

# Floristic description and environmental relationships of *Sphagnum* communities in NSW and the ACT and their conservation management

J. Whinam and N. Chilcott

Whinam, J. and Chilcott, N. (Nature Conservation Branch, Department of Primary Industries, Water and Environment GPO Box 44, Hobart, Tas, Australia 7001. Corresponding author, email: Jennie.Whinam@dpiwe.tas.gov.au) 2002. Floristic description and environmental relationships of *Sphagnum* communities in NSW and the ACT and their conservation management. *Cunninghamia* 7(3): 463–500.

Investigations were conducted at 49 sites in New South Wales (NSW) and the Australian Capital Territory (ACT) to map the location and extent of *Sphagnum* peatland communities, some of which no longer contained *Sphagnum* moss. Nine floristic groups were identified for the *Sphagnum* peatlands based on data from 39 of the surveyed sites. The data were ordinated by hybrid multi-dimensional scaling. The strongest floristic gradients corresponded to changes in altitude, climate and geology and were strongly related to the geographic distribution of sites. While some groups are on land reserved for conservation, others occur on forestry and private land tenures. Reservation has not protected some sites from threatening processes, with most *Sphagnum* peatland communities surveyed being moss remnants or peatlands in poor condition with invading weed species. The main factors that have led to this degradation are fire, grazing, clearing, feral animals (pigs and brumbies), forestry operations and peat mining.

This paper is dedicated to the memory of my friend and colleague, Don Adamson (JW).

## Introduction

*Sphagnum* peatlands are an unusual and infrequent component of the Australian landscape, and are often associated with drainage basins and watercourses (Campbell 1983, Whinam et al., in press). They are found primarily at montane and alpine altitudes in poorly drained, relatively infertile sites. Australian peatlands dominated by *Sphagnum* are generally small in area, restricted in distribution, and have relatively few *Sphagnum* species — six taxa (*Sphagnum cristatum*, *S. perichaetiale*, *S. australe*, *S. falcatulum*, *S. fuscovinosum* and *S. novo-zelandicum*) being recognised in a recent taxonomic revision (Seppelt 2000). *Sphagnum cristatum* is the most common species and is economically important in both Australia and New Zealand, as the main species harvested for horticultural use.

The majority of peat deposits in eastern Australia are sedge peats, mostly derived from the plant families Restionaceae or Cyperaceae. *Sphagnum* peatlands are defined as areas where the peatland is greater than 1000 m<sup>2</sup> and forms a distinct ecosystem and where *Sphagnum* species are the dominant peat formers (Whinam et al. in press). They occur in Australia most frequently between 600–1000 m altitude. However they can occur down to sea level, for example a small hanging swamp on top of a seacliff in Sydney (Bridgman et al. 1995), and in coastal dune swales (P. Adam pers. comm.). The bulk of Australian *Sphagnum* peatlands are found in Tasmania (Whinam et al. 2001).

In New South Wales (NSW) and the Australian Capital Territory (ACT) several regional peatland studies have been undertaken, including an inventory of significant mires in southern montane NSW and the ACT (Hope & Southern 1983). However this inventory did not distinguish *Sphagnum* peatlands from the more common sedge peatlands. The montane/sub-alpine bogs (above 1000 m) of the ACT, with and without *Sphagnum*, have been described (Helman & Gilmour 1985). Several *Sphagnum* peatlands in the ACT have also been described as part of the Mountain Occupation Project (Hope 1997, 1999, Saunders et al. 1996), and in local surveys, for example Ginini Flats (Clark 1980) and Tinderry Nature Reserve (Doherty 1997). Nationally significant peatlands, including mires with *Sphagnum* moss are included in *A Directory of Important Wetlands in Australia* (ANCA 1996).

There have been some regional studies of *Sphagnum* peatlands, notably the *Sphagnum* peatlands of New England (Millington 1954), Boyd Plateau (Black 1982) and the bogs of the Snowy Mountains (Costin 1954, Clarke & Martin 1999). Some vegetation descriptions of mires do not record *Sphagnum* moss, even though it is present e.g. Hanging Rock Swamp (Klaphake 1994) and the classification of sub-alpine bogs of the south-east forests (Keith & Bedward 1999) as these surveys did not record bryophytes.

The distribution of *Sphagnum* peatlands is largely limited by evapotranspiration in the warmest months (Whinam et al. 1989). They occur in areas where there is a seasonally stable high watertable, where there is a constant supply of surface or seepage water (Millington 1954). The geographic extent and conservation status of *Sphagnum* peatlands are affected by *Sphagnum* moss harvesting, peat mining, burning, grazing and forestry operations (Whinam et al. in press). In addition the impacts of feral animals, particularly pigs and brumbies, have also affected the condition of *Sphagnum* peatlands in NSW and the ACT (Helman & Gilmour 1985, Dyring 1990). In future, the increased temperatures and altered rainfall patterns predicted with global warming may result in the demise of *Sphagnum* peatlands at the hottest and driest margins of their distribution (Whinam et al. in press).

The aim of this survey was to collect data on the current extent and floristics of *Sphagnum* peatlands in NSW and the ACT, to describe their floristic variation and the environmental factors influencing them, to determine their conservation status, and to identify threats to their survival.

## Methods

### Site selection

Potential survey sites were identified from Herbarium records, *A Directory of Important Wetlands in Australia* (ANCA 1996), previous publications and on the advice of our botanical colleagues. Floristic surveys were conducted during the 2000–01 field season. Revisiting of some sites identified in the past (e.g. Millington 1954) has meant that some fieldwork has necessarily resulted in 'negative data' — i.e. removal of *Sphagnum* records or recording data at very degraded sites.

### Field methods

Species cover abundance data were collected in 10 × 10 m quadrats. Species nomenclature follows Harden (1990–93) and the Australian National Botanic Gardens *Australian Plant Names Index* (ANBG 2001). Site descriptions included species recorded outside the quadrat, aspect and slope. Peat depth was measured with a stainless steel probe, with three measurements taken in each quadrat to obtain a mean peat depth. Three measurements were also taken to calculate the mean height between hummocks and hollows for each quadrat. A soil pH test kit was used to test the pH of the peat in each quadrat. Moss tendril length was recorded for *Sphagnum* at each site. Grid references were recorded with a GPS (accuracy ± 10 m), with altitudes determined from topographic maps.

### Analytical methods

The data consisted of 39 sites and 355 taxa of vascular plants and *Sphagnum* species, from which singleton species (i.e. species found at only one site) were then deleted. Other mosses and lichens were recorded but not identified to species level. Owing to the high number of taxa with less than 5% cover, all data were converted to presence/absence prior to the analyses. The Bray-Curtis coefficient (Faith et al. 1987) was used to represent floristic dissimilarity between sites, and all clustering and ordination analyses were performed on this dissimilarity matrix.

Because floristic variation was anticipated to be relatively continuous, ordination was used initially, with cluster analysis used to dissect the data for ease of description. Sites were ordinated by hybrid multidimensional scaling (Faith et al. 1987) with the semi-strong algorithm (Belbin 1991a) implemented in PATN (Belbin 1995). Multidimensional scaling has been shown to be most robust method for ordinating community data (Kenkel & Orłóci 1986, Minchin 1987).

Ordinations were performed for the first six dimensions with 50 different random starting configurations for each dimension, in order to minimise the chance of entrapment at a local minimum. A plot of minimum stress versus number of

dimensions suggested that a three-dimensional ordination adequately summarised the data. The three-dimensional solution yielded a stress of 0.2200, which was substantially better than the best two-dimensional solution (stress = 0.3113). The four-dimensional solution revealed no further structure in the data beyond that already apparent in the three-dimensional solution. Groups were clustered by  $\beta$ -flexible weighted arithmetic average clustering (WPGMA) with  $\beta = -0.1$  in PATN (Belbin 1995).

Floristic characteristics of the groups in the resulting hierarchy were investigated with the indicator value index of Dufrêne and Legendre (1997). There are two components to this index for presence/absence data — 'specificity' and 'fidelity' (Dufrêne 1999). The two components are multiplied together and then multiplied by 100 to give the indicator value for that species.

For any given partition of a dendrogram, the indicator values of all the species can be computed for each site group; in a set of hierarchical partitions a species is allocated to the node in the hierarchy where its indicator value reaches a maximum. The statistical significance of the indicator values is assessed by a randomisation procedure, and these results can be used as a guide to establish the number of groups that should be discriminated in the final dendrogram (Dufrêne & Legendre 1997). The indicator values were calculated by IndVal 2.0 (Dufrêne 1999) with equal weightings for the two components of the index, and 499 randomisations to assess significance at the 0.05 level.

Bioclimatic variables were predicted by the BIOCLIM component of the ANUCLIM package (CRES 1999). BIOCLIM uses bioclimatic parameters derived from monthly climatic estimates to approximate energy and water balances at a given location (Nix and Bushby 1986). Based on the climatic variables of maximum temperature, minimum temperature, rainfall, solar radiation and pan evaporation BIOCLIM can produce up to 35 bioclimatic parameters (Houlder et al. 1999). The BIOCLIM variables included in these analyses are defined in Table 1. Interpretation of the statistical significance for climate variables is however limited as they are modelled data derived from a relatively sparse distribution of climate stations. Median values are given for environmental variables for each floristic group (Table 2), as they are more resistant to outlying values than means (Fowler & Cohen 1990).

The continuous environmental variables were fitted to the ordination space by a vector-fitting approach (Bowman & Minchin 1987, Dargie 1984). The statistical significance of the resulting correlations (Table 1) was determined by randomly permuting the values of the variables amongst the sites (Faith & Norris 1989) 100 times using Monte-Carlo testing of environmental attributes (MCAO) in PATN. These analyses were performed by the principal axis correlation (PCC) routines in PATN (Belbin 1991b).

**Table 1. Codes and descriptions of bioclimatic variables from BIOCLIM (Houlihan et al. 1999) and results of vector fitting of environmental variables and species richness to the three-dimensional ordination space with the number of observations (n), multiple correlation coefficient (R) and range of each variable. All correlations were significant to  $P < 0.05$ .**

Code	Variable name	n	R	Range
Alt	Altitude (m)	39	0.7265	630–2048
Geol	Geology	39	0.6677	Sandstone, granite, shale, basalt, trachyte
SRich	Species richness	39	0.6835	9–38
AnMeTemp	Annual mean temperature (°C): The annual mean of weekly mean temperatures. Each weekly mean temperature is the mean of that week's maximum and minimum temperature.	39	0.8823	3.3–14.2
MeTWaQ	Mean temperature of the warmest period (°C): The highest temperature of any weekly maximum temperature.	39	0.8919	9.4–21.9
MeTCo	Mean temperature of the coldest period (°C).	39	0.8379	-2.5–6.7
AnnPrec	Annual mean precipitation (mm): the sum of all the monthly precipitation estimates.	39	0.7744	464–2496
PrecDP	Precipitation of the driest period (mm): the precipitation of the driest week.	39	0.7501	0–29
AMMI	Mean moisture index of the warmest quarter: The warmest quarter of the year is determined (to the nearest week), and the average moisture index value is calculated.	39	0.8338	0.39–1
MICV	Moisture index seasonality (C of V): The Coefficient of Variation (C of V) is the standard deviation of the weekly moisture index values expressed as a percentage of the mean of those values (i.e. the annual mean).	39	0.7449	0–63

**Table 2. *Sphagnum* communities in New South Wales and Australian Capital Territory. Ranges and median values (bold type) of environmental variables and species richness (with group numbers from the clustering in brackets).**

<b>Floristic Community</b>	<b>No. of plots</b>	<b>Altitude (m)</b>	<b>Mean annual temperature (°C)</b>	<b>Mean annual precipitation (mm)</b>	<b>pH</b>	<b>Mean peat depth (cm)</b>	<b>Species richness</b>
Seepage <i>Sphagnum</i> moss beds (Group 1)	2	650–900 <b>775</b>	12.4–13.7 <b>13</b>	464–542 <b>503</b>	4.5 <b>4.5</b>	1 <b>1</b>	9–13 <b>11</b>
Rainforest <i>Sphagnum</i> peatlands (Group 2)	2	1300–1460 <b>1380</b>	11.4–11.7 <b>11.6</b>	654–915 <b>785</b>	4.5–7 <b>5.8</b>	5–43 <b>24</b>	12–26 <b>19</b>
Tea tree <i>Sphagnum</i> peatlands (Group 3)	2	763–786 <b>775</b>	11.2 <b>11.2</b>	1088–1094 <b>1091</b>	6.0 <b>6.0</b>	85–87 <b>86</b>	22–26 <b>24</b>
Shrubby herbaceous <i>Sphagnum</i> peatlands (Group 4)	11	796–1210 <b>1040</b>	9.0–10.5 <b>9.5</b>	648–1413 <b>1100</b>	4.5–6.0 <b>6.0</b>	20–7200 <b>61</b>	18–38 <b>28</b>
Shrubby-sedgey <i>Sphagnum</i> peatlands (Group 5)	7	985–1740 <b>1430</b>	4.8–10.3 <b>7.0</b>	1056–2184 <b>1317</b>	5.5–6.5 <b>6.0</b>	65–235 <b>157</b>	15–29 <b>25</b>
Heathy <i>Sphagnum</i> peatlands (Group 6)	6	1050–1300 <b>1280</b>	12.4–14.2 <b>12.6</b>	711–839 <b>831</b>	5.0–6.0 <b>6.0</b>	23–87 <b>37.5</b>	21–34 <b>31</b>
<i>Sphagnum</i> swamps (Group 7)	4	1300–1500 <b>1300</b>	10.3–11.4 <b>11.4</b>	668–750 <b>668</b>	4.5–6.0 <b>4.8</b>	37–147 <b>62.5</b>	22–37 <b>29</b>
Degraded <i>Sphagnum</i> moss beds (Group 8)	3	630–680 <b>680</b>	12.8–13.1 <b>12.9</b>	484–512 <b>501</b>	4.5–6.0 <b>5.0</b>	19–70 <b>38</b>	28–33 <b>31</b>
Alpine <i>Sphagnum</i> moss beds (Group 9)	2	1900–2048 <b>1974</b>	3.3–4.0 <b>3.7</b>	2343–2496 <b>2420</b>	4.5–6.0 <b>5.3</b>	38–42 <b>40</b>	22–32 <b>27</b>

## Results

Locations of *Sphagnum* peatlands surveyed in NSW and the ACT, identified by their floristic groups (and two additional sites over the Victorian border) are shown Fig. 1. The majority of *Sphagnum* peatlands tend to be regionally clumped, and only small *Sphagnum* moss beds occur at the highest altitude sites. A summary of environmental variables for each floristic group is presented in Table 2.

A total of 196 singleton species were recorded at 39 sites, varying from one singleton per site (Mongarlowe River) to 16 singletons (The Sentinel at Pippit Creek, Kosciuszko National Park). The number of singleton species at sites is not correlated with species richness. Mean species richness (native and weed species) of all sites (26 taxa) is generally high, as is the number of weed species recorded when compared with Tasmanian *Sphagnum* peatlands (Whinam et al. 2001). Only two species of *Sphagnum* were recorded: *S. cristatum* and *S. novo-zelandicum*.

### Community classification

A comparison of the dendrogram (Fig. 2) with the HMDS ordination suggested that nine groups would be sufficient to describe the data set. Further dissection of the diagram was not supported by indicator values for species at lower nodes in the hierarchy because most of these nodes did not have significant ( $P < 0.05$ ) indicator species associated with them. A notable feature of the classification was the presence of several groups that consist of only a few sites. There was a tendency for these groups to be characterised by sites with low numbers of taxa. While the group with highest species diversity also contained the most weed species, there is no trend correlating diversity with weed occurrence within groups.

The community classification including significant ( $P < 0.05$ ) indicator species for each of the final groups is shown in Figs 2 and 3, and the full hierarchically arranged two-way table of species by site groups together with indicator values, is given in Appendix 1. These analyses yield the nine identifiable *Sphagnum* peatland types and their environmental attributes which are described below. A list of all species recorded (native and weed species) is given in Appendix 2.

The dendrogram (Fig. 2) suggests a major division of these *Sphagnum* communities into those with *Blechnum nudum* as the principal discriminatory species (i.e. Groups 1–3 in Figs 2 and 3 and in Appendix 1) and those with *Empodisma minus* (Groups 4–8 in Figs 2 and 3 and in Appendix 1). As well, one group of species (including *Chinogentias muelleriana*, *Deschampsia caespitosa* and *Astelia alpina*) separates at a high level of the ordination (Group 9, Figs 2 and 3 and in Appendix 1). This apparent division of Group 9 is not as marked in the ordination (Fig. 4).

Groups 1–3 are small, each group having only 2 plots. However, these groups are distinct floristically — demonstrated by the indicator species in Fig. 3 and Appendix 1. Groups 4–8 include most of the plots surveyed and include a diversity of species, reflecting the structural and altitudinal variety of some of the groups, but all have *Empodisma minus* as a discriminatory species. Group 9 contains grasses and herbs found only at higher altitudes (e.g. *Poa hiemalis*, *Deschampsia caespitosa*, *Chinogentias muelleriana*, and *Celmisia tomentella*).

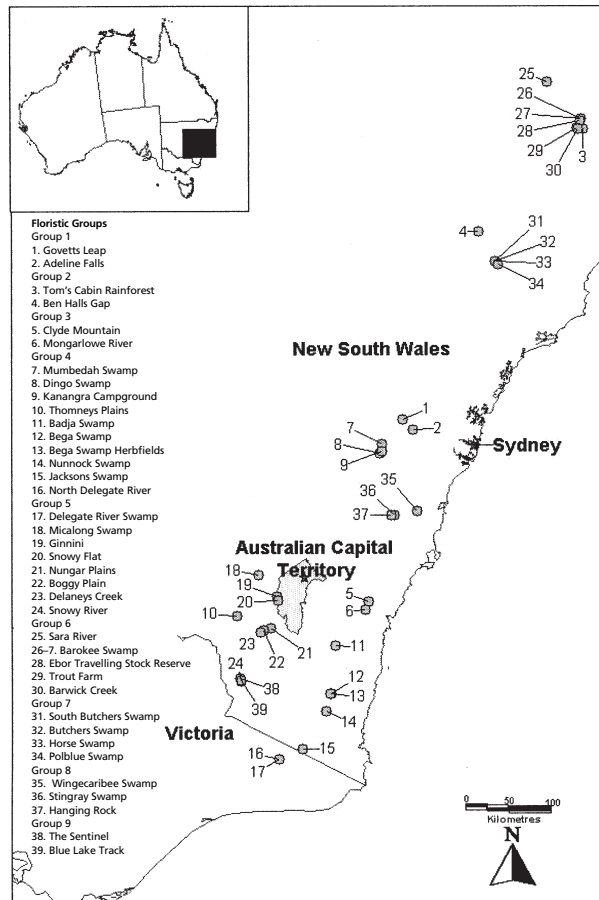


Fig. 1. Distribution of *Sphagnum* peatlands in NSW and ACT See text for descriptions of floristic groups.

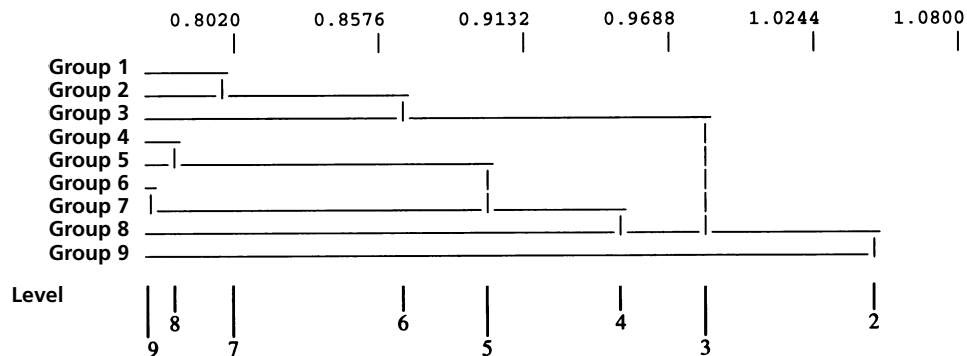
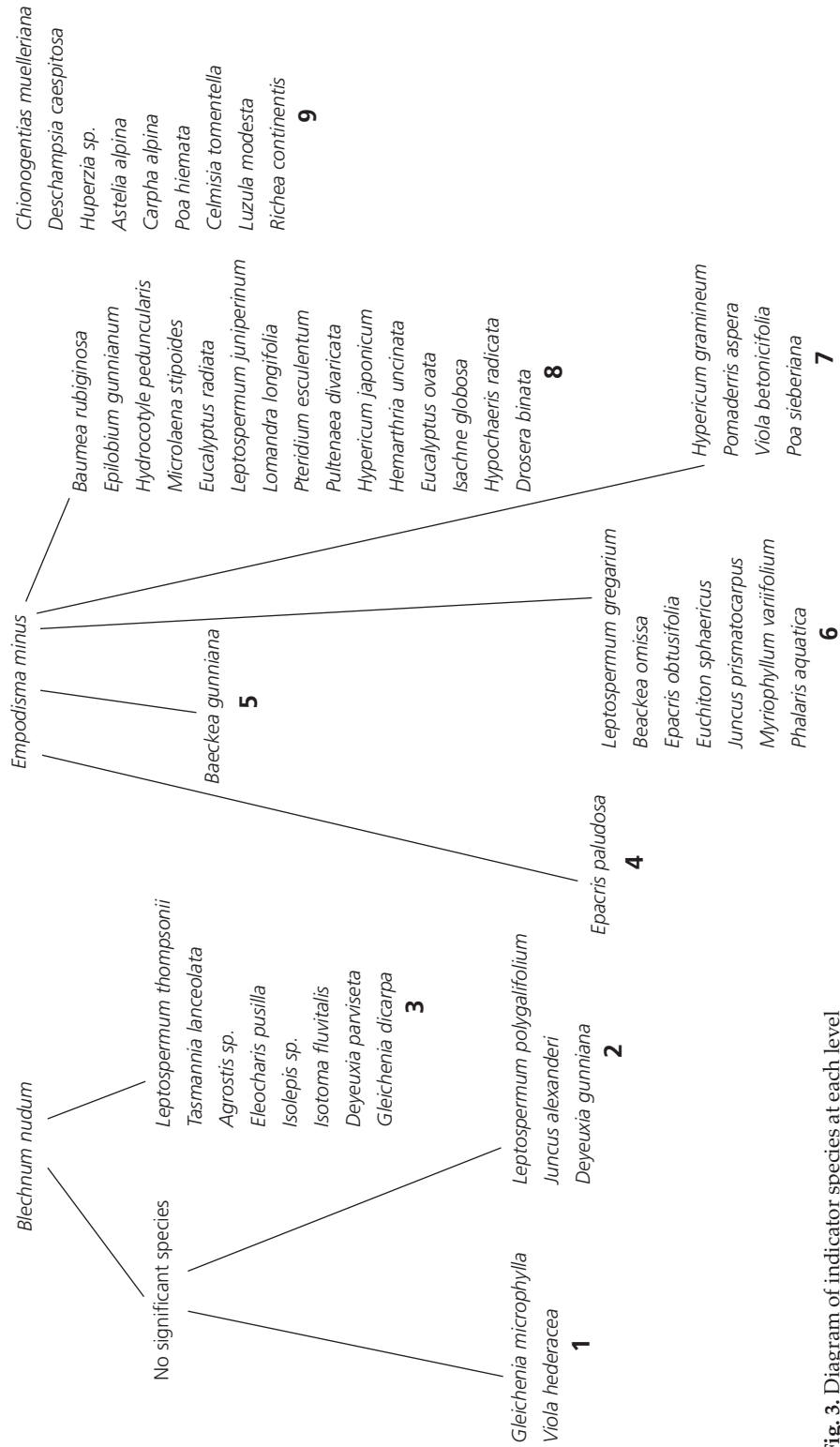
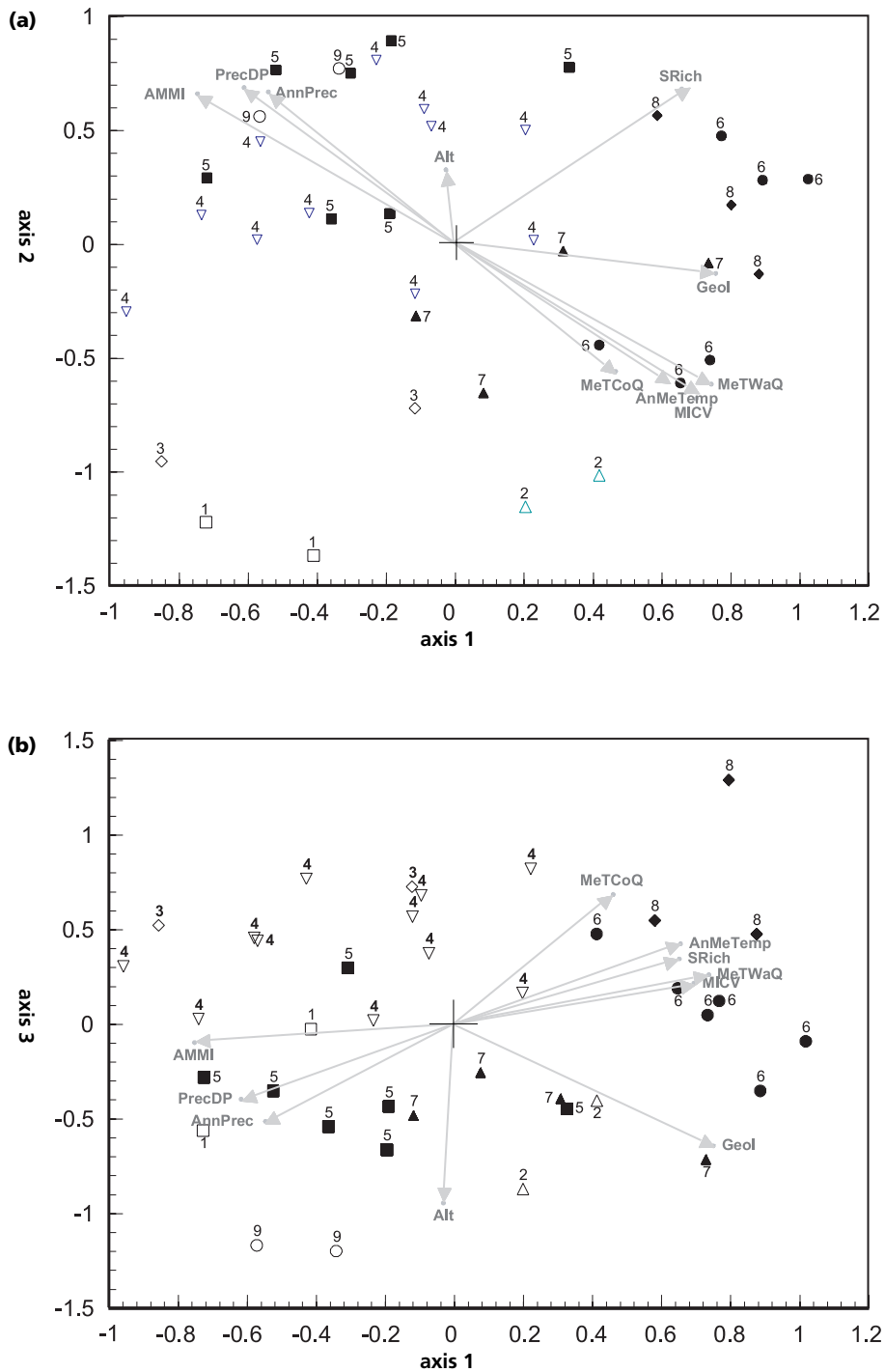


Fig. 2. Dendrogram from the WPGMA clustering of *Sphagnum* plots in NSW and ACT The dissimilarity is displayed on the top edge of the dendrogram, while 'Level' (displayed) along the bottom edge of the dendrogram denotes the fusions for reference to the two-way table of indicator species displayed in Appendix 1.





**Fig. 3.** Diagram of indicator species at each level of split in PAINT. Bold text denotes the nine floristic groups (see text for group definitions).



**Fig. 4.** HMDs in three dimensions, showing sites and significant ( $p < 0.05$ ) fitted vectors for environmental variables and species richness with respect to (a) axis 1 v 2, and (b) axis 1 v 3. Abbreviations for environmental variables are: Alt = altitude, Geol = Geology, SRich = species richness, AnMeTemp = annual mean temperature, MeTCoQ = Mean temperature coldest quarter, MeTWaQ = Mean temperature warmest quarter, AnnPrec = annual precipitation, PrecDP = precipitation of driest period, AMMI = mean moisture index of warmest quarter, MICV = moisture index seasonality (Coefficient of Variation).

**Floristic Group 1. Seepage *Sphagnum* moss beds – Blue Mountains Sandstone**

This group of seepage *Sphagnum* moss beds is characterised by the ferns *Gleichenia microphylla* and *Blechnum nudum* and the herb *Viola hederacea*. A small group (represented by 2 plots), these sites are moss beds on seepage lines at the bottom of cliffs. These moss beds occur on sandstone in the Blue Mountains area, at altitudes ranging from 650–900 m, and are acidic (median pH 4.5). Mean annual temperature ranges from 12.4–13.7°C and mean annual precipitation ranges from 464–542 mm. Species richness of sites in this group ranges from 9–13, and mean peat depth is extremely shallow (1 cm). The flat moss beds, while small, are in good condition and occur in the reserve system.

**Floristic Group 2. Rainforest *Sphagnum* peatlands – Northern Tablelands**

Rainforest *Sphagnum* peatlands occur under a rainforest canopy at moderately high altitude (range 1300–1460 m). The community is distinguished by four metre tall *Leptospermum polygalifolium* subsp. *montanum*, with *Blechnum nudum*, *Juncus alexanderi* and *Deyeuxia gunniana* as the understorey. These rainforest *Sphagnum* peatlands, with large hummocks of *Sphagnum* moss (median 34.5 cm) occur on basalt and trachyte. Mean annual temperature ranges from 11.4–11.7°C and mean annual precipitation ranges from 654–915 mm. Species richness of this group ranges from 12–26, and mean peat depth ranges from 5–43 cm. The two quadrats surveyed are in good condition and occur in Ben Halls Gap National Park. This community — the Ben Halls Gap National Park *Sphagnum* Moss Cool Temperate Rainforest Community — is listed as an Endangered Ecological Community under the *NSW Threatened Species Conservation Act 1995*.

**Floristic Group 3. Tea tree *Sphagnum* peatlands – Monga**

Tea tree *Sphagnum* peatlands occur along drainage channels at altitudes ranging from 763–786 m. This group is distinguished by an overstorey of the vulnerable shrub *Leptospermum thompsonii*, with *Tasmannia lanceolata*, *Agrostis* sp., *Eleocharis pusilla*, *Isolepis* sp., *Isolepis fluviatilis*, *Deyeuxia parviseta* and *Gleichenia dicarpa*. Mean annual temperature is 11.2°C and mean annual precipitation ranges from 1088–1094 mm. Species richness of this group ranges from 22–26 species. Mean peat depth ranges from 85–87 cm. The two peatlands in this group are in good condition and are in Monga National Park.

**Floristic Group 4. Shrubby herbaceous *Sphagnum* peatlands**

This largest group of sites (11 plots) includes the indicator shrub *Epacris paludosa*. The herbs vary regionally but include *Asperula gunnii*, *Hydrocotyle* spp., *Brachyscome* spp., *Wahlenbergia* spp. and *Hypericum japonicum*. The majority of sites have a number of weed species including *Hypochaeris radicata*, *Rubus fruticosus*, *Taraxacum* spp. and *Holcus lanatus*. The number of weeds reflects the highly disturbed nature of many of the sites, caused by cattle grazing, feral pig damage and past fires. While some of the sites have substantial areas of *Sphagnum* moss, the condition of the peatlands is

deteriorating from disturbance. The sites vary geographically from Jacksons Swamp near the NSW border north to the Kanangra-Boyd National Park and altitudinally from 796–1210 m (median 1040 m). While sites in the Kanangra-Boyd National Park are reserved, they are not protected from the feral pig damage currently occurring. Mean annual temperature ranges from 9.0–10.5°C (median 9.5°C) and mean annual precipitation ranges from 648–1413 mm (median 1100 mm). Species richness of sites in this group ranges from 18–38 (median 28), and mean peat depth ranges from 20–7200 cm (median 61 cm). The pH of this group tends towards neutral (median pH 6.0).

#### **Floristic Group 5. Shrubby-sedgey *Sphagnum* peatlands**

Shrubby-sedgey *Sphagnum* peatlands with large undulating moss hummocks (median 50 cm) are characterised by the shrub *Baeckea gunniana*. They occur at altitudes from 985–1740 m, from subalpine Kosciuszko National Park through to the ACT border and have a variety of sedges including *Empodisma minus*, *Baloskion australe*, *Luzula* spp., as well as the grass *Poa costiniana*. Several of the sites in Kosciuszko National Park contain weeds, again reflecting the past grazing history of some mid-altitude sites near the Snowy River, as well as the encroachment of pine plantations at Micalong Swamp. Many of these sites appear to be remnants, confined to drainage lines or peatland margins. Mean annual temperature ranges from 4.8–10.3 °C (median 7°C) and mean annual precipitation ranges from 1056–2184 mm (median 1317 mm). Species richness of sites in this group ranges from 15–29, and mean peat depth ranges from 65–235 cm (median 157 cm).

#### **Floristic Group 6. Heathy *Sphagnum* peatlands – Northern Tablelands granite and basalt**

Heathy *Sphagnum* peatlands are characterised by *Leptospermum gregarium*, *Baeckea omissa*, *Epacris obtusifolia*, *Euchiton sphaericus*, *Juncus prismatocarpus*, *Myriophyllum variifolium* and *Phalaris aquatica*. Mean annual temperature ranges from 12.4–14.2°C and mean annual precipitation ranges from 711–839 mm. Species richness of this group ranges from 21–34 (median 31), and mean peat depth ranges from 23–87 cm (median 37.5 cm). These poorly drained sites (6 plots) are on granite and basalt at altitudes from 1050–1300 m. Some of the sites occur in Travelling Stock Reserves, degraded by cattle trampling. The degraded condition of these New England sites subject to cattle grazing is reflected by the presence of weed species including *Hypochaeris radicata*, *Holcus lanatus*, *Taraxacum* sp. *Rubus fruticosus* and *Sonchus oleraceus*.

#### **Floristic Group 7. Barrington drainage line *Sphagnum* swamps**

This group is distinguished by the species *Pomaderris aspera*, *Hypericum gramineum*, *Viola betonicifolia* and *Poa sieberiana*. The four sites occur on drainage lines through acidic swamps (median pH 4.75), primarily on basalt at altitudes from 1300–1500 m, with *Sphagnum* confined to drainage lines. No weeds were recorded in the *Sphagnum* swamps, reflecting their good condition. All the sites are in Barrington Tops National Park. Mean annual temperature ranges from 10.3–11.4°C and mean annual precipitation ranges from 668–750 mm. Species richness of this group ranges from 22–37, and mean peat depth ranges from 37–147 cm (median 62.5 cm).

### Floristic Group 8. Degraded *Sphagnum* moss beds — Southern Highlands

These montane (630–680 m) *Sphagnum* moss beds occur as remnants restricted to drainage margins of peatlands on the Southern Highlands. The three sites in this group are all suffering degradation and weed species were recorded in the moss beds at each of the sites. None are in conservation areas. The characteristic species include *Baumea rubiginosa*, *Epilobium gunnianum*, *Hydrocotyle peduncularis*, *Microlaena stipoides*, *Eucalyptus radiata*, *Leptospermum juniperinum*, *Lomandra longifolia* and *Pteridium esculentum*. Mean annual temperature ranges from 12.8–13.1°C and mean annual precipitation ranges from 484–512 mm. Species richness of sites in this group ranges from 28–33, and mean peat depth ranges from 19–70 cm (median 38 cm). This floristic group had the highest mean number of weed species (4 taxa). One site is suffering major weed invasion (e.g. willows and blackberries) after extensive changes associated with peat mining (Wingecarribee Swamp), while another appears to be a remnant affected by changes in drainage and sedimentation due to forestry operations (e.g. Hanging Rock).

### Floristic Group 9. Alpine *Sphagnum* moss beds

Two high altitude sites (1900–2048 m) make up these alpine *Sphagnum* moss beds, with the distinguishing species being *Chinogentias muelleriana*, *Deschampsia caespitosa*, *Hypericum* sp., *Astelia alpina*, *Carpha alpina*, *Poa hiemata*, *Celmisia tomentella*, *Luzula modesta* and *Richea continentis*. Both these sites have shown recent expansion of the moss beds, indicating successful recovery in the catchment after long-term erosion control works following the cessation of grazing (R. Good, pers. comm.). Mean annual temperature ranges from 3.3–4.0°C and mean annual precipitation ranges from 2343–2496 mm. Species richness of sites in this group ranges from 22–32 (median 27), and mean peat depth ranges from 38–42 cm. These sites are within Kosciuszko National Park.

### Ordination and correlation with environmental variables

Overlaying the site groups derived from the clustering on the ordination (Figs 4a and 4b) shows that most peripheral plots are represented by the smallest groups, with lower species diversity, and a higher number of singletons. They tend to be highly dissimilar from the bulk of the data (as indicated in Appendix 1). Groups 1, 2 and 3 (all groups with low species richness) have high negative scores on axis 2 (Fig. 4a) while Group 9 (high altitude sites) has a high negative score on both axis 1 and 3 (Fig. 4b). Groups 6 and 8 have high positive scores on axis 1 (Fig. 4a). Sites in these two groups have high species richness and are the most disturbed sites with higher numbers of introduced species and singletons.

Patterns in the environmental variables across this ordination are evident. The strongest gradient contrasts the generally higher altitude, cooler and wetter sites (upper left corner of Fig. 4a — predominantly sites from Groups 5 and 9), with sites from lower altitude, warmer areas and higher seasonal variation (sites on the lower right portion of axis 1 v 2 — predominantly from Groups 2 and 6; see also Table 2) (all correlations significant at  $P < 0.05$ ). On the plot of axes 1 v 3 (Fig. 4b), sites tend to be grouped regionally and are correlated with geology. Sandstone geology (associated with Group 1) separates from granite (associated with Groups 5 and 9) and basalt (Group 7) rock types.

## Discussion

Many of the alpine and sub-alpine *Sphagnum* peatlands of NSW and all the montane/sub-alpine *Sphagnum* peatlands of the ACT are in nature reserves (Groups 1, 2, 3, 7 and 9). However few of the lowland and highland *Sphagnum* peatlands are reserved (Group 8 is unreserved and Groups 4 and 6 are poorly reserved). Unfortunately, reservation has not equated with protection from the many activities that currently threaten the survival of *Sphagnum* peatlands.

The majority of *Sphagnum* peatlands surveyed are either *Sphagnum* remnants or severely degraded peatlands. The most potent threats to their survival are posed by fire, grazing, peat mining, clearing, feral animals (both pigs and brumbies), and forestry operations. The most disturbed sites contain the highest number of introduced species, and have a high native species richness, as well as a high number of species occurring at single sites. These disturbed sites also tend to have a neutral pH (6.0), indicating an absence of the acidity commonly associated with *Sphagnum* bogs (Clymo 1973). This suggests that whilst *Sphagnum* is present, these sites can only be considered as marginal (restricted to peatland or drainage margins) or remnant *Sphagnum* peatlands, where *Sphagnum* moss now constitutes only a small percentage of the peatland vegetation cover.

The remnants of *Sphagnum* moss in areas where larger mossbeds were previously described, combined with pollen data (Clark 1986), confirm the detrimental impacts of fire on *Sphagnum* peatlands (Whinam et al. 1989, 2001). An increase in either the frequency or intensity of fire is likely to favour fire-tolerant rhizomatous sedges at the expense of *Sphagnum* moss, and its associated herbs and fire sensitive shrubs (Whinam 1995). Fire, along with grazing and logging, can also lead to increased sedimentation, particularly when peatlands are in the bottom of valleys and in topographic depressions. Increased sedimentation may affect the organic content of the site and make re-establishment by *Sphagnum* moss less likely. *Sphagnum* moss is also thought to provide some protection from fire for fire sensitive species, such as *Athrotaxis selaginoides* in Tasmania (Whinam et al. 2001), because there are few days when the wet moss will carry fires. However field evidence suggests that during dry periods when the buffering ability of *Sphagnum* is reduced, intense fires are able to burn at least the margins of *Sphagnum* peatlands (Whinam et al. 2001). The impacts of fire on *Sphagnum* peatlands in the ACT have included burning through the moss hummocks into the peat (Helman & Gilmour 1985, Clark 1980). Once drier conditions are established, future fires can destroy remaining areas of *Sphagnum* (Clark 1980). Fire or associated changes alter the ecological role that *Sphagnum* moss beds play in a water catchment. *Sphagnum* moss stabilises both the soil surface and stream banks, and acts as a filter, removing suspended sediment. *Sphagnum* peatlands impede flow and return water, maintaining a more even moisture regime between rainfall events.

We observed extensive damage by feral pigs (notably in sub-alpine areas of Kosciuszko National Park and in Kanangra-Boyd National Park) and brumbies (in the ACT). The severe impacts of these feral animals on bogs in the ACT have been noted previously (Helman & Gilmour 1985, Clark 1980). Trampling by feral animals, grazing

animals and people, causes channelling, leading to changes in water flow, which may completely alter the drainage pattern (Helman & Gilmour 1985), and result in drier conditions (Clark 1986). Preferential grazing of palatable herbs and grasses in *Sphagnum* bogs, combined with browsing of new growth of shrubs (J. Whinam, unpublished data) can lead to increased dominance by unpalatable species. Several of the surveyed sites, with a history of either feral animals or cattle grazing, included weed species, such as blackberries. Some of the New England region sites described by Millington (1954) and subject to grazing have changed significantly with nutrient influx from aerial fertiliser spraying and altered drainage patterns.

Australia is a net importer of peat, with supplies coming primarily from Canada, New Zealand, Germany and Ireland (in descending order of amount supplied) and, compared to northern hemisphere operations, the scale of peat mining in Australia is very small. However, where peat mining occurs, the hydrologic and ecosystem changes are catastrophic for peatland communities (Kodela et al. 1992). Changes in the hydrology and ecology of Wingecarribee Swamp, following a collapse of the peats in 1998, as a consequence of peat mining (Arachchi & Lambkin 1999), have left only one *Sphagnum* moss bed surviving, where three had previously been recorded (P. Kodela, pers. comm.).

Logging operations and associated changes in drainage and sedimentation have left only remnant *Sphagnum* moss patches along drainage margins, with *Sphagnum* now rare or absent throughout the bulk of the peatland. This is especially noticeable where *Pinus radiata* has escaped from plantations and invaded *Sphagnum* moss beds (e.g. Hanging Rock Swamp, Southern Highlands and Micalong Swamp, ACT border).

The only area that has shown a recent increase in the amount of *Sphagnum* moss present is the higher area of Kosciuszko National Park, which is thought to be due to recovery resulting from rehabilitation works and the cessation of grazing (Clarke & Martin 1999, Wimbush & Costin 1979a, 1979b). Much of the expansion in *Sphagnum* moss has only occurred in the past 5 years (R. Good, pers. comm). While both healthy and expanding, these moss beds are still quite small and it will be some time before they form fully functioning *Sphagnum* ecosystems.

An outstanding example of a rainforest-*Sphagnum* community in good condition is in Ben Halls Gap National Park. Its conservation significance has been recognised by its listing as a Threatened Ecological Community under the *NSW Threatened Species Conservation Act 1995*. Unfortunately many of the remaining *Sphagnum* peatlands sites surveyed are in a severely degraded state suggesting that there is a strong case for listing some *Sphagnum* peatlands as threatened communities in New South Wales, particularly shrubby herbaceous *Sphagnum* peatlands, shrubby-sedgey *Sphagnum* peatlands and heathy *Sphagnum* peatlands. Two plant species recorded in our survey, *Leptospermum thompsonii* and *Gentiana wingecarribiensis* (Kodela et al. 1994), are listed under the *NSW Threatened Species Conservation Act 1995* and nationally under the *Environment Protection and Biodiversity Conservation Act 1999*. None of the species recorded are restricted to *Sphagnum* communities.

## Conclusion

Our analyses of *Sphagnum* peatlands throughout NSW and the ACT have shown a strong regional distribution of floristic communities (at least partially related to geology, altitude and climate). The survey has documented the degradation and demise of many *Sphagnum* peatlands and has identified past and ongoing threatening processes. The future for many of these *Sphagnum* peatlands is bleak, especially when the impacts of increased temperatures and altered rainfall patterns predicted with global warming are considered (Whinam et al. in press). Without management actions that mitigate against trampling, fire, drainage and sedimentation impacts, many of the sites surveyed are likely to continue to deteriorate.

## Acknowledgments

We acknowledge the assistance of our botanical colleagues who willingly gave information on *Sphagnum* peatlands and cheerfully assisted with fieldwork, despite torrential rain, marauding leaches, feral pigs and depressing devastation. In particular, we thank Paul Adam, the late Don Adamson, Peter Clarke, Roger Good, Geoff Hope, David Keith, Philip Kodela, Keith McDougall and Patricia Selkirk. Herbert Dartnell and Ben Keaney also assisted with fieldwork. We thank Peter Clarke, David Keith, Keith McDougall and Patricia Selkirk for assistance with vascular species identification. Alison Downing and Rod Seppelt verified *Sphagnum* species.

We thank the Royal Botanic Gardens Sydney for providing *Sphagnum* Herbarium data and NSW National Parks and Wildlife Service for issuing a scientific permit. The Sydney Catchment Authority granted approval for access to Wingecarribee Swamp. Brian Flannery of NSW National Parks and Wildlife Service provided access to Ben Halls Gap. Daryl Mummery assisted with BIOCLIM analysis. Leon Barmuta provided statistical advice. Paul Adam, Jayne Balmer and an anonymous referee provided useful comments.

Research and the collation of information presented in this report was undertaken with funding provided by the Biodiversity Group, Environment Australia. The project was undertaken for the National Reserve System program.

## References

- Arachchi, B.K. & Lambkin, K.L. (1999) Wingecarribee Reservoir swamp failure. *ANCOLD Bulletin* 113: 37–45.
- Australian National Botanic Gardens (2001) *Australian Plant Names Index*. At <http://www.anbg.gov.au/cgi-bin/apni>
- Australian Nature Conservation Agency (1996) *A Directory of Important Wetlands in Australia. Second Edition* (Australian Nature Conservation Agency: Canberra).
- Belbin, L. (1991a) Semi-strong hybrid scaling: a new ordination algorithm. *Journal of Vegetation Science* 2: 491–496.
- Belbin, L. (1991b) *PATN: Technical reference* (CSIRO Wildlife Research: Canberra).



- Belbin, L. (1995) *PATN Pattern Analysis Package* (CSIRO Division of Wildlife Ecology: Canberra).
- Black, D. (1982) The vegetation of the Boyd Plateau, N.S.W. *Vegetatio* 50: 93–111.
- Bowman, D. M. J. S. & Minchin, P. R. (1987) Environmental relationships of woody vegetation patterns in the Australian monsoon tropics. *Ambio. Australian Journal of Botany* 35: 151–169.
- Bridgman, H.A., Warner, R.F. & Dodson, J.R. (1995) *Urban biophysical environments* (Oxford University Press: Melbourne).
- Campbell, E.O. (1983) Mires of Australasia. Mires: Swamp, Bog, Fen and Moor. In: *Ecosystems of the World. Vol. 4B* (Ed. A.J.P. Gore) (Elsevier Scientific, Amsterdam).
- Clarke, P.J. & Martin, A.R.H. (1999) *Sphagnum* peatlands of Kosciuszko National Park in relation to altitude, time and disturbance. *Australian Journal of Botany* 47: 519–536.
- Clark, R.L. (1980) *Sphagnum* growth on Ginini Flats, A.C.T. Unpublished report to Department of Biogeography and Geomorphology, (Australian National University: Canberra).
- Clark, R.L. (1986) The fire history of Rotten Swamp, A.C.T. Unpublished report to A.C.T. Parks and Conservation Service.
- Clymo, R.S. (1973) The growth of *Sphagnum*: methods of measurements: some effects of environment. *Journal of Ecology* 61: 849–69.
- Costin, A.B. (1954) *A study of the ecosystems of the Monaro Region of New South Wales*. (Government Printer: Sydney).
- CRES (1999) *ANUCLIM Version 5.0*. Canberra, Centre for Resource and Environmental Studies, (Australian National University: Canberra).
- Dargie, T. C. D. (1984) On the integrated interpretation of indirect site ordinations: a case study using semi-arid vegetation in south-eastern Spain. *Vegetatio* 55: 37–55.
- Doherty, M. (1997) Vegetation survey and mapping of Tinderry Nature Reserve. Unpublished report to New South Wales National Parks and Wildlife Service, Queanbeyan District.
- Dufrêne, M. (1999) *IndVal or how to identify indicator species of a sample typology ?* Direction générale des Ressources naturelles et de l'Environnement — Région wallonne: Serveur d'informations sur la biodiversité en Wallonie.
- Dufrêne, M. & Legendre, P. (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* 67: 345–366.
- Dyring, J. (1990) The impact of feral horses (*Equus caballus*) on sub-alpine and montane environments in Australia. Masters of Applied Science thesis. Department of Resource and Environmental Studies, University of Canberra.
- 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.
- Faith, D. P. & Norris, R. H. (1989) Correlation of environmental variables with patterns of distribution and abundance of common and rare freshwater macroinvertebrates. *Biological Conservation* 50: 77–98.
- Fowler, J. & Cohen, L. (1990) *Practical Statistics for Field Biology*. John Wiley & Sons Ltd. West Sussex, England.
- Harden, G. (1990–93) *Flora of New South Wales*. (Gwen Harden, Ed.) 4 Volumes. New South Wales University Press, Sydney.
- Helman, C.E. & Gilmour, P.M. (1985) Treeless vegetation above 1000 metres altitude in the A.C.T. Unpublished report to the Conservation Council of the Southeast Region and Canberra.
- Hope, G. (1997) Mountain Occupation Project: Report on additional field investigations on Mt Scabby and Mt Bimberi in the Australian Capital Territory. Unpublished report.

- Hope, G. (1999) Mountain Occupation Project: Report Little Creamy, Rock Flats and Lower Cotter Source Bogs in the Australian Capital Territory and Yaouk Swamp, New South Wales. Unpublished report.
- Hope, G.S. & Southern, W. (1983) Peatlands of the Southern Tablelands of New South Wales. Unpublished report to NSW National Parks and Wildlife Service.
- Houlder, D., Hutchinson, M., Nix, H. & McMahon, J. (1999) *ANUCLIM Version 5.0 User Guide*. Centre for Resource and Environmental Studies (Australian National University: Canberra).
- Keith, D.A. & Bedward, M. (1999) Native vegetation of the South East Forests Region. *Cunninghamia* 6: 1–218.
- Kenkel, N. C. & Orlóci, L. (1986) Applying metric and non-metric multidimensional scaling to ecological studies: some new results. *Ecology* 67: 919–928.
- Klaphake, V (1994) Plant survey of Hanging Rock Swamp and surrounding area, Penrose, Central Tablelands, NSW Unpublished report.
- Kodala, P., Adam, P. & Wright, P. (1992) Protecting upland wetlands: Mining swamps for organic sediments — the need for State Government environmental planning policies. *National Parks Journal* October, 7–12.
- Kodala, P.G., James, T.A. & Hind, P.D. (1994) Observations on the ecology and conservation status of the rare herb, *Gentiana wingecarribiensis*. *Cunninghamia* 3: 535–541.
- Millington, R.J. (1954) *Sphagnum* bogs of the New England Plateau, New South Wales. *Journal of Ecology* 42: 328–344.
- Minchin, P. R. (1987) An evaluation of the relative robustness of techniques used for ecological ordination. *Vegatatio* 69: 89–107.
- Nix, H. A. & Busby, J. (1986) *BIOCLIM — A bioclimatic analysis and prediction system*. Division of Water and Land Resources: Canberra. Research Report No. 1983–85.
- Saunders, P., Buckle, D., Hope, G. & Spooner, N. (1996) Namadgi National Park Mountain Occupation Project: A Multi-disciplinary investigation of an Aboriginal site complex in the Mount Scabby Range, ACT. Unpublished report to Namadgi National Park.
- Seppelt, R.D. (2000) The Sphagnopsida (Sphagnaceae; Ambuchananiaceae) in Australia. *Hikobia* 13: 163–183.
- Whinam, J. (1995) Effects of fire on Tasmanian *Sphagnum* peatlands. In: Papers presented at Bushfire '95, an Australian Bushfire Conference, Hobart, Tasmania, 27–29 September 1995.
- Whinam, J., Eberhard, S., Kirkpatrick, J. & Moscal, T. (1989) *Ecology and conservation of Sphagnum peatlands in Tasmania* (Tasmanian Conservation Trust Inc.: Hobart).
- Whinam, J. & Buxton, R. (1997) *Sphagnum* peatlands of Australasia: an assessment of harvesting sustainability. *Biological Conservation* 82: 21–29.
- Whinam, J., Barmuta, L.A. & Chilcott, N. (2001) Floristic descriptions and environmental relationships of Tasmanian *Sphagnum* communities and their conservation management. *Australian Journal of Botany* 4: 673–685.
- Whinam, J., Hope, G. S., Adam, P., Clarkson, B. R., Alspach, P. A. & Buxton, R. P. (in press) *Sphagnum* peatlands of Australasia: the resource, its utilisation and management. *Wetlands Ecology and Management*.
- Wimbush, D.J. & Costin, A.B. (1979a) Trends in vegetation at Kosciuszko. I. Grazing trials in the subalpine zone, 1957–1971. *Australian Journal of Botany* 27: 741–787.
- Wimbush, D.J. & Costin, A.B. (1979b) Trends in vegetation at Kosciuszko. II. Subalpine range transects, 1959–1978. *Australian Journal of Botany* 27: 789–831.

## Appendices

**Appendix 1. Two-way table of indicator species (INDVAL 2.0) for NSW and ACT *Sphagnum* peatlands.**

Species	Final Group	1	2	3	4	5	6	7	8	9	IndVal
	Group size	2	2	2	11	7	6	4	3	2	
Level											
<i>Gleichenia microphylla</i>	7	2									100
<i>Viola hederacea</i>	7	2			1		3	2	1		52.94
<i>Leptospermum polygalifolium</i>	7		2				1				90.91
<i>Juncus alexandri</i>	7		2						2		83.33
<i>Deyeuxia gunniana</i>	7		2				4	2			62.50
<i>Blechnum nudum</i>	3	2	2	2						1	96.88
<i>Bursaria spinosa</i>	6			2							100
<i>Leptospermum thompsonii</i>	6			2							100
<i>Tasmania lanceolata</i>	6			2							100
<i>Agrostis</i> sp.	6			2	1						94.74
<i>Eleocharis pusilla</i>	6			2	1						94.74
<i>Isolepis</i> sp.	6			2	2	1					85.71
<i>Isotoma fluvitalis</i>	6			2	2		1				82.57
<i>Deyeuxia parviseta</i>	6			2			1	3			71.43
<i>Gleichenia dicarpa</i>	6			2			2		1		65.22
<i>Epacris paludosa</i>	5				9	4					72.22
<i>Baekea gunniana</i>	8				1	6				1	50.74
<i>Leptospermum gregarium</i>	9						6				100
<i>Baeckea omissa</i>	9						4				66.67
<i>Epacris obtusifolia</i>	9						3				50.00
<i>Euchiton sphaericus</i>	9						3				50.00
<i>Juncus prismatocarpus</i>	9						3				50.00
<i>Myriophyllum variifolium</i>	9						3				50.00
<i>Phalaris aquatica</i>	9						3				50.00

Species	Final	Group 1	2	3	4	5	6	7	8	9	IndVal
	Group size	2	2	2	11	7	6	4	3	2	
	Level										
<i>Baloskion stenocoleum</i>	5						5	2			70.00
<i>Epacris microphylla</i>	5				1		3	3			54.92
<i>Hakea microcarpa</i>	5				4	1	5	2			50.11
<i>Hypericum gramineum</i>	9							2			50.00
<i>Pomaderris aspera</i>	9							2			50.00
<i>Viola betonicifolia</i>	9							2			50.00
<i>Poa sieberiana</i>	9		1			3	2	4			44.21
<i>Empodisma minus</i>	3				10	7	4	1	1		74.19
<i>Baumea rubiginosa</i>	4						2		3		93.33
<i>Epilobium gunnianum</i>	4					2		1	3		90.32
<i>Hydrocotyle peduncularis</i>	4		1		2		3	1	3		72.41
<i>Microlaena stipoides</i>	4								2		66.67
<i>Eucalyptus radiata</i>	4								2		66.67
<i>Leptospermum juniperinum</i>	4								2		66.67
<i>Lomandra longifolia</i>	4								2		66.67
<i>Pteridium esculentum</i>	4								2		66.67
<i>Pultenaea divaricata</i>	4								2		66.67
<i>Hypericum japonicum</i>	4			1	7	1	3		3		64.12
<i>Hemarthria uncinata</i>	4				1				2		63.28
<i>Eucalyptus ovata</i>	4				2				2		60.22
<i>Isachne globosa</i>	4						2		2		60.22
<i>Hypochaeris radicata</i>	4			1	9	2	4		3		58.74
<i>Drosera binata</i>	4	1		1					2		44.44
<i>Chionogentias muelleriana</i>	2								2		100
<i>Deschampsia caespitosa</i>	2								2		100
<i>Huperzia</i> sp.	2								2		100
<i>Astelia alpina</i>	2					1			2		97.37
<i>Carpha alpina</i>	2					1			2		97.37
<i>Poa hiemata</i>	2					1			2		97.37
<i>Celmisia tomentella</i>	2					2			2		94.87
<i>Luzula modesta</i>	2				2	1			2		92.50
<i>Richea continentis</i>	2					4			2		90.24



Wingecaribee	
Trout Farm	
Tom's Cabin Rainforest	
Thomeleys Plains	x
Stringray Swamp	
South Butchers Swamp	x
Snowy River	
Snowy Flat	
Sentinel at Pippit Creek	x
Sara River	
Polblue Swamp	
Nunock Swamp	x
Nungar Plains	
North Delegate River	x
Mumbedah Swamp	
Mongarlowe River	
Micalong Swamp	
Kanangra Campground	x
Jackson's Swamp	
Horse Swamp	
Hangling Rock Swamp	
Govett's Leap	
Ginnin!	
Ebor TSR	
Dingo Swamp	x
Delegate River Swamp	
Delaney's Creek	
Clyde Mountain	x
Butchers Swamp	
Boggy Plain	
Blue Lake Track	x
Ben Hall's Gap	
Bega Swamp Herbfields	x
Bega Swamp	x
Barwick Creek	x
Barokee Swamp 2	x
Barokee Swamp 1	
Badja Swamp	
Adeline Falls	x

**ASTERACEAE**

1	<i>Achillea millefolium*</i>	
1	<i>Brachyscome graminea</i>	x
1	<i>Brachyscome obovata</i>	x
1	<i>Brachyscome ptychocarpa</i>	
1	<i>Brachyscome scapigera</i>	x
5	<i>Brachyscome</i> sp.	x
1	<i>Brachyscome spathulata</i>	
5	<i>Bracteantha bracteata</i>	x
1	<i>Celmisia</i> sp.	
5	<i>Celmisia tomentella</i>	x
1	<i>Cirsium vulgare*</i>	x
1	<i>Conyza bonariensis*</i>	x
4	<i>Cotula alpina</i>	
1	<i>Craspedia aurantia</i>	x
2	<i>Craspedia costiniana</i>	x
1	<i>Craspedia lucantha</i>	x
2	<i>Erigeron pappocromus</i>	x
1	<i>Erigeron setosus</i>	
1	<i>Erigeron</i> sp.	x
1	<i>Euchiton argentifolius</i>	x
1	<i>Euchiton collinus</i>	x
1	<i>Euchiton fordianus</i>	x
5	<i>Euchiton involucreatus</i>	x



































