Vegetation of montane bogs in east-flowing catchments of northern New England, New South Wales

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Abstract: The floristics of the montane bogs in east-flowing catchments of northern New England, north-eastern New South Wales (lat 28° 47'–31° 25' S; long 151° 50'–152° 30' E), are described from 62 full floristic survey sites (20 x 20 m in area). Eight vegetation communities are based on flexible UPGMA analysis of cover-abundance scores of vascular plant taxa. Shrub species make up 26% of the flora and herb species 69%, with the remaining taxa trees, climbers or vines. Shrub species were of little diagnostic value, as a few common dominants were shared across most communities. The herbaceous layer was found to be of better circumscriptive value. Communities described (based on dominant herbaceous species) are: (1) *Themeda australis – Gonocarpus micranthus,* (2) *Baumea articulata – Baloskion stenocoleum*, (3) *Lepidosperma limicola – Baloskion stenocoleum*, (4) *Baloskion fimbriatum – Lomandra longifolia*, (5) *Lepyrodia scariosa – Blandfordia grandiflora,* (6) *Lepidosperma gunnii – Lepidosperma scariosa,* (7) *Baloskion stenocoleum – Empodisma minus*, (8) *Lepidosperma limicola – Xyris operculata*. The mean annual moisture index was found to account for 26% of the variation in species density.

These montane bog systems are some of the richest in Australia, with a high number of rare and restricted taxa. They are vulnerable to both present landuse practices and future changes in climate, are restricted in area, and need further conservation efforts to ensure their long-term survival.

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Introduction

According to the RAMSAR definition, wetlands consist of 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres'. Despite this encompassing definition, wetlands only occupy 4% of the global land surface (Weltzin et al. 2000).

In Australia, only a very small amount of the land area is in montane environments, and it is not surprising that temporary montane wetlands are sparsely distributed, and rare in the landscape (Jarman et al. 1988; Whinam & Hope 2005). Although there are some outliers in western Victoria and parts of eastern South Australia, montane wetlands are restricted to the Great Dividing Range south from Stanthorpe in Queensland, to east of Melbourne in Victoria, and to upland areas of Tasmania (Fig. 1).

On the Northern Tablelands of New South Wales natural wetlands include bogs (generally nutrient-poor, low pH and dominated by sclerophyllous shrubs) and fens (generally more nutrient-rich with higher pH and dominated by soft-leaved tussock sedges and grasses), as well as lagoons (areas of perennial or ephemeral open water). When describing the montane wetland environments of New South Wales, Keith (2004) retained these terms and their associated hydro-chemical meanings, though the chemical distinction between these types of wetlands is often indistinct in the Australian literature (Jarman et al. 1988; Whinam & Hope 2005). Bogs and fens are sometimes collectively termed mires, and in the European context, ombrotrophic mires (often nutrient-poor and low pH) are termed 'bogs', and minerotrophic mires (often more nutrient-rich with higher pH), are termed 'fens' (Wheeler & Proctor 2000; Økland et al. 2001).

Cool or cold wet climates with slow runoff and low evapotranspiration are most favourable for peat development and many Australian montane wetlands have minor to significant amounts of peat (Jarman et al. 1988; Keith 2004; Whinam & Hope 2005). These montane peat-forming wetlands can be complex hydrological and edaphic environments commonly consisting of mosaics of grasslands, heaths, herbfields or fens dominated by sedges, or fairly uniform compositional units (Wahren et al. 1999; Keith 2004; Williams & Clarke 2006). The description of temporary montane wetlands has often concentrated on vegetation structure and life form (Whinam & Hope 2005) and many of these systems are labelled sedgelands, wet heaths, sedge-heaths or heath swamps (Beadle 1981; Binns 1992; Binns 1995; Chapman & Binns 1995; Benson & Ashby 2000; Clarke et al. 2000; Zoete 2000).

Australian montane wetlands would be considered significant if only due to their rarity in the landscape alone (Wahren et al. 1999), but many of these environments are also threatened by anthropogenic landuse practices such as grazing, draining and burning (Benson & Ashby 2000; Whinam et al. 2001; Whinam & Chilcott 2002; Whinam et al. 2002; Hope & Kershaw 2005). As a result of such threats, *Montane peatlands and swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and the Australian Alps bioregions* have been listed (17 December 2004) as an Endangered Ecological Community under the NSW *Threatened Species Conservation Act* (1995).

Within the New England Bioregion many montane bogs, including some of the most extensive, occur where *Sphagnum* is not always a dominant component of the vegetation (Whinam & Hope 2005). The New England Bioregion represents the northern limit of this vegetation type in Australia (Jarman et al. 1988; Whinam & Chilcott 2002) and many floristic investigations have been undertaken there, mostly within bogs (Millington 1954; Binns 1992; Binns 1995; Chapman & Binns 1995; Hunter 1998; Hunter 1999; Hunter et al. 1999; Benson & Ashby 2000; Clarke *et al*. 2000; Hunter 2000; Hunter 2002; Sheringham & Hunter 2002; Hunter 2004ab; Hunter 2005ab). Whinam and Chilcott (2002) provided a broader floristic context for the New South Wales montane bogs, but their investigations were restricted to *Sphagnum*-dominated bogs south of the Sara River, north-east of Guyra. Bogs in the Barrington Tops area are distinctive (Zoete 2000) and shown in statistical analyses (Whinam & Chilcott 2002) to be allied but separate from the rest of the New England communities. Limited occurrences of montane bogs are known from west-flowing catchments within the New England Bioregion, such as at Torrington (Clarke et al. 1999) and Bolivia Hill (Hunter 2002b) and appear compositionally distinct from those on east-flowing catchments, based on preliminary analyses (Hunter & Bell, unpublished). This paper aims to put the floristic composition of the montane bog systems of east-flowing catchments of the northern New England into a regional context.

Methods

Study area

All major bog occurrences in the east-flowing catchments of northern New England, an area of about 300 km north to south and 100 km east to west (lat 28° 47'–31° 25' S; long 151° 50'–152° 30' E) were surveyed. Sixty-two quadrats were placed within 11 bog localities including Backwater, Bald Rock, Basket Swamp, Boonoo Boonoo, Capoompeta, Cathedral Rocks (Ebor), Gibraltar Range, Malara, Mann River, Werrikimbe and Western Washpool areas (Fig. 1). Sampled areas occurred on four bedrock types: basalt, metasediments, acid volcanics and granite. Altitudes ranged from 850 to 1370 m above sea level. The most northerly sampled area at Bald Rock was 260 km from the most southerly at Werrikimbe. Mean annual rainfall ranges from 870 mm to 1750 mm. The number of sites placed on each bedrock type and each site was proportional to area.

Survey methods

Vascular plants and *Sphagnum* were recorded using a modified Braun-Blanquet six point cover abundance scale in 62, 20 x 20 m quadrats. Quadrats were placed randomly within montane bog vegetation. Species not recorded in quadrats but found within the general montane bog environments were recorded opportunistically but not used in formal analyses (Appendix 1). Species nomenclature follows that of Harden (1992–2002) except where recent taxonomic changes have been suggested (PlantNET 2006).

Analyses and data exploration used options available in the PATN Analysis Package (Belbin 2004). For the final presentation, all species and their relative cover scores were included and the analysis performed used the Kulczynski association measure which is recommended for ecological applications (Belbin 2004), along with flexible Unweighted Pair Group arithmetic Averaging (UPGMA) and the default PATN settings. Community structural names are based on the most consistently dominant taxa in the shrub and herbaceous strata. To determine the effects of evapotranspiration, mean moisture index was approximated for each site by the use of BIOCLIM within the ANUCLIM Vers. 5.1 software package (Houlder 2000) and regressed against the number of species per plot (species density).

Results

A total of 438 vascular plant taxa were recorded, 353 within survey sites and 85 opportunistically (Appendix) covering 72 families and 215 genera. The families with the greatest number of taxa were: Poaceae (62 taxa), Cyperaceae (47), Myrtaceae (39), Fabaceae (33), Asteraceae (32), Proteaceae (20), Orchidaceae (15), Juncaceae (14) and Epacridaceae (11). The richest genera were: *Eucalyptus* (19 taxa), *Juncus* (12), *Carex* (8), *Leptospermum* (8), *Austrodanthonia* (7), *Brachyscome* (7), *Isolepis* (7), *Lepidosperma* (7), *Callistemon* (6) and *Pultenaea* (6). 28 taxa (6%) were exotic in origin. Overall 26% of taxa were shrubs and 69% herbs. Species density was found to be highly correlated to the modelled mean moisture index at each site. Mean moisture index itself accounted for 26% of the variation shown in species density scores (Fig. 3).

Vegetation communities

Eight communities were recognised at a dissimilarity measure of 0.75 (Fig. 2). Within communities about 20% of species present were shrubs, though in some communities over 40%

of taxa were shrubs (Table 1). The most characteristic shrub species were (summed cover scores) *Baeckea omissa, Epacris microphylla, Leptospermum gregarium, Leptospermum arachnoides, Callistemon pityoides* and *Hakea macrocarpa*. Characteristic herb layer species were *Baloskion stenocoleum, Goodenia bellidifolia, Lepidosperma limicola, Gonocarpus micranthus* and *Lepyrodia scariosa*. *Sphagnum cristatum* was common, and a major part of many of the communities sampled, including the most northerly. The order of names within the community descriptions reflects the importance of each species in terms of cover and fidelity. The community title includes both dominant overstorey shrub species and the dominant understorey herbs. The shrub component, however, varied less across the communities than the herbaceous layer *Baeckea omissa*, for example, was the dominant shrub in six of the eight communities. Herbaceous species were more diagnostic of differences between communities. Species richness was highest in community 4 and lowest in community 5 (Table 1). Introduced taxa presence was low across all communities (8% for community 1 being the highest) and not apparent in communities 5 and 6. Altitude, geology and rainfall did not appear to be of diagnostic value at this level of analysis (Table 1).

Community 1: *Epacris microphylla – Leptospermum arachnoides/Themeda australis – Gonocarpus micranthus*

Shrubs: *Epacris microphylla, Leptospermum arachnoides, Baeckea omissa, Leptospermum minutifolium, Hakea microcarpa, Leptospermum gregarium, Banksia spinulosa, Callistemon pityoides, Boronia parviflora, Pimelea linifolia, Petrophile canescens, Persoonia sericea, Banksia cunninghamii*.

Ground cover: *Themeda australis, Gonocarpus micranthus, Goodenia bellidifolia, Ptilothrix deusta, Schoenus apogon, Poa queenslandica, Baloskion stenocoleum, Lepyrodia scariosa, Entolasia stricta, Rhynchospora brownii, Hypericum gramineum, Austrostipa rudis, Lepidosperma elatius, Hydrocotyle peduncularis, Spiranthes sinensis, Xyris operculata, Tricoryne elatior, Schoenus melanostachys, Pratia purpurascens, Patersonia fragilis, Euchiton sphaericus, Austrostipa scabra, Austrodanthonia racemosa, Austrodanthonia monticola, Viola hederacea, Viola betonicifolia, Patersonia sericea, Hydrocotyle geraniifolia, Euchiton gymnocephalus, Dichelachne*

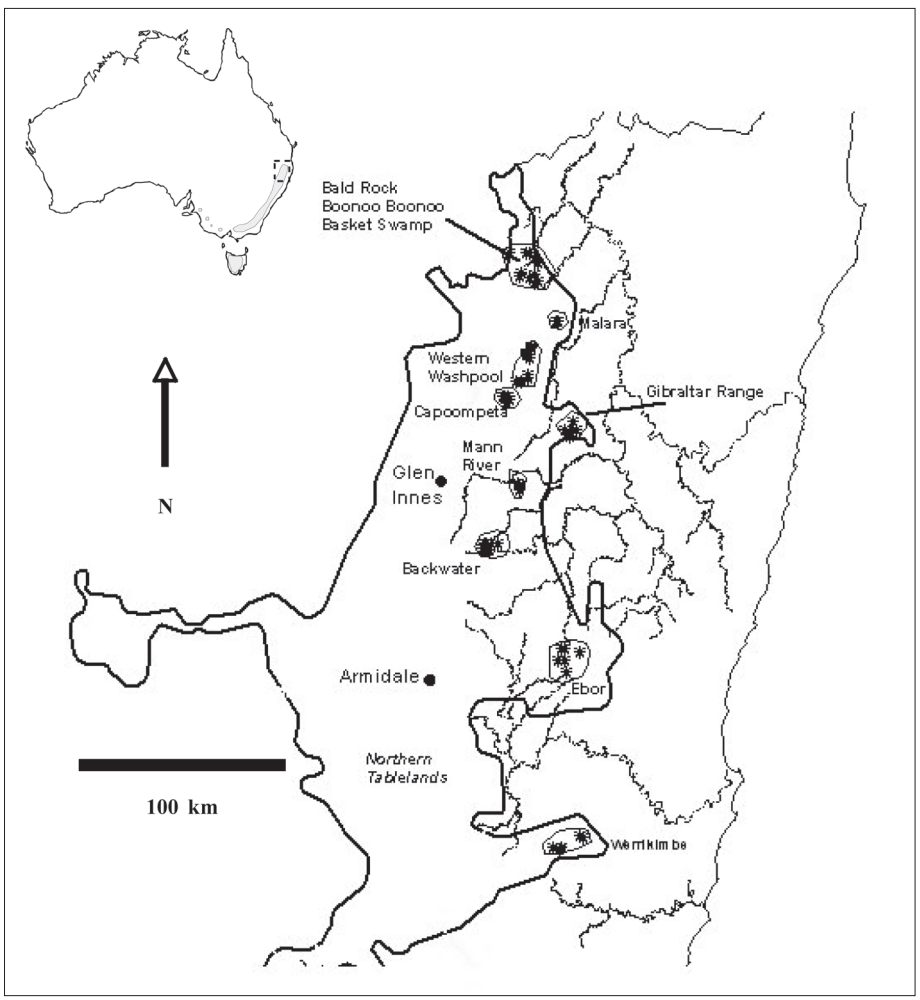

Fig. 1. Location of sampled montane bog areas in northern New England. Inset shows distribution of montane mires within Australia

sieberiana, Dianella revoluta, Dianella caerulea, Craspedia variabilis, Chrysocephalum apiculatum, Caladenia carnea, Brachyscome scapigera, Baloskion fimbriatum.

Occasional emergents: *Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus acaciiformis, Eucalyptus cameronii, Allocasuarina littoralis, Banksia integrifolia, Eucalyptus propinqua, Eucalyptus dorrigoensis*.

Introduced taxa: *Axonopus affinis, Hypochaeris radicata, Setaria pumila, Centaurium erythraea, Prunella vulgaris, Hypochaeris glabra, Cirsium vulgare, Taraxacum officinale, Plantago lanceolata, Phalaris aquatica, Marrubium vulgare, Conyza albida*.

Rock type: granite and acid volcanics.

Distribution: found from north east of Tenterfield south to south-east of Glen Innes.

Reservation: Bald Rock NP, Boonoo Boonoo NP, Capoompeta NP, Western Washpool NP, Mann River NR.

Community 2: *Baeckea omissa – Leptospermum gregarium/Baumea articulata – Baloskion stenocoleum*

Shrubs: *Baeckea omissa, Leptospermum gregarium, Epacris microphylla, Hakea microcarpa, Callistemon pityoides, Callistemon pallidus, Banksia cunninghamii, Banksia spinulosa, Haka eriantha, Pultenaea villosa, Leptospermum trinervium, Leptospermum arachnoides, Persoonia oleoides, Hakea laevipes, Grevillea juniperina, Daviesia latifolia*.

Ground cover: *Baumea articulata, Baloskion stenocoleum, Gonocarpus micranthus, Themeda ausralis, Lomandra multiflora, Schoenus apogon, Lepidosperma limicola, Xyris operculata, Pteridium esculentum, Poa queenslandica, Pennisetum alopecuroides, Lepidosperma elatius, Goodenia bellidifolia, Geranium solanderi* subsp. *grande, Entolasia stricta, Cyperus gracilis, Stylidium graminifolium, Ranunculus lappaceus, Lycopodiella cernua, Imperata cylindrica, Drosera burmannii, Dianella longifolia, Utricularia dichotoma, Schoenus melanostachys, Rhynchospora brownii, Plantago varia, Persicaria decipiens, Lindsaea linearis, Lepidosperma laterale, Isolepis*

Table 1: Selected attributes of the seven defined montane bog communities in eastern flowing catchments of the northern New England.

Community	Number of sites	Mean species richness per 400 m² (range)	Total number of species	Number of exotic species	%Shrubs %Herbs %Trees	Altitude (metres)	Mean annual rainfall range (mm)
C1: *Epacris microphylla – Leptospermum arachnoides / Themeda australis – Gonocarpus micranthus*	10	30 (21–38)	144	12	18 81 1	990–1230	978–1074
C2: *Baeckea omissa – Leptospermum gregarium / Baumea articulata – Baloskion stenocoleum*	7	24 (16–37)	101	3	26 72 2	955–1060	872–1097
C3: *Baeckea omissa – Epacris microphylla / Lepidosperma limicola – Baloskion stenocoleum*	13	28 (19–45)	145	8	30 68 2	940–1250	915–1142
C4: *Baeckea omissa – Leptospermum gregarium / Baloskion fimbriatum – Lomandra longifolia*	5	42 (30–62)	119	6	20 72 8	1070–1225	882–956
C5: *Baeckea omissa – Leptospermum gregarium / Lepyrodia scariosa – Blandfordia grandiflora*	4	14 (13–15)	26	0	27 73 0	1150–1160	1136–1154
C6: *Epacris microphylla – Leptospermum arachnoides / Lepidosperma gunnii – Lepidosperma scariosa*	3	22–33 (28)	54	0	45 49 6	1050–1125	1138–1257
C7: *Baeckea omissa – Hakea microcarpa / Baloskion stenocoleum – Empodisma minus*	11	23 (18–35)	90	8	22 73 4	851–1372	1043–1715
C8: *Baeckea omissa – Epacris obtusifolia / Lepidosperma limicola – Xyris operculata*	8	22 (12–35)	69	1	38 63 0	920–1040	1210–1253

subtilissima, Isolepis nodosa, Haloragis heterophylla, Gleichenia dicarpa, Gahnia sieberiana, Epilobium gunnianum, Entolasia marginata, Drosera binata, Cyperus unioloides, Carex fascicularis, Blechnum penna-marina, Austrofestuca eriopoda.

Occasional emergents: *Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus radiata* subsp. *sejuncta, Eucalyptus camphora* subsp. *relicta, Eucalyptus pauciflora, Eucalyptus nova-anglica, Eucalytpus notabilis, Eucalyptus cameronii, Eucalytpus brunnea, Allocasuarina littoralis*.

Introduced taxa: *Axonopus affinis, Hainardia cylindrica, Cyperus eragrostis*.

Rock type: granite and metasediments.

Distribution: known from north-east of Tenterfield south to the Backwater area.

Reservation: Basket Swamp NP, Warra NP, Western Washpool NP.

Community 3: *Baeckea omissa – Epacris microphylla/ Lepidosperma limicola – Baloskion stenocoleum*

Shrubs: *Baeckea omissa, Epacris microphylla, Callistemon pityoides, Leptospermum gregarium, Leptospermum arachnoides, Hakea microcarpa, Banksia cunninghamii, Boronia parviflora, Hibbertia acicularis, Pimelea linifolia, Callistemon citrinus, Epacris obtusifolia, Pultenaea pycnocephala, Pimelea glauca, Hibbertia riparia, Grevillea acanthifolia* subsp. *stenomera, Callistemon pallidus*.

Ground cover: *Lepidosperma limicola, Baloskion stenocoleum, Goodenia bellidifolia, Entolasia stricta, Xyris complanata, Gonocarpus micranthus, Themeda australis, Thelionema grande, Xyris operculata, Gymnoschoenus sphaerocephalus, Gleichenia dicarpa, Geranium solanderi* var. *grande, Austrostipa rudis, Lepyrodia anarthria, Hypericum gramineum, Rhynchospora brownii, Lycopodiella cernua, Lindsaea linearis, Baloskion fimbriatum, Thelionema caespitosum, Schoenus apogon, Ranunculus lappaceus, Patersonia glabrate, Lepidosperma gunnii, Haemodorum planifolium, Drosera binata, Deyeuxia imbricata, Craspedia variabilis, Utricularia dichotoma, Lomandra longifolia, Goodenia hederacea, Gahnia sieberiana, Eleocharis sphacelata, Cryptostylis subulata, Selaginella uliginosa, Schoenus melanostachys, Ptilothrix deusta, Hypericum japonicum, Hydrocotyle peduncularis*.

Occasional emergents: *Eucalyptus pauciflora*, *Eucalyptus dalrympleana* subsp. *heptantha, Banksia integrifolia*.

Introduced taxa: *Andropogon virginicus, Prunella vulgaris, Phalaris aquatica, Dactylis glomerata, Conyza albida, Hypochaeris radicata, Hypochaeris glabra, Axonopus affinis*.

Rock type: granite and acid volcanic.

Distribution: found from north-east of Tenterfield to the Backwater area.

Reservation: Bald Rock NP, Boonoo Boonoo NP, Basket Swamp NP, Warra NP, Capoompeta NP, Mann River NR.

Community 4: *Baeckea omissa – Leptospermum gregarium/Baloskion fimbriatum – Lomandra longifolia*

Shrubs: *Baeckea omissa, Leptospermum gregarium, Hakea microcarpa, Epacris microphylla, Callistemon pityoides, Banksia cunninghamii, Lomatia fraseri, Petrophile canescens, Monotoca scoparia*.

Ground cover: *Baloskion fimbriatum, Lomandra longifolia, Goodenia bellidifolia, Viola hederacea, Patersonia fragilis, Lepyrodia anarthria, Helichrysum scorpioides, Gonocarpus micranthus, Geranium solanderi* var. *grande, Juncus vaginatus, Gratiola peruviana, Dichelachne inaequiglumis, Stylidium graminifolium, Scirpus polystachyus, Pteridium esculentum, Isachne globosa, Echinopogon caespitosus, Carex lobolepis, Schoenus apogon, Scaevola ramosissima, Poa sieberiana, Imperata cylindrica, Haloragis heterophylla, Craspedia variabilis, Austrodanthonia racemosa, Poranthera microphylla, Lythrum salicaria, Lepyrodia leptocaulis, Lepidosperma limicola, Hydrocotyle geraniifolia, Goodenia hederacea, Dichondra repens, Cyperus sphaeroideus, Carex inversa, Austrofestuca eriopoda*.

Occasional emergents: *Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus pauciflora, Eucalyptus camphora* subsp. *relicta, Banksia integrifolia, Acacia filicifolia, Eucalyptus acaciiformis, Eucalyptus caliginosa, Eucalyptus nova-anglica, Eucalyptus nobilis*.

Introduced taxa: *Hypochaeris radicata, Hypochaeris glabra, Centaurium erythraea, Prunella vulgaris, Juncus capitatus, Holcus lanatus*.

Rock type: granite.

Distribution: restricted to the Backwater area, north-east of Guyra.

Reservation: Warra NP.

Community 5: *Baeckea omissa – Leptospermum gregarium/Lepyrodia scariosa – Blandfordia grandiflora*

Shrubs: *Baeckea omissa, Leptospermum gregarium, Callistemon pityoides, Banksia spinulosa, Epacris microphylla, Triplarina imbricata, Callistemon sieberi*.

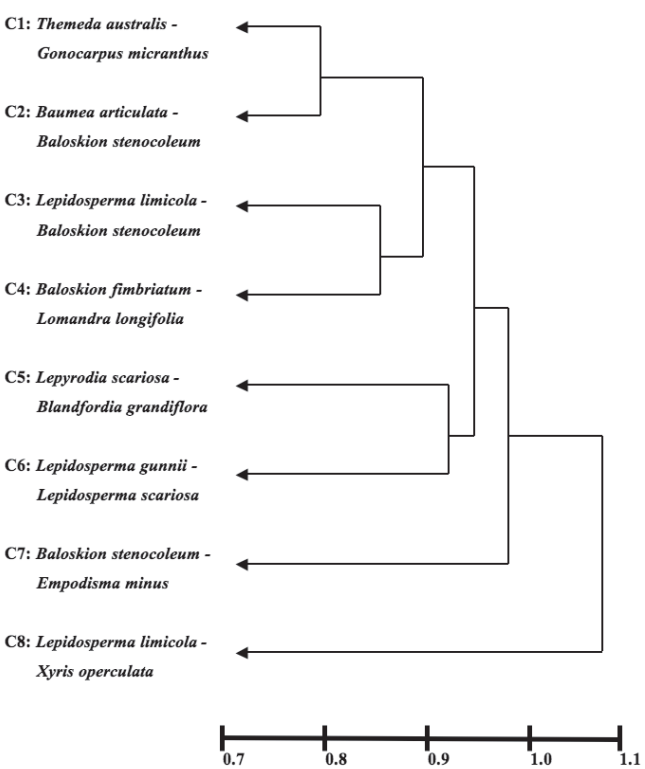

Fig. 2. Summary dendrogram of full dataset of sites using Kulczynski association and flexible UPGMA fusion strategy. Community descriptors use herbaceous species names as they were more diagnostic than overstorey shrubs.

Ground cover: *Lepyrodia scariosa, Blandfordia grandiflora, Goodenia bellidifolia, Gonocarpus micranthus, Xyris complanata, Baloskion stenocoleum, Austrostipa scabra, Xanthorrhoea acaulis, Lepyrodia anarthria, Schoenus apogon, Lepidosperma tortuosum, Drosera peltata, Utricularia dichotoma, Gonocarpus oreophilus, Entolasia stricta, Drosera spatulata, Drosera binata, Cynoglossum australe, Poa queenslandica*.

Occasional emergents: none apparent.

Introduced taxa: none apparent.

Rock type: granite.

Distribution: restricted to south-east of Tenterfield.

Reservation: Western Washpool NP.

Community 6: *Epacris microphylla – Leptospermum arachnoides/Lepidosperma gunnii – Lepyrodia scariosa*

Shrubs: *Epacris microphylla, Leptospermum arachnoides, Baeckea omissa, Comesperma retusum, Dillwynia phylicoides, Petrophile canescens, Persoonia oleoides, Melichrus procumbens, Callistemon citrinus, Melichrus urceolatus, Leptospermum novae-angliae, Banksia spinulosa, Pultenaea pycnocephala, Leptospermum minutifolium, Pimelea linifolia, Hakea laevipes* subsp. *graniticola, Callistemon viminalis, Boronia parviflora, Brachyloma daphnoides* subsp. *glabrum*.

Ground cover: *Lepidosperma gunnii, Goodenia bellidifolia, Aristida jerichoensis, Lepyrodia scariosa, Dampiera stricta, Austrostipa pubescens, Entolasia stricta, Baloskion stenocoleum, Trachymene incisa, Selaginella uliginosa, Lepidosperma limicola, Gonocarpus micranthus, Pteridium esculentum, Lindsaea linearis, Lepidosperma neesii, Hovea heterophylla, Drosera spatulata, Dianella caerulea, Bossiaea neo-anglica, Stylidium graminifolium, Schoenus melanostachys, Rhytidosporum diosmoides, Patersonia fragilis, Lomandra longifolia, Lepidosperma tortuosum, Haemodorum planifolium, Gleichenia dicarpa, Dianella longifolia, Austrostipa scabra*.

Occasional emergents: *Eucalyptus williamsiana, Eucalytpus radiata* subsp. *sejuncta, Eucalyptus dorrigoensis*.

Rock type: granite.

Introduced taxa: *Axonopus affinis*.

Distribution: from the Malara Plateau south to east of Deepwater.

Reservation: Western Washpool NP, Demon NR.

Community 7: *Baeckea omissa – Hakea microcarpa/ Baloskion stenocoleum – Empodisma minus*

Shrubs: *Baeckea omissa, Hakea microcarpa, Epacris microphylla, Leptospermum gregarium, Callistemon pityoides, Hibbertia acicularis, Epacris obtusifolia, Grevillea acanthifolia* var. *stenomera, Pultenaea villosa, Epacris breviflora, Boronia microphylla, Leptospermum novae-angliae, Choretrum candollei, Banksia cunninghamii*.

Ground cover: *Baloskion stenocoleum, Empodisma minus, Xyris complanata, Patersonia fragilis, Juncus subsecundus, Tetrarrhena turfosa, Isachne globosa, Deyeuxia gunniana, Lepidosperma limicola, Gleichenia dicarpa, Scaevola hookeri, Gymnoschoenus sphaerocephalus, Galium gaudichaudii, Ranunculus lappaceus, Lepyrodia anarthria, Hypericum japonicum, Geranium solanderi* var. *grande, Mitrasacme serpyllifolia, Lepyrodia scariosa, Juncus alexandri, Gonocarpus micranthus, Gahnia sieberiana, Austrostipa rudis, Hydrocotyle peduncularis, Goodenia bellidifolia, Euchiton sphaericus, Viola hederacea, Poa sieberiana, Dichondra repens, Austrodanthonia monticola, Scirpus polystachyus, Lomandra longifolia, Lepidosperma gunnii, Isotoma fluviatilis, Isolepis Habra, Epilobium billardierianum, Deyeuxia parviseta, Thelionema grande, Selaginella uliginosa, Plantago debilis, Pennisetum alopecuroides, Myriophyllum variifolium, Juncus continuus, Gonocarpus oreophilus, Eriocaulon scariosum, Carex gaudichaudii, Carex appressa, Blechnum nudum, Baumea rubiginosa*.

Occasional emergents: *Eucalyptus acaciiformis, Eucalyptus pauciflorus, Eucalyptus dalrympleana* subsp. *heptantha*.

Introduced taxa: *Phalaris aquatica, Callitriche stagnalis, Holcus lanatus, Anthoxanthum odoratum, Rubus fruticosus, Juncus capitatus, Conyza albida, Cirsium vulgare*.

Rock type: granite and basalt.

Distribution: restricted to the southern locations within the study area from Ebor south to east of Walcha.

Reservation: Cathedral Rocks NP, Werrikimbe NP

Community 8: *Baeckea omissa – Epacris obtusifolia/ Lepidosperma limicola – Xyris operculata*

Shrubs: *Baeckea omissa, Epacris obtusifolia, Leptospermum arachnoides, Banksia spinulosa, Epacris microphylla, Hibbertia rufa, Boronia polygalifolia, Prostanthera saxicola, Logania pusilla, Hakea laevipes* subsp. *graniticola, Callistemon citrinus, Pultenaea villosa, Notelaea linearis, Grevillea acanthifolia* var. *stenomera, Boronia parviflora, Bauera rubioides*.

Ground cover: *Lepidosperma limicola, Xyris operculata, Lepyrodia scariosa, Drosera binata, Drosera spatulata, Baloskion fimbriatum, Amphipogon strictus, Thelionema caespitosum, Gonocarpus micranthus, Caustis flexuosa, Goodenia bellidifolia, Entolasia stricta, Tricostularia pauciflora, Schoenus brevifolius, Blandfordia grandiflora, Geranium solanderi* var. *solanderi, Selaginella uliginosa, Patersonia fragilis, Eragrostis elongata, Tetrarrhena juncea, Gymnoschoenus sphaerocephalus, Trachymene incisa, Lycopodiella lateralis, Lindsaea linearis, Hypericum gramineum, Rhytidosporum procumbens, Panicum paludosum, Drosera peltata, Deyeuxia gunniana, Baloskion stenocoleum, Austrostipa pubescens, Austrodanthonia induta*.

Occasional emergents: none apparent.

Introduced taxa: *Axonopus affinis*.

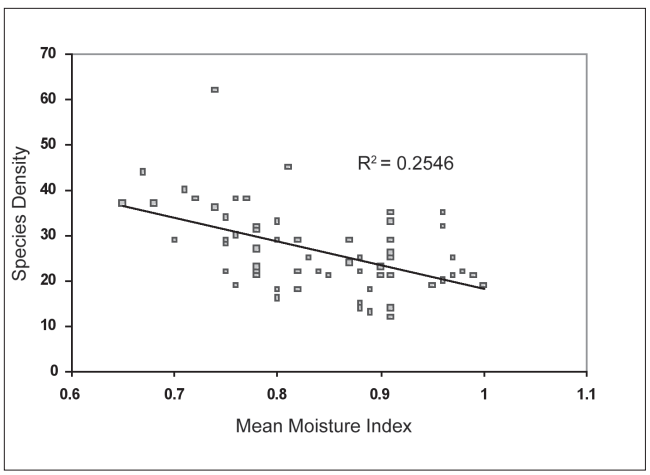

Fig. 3. The affect of annual mean moisture index on species density. Mean moisture index accounts for nearly 26% of the variation shown in the number of species per plot.

Distribution: from the Malara Plateau east of Tenterfield south to Carrai east of Walcha.

Reservation: Demon NR, Gibraltar Range NP. Carrai NP and SCA.

Discussion

Montane bogs in northern New England, with 438 taxa (including 28 exotic species), have a large species pool, compared to other montane bogs in Australia. This compares to 269 (19 exotics) in Victoria (Whinam et al. 2002) and 171 in Tasmania (Whinam et al. 2001). The dominant life-form types across all communities were herbs, reflected in many sedge genera being rich in species (*Carex, Isolepis, Lepidosperma*). It has been suggested (Keith 2004; Williams & Clarke 2006), that groundlayer species in such bog systems are dominated by the monocotyledon families Cyperaceae, Juncaceae and Restionaceae, and the shrub layer by Epacridaceae, Fabaceae and Myrtaceae, and our study shows some correlation with this list, but some exceptions. We found, in order of importance, that Poaceae, Cyperaceae and Asteraceae were the most prominent herbaceous families with Myrtaceae, Fabaceae and Proteaceae being the more important shrub families. Pemberton et al. (2005) list five species-rich families in Tasmanian bogs, four of which were also found in our list of the richest families, the exception being Restionaceae, which was of less importance in this study.

Surprisingly *Eucalyptus* was found to be the richest genus (19 species), even though in most situations none were present within bog communities. Occasionally however, a few eucalypts occurred as single or scattered individuals. Emergent eucalypts can be considered to fall into three broad types, those that are adapted to montane bog environments, those that occur in marginal montane bog environments and those that have opportunistically-germinated due to local or temporal safe sites. Only one eucalypt taxon, *Eucalyptus camphora* subsp. *relicta,* could be considered to be a montane bog specialist within the study area. *Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus acaciiformis, Eucalyptus nova-anglica, Eucalyptus pauciflora* and *Eucalyptus radiata* subsp. *sejuncta* are taxa that are often found around the margins of montane bogs and may periodically encroach and then die back due to fluctuations in the watertable. The other eucalypt taxa recorded are opportunists that may be found around the margins where the watertable is lower, on occasional isolated 'humps' of mounded soil, on fugitive underlying rock outcrops or temporarily within the bogs when reduced rainfall initiates a drop in watertables. This same phenomenon may also account for the high richness in the Poaceae.

Shrubs on average accounted for 26% (110 taxa) of the total flora, though only 26% of these (29 taxa) could be called montane bog specialists. The percentage of shrubs was less than for Tasmanian bogs (32%) (Pemberton et al. 2005). Five of the New England montane bog specialist shrubs (*Baeckea omissa, Leptospermum gregarium, Leptospermum arachnoides, Hakea microcarpa, Epacris microphylla*) were widespread and dominated nearly all of the communities described but although important as a dominant structural life form (in the sense that they form the tallest stratum), shrubs are non-diagnostic of composition within montane bog communities of this region. The herbaceous layer was far richer and more useful as a diagnostic tool for delineating assemblages within the northern New England. The shrubs are highly diagnostic for cross comparison purposes over larger extents (i.e. across more regions).

Within the study area mean moisture index was found to be a highly predictive variable accounting for 26% of the variation in the number of species found in each plot, providing evidence that this is a common correlative feature of bog communities (Jarman et al. 1988; Keith 2004; Whinam & Hope 2005).

This investigation builds on work of Whinam and Chilcott (2002) who sampled *Sphagnum*-dominated communities in NSW as far north as Backwater. From our observations the incidence of *Sphagnum cristatum* ranged from well-developed hummock-hollow micro-topography (e.g. Werrikimbe, Cathedral Rocks, New England National Park, Western Washpool and Malara), through occasional occurrence of *Sphagnum* in the wettest parts of sites, to total absence in dry or heavily fire-impacted localities. At the community level *Sphagnum* was present and prominent in all the assemblages described here, and was also a feature of the communities in the most northerly sites.

Though depth of peat was not formally measured, observations suggest that peat depth varied considerably within and between communities, but more consistently was less well-developed to the north and west. In some sites the peat layer was almost absent. Possible explanations for variation in peat depth include lower peat accumulation due to reduced rainfall, increased evapotranspiration, the composition of the flora, increased temperature, or peat destruction such as through slippage and fire (Whinam & Chilcott 2002; Hope & Kershaw 2005; Whinam & Hope 2005). The origin of peat in the study area is not known but is likely to be largely based on cyperaceous litter (Agnew et al. 1993; Whinam & Chilcott 2002; Clarkson & Buxton 2005).

In previous analyses of *Sphagnum*-dominated vegetation (Whinam & Chilcott 2002; Whinam et al. 2002) vegetation assemblages have been largely related to geographic location and altitude. Clarke et al. (2000) suggested that rock type was also a significant factor in differentiating montane bog vegetation in New England National Park. However in this current investigation most communities were shared across many sample areas, and neither locality, nor rock type appears to be significant in differentiating montane bog communities in our analyses. Some authors have suggested distinctive banding within New England bog systems (Millington 1954; Williams & Clarke 1997; Williams & Clarke 2006) but our experience is that, except where extreme gradients exist,

banding is largely indistinct. Patterning is more an exception, as mosaics are formed by temporal changes in groundwater and flooding levels, and the occurrence and frequency of fire. Where extreme gradients occur, such as along permanent water channels, specialist shrub species that are usually not found in the general bog matrix, (e.g. *Callistemon pungens, Callistemon pallidus, Callistemon viminalis, Leptospermum polygalifolium*) may occur.

Floristic affinities

Previous floristic investigations have involved numeric comparisons between local montane bogs and other vegetation communities within the local landscape. In all instances montane bog vegetation has been delineated as a separate and distinct vegetation assemblage, but showing a great affinity with other heathy systems, such as rock outcrops, heathy forests, woodlands and heathy rocky riparian environments (Binns 1992; Binns 1995; Chapman & Binns 1995; Hunter 1998; Hunter 1999; Hunter et al. 1999; Benson & Ashby 2000; Clarke et al. 2000; Hunter 2000; Sheringham & Hunter 2002; Hunter 2004ab; Hunter 2005b). This affinity is initially somewhat surprising as shrubs account for only 26% of all species in montane bogs, and the most common dominant shrubs (*Baeckea omissa, Epacris microphylla, Leptospermum gregarium, Leptospermum arachnoides, Callistemon pityoides* and *Hakea microcarpa*) are restricted to bogs. In addition species of the dominant herbaceous layer are highly restricted to bog environments. However, as has been found with the highly endemic rock outcrop floras of the same region, the highly specialised montane bog endemics may be abundant, but are low in richness (Hunter 2001; Hunter 2003). The majority of taxa, especially within the herbaceous flora, occur infrequently, are not dominants, and are generally ubiquitous in nearby communities.

The shrub flora however is generally shared more specifically with other heathy assemblages, and some taxa that are primarily rock outcrop taxa (Hunter & Clarke 1998; Hunter 2002), e.g. *Leptospermum novae-angliae, Kunzea bracteolata, Eucalyptus scias* subsp. *apoda* and *Thelionema grande,* will also occur within montane bogs, but within no other communities. Both these environments share low pH (Hunter 2001; Whinam & Chilcott 2002) and at least physiological drought conditions.

Conservation issues

Benson & Ashby (2000) found that for the Guyra 1: 100 000 Map Sheet area, 80% of the original extent of montane bogs were still extant and generally in good condition, though poorly-represented in conservation reserves. The Guyra map sheet area was thought to contain 370 ha of montane bogs of which 15 ha were in reserves. Based on current mapping technology (using on ground surveying and verification), it is estimated that potentially 2700 ha of bog communities are incorporated in the reserve network (Hunter 1998; Hunter 1999; Hunter et al. 1999; Benson & Ashby 2000; Clarke et al. 2000; Hunter 2000; Sheringham & Hunter 2002; Hunter 2004ab; Hunter 2005b) and that at least 10 000 ha in total potentially exist in northern New England. If wetlands other than bogs, such as fens and lagoons were to be included this figure would be much enlarged. This is far in excess of the total swamp/wetlands area (1970 ha) thought to exist on the northern tablelands and north western slopes by Wall (2000). This large discrepancy is difficult to explain without close inspection of the data used by Wall (2000) in modelling. However, when comparing previous mapping products, areas such as wetlands (and low dry heathlands) have often been misinterpreted, from remote sensing alone, as cleared lands (pers. obs.). Previous modelling of vegetation assemblages on the Northern Tablelands have often emphasised forest associations, due to disputes over forestry, and this emphasis may also account for the low number of hectares previously predicted for wetlands on the Tablelands. These suggestions are speculative; the main reason for our increase in the amount of wetlands on the tablelands is likely to be purely due to an increased on-ground effort.

Whinam and Chilcott (2002) found that *Sphagnum*-dominated bog communities, even within conservation reserves, were in poor condition due to past land use practices. Much of our surveying occurred within conservation reserves and where the bogs were considered to be in good condition. However threatening processes such as over-grazing, frequent fire and nutrient enrichment were evident in many locations outside reserves. Even within reserves some locations appeared to have been burnt too frequently. However, some extensive, relatively intact bogs such as Tin Swamp (east of Tenterfield), along road reserves throughout the region and above the northern boundary of Butterleaf National Park also exist outside the reserve network.

Species associated with higher nutrient wetland systems (e.g. *Phragmites australis, Scirpus polystachyus* and *Carex gaudichaudii*) have been encroaching into bogs in and near Cathedral Rocks and New England National Parks within the last ten years (*pers. obs.*). Some bogs were affected by *Phytophthora*, particularly those in the Werrikimbe area. Drought also was noted to have affected the shrub layer causing much dieback and death in the worst affected areas. Montane bog systems have developed due to particular combinations of temperature and rainfall, we concur with others who consider them highly susceptible to future climate change (Whinam & Chilcott 2002).

Despite the shrub species richness being comparatively low in bogs of the region, shrubs are over-represented in those taxa considered to be rare and threatened. Of the 20 rare taxa found associated with New England Bioregion montane bogs, 15 were shrubs and two were trees. Of the three taxa listed on the NSW *Threatened Species Conservation Act* (1995), two are endangered (*Eucalyptus camphora* subsp. *relicta, Triplarina imbricata*) and one vulnerable (*Grevillea juniperina* subsp. *allojohnsonii*). 17 other species were listed on the RoTAP list

as either vulnerable (*Baeckea gunniana*), rare (*Callistemon pungens, Thelionema grande, Eucalyptus dorrigoensis, Pultenaea pycnocephala, Acacia barringtonensis, Carex capillacea, Persoonia daphnoides, Kunzea bracteolata, Grevillea acanthifolia* subsp. *stenomera, Melaleuca tortifolia, Grevillea acerata, Acacia orites, Acacia floydii, Persoonia procumbens* and *Acianthus apprimus*) or as poorly known (*Eucalyptus scias* subsp. *apoda*) (Briggs & Leigh 1996; Richards & Hunter 1997; Copeland & Hunter 1999).

This study has highlighted the significance of New England montane bogs. These systems are some of the richest within Australia with a high number of rare and restricted taxa. They are vulnerable to both present landuse practices and future changes in climate, and are restricted in area, thus needing further conservation initiatives. Despite the apparent similarity in structure and composition of the overstorey shrubs these communities are best delineated by the composition of their herbaceous substratum. Further work is required to interpret the complexities associated with the dynamics of these systems.

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Appendix: Floristic composition of montane bogs of east flowing catchments of northern New England.

Taxa present in each of the eight communities. Some taxa were found in previous surveys or opportunistically (Op). Some orchid identifications may be identified in a broad taxonomic sense (*sens. lat.*). Nomenclature follows that of Harden (1990–1993) except where recent changes have occurred (PlantNET 2006).* Indicates exotic species.

1 = *Epacris microphylla – Leptospermum arachnoides/ Themeda australis – Gonocarpus micranthus*,

2 = *Baeckea omissa – Leptospermum gregarium/Baumea articulata – Baloskion stenocoleum*,

3 = *Baeckea omissa – Epacris microphylla/Lepidosperma limicola – Baloskion stenocoleum*,

4 = *Baeckea omissa – Leptospermum gregarium/Baloskion fimbriatum – Lomandra longifolia*,

5 = *Baeckea omissa – Leptospermum gregarium/Lepyrodia scariosa – Blandfordia grandiflora*,

6 = *Epacris microphylla – Leptospermum arachnoides/ Lepidosperma gunnii – Lepidosperma scariosa*,

7 = *Baeckea omissa – Hakea microcarpa/Baloskion stenocoleum – Empodisma minus*,

8 = *Baeckea omissa – Epacris obtusifolia/Lepidosperma limicola – Xyris operculata*.

	1	2	3	4	5	6	7	8	Op
Anthericaceae									
Arthropodium milleflorum				4					
Caesia parviflora									Op
Dichopogon fimbriatus				4					
Thysanotus tuberosus	1								
Tricoryne elatior	1		3	4					
Apiaceae									
Centella asiatica	1			4					
Hydrocotyle geraniifolia	1			4			7		
Hydrocotyle laxiflora									
Hydrocotyle peduncularis	1		3	4			7		
Platysace ericoides									Op
Trachymene incisa subsp. *incisa*			3	4		6		8	
Araceae									
Gymnostachys anceps			3						
Aspleniaceae									
Asplenium flavellifolium							7		
Asteraceae									
Brachyscome angustifolia var. *angustifolia*	1								
Brachyscome angustifolia var. *heterophylla*									Op
Brachyscome microcarpa	1								
Brachyscome nova-anglica			3	4					
Brachyscome scapigera	1								
Brachyscome spathulata									Op
Brachyscome tenuiscapa var. *pubescens*				4					
Chrysocephalum apiculatum	1		3						
Chrysocephalum semipapposum		2	3	4					
**Cirsium vulgare*	1						7		
**Conyza albida*	1		3				7		
**Conyza bonariensis*									Op
Craspedia canens	1		3						
Craspedia variabilis	1		3	4					
Euchiton gymnocephalus	1								
Euchiton sphaericus	1			4			7		
Helichrysum boormanii			3						
Helichrysum rutidolepis									Op
Helichrysum scorpioides	1		3	4					
**Hypochaeris glabra*	1		3	4					
**Hypochaeris radicata*	1		3	4					
Microseris lanceolata	1								
Ozothamnus diosmifolius	1								
Podolepis jaceoides		2							
Rhodanthe anthemoides									Op
Senecio biserratus	1								
Senecio diaschides				4					
Senecio hispidulus var. *hispidulus*			3						
Senecio prenanthoides									Op
**Sonchus oleraceus*									Op
**Taraxacum officinale*	1								
Xerochrysum bracteatum									Op
Baueraceae									
Bauera rubioides var. *rubioides*								8	
Blandfordiaceae									
Blandfordia grandiflora	1				5				
Blechnaceae									
Blechnum nudum							7		
Blechnum penna-marina subsp. *alpina*		2							
Blechnum wattsii				4					
Boraginaceae									
Cynoglossum australe					5				
Myosotis australis									Op
Callitrichaceae									
**Callitriche stagnalis*							7		
Campanulaceae									
Wahlenbergia ceracea	1	2							
Wahlenbergia communis				4					
Wahlenbergia stricta subsp. *stricta*									Op

Caryophyllaceae								
Cerastium vulgare								Op
Stellaria angustifolia				4				
Casuarinaceae								
Allocasuarina littoralis	1	2						
Allocasuarina rigida subsp. *rigida*						7		
Clusiaceae								
Hypericum gramineum	1	2	3	4		7	8	
Hypericum japonicum	1		3			7		
Colchicaceae								
Wurmbea dioica subsp. *dioica*	1							
Convolvulaceae								
Dichondra repens	1			4		7		
Cyperaceae								
Baumea articulata		2						
Baumea gunnii								Op
Baumea rubiginosa						7		
Bulbostylis densa	1							
Carex appressa						7		
Carex capillacea								Op
Carex fascicularis		2						
Carex gaudichaudiana						7		
Carex incomitata								Op
Carex inversa				4				
Carex lobolepis				4				
Carex longebrachiata	1							
Caustis flexuosa			3				8	
**Cyperus eragrostis*		2						
Cyperus gracilis	1	2						
Cyperus sanguinolentus						7		
Cyperus sphaeroideus				4				
Cyperus unioloides		2						
Eleocharis dietrichiana		2						
Eleocharis sphacelata			3					
Fimbristylis dichotoma		2						
Gahnia aspera	1							
Gahnia sieberiana	1	2	3			7		
Gymnoschoenus sphaerocephalus			3			7	8	
Isolepis cernua		2						
Isolepis crassiuscula								Op
Isolepis habra						7		
Isolepis hookeriana				4				
Isolepis inundata								Op
Isolepis nodosa		2	3					
Isolepis subtilissima		2						
Lepidosperma elatius	1	2						
Lepidosperma filiforme	1							
Lepidosperma gunnii			3		6	7		
Lepidosperma laterale		2	3					
Lepidosperma limicola	1	2	3	4	6	7	8	
Lepidosperma neesii	1		3			6		
Lepidosperma tortuosum			3		5	6		8
Philothrix deusta	1		3					
Rhynchospora brownii	1	2	3				7	
Schoenus apogon	1	2	3	4	5			
Schoenus brevifolius								8
Schoenus melanostachys	1	2	3			6		
Schoenus turbinatus								8
Scirpus polystachyus				4			7	
Tricostularia pauciflora								8
Dennstaedtiaceae								
Pteridium esculentum	1	2		4		6		8
Dilleniaceae								
Hibbertia acicularis			3				7	
Hibbertia linearis								Op
Hibbertia pedunculata			3					
Hibbertia riparia	1		3					
Hibbertia rufa								8
Droseraceae								
Drosera binata		2	3	4	5			8
Drosera burmannii	1	2	3	4				
Drosera peltata				4	5			8
Drosera spatulata	1	2	3		5	6		8
Epacridaceae								
Brachyloma daphnoides subsp. *glabrum*						6		8
Epacris breviflora							7	
Epacris microphylla var. *microphylla*	1	2	3	4	5	6	7	8
Epacris obtusifolia			3				7	8
Epacris pulchella			3					
Leucopogon lanceolatus var. *lanceolatus*			3					
Melichrus procumbens				4		6		
Melichrus urceolatus						6		
Monotoca scoparia		2	3	4				
Sprengelia incarnata								Op
Trochocarpa laurina								Op
Eriocaulaceae								
Eriocaulon scariosum				4			7	
Euphorbiaceae								
Poranthera microphylla		2		4				
Fabaceae								
Acacia barringtonensis								8
Acacia filicifolia				4				
Acacia floydii								
Acacia melanoxylon								Op
Acacia ulicifolia							7	
Aotus subglauca var. *subglauca*			3	4				
Bossiaea neo-anglica						6		
Bossiaea scortechinii		2						Op

Daviesia latifolia		2							
Daviesia nova-anglica			3						
Daviesia ulicifolia							7		
Desmodium varians				4					
Dillwynia phylicoides			3	4		6			
Dillwynia retorta				4					
Dillwynia sericea									Op
Dillwynia sieberi				4					
Glycine clandestina				4					
Glycine sp. A				4					
Gompholobium inconspicuum									Op
Hovea heterophylla						6			
Lotus uliginosus									Op
Mirbelia rubifolia									Op
Mirbelia speciosa subsp. *speciosa*								8	
Phyllota phylicoides									Op
Pultenaea altissima			3						
Pultenaea dentata									Op
Pultenaea myrtoides									Op
Pultenaea pycnocephala			3			6			
Pultenaea retusa			3						
Pultenaea villosa		2	3				7	8	
Sphaerolobium minus									Op
Sphaerolobium vimineum			3					8	
Trifolium repens									Op
Gentianaceae									
**Centaurium erythraea*	1			4					
Geraniaceae									
Geranium neglectum									Op
Geranium potentilloides var. *potentilloides*									Op
Geranium solanderi var. *grande*	1	2	3	4			7		
Geranium solanderi var. *solanderi*				4				8	
Gleicheniaceae									
Gleichenia dicarpa	1	2	3			6	7		
Goodeniaceae									
Dampiera stricta						6	7	8	
Goodenia bellidifolia subsp. *bellidifolia*	1	2	3	4	5	6	7	8	
Goodenia hederacea subsp. *hederacea*		2	3	4					
Scaevola hookeri							7		
Scaevola ramosissima				4					
Velleia montana									Op
Haemodoraceae									
Haemodorum planifolium	1		3			6			
Haloragaceae									
Gonocarpus humilis			3						
Gonocarpus micranthus	1	2	3	4	5	6	7	8	
Gonocarpus oreophilus		2			5		7		
Gonocarpus tetragynus	1	2	3	4		6	7	8	
Gonocarpus teucrioides	1		3	4					
Haloragis heterophylla		2		4					
Myriophyllum pedunculatum			3						
Myriophyllum variifolium							7		
Hypoxidaceae									
Hypoxis exilis	1								
Hypoxis hygrometrica var. *splendida*									Op
Iridaceae									
Patersonia fragilis	1		3	4		6	7	8	
Patersonia glabrate			3						
Patersonia sericea	1		3						
Juncaceae									
Juncus alexandri	1						7		
**Juncus capitatus*				4			7		
Juncus continuus		2	3				7		
Juncus firmus	1		3						
Juncus pauciflorus	1								
Juncus ochrocoleus		2	3	4	5	6	7	8	
Juncus phaeanthus							7		
Juncus planifolius									Op
Juncus prismatocarpus							7		
Juncus remotiflorus		2	3						
Juncus subsecundus				4			7		
Juncus usitatus		2							
Juncus vaginatus				4					
Luzula densiflora									Op
Luzula flaccida				4					
Lamiaceae									
Ajuga australis			3						
**Marrubium vulgare*	1								
Prostanthera saxicola								8	
Prostanthera scutellarioides									Op
**Prunella vulgaris*	1		3	4					
Lauraceae									
Cassytha glabella								8	
Lentibulariaceae									
Utricularia dichotoma	1	2	3	4	5			8	
Liliaceae									
Blandfordia grandiflora								8	
Lindsaeaceae									
Lindsaea linearis	1	2	3			6		8	
Lobeliaceae									
Isotoma fluviatilis							7		
Pratia pedunculata									Op
Pratia purpurascens	1								
Loganiaceae									
Logania pusilla								8	
Mitrasacme serpyllifolia							7		

Lomandraceae
Lomandra elongata Op
Lomandra filiformis 1
Lomandra longifolia 1 2 3 4 6 7
Lomandra multiflora subsp. *multiflora* 1 2 3 6

Lycopodiaceae
Lycopodiella cernua 2 3
Lycopodiella lateralis 8
Lycopodium deuterodensum Op

Lythraceae
Lythrum salicaria 4

Menyanthaceae
Nymphoides geminata 3

Myrtaceae
Baeckea gunniana Op
Baeckea omissa 1 2 3 4 5 6 7 8
Baeckea utilis Op
Callistemon citrinus 2 3 6 8
Callistemon pallidus 2 3 4
Callistemon pityoides 1 2 3 4 5 7
Callistemon pungens 7
Callistemon sieberi 1 3 5
Callistemon viminalis 6
Eucalyptus acaciiformis 1 4 7
Eucalyptus brunnea 1 2
Eucalyptus caliginosa 4
Eucalyptus cameronii 1 2
Eucalyptus campanulata 3
Eucalyptus camphora subsp. *relicta* 2 4
Eucalyptus dalrympleana subsp. *heptantha* 1 2 3 4 7
Eucalyptus dorrigoensis 1 6
Eucalyptus ligustrina Op
Eucalyptus nitens Op
Eucalyptus nobilis 4
Eucalyptus notabilis 2
Eucalyptus nova-anglica 2 4
Eucalyptus obliqua Op
Eucalyptus pauciflora 1 2 3 4 7
Eucalyptus propinqua 1
Eucalyptus radiata subsp. *sejuncta* 2 6
Eucalyptus scias subsp. *apoda*
Eucalyptus williamsiana 6
Kunzea bracteolata Op
Leptospermum arachnoides 1 2 3 6 8
Leptospermum brevipes 2
Leptospermum gregarium 1 2 3 4 5 7
Leptospermum minutifolium 1 3 6 8
Leptospermum novae-angliae 6 7
Leptospermum polygalifolium subsp. *montanum* Op
Leptospermum polygalifolium subsp. *transmontanum* 3 4
Leptospermum trinervium 2
Melaleuca tortifolia Op
Triplarina imbricata 2 5

Oleaceae
Notelaea linearis 8

Onagraceae
Epilobium billardierianum 1 7
Epilobium gunnianum 2 4
Epilobium hirtigerum Op

Orchidaceae
Acianthus fornicatus Op
Acianthus pusillus 3
Caladenia carnea 1
Calochilus robertsonii 3
Chiloglottis diphylla 8
Chiloglottis pluricallata Op
Cryptostylis subulata 3
Microtis unifolia 2
Orthoceras strictum 8
Pterostylis cycnocephala 1
Pterostylis furcata Op
Pterostylis parviflora Op
Spiranthes sinensis subsp. *australis* 1 3
Thelymitra ixioides var. *ixioides* Op
Thelymitra pauciflora 1

Oxalidaceae
Oxalis perennans 1

Philydraceae
Philydrum lanuginosum 3

Phormiaceae
Dianella caerulea 1 4 6
Dianella longifolia 2 6
Dianella revoluta var. *revoluta* 1 4
Thelionema caespitosum 1 3 4 8
Thelionema grande 2 3 4 7 8

Pittosporaceae
Billardiera scandens var. *scandens* 2
Rhytidosporum diosmoides 6
Rhytidosporum procumbens 8

Plantaginaceae
Plantago debilis 7
**Plantago lanceolata* 1
Plantago varia 2

Poaceae

Amphipogon strictus 8
**Andropogon virginicus* 3
**Anthoxanthum odoratum* 7
Aristida jerichoensis s ubsp. *subspinulifera* 6
Aristida ramosa var. *speciosa* 4
Austrodanthonia caespitosa 3
Austrodanthonia induta 6 8
Austrodanthonia laevis 2
Austrodanthonia monticola 1 3 7
Austrodanthonia racemosa var. *obtusata* 1
Austrodanthonia racemosa var. *racemosa* 1 3 4
Austrodanthonia tenuior Op
Austrofestuca eriopoda 2 4
Austrostipa pubescens 6 8
Austrostipa rudis subsp. *nervosa* 3
Austrostipa rudis subsp. *rudis* 1 3 7
Austrostipa scabra 1 5 6
**Axonopus affinis* 1 2 3 8
**Axonopus compressus* Op
**Dactylis glomerata* 3
Deyeuxia gunniana 7 8
Deyeuxia imbricata 3
Deyeuxia mckiei 3
Deyeuxia parviseta 7
Dichelachne inaequiglumis 1 2 4
Dichelachne micrantha Op
Dichelachne parva 1
Dichelachne sieberiana 1
Echinopogon caespitosus var. *caespitosus* 1 4
Echinopogon ovatus 4
Entolasia marginata 2
Entolasia stricta 1 2 3 4 5 6 8
Eragrostis brownii 1
Eragrostis elongata 8
**Hainardia cylindrica* 2
Hemarthria uncinata 7
**Holcus lanatus* 4 7
Imperata cylindrica var. *major* 2 3 4
Isachne globosa 3 4 7
Joycea pallida 3
Lachnagrostis aemula Op
Lachnagrostis filiformis 4
Microlaena stipoides var. *stipoides* 1 4
Oplismenus imbecillis 4
Panicum buncei Op
Panicum paludosum 8
Panicum simile 1
Pennisetum alopecuroides 2 3 7
**Phalaris aquatica* 1 3 7
Phragmites australis 3 7
Poa costiniana Op
Poa queenslandica 1 2 5
Poa sieberiana 3 4 7
Sacciolepis indica 4
**Setaria pumila* 1
Sorghum leiocladum 1 4
Sporobolus creber 1
Sporobolus elongatus 3
Tetrarrhena juncea 8
Tetrarrhena turfosa 7
Themeda australis 1 2 3 4
**Vulpia myuros* forma *megalura* Op

Polygalaceae

Comesperma defoliatum 8
Comesperma ericinum 4 7
Comesperma retusum 6
Comesperma sphaerocarpum 1 3

Polygonaceae

Persicaria decipiens 2

Polypodiaceae

Microsorum scandens Op

Proteaceae

Banksia cunninghamii subsp. A 1 2 3 4 7
Banksia integrifolia subsp. *integrifolia* 1 3 4
Banksia marginata Op
Banksia spinulosa var. *collina* 1 2 3 5 6 8
Conospermum taxifolium Op
Grevillea acanthifolia subsp. *stenomera* 3 7 8
Grevillea acerata Op
Grevillea juniperinum 2 3
Hakea eriantha 2 3
Hakea laevipes subsp. *graniticola* 2 6 8
Hakea microcarpa 1 2 3 4 7
Isopogon petiolaris 3 8
Lomatia fraseri 4
Lomatia silaifolia Op
Persoonia cornifolia 4
Persoonia daphnoides 1
Persoonia oleoides 2 6
Persoonia procumbens 4
Persoonia tenuifolia 1 3
Petrophile canescens 1 3 4 6

Ranunculaceae									
Ranunculus lappaceus	1	2	3				7		
Restionaceae									
Baloskion fimbriatum	1	2	3	4				8	
Baloskion stenocoleum	1	2	3		5	6	7	8	
Empodisma minus		2	3				7		
Lepyrodia anarthria			3	4	5		7	8	
Lepyrodia leptocaulis				4					
Lepyrodia scariosa	1	2			5	6	7	8	
Rosaceae									
Acaena novae-zelandiae				4					
Acaena ovina									Op
**Rubus fruticosus*							7		
Rubus parvifolius		2		4					
Rubiaceae									
Asperula gunnii									Op
Coprosma quadrifida									Op
Galium gaudichaudii		2					7		
Galium migrans				4					
Nertera granadensis							7		
Opercularia hispida				4					
Rutaceae									
Boronia anethifolia			3						
Boronia microphylla			3				7		
Boronia parviflora	1		3			6		8	
Boronia polygalifolia			3					8	
Crowea exalata subsp. *exalata*	1								
Santalaceae									
Choretrum candollei							7		
Choretrum pauciflorum									Op
Schizaeaceae									
Schizaea bifida	1								
Scrophulariaceae									
Euphrasia collina subsp. *paludosa*									Op
Gratiola peruviana	1			4					
Limosella australis									Op
Veronica calycina	1								
Veronica plebeia				4					
Selaginaceae									
Selaginella uliginosa	1		3			6	7	8	
Smilaceae									
Smilax australis									Op
Solanaceae									
Solanum nigrum									Op
Stylidiaceae									
Stylidium graminifolium	1	2	3	4		6	7		
Thymelaeaceae									
Pimelea glauca			3						
Pimelea linifolia	1		3			6			
Pimelea linifolia subsp. *linifolia*			3	4					
Pimelea strigosa	1								
Violaceae									
Hybanthus monopetalus								8	
Viola betonicifolia	1		3						
Viola caleyana									Op
Viola hederacea	1		3	4			7		
Xanthorrhoeaceae									
Xanthorrhoea acaulis	1	2			5				
Xanthorrhoea glauca subsp. *glauca*			3						
Xanthorrhoea johnsonii									Op
Xanthorrhoea macronema	1		3						
Xyridaceae									
Xyris complanata	1		3	4	5		7		
Xyris gracilis subsp. *gracilis*									Op
Xyris operculata	1	2	3					8	