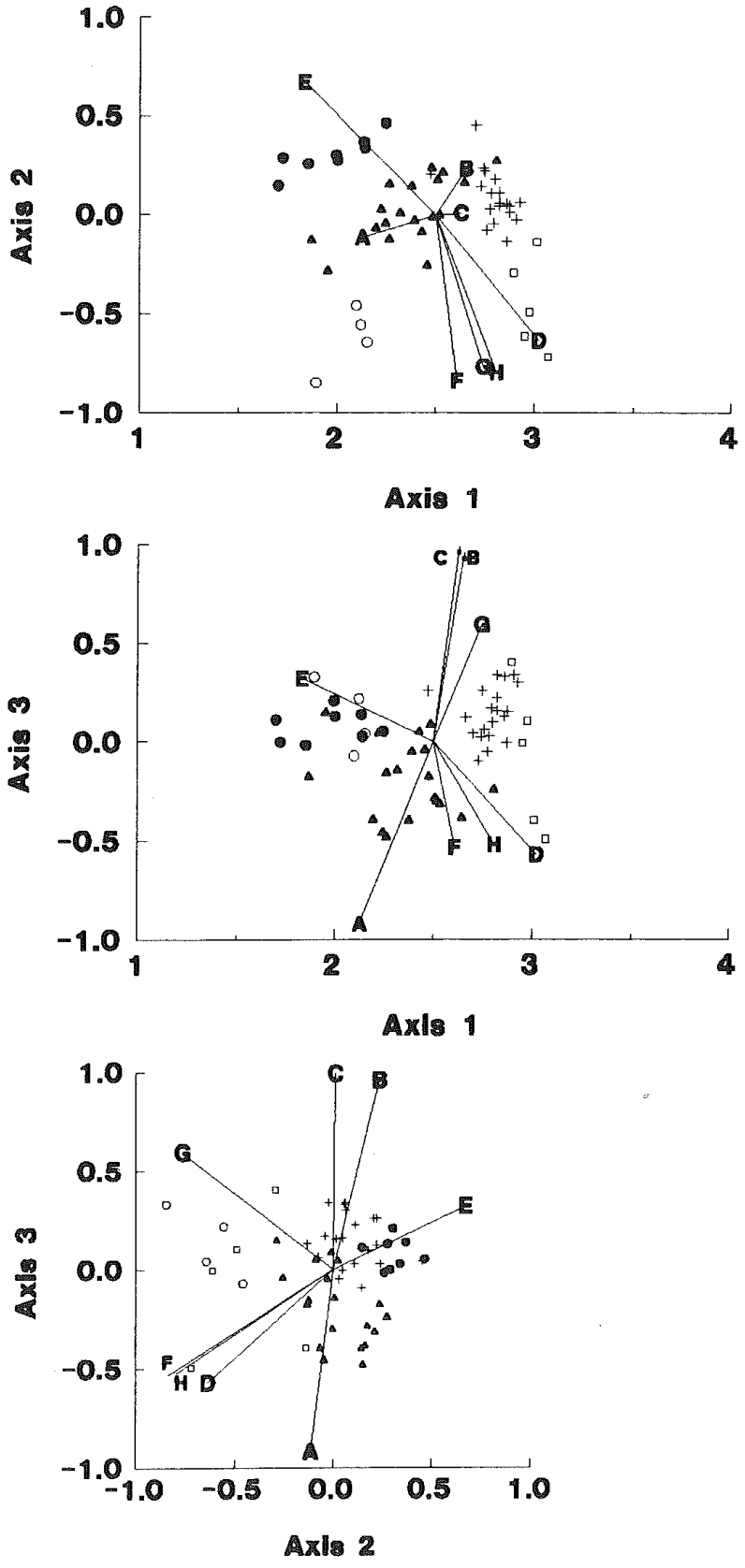

Figure 4. Three-dimensional ordination of non-swamp sites showing vectors significantly correlated with environmental variables: A – slope; B – elevation; C – distance from coast; D – parent material; E – soil depth; F – soil quartz; G – soil moisture; H – rock cover. Symbols show groups of plant communities: - SF; - - EGF and WGF; o - RS; [] - RPH; + - all other communities.

Two heath sites on ironstone (16, 17) had similar floristic composition to the Heath Woodland sites (44, 45, 46) but, primarily because of their different structure, were mapped separately as 'Ironstone Heath'. The fifth major group in Figure 2 was recognised as a single community, 'Rock Pavement Heath'.

Classification of upland swamp (heath on plateau alluvium) communities was based on the analysis by Keith & Myerscough (1993) which recognised five communities: Ti-Tree Thicket; Cyperoid Heath; Sedgeland; Restioid Heath; and Banksia Thicket. However, only two of these could be mapped separately using aerial photopattern (Ti-tree Thicket and Banksia Thicket), so the remaining three were included in a single map unit, 'Sedgeland–Heath Complex'.

The vegetation map shows the distribution of plant communities described in Appendixes 1 and 2.

Environmental and structural relationships with floristic composition and richness

The 4-dimensional ordination had a lower level of stress (0.0777), than ordinations in three (0.0992) and two (0.1587) dimensions. Vectors fitted to the 4-dimensional ordination were more highly correlated with environmental and structural variables than those fitted in three and two dimensions, the latter giving a poor representation of floristic relationships, particularly with slope and elevation (Table 3). However, the 3-dimensional ordination (Figure 3) represented all significant relationships in fewest dimensions.

Slope, elevation, distance from coast, parent material, soil depth, quartz and moisture, rock cover, tree height and cover, shrub height, ground stratum height and cover were all highly correlated with floristic composition, as indicated by the 3- and 4-dimensional ordinations ($P < 0.001$, Table 3). Shrub cover was marginally correlated with floristic composition ($P < 0.05$). There was no correlation between floristics and aspect ($P > 0.05$). Soil depth, soil quartz, rock cover and parent material were closely related ($P < 0.001$, Figure 4). Height and tree cover were highly correlated with one another and with soil moisture ($P < 0.001$). There were also significant correlations between the tree stratum and soil depth, slope and shrub cover (Figure 4). Elevation and distance from the coast were inversely correlated ($P < 0.001$), but independent of other variables. Aspect was not correlated with any of the other environmental or structural variables ($P > 0.05$, Figure 4).

Plant communities showed high fidelity with one type of parent material, and there were corresponding differences between communities in soil properties (Table 4). The five swamp communities occupied soils that were deep, fine-textured, water-logged and without exposed rock. Shale Forest also occupied deep fine-textured soils, but these were well drained and their fine texture was due to a high proportion of mineral clay and silt, rather than fine organic particles as was the case in swamp soils. Rock Pavement Heath was distinguished from remaining communities by its skeletal soils and extensive outcrops of rock. Communities on sandstone had the highest levels of soil quartz and exposed rock. Forest and woodland communities occupied well-drained soils, while heath and swamp communities occurred on soils whose drainage is impeded to varying degrees. Soils supporting Ironstone Woodland, Sandstone Woodland, Mallee Heath, Ti-tree Thicket and Shale Forest had higher pH than other communities. Shale Forest, Eastern Gully Forest, Ironstone Woodland, Sandstone Woodland and Mallee Heath form a sequence of decreasing soil fertility, as indicated by conductivity and exchangeable cations (Table 4). Among

Table 4. Soil characteristics of plant communities

Data for soil depth, quartz and moisture are medians with ranges in parentheses for scales of 1–5, 1–4 and 1–3, respectively. All other data are means with standard errors in parentheses. Parent materials: Sh– shale; Ss– sandstone; Al– creek alluvium; Is ironstone; Sw– swamp alluvium. Rock cover in %, electrical conductivity in $mS.cm^{-1}$, exchangeable cations in milliequivalents/100g air-dried soil.

Community Cat.	Parent Material	Soil Depth	Soil Quartz	Soil Moisture	Rock Cover	pH	Elec. Cond.	Exch. Na	Exch. K	Exch. Ca	Exch. Mg	Exch. Al	Total Ex.
Shale Forest	Sh	5	1	1	1	4.3	0.062	0.16	0.23	2.12	1.39	1.72	5.62
		(3–5)	(1–3)	(1–2)	(1)	(0.3)	(0.012)	(0.05)	(0.10)	(1.29)	(0.39)	(0.65)	(2.28)
Western Gully Forest	Ss	3	3	1	5	–	–	–	–	–	–	–	–
		(2–4)	(2–4)	(1–1)	(2)								
Eastern Gully Forest	Ss	3	4	1	11	3.6	0.050	0.07	0.14	0.80	0.88	0.81	2.70
		(3–3)	(3–4)	(1–2)	(2)	(0.1)	(0.006)	(0.02)	(0.02)	(0.03)	(0.36)	(0.15)	(0.56)
Riparian Scrub	Al	3	4	3	11	–	–	–	–	–	–	–	–
		(3–4)	(3–4)	(1–3)	(2)								
Ironstone Woodland	Is	3	2	1	1	4.5	0.038	0.06	0.05	0.52	0.36	0.72	1.70
		(3–3)	(2–3)	(1–2)	(1)	(0.1)	(0.003)	(0.01)	(0)	(0.11)	(0.14)	(0.22)	(0.48)
Sandstone Woodland	Ss	3	3	1	3	4.4	0.027	0.05	0.06	0.32	0.28	0.28	0.99
		(3–3)	(2–4)	(1–2)	(2)	(0.1)	(0.002)	(0.01)	(0.01)	(0.08)	(0.07)	(0.11)	(0.16)

Ironstone Heath	Is	3	1	3	0	–	–	–	–	–	–	–	–
		(3–3)	(1–1)	(3–3)	(0)								
Heath Woodland	Is	3	2	2	0	–	–	–	–	–	–	–	–
		(3–3)	(2–2)	(1–3)	(0)								
Rock Pavement Heath	Ss	1	4	2	60	–	–	–	–	–	–	–	–
		(1–1)	(4–4)	(2–3)	(9)								
Banksia Thicket	Sw/Ss	4	2	3	0	3.8	0.059	0.08	0.04	0.13	0.28	1.75	2.30
		(3–4)	(2–3)	(3–3)	(0)	(0.1)	(0.007)	(0.01)	(0.01)	(0.05)	(0.04)	(0.40)	(0.45)
Restioid Heath	Sw	4	2	3	0	3.9	0.043	0.05	0.03	<0.05	0.11	0.67	0.83
		(3–4)	(1–3)	(3–3)	(0)	(0.1)	(0.004)	(0.01)	(0.01)	(–)	(0.04)	(0.18)	(0.24)
Sedgeland	Sw	4	1	3	0	4.1	0.049	0.05	0.04	<0.05	0.12	0.68	0.85
		(3–4)	(1–3)	(3–4)	(0)	(0.1)	(0.003)	(0.01)	(0.01)	(–)	(0.02)	(0.12)	(0.15)
Cyperoid Heath	Sw	5	1	4	0	3.8	0.080	0.12	0.08	0.08	0.30	2.33	2.86
		(4–5)	(1–3)	(3–4)	(0)	(0.1)	(0.012)	(0.02)	(0.01)	(0.03)	(0.04)	(0.45)	(0.54)
Ti–tree Thicket	Sw	5	1	4	0	4.4	0.164	0.53	0.20	1.31	0.97	2.80	4.94
		(5–5)	(1–2)	(4–4)	(0)	(0.2)	(0.013)	(0.20)	(0.03)	(0.74)	(0.41)	(0.57	(1.00)

the swamp communities, Ti-tree Thicket had the most fertile soils, Restioid Heath and Sedgeland the least fertile and Cyperoid Heath and Banksia Thicket were intermediate. Swamp soils had higher levels of Aluminium as a proportion of total exchangeable cations than soils supporting forest and woodland vegetation. Swamp soils had similar levels of total exchangeable cations and greater conductivity than those of forests and woodlands when considered on a dry-weight basis. However, if data in Table 4 could be corrected for variations in bulk density due to organic matter, overall fertility of swamp soils would be low to moderate, relative to soils supporting forests and woodlands.

Trees were tallest in Shale Forest and Eastern and Western Gully Forests, but had more cover in Shale Forest than the other two forest communities (Figure 6a). Mallee Heath had the shortest trees, but these were greater in cover than those of the three woodland communities. Trees were generally absent from Riparian Scrub, Ironstone Heath, Rock Pavement Heath and the five swamp communities. Shrubs were tallest and had least cover in Shale Forest and were tall with most cover in Banksia Thicket. The remaining communities had similar shrub strata, except that shrubs were taller in Riparian Scrub, Ti-tree Thicket and Eastern and Western Gully Forests (Figure 6b).

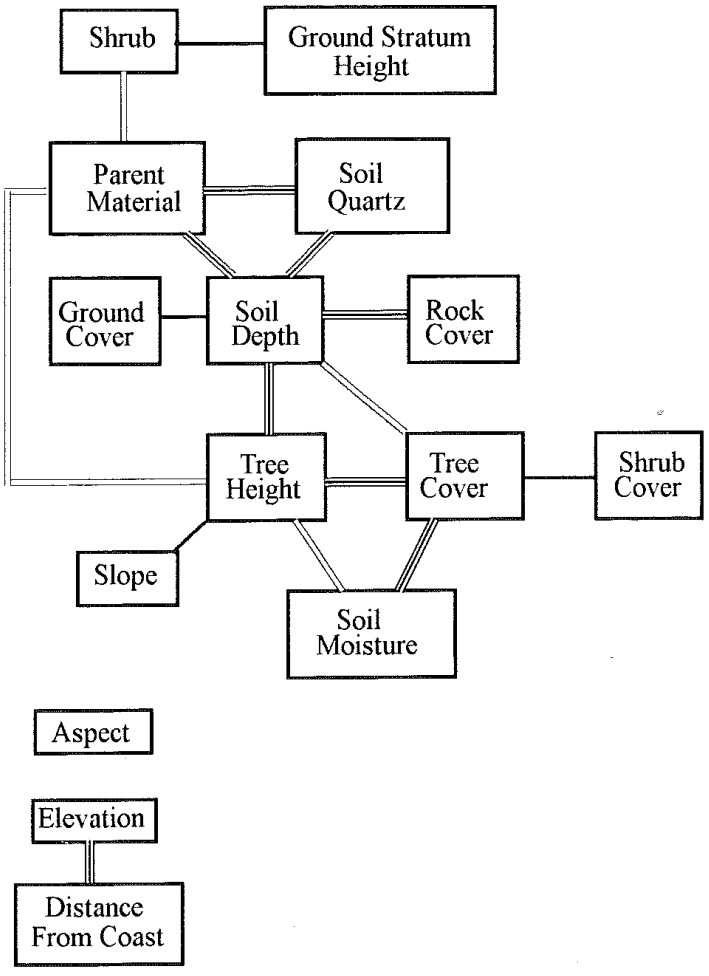

Figure 5. Correlations among environmental variables and structural characteristics of vegetation. Triple line P < 0.001; double line P < 0.01; single line P < 0.05.

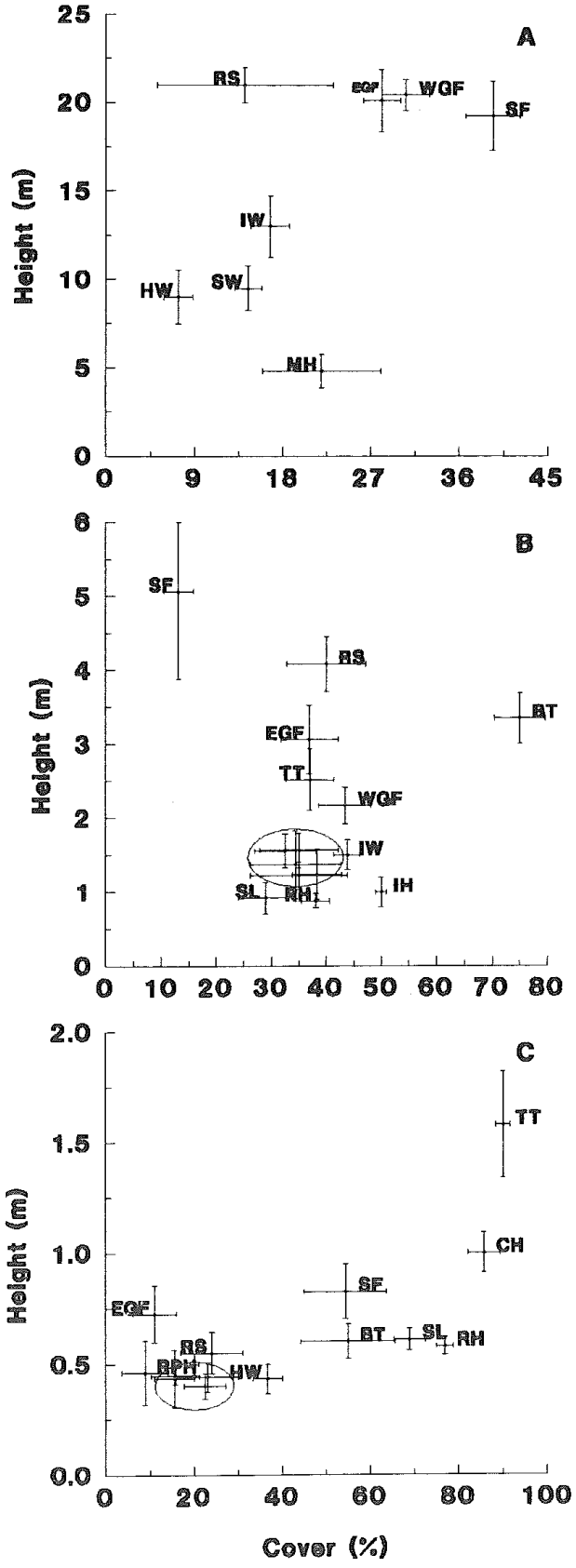

Figure 6. Mean height and cover of (a) tree strata, (b) shrub strata and (c) ground strata for each plant community. Refer to Appendix 1 or vegetation map for abbreviations of plant community names. Errors bars are standard errors of the mean. In (b) the ellipse contains unlabelled data points for SW, HW, MH, RPH & CH. In (c) the ellipse contains unlabelled data points for WGF, IW, SW, MH & IH.

The five swamp communities had a dense and tall groundcover, as did Shale Forest, though its composition was very different. The groundcover of Heath Woodland and Ironstone Heath was similar in composition to the swamp communities, though less dense. Rock Pavement Heath had the least ground cover (Figure 6c).

The most species-rich communities were Mallee Heath, Ironstone Heath and Heath Woodland (Table 5). Restioid Heath is similarly species rich, but caution is required when comparing richness between swamp and non-swamp communities because of the different scales at which they were recorded. Species Richness was lowest in Rock Pavement Heath and Ti-tree Thicket.

Discussion

Vegetation patterns and environmental relations

The major dichotomy in the dendrogram (Figure 3) distinguishes plant communities on shale, creek alluvium and sandstone gullies from those on sandstone and ironstone sites on the plateau. Upland swamps comprise a third major group of communities. The first group of communities is characterised by relatively fertile, well-drained soils, the second group occurs on soils of low fertility and free to moderate drainage, while the third group is restricted to waterlogged soils of varying fertility. Differences in soil chemistry, texture and moisture also delimit individual communities within these groups (Table 4). A suite of inter-related soil factors are highly correlated with overall trends in floristic composition (Table 3) and with aspects of vegetation structure (Figure 5).

The identification of soil fertility and moisture as determinants of plant community distribution is consistent with findings of earlier workers. Beadle (1954, 1962) and Clements (1983) demonstrated the role of soil nutrients, particularly phosphorus, in delimiting forest and woodland communities on Sydney shales and sandstones. Pidgeon (1938), Davis (1941) and Buchanan (1980) identified soil moisture as a factor influencing structure and composition, especially on sandstone. In the Darkes Forest–Maddens Plains–Sublime Point area, Davis (1941) demonstrated differences in the water-retaining capacity and organic content of soils between a *Eucalyptus piperita* association (cf. Shale Forest), an *E. sieberi* association (cf. Sandstone Woodland, Ironstone Woodland and Heath Woodland) and a *Gymnoschoenus sphaerocephalus* association (cf. Cyperoid Heath and Restioid Heath).

Within O'Hares Creek catchment, vegetation patterns attributable to variation in soil moisture may be thought of at local and regional scales. At a local level, the response of floristics and structure to changes in drainage due to parent material and landform over short distances is illustrated by the large number of map units present in a small area, particularly in the eastern part of the catchment where there are fine-scale mosaics including three woodland communities, three heath communities and five upland swamp communities. The rainfall gradient superimposes a regional trend on moisture availability due to the occurrence of certain plant communities and species. Such a trend is illustrated, for example, by the diminishing extent of upland swamps, the replacement of Eastern Gully Forest with Western Gully Forest and the correlation of overall floristic composition with decreasing elevation and increasing distance from the coast (Table 3). Burrough et al. (1977) identified similar regional trends in vegetation in relation to a rainfall gradient across the Budderoo Plateau, 50 km south of Darkes Forest.

Table 5. Species richness of plant communities

Community		mean	se	n	area (m^2)
O'Hares Creek catchment					
Shale Forest		41	2	8	400
Western Gully Forest		40	1	9	400
Eastern Gully Forest		57	4	8	400
Riparian Scrub		36	6	6	400
Ironstone Woodland		52	2	4	400
Sandstone Woodland		57	2	6	400
Mallee Heath		64	4	5	400
Ironstone Heath		62	0	2	400
Open Ironstone Woodland		66	3	3	400
Rock Pavement Heath		23	6	5	400
Banksia Thicket		40	2	7	15
Restioid Heath		55	2	15	15
Sedgeland		40	3	13	15
Cyperoid Heath		37	2	16	15
Ti-tree Thicket		24	2	9	15
Yengo National Park[1]					
Dry forest	(1)	44		11	400
	(2)	47		6	400
	(3)	45		15	400
Dry woodland	(4)	37		43	400
Garrigal National Park[2]					
Dry forest	(7)	42		2	400
Dry forest/woodland	(10)	49		3	400
	(12)	55		6	400
Dry woodland	(13)	55		8	400
Yuraygir National Park[3]					
Wet/dry forest	(5)	52	8	3	400
Dry forest	(6)	30	2	10	400
	(7)	40	2	3	400
	(17)	42	3	3	400
Dry heath	(35)	38	2	11	400
Wet heath	(37)	30	1	11	400
	(39)	26	2	18	400
South East Forests[4]					
Wet forest	(9l)	39	2		400
Dry forest	(16)	39	2		400
	(26l)	30	2	17	400
	(28)	33	3	11	400
Dry heath	(33)	35	4	6	400
Upland swamp	(40)	35	4	5	400

Sources: 1. Sanders et al. (1988); 2. Sherringham & Sanders (1993); 3. Griffith (1988); 4. Keith & Sanders (1990). Numbers in parentheses are community numbers used by respective authors.

Conservation

Representativeness of plant communities and species

O'Hares Creek catchment samples a small part of the extensive Sydney sandstone landscape. Sandstone Woodland and Eastern Gully Forest, collectively covering 64% of the catchment, typify a recurring pattern of woodland on ridges and forest in gullies that is widespread throughout the Sydney sandstone landscape (Pidgeon 1938). While a large proportion of this landscape is represented within reserves, the diversity and regional variability of its vegetation may not be fully appreciated.

Keith & Myerscough (1993) have drawn attention to the species richness of upland swamps in O'Hares Creek catchment, which is high relative to other shrub-dominated vegetation types around the world. Levels of species richness in dry sclerophyll forests, dry sclerophyll woodlands and heathlands at O'Hares Creek are higher than in comparable plant communities in other parts of coastal New South Wales (Table 5), exceed those in wet sclerophyll forests on the north and south coast (e.g. Binns & Chapman 1992, Keith & Sanders 1990) and are high relative to those in temperate forests and woodlands on other continents (e.g. Peet 1978).

Pidgeon (1941) noted that many species are restricted in their distribution to parts of the sandstone area, while others occur throughout. She divided the Sydney sandstone into regions that differ from one another physiographically, climatically and in the groups of vegetation types they support. Most of O'Hares Creek catchment samples the Nepean Ramp sub-region, but in the west it includes a southern outlier of the Macdonald region. Of six existing conservation reserves on the Nepean Ramp, two (Illawarra and Macquarie Pass National Parks) are located on the Illawarra Escarpment and sample extremely small areas of the sandstone plateau, and four (Royal, Heathcote, Garrawarra and Georges River NPs) are located on the northern edge of the plateau. The southern outlier of the Macdonald region is not represented in any reserves. Unlike the combined reserves to the north, O'Hares Creek samples a transition from the Coastal region to the Macdonald region (Pidgeon 1941) that also occurs over a longer and interrupted stretch of country to the north of Sydney.

Data gathered since Pidgeon's (1941) work allow further insight into the heterogeneity of Sydney sandstone vegetation by comparing the occurrence of selected taxa in analogous communities of different regions. The taxa selected for comparison were trees and widespread genera of understorey shrubs (*Grevillea, Leucopogon, Acacia* and *Pultenaea*). Analogies between plant communities in different part of Sydney were determined by identifying vegetation in similar habitats (i.e. sandstone gullies and ridges capped by Hawkesbury shale). In forest communities in sandstone gullies only four of 42 species (10%) were represented in more than seven of ten localities surveyed, whereas 27 species (64%) were recorded at three or less of the ten localities (Table 6a). Representation of species is even more localised in widely scattered, but locally restricted vegetation types, in which floristic similarities between stands may be limited by dispersal. In forests on shale lenses only five of 30 species (17%) were represented at more than three of five localities surveyed, whereas 22 species (73%) were represented at less than three of the five localities (Table 6b). Moreover, each of the five 'shale forests' includes species not known from any of the others.

Full assessment of the conservation status of Sydney sandstone vegetation requires quantitative analysis of more comprehensive data than that currently available. Nonetheless, these data emphasise the importance of conserving samples of vegetation types throughout their range, if the full diversity and variability of Sydney sandstone vegetation is to be conserved.

Table 6. Representation of selected taxa in analogous vegetation types at various localities on Sydney sandstone (X-dominant, x-other taxa)

a) Forest in Sandstone Gullies. Regions after Pidgeon (1941): Cn- Coastal, Nepean Ramp sub-region; Ch- Coastal, Hornsby Plateau sub-region; Co- Coastal, Ourimbah sub-region; Mn- Macdonald north; Ms- Macdonald south; LBM- Lower Blue Mountains; UBM- Upper Blue Mountains. Localities: OHE- O'Hares Creek east (comm. EGF, this study); OHW -O'Hares Creek west (comm. WGF, this study); RNP- Royal NP (Keith unpubl. data); BBP- Bents Basin NP (comms. 8, 9 & 10, Benson et al. 1990); KAT- Katoomba area (comm. 9i, Keith & Benson 1988); YNP- Yengo NP (comms. 1, 2 & 3, Sanders et al. 1988); DNP- Dharug NP (comm. C1, Clarke & Benson 1986); GNP- Garrigal NP (map unit 9, Sherringham & Sanders 1993); KCP- Ku-ring-gai Chase NP (comm. 9, Thomas & Benson 1985); BWP- Brisbane Water NP (comm. 4, Benson & Fallding 1981).

Region:	**Cn**	**Ms**	**Cn**	**LBM**	**UBM**	**Mn**	**Mn**	**Ch**	**Ch**	**Co**	
Locality:	**OHE**	**OHW**	**RNP**	**BBP**	**KAT**	**YNP**	**DNP**	**GNP**	**KCP**	**BWP**	**Tot**
Trees											
Angophora bakeri						x					1
Angophora costata	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	9
Angophora floribunda						x				x	2
Eucalyptus agglomerata	x	**X**	x	x		x	x				6
Eucalyptus capitellata										x	1
Eucalyptus consideniana		x									1
Eucalyptus eugenioides				x							1
Eucalyptus eximia				x		x	x		x	x	5
Eucalyptus gummifera	x	**X**	x	**X**		x	x	**X**	x	**X**	9
Eucalyptus haemastoma									x	x	2
Eucalyptus multicaulis		x									1
Eucalyptus oblonga	x	x							x	x	4
Eucalyptus oreades				**X**							1
Eucalyptus pellita										x	1
Eucalyptus pilularis		x		**X**		**X**					3
Eucalyptus piperita	**X**	x	**X**		**X**	**X**	**X**	**X**	**X**	**X**	9
Eucalyptus punctata		**X**	x	x		x	x		x	x	7

Eucalyptus radiata						x						1
Eucalyptus scias									x			1
Eucalyptus sieberi	x			**X**			**X**			**X**	x	x	6
Eucalyptus umbra ssp. *umbra*											x	x	2
Syncarpia glomulifera								**X**	x			x	3
Shrubs													
Grevillea buxifolia		x		x				x	x	x	x	x	7
Grevillea diffusa	x	x		x									3
Grevillea linearifolia										x	x	x	3
Grevillea longifolia	x	x											2
Grevillea mucronulata	x	x		x		x			x				6
Grevillea oldei												x	1
Grevillea oleoides		x		x									2
Grevillea phylicoides									x				1
Grevillea sericea	x			x		x			x	x	x	x	8
Grevillea sphacelata		x		x									2
Leucopogon amplexicaulis	x			x						x	x	x	5
Leucopogon ericoides	x	x		x							x	x	5
Leucopogon esquamatus	x												1
Leucopogon exolasius	x	x											2
Leucopogon lanceolatus	x			x		x			x			x	6
Leucopogon margarodes												x	1
Leucopogon microphyllus		x		x						x			3
Leucopogon muticus						x		x	x				4
Leucopogon setiger				x						x		x	3
Leucopogon virgatus						x							1

b) Forest on Hawkesbury Shale caps. Regions after Pidgeon (1941): Cn- Coastal, Nepean Ramp sub-region; Ch- Coastal, Hornsby Plateau sub-region; Co- Coastal, Ourimbah sub-region. Localities: O'Hares Creek catchment (comm. SF, this study); RNP- Royal NP (Keith unpubl. data); GNP- Garrigal NP (map units 10 & 12, Sherringham & Sanders 1993); KCP- Ku-ring-gai Chase NP (comm. 8, Thomas & Benson 1985); BWP- Brisbane Water NP (comm. 4S, Benson & Fallding 1981).

Region:	**Cn**	**Cn**	**Ch**	**Ch**	**Co**	
Locality:	**OHC**	**RNP**	**GNP**	**KCP**	**BWP**	**Total**
Trees						
Angophora costata	**X**	x	**X**	**X**	**X**	5
Eucalyptus capitellata			**X**			1
Eucalyptus globoidea	**X**	**X**			x	3
Eucalyptus gummifera	**X**	x	**X**		**X**	4
Eucalyptus haemastoma					x	1
Eucalyptus oblonga					x	1
Eucalyptus paniculata		x				1
Eucalyptus pilularis		**X**		**X**		2
Eucalyptus piperita	**X**					1
Eucalyptus punctata				**X**		1
Eucalyptus resinifera		x		x		2
Eucalyptus saligna	x					1
Eucalyptus sieberi	x		**X**			2
Eucalyptus umbra ssp. *umbra*			**X**		x	2
Syncarpia glomulifera		x		x	x	3

Shrubs						
Acacia binervata	x					1
Acacia irrorata	x	x				2
Acacia linifolia	x	x		x	x	4
Acacia longifolia	x	x				2
Acacia longissima			x	x		2
Acacia myrtifolia	x	x	x		x	4
Acacia stricta	x					1
Acacia ulicifolia				x		1
Pultenaea daphnoides	x			x	x	3
Pultenaea elliptica					x	1
Pultenaea ferruginea var. *deanei*				x	1	
Pultenaea hispidula	x	x	x	x		4
Pultenaea linophylla	x					1
Pultenaea microphylla			x			1
Pultenaea rosmarinifolia					x	1

O'Hares Creek catchment contains plant communities that are not well sampled in existing conservation reserves on Sydney sandstone (Table 6, Appendix 1). These include the five upland swamp communities, Shale Forest, Western Gully Forest, Ironstone Woodland, Heath Woodland and Rock Pavement Heath. Sandstone Woodland and Eastern Gully Forest are comparatively well represented in reserves. Stands of Mallee Heath and Ironstone Heath are significant because these represent the southern distributional limits of these community types. Examples of Riparian Scrub in O'Hares Creek catchment are unaffected by weed invasion, unlike many comparable stands within reserves where runoff is polluted by urban and industrial development in upper catchments. Overall levels of disturbance are minimal and the introduced flora is small, though both are increasing in recent years mainly as a result of mining activities. Disturbed areas such as clay quarries and tracks regenerate over time with native species, though not necessarily to their original species composition. Exceptions with significant weed invasion include sites exposed to frequent vehicular use (e.g. Bulli–Appin Rd) and sites exposed to enriched moisture and/or nutrients (e.g. mine effluent irrigation sites, rural interfaces).

O'Hares Creek Catchment includes a large number (17) of nationally rare or threatened plant taxa (Table 2). For three of the most restricted taxa (*Pultenaea aristata, Leucopogon exolasius* and *Grevillea longifolia)* the area contains major populations, whose maintenance is important for overall conservation of these species. O'Hares Creek is also an important biogeographic location for eleven taxa that reach their southern limit of distribution in the area, including seven Sydney sandstone endemics and two species that extend well north of Sydney along coastal sands. The population of *Callitris endlicheri* is also of biogeographic significance. Its presence in an area that receives two to three times the average annual rainfall of typical *C. endlicheri* habitat, and its isolation from other populations of the species, suggest that it persists as a relic of populations that were more widespread during a drier late Pleistocene climate.

A large volume of biological and geomorphological data has been gathered in O'Hares Creek area since Allan Cunningham made his early collections. Completed studies address topics of stream dynamics and landscape evolution (Harden 1965), upland swamp geomorphology and palynology (Young 1983, 1986a,b), vegetation patterns and dynamics (Davis 1936, 1941, Keith 1991, Keith & Myerscough 1993), rare plant ecology (Andren et al. 1987, Auld et al. 1993) and koala ecology (Cork et al. 1988, Close 1993). Further studies in fire ecology, plant reproductive biology and ecological modelling are in progress. Universities of Sydney and Wollongong use the area for practical components of undergraduate courses on ecology and conservation biology. These studies and a geographic information system developed as part of the current work underpin the value of O'Hares Creek catchment as a scientific reference area and as an important augmentation to the regional network of conservation reserves.

Acknowledgements

Mark Tozer assisted with GIS management and prepared the map and figures. Mark, with assistance from Lisa Metcalfe, overcame many technical difficulties to develop the procedure for translating GIS map data into a final publishable layout. The first fully computer-generated vegetation map published in *Cunninghamia* is his innovative contribution. Vegetation boundaries were digitised by David Eckstein. Belinda Pellow and Elizabeth Ashby assisted with data collection. George Williams of the Sydney Water Board provided logistic support and local knowledge in the field. Peter Myerscough, Dominic Sivertsen and Peter Clarke commented on the draft.

References

Andren, M., Chaffe, C., Stephens, K. & Telford, E. (1987) Rare plants of the Metropolitan, O'Hares and Woronora water catchment areas. In Telford, E., Marthick, J., Russel, D. & Lambkin, K. (eds.) *Environmental science studies in ecology.* (University of Wollongong: Wollongong).

Auld, T.D., Bradstock, R.A. & Keith, D.A. (1993) *Fire as a threat to populations of rare plants. Endangered Species Project No. 31.* Australian National Parks & Wildlife Service Endangered Species Program.

Beadle, N.C.W. (1954) Soil phosphate and the delimitation of plant communities in eastern Australia I. *Ecology* 35: 370–375.

Beadle, N.C.W. (1962) Soil phosphate and the delimitation of plant communities in eastern Australia II. *Ecology* 43: 281–288.

Bedward, M., Keith, D.A. & Pressey, R.L. (1992) Homogeneity analysis: assessing the utility of classifications and maps of natural resources. *Australian Journal of Ecology* 17: 133–139.

Belbin, L. & McDonald, C. (1993) Comparing three classification strategies for use in ecology. *Journal of Vegetation Science* 4: 341–348.

Benson, D.H., Burkitt, J. & Thomas, J. (1990) The natural vegetation of Bents Basin State Recreation Area. *Cunninghamia* 2: 223–262.

Benson, J.S. & Fallding, H. (1981) Vegetation survey of Brisbane Water National Park. *Cunninghamia* 1: 79–113.

Binns, D. & Chapman, W. (1992) Flora survey, Wingham management area, Port Macquarie region. Forest Resources Series No. 18. Forestry Commission of NSW.

Bowman, H. N., Stroud, W. J., Sherwin, L. & Ray, H. N. (1986) Sydney Basin stratigraphy. In Sherwin, L. and Holmes, G.G. (eds).*Geology of the Wollongong and Port Hacking 1:100,000 sheets.* (Geological Survey of New South Wales: Sydney).

Briggs, J.D. & Leigh, J.L. (1988) *Rare or threatened Australian plants.* Special Publication No. 14. (Australian National Parks & Wildlife Service: Canberra).

Buchanan, R. A. (1980). The Lambert Peninsula Ku-ring-gai Chase National Park. Physiography and the distribution of podzols, shrublands and swamps, with details of swamp vegetation and sediments. *Proceedings of the Linnean Society of New South Wales* 104: 73–94.

Burrough, P.A., Brown, L. & Morris, E.C. (1977) Variations in vegetation and soil pattern across the Hawkesbury Sandstone plateau from Barren Grounds to Fitzroy Falls, New South Wales. *Australian Journal of Ecology* 2: 137–159.

Clarke, P.J. & Benson, D.H. (1986) Vegetation survey of Dharug National Park. National Herbarium of NSW, Royal Botanic Gardens, Sydney.

Clements, A. (1983) Suburban development and resultant changes in the vegetation of the bushland of the northern Sydney region. *Australian Journal of Ecology* 8: 307–319.

Close, R. (1993) Campbelltown koalas: what is their future? *National Parks Journal* 37: 22–25.

Cork, S.J, Margules, C.R. & Braithwaite, L.W. (1988) *A survey of koalas and their habitat near Wedderburn N.S.W., suggestions for management, and an assessment of the potential effects of a proposed subdivision of four-hectare environmental lots.* (CSIRO Division of Wildlife and Ecology: Canberra).

Davis, C. (1936) Plant ecology of the Bulli district I: Stratigraphy, physiography and climate; general description of plant communities and interpretation. *Proceedings of the Linnean Society of New South Wales* 61: 285–297.

Davis, C. (1941) Plant Ecology of the Bulli district II: Plant communities of the plateau and scarp. *Proceedings of the Linnean Society of New South Wales* 66: 1–19.

Faith, D.P., Minchin, P.R. & Belbin, L. (1987) Compositional dissimilarity as a robust measure of ecological distance: a theoretical model and computer simulations. *Vegetatio* 69: 57–68.

Griffith, S.J. (1988) A survey of the vegetation of Yuraygir National Park. NSW National Parks & Wildlife Service.

Harden, R.W. (1965) *Some aspects of the fluvial morphology of the upper Georges River basin.* MSc thesis. University of Sydney.

Harden, G. (1990, 1991, 1992, 1993) *Flora of New South Wales* Volumes 1–4. (University of New South Wales Press: Kensington).

Hill, M.O. (1978) *TWINSPAN: A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes.* Section of Ecology and Systematics. (New York: Cornell University).

Hovenden, M. (1989) *Serotinous seed bank of Hakea dactyloides (Gaertner) Cav: its characteristics and responses.* BSc(Hons.) thesis. University of Sydney.
Keith, D.A. (1991) Coexistence and species diversity in upland swamp vegetation: the roles of an environmental gradient and recurring fires. PhD thesis. University of Sydney.
Keith, D.A. & Benson, D.H. (1988) Natural vegetation of the Katoomba 1:100 000 map sheet. *Cunninghamia* 2: 107–143.
Keith, D.A. & Myerscough, P.J. (1993) Floristics and soil relations of upland swamp vegetation near Sydney. *Australian Journal of Ecology* 18: 325–344.
Keith, D.A. & Sanders, J.M. (1990) Vegetation of the Eden region, south-eastern New South Wales, Australia. *Journal of Vegetation Science* 1: 203–232.
Krauss, S. (1994) *V*ariation in *Leptospermum trinervium* (Myrtaceae): a problem species and the species problem. *Australian Systematic Botany* 7: 251–263.
Lance, G.N. & Williams, W.T. (1967) A general theory of classificatory sorting strategies I. Hierarchical systems. *Computing Journal* 9: 373–380.
Lee, I. (1925) *Early explorers in Australia.* (Metheuen: London).
Minchin, P.R. (1987). An evaluation of the relative robustness of techniques for ecological ordination.*Vegetatio* 69: 89–107.
Minchin, P.R. (1991) DECODA: Database for Ecological Community Data. Version 2.04. Australian National University.
Peet, R.K. (1978) Forest vegetation on the Colorado Front Range: patterns of species diversity. *Vegetatio* 37: 65–78.
Pidgeon, I. (1938) The ecology of the central coast area of New South Wales. II. Plant succession on the Hawkesbury Sandstone. *Proceedings of the Linnean Society of New South Wales* 63: 1–26.
Pidgeon, I. (1941) The ecology of the central coast area of New South Wales. IV. Forest types on soils from Hawkesbury Sandstone and Wianamatta Shale. *Proceedings of the Linnean Society of New South Wales* 66: 113–137.
Poore, M. E. D. (1955) The use of phytosociological methods in ecological investigations. I. The Braun-blanquet system. *Journal of Ecology* 43: 226–244.
Sanders, J.M., Bedward, M., Leahy, B., Robinson, M. & Sherringham, P. (1988) Preliminary report on the vegetation of Yengo National Park and Parr State Recreation Area. NSW National Parks and Wildlife Service.
Sherringham, P.R. & Sanders, J.M. (1993) Vegetation survey of Garrigal National Park and surrounding crown lands. NSW National Parks & Wildlife Service.
Sherwin, L., Walsh, I.L., Roy, P.S. & Hann, J. (1986) Cainozoic sediments. In Sherwin, L. & Holmes, G.G. (eds). *Geology of the Wollongong and Port Hacking 1:100,000 sheets.* Geological Survey of New South Wales: Sydney).
Thomas, J. & Benson, D.H. (1985) Vegetation survey of Ku-ring-gai Chase National Park. National Herbarium of NSW, Royal Botanic Gardens, Sydney.
Young, A.R.M. (1983) Upland swamps (dells) on the Woronora Plateau, NSW. PhD thesis. University of Wollongong.
Young, A R.M. (1986a) The geomorphic development of dells (upland swamps) on the Woronora Plateau, NSW, Australia. *Zeitscrift fur Geomorphologie* 30: 317–327.
Young, A.R.M. (1986b) Quaternary sedimentation on the Woronora Plateau and its implications for climatic change. *Australian Geographer* 17: 1–5.

Manuscript received 21 September 1993
Manuscript accepted 14 March 1994

Appendix 1: Description of Plant Communities

SF Shale Forest (Figure 7)

Samples: 1,2,3,4,5,6,7,8.

Habitat: Deep, well-drained red loam on outcrops of Hawkesbury Shale. Flat ridgetops and adjacent slopes.

Distribution: 176 ha (1.9% of study area). Restricted to patches on broad ridges in the eastern third of the catchment.

Trees: 20 m tall, 39% cover; *Eucalyptus globoidea* is exclusive to this community. *Angophora costata, E. piperita* and *E. gummifera* co-occur in various combinations. Rare occurrences of *Eucalyptus saligna.*

Shrubs: 5 m tall, 13% cover; *Acacia binervata, A. longifolia, Pultenaea linophylla, P. hispidula* and *Olearia erubescens* are exclusive. Other common taxa include *Banksia spinulosa, Lomatia silaifolia, Phyllanthus hirtella, Ozothamnus diosmifolius, Hibbertia empetrifolia, Leucopogon lanceolata* and *Persoonia linearis.*

Groundcover: 0.8 m tall, 54% cover; dominated by grasses, forbs, vines and ferns. *Themeda australis, Pratia purpurascens, Pterostylis grandiflora, Viola betonicifolia, Goodenia heterophylla, Eustrephus latifolius, Kennedia rubicunda, Clematis aristata* and *Comesperma volubile* are exclusive. Other common taxa include *Imperata cylindrica, Dichelachne rara, Brunoniella pumilio, Lagenifera stipitata, Doryanthes excelsa, Lomandra longifloia, Lepidosperma laterale, Glycine clandestina, Blechnum cartilagineum* and *Calochlaena dubia.*

Variability: Samples on the Darkes Forest ridge are typified by a more mesic understorey than on smaller shale outcrops further west.

Figure 7. Shale Forest dominated by *Eucalyptus globoidea* with dense stands of *Doryanthes excelsa* and native grasses in the understorey.

Disturbance: Most stands have been selectively logged for fencing and firewood. The patch at Darkes Forest has been partly cleared for agricultural uses. Three other stands have been partly cleared for clay quarry operations.

Conservation: Shale Forest is important locally as habitat because it differs in markedly in composition and structure from surrounding vegetation on sandstone. Regionally, isolated stands of O'Hares Creek Shale Forest is transitional between more mesic escarpment forests on Narrabeen shales to the east and drier Cumberland Plain woodlands on Wianamatta shales to the west. However, widespread elements of the escarpment forests (e.g. *Eucalyptus pilularis, Syncarpia glomulifera*) and the plain woodlands (e.g. *Eucalyptus moluccana, Bursaria spinosa*) are absent from the O'Hares Creek Shale Forest, and some species found in the latter (e.g. *Pultenaea hispidula*) are poorly represented on the escarpment and plain. Forests occur on Hawkesbury Shale further north, but have a restricted distribution, and differ in floristic composition from those at O'Hares Creek (Table 6b). Such forests at Sutherland–Cronulla, Engadine, Frenchs Forest and Duffeys Forest have been cleared, while smaller patches such as those at Menai and Helensburgh retain forests under threat from urban development. Small, but differing stands are reserved near Loftus (Keith unpubl.) and near Wondabyne (Benson & Fallding 1981).

WGF Western Gully Forest

Samples: 9,10,11,26,33,34,35,36,43.

Habitat: Sheltered slopes of major sandstone gullies and restricted patches on narrow ridges (possibly with relictual shale influence). Soils are shallow, well-drained, moist sands and sandy loams.

Distribution: 822 ha (8.7% of study area). Gullies and adjacent ridges in western part of catchment.

Trees: 20 m tall, 31% cover; *Eucalyptus punctata* and *E. pilularis* occur exclusively in gullies in this community, while *E. consideniana* and *E. multicaulis* are exclusive to ridgetops. Other taxa include *E. agglomerata* and *Angophora costata* in gullies, and *E. gummifera* and *E. oblonga* on ridgetops.

Shrubs: 2.2 m tall, 43% cover; *Exocarpos strictus* and *Pomaderris lanigera* are exclusive. Other common taxa include *Banksia spinulosa, Dodonaea triquetra, Pultenaea flexilis, Lissanthe strigosa, Dillwynia retorta, Bossiaea heterophylla, Leptospermum trinervium* (narrow-leaved form), *Petrophile sessilis, Grevillea mucronulata, Persoonia linearis, P. levis, Platysace linearifolia* and *Eriostemon australasius*.

Groundcover: 0.4 m tall, 16% cover; *Aristida vagans* and *Xanthorrhoea concava* are exclusive. Other common taxa include *Acianthus fornicatus, Entolasia stricta, Caustis flexuosa* and *Pomax umbellata*.

Variability: In gullies the tree stratum is taller and includes *Eucalyptus punctata, E. pilularis, E. agglomerata* and *Angophora costata* (samples 11,26,33,35,36). Stands on ridges are restricted and include *E. consideniana, E. multicaulis, E. gummifera* and *E. oblonga* (samples 10,11,34,43).

Disturbance: Selective logging in small accessible areas.

Conservation: The community is likely to extend along the western edge of the Woronora Plateau to the Holsworthy Military Area in the north and Water Board catchments in the south. Similar communities may occur in conservation reserves in the Nattai area and lower Blue Mountains, although some differences in composition may be expected. Near Wedderburn, Western Gully Forest is habitat for a significant population of koalas (Cork et al. 1988, Close 1993).

EGF Eastern Gully Forest (Figure 8)

Samples: 23,25,27,28,29,30,31,32

Habitat: Sheltered slopes of major sandstone gullies. Soils are shallow, well-drained, moist sands and sandy loams.

Distribution: 1562 ha (16.6% of study area). Gullies in the eastern part of the catchment.

Trees: 20 m tall, 28% cover; *Eucalyptus piperita* with *Angophora costata, E. gummifera* and *E. sieberi*.

Shrubs: 3.0 m tall, 37% cover; *Banksia cunninghamii* is exclusive to this community. Other common taxa

Figure 8. Eastern Gully Forest dominated by *Eucalyptus piperita* (foreground) and *Angophora costata* (smooth bark) with dense understorey of proteaceous, myrtaceous and fabaceous shrubs.

Figure 9. Riparian Scrub with *Leptospermum morrisonii, Tristaniopsis laurina* and other myrtaceous shrubs.

include *Aotus ericoides, Zieria laevigata, Hakea dactyloides* (single-stemmed form), *Monotoca scoparia, Hibbertia monogyna, Banksia serrata, Lambertia formosa, Persoonia pinifolia, P. levis, Platysace linearifolia, Acacia ulicifolia, Eriostemon australasius* and *Leptomeria acida*.

Groundcover: 0.7 m tall, 11% cover; *Lycopodium deuterodensum, Stylidium productum, Chloanthes stoechardis* and *Gahnia radula* are exclusive. Other common taxa include *Xanthosia pilosa* (entire-leafed form), *Gonocarpus teucrioides, Smilax glyciphylla, Cassytha pubescens, Lomandra gracilis, Patersonia glabrata, Lepidosperma laterale* and *Lepyrodia scariosa*.

Disturbance: No obvious disturbance.

Conservation: Similar vegetation is represented within Heathcote and Royal NPs (Keith unpubl. data). Forests in sandstone gullies further south are without *A. costata*, but otherwise similar. Reserves north and west of Sydney sample large areas of forest in sandstone gullies, but these differ in composition (Table 6a).

RS Riparian Scrub (Figure 9)

Samples: 19,20,21,22; outliers: 18,24.

Habitat: Moist, sandy alluvium amongst rocks along major creeks.

Distribution: 216 ha (2.3% of study area). O'Hares and Stokes Creeks and their major tributaries.

Trees: Typically none.

Shrubs: 4.1 m tall, 40% cover; *Tristaniopsis laurina, Tristania neriifolia, Leptospermum morrisonii, Ceratopetalum apetalum, Pseudanthus pimelioides, Lomatia myricoides, Prostanthera linearis, Phebalium dentatum, P. squamulosum* and *Micrantheum hexandrum* are exclusive to this community. Other common taxa include *Acacia obtusifolia, A. irrorata, Monotoca scoparia, Bauera rubioides* and *Grevillea longifolia*.

Groundcover: 0.6 m tall, 24% cover; *Lomandra fluviatilis* is exclusive. Other common taxa include *Restio dimorphus, Sticherus flabellatus, Lomandra longifolia* and *Lepidosperma laterale*.

Variability: Sheltered, rocky sites support tall scrub dominated by *T. laurina* and *C. apetalum*. Open sandy sites support heath with various smaller shrubs. Samples 18 & 24, on sandstone slopes adjacent to creeks, are intermediate in composition between Riparian Scrub and Eastern Gully Forest.

Disturbance: Small weirs on O'Hares and Stokes record stream flow. Each creek is also crossed by one ford. Otherwise, no evidence of disturbance. No exotic species recorded.

Conservation: Similar vegetation is represented in Royal and Heathcote NPs, as well as other sandstone reserves. However, O'Hares Creek catchment includes an example that is significant because of its condition, much riparian vegetation on Sydney sandstone being infested with weeds.

IW Ironstone Woodland (Figure 10)

Samples: 12,13,14,15.

Habitat: Flat areas of the plateau with a thick mantle of ironstone. Soils are well-drained red loams.

Distribution: 297 ha (3.2% of study area). Restricted to 2 main patches. Along 10B fire trail between Appin Rd and 10C fire trail and from the head of O'Hares Creek to Maddens Plains.

Trees: 13 m tall, 17% cover; *Eucalyptus sieberi* is most abundant in this community. Other common taxa include *E. racemosa* and *E. gummifera*.

Shrubs: 1.5 m tall, 44% cover; *Acacia myrtifolia, Daviesia corymbosa* and *Banksia paludosa* are most abundant in this community. Other common taxa include *Lambertia formosa, Hakea dactyloides* (multi-stemmed form), *Persoonia levis, Gompholobium grandifolium* and *Pimelea linifolia*.

Figure 10. Ironstone Woodland with *Eucalyptus sieberi* (left), *E. racemosa* (right) and mallee *E. gummifera*. The understorey is dominated by shrubs in the Fabaceae and Proteaceae.

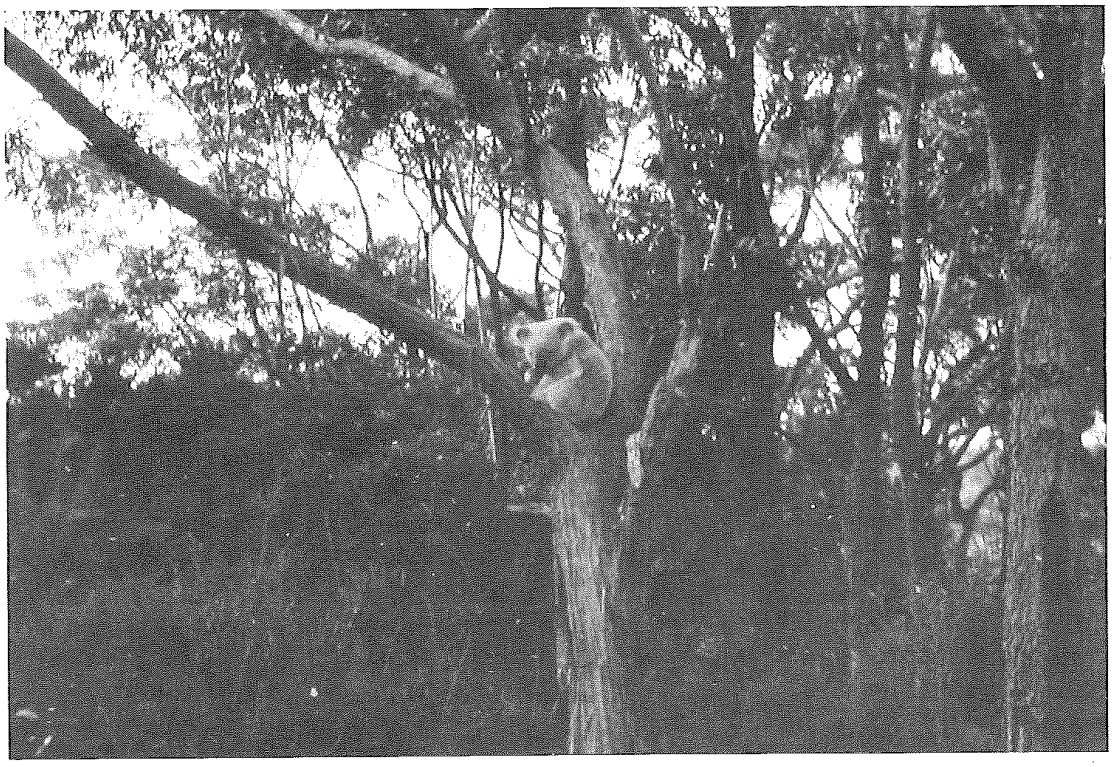

Figure 11. Sandstone Woodland near Wedderburn with *Eucayptus gummifera* (right) and *E. oblonga* (centre) and a diverse shrubby understorey. Sandstone Woodland and Western Gully Forest provide habitat for a population of koalas in this area.

Groundcover: 0.4 m tall, 23% cover; *Dampiera stricta, Gonocarpus tetragynus, Patersonia glabrata* and *Anisopogon avenaceus*.

Disturbance: Small borrow pits for gravel.

Conservation: Limited stands of similar vegetation in Royal NP (Keith unpubl. data), Garigal NP (map unit 11, Sherringham & Sanders 1993), Ku-ring-gai Chase NP (comm. 10, Thomas & Benson 1985) and around Warrah trig in Brisbane Water NP (comm. 4P, Benson & Fallding 1981).

SW Sandstone Woodland (Figure 11)

Samples: 37,38,42,47; outliers 39,40.

Habitat: Flat and undulating sandstone ridges and plateau tops. Soils are well-drained shallow sandy loams.

Distribution: 4446 ha (47.2% of study area). Widespread throughout catchment.

Trees: 9.5 m tall, 22% cover; *Eucalyptus oblonga* is characteristic of this community. Other trees include *E. gummifera, E. racemosa* and *E. sieberi*.

Shrubs: 1.2 m tall, 35% cover; *Bossiaea obcordata* is exclusive. Other common taxa include *Banksia spinulosa, B. marginata, B. serrata, Conospermum longifolium var. angustifolium, Grevillea sphacelata, Persoonia pinifolia, P. levis, Leptospermum trinervium* (narrow-leaved form), *Platysace ericoides, Hakea dactyloides* (multi-stemmed form), *Isopogon anemonifolius, Bossiaea heterophylla, Eriostemon australasius* and *Phyllota phylicoides*.

Groundcover: 0.4 m tall, 23% cover; common taxa include *Caustis flexuosa, Dampiera stricta, Lomandra glauca, Xanthorrhoea media* and *Cyathochaeta diandra*.

Variability: Closely related to Mallee Heath and Ironstone Woodland. Samples 39 & 40 are less clearly differentiated from these related communities than the other four samples.

Disturbance: Localised clearing for mine ventilation shafts, otherwise no obvious disturbance.

Conservation: Similar vegetation is represented within Royal, Heathcote and Garrawarra NPs and in Water Board catchments elsewhere on the Woronora Plateau (Keith unpubl. data). Analogous communities are widespread on sandstone plateaux north and west of Sydney (e.g. comm. 6 of Benson & Fallding (1981), 15 of Thomas & Benson (1985), C2 of Clarke & Benson (1986), 10ar of Keith & Benson (1988), map unit 7 of Sherringham & Sanders (1993)).

HW Heath Woodland

Samples: 44,45,46.

Habitat: Broad, flat plateau tops with an ironstone mantle overlying sandstone. Soils are damp, shallow sandy loams.

Distribution: 156 ha (1.7% of study area). Two main patches: along 10B fire trail between its junction with 10C and 10K trails; and along 10H fire trail near its junction with Darkes Forest Road.

Trees: 9.0 m tall, 7% cover; *Eucalyptus haemastoma* is dominant, *E. gummifera* in its mallee growth form is common, infrequent taxa include *E. racemosa, E. sieberi* and *E. oblonga*.

Shrubs: 1.2 m tall, 38% cover; *Petrophile pulchella, Banksia oblongifolia, Persoonia pinifolia, Hakea dactyloides* (multi-stemmed form), *Pimelea linifolia, Isopogon anemonifolius, Lambertia formosa, Grevillea oleoides, Hemigenia purpurea, Leucopogon esquamatus* and *Leptospermum trinervium* (broad-leaved form) are common taxa.

Groundcover: 0.4 m tall, 37% cover; *Patersonia glabrata, P. sericea, Lindsaea linearis, Lomandra obliqua, Cyathochaeta diandra, Lepyrodia scariosa, Ptilanthelium deustum, Schoenus pachylepis, Leptocarpus tenax, Mitrasacme polymorpha, Dampiera stricta, Xyris gracilis* ssp. *laxa, Xanthorrhoea media, Gonocar-*

Figure 12. Ironstone Heath dominated by *Angophora hispida, Banksia oblongifolia* (bottom left) and emergent *Leptospermum trinervium*. Groundcover consists of graminoid and lilioid taxa.

Figure 13. Mallee Heath dominated by *Eucalyptus luehmanniana*. *Banksia ericifolia* is conspicuous in the diverse understorey.

pus tetragynus, Anisopogon avenaceus, Actinotus minor, Mirbelia rubiifolia, Cassytha glabella, Selaginella uliginosa, Goodenia bellidifolia, Xanthosia tridentata, Thysanotus juncifolius and *Drosera peltata* are common taxa.

Disturbance: Localised patches cleared for army bivouacs.

Conservation: Limited stands represented in Royal NP (Keith unpubl. data). Larger stands in the Menai-Holsworthy area. Analogous vegetation types have been described on the Hornsby Plateau, but these are restricted in area (e.g. community C3 of Clarke & Benson (1986), map unit 6 of Sanders & Sherringham (1993)).

IH Ironstone Heath (Figure 12)

Samples: 16,17.

Habitat: Broad, flat plateau top with an ironstone mantle overlying sandstone. Soils are damp, shallow sandy loams.

Distribution: 12 ha (0.1% of study area). One small patch near 10B trig.

Shrubs: 1.0 m tall, 50% cover; *Angophora hispida, Hakea dactyloides* (multi-stemmed form), *Lomatia silaifolia, Pultenaea elliptica* (red-flowered form), *Conospermum taxifolium, Brachyloma daphnoides, Kunzea capitata* and *Eucalyptus haemastoma* are characteristic of this community. Other common taxa include *Hibbertia serpyllifolia, Acacia suaveolens, Leptospermum arachnoides, Petrophile pulchella, Pimelea linifolia, Isopogon anemonifolius, Lambertia formosa, Banksia oblongifolia, B. paludosa, Daviesia corymbosa, Grevillea oleoides, Persoonia levis, Platysace linearifolia, Eriostemon australasius, Leucopogon esquamatus* and *Leptospermum trinervium* (broad-leaved form).

Groundcover: 0.5 m tall, 20% cover; *Cyathochaeta diandra, Ptilanthelium deustum, Schoenus pachylepis, Patersonia glabrata, P. sericea, Scaevola ramosissima, Platysace ericoides, Dampiera stricta, Lomandra glauca, L. obliqua, Xyris gracilis* ssp. *laxa, Xanthorrhoea media, Gonocarpus tetragynus, Anisopogon avenaceus, Lindsaea linearis, Haemadorum corymbosum, Lepyrodia scariosa, Tricostularia pauciflora, Mirbelia rubiifloia, Cassytha glabella, Xanthosia tridentata, Drosera peltata, Burchardia umbellata, Sowerbaea juncea* and *Blandfordia nobilis*.

Variability: Closely related to woodland heath, but treeless.

Disturbance: Small area cleared for road gravel extraction.

Conservation: Larger areas in the north of Holsworthy Military Area to Menai area. Several patches represented in Royal NP, though these heathlands are more variable in composition (Keith unpubl. data). Heathlands in Ku-ring-gai Chase, Dharug and Garrigal NFs share some species, but differ in overall composition (Thomas & Benson 1985, Sherringham & Sanders 1993, Clarke & Benson 1986).

MH Mallee Heath (Figure 13)

Sites: 41,48,49,50,52.

Habitat: Stoney sandstone ridgetops with shallow, well-drained sandy loams.

Distribution: 28 ha (0.3% of study area). Small patches scattered in eastern part of catchment.

Trees: 4.8 m tall, 22% cover; *Eucalyptus luehmanniana* is characteristic of this community, *E. gummifera* (mallee growth form) is common.

Shrubs: 1.2 m tall, 35% cover; *Leucopogon microphyllus, Epacris microphylla, Leptospermum trinervium* (narrow-leaved form), *L. arachnoides, Monotoca scoparia, Acacia suaveolens, Petrophile pulchella, Hakea dactyloides* (multi-stemmed form), *Pimelea linifolia, Banksia ericifolia, B. serrata, B. oblongifolia, Hibbertia serpyllifolia, Daviesia corymbosa, Grevillea oleoides, Acacia ulicifolia, Platysace linearifolia, Eriostemon australasius, Xanthosia tridentata* and *Kunzea capitata*.

Groundcover: 0.4 m tall, 23% cover; *Entolasia stricta, Scaevola ramosissima, Dampiera stricta, Lomandra glauca, L. obliqua, Xyris gracilis* ssp. *laxa, Xanthorrhoea media, Bossiaea ensata, Gonocarpus tetragynus, Anisopogon avenaceus, Lindsaea linearis, Cyathochaeta diandra, Actinotus minor* and *Lepyrodia scariosa*.

Variability: Closely related to Sandstone Woodland.

Disturbance: No obvious disturbance.

Conservation: Mallee heath dominated by *E. luehmanniana* and *E. gummifera* is represented within Royal NP (Keith unpubl. data), Garrigal NP (map unit 5 of Sherringham & Sanders 1993), Ku-ring-gai Chase NP (community 16 of Thomas & Benson 1985) and Brisbane Water NP (part of community 6 of Benson & Fallding 1981). However, there are minor differences in understorey floristics and the community is locally restricted in these areas, as it is in O'Hares Creek catchment where it reaches its southern limit.

RPH Rock Pavement Heath

Sites: 51,53,54,55,56.

Habitat: Massive sandstone pavements on the plateau. Soils are skeletal, sandy and damp to very dry, depending on recent weather.

Distribution: 11 ha (0.1% of study area). Restricted to a few very small patches in the eastern and southern part of the catchment.

Shrubs: 1.5 m tall, 35% cover; *Monotoca ledifolia* is exclusive to this community. Characteristic taxa include *Kunzea ambigua* and *Darwinia fascicularis*. *Persoonia pinifola* is also present.

Groundcover: 0.5 m tall, 9% cover; *Lepidosperma viscidum* (red-gum form) and *Thelionema umbellatum* are exclusive. *Lepyrodia scariosa* is also present.

Variability: Few species occur consistently across most sites.

Disturbance: No obvious disturbance.

Conservation: Similar heath occurs in Royal NP (Keith unpubl. data). Heath on rock pavements north of Sydney differs in some of the major species (notably *Baeckea* spp.). Examples include community 18 of Thomas & Benson (1985), map unit 1 of Sherringham & Sanders (1993), community C5 of Clarke & Benson (1986) and community 9 of Benson & Fallding (1981). All these communities are highly restricted.

BT Banksia Thicket

Sites: S3,S14,S18,S31,S37,S48,S53.

Habitat: Upper slopes of large upland swamps. Soils are damp, shallow sandy loams.

Distribution: 95 ha (1.0% of study area). Patches restricted to southern part of catchment.

Shrubs: 3.4 m tall, 75% cover; *Banksia ericifolia* and *Hakea teretifolia* (single-stemmed form) are dominant and, with *Pultenaea aristata*, characteristic of this community. Other common taxa include *Banksia oblongifolia, Dillwynia floribunda* and *Grevillea oleoides*.

Groundcover: 0.6 m tall, 55% cover; *Tetrarrhena turfosa, Selaginella uliginosa, Lindsaea linearis, Empodisma minus, Gonocarpus tetragynus, Dampiera stricta, Lepidosperma neesii, Ptilanthelium deustum, Leptocarpus tenax, Lepyrodia scariosa, Schoenus brevifolius, Cassytha glabella, Entolasia stricta* and *Xanthorrhoea resinifera*.

Variability: Distribution, structure and composition vary depending on fire history. Frequent fires eliminate the overstorey or reduce its density (Keith 1991). Some stands include emergent eucalypts of Sandstone Woodland.

Disturbance: No obvious disturbance.

Conservation: Examples further south may be limited. Analogous communities further north in Royal NP (Keith unpubl. data), Ku-ring-gai Chase NP (community 17 of Thomas & Benson 1985), Garrigal NP (map unit 3 of Sherringham & Sanders 1993) and Brisbane Water NP (community 8 of Benson & Fallding 1981). However, these latter communities differ in composition, notably in the presence of *Allocasuarina distyla* as co-dominant.

SHC Sedgeland-Heath Complex (Figure 14)

– RH. Restioid Heath

Sites: S4,S6,S8,S9,S17,S2,S32,S36,S38,S39,S44,S47,S51,S52,S55.

Habitat: Damp upper slopes of large upland swamps or widespread in swamps without major seepage zones. Soils are occasionally waterlogged shallow sandy loams.

Distribution: Patches scattered throughout the south and east of the catchment. Restioid Heath occupies *ca.* 60% of the Heath-Sedgeland Mosaic (860 ha, 9.1% of study area).

Shrubs: 0.9 m tall, 38% cover; *Banksia oblongifolia, Hakea teretifolia* (multi-stemmed form), *Cryptandra ericoides* and *Grevillea parviflora* are characteristic of this community. Other common taxa include *Grevillea oleoides, Conospermum ellipticum, Bauera microphylla* and *Epacris obtusifolia*.

Groundcover: 0.6 m tall, 77% cover; *Lomandra filiformis* ssp. *filiformis, L. cylindrica, Plinthanthesis paradoxa, Burchardia umbellata, Patersonia* sp. aff. *fragilis, P. sericea and Haemadorum corymbosum* are characteristic. Other common taxa include *Stackhousia nuda, Thysanotus juncifolius, Lepidosperma neesii, Lindsaea linearis, Gonocarpus tetragynus, Dampiera stricta, Drosera spathulata, Goodenia bellidifolia, G. dimorpha* var. *angustifolia, Stylidium lineare, Sowerbaea juncea, Blandfordia nobilis, Mitrasacme polymorpha, Ptilanthelium deustum, Leptocarpus tenax, Lepyrodia scariosa, Empodisma minus, Schoenus*

Figure 14. Sedgeland-Heath Complex at Maddens Plains showing Restioid Heath (foreground) with *Xanthorrhoea resinifera* and *Banksia oblongifolia*, grading into Cyperoid Heath (middle distance). The drainage line in the distance supports Ti-tree Thicket.

brevifolius, Cassytha glabella, Entolasia stricta, Xanthorrhoea resinifera, Xyris gracilis ssp. *laxa* and *X. operculata*.

Disturbance: Small patches excavated for clay extraction, otherwise undisturbed.

Conservation: Common in Water Board catchments on Woronora Plateau. Limited examples in Royal NP (Keith unpubl. data), on Lambert Peninsula in Ku-ring-gai Chase NP (Buchanan 1980) and around Kariong (part of community 12 of Benson & Fallding 1981).

– SL Sedgeland

Sites: S2,S5,S7,S20,S27,S29,S30,S33,S41,S43,S50,S56,S59.

Habitat: Seepage slopes perched on sandstone benches or on the sides of large upland swamps. Soils are sandy, humic sandy loams.

Distribution: Small patches mainly in the eastern part of the catchment. Sedgeland occupies about 10% of the Heath-Sedgeland Mosaic (860 ha, 9.1% of study area).

Shrubs: 0.9 m tall, 29% cover; *Sprengelia incarnata, Bauera microphylla, Symphionema paludosum, Baeckea imbricata* and *Boronia parviflora* are characteristic of this community. Other common taxa include *Epacris obtusifolia* and *Almaleea paludosa*.

Groundcover: 0.6 m tall, 69% cover; *Lepidosperma filiforme* and *Schoenus paludosum* are characteristic. Other common taxa include *Ptilanthelium deustum, Leptocarpus tenax, Lepyrodia scariosa, Schoenus brevifolius, Cassytha glabella, Entolasia stricta, Drosera spathulata, Goodenia dimorpha* var. *angustifolia, Stylidium lineare, Xyris operculata, Empodisma minus* and *Chorizandra sphaerocephala*.

Disturbance: No obvious disturbance.

Conservation: Very localised on the Woronora Plateau. Representation within Royal NP is likely to be very limited.

– CH Cyperoid Heath

Sites: S1,S10,S11,S12,S13,S19,S25,S26,S28,S34,S40,S42,S45,S49,S57,S58

Habitat: Periodically waterlogged seepage zones in upland swamps. Soils are moderately deep gleyed organic sands and sandy loams.

Distribution: Southern and eastern parts of the catchment. Cyperoid Heath occupies about 30% of the Heath–Sedgeland Mosaic (860 ha, 9.1% of study area).

Shrubs: 1.4 m tall, 34% cover; Characteristic taxa include *Banksia robur, Hakea teretifolia* (multi-stemmed form), *Leptospermum juniperinum, Almaleea paludosa* and *Epacris obtusifolia*.

Groundcover: 1.0 m tall, 86% cover; characteristic taxa include *Lepidosperma limicola, Gymnoschoenus sphaerocephalus, Selaginella uliginosa* and *Xyris ustulata*. Other common taxa include *Xyris operculata, Tetrarrhena turfosa, Baumea teretifolia, Chorizandra sphaerocephala, Empodisma minus, Leptocarpus tenax, Schoenus brevifolius, Entolasia stricta* and *Xanthorrhoea resinifera*.

Disturbance: Small patches excavated for clay extraction, otherwise undisturbed.

Conservation: Most common on eastern Woronora Plateau in Water Board catchments. Limited examples in Royal NP (Keith unpubl. data), on Lambert Peninsula in Ku-ring-gai Chase NP (Buchanan 1980) and around Kariong (part of community 12 of Benson & Fallding 1981).

TT Ti-Tree Thicket

Sites: S15,S16,S21,S23,S24,S35,S46,S54,S60.

Habitat: Waterlogged drainage lines in large upland swamps. Soils are deep, highly organic gleyed loams and clay loams.

Distribution: 51 ha (0.5% of study area). Scattered in southern and eastern parts of the catchment.

Shrubs: 2.5 m tall, 37% cover; Characteristic taxa include *Leptospermum juniperinum, L. grandifolium, Epacris paludosa, Banksia robur, Melaleuca squarrosa, Viminaria juncea* and *Acacia rubida*.

Groundcover: 1.6 m tall, 90% cover; *Gleichenia microphylla, G. dicarpa, Gahnia sieberiana, Lepyrodia anarthria* and *Baumea teretifolia* are characteristic. Other common taxa include *Chorizandra sphaerocephala, Empodisma minus* and *Tetrarrhena turfosa*.

Variability: The shrub stratum varies from dense to almost absent, depending on water table fluctuation and long-term fire history.

Disturbance: No obvious disturbance.

Conservation: Most common on eastern Woronora Plateau in Water Board catchments. Limited examples in Royal NP (Keith unpubl. data) and on Lambert Peninsula in Ku-ring-gai Chase NP (Buchanan 1980).

Appendix 2. Two-way table of non-swamp quadrat data. Data are cover-abundance values (Poore 1955). Nomenclature follows Harden (1990–1993).

Refer to Appendix 1 for abbreviations of plant community names. Read site numbers vertically. Refer to Keith & Myerscough (1993) for two-way table of swamp data.

Plant Community	SF	WGF	EGF	RS	IW	MH	SW	IH	HW	RPH
Site Number		34113323	23332222	121222	1111	45445	343434	11	444	55555
	12538746	943015663	31205897	849201	2354	12980	728790	67	456	13654
Acacia binervata	333-11-2	---------	--------	------	----	-----	------	--	---	-----
Eucalyptus globoidea	33333343	---------	--------	------	----	-----	------	--	---	-----
Pterostylis grandiflora	11--1---	---------	--------	------	----	-----	------	--	---	-----
Desmodium varians	-1--1---	---------	--------	------	----	-----	------	--	---	-----
Pultenaea linophylla	11--21--	---------	--------	------	----	-----	------	--	---	-----
Acacia longifolia longifolia	31-21---	---------	--------	------	----	-----	------	--	---	-----
Viola hederacea	-1-21---	---------	--------	-----1	----	-----	------	--	---	-----
Blechnum cartilagineum	12331---	---------	--------	11----	----	-----	------	--	---	-----
Calochlaena dubia	55232---	---------	------1-	21----	----	-----	------	--	---	-----
Gahnia clarkei	12------	---------	-1------	1----1	----	-----	------	--	---	-----
Hibbertia dentata	-2------	---------	--------	------	----	-----	------	--	---	-----
Hydrocotyle acutiloba	-21-----	---------	--------	------	----	-----	------	--	---	-----
Echinopogon ovatus	-1------	---------	--------	------	----	-----	------	--	---	-----
Tylophora barbata	-1------	---------	--------	------	----	-----	------	--	---	-----
Galium binifolium	-1------	---------	--------	------	----	-----	------	--	---	-----
Adiantum aethiopicum	-1------	---------	--------	------	----	-----	------	--	---	-----
Santalum obtusifolium	-1------	---------	--------	------	----	-----	------	--	---	-----
Vernonia cinerea	-1------	---------	--------	------	----	-----	------	--	---	-----
Billardiera scandens	1111---1	-1-------	1----1--	11----	111-	-----	11--1-	--	---	-----
Eustrephus latifolius	111-----	---------	--------	------	----	-----	------	--	---	-----
Ozothamnus diosmifolius	1-1-----	---------	--------	------	----	-----	------	--	---	-----

Rapanea variabile	1-------	---------	--------	------	----	-----	------	--	---	-----
Cryptostylis erecta	1-------	---------	--------	------	----	-----	------	--	---	-----
Persoonia mollis nectans	1-------	---------	--------	------	----	-----	------	--	---	-----
Hakea salicifolia	2-------	---------	--------	-----1	----	-----	------	--	---	-----
Oxylobium ilicifolium	2-------	-------1-	--------	------	----	-----	------	--	---	-----
Acianthus fornicatus	-1-111--	-11111--2	1---2---	------	---1	-----	1-1---	--	---	-----
Pterostylis longifolia	-1---1--	---------	----1---	------	----	-----	------	--	---	-----
Lomatia silaifolia	--1112-1	11---1-1-	--1-111-	------	1-11	---11	1-111-	11	1--	-----
Xylomelum pyriforme	-----2--	1i-----1-	------1-	------	1---	-----	------	--	---	-----
Olearia erubescens	-----2--	---------	--------	------	----	-----	------	--	---	-----
Glycine tabacina	-----1--	---------	--------	------	----	-----	------	--	---	-----
Persoonia laurina	-----1--	---------	--------	------	----	-----	------	--	---	-----
Banksia spinulosa spinulosa	--1-1222	323311111	211--111	------	1113	-11--	111121	--	-1-	-----
Entolasia stricta	-1221221	2-2422111	112-1111	1-1--2	1-22	111-1	--1-12	-1	1--	-----
Phyllanthus hirtellus	--111111	1-1-111-1	-----111	------	1---	-----	-11-1-	--	---	-----
Gompholobium latifolium	----1--1	---------	------1-	------	----	-----	------	--	---	-----
Hardenbergia violacea	----1--1	----1-1--	------11	------	----	-----	------	--	---	-----
Poranthera corymbosa	----1---	---------	--------	------	--1-	-----	-1----	--	---	-----
Lepidosperma lineare	----1---	--------1	--------	------	----	-----	------	--	---	-----
Poranthera microphylla	----1---	---------	--------	------	----	-----	------	--	---	-----
Brunoniella pumilio	--111211	---------	------1-	------	1--1	-----	------	--	---	-----
Hibbertia empetrifolia	1-121311	---------	--1---1-	--1---	1--1	-----	------	--	---	-----
Doryanthes excelsa	3--213-1	---------	1-1---1-	------	---3	-----	------	--	---	-----
Dianella caerulea	211212-2	---1--112	11----1-	-1---1	---1	-----	------	--	---	-----
Pteridium esculentum	111222-1	-----2112	111--111	-1---3	---1	-----	------	--	---	-----
Lomandra longifolia	11122232	---1-1--1	11111-2-	1111-2	---2	-----	------	--	---	-----
Kennedia rubicunda	1-11---1	---------	--------	------	----	-----	------	--	---	-----
Leucopogon lanceolatus	2-1111-1	---------	-----11-	11---1	----	-----	------	--	---	-----
Clematis aristata	-12111--	---------	--------	------	----	-----	------	--	---	-----
Pratia purpurascens	-111-1--	---------	--------	------	----	-----	------	--	---	-----

Glycine clandestina	-1111-1-	-----1---	--------	------	----	-----	------	--	---	-----
Dianella revoluta	--11----	-----1---	--------	------	----	-----	----1-	--	---	-----
Oxalis perennans	--11----	--------	--------	------	----	-----	------	--	---	-----
Pterostylis curta	---1----	--------	--------	------	----	-----	------	--	---	-----
Comesperma volubile	---111--	--------	--------	------	----	-----	------	--	---	-----
Viola betonicifolia	---11---	--------	--------	------	----	-----	------	--	---	-----
Themeda australis	---12---	--------	--------	------	----	-----	------	--	---	-----
Imperata cylindrica	-2-13121	-----4---	--------	------	----	-----	------	--	---	-----
Chionochloa pallida	------21	--------	--------	------	1---	-----	----4-	--	---	-----
Poa labillardieri	------2-	--------	--------	------	----	-----	------	--	---	-----
Dichelachne rara	1112--2-	--------	-----11-	------	----	-----	------	--	---	-----
Microlaena stipoides	--1---21	--------	-----11-	-1----	----	----1	----1-	--	---	-----
Goodenia heterophylla	--1-1111	--------	--------	------	----	-----	------	--	---	-----
Lagenifera stipitata	-1111111	--------	1----1--	------	1---	-----	----11	--	---	-----
Pultenaea hispidula	----1-1-	--------	--------	------	----	-----	------	--	---	-----
Daviesia ulicifolia	------1-	--------	--------	------	----	-----	------	--	---	-----
Goodenia hederacea	------1-	--------	------1	------	1---	-----	------	--	---	-----
Lomandra multiflora	------1-	------11-	--------	------	1---	-----	-----1	--	-1-	-----
Chiloglottis reflexa	--1----1	--------	----1---	------	----	-----	------	--	---	-----
Pultenaea daphnoides	--1----2	--------	----1-1-	------	----	-----	------	--	---	-----
Hibbertia scandens	-11-----	--------	--------	------	----	-----	------	--	---	-----
Centella asiatica	--1-----	--------	--------	------	----	-----	------	--	---	-----
Oplismenus imbecillus	--1-----	--------	--------	------	----	-----	------	--	---	-----
Acacia stricta	--1-----	--------	--------	------	----	-----	------	--	---	-----
Entolasia marginata	--2-----	--------	--------	------	----	-----	------	--	---	-----
Opercularia aspera	--1-1---	-------1	----1-1-	11----	----	-----	------	--	---	-----
Tetraria capillaris	--1-1---	--------	------1-	------	----	-----	------	--	---	-----
Schoenus melanostachyus	--1-----	--------1	----111-	1--1-1	----	-----	------	--	---	-----
Acacia linifolia	------11	2---221--	1-1--111	---1--	----	----1	1---11	--	---	-----
Aristida vagans	--------	----22---	--------	------	----	-----	------	--	---	-----

Leucopogon ericoides	--------	11--11---	--1--1--	------	----	--1--	------	--	---	--1--
Lissanthe strigosa	--------	1---11---	--------	------	----	-----	--1---	--	---	-----
Xanthorrhoea concava	--------	-1--1-1--	--------	------	----	-----	------	--	---	-----
Eragrostis brownii	--------	----1----	--------	-----1	----	-----	------	--	---	-----
Cheilanthes sieberi	--------	----1----	--------	------	----	-----	------	--	---	-----
Dodonaea triquetra	--------	---1333-3	1----1--	--2--3	----	-----	------	--	---	-----
Eucalyptus punctata	--------	---3433-3	--------	------	----	-----	------	--	---	-----
Exocarpos strictus	--------	----113--	--------	------	----	-----	------	--	---	-----
Eucalyptus pilularis	--------	-----33--	--------	------	----	-----	------	--	---	-----
Cheilanthes distans	--------	------1--	--------	------	----	-----	------	--	---	-----
Danthonia longifolia	--------	------1--	--------	------	----	-----	------	--	---	1----
Banksia marginata	--------	--4------	---1----	------	----	-----	112---	--	---	----1
Conospermum longifolium	--------	--1------	--------	------	----	----1	1111--	--	---	----1
Schoenus ericetorum	--------	--1------	--------	------	----	1----	1-11--	--	---	----1
Grevillea sphacelata	--------	--1------	--------	------	1---	1-1--	11112-	--	---	----1
Caustis flexuosa	--------	2--211112	1--222-1	-1----	----	--111	2111-1	--	---	-----
Dillwynia retorta	--------	33311-111	-211-2-1	------	1---	---11	2-11-1	--	---	----1
Leptospermum trinervium (nl)	--------	-331132-1	-11211-2	--12--	---1	1421-	221212	--	---	----2
Grevillea buxifolia	--------	--11-----	--------	------	----	-----	--1---	--	---	-----
Melichrus urceolatus	--------	--------	--------	------	----	-----	--1---	--	---	-----
Grevillea diffusa diffusa	1-------	3-1-1----	2---12--	1-----	----	--11-	121--1	--	---	----1
Lomandra filiformis filiformis	--------	1-------	----11--	------	----	1----	--1---	--	---	-----
Eucalyptus multicaulis	--------	--31-----	--------	------	----	-----	------	--	---	-----
Petrophile sessilis	--------	1332-----	--------	------	----	-----	-11-21	--	---	----1
Hakea sericea	------1-	1132-1--1	2-1-1---	-----1	-1--	-11--	111-1-	--	---	----2
Bossiaea obcordata	--------	--------	-------2	------	----	-----	-12-11	--	---	-----
Eucalyptus oblonga	--------	3-3-1----	-------1	------	21--	----1	222-12	--	-1-	-----
Mirbelia speciosa	--------	--------	--------	------	-1--	----1	111---	--	--1	-----
Schoenus turbinatus	--------	--------	--------	------	-1--	-----	11---1	--	---	-----
Boronia ledifolia	--------	--2-1--1-	--------	------	----	-----	1-----	--	---	-----

Caustis pentandra	--------	--1------	-1------	--1---	----	-----	------	--	---	1----
Gompholobium minus	--------	--1------	--------	------	----	-----	------	--	---	-----
Hovea linearis	--------	-11--1-1-	-----1--	------	-1-1	-----	----1-	--	-1-	-----
Pomax umbellata	--------	111--1-11	-------1	------	----	-----	------	--	---	--1--
Acacia terminalis	--------	-1-1-1112	11-1211-	-1----	--1-	--1-1	-----1	--	---	1----
Xanthosia pilosa (el)	----1---	11----112	11111111	------	----	--1--	1-----	--	---	-----
Hakea dactyloides (ss)	--------	1----1121	1-1112--	---1-1	----	-----	------	--	---	-----
Ricinocapus pinifolius	--------	-------1-	1--1----	------	----	-----	------	--	---	-----
Eucalyptus agglomerata	--------	-3---3333	---1-2--	-2---1	----	-----	------	--	---	-----
Pultenaea flexilis	--------	-1---314-	-----1--	------	----	-----	------	--	---	-----
Xanthorrhoea arborea	--------	-------11	----22-2	------	----	-----	------	--	---	-----
Stylidium laricifolium	--------	-------1-	-----1--	------	----	-----	------	--	---	-----
Liparis reflexa	--------	--------	-----1--	------	----	-----	------	--	---	-----
Angophora costata	443---33	33-311322	3-2-3333	24-1-1	----	-----	------	--	---	-----
Ceratopetalum gummiferum	-------1	31-1---21	1-1-1-1-	11----	----	-----	------	--	---	-----
Grevillea mucronulata	--------	31-1-3111	----211-	-1---1	----	-----	----1-	--	---	-----
Persoonia linearis	-1121--1	21---1111	----11--	11----	----	-----	------	--	---	-----
Dampiera purpurea	-1------	1--1-1---	----11-1	-----1	----	-----	------	--	---	-----
Eucalyptus consideniana	--------	1--1-----	--------	------	----	-----	------	--	---	-----
Callistemon linearis	--------	---1-----	--------	------	----	-----	------	--	---	-----
Amperea xiphoclada	--------	--------	11-11---	------	1-11	11---	------	--	---	-----
Leucopogon exolasius	--------	-------1-	---11---	-----1	----	-----	------	--	---	-----
Banksia cunninghamii	--------	--------	---11---	------	----	-----	------	--	---	-----
Petrophile pedunculata	--------	--------	----1---	------	----	-----	------	--	---	-----
Correa reflexa	--------	--------	----1---	------	----	-----	------	--	---	-----
Epacris longiflora	--------	--------	----1-1-	------	----	--11-	------	--	---	-----
Monotoca scoparia	--------	--1----1-	111-111-	--21-1	-1--	1111-	1111--	--	---	-1---
Leptomeria acida	---1---1	-1-----1-	1111111-	------	11-1	-----	111---	--	---	-----
Lycopodium deuterodensum	--------	--------	---1111-	------	----	-----	------	--	---	-----
Persoonia pinifolia	---11---	1-------	1211111-	1111-1	1--1	---11	2111-1	-1	111	1--12

Patersonia glabrata	---113--	--------1	111-1111	1-----	22-2	1-1-1	11-1-1	11	121	-----
Telopea speciosissmia	----11--	---------	----111-	------	11--	-----	1-----	--	---	-----
Aotus ericoides	--------	---------	22123-1-	------	----	1-1--	-----1	--	---	-----
Eucalyptus piperita	233-23--	-1-------	33333333	22----	----	-----	------	--	---	-----
Empodisma minus	--------	---------	111-----	------	----	--1--	------	--	1--	-1---
Gleichenia dicarpa	--------	---------	11------	------	----	-----	------	--	---	-----
Exocarpos cupressiformis	--------	---------	-1------	------	----	-----	------	--	---	-----
Gonocarpus teucrioides	----1---	1--2-----	11111-2-	1-1---	---1	--1--	-----1	--	---	-----
Smilax glyciphylla	1-1-1---	-1------1	1111111-	112---	---1	--11-	------	--	---	-----
Cassytha pubescens	-----1--	112------	1111-11-	-12---	11--	-----	--11-1	--	---	---1-
Zieria laevigata	--------	---------	111--11-	-1----	----	-----	------	--	---	-1---
Gahnia radula	--------	---------	1-----1-	------	----	-----	------	--	---	-----
Lomandra gracilis	--1--11-	----2--1-	1111-11-	------	----	--11-	--1---	--	---	-----
Tetrarrhena turfosa	-11--2--	---------	1--1-11-	-1----	---1	--1--	------	--	---	-----
Lomandra cylindrica	--------	12----1-1	1----111	------	-1--	1----	-----1	1-	--1	----1
Isopogon anethifolius	--------	---------	1-------	------	----	-----	------	1-	---	-----
Styphelia tubiflora	--------	---------	1-------	------	----	-----	------	--	---	-----
Wahlenbergia gracilis	--------	---------	1-------	------	----	-----	------	--	---	-----
Pultenaea scabra	--------	2--------	1-1-----	------	---1	-----	------	--	---	-----
Hibbertia monogyna	--------	---------	2-11-1-1	------	----	1----	------	--	---	-----
Woollsia pungens	--------	---------	--11-1--	------	----	-----	-1----	--	---	-----
Stylidium productum	--------	---------	--1--1--	------	----	-----	------	--	---	-----
Tetratheca shiressii	--------	---------	--1-----	------	----	-----	------	--	---	-----
Schizea bifida	--------	---------	--1----1	------	----	-----	------	-1	-1-	-----
Lomandra filiformis coriacea	-----1-1	----1----	-----1-1	------	1-1-	1----	-----1	--	---	-----
Thysanotus tuberosus	--------	---------	-----1-1	------	----	-----	-1---1	--	---	-----
Chloanthes stoechardis	--------	---------	-----1-1	------	----	-----	------	--	---	-----
Choretrum candollei	--------	---------	-------1	------	----	-----	------	--	---	-----
Bauera rubioides	--------	---------	--11--1-	1--111	----	-----	------	--	---	-----
Gleichenia microphylla	--------	---------	---1--1-	1--2-2	----	-----	------	--	---	-----

Gahnia sieberiana	--------	---------	--11----	------	----	-----	------	--	---	---1-
Stylidium graminifolium	--------	---------	---1----	------	----	-----	------	--	---	-----
Leucopogon amplexicaule	--------	---------	---1----	------	----	-----	------	--	---	-----
Notelaea longifolia	---1----	---------	--------	1---1-	----	-----	------	--	---	-----
Todea barbara	--------	---------	--------	----1-	----	-----	------	--	---	-----
Dendrobium speciosum	--------	---------	-----1--	1-----	----	-----	------	--	---	---1-
Adiantum hispidulum	--------	---------	--------	1-----	----	-----	------	--	---	-----
Lindsaea microphylla	--------	---------	-----11-	11----	----	-----	------	--	---	-----
Logania albiflora	--------	---------	------1-	11----	----	-----	------	--	---	-----
Marsdenia suaveolens	--------	--------1	-1---1--	11----	----	-----	------	--	---	-----
Epacris pulchella	------1-	---1-----	11-1-1--	11----	----	----1	------	--	---	-----
Lepidosperma laterale	1--1-211	---1-1---	11-111--	1211-1	----	-----	21----	--	---	-----
Dracophyllum secundatum	--------	---------	-1--1---	-1----	----	-----	------	--	---	-----
Elaeocarpus reticulatus	-----1--	---------	-1------	-1----	----	-----	------	--	---	-----
Helichrysum elatum	11------	---------	--------	-1----	----	-----	------	--	---	-----
Hymenophyllum cupressiforme	--------	---------	--------	-1----	----	-----	------	--	---	-----
Olearia viscidula	--------	---------	--------	-1----	----	-----	------	--	---	-----
Lepidosperma urophorum	--------	---------	--------	-1----	----	-----	------	--	---	-----
Pultenaea blakelyi	--------	---------	--------	-31---	----	-----	------	--	---	-----
Tristaniopsis collina	--------	---------	--------	-3----	----	-----	------	--	---	-----
Acrotriche divaricata	--------	---------	--------	-2----	----	-----	------	--	---	-----
Pomaderris lanigera	--------	-----1-13	--------	------	----	-----	------	--	---	-----
Callitris rhomboidea	--------	--------3	--------	------	----	-----	------	--	---	-----
Eriostemon scaber	--------	-------12	--------	------	----	-----	------	--	---	-----
Dendrobium linguiforme	--------	----~---11	--------	------	----	-----	------	--	---	-----
Grammitis billardieri	--------	--------1	--------	------	----	-----	------	--	---	-----
Platycerium bifurcatum	--------	--------1	--------	------	----	-----	------	--	---	-----
Cassinia aureonitens	--------	--------1	--------	------	----	-----	------	--	---	-----
Zieria cytisoides	--------	--------1	--------	------	----	-----	------	--	---	-----
Platysace lanceolata	--------	--------1	--------	------	----	---1-	------	--	---	-----
Acacia obtusifolia	--------	-------12	---1111-	213413	----	-----	------	--	---	-----

Leptospermum morrisonii	--------	--------	--------	1-2413	---1	-----	------	--	---	-----
Pseudanthus pimelioides	--------	--------	--------	--13-1	----	-----	------	--	---	-----
Tristaniopsis laurina	--------	--------	--------	--43-1	----	-----	------	--	---	-----
Lomandra fluviatilis	--------	--------	--------	--232-	----	-----	------	--	---	-----
Tristania neriifolia	--------	--------	--------	1-324-	----	-----	------	--	---	-----
Phebalium dentatum	--------	--------	--------	--111-	----	-----	------	--	---	-----
Lomatia myricoides	--------	--------	--------	3-3221	----	--1--	------	--	---	-----
Sticherus flabellatus	2-------	--------	--------	3-311-	----	-----	------	--	---	-----
Micrantheum hexandrum	--------	--------	--------	--31-4	----	-----	------	--	---	-----
Restio dimorpha	--------	--------	--------	--21-2	----	----2	------	--	---	-----
Stenocapus salignus	--------	--------	--------	--3---	----	-----	------	--	---	-----
Bossiaea rhombifolia	--------	--------	--------	--2---	----	-----	------	--	---	-----
Allocasuarina littoralis	1-------	-------41	1-1---1-	--23--	----	-----	------	--	---	-----
Ceratopetalum apetalum	--------	--------	--------	4131-1	----	-----	------	--	---	-----
Phebalium squamulosum squamulosum	--------	--------	--------	211--1	----	-----	------	--	---	-----
Hibbertia nitida	--------	--------	---1----	1-1--1	----	-----	------	--	---	-----
Prostanthera linearis	--------	--------	--------	1-2--1	----	-----	------	--	---	-----
Acacia irrorata	--------	--------	--------	--1--1	----	-----	------	--	---	-----
Grevillea longifolia	--------	--------	--------	--1--1	----	-----	------	--	---	-----
Pomaderris intermedia	--------	--------	-----1--	-11--2	----	-----	------	--	---	-----
Pomaderris andromedifolia	--------	--------	--------	--1---	----	-----	------	--	---	-----
Backhousia myrtifolia	--------	--------	--------	-11---	----	-----	------	--	---	-----
Lasiopetalum ferrugineum	--------	-1------2	--------	-----1	----	-----	------	--	---	-----
Bertya pomaderroides	--------	--------	--------	-----1	----	-----	------	--	---	-----
Gonocarpus microphyllus	--------	--------	--------	-----1	----	-----	------	--	---	-----
Chorizandra cymbaria	--------	--------	--------	-----1	----	-----	------	--	---	-----
Westringia longifolia	--------	--------	--------	-----1	----	-----	------	--	---	-----
Callistemon citrinus	--------	--------	--------	---1-1	----	-----	------	--	---	-----
Leptospermum polygalifolium	--1-----	---3-----	--1---1-	1----1	----	--1-1	------	--	---	----1

Acacia myrtifolia	----111-	----1----	--------	------	3212	-----	2-1-11	--	11-	----1
Eucalyptus gummifera	---32322	32332-3--	-131--22	------	2343	34123	133233	--	122	11---
Eucalyptus racemosa	--------	--------	--------	------	2332	2----	23--33	--	1--	1----
Eucalyptus sieberi	-----1--	--------	-121---1	------	3333	3----	3-----	--	-1-	-----
Lobelia dentata	--------	--------	--------	------	---1	1----	----2-	--	---	-----
Stipa pubescens	---112--	---112---	------1-	------	11-1	-----	-1--21	--	---	-----
Haemadorum planifolium	--------	--------	--------	------	--1-	1----	----1-	--	---	-----
Viola sieberiana	--------	--------	--------	------	--1-	-----	------	--	---	-----
Mitrasacme polymorpha	--------	--------	--------	------	--1-	11---	----11	1-	111	-----
Scaevola ramosissima	--------	--------	-----1--	------	1-1-	111-1	----11	11	-1-	-----
Hypericum gramineum	---1--11	--------	--------	------	----	-----	----1-	--	---	-----
Deyeuxia decipiens	-------1	--------	--------	------	----	-----	----1-	--	---	-----
Opercularia varia	------11	--------	--------	--1---	--1-	-----	----2-	--	---	-----
Pelargonium inodorum	--------	--------	--------	------	----	-----	----1-	--	---	-----
Caesia vittata	--------	--------	--------	------	----	-----	----1-	--	---	-----
Leucopogon virgatus	--------	--------	--------	------	----	-----	----1-	--	---	-----
Caesia parviflora	--------	--------	--------	------	----	-----	-----1	--	1-1	-----
Hakea teretifolia (ss)	------1-	--------	--1-----	------	--1-	11---	-----1	--	1-1	1----
Goodenia dimorpha angustifolia	--------	--------	--------	------	----	-----	-----1	--	---	-----
Genoplesium nublingii	--------	--------	--------	------	----	-----	-----1	--	---	-----
Hybanthus monopetalus	--------	--------	--1---1-	------	--1-	-----	-1---1	--	11-	-----
Sphaerolobium vimineum	--------	--------	--------	------	----	--1--	-1---1	--	11-	1----
Platysace ericoides	------1-	--------	--------	------	----	-11--	11-122	11	1--	---1-
Thelymitra circumsepta	--------	--------	--------	------	----	-----	----11	-1	---	-----
Tricoryne simplex	--------	--------	--------	------	----	-----	----11	-1	1--	-----
Acacia suaveolens	--------	----1----	11-----1	------	11--	11111	11-11-	11	1-1	11---
Dampiera stricta	------11	1-------	--1--11-	------	1211	11111	111111	11	111	1----
Lomandra glauca	--------	----1----	--1--1--	------	12--	11111	1112-1	11	-11	---1-
Xyris gracilis laxa	--------	--------	--------	------	-1--	11111	11---1	11	111	-----

Leptospermum arachnoides	--------	--------	--------	------	--1-	11111	1-----	11	-1-	1--1-
Petrophile pulchella	--------	----1---1	1--2-1--	-----1	111-	11111	11-1--	11	121	1--1-
Xanthorrhoea media	--------	2-2------	---1----	------	111-	11111	11111-	11	111	1--1-
Bossiaea ensata	--------	--1------	--------	------	111-	11111	-1-1--	--	--1	----1
Gonocarpus tetragynus	---2----	--1------	--------	------	1111	11-11	-1-11-	11	111	-----
Hakea dactyloides (ms)	--------	--------	--------	------	1113	11111	-11111	12	111	-----
Anisopogon avenaceus	--------	-3-------	1111--1-	------	1112	111-1	-111-2	11	111	1----
Pimelea linifolia	--------	--1------	-1111---	------	1112	1111-	111--1	11	111	-----
Isopogon anemonifolius	--------	-111-----	1-1--1-1	------	11--	11--1	111111	11	111	-----
Lambertia formosa	--------	-21----1-	1111-1-1	-----1	1212	11---	1111--	11	111	-----
Banksia serrata	--------	-3---1--1	11111111	------	11--	11111	1121-1	1-	-1-	-----
Hibbertia stricta group	--------	--------	-111--1-	------	111-	11111	1111--	--	---	1----
Banksia paludosa	--------	--------	--1-----	------	-331	1---1	------	11	11-	-----
Daviesia corymbosa	--------	--------	-11-----	------	2113	1-111	---1--	11	12-	-----
Grevillea oleoides	--------	--------	-11-----	--11-4	1-12	11111	-1-1--	11	111	-----
Lindsaea linearis	----1--1	--------	--1-----	------	--11	11111	------	11	121	-----
Acacia ulicifolia	--------	21--112--	21-11--1	------	11--	1-111	1-11--	--	-1-	---1-
Lomandra obliqua	-------1	11---11--	11-1--11	------	-111	11111	1-1-1-	11	221	1--1-
Bossiaea heterophylla	--------	112-1-1-1	1--111--	------	11--	1-11-	1111-1	-1	11-	-----
Persoonia levis	-----111	21111-111	111-1111	------	1111	--1-1	111111	11	11-	-----
Platysace linearifolius	--------	21112-111	111-11-1	------	112-	11111	2111--	11	11-	-----
Eriostemon australasius	--------	12-11-11-	11-1-1-2	------	-1--	1111-	-11111	11	-1-	-----
Gompholobium grandiflorum	--------	2121-1---	1-1-----	------	1111	1-1-1	1-11--	--	-1-	-----
Tetratheca neglecta	--------	1-1------	--------	------	111-	--111	--11-1	--	-1-	-----
Phyllota phylicoides	--------	11-------	--------	------	----	-----	1-12--	1-	-1-	-----
Baeckea ramosissima	--------	--------	--------	------	----	-----	-1-1--	--	-1-	-----
Gompholobium glabratum	--------	--------	--------	------	----	---1-	-1-111	1-	--1	-----
Conospermum ellipticum	--------	--------	--------	------	----	-----	---1--	--	--1	-----
Caustis recurvata	--------	--------	--------	------	----	-----	---1--	--	---	-----
Cyathochaeta diandra	-----1--	-33-1----	-------1	------	2-11	112-3	121222 22		211	----1

Hemigenia purpurea	--------	---------	--------	------	----	--2-1	1--1--	1-	111	-----
Haemadorum corymbosum	--------	---------	--------	------	--1-	-1--1	1--1--	11	--1	-----
Pultenaea elliptica (yf)	--------	---------	--------	------	--1-	-12-1	12-11-	--	--1	----2
Actinotus minor	--------	--23-----	1--1-1--	1-----	-11-	11222	-1-1--	1-	111	1----
Leucopogon microphyllus	--------	---1-----	--------	------	----	11112	1--1--	1-	---	11---
Epacris microphylla	--------	---1-----	--1-----	------	----	-1222	11---1	-1	-12	1211-
Lepyrodia scariosa	--------	---3-----	11111-1-	--1---	--1-	22322	111---	11	213	12-2-
Eucalyptus luehmanniana	--------	---------	--------	------	----	-433-	---3--	--	---	-----
Pultenaea aristata	--------	---------	--------	------	----	-1-1-	------	--	---	-----
Darwinia grandiflora	--------	---------	--------	------	----	-1-1-	------	--	---	-----
Baeckea diosmifolia	--------	---------	--------	------	----	-1---	------	--	---	-----
Allocasuarina nana	--------	---------	--------	------	----	-1---	------	--	---	-----
Laxmannia gracilis	--------	---------	--------	------	----	-1---	------	--	---	---1-
Cryptostylis subulata	-------1	---------	--------	------	----	---1-	-1----	--	---	-----
Persoonia lanceolata	--------	-1-------	--------	------	-1-1	----1	1-----	-1	1--	----1
Microtis unifolia	--------	---------	--------	------	----	-----	------	--	---	----1
Poranthera ericifolia	--------	---------	-------1	------	----	---1-	1--1--	--	11-	----1
Tricostularia pauciflora	--------	---------	--------	------	-1--	---1-	11-1--	11	1--	----1
Amphipogon strictus	--------	---------	--------	------	----	-1---	------	-1	111	-----
Mirbelia rubiifolia	--------	---------	--------	------	--1-	-1---	------	11	111	1----
Cassytha glabella	--------	---------	--------	1-----	---1	-1--1	-1----	11	111	1----
Selaginella uliginosa	--------	---------	--------	------	---1	-----	------	--	111	-----
Banksia oblongifolia	--------	---------	--1-----	------	----	111-1	-----1	12	113	1----
Ptilanthelium deustum	------1-	---3-----	--1-----	------	-121	-21-2	11--22	12	212	1----
Patersonia sericea	--------	1--11----	--------	------	----	-1--1	--11-1	11	111	----1
Goodenia bellidifolia	------11	---------	--------	------	1-1-	-----	-1----	-1	111	-----
Xanthosia tridentata	------11	-121-----	1-1-1-1-	--1--1	1--1	-1111	-----1	11	111	-----
Cryptandra ericoides	--------	---------	--------	------	----	---1-	------	--	1-1	-----
Thysanotus juncifolius	--------	---------	--------	------	----	---1-	------	-1	111	1----
Leucopogon esquamatus	--------	---------	--1-----	------	-1--	---1-	-1---1	11	111	2----

Drosera peltata	-----1--	--11-----	--------	------	----	--11-	-1--1-	11	111	-1---
Baeckea brevifolia	--------	--------	--------	------	----	-----	------	-1	11-	-----
Burchardia umbellata	--------	--------	--------	------	----	-----	------	11	11-	-----
Sowerbaea juncea	--------	--------	--------	------	----	-----	------	11	11-	-----
Pultenaea elliptica (rf)	--------	--------	--------	------	----	-----	------	13	11-	-----
Blandfordia nobilis	--------	--------	--------	-----1	----	-----	------	11	1-1	-----
Conospermum taxifolium	--------	--------	--------	------	----	-----	------	11	1--	-----
Hibbertia serpyllifolia	--------	--------	1-------	------	----	-----	-----2	22	21-	-----
Schoenus pachylepis	--------	--------	--------	------	----	---1-	------	22	211	-----
Restio gracilis	--------	--------	------2-	------	--1-	--1-1	------	1-	1--	-----
Stackhousia viminea	--------	--------	--------	------	----	-1--1	------	--	1--	-----
Conospermum tenuifolium	--------	--------	--------	------	----	-----	------	--	1--	-----
Xyris juncea	--------	--------	--------	------	----	-----	------	--	1--	-----
Angophora hispida	--------	--------	--------	------	----	--3--	------	33	---	-----
Brachyloma daphnoides	--------	--------	--------	------	----	1----	--1---	11	---	-----
Kunzea capitata	--------	--------	--------	------	----	11-31	------	32	1-2	3----
Lepidosperma neesii	--------	--------	--------	------	--11	11-1-	------	1-	1--	2----
Grevillea parviflora	--------	--------	--------	------	----	-----	------	1-	---	1----
Hypoxis hygrometrica	--------	--------	--------	------	----	-----	------	1-	---	-----
Stylidium lineare	--------	--1-----	--------	------	----	---11	------	--	--1	1----
Thelionema caespitosum	--------	--------	--------	------	----	----1	------	--	--1	-----
Sprengelia incarnata	--------	--------	--------	------	----	-----	------	--	--1	-----
Stackhousia nuda	--------	--------	--------	------	----	-----	------	--	--1	-----
Orthoceras strictum	--------	--------	--------	------	----	-----	------	--	--1	-----
Aristida warburgii	--------	--------	--------	------	----	-----	------	--	--1	-----
Dillwynia floribunda	--------	--------	--1-----	------	--2-	1-1--	------	--	--1	1----
Leptocapus tenax	--------	--------	--2---1-	------	----	111--	------	--	312	-----
Lepidosperma squamatum	--------	-3-------	--------	------	1---	-11--	------	--	---	-----
Actinotus helianthi	--------	--------	--------	------	----	--1--	------	--	---	-----
Pseudanthus orientalis	--------	--------	--------	------	----	--1--	------	--	---	-----
Styphelia triflora	--------	--------	--------	------	----	--1--	------	--	---	-----

Baumea acuta	--------	---------	--------	------	----	--1--	------	--	---	-----
Baeckea imbricata	--------	---------	--------	------	----	---32	------	--	---	1----
Restio fastigiata	--------	---------	--------	------	----	---3-	------	--	---	1----
Lepidosperma filiforme	--------	---------	1-2-----	------	----	---22	1--1--	--	---	2----
Banksia ericifolia	------1-	---------	111-1---	---1--	-1--	21243	3----1	--	--1	3---1
Eucalyptus apiculata	--------	---------	--------	------	----	----3	------	--	---	3----
Drosera spathulata	--------	---------	--------	-----1	----	-----	------	--	1--	1----
Allocasuarina distyla	--------	---------	--------	------	----	-----	------	--	---	1----
Leptospermum trinervium (bl)	--------	---------	2-------	-----1	111-	----1	------	11	111	1--1-
Eucalyptus haemastoma	--------	---------	--------	------	----	----1	------	21	-22	-----
Baeckea densifolia	--------	---------	--------	------	----	----1	------	-1	---	-----
Darwinia diminuta	--------	---------	--------	------	----	----1	------	--	---	-----
Micrantheum ericoides	--------	---------	--------	------	----	----1	------	--	---	-----
Lepidosperma viscidum (cg)	--------	---------	--------	------	-1--	--1-1	---1--	--	---	1----
Epacris obtusifolia	--------	---------	--------	------	----	-----	---1--	--	---	1----
Lepidosperma flexuosum	--------	---------	--------	------	----	----1	------	--	---	1----
Olax stricta	--------	---------	--------	------	-1--	----1	---1-1	--	---	1---1
Xanthosia pilosa (dl)	--------	---------	--------	--11--	----	----1	---1--	--	---	1----
Leptospermum squarrosum	--------	---------	--1-----	------	----	----1	------	--	---	11---
Darwinia fascicularis	--------	---------	--------	---1--	----	-----	------	--	---	32-2-
Thelionema umbellatum	--------	---------	--------	------	----	-----	------	--	---	-1-1-
Pterostylis parviflora	--------	---------	--------	------	----	-----	---1--	--	---	-1---
Prasophyllum brevilabre	--------	---------	--------	------	----	-----	------	--	---	-1---
Hypolaena fastigiata	--------	---------	--------	------	-1--	1----	2-----	--	---	---2-
Kunzea ambigua	--------	----1----	--------	-----1	----	-----	------	--	---	-4434
Callitris endlicheri	--------	---------	--------	------	----	-----	------	--	---	---3-
Lepidosperma viscidum (rg)	--------	---------	--------	------	----	-----	------	--	---	122--
Monotoca ledifolia	--------	---------	--------	------	----	-----	------	--	---	--11-
Calytrix tetragona	--------	---------	--------	------	----	-----	------	--	---	--1--
Oxylobium cordifolium	--------	---------	--------	------	----	-----	------	--	---	--1--
Astroloma humifusum	--------	---------	--------	------	----	-----	------	--	---	--1--