Bryophytes and their distribution in the Blue Mountains region of New South Wales

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***Abstract*:** The bryophytes (mosses, liverworts and hornworts) that occur in the Blue Mountains region of New South Wales (latitude 33˚–34˚ S, longitude 151˚–151˚40' E) are listed and information is provided on their distribution in the region. Species lists are based on herbarium specimens and field collections.

348 bryophyte taxa have been recorded from 70 families, including 225 moss taxa (in 108 genera from 45 families), 120 liverwort taxa (in 51 genera from 24 families) and 3 hornwort taxa (in 3 genera from one family). The moss families with most taxa are the Pottiaceae (with 23 taxa in 13 genera), Bryaceae (with 15 taxa in 3 genera) and Fissidentaceae (with 13 taxa). The largest genera are *Fissidens* (13 taxa), *Campylopus* (9) and *Macromitrium* (8). The liverwort family with the most taxa is Lepidoziaceae, with 29 taxa in 10 genera. The largest liverwort genera are *Frullania* (11 taxa) and *Riccardia* (8).

The species lists include collections from both bushland and urban areas. Natural features of the Blue Mountains, including topography, altitude, climate and vegetation appear to be important factors influencing the number of bryophyte species recorded from each location. The number of collections from particular locations has been considerably influenced by ease of access, particularly proximity to roads, public transport and railway stations. The species lists include many records from areas that were not accessible to the early collectors of the late 19th and early 20th centuries such as Wollemi National Park, Gardens of Stone National Park, Newnes Plateau and Kanangra-Boyd National Park.

***Cunninghamia* (2007) 10(2): 225–254**

Introduction

The Blue Mountains region, 60 km west of Sydney, is an area of rugged beauty with considerable variety in landscape and vegetation. Perhaps it should more realistically be referred to as the 'Blue Mountains Plateau', a title that reflects more accurately the deeply dissected sandstone plateau, with its sheer sandstone cliffs and deep gorges. The Greater Blue Mountains World Heritage Area was inscribed on the World Heritage List in 2000, principally for the great diversity of *Eucalyptus* species that occur within the area (Department of Environment & Heritage 2003). Bryophytes include mosses, liverworts and hornworts, and are a fascinating group of non-vascular plants that have been overlooked in most botanical and ecological studies. We list some 350 bryophyte taxa (mosses, liverworts and hornworts) that occur in the Blue Mountains and provide information on bryophyte distribution in the region.

Location

Our study area includes the Blue Mountains region from the Nepean River in the east, to the sheer cliffs of Lithgow, Hartley and Portland in the west, as well as parts of the Great Dividing Range, from Mount Colong and Colong Caves in the south, to the Capertee River in the north (Figure 1). The area (latitude 33˚–34˚ S, longitude 151˚–151˚40' E), approximately 40 km east to west and 120 km north to south, takes in part of the Central Coast and the Central Tablelands Botanical Divisions of New South Wales. The area includes Blue Mountains National Park, Kanangra Boyd National Park, Wollemi National Park, Gardens of Stone National Park, council reserves, state forests, crown lands, urban parks and private gardens.

Topography/geology

The Blue Mountains plateau rises rapidly immediately west of the Nepean River and then slopes gradually westwards to its highest elevations just over 1000 m a.s.l. near Blackheath, Mount Victoria and the Newnes Plateau (Figures 1 & 2). The uppermost section of the plateau is sandstone, deposited in massive river deltas during the Triassic Period, 180 million years ago. At the edges of the sandstone massive cliffs form, as the gradual slopes formed by the underlying Permian coal-bearing shales erode more rapidly than sandstone above, undercutting the sandstone and leading to massive cliff wall collapses (Figure 2). In the most spectacular gorges of the upper Blue Mountains, the sandstone has been deeply dissected by streams and rivers, and many valleys are lined with sheer sandstone cliffs. Visible in various locations are shale bands sandwiched between sandstone layers. Vertical-walled slot canyons occur at many places, the deepest occurring near Mt Banks and Mt Wilson, and along the western and northern edges of the Newnes Plateau.

In lower areas of the Blue Mountains, such as the Blue Labyrinth, south and east of Springwood, the plateau has been dissected to form an extensive network of steep, sandstone ridges with small cliffs and sandstone outcrops (Prosser 1994).

Triassic shales cap sandstone between Kurrajong and Mount Tomah on Bells Line of Road and near Springwood on the Great Western Highway.

Tertiary basalt caps (1000 m a.s.l.) occur at Mount Wilson, Mount Irvine (7 km north east of Mount Wilson), Mount Tomah, Mount Banks and Mount Hay (14 km north east of Katoomba). These were originally lava flows along valleys, but following erosion of the softer sandstone of the surrounding landforms, they now form some of the few distinctive peaks of the Blue Mountains plateau (Branagan & Packham 2000).

The oldest geological formations are those of Early Permian and Mid Permian of Kanangra-Boyd National Park. The sheer sandstone cliffs at Kanangra Walls are very similar in appearance to the Triassic sandstones of the upper Blue Mountains. There are outcrops of Carboniferous granodiorite at Boyd River Crossing on the Jenolan Caves to Kanangra Road and limestone at Colong (Prosser 1994).

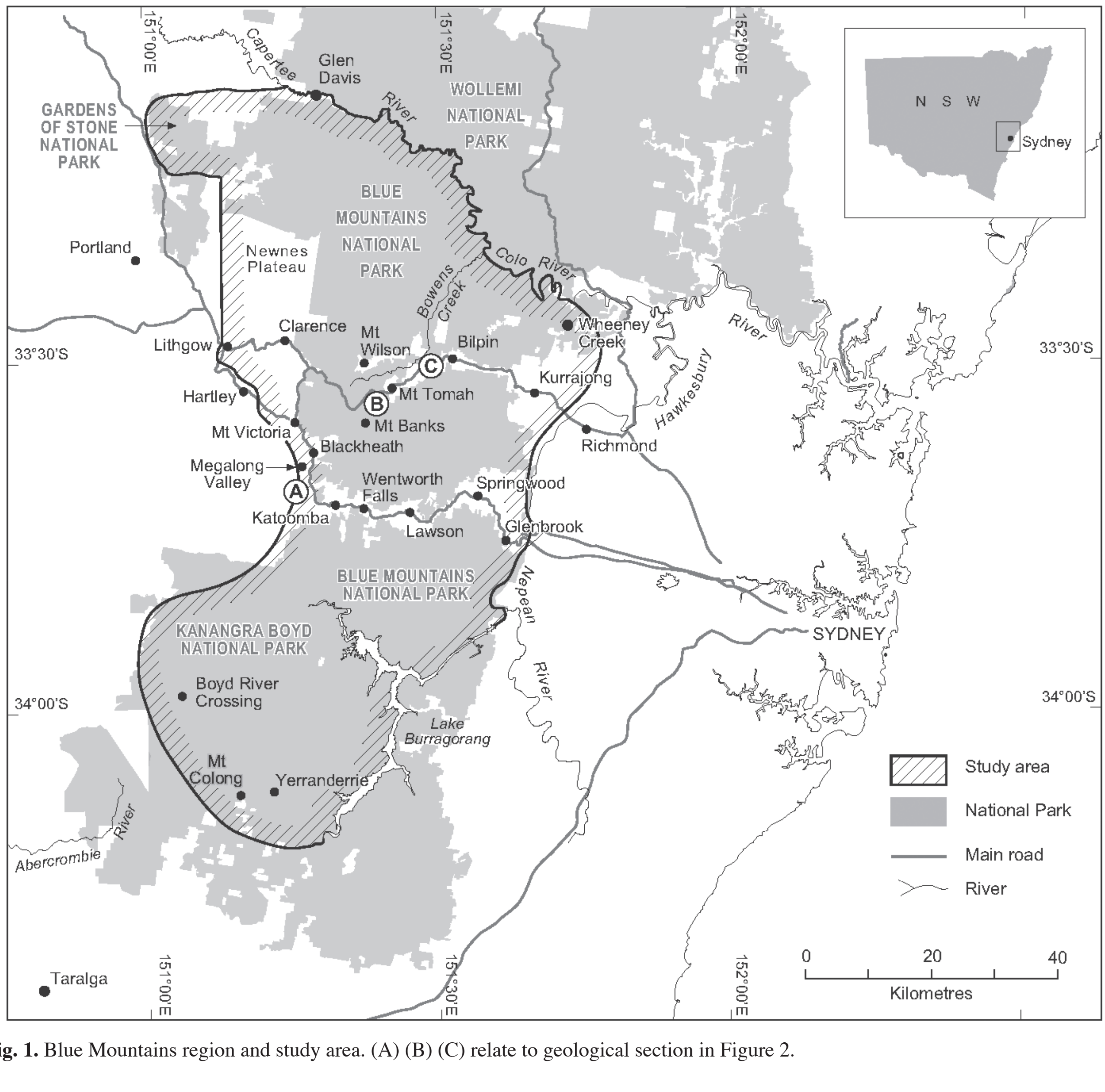

Fig. 1. Blue Mountains region and study area. (A) (B) (C) relate to geological section in Figure 2.

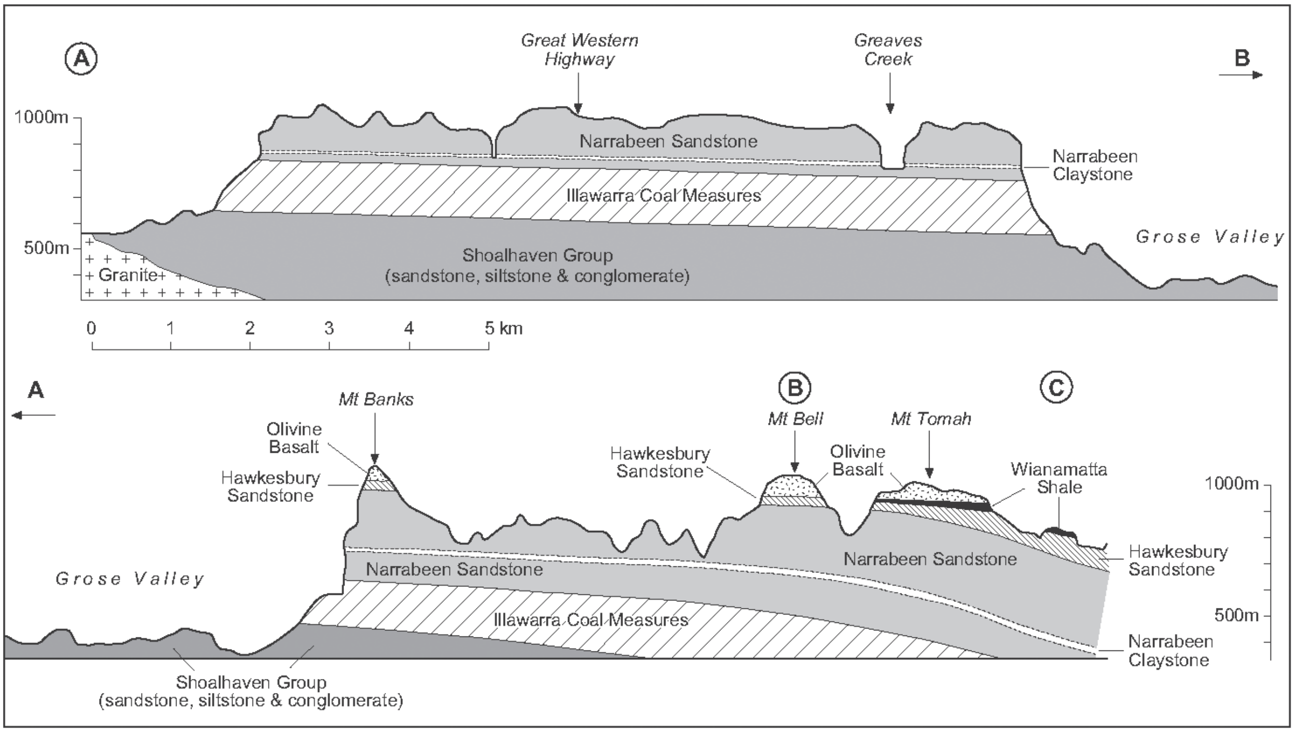

Fig. 2. Section showing geological strata and landforms along (A) (B) (C) in Figure 1. (Modified from Geological Survey of New South Wales 1997)

Climate

Rainfall is significantly higher in the upper mountains (1200–1400 mm p.a.) than in lower areas to the east and west (about 700–800 mm) (Table 1). The basalt peaks are high points (above 1000 m a.s.l.) on the Blue Mountains plateau, and correspondingly their rainfall is higher than surrounding areas. Mount Tomah has an annual average rainfall of 1541 mm and probably similar rainfall is experienced at the other high peaks (Rodd 1987). Rainfall is relatively evenly distributed throughout the year, but slightly lower in winter. Cloud, mist and fog are not uncommon and snow falls occasionally in winter on the higher parts above 1000 m.

Temperatures in the Blue Mountains are cooler both in summer and in winter than those in Sydney (Table 1). In general, temperatures are higher in areas to the north-west of the area (eg Glen Davis) but rainfall is much lower, about 650 mm per annum. To the south, (Taralga) temperatures are close to those of the higher Blue Mountains, but rainfall is lower, about 800–900 mm p.a. (Commonwealth Bureau of Meteorology 2006).

Table 1. Climatic Records for sites in and near the Blue Mountains study area (Mount Tomah data from Rodd (1987), other sites from Commonwealth Bureau of Meteorology (2006)).

Measurement	**Sydney**	**Richmond**	**Mt Tomah**	**Katoomba**	**Mt Victoria**	**Lithgow**	**Glen Davis**	**Taralga**
Metres above sea level	39	19	1016	1030	1064	950	282	845
Mean daily maximum temperature for January °C	25.8	29.6	26.5	23.1	23.0	25.5	30.3	25.7
Highest maximum temperature for January °C	45.3	47.8	N/A	36.1	35.5	37.7	N/A	38.8
Mean daily minimum temperature for July °C	8.0	3.6	3.6	2.5	1.7	0.7	2.0	0.6
Lowest minimum temperature for July °C	2.2	-8.3	-5.0	-8.2	-6.3	-8.0	N/A	-9.6
Rainfall mm per annum	1217	810	1541	1402	1061	863	634	804
Cloudy days per annum	134	123	N/A	148	126	142	N/A	124

Table 2. Distribution of Bryophytes in relation to topography and vegetation in Greaves Creek Valley, Blackheath NSW
Open forest dominated by *Eucalyptus piperita* and *Eucalyptus sieberi*, Forest dominated by *Eucalyptus oreades* and *Callicoma serratifolia*, Closed forest dominated by *Ceratopetalum apetalum* and *Doryphora sassafras*.
Table modified from Selkirk, Adamson & Downing (2001).

Taxa	Open Forest Plateau	Forest Valley Side	Closed Forest Deep Gully
Breutelia pendula	1		
Campylopus clavatus	1		1
Cephaloziella exiliflora	1		
Ditrichum difficile	1		1
Ditrichum punctulatum	1		
Eucamptodon muelleri	1		1
Frullania rostrata	1		1
Frullania squarrosula	1		
Goebelobryum unguiculatum	1		
Kurzia compacta	1		
Lepidozia ulothrix	1		1
Lethocolea pansa	1		1
Pogonatum subulatum	1		1
Rhacocarpus purpurascens	1	1	
Sclerodontium pallidum	1		
Sematophyllum contiguum	1		
Telaranea elegans	1		1
Tortula muralis	1		
Andreaea mutabilis		1	1
Balantiopsis diplophylla		1	1
Bartramia hampeana		1	
Bazzania involuta		1	1
Campylopus introflexus		1	
Chiloscyphus coalitus			1
Chiloscyphus limosus		1	
Dicranoloma billardieri		1	1
Leucobryum candidum		1	1
Rhapidorrhynchium amoeum		1	1
Rhizogonium novaehollandiae		1	
Symphyogyna podophylla		1	1
Achrophyllum dentatum			1
Acromastigum colensoanum			1
Andreaea subulata			1
Breutelia affinis			1
Rosulabryum billarderi			1
Heteroscyphus fissistipus			1
Ctenidium pubescens			1
Dawsonia superba			1
Dicranoloma dicarpum			1
Dicranoloma menziesii			1
Distichophyllum crispulum			1
Distichophyllum pulchellum			1
Fissidens humilis			1
Fissidens pallidus			1
Frullania falciloba			1
Frullania monocera			1
Hampeella pallens			1
Paracromastigum longiscyphum			1
Hymenophyton flabellatum			1
Hypnodendron vitiense			1
Hypnum cupressiforme			1
Isopterygium limatum			1
Kurzia hippuroides			1
Chiloscyphus semiteres			1
Solenostoma inundatum			1
Macromitrium archeri			1
Macromitrium ligulaefolium			1
Marsupidium surculosum			1
Megaceros gracilis			1
Mittenia plumula			1
Papillaria crocea			1
Papillaria flavolimbata			1
Plagiochila fasciculata			1
Podomitrium phyllanthus			1
Porella crawfordii			1
Ptychomnium aciculare			1
Pyrrhobryum mnioides			1
Pyrrhobryum paramattense			1
Radula buccinifera			1
Riccardia aequicellularis			1
Riccardia bipinnatifida			1
Riccardia colensoi			1
Riccardia crassa			1
Sphagnum cristatum			1
Thuidiopsis sparsa			1
Wijkia extenuata			1
Zoopsis leitgebiana			1
Zoopsis setulosa			1

Vegetation

The vegetation of the Blue Mountains area has been documented by Keith & Benson (1988), James & Kodela (1994), and Harden (1994). *Eucalyptus* woodland dominates the vegetation of the plateaus and ridges, with mallee eucalypts often growing in shallow soils over sandstone rock. Hanging swamps occur in many parts of the Blue Mountains where shallow soils of clay and peat accumulate over impervious rock. Dry heaths may be found on the tops of sandstone cliffs, particularly where exposed to southerly and southwesterly winds. Granite heath is restricted to granite outcrops above 1100 m in Kanangra-Boyd National Park.

The soils of the gentle slopes that lie below the sheer sandstone cliffs are richer in nutrients and have a better capacity to retain water than the plateau sandstone soils. Aspect plays an important part in the development of the vegetation in these lower valleys. North facing slopes such as in the Grose Valley below Blackheath tend to be dominated by *Eucalyptus* woodland or forest. (Figure 3) Southern slopes, such as Megalong Valley to the south of Blackheath, and below the scenic railway at Katoomba, support closed forest, or tall, open or closed *Eucalyptus* forest.

Soils derived from shales have better moisture retention than those derived from sandstone, thus *Eucalyptus* forest occurs in shale gullies and on clay based soils that cap sandstones, for example at Springwood and Bilpin. Many of these areas have been cleared for orchards (along Bells Line of Road) or for urban development along the railway towns of the lower Blue Mountains.

High light, high temperatures, desiccating winds and frequent fire have limited rainforest to south and east facing slopes, bottoms of moist, sheltered gorges with alluvial soils, and shales and Coal Measures on sheltered sites below cliffs. Closed forest species include *Doryphora sassafras, Ceratopetalum apetalum, Callicoma serratifolia* and the tree ferns, *Cyathea* spp. and *Dicksonia antarctica* (vascular plant names follow those currently recognised at the National Herbarium of New South Wales). Similar vegetation is found on the nutrient-rich, moisture retentive soils of the basalt caps (Harden 1994). In the slot canyons, formed by the rapid erosion of vertical fault lines in sandstone, light levels are so low that only ferns and bryophytes survive.

Fig. 3. View northwards from Blackheath across the Grose Valley to Mount Banks. *Eucalyptus* woodland dominates vegetation on the plateau while *Eucalyptus* forest grows on the slopes below the sandstone cliffs. Mixed *Eucalyptus* and closed forest clothe the basalt cap of Mount Banks.

Bryophyte studies

The earliest published bryophyte records for the Blue Mountains are in Forsyth's (1899) list of 61 moss species for New South Wales, which included seven species collected in the Blue Mountains. Watts & Whitelegge's (1902, 1905) two lists of Australian mosses included species from the Blue Mountains. Burges (1932, 1935) updated this list, including 17 records from the Blue Mountains. Stephani & Watts (1914) described at least 25 species of liverworts based on specimens from the Blue Mountains. Ramsay's (1984) *Census of New South Wales Mosses* listed 204 moss taxa for the New South Wales Central Tablelands Botanical Subdivision which includes part of the Blue Mountains.

A list of bryophytes occurring in the Blue Mountains region was prepared by H. Ramsay and P. Selkirk for inclusion in the documentation for World Heritage Listing of the Blue Mountains (ed. T. James 1994). This species list included 247 moss taxa, 122 liverwort taxa and one hornwort, but covered a significantly greater area including Nattai, Goulburn River and Dharug National Parks, than the current study.

Recent studies of particular sites include Mount Tomah Botanic Gardens where Ramsay, Downing & Schofield (1990) listed 85 bryophyte taxa (63 mosses, 21 liverworts and one hornwort). The list includes taxa from both the gardens and forest on the basalt cap and from areas of natural woodlands and forest growing on shales and sandstones of adjoining areas. A study of landform and vegetation of the Greaves Creek Basin, near Blackheath (Selkirk, Adamson & Downing 2001), includes a species list for the valley, information important in understanding bryophyte distribution in relation to the deep canyon topography of the Blue Mountains.

The bryoflora of the limestone areas of Jenolan and Wombeyan are particularly interesting but are very different from the bryophyte assemblages of the predominant sandstones, shales and basalt caps of the Blue Mountains that this paper highlights. Jenolan and Wombeyan have been excluded from this study because they lie marginally outside the study area, and because there are already a number of publications on their bryoflora (Downing 1992; Downing, Ramsay & Schofield 1991; Downing, Oldfield & Selkirk 1995). However, collections by Roger Carolin (John Ray Herbarium, SYD) from limestones near Colong Caves have been included as there are no previously published records from this area which is in Kanangra-Boyd National Park.

Methods

Records of bryophytes (mosses, liverworts and hornworts) that occur in the Blue Mountains region of New South Wales (latitude 33°–34° S, longitude 151°–151°40' E) were tabulated by geographical areas based on species lists from field collections and herbarium records.

During the last 25 years, the authors have made regular field trips to the Blue Mountains for a variety of purposes, including collecting bryophytes for taxonomic and genetic studies, and for teaching. The resulting collections, now variously housed at the National Herbarium of New South Wales (NSW), University of Sydney (SYD) and Macquarie University, have provided the base for this work. Geographically based species lists from Ramsay, Downing & Schofield (1990), and Selkirk, Adamson & Downing (2001), vouchers for which are held at Macquarie University, have been included. Lists of bryophyte species collected, at each Blue Mountains field trip location, by participants of the Australasian Bryological Workshop held in the Blue Mountains in 2001 have also been included.

Other records of bryophytes from the Blue Mountains were sought from herbaria, including the National Herbarium of New South Wales (NSW), the Downing Herbarium at Macquarie University, the John Ray Herbarium at University of Sydney (SYD), the Australian National Herbarium (CANB) and the National Herbarium of Victoria (MEL). Previously unpublished specimen-based records include approximately 2000 mosses and 1000 liverwort records.

Records were grouped for locations with similar geography and elevation. For example, Lapstone, Glenbrook, Blaxland and Mount Riverview have been grouped under Glenbrook; Valley Heights, Springwood and Faulconbridge have been grouped under Springwood. Locations range from low elevations at Glenbrook to high elevations at Blackheath and Newnes Plateau, and include sites on a range of geological substrates including sandstone, shale and basalt.

For the most part, collected material was returned to the laboratory, and identified using published keys, such as *Mosses of Southern Australia* (Scott & Stone 1976), *Southern Australian Liverworts* (Scott 1985), *Mosses of South Australia* (Catcheside, 1980) and *The Mosses of New Zealand* (Beever, Allison & Child 1992). More recently, the *Key to the Genera of Australian Mosses* (Buck, Vitt & Malcolm 2002) has been a valuable addition to this list. Also invaluable have been a raft of taxonomic papers published in recent years that have allowed accurate identification of particular taxa, for example: Bryaceae (Spence & Ramsay 1996, 1999), *Dicranoloma* (Klazenga 2003), Funariaceae (Fife & Seppelt 2001), *Grimmia* (Greven 2000), Hookeriaceae (Streimann 1997), *Macromitrium* (Vitt & Ramsay 1985), Sematophyllaceae (Ramsay, Schofield & Tan 2002), *Sphagnum* (Seppelt 2000), *Papillaria* (Streimann 1991) and as yet unpublished taxonomic keys prepared by S. Gilmore (Echinodiaceae and Fabroniaceae).

Taxonomy and allocation to families for moss taxa follows Streimann & Klazenga (2002) with the exception of some Bryaceae taxa, for which we have referred to Spence & Ramsay (2006). Taxonomy and allocation to families for liverwort and hornwort taxa follows McCarthy (2003). New state records for mosses, liverworts and hornworts were determined from the respective *Catalogues*. Records of moss taxa new for the Central Tablelands Botanical Division have been determined from Ramsay's (1984) *Census of New South Wales Mosses*. Authorities for taxa that occur in the Blue Mountains are included in Tables 3 & 4.

The following notation has been used where relevant in the text and in the appendices.

* Indicates an introduced species.
c Indicates a cosmopolitan species.
† Indicates an Australian endemic species.
# Indicates a new record for New South Wales.

Results

We have tabulated records of 348 bryophyte taxa for the Blue Mountains region. The moss taxa comprise 225 moss species in 108 genera and 45 families (Table 3), and include 23 Australian endemics and eight new species records for New South Wales. The moss families with most taxa were the Pottiaceae with 23 species in 13 genera, Bryaceae with 15 species in 3 genera and Fissidentaceae with 13 species of *Fissidens*. *Calomnion complanatum,* previously known in New South Wales only from Cambewarra Mountain on the south coast, is reported from Mount Wilson and Rocky Creek on the Newnes Plateau.

Liverwort taxa include 120 taxa in 51 genera in 24 families (Table 4), including eight species that are new records for New South Wales. There were many more species of Lepidoziaceae (29 species in 10 genera) than there were of any other liverwort family. The rare liverwort *Haplomitrium intermedium* is recorded from Bowens Creek and Lawson. Elsewhere in New South Wales it is only known from Kuring-gai Chase National Park. *Enigmella thallina* was observed (but not collected) by K. Beckman at Pierces Pass near Mount Banks (K. Beckman pers. comm.). It has not been previously recorded from the Blue Mountains.

Hornwort taxa included three species from three genera in one family (Table 4), adding two species and two genera to Ramsay & Selkirk's 1994 listing.

Table 3: Mosses of the Blue Mountains Region

G = Glenbrook + Lapstone + Blaxland, S = Springwood + Valley Heights + Faulconbridge, La = Lawson + Woodford + Hazelbrook, WF = Wentworth Falls, Ka = Katoomba, KB = Kanangra-Boyd, C = Colong + Yerranderie, Bl = Blackheath, Mg = Megalong Valley, MV = Mount Victoria, Li = Lithgow + Clarence, N = Newnes Plateau, MB = Mt Banks + Pierces Pass, MW = Mount Wilson + Mount Irvine, T = Mount Tomah, WC = Wheeney Creek + Mountain Lagoon, BC = Bowens Creek, Bi = Bilpin, Ku = Kurrajong, BM = Blue Mountains (locality unknown).

† indicates that the species is an Australian endemic (Streimann & Klazenga 2002)

New records for NSW (Streimann & Klazenga 2002)

* Introduced species

[c] Cosmopolitan species

Family/Taxon	G	S	La	WF	Ka	KB	C	Bl	Mg	MV	Li	N	MB	MW	T	WC	BC	Bi	Ku	BM
Andreaeaceae																				
† # *Andreaea amblyophylla* Müll. Hal. ex Broth.								Bl												
Andreaea mutabilis Hook.f. & Wilson				WF	Ka			Bl												
Andreaea subulata Harv. ex Hook.				WF	Ka			Bl												
Bartramiaceae																				
†*Bartramia hampeana* Müll. Hal. subsp. *hampei* (Mitt.) Fansén						KB		Bl												
Bartramia ithyphylla Brid.						KB		Bl	Mg					MW						
Breutelia affinis (Hook.) Mitt.			La	WF				Bl	Mg					MW			BC	Bi		
Breutelia pendula (Sm.) Mitt.			La	WF	Ka	KB		Bl			Li	N	MB	MW	T					
†*Breutelia pseudophilonotis* (Müll.Hal.) Watts & Whitelegge			La					Bl			Li	N		MW				Bi		
Conostomum pusillum Hook.f. & Wilson var. *pusillum*				WF	Ka	KB		Bl												
Philonotis scabrifolia (Hook.f. & Wilson) Braithwaite			La	WF					Mg					MW						
Philonotis tenuis (Taylor) Reichardt			La				C	Bl							T	WC				
†*Philonotis tortifolia* (Müll.Hal.) Watts & Whitelegge				WF										MW						
Brachytheciaceae																				
**Brachythecium albicans* (Hedw.) Schimp.								Bl		MV										
[c]*Brachythecium rutabulum* (Hedw.) Schimp.			La																	
**Pseudoscleropodium purum* (Hedw.) M.Fleisch. ex Broth.								Bl	Mg											
Rhynchostegium laxatum (Mitt.) Paris								Bl						MW						
Rhynchostegium muriculatum (Hook.f. & Wilson) Reichardt														MW						
Rhynchostegium tenuifolium (Hedw.) Reichardt var. *tenuifolium*				WF	Ka			Bl	Mg					MW	T		BC			
Bruchiaceae																				
Trematodon longescens Müll.Hal.								Bl											Ku	
Bryaceae																				
[c]*Bryum argenteum* Hedw.			La		Ka			Bl		MV	Li		MB	MW	T	WC				
Bryum lanatum P. Beauv.								Bl			Li	N				WC	BC			

Family/Taxon	**G**	**S**	**La**	**WF**	**Ka**	**KB**	**C**	**Bl**	**Mg**	**MV**	**Li**	**N**	**MB**	**MW**	**T**	**WC**	**BC**	**Bi**	**Ku**	**BM**
Gemmabryum apiculatum (Schwägr.) J.R.Spence & H.P.Ramsay															T					
Gemmabryum chrysoneuron (Müll.Hal.) J.R.Spence & H.P.Ramsay								Bl												
Gemmabryum coronatum (Schwägr.) J.R.Spence & H.P.Ramsay				WF				Bl												
Gemmabryum dichotomum (Hedw.) J.R.Spence & H.P.Ramsay	G			WF				Bl			Li		MB	MW	T		BC			
†*Gemmabryum eremaeum* (Catches.) J.R.Spence & H.P.Ramsay																				BM
Gemmabryum pachythecum (Müll.Hal.) J.R.Spence & H.P.Ramsa var. *pachythecum*	G																			
Gemmabryum sauteri (Bruch & Schimp.) J.R.Spence & H.P.Ramsay															T					
Rosulabryum albolimbatum (Hampe) J.R.Spence			La																	
Rosulabryum billarderi (Schwägr.) J.R.Spence		S	La	WF	Ka			Bl	Mg					MW	T		BC	Bi		BM
Rosulabryum capillare (Hedw.) J.R.Spence			La					Bl							T					
Rosulabryum subfasciculatum (Hampe) J.R.Spence		S	La	WF												WC			Ku	
Rosulabryum subtomentosum (Hampe) J.R.Spence				WF																
Rosulabryum torquescens (Hampe) J.R.Spence			La	WF	Ka		C	Bl	Mg											
Callicostaceae																				
Sauloma tenella (Hook.f. & Wilson) Mitt.														MW						
Calomniaceae																				
Calomnion complanatum (Hook.f. & Wilson) Lindb.												N		MW						
Cryphaeaceae																				
Cryphaea tenella (Schwägr) Hornsch. ex Müll.Hal.													MB	MW	T					
†*Cyptodon muelleri* (Hampe) M.Fleisch.														MW						
Dicranaceae																				
Dicranella dietrichiae (Müll.Hal.) A. Jaeger		S		WF				Bl	Mg	MV				MW	T		BC		Ku	
Dicranoloma billarderi (Brid. ex Anon.) Paris			La	WF				Bl	Mg	MV	Li		MB	MW					Ku	
Dicranoloma dicarpum (Nees) Paris			La					Bl	Mg			N		MW			BC			
†*Dicranoloma leichhardtii* (Hampe) Watts & Whitelegge		S	La	WF				Bl	Mg				MB	MW	T		BC	Bi		
Dicranoloma menziesii (Taylor) Reynauld			La	WF				Bl	Mg	MV			MB	MW				Bi		
Eucamptodon muelleri Hampe & Müll.Hal. var. *muelleri*			La	WF	Ka	KB		Bl		MV	Li	N	MB	MW			BC			
Holomitrium perichaetiale (Hook.) Brid. var. *perichaetiale*			La	WF	Ka			Bl						MW						
Sclerodontium pallidum (Hook.) Schwägr. subsp. *pallidum*	G	S	La	WF	Ka	KB	C	Bl	Mg	MV	Li	N	MB	MW	T	WC	BC	Bi	Ku	
Ditrichaceae																				
[c]*Ceratodon purpureus* (Hedw.) Brid. subsp. *convolutus* (Reichardt) Burley		S	La	WF	Ka	KB	C	Bl		MV	Li	N	MB	MW	T			Bi		
Ditrichum brevirostre (R.Br.bis) Broth.			La					Bl												

Ditrichum cylindricarpum (Müll.Hal.) F.Muell.								Bl		MV			MW			BC			
Ditrichum difficile (Duby) M.Fleisch.		S	La	WF	Ka	KB		Bl	Mg	MV	Li	N	MW	T		BC			
# *Ditrichum punctulatum* Mitt.								Bl											
Eccremidium brisbanicum (Broth.) I.G.Stone & G.A.M.Scott								Bl											
Pleuridium nervosum (Hook.) Mitt.				WF					Mg	MV									
Entodontaceae																			
Entodon mackaviense Müll.Hal.							C							T					
Fabroniaceae																			
Fabronia australis Hook.			La		Ka									T					
†*Fabronia scottiae* Müll.Hal.							C								WC				
Fissidentaceae																			
# *Fissidens adianthoides* Hedw.								Bl											
ᶜ*Fissidens asplenioides* Hedw.	G		La	WF					Mg			N	MW				Bi		
Fissidens curvatus Hornsch. var. *curvatus*			La	WF				Bl					MW	T					
Fissidens leptocladus Müll.Hal.							C	Bl	Mg					T					
Fissidens linearis Brid. var. *linearis*		S	La	WF				Bl	Mg					T					BM
Fissidens megalotis Schimp. ex Müll.Hal.													MW						
Fissidens oblongifolius Hook.f. & Wilson var. *oblongifolius*		S	La	WF	Ka			Bl	Mg	MV			MW		WC			Ku	
Fissidens oblongifolius Hook.f. & Wilson var. *hyophilus* (Mitt.) Beever & I.G.Stone					Ka														
Fissidens pallidus Hook.f. & Wilson var. *pallidus*	G		La	WF	Ka			Bl	Mg	MV		N	MW	T	WC	BC	Bi		
Fissidens rigidulus Hook.f. & Wilson var. *rigidulus*													MW						
Fissidens taylorii Müll.Hal var. *taylorii*							C		Mg					T					
†*Fissidens tenellus* Hook.f. & Wilson var. *australiensis* (A.Jaeger) Beever & I.G.Stone				WF															
Fissidens tenellus Hook.f. & Wilson var. *tenellus*		S	La	WF			C		Mg		Li		MW	T					
Funariaceae																			
Entosthodon apophysatus (Taylor) Mitt.										MV									
Entosthodon muehlenbergii (Turner) Fife	G		La	WF															
Entosthodon radians (Hedw.) Müll.Hal.	G			WF														Ku	
Entosthodon subnudus (Taylor) Fife var. *gracilis* (Hook.f. & Wilson) Fife																			BM
ᶜ*Funaria hygrometrica* Hedw.		S	La	WF	Ka		C				Li	N	MW	T					BM
Grimmiaceae																			
Grimmia austrofunalis Müll.Hal.					Ka														
ᶜ*Grimmia laevigata* (Brid.) Brid.						KB		Bl		MV			MW						
ᶜ*Grimmia pulvinata* (Hedw.) Sm. var. *africana* (Hedw.) Hook.f. & Wilson				WF	Ka	KB	C	Bl		MV			MW	T			Bi		
Grimmia trichophylla Grev.					Ka	KB													
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson var. *crispulum*						KB			Mg		Li								

Family/Taxon	G	S	La	WF	Ka	KB	C	Bl	Mg	MV	Li	N	MB	MW	T	WC	BC	Bi	Ku	BM
Racomitrium pruinosum (Wilson) Müll.Hal.						KB									T					
[c]*Schistidium apocarpum* (Hedw.) Bruch & Schimp.															T					
Hedwigiaceae																				
[c]*Hedwigia ciliata* (Hedw.) P.Beauv.					Ka	KB	C						MB	MW						
[c]*Hedwigidium integrifolium* (P.Beauv.) Dixon					Ka	KB		Bl				N	MB	MW	T					
Hookeriaceae																				
Achrophyllum dentatum (Hook.f. & Wilson) Vitt & Crosby			La		Ka			Bl	Mg			N		MW		WC	BC	Bi		
Distichophyllum crispulum (Hook.f. & Wilson) Mitt.			La		Ka			Bl			Li	N				WC		Bi		BM
Distichophyllum microcarpum (Hedw.) Mitt.				WF										MW						BM
Distichophyllum pulchellum (Hampe) Mitt.		S	La	WF	Ka			Bl	Mg		Li	N		MW					Ku	
Distichophyllum rotundifolium (Hook.f. & Wilson) Müll.Hal. & Broth.				WF	Ka													Bi		
Hypnaceae																				
Ctenidium pubescens (Hook.f. & Wilson) Broth.			La	WF				Bl												
[c]*Hypnum cupressiforme* Hedw. var. *cupressiforme*			La		Ka	KB		Bl						MW						
Hypnum cupressiforme Hedw. var. *mossmanianum* (Müll.Hal.) Ando				WF	Ka			Bl				N		MW	T					
# *Isopterygium limatum* (Hook.f. & Wilson) Broth.			La	WF			C	Bl	Mg			N	MB	MW	T	WC		Bi	Ku	
Hypnodendraceae																				
Hypnodendron vitiense Mitt. subsp. *australe* Touw		S	La	WF	Ka			Bl	Mg	MV	Li	N	MB	MW	T	WC	BC	Bi	Ku	
Hypopterygiaceae																				
Cyathophorum bulbosum (Hedw.) Müll.Hal.									Mg					MW						
Hypopterygium didictyon Müll.Hal.									Mg					MW						
Hypopterygium tamarisci (Sw.) Brid. ex Müll.Hal.			La	WF	Ka			Bl	Mg				MB	MW	T	WC	BC	Bi	Ku	
Lopidium concinnum (Hook.) Wilson			La	WF	Ka			Bl	Mg		Li	N	MB	MW			BC	Bi		BM
Lembophyllaceae																				
#*Camptochaete arbuscula* (Sm.) Reichardt var. *arbuscula*									Mg					MW	T					
Camptochaete deflexa (Wilson) A.Jaeger															T					
†*Camptochaete excavata* (Taylor) A.Jaeger				WF			C	Bl	Mg					MW	T					
Fallaciella gracilis (Hook.f. & Wilson) H.A.Crum														MW	T					
Lembophyllum divulsum (Hook.f. & Wilson) Lindb. var. *divulsum*			La				C	Bl				N		MW	T	WC				
Weymouthia mollis (Hedw.) Broth.														MW						
Leptodontaceae																				
Leptodon smithii (Hedw.) F.Weber & D.Mohr				WF										MW	T	WC				
Leptostomataceae																				

†*Leptostomum erectum* R.Br.				WF				Bl	Mg					MW	T					
Leptostomum inclinans R.Br.				WF				Bl	Mg			N		MW	T					
Leskeaceae																				
Pseudoleskeopsis imbricata (Hook.f. & Wilson) Thér.					Ka		C													
Leucobryaceae																				
Campylopus acuminatus Mitt. var. *acuminatus*			La					Bl							T					
†*Campylopus australis* Catches. & J.-P.Frahm			La		Ka			Bl		MV										
Campylopus bicolor (Hornsch. ex Müll.Hal.) Wilson			La	WF	Ka	KB		Bl						MW						
Campylopus catarractilis (Müll.Hal.) Paris				WF				Bl		MV										
Campylopus clavatus (R.Br.) Wilson			La	WF		KB		Bl						MW		WC	BC	Bi		
†*Campylopus flindersii* Catches. & J.-P.Frahm				WF				Bl			Li									
Campylopus incrassatus Müll.Hal.			La	WF				Bl					MB	MW						
Campylopus introflexus (Hedw.) Brid.			La	WF	Ka	KB		Bl		MV	Li	N	MB	MW	T	WC	BC	Bi	Ku	
Campylopus pyriformis (Schultz) Brid.	G	S		WF	Ka			Bl						MW						
# *Leucobryum aduncum* Dozy & Molk. var. *aduncum*		S	La	WF	Ka			Bl				N						Bi		BM
# *Leucobryum aduncum* Dozy & Molk. var. *scalare* (Müll.Hal. ex M.Fleisch.) A. Eddy																		Bi		
Leucobryum candidum (Brid. ex P.Beauv.) Wilson		S	La	WF				Bl	Mg	MV	Li	N	MB	MW	T	WC	BC	Bi		
†*Leucobryum turgidulum* Müll.Hal.					Ka															
Meteoriaceae																				
Papillaria crocea (Hampe) A.Jaeger				WF	Ka			Bl			Li			MW	T	WC			Ku	BM
Papillaria flavolimbata (Müll.Hal. & Hampe) A.Jaeger		S	La	WF	Ka			Bl	Mg	MV		N	MB	MW	T			Bi		
Papillaria flexicaulis (Wilson) A.Jaeger							C		Mg					MW	T					
Papillaria leuconeura (Müll.Hal.) A.Jaeger			La	WF	Ka			Bl	Mg	MV	Li	N	MB	MW	T			Bi		
Papillaria nitens (Hook.f. & Wilson) Sainsbury									Mg					MW	T					
Papillaria zeloflexicaulis Streimann			La					Bl	Mg		Li			MW	T			Bi		
Mniaceae																				
Plagiomnium novae-zealandiae (Colenso) T.J.Kop.			La				C		Mg						T	WC				
Pohlia cruda (Hedw.) Lindenb.																				BM
Pohlia nutans (Hedw.) Lindenb.			La		Ka			Bl									BC			
Schizymenium bryoides Harv. ex Hook.															T					
Mitteniaceae																				
Mittenia plumula (Mitt.) Lindb.			La	WF	Ka			Bl	Mg					MW	T					
Neckeraceae																				
Neckera pennata Hedw.				WF			C		Mg							WC		Bi	Ku	
Thamnobryum pandum (Hook.f. & Wilson) I.G.Stone & G.A.M.Scott														MW		WC				
Thamnobryum pumilum (Hook.f. & Wilson) Nieuwl.									Mg					MW						BM
Orthodontaceae																				

†*Orthodontium inflatum* (Mitt.) Paris																				BM
Orthodontium lineare Schwägr.		S	La	WF	Ka	KB		Bl	Mg					MW	T					
†*Orthodontium pallens* (Hook.f. & Wilson) Broth.																				BM

Family/Taxon	**G**	**S**	**La**	**WF**	**Ka**	**KB**	**C**	**Bl**	**Mg**	**MV**	**Li**	**N**	**MB**	**MW**	**T**	**WC**	**BC**	**Bi**	**Ku**	**BM**
Orthotrichaceae																				
Macrocoma tenuis (Hook. & Grev.) Vitt subsp. *tenuis*			La	WF	Ka		C	Bl	Mg		Li		MB	MW	T					
†*Macromitrium archeri* Mitt.			La	WF	Ka			Bl	Mg		Li			MW	T					
†*Macromitrium hemitrichodes* Schwägr.	G		La	WF	Ka			Bl	Mg				MB	MW	T	WC	BC		Ku	
Macromitrium involutifolium (Hook. & Grev.) Schwägr. subsp. *involutifolium*	G		La	WF				Bl						MW			BC		Ku	
Macromitrium involutifolium (Hook. & Grev.) Schwägr. subsp. *ptychomitrioides* (Besch.) Vitt & H.P.Ramsay	G		La	WF									MB	MW	T	WC	BC		Ku	
Macromitrium ligulaefolium Broth.		S	La	WF	Ka			Bl	Mg		Li			MW		WC			Ku	
Macromitrium ligulare Mitt.			La	WF	Ka		C	Bl	Mg					MW	T					
Macromitrium microstomum (Hook. & Grev.) Schwägr.		S	La	WF	Ka			Bl	Mg	MV	Li			MW					Ku	
†*Macromitrium repandum* Müll.Hal.			La	WF	Ka			Bl	Mg			N		MW	T					
Orthotrichum assimile Müll.Hal.		S		WF	Ka	KB			Mg					MW	T					
Orthotrichum tasmanicum Hook.f. & Wilson var. *tasmanicum*														MW						BM
Schlotheimia brownii Schwägr.				WF				Bl		MV										
Zygodon intermedius Bruch & Schimp.						KB								MW						
Plagiotheciaceae																				
Plagiothecium lamprostachys (Hampe) A.Jaeger				WF								N		MW						
Polytrichaceae																				
Atrichum androgynum (Müll.Hal.) A.Jaeger			La		Ka				Mg											
†*Dawsonia longiseta* Hampe	G		La				C													
†*Dawsonia polytrichoides* R.Br.	G	S	La	WF							Li	N		MW	T		BC		Ku	
Dawsonia superba Grev. var. *pulchra* Zanten								Bl						MW	T		BC			
Pogonatum neesii (Müll.Hal.) Dozy			La					Bl	Mg			N		MW			BC			
Pogonatum subulatum (Brid.) Brid.			La	WF	Ka	KB		Bl	Mg	MV				MW	T					
[c]*Polytrichastrum alpinum* (Hedw) G.L.Sm.				WF		KB														
# *Polytrichastrum formosum* (Hedw.) G.L.Sm.				WF																
[c]*Polytrichum commune* Hedw. var. *commune*			La	WF	Ka	KB		Bl	Mg		Li	N		MW	T					
[c]*Polytrichum juniperinum* Hedw.			La	WF	Ka	KB		Bl	Mg	MV	Li	N			T					
Pottiaceae																				
Acaulon integrifolium Müll.Hal.														MW						
Aloina aloides (Schultz) Kindb. var. *ambigua* (Bruch. & Schimp.) E.J.Craig									Mg											
Barbula calycina Schwägr.			La	WF		KB		Bl	Mg	MV	Li	N		MW	T		BC	Bi	Ku	
Barbula crinita Schultz			La	WF				Bl		MV	Li				T					
Barbula cf. *rehmannii*															T					
†*Barbula speirostega* Müll.Hal.			La																	

Barbula subcalycina Müll.Hal.		La																	
**Barbula unguiculata* Hedw.	S			Ka			Bl					MB		T					
Bryoerythrophyllum binnsii (R.Br. bis) Wijk & Margad.							Bl						MW						
Calyptopogon mnioides (Schwägr.) Broth.													MW						
Didymodon torquatus (Taylor) Catches.					KB				MV						WC				
ᶜ*Gymnostomum calcareum* Nees & Hornsch.		La					Bl												
Tetrapterum cylindricum (Taylor) A.Jaeger																			BM
Tortula antarctica (Hampe) Wilson													MW						
ᶜ*Tortula muralis* Hedw.		La	WF	Ka			Bl			Li		MB		T	WC				
Tortula pagorum (Milde) de Not.				Ka			Bl		MV				MW	T					
Tortula papillosa Wilson		La					Bl		MV				MW	T				Ku	
Tortula phaea (Hook.f. & Wilson) Dixon																			BM
†*Trachycarpidium brisbanicum* (Müll.Hal.) I.G.Stone														T					
**Trichostomum brachydontium* Bruch.			WF						MV										
Trichostomum eckelianum R.H. Zander						C			MV										
Triquetrella papillata (Hook.f. & Wilson) Broth.		La				C	Bl		MV	Li								Ku	
ᶜ*Weissia controversa* Hedw.		La	WF	Ka			Bl	Mg	MV	Li		MB		T		BC	Bi	Ku	
Pterobryaceae																			
Trachyloma diversinerve Hampe							Bl												
Trachyloma planifolium (Hedw.) Brid.							Bl										Bi		
Ptychomitriaceae																			
Ptychomitrium australe (Hampe) A.Jaeger				Ka		C	Bl					MB		T					
Ptychomitrium muelleri (Mitt.) A.Jaeger													MW						
Pytchomniaceae																			
Glyphothecium sciuroides (Hook.) Hampe								Mg											
Hampeella pallens (Sande Lac.) M.Fleisch.		La					Bl	Mg		Li	N		MW	T	WC				
Ptychomnion aciculare (Brid.) Mitt.		La	WF	Ka			Bl					MB	MW	T		BC			
Racopilaceae																			
Racopilum cuspidigerum (Schwägr) Ångstr. var. *convolutaceum* (Müll.Hal.) Zanten & Dijkstra	S						Bl	Mg	MV				MW			BC			
Racopilum cuspidigerum (Schwägr) Ångstr. var. *cuspidigerum*		La				C	Bl	Mg			N		MW	T	WC		Bi		
Rhacocarpaceae																			
Rhacocarpus purpurascens (Brid.) Paris	S	La	WF	Ka	KB		Bl	Mg	MV	Li	N	MB	MW	T		BC	Bi		
Rhizogoniaceae																			
Goniobryum subbasilare (Hook.) Lindb.													MW						
Hymenodon pilifer Hook.f. & Wilson													MW						
Leptotheca gaudichaudii Schwägr. var. *gaudichaudii*			WF		KB		Bl	Mg	MV		N		MW	T					
†*Mesochaete undulata* Lindb.		La	WF	Ka			Bl	Mg	MV				MW		WC		Bi	Ku	
Pyrrhobryum mnioides (Hook.) Manuel subsp. *contortum* (Wilson) Fife							Bl	Mg	MV				MW						

Family/Taxon	**G**	**S**	**La**	**WF**	**Ka**	**KB**	**C**	**Bl**	**Mg**	**MV**	**Li**	**N**	**MB**	**MW**	**T**	**WC**	**BC**	**Bi**	**Ku**	**BM**
Pyrrhobryum paramattense (Müll.Hal.) Manuel		S	La	WF	Ka			Bl	Mg			N	MB	MW	T	WC	BC	Bi	Ku	
Pyrrhobryum spiniforme (Hedw.) Mitt.			La	WF	Ka			Bl							T					
Rhizogonium distichum (Sw.) Brid.				WF										MW						
Rhizogonium novae-hollandiae (Brid.) Brid.					Ka			Bl							T					BM
Rhizogonium pennatum Hook.f. & Wilson				WF	Ka									MW						
Seligeriaceae																				
Blindia robusta Hampe				WF																BM
Sematophyllaceae																				
Rhaphidorrhynchium amoenum (Hedw.) M.Fleisch. var. *amoenum*			La		Ka			Bl	Mg						T		BC			
Sematophyllum homomallum (Hampe) Broth.			La				C											Bi		
Sematophyllum joliffii (Hook.f.) Dixon								Bl												
Sematophyllum subhumile (Müll.Hal.) M.Fleisch. var. *contiguum* (Mitt.) B.C.Tan				WF				Bl							T			Bi		
Sematophyllum subhumile (Müll.Hal.) M.Fleisch. var. *subhumile*		S	La	WF	Ka			Bl	Mg					MW						
Sematophyllum subpinnatum (Brid.) E.Britton				WF																
Sematophyllum uncinatum I.G.Stone & G.A.M.Scott					Ka			Bl												
†*Trichosteleum subfalcatulum* (Broth. & Watts) B.C.Tan, W.B.Schofield & H.P.Ramsay				WF																
#*Warburgiella macrospora* (Dixon & Sainsbury) B.C.Tan, W.B.Schofield & H.P.Ramsay														MW						
Wijkia extenuata (Brid.) H.A.Crum		S	La	WF	Ka			Bl	Mg	MV	Li	N	MB	MW	T	WC		Bi	Ku	BM
Sphagnaceae																				
Sphagnum australe Mitt.								Bl												
Sphagnum cristatum Hampe			La	WF	Ka	KB		Bl			Li			MW	T					
Sphagnum falcatulum Besch.								Bl												
Sphagnum novo-zelandicum Mitt.					Ka			Bl			Li									
Sphagnum perichaetiale Hampe								Bl												
Splachnaceae																				
Tayloria octoblepharum (Hook.) Mitt. var. *octoblepharum*	G		La	WF	Ka	KB		Bl		MV				MW				Bi		
Thuidiaceae																				
Thuidiopsis furfurosa (Hook.f. & Wilson) M.Fleisch.				WF				Bl												
Thuidiopsis sparsa (Hook.f. & Wilson) Broth.		S	La	WF	Ka		C	Bl	Mg	MV	Li	N		MW	T	WC		Bi		
Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk.					Ka			Bl						MW	T				Ku	
Thuidium laeviusculum (Mitt.) A.Jaeger														MW						
Total number of taxa at each location	**14**	**29**	**95**	**104**	**78**	**32**	**28**	**131**	**75**	**44**	**41**	**41**	**32**	**120**	**89**	**33**	**34**	**38**	**28**	**20**

Table 4: Liverworts and Hornworts of the Blue Mountains Region

G = Glenbrook + Lapstone + Blaxland, S = Springwood + Valley Heights + Faulconbridge, La = Lawson + Woodford + Hazelbrook, WF = Wentworth Falls, Ka = Katoomba, KB = Kanangra-Boyd, C = Colong + Yerranderie, Bl = Blackheath, Mg = Megalong Valley, MV = Mount Victoria, Li = Lithgow + Clarence, N = Newnes Plateau, MB = Mt Banks + Pierces Pass, MW = Mount Wilson + Mount Irvine, T = Mount Tomah, WC = Wheeney Creek + Mountain Lagoon, BC = Bowens Creek, Bi = Bilpin, Ku = Kurrajong, BM = Blue Mountains (locality unknown).

New records for NSW (McCarthy 2003)

* Introduced species

Family/Taxon	**G**	**S**	**La**	**WF**	**Ka**	**KB**	**C**	**Bl**	**Mg**	**MV**	**Li**	**N**	**MB**	**MW**	**T**	**WC**	**BC**	**Bi**	**Ku**	**BM**
Acrobolbaceae																				
Enigmella thallina G.A.M.Scott & K.G.Beckm.													MB							
Goebelobryum unguiculatum (Hook.f. & Taylor) Grolle			La	WF				Bl					MB	MW			BC			
Lethocolea pansa (Taylor) G.A.M.Scott & K.G.Beckm.			La	WF				Bl	Mg			N	MB				BC	Bi		
Marsupidium surculosum (Nees) Schiffn.								Bl	Mg											
Tylimanthus diversifolius E.A.Hodgs.								Bl												
Tylimanthus tenellus (Hook.f. & Taylor) Mitt.					Ka										T					
Aneuraceae																				
Aneura alterniloba (Hook.f. & Taylor) Taylor & Hook.f. var. *alterniloba*			La	WF				Bl			Li						BC			
Aneura alterniloba (Hook.f. & Taylor) Taylor & Hook.f. var. *gigantea* (Steph.) Hewson			La	WF				Bl					MB				BC	Bi		
Aneura rodwayi Hewson			La	WF																
Riccardia aequicellularis (Steph.) Hewson			La	WF	Ka			Bl						MW						
Riccardia bipinnatifida (Colenso) Hewson			La		Ka			Bl						MW						
Riccardia cochleata (Hook.f. & Taylor) Kuntze			La					Bl												
Riccardia colensoi (Steph.) W.Martin								Bl		MV		N		MW		WC				
Riccardia crassa (Schwägr.) Carrington & Pearson		S	La	WF	Ka			Bl		MV		N	MB	MW			BC	Bi		
Riccardia graeffei (Steph.) Hewson								Bl												
Riccardia lobulata (Colenso) E.A.Hodgs.								Bl												
Riccardia rupicola (Steph.) Hewson			La					Bl		MV				MW				Bi		
Anthocerotaceae (Hornworts)																				
Anthoceros punctatus L.							C						MB							
Megaceros gracilis (Rchdt.) Steph.							C	Bl	Mg					MW	T					
Phaeoceros carolinianus (Michx.) Prosk.			La	WF			C	Bl						MW			BC		Ku	
Aytoniaceae																				
Asterella drummondii (Hook.f. & Taylor) R.M.Schust. ex D.G.Long														MW						
Plagiochasma rupestre (J.R.Forst. & G.Forst.) Stephani							C							MW						
Reboulia hemisphaerica (L.) Raddi			La	WF			C		Mg					MW		WC				BM

Family/Taxon	**G**	**S**	**La**	**WF**	**Ka**	**KB**	**C**	**Bl**	**Mg**	**MV**	**Li**	**N**	**MB**	**MW**	**T**	**WC**	**BC**	**Bi**	**Ku**	**BM**
Balantiopsidaceae																				
Balantiopsis diplophylla (Hook.f. & Taylor) Mitt.		S	La	WF	Ka			Bl		MV		N	MB	MW	T	WC		Bi		
Balantiopsis tumida Berggr.																		Bi		
Isotachis grandis Carrington & Pearson			La					Bl												
Isotachis intortifolia (Hook.f. & Taylor) Gottsche			La	WF				Bl				N		MW						
Cephaloziellaceae																				
Cephaloziella exiliflora (Taylor) Douin			La				C	Bl							T	WC				
Cephaloziella hirta (Steph.) R.M.Schust.											Li									
Cephaloziella varians (Gottsche) Steph.												N								
Chaetophyllopsidaceae																				
Chaetophyllopsis whiteleggei (Carrington & Pearson) R.M.Schust.				WF																
Fossombroniaceae																				
Fossombronia pusilla (L.) Nees				WF					Mg					MW					Ku	
Fossombronia wondraczekii (Corda) Dumort. ex Lindenb.														MW						
Geocalycaceae																				
Chiloscyphus glaucescens Steph.				WF																
Chiloscyphus latifolius (Nees) J.J.Engel							C													
Chiloscyphus multipennus (Hook.f. & Taylor) J.J.Engel & R.M.Schust									Mg											
Chiloscyphus semiteres (Lehm. & Lindenb.) Lehm. & Lindenb.			La	WF		KB	C	Bl				N		MW	T	WC	BC	Bi		
Geocalyx caledonicus Steph.								Bl												
Heteroscyphus argutus (Reinw., Blume & Nees) Schiffn.			La						Mg			N		MW	T		BC			
Heteroscyphus biciliatus (Hook.f. & Taylor) J.J.Engel														MW						
Heteroscyphus cambewarranus (Steph.) J.J.Engel & R.M.Schust.														MW						
Heteroscyphus coalitus (Hook.) Schiffn.								Bl				N								
Heteroscyphus fissistipus (Hook.f. & Taylor) Schiffn.	G				Ka			Bl	Mg					MW			BC			
Heteroscyphus limosus (Carrington & Pearson) Schiffn.								Bl	Mg							WC		Bi		
Leptoscyphus expansus (Lehm.) Grolle								Bl												
Haplomitriaceae																				
Haplomitrium intermedium Berrie			La														BC			
Hymenophytaceae																				
Hymenophyton flabellatum (Labill.) Dumort. ex Trevis.				WF				Bl					MB	MW	T	WC	BC	Bi		
Jackiellaceae																				
Jackiella curvata E.A.Hodgs. & Allison				WF																

Jubulaceae																
# *Frullania allanii* E.A.Hodgs.			WF													
Frullania cataractarum Steph.														BC		
Frullania clavata (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees						Bl	Mg				MW	T				
Frullania falciloba Taylor ex Lehm.					C	Bl	Mg				MW	T				
Frullania monocera (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees var. *monocera*		La	WF		C	Bl					MW	T		BC		
Frullania pentapleura Taylor					C							T				
Frullania probosciphora Taylor					C							T				
Frullania aff. *rostrata*		La														
Frullania rostrata (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees		La	WF			Bl			N	MB	MW			BC	Bi	
Frullania rubella Gottsche ex Steph. var. *rubella*				Ka												
Frullania squarrosula (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees	S	La		Ka	C	Bl					MW	T				
Jungermanniaceae																
Cryptochila grandiflora (Lindenb. & Gottsche) Grolle																BM
Cryptochila nigrescens (Steph.) Grolle		La														
Solenostoma inundatum (Hook.f. & Taylor) Mitt. ex Steph.						Bl					MW					
Lejeuneaceae																
Acrolejeunea securifolia (Nees) Steph. & Watts																BM
Cheilolejeunea mimosa (Hook.f. & Taylor) R.M. Schust.		La					Mg						WC			
Diplasiolejeunea plicatiloba (Hook.f. & Taylor) Grolle			WF													
Lejeunea drummondii Taylor					C		Mg		N			T		BC		
Lepidoziaceae																
Acromastigum furcatifolia (Steph.) E.A.Br. ms		La								MB					Bi	
Acromastigum colensoanum (Mitt.) A.Evans ex Reimers						Bl	Mg				MW					
Acromastigum exiguum (Steph.) A.Evans		La				Bl	Mg						WC		Bi	
Bazzania involuta (Mont.) Trevis.		La	WF			Bl	Mg		N	MB			WC	BC	Bi	
Bazzania monilinervis (Lehm. & Lindenb.) Trevis.								MV							Bi	
Bazzania wattsiana (Steph.) comb. nov.													WC			
# *Drucella integristipula* (Steph.) E.A.Hodgs.													BC			
Hygrolembidium acrocladum (Berggr.) R.M.Schust.			WF													
Kurzia compacta (Steph.) Grolle		La	WF			Bl	Mg	MV	N	MB				BC	Bi	
Kurzia calcarata (Steph.) Grolle						Bl										
Kurzia dendroides (Carrington & Pearson) Grolle				Ka		Bl				MB						
Kurzia hippurioides (Hook.f. & Taylor) Grolle	S	La	WF			Bl	Mg		N	MB	MW	T	WC	BC	Bi	
# *Kurzia temnoides* R.M. Schust.														BC		
Lepidozia asymmetrica Steph.						Bl										
Lepidozia laevifolia (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees var. *laevifolia*		La	WF	Ka		Bl				MB	MW	T		BC	Bi	

Family/Taxon	G	S	La	WF	Ka	KB	C	Bl	Mg	MV	Li	N	MB	MW	T	WC	BC	Bi	Ku	BM
# *Lepidozia procera* Mitt.			La	WF																
Lepidozia quadrifida Kunze ex Lindenb.			La																	
Lepidozia quadristipula Steph.								Bl												
Lepidozia ulothrix (Schwägr.) Lindenb.			La	WF	Ka			Bl	Mg	MV		N	MB	MW			BC	Bi		
Lepidozia wattsiana Steph.																WC				BM
Paracromastigum longiscyphum (Taylor) R.M.Schust. & J.J.Engel			La	WF													BC			
# *Psiloclada clandestina* Mitt. subsp. *clandestina*													MB				BC			
Telaranea capilligera (Schwägr.) R.M.Schust.				WF				Bl												
Telaranea elegans (Colenso) J.J.Engelo & G.L.Sm.		S	La	WF	Ka			Bl	Mg	MV	Li	N	MB	MW			BC	Bi		
Telaranea quinquespina (J.J.Engel & G.L.Sm.) J.J.Engel & G.L.Sm.																	BC			
Telaranea tetradactyla (Hook.f. & Taylor) E.A.Hodgs.			La					Bl												
Zoopsis argentea (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees			La					Bl	Mg				MB					Bi		
Zoopsis leitgebiana (Carrington & Pearson) Bastow		S	La	WF	Ka			Bl		MV		N		MW				Bi		
Zoopsis setulosa Leitg.		S	La	WF	Ka			Bl	Mg			N	MB	MW		WC		Bi		
Lunulariaceae																				
Lunulariaceae																				
*_Lunularia cruciata_ (L.) Dumort.				WF			C	Bl	Mg					MW	T					
Marchantiaceae																				
Marchantia berteroana Lehm. & Lindenb.								Bl				N		MW						
Marchantia polymorpha L. var. *aquatica* Nees		S		WF							Li			MW	T					
Metzgeriaceae																				
Metzgeria furcata (L.) Dumort.			La	WF	Ka			Bl				N		MW	T	WC	BC			
Metzgeria leptoneura Spruce					Ka			Bl												
# *Metzgeria submarginata* So								Bl												
Pallaviciniaceae																				
Jensenia connivens (Colenso) Grolle				WF																
Pallavicinia lyellii (Hook.) Grey			La	WF				Bl									BC	Bi		
Pallavicinia purpurea Steph.				WF																
Pallavicinia xiphoides (Hook.f. & Taylor) Trevis.					Ka															
Podomitrium phyllanthus (Hook.) Mitt.			La	WF				Bl				N	MB							
Symphyogyna interrupta Carrington & Pearson			La					Bl	Mg					MW						
Symphyogyna multiflora Steph.				WF																
Symphyogyna podophylla (Thunb.) Mont. & Nees			La	WF				Bl	Mg			N	MB	MW	T		BC	Bi		
Plagiochilaceae																				
# *Plagiochila arbuscula* (Brid. ex Lehm. & Lindenb.) Lindenb.			La																	
Plagiochila baileyana Steph.								Bl	Mg											
Plagiochila fasciculata Lindenb.			La	WF				Bl	Mg					MW			BC			
Plagiochila strombifolia Taylor ex Lehm.								Bl	Mg											

Porellaceae																				
Porella crawfordii Steph.							C	Bl						MW	T	WC	BC			
Radulaceae																				
Radula acutiloba Steph.														MW						
Radula buccinifera (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees		S	La					Bl		MV				MW			BC	Bi		
Radula pulchella Mitt. ex Steph.																	BC			
Radula wattsiana Steph.								Bl												
Ricciaceae																				
Riccia bifurca Hoffm.																			Ku	
Riccia crinita Taylor																			Ku	
Riccia papulosa (Steph.) Steph. var. *papulosa*																			Ku	
Trichocoleaceae																				
Trichocolea mollissima (Hook.f. & Taylor) Gottsche								Bl						MW					Ku	
# *Trichocolea rigida* R.M.Schust.			La						Mg				MB	MW		WC		Bl		
Total number of taxa at each location	**1**	**9**	**49**	**43**	**17**	**1**	**16**	**66**	**29**	**10**	**4**	**22**	**23**	**46**	**21**	**17**	**33**	**26**	**6**	**4**

Comparison with published bryophyte records

The 225 moss taxa of the Blue Mountains reported here make up nearly half (43%) of the 527 moss taxa recorded for New South Wales in Ramsay's (1984) *Census of New South Wales Mosses*. Comparison with regional species numbers from Ramsay is difficult, as our study area includes sections of both the Central Tablelands and Central Coast Botanical Subdivisions. However, 159 moss taxa listed by Ramsay for the Central Tablelands Botanical Subdivision, which includes the greater part of our survey area, were recorded in this study, together with an additional 45 taxa not listed by Ramsay.

175 of the 247 moss taxa listed by Ramsay and Selkirk for the Blue Mountains World Heritage Listing assessment (James 1994) were recorded in this study, plus a further 52 taxa. Of the 71 taxa on Ramsay and Selkirk's list not recorded in this study, many, such as *Gigaspermum repens* (Hook.) Lindb., *Encalypta vulgaris* Hedw. and species of Bryaceae and Pottiaceae, are likely to have been collected on the Jenolan and Wombeyan Caves limestones, which are known to have a unique and diverse bryophyte assemblage (Downing 1992; Downing, Ramsay & Schofield 1991, Downing, Oldfield & Selkirk 1995). Others such as *Echinodium hispidum* (Hook.f. & Wilson) Reichardt and *Rhodobryum aubertii* (Schwägr.) Thér. are likely to have come from the lower altitude closed forests of Nattai or Dharug National Parks. Both areas are outside our Blue Mountains study area.

Of a total of 122 liverwort taxa listed by Ramsay & Selkirk (James 1994), 82 were recorded in this study, together with an additional 43 species. Of the 40 species not recorded in this study, some species such as *Targionia hypophylla* L. and *Riccia limbata* Bisch. commonly occur on limestone and are likely to have been collected at Jenolan or Wombeyan. Other taxa listed by Ramsay & Selkirk, such as *Mastigobryum dentistipulum* and *M. gracillimum* have since been transferred to other taxa.

We have been able to add 26 moss taxa to Ramsay, Downing & Schofield's (1990) list for Mount Tomah Botanic Gardens, increasing the total number of bryophyte taxa there to 110. The number of liverwort species has decreased by one (*Metzgeria decipiens* is now synonymous with *M. furcata*).

Bryophyte collection difficulties

Information for this study has been gleaned from many sources rather than from a single field investigation and there are some problems with information (or the lack of it) on specimen packets. In some cases, the location has been given simply as *Blue Mountains* (included in Tables 3 and 4 as 'Blue Mountains').We have excluded from our species list some specimens (held in MEL) collected by Ferdinand von Mueller about 1855, supposedly from the *Blue Mountains*, but unlikely to have been collected within our definition of the Blue Mountains region. It is likely that they were collected in the Southern Alps near Mount Kosciuszko, at that time perhaps seen as a southern extension of the Blue Mountains. Most are accepted as alpine species and have been listed by Ramsay *et al*. (1986) as occurring in the alpine areas of New South Wales above 1800 m elevation. The species are: *Aulacomnium palustre* (Hedw.) Schwägr., *Blindia robusta* Hampe, *Bryum australe* Hampe, *Catagonium nitens* (Brid.) Cardot, *Entosthodon apophysatus* (Taylor) Mitt., *Lepyrodon pseudoalgurus* B.H.Allen, *Notoligotrichum crispulum* (Hook.f. & Wilson) G.M.Sm., *Physcomitrium conicum* Mitt., *Polytrichastrum alpinum* (Hedw.) G.L.Sm. and *Sanionia uncinata* (Hedw.) Loeske. Only two of these species collected by von Mueller, *Polytrichastrum alpinum* and *Blindia robusta,* have since been recorded from the Blue Mountains.

Polytrichastrum alpinum has been recorded from Kanangra Boyd National Park, above 1000 m a.s.l., (by J. Glime in 1981) and at Wentworth Falls (by H. Ramsay in 1977). This species has also been recorded from the summit of Mount Canobolas, 1395 m a.s.l., 130 km north-west of Katoomba (Downing, Oldfield & Fairburn-Wilson 2002), making its presence in the higher areas of the Blue Mountains not surprising.

Blindia robusta is a conspicuous species and there are two specimens (in the John Ray Herbarium, University of Sydney (SYD)) collected in 1930 at Wentworth Falls by A. Burges. There are a number of other moss specimens collected by Burges at Wentworth Falls on the same date, and as these species still commonly occur in the vicinity of Wentworth Falls, it is apparent that Burges did collect *B. robusta* from this location. It is difficult to imagine how its occurrence along stream banks would have been overlooked by both earlier and later collectors. We have been unable to find it anywhere in the Blue Mountains and it may have been destroyed by drought, fire or urban development.

Habitat and ecological information on bryophytes is generally very limited. Many herbarium packets (although appropriately labelled with location) bear minimal information describing landform (plateau, ridge, valley, and canyon), aspect, moisture or lack of it, vegetation type (heath, woodland, forest, and closed forest), degree of shading, substrate (rock, soil or sand, tree trunk, tree branches, tree fern, fallen log), underlying rock (sandstone, shale, basalt, limestone, and granodiorite) or associated bryophytes. Such specimens have contributed to species lists for locations, but could not contribute information concerning habitat.

Other problems relate to identification. In the case of taxa that have been viewed by experts in recent years, it is possible to be confident in the names allocated to specimens, e.g. *Macromitrium* specimens determined by Vitt & Ramsay, *Papillaria* determined by H. Streimann, *Sphagnum* by R. Seppelt and *Aneura* and *Riccardia* determined by H. Hewson. However, there are many groups, such as *Campylopus, Grimmia* and *Leucobryum*, for which identification is challenging. Often there are no recent publications and it is not within the scope of this study to check the determinations of all the specimens held in various herbaria.

Discussion

The effect of accessibility on bryophyte recording

There was a considerable difference in the number of species recorded at different locations (Table 5) and accessibility has probably been the major factor determining the number of species recorded from some locations. Following construction of the railway in 1868, visitors were able to travel by train to Lawson, Wentworth Falls and Blackheath (Valder 1988). Govetts Leap (at Blackheath) and Wentworth Falls were the most popular Blue Mountains destinations, according to The Railway Guide of the day. Cheap train fares and a growth in tourist facilities attracted many visitors. Construction of walking tracks at Wentworth Falls and Govetts Leap began in 1890. By 1910, motor coaches facilitated travel from the railway to more distant locations (Burke 1988). In 1875, when the Mount Wilson Railway Station (later changed to Bell) was completed, it became much easier to travel to Mount Wilson and Mount Irvine (Valder 1988).

The early collectors, Whitelegge, Forsyth and Watts, all used rail and their collections, for example from Grand Canyon at Blackheath, from Valley of the Waters at Wentworth Falls, from Dantes Glen at Lawson, all indicate they used the same walking paths that we use today. The Rev. W.W. Watts walked or travelled on horseback to visit parishioners (Ramsay 1980) but today we still use the same road that Watts used, winding through closed forest from Mount Wilson to Mount Irvine.

Factors affecting distribution of bryophytes in the Blue Mountains: topography and geology

Most of the bryophytes in the Blue Mountains are found in the closed forests of gullies and valleys on sandstone and shale. The dense canopies of closed forests protect bryophytes from high light, extreme temperatures and desiccation by strong winds. Damp rocks, soil, fallen logs and tree roots are often covered with bryophytes. Unlike many eucalypts, trees of the closed forest, such as *Doryphora sassafras, Ceratopetalum apetalum* and *Callicoma serratifolia* have persistent bark, allowing epiphytic bryophytes to colonise tree trunks, branches and twigs. Bryophytes that can survive in low light levels of closed forest are often large and conspicuous, with growth forms that allow them to access maximum light levels. For example, pendulous mosses (*Papillaria* spp.) hang from tree trunks and tree fern trunks, and dendroid mosses and liverworts (*Hypnodendron vitiense* subsp. *australe, Hypopterygium* spp. and *Hymenophyton flabellatum)* grow upwards from wet rocks and soil along creek banks (Figures 4, 5). Tall, upright species, such as *Dawsonia superba* (Figure 12) rapidly colonise newly exposed earth of land slips, or gaping holes in the ground where mature trees have fallen. Three beautiful mosses, *Neckera pennata, Cyathophorum bulbosum* and *Calomnion complanatum* grow on the trunks of tree ferns, tree trunks and wet rocks, almost always in deep shade close to streams.

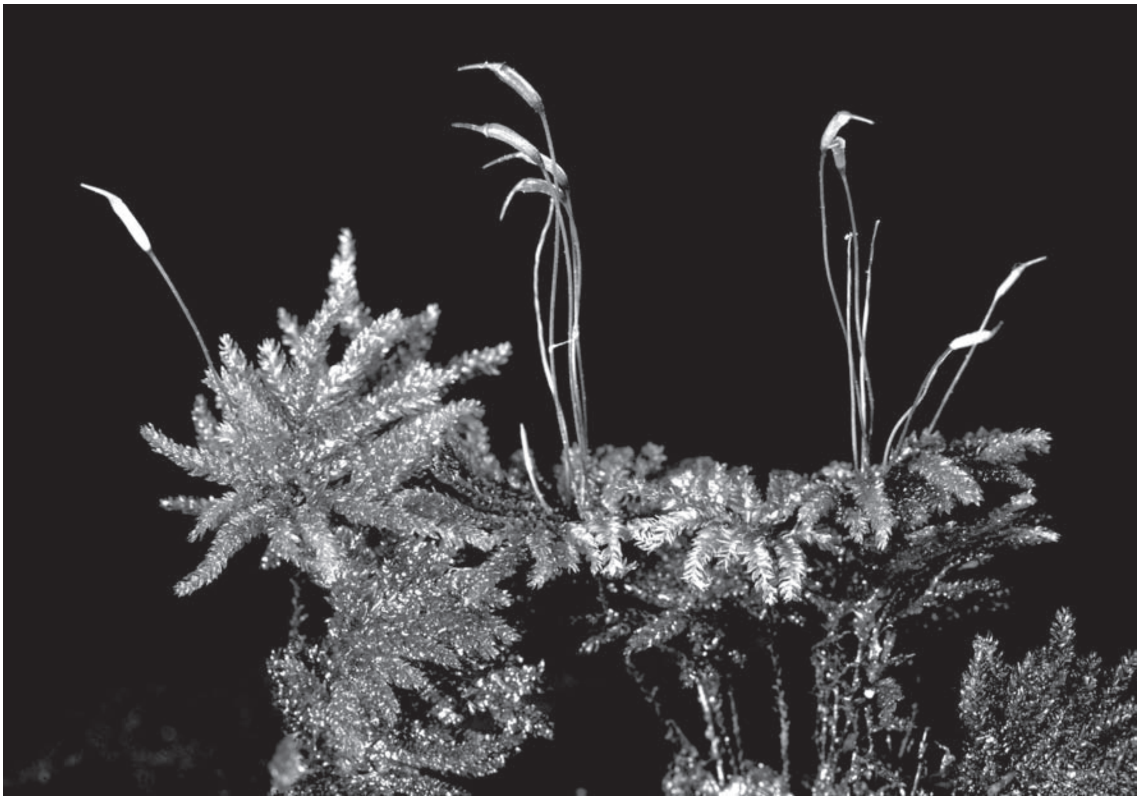

Fig. 4. Capsules of the dendroid moss, *Hypnodendron vitiense* subsp. *australe* are held on long setae above the branches. *Hypnodendron* is abundant on wet rock in and along creek beds in closed forest.

Fig. 5. *Papillaria* spp. festoon the branches of trees and shrubs along the edges of closed forest beside the Mount Wilson to Mount Irvine Road.

Cyathophorum bulbosum has long, unbranched stems, up to 10 cm long and can easily be mistaken for a fern.

In deep slot canyons, liverworts dominate the bryoflora, including thallose *Aneura alterniloba, Riccardia* spp., *Pallavicinia* spp. and *Symphyogyna* spp. and leafy liverworts, such as *Kurzia* spp., *Lepidozia* spp. and *Zoopsis* spp.

The upper branches of the rainforest canopy are also utilised by many bryophytes; these have different requirements from those of the forest floor. Gradients of light and humidity determine the number and type of species present in rainforests. Approaching the forest crown, humidity decreases and temperature and light levels increase (Ramsay, Streimann & Harden 1987) and a different assemblage of bryophytes survives these relatively harsh conditions, including *Macromitrium* spp., *Leptostomum* spp. and some Pottiaceae (e.g. *Tortula pagorum, Tortula papillosa* and *Calyptopogon mnioides)*.

In the forests and closed forests of the valley sides, mosses such as *Dicranoloma billarderi, Leucobryum candidum, Rhaphidorrhynchium amoenum* and *Sclerodontium pallidum* dominate the upper levels, while liverworts, such as *Balantiopsis diplophylla, Bazzania involuta* and*Symphyogyna podophylla* are more conspicuous at lower levels.

Few bryophyte species grow in the harsh conditions on the sandstone plateaus and ridges. The sandy soils and sandstone rock are both nutrient poor and freely draining, retaining little moisture. In *Eucalyptus* woodland, bryophytes are exposed to high light intensity, extremes of temperature, desiccation from drying winds, and bushfires. Most species survive in niches e.g. under logs, or where rocks provide protection from direct sunlight and wind. Shallow depressions on flat sheets of sandstone often hold water and decomposing leaf litter. Roadside and trackside banks and gutters provide shade and moisture.

The bryophytes that do occur on the plateau and ridge tops often occur abundantly and cover large areas of rock and sandy soil, e.g. the mosses *Campylopus clavatus, Campylopus flindersii, Campylopus introflexus* and *Campylopus pyriformis* and liverwort *Chiloscyphus semiteres* (Figure 7). *Cephaloziella exiliflora* can often be found in charcoal on burnt logs. *Rhacocarpus purpurascens, Breutelia* spp. and *Riccardia* spp. can be abundant in seepage areas, such as roadside and trackside drains, or on sandstone cliffs, often associated with ferns and epacrids (Figure 8). Surprisingly, the presence of few bryophyte species on sandstone ridges and plateaus is usually an indication of an undisturbed natural environment. Disturbed areas are likely to have a much greater diversity of bryophytes, including many introduced or cosmopolitan species.

The changes in bryophyte distribution from plateau to canyon have been well documented by Selkirk, Adamson & Downing (2001) (Table 2, Figure 6).

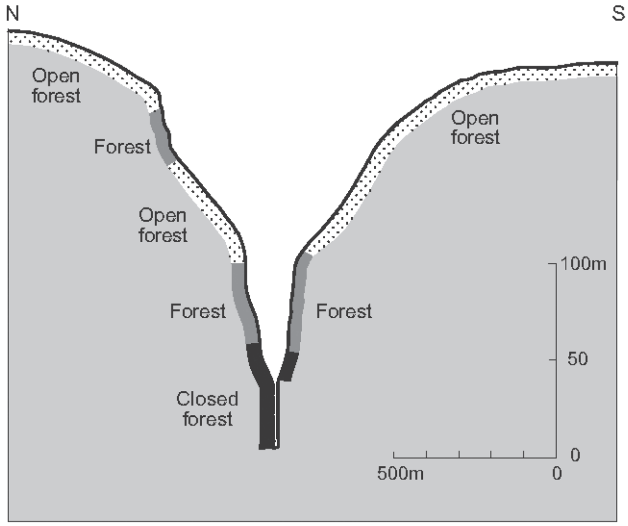

Fig. 6. Section across Greaves Creek, Blackheath, showing vegetation on plateau surface and valley sides. (modified after Selkirk, Adamson & Downing 2001).

Basalt caps

Most of the bryophytes that grow in closed forests in shale and sandstone gullies also occur on the basalt caps, where the combination of high rainfall, nutrient rich soils and abundant soil moisture support tall forests of *Eucalyptus fastigata* on the tops of basalt outcrops, and rainforest trees such as *Doryphora sassafras, Ceratopetalum apetalum, Acacia melanoxylon* and *Acmena smithii* on south and east-facing slopes. The establishment of gardens and small farms at Mount Tomah, Mount Wilson and Mount Irvine, has also influenced the bryophyte assemblages. Epiphytic mosses and liverworts are abundant, both on the trunks of exotic trees, such as *Aesculus* sp. (chestnut) and *Platanus* sp. (London Plane), and on native rainforest trees.

Granodiorites of Kanangra/Boyd

At Boyd River Crossing on the Jenolan Caves to Kanangra Walls Road, bryophytes are abundant on broad, open areas of granodiorite fringed with low heath which in turn is bordered by low *Eucalyptus* woodland. *Sphagnum cristatum* is plentiful along creek banks, *Conostomum pusillum*, *Racomitrium crispulum, Racomitrium pruinosum* and *Rhacocarpus purpurascens* form dense mats on the flat rock exposures. *Grimmia* spp. grow on small rocks. Large boulders scattered throughout the woodland are covered in dense mats of *Eucamptodon muelleri, Hedwigia ciliata, Hedwigidium integrifolium, Hypnum cupressiforme* and *Sclerodontium pallidum. Polytrichastrum alpinum, Polytrichum commune* and *Polytrichum juniperinum* are common in deep roadside soil. This is the highest area (> 1100 m a.s.l.) in this study and there is a clearly defined alpine element to the local species, with 21 of the 32 species of mosses recorded at Kanangra-Boyd listed as occurring in alpine areas (Ramsay *et al*. 1986).

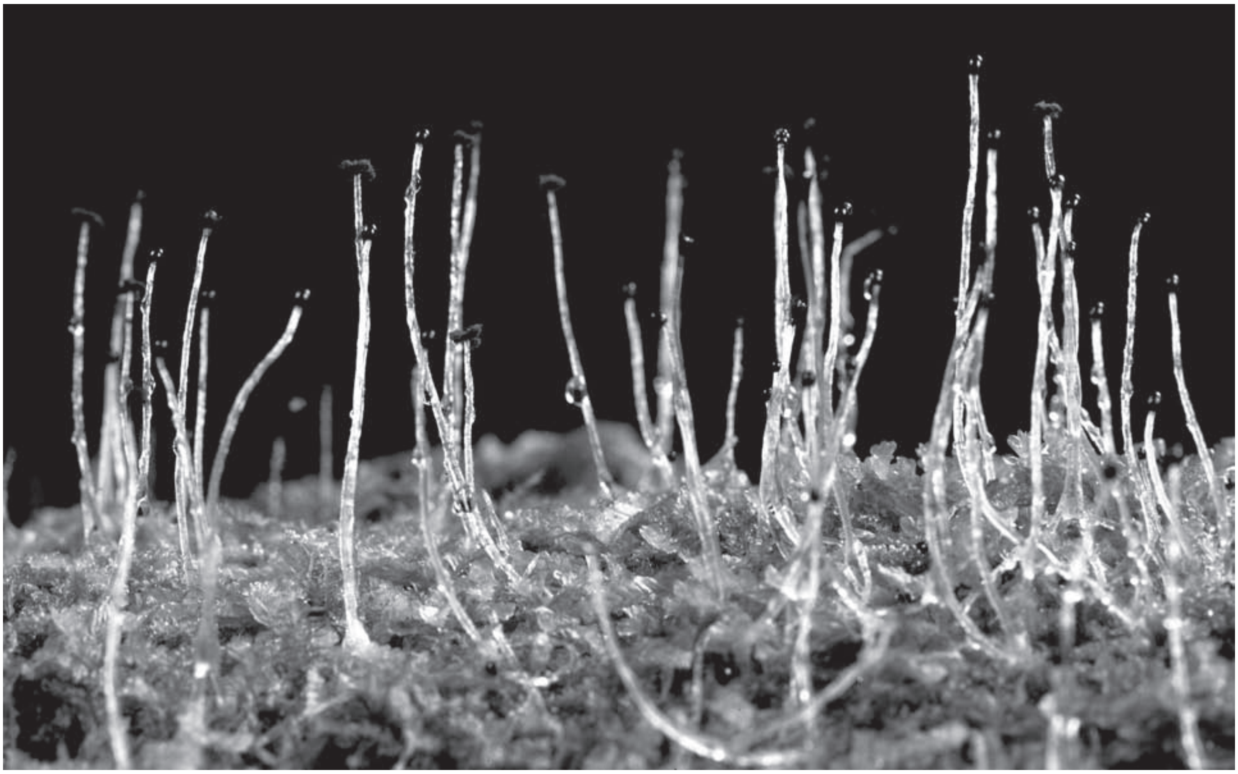

Fig. 7. *Chiloscyphus semiteres* can cover large areas of soil, rock and fallen logs. The delicate, translucent setae hold the black capsules above the leaves. Some have opened to release the spores. This is probably the most commonly occurring leafy liverwort in the Blue Mountains.

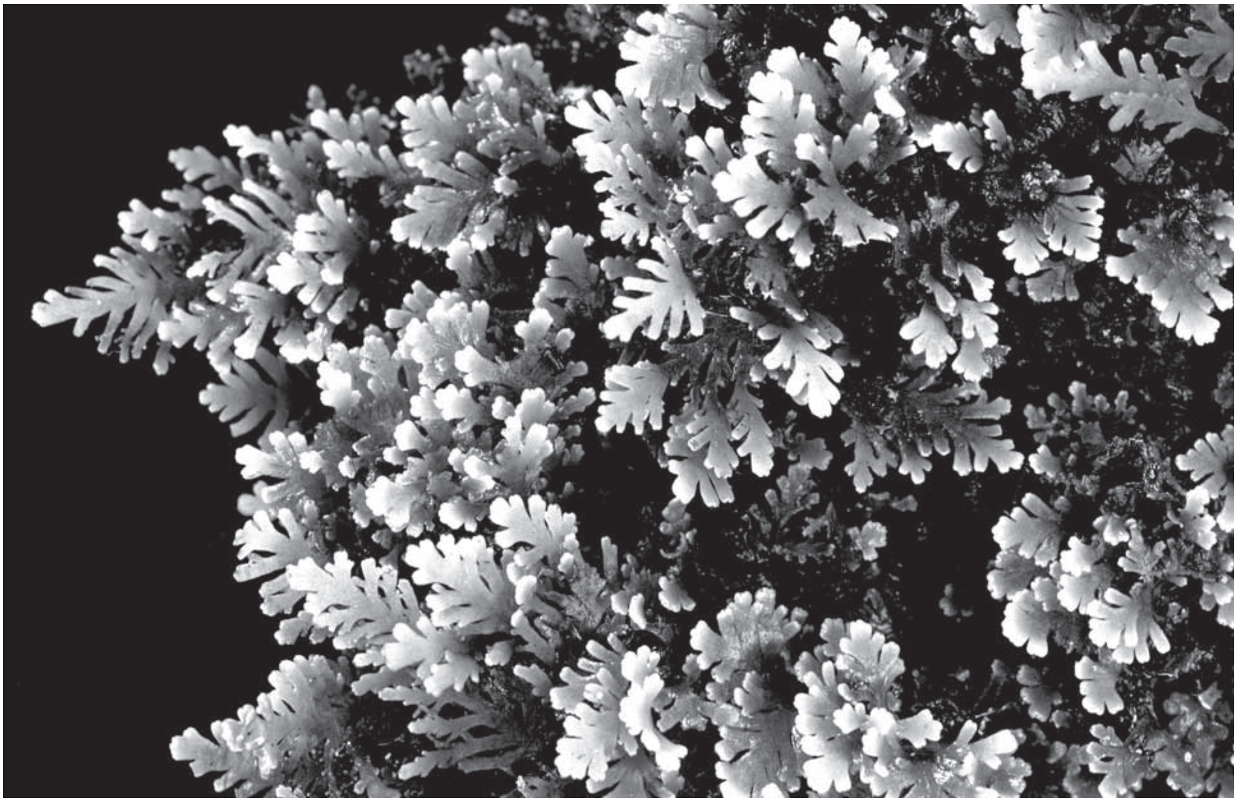

Fig. 8. The thallose liverwort *Riccardia crassa* is common along creeks, in roadside and trackside drains.

Colong limestones

At Colong, Silurian limestone lenses are dispersed through the slate and quartzite of the southern end of Kanangra-Boyd National Park. The bryophyte assemblage at Colong is typical of those found on other south-eastern Australian limestone deposits (Downing 1992).

Bryophytes and fire

Adam (1994) considered that refugia suitable for vascular rainforest plant species were characterised by the presence of water and protection from fire. In the Blue Mountains, sites with these characteristics also protect many species of bryophytes found in closed forest, such as *Achrophyllum dentatum, Dicranoloma* spp., *Hymenophyton flabellatum, Hypnodendron vitiense* subsp. *australe, Hypopterygium tamarisci, Isotachis intortifolia, Pyrrhobryum* spp. and *Riccardia* spp. Some species, such as [c]*Funaria hygrometrica,* [c]*Ceratodon purpureus* and [c]*Polytrichum juniperinum* are known to rapidly colonise newly burnt areas in mixed forest in southern Tasmania (Duncan & Dalton 1982) and we have observed similar colonisation in *Eucalyptus* forests and woodlands in the Blue Mountains.

Frequently recorded bryophyte species

- The moss *Sclerodontium pallidum* occurred at every location in this study, growing in abundance on sandstone outcrops and boulders usually on hillsides.
- There were more records of *Wijkia extenuata* than any other rainforest moss, possibly because of its extreme variability.
- Many rainforest bryophytes are large and conspicuous, and these may be important factors in explaining their abundance in collections. They include the dendroid (tree-like) mosses *Hypnodendron vitiense* subsp. *australe*, *Hypopterygium tamarisci* and *Lopidium concinnum,* pendulous mosses, such as *apillaria* spp., and the milky green cushions and stems of *Leucobryum candidum* (Figure 4).
- Some mosses that thrive in disturbed areas such as roadside and trackside banks, are surprisingly common and occur at many locations. They include *Barbula calycina,* [c]*Ceratodon purpureus, Ditrichum difficile,* [c]*Polytrichum juniperinum, Rosulabryum billarderi* and [c]*Weissia controversa.*
- *Telaranea elegans* (formerly *Telaranea centipes*) was collected at more locations than any other liverwort species, closely followed by *Balantiopsis diplophylla* and *Kurzia hippuroides*. All three are attractive and conspicuous.
- *Chiloscyphus semiteres* is probably the most commonly occurring liverwort on sandstone and shale of plateaus and ridges. It is easy to identify, but is not particularly appealing and is likely to have been overlooked by collectors (Figure 7).
- Hornwort species are neither numerous nor abundant in the Blue Mountains.

Alpine zone mosses in the Blue Mountains

There are a number of mosses in the Blue Mountains (44 taxa) that are also listed by Ramsay *et al*. (1986) as occurring in alpine areas above 1800 m a.s.l. For example *Andreaea subulata* and *Andreaea mutabilis, Bartramia ithyphylla, Blindia robusta, Conostomum pusillum, Polytrichastrum alpinum, Racomitrium crispulum* and *Racomitrium pruinosum* commonly occur at high altitude in Kosciuszko National Park. In the Blue Mountains these species grow on higher parts of the plateau, including Wentworth Falls, Katoomba, Blackheath and at Boyd River Crossing in Kanangra-Boyd National Park (Figure 9). Surprisingly, in addition to growing on sandstones of the plateau top at Wentworth Falls and Katoomba, *Andreaea subulata* and *Andreaea mutabilis* can be found on sandstone boulders deep in the Greaves Creek valley just below Grand Canyon at Blackheath. Recently they have been found in a deep gully in the Grampians in north-western Victoria (D. Meagher, pers. comm.).

Arid zone mosses in the Blue Mountains

In the western areas of the Blue Mountains, in particular at Mount York (6 km west of Mount Victoria) and Blackheath, bryophyte assemblages on compacted soils of lookouts, public parks and gardens, often include species that are more usually associated with the microphytic soil crusts in more arid areas of Australia. These include Pottiaceae (e.g. *Aloina aloides* var. *ambigua, Barbula calycina, Barbula crinita, Didymodon torquatus, Triquetrella papillata* and *Weissia controversa*) and Bryaceae (for example *Bryum argenteum, Gemmabryum dichotomum, Gemmabryum eremaeum* and *Gemmabryum pachytheca*). Their presence at these sites in the Blue Mountains is a matter for conjecture. Propagules may have been carried by dust storms originating in the arid zone of far western New South Wales and deposited on the western fringes of the Blue Mountains. Stock movements may also have contributed to the spread of propagules. From the time William Cox and his convicts completed the first road over the Blue Mountains in 1815, until the completion of the railway line in 1869 to Bowenfels just west of Lithgow, the road from Hampton to Mount Victoria and Blackheath was the route by which sheep and cattle were moved from the western plains to the Sydney markets (Low 1988).

Calciphile bryophytes in the Blue Mountains

Very distinct assemblages of bryophytes grow on calcareous soils throughout the world, and in south-eastern Australia, more bryophyte species are found on calcareous substrates than on non-calcareous substrates. The assemblage is always dominated by mosses from the Pottiaceae and Bryaceae, and by thallose liverworts from the Marchantiales (Downing 1992).

The limestones at Colong Caves include calciphile mosses *Gymnostomum calcareum, Trichostomum eckelianum* and *Triquetrella papillata* (Pottiaceae), *Rosulabryum torquescens* (Bryaceae), *Fissidens leptocladus, Plagiomnium novae-zealandiae* and *Pseudoleskeopsis imbricata*, and thallose liverworts *Plagiochasma rupestre, Reboulia hemisphaerica* and **Lunularia cruciata*. Three hornworts, *Anthoceros punctatus, Megaceros gracilis* and *Phaeoceros* cf. *carolinianus* have also been recorded at Colong.

In addition to naturally-occurring limestone areas, many walls, arches and shelter sheds in the Blue Mountains have been built from sandstone and cemented with lime mortar, a perfect substrate for calciphiles. At Blackheath, *Bryoerythrophyllum binnsii* (Pottiaceae) grows on compacted soil near low concrete drains along the path through natural bushland to Govetts Leap. Similarly, *Aloina aloides* var. *ambigua* (Pottiaceae) grows on mortar of an old stone fire place in Megalong Valley, on the southern side of Blackheath. At Mount York Lookout and Mitchells Lookout, west of Mount Victoria, and at the Three Sisters at Katoomba, stone walls in parking areas have an abundance of mosses from the Pottiaceae, including *Barbula crinita, Tortula muralis, Tortula antarctica, Triquetrella papillata* and *Weissia controversa*. *Grimmia pulvinata* is also common and abundant on these walls. Compacted soil close to these structures supports populations of Bryaceae, including *Bryum argenteum, Bryum lanatum, Gemmabryum dichotomum, Gemmabryum pachytheca* and *Rosulabryum torquescens*. *Pseudoleskeopsis imbricata* is occasionally found on mortar or cement.

Urban development in the Blue Mountains– cosmopolitan and introduced species

Urban development in the Blue Mountains rapidly followed the construction of the railway in 1869. The new towns extensively changed the local environment. Non-native species of bryophytes have been introduced and some native species have become particularly abundant.

The small but very conspicuous silver cosmopolitan moss [c]*Bryum argenteum* and the thallose liverwort **Lunularia cruciata* thrive in areas of high nitrogen, which may originate from garden fertilizer, animal faeces or sewage. [c]*Bryum argenteum* also grows in dense cushions in crevices in bitumen or concrete paths. [c]*Bryum argenteum* and *Gemmabryum dichotomum* were collected from dumped concrete rubble at Mount Banks.

The mosses [c]*Funaria hygrometrica, Gemmabryum dichotomum, Racopilum cuspidigerum* var. *convolutaceum* and *Rosulabryum billarderi* together with liverworts *Marchantia berteroana* and **Marchantia polymorpha* var. *aquatica* are common glasshouse 'weeds' and are often transplanted into gardens with their accompanying plants. Yellowish-orange wefts of the moss *Thuidiopsis sparsa* are common on concrete gutters and drains. *Barbula calycina* and [c]*Weissia controversa,* both native species, thrive in compacted roadside soil.

Fig. 9. Alpine bryophytes including *Andreaea subulata*, *Andreaea mutabilis*, *Blindia robusta* and *Polytrichastrum formosum* are part of the vegetation near Darwins Walk, along Jamison Creek from nearby Wentworth Falls Railway Station to the top of Wentworth Falls, shown here.

Table 5. Blue Mountains locations with greatest and least bryophyte species richness

Locations with greatest species richness

	Mosses	Liverworts	Total taxa
Blackheath	131	66	197
Mount Wilson	120	46	166
Wentworth Falls	104	43	147
Lawson	95	49	144

Locations with least species richness

	Mosses	Liverworts	Total taxa
Glenbrook	14	1	15
Kurrajong	28	6	32
Kanangra-Boyd	32	1	33
Springwood	29	9	38

Most of the northern hemisphere trees, such as chestnuts, plane trees, poplars and willows, planted in urban areas of the Blue Mountains, do not shed their bark and their trunks and branches are frequently colonised by many of the epiphytic rainforest bryophytes.

The introduced mosses **Pseudoscleropodium purum,* **Barbula unguiculata,* **Brachythecium albicans* and the introduced thallose liverwort **Lunularia cruciata* occur commonly in parks, home gardens and adjoining bushland. **Barbula unguiculata* grows in abundance on dumped bitumen and soil at Mount Bell on Bells Line of Road; **Pseudoscleropodium purum* and **Brachythecium albicans* grow through lawns in many Blackheath gardens.

Some bryophytes native to the Blue Mountains now grow as ‘weeds’ elsewhere in the world. These include *Campylopus introflexus, Chiloscyphus semiteres, Heteroscyphus fissistipus, Orthodontium lineare, Achrophyllum dentatum* and *Hypopterygium tamarisci*. *Achrophyllum dentatum* and *Hypopterygium tamarisci* are believed to have been imported into Europe on living tree ferns, shipped from Australia for the horticultural industry (Rumsey 2001, Stech & Pfeiffer 2006).

Locations with most taxa: Blackheath, Wentworth Falls, Lawson, Mount Wilson

Blackheath has one of the most extraordinary assemblages of bryophytes of any location in the Blue Mountains. It is located in the higher, western region of the Blue Mountains where rainfall is correspondingly high. The habitats are extremely diverse and include low hills and shallow valleys on the

Fig 10. At Bridal Veil Falls, Blackheath, bryophytes, ferns and epacrids are abundant on the cliff face where moisture seeps from horizontal shale bands sandwiched between layers of sandstone.

Fig. 11. In closed forest in Megalong Valley, bryophytes are conspicuous on soil, rocks and fallen logs along the creek bank.

plateau tops, steep ridges, sheer cliffs, deep gullies, narrow canyons and massive, wide and deep valleys, including the Grose to the north and the Kanimbla and Jamison Valleys to the south. Access by road and rail is easy and there are many walking tracks that allow access to the valleys (Figure 10).

The bryoflora of the sandstone plateaus includes native species of undisturbed areas, and many species, some native, many introduced, associated with urban and peri-urban sites e.g. epiphytic bryophytes are abundant on many northern hemisphere trees in parks and gardens. There is a great variety of mosses and liverworts in the closed forests of the deep gullies and canyons that dissect the plateau.

Five *Sphagnum* species, *Sphagnum australe, Sphagnum cristatum, Sphagnum falcatulum, Sphagnum novo-zelandicum* and *Sphagnum perichaetiale,* grow in swamp and seepage areas in hanging valleys on the plateau above the Grose River. The occurrence of five *Sphagnum* species in one area is very rare in New South Wales. Three species of *Andreaea* grow on sandstone boulders deep in gullies and canyons, an unusual location given that the genus normally occurs on granite boulders in alpine areas (Buck, Vitt & Malcolm 2002).

Megalong Valley, south-east of Blackheath, has 25 moss taxa that do not occur at Blackheath, including the very conspicuous mosses *Atrichum androgynum, Cyathophorum bulbosum, Glyphothecium sciurioides, Hypopterygium didictyon, Mesochaete undulata, Neckera pennata* and *Thamnobryum pumilum* (Figure 13). These very conspicuous species are absent from other gullies and canyons at Blackheath. Megalong Valley is lower in altitude and drier than Blackheath, and is the only location in this study on marine mudstones of the Permian Berry Formation (Figure 11).

Wentworth Falls also has a remarkable bryophyte assemblage. Again, it is in the higher, western section of the Blue Mountains where rainfall is high, access is easy and there is a great range of habitats including many small streams at the top of the plateau and the wet, weeping walls that fringe the sheer cliffs. Alpine taxa found here include *Andreaea mutabilis* and *Andreaea subulata*, *Polytrichastrum alpinum* and *Polytrichastrum formosum,* and *Blindia robusta*. Of 104 moss taxa recorded from Wentworth Falls, 23 are listed as alpine species (Ramsay *et al*. 1986).

Mount Wilson is another high point with high rainfall. It is easily accessible by road and has a great diversity of habitats with heath and woodland on sandstone plateaus and ridges, open and closed forest on basalt tops, closed forest in gullies that dissect sandstone ridges, sheer sandstone cliffs, and deep canyons, including the deep valleys and canyons of the Wollangambe River to the north and Bowens Creek to the south.

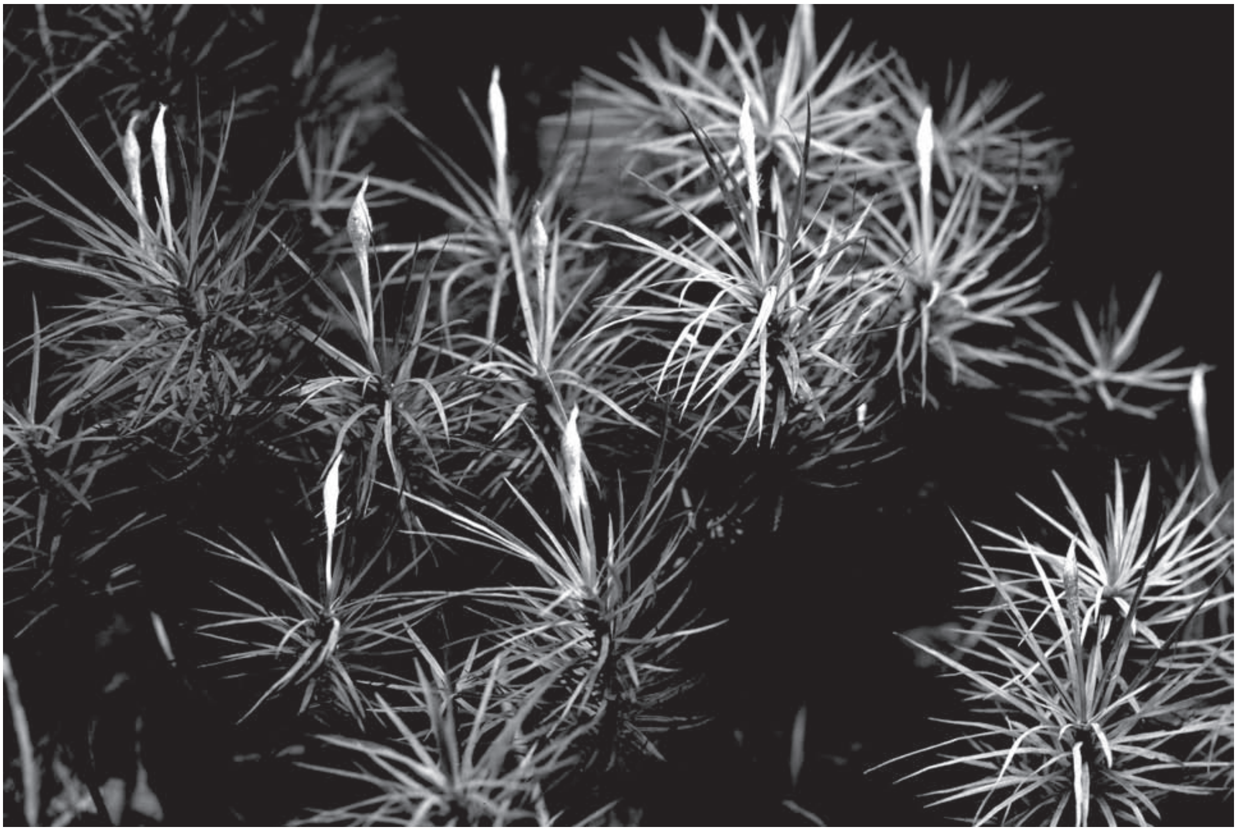

Fig. 12. *Dawsonia superba* var. *pulchra* is common on nutrient rich soils in closed forests. It is a very striking moss with tall, bluish-green stems and red calyptras protecting the young capsules.

Fig. 13. *Mesochaete undulata* from the closed forest of Megalong Valley is a large, spectacular moss that can be mistaken for a filmy fern.

Bryophytes are abundant in deep shade of closed forests, and include dendroid bryophytes, such as the moss *Hypnodendron vitiense* subsp. *australe* and the liverwort *Hymenophyton flabellatum*, the liverwort-like moss *Achrophyllum dentatum* and thallose liverworts such as *Podomitrium phyllanthus, Pallavicinia* spp. and *Symphyogyna* spp. The road from Mount Wilson to Mount Irvine is cut through closed forest providing an 'edge' that is open to the light, thus supporting an assemblage of bryophytes that normally grow on the margins of closed forests such as the epiphytes *Macrocoma tenuis, Macromitrium* spp., *Papillaria* spp. and *Frullania* spp. Epiphytes are abundant on ornamental street trees. Bryophyte taxa that are uncommon in the Blue Mountains, including *Asterella drummondii, Plagiochasma rupestre, Reboulia hemisphaerica* and *Solenostoma inundatum* grow on basalt-derived soils on steep, roadside banks. The thallose liverwort **Lunularia cruciata* occurs here with capsules, rare in the Blue Mountains. Colonising species such as *Dawsonia superba* var. *pulchra, Pogonatum neesii* and *Pogonatum subulatum* are common on landslips (Figure 12). Roadsides are commonly covered with *Rosulabryum billarderi* and [c]*Polytrichum juniperinum*. Mount Wilson is one of the few locations where hornworts are a conspicuous component of the bryoflora.

Lawson is lower in altitude than Blackheath, Wentworth Falls or Mount Wilson, and has a correspondingly lower rainfall. Although the gullies are not as deep or dramatic as those of the upper Blue Mountains, there is a big range of habitats with creeks, waterfalls and gullies associated with swamps, heath, woodland, open and closed forest, all within close walking distance of the railway station and main highway. Accessibility has probably been a major factor in the size of the collections from this area, with many well-developed walking tracks on both the northern and southern side of the railway station.

Conclusion

This study presents species lists of mosses, liverworts and hornworts recorded from, and provides information on their distribution within the Blue Mountains region of New South Wales. The species lists include collections from both bushland and urban areas. The locations with the most species are in the upper Blue Mountains, where diversity is likely to result from a combination of altitude, rainfall, range of topographic features and accessibility. The species lists include many records from areas, such as Wollemi National Park, Gardens of Stone National Park, Newnes Plateau and Kanangra-Boyd National Park that were not accessible to the early collectors of the late 19th and early 20th centuries. Future collecting in areas that at present are poorly represented, such as Glenbrook, Springwood, Wheeney Creek, Kanangra-Boyd National Park and the canyons fringing Newnes plateau should result in significantly increased species numbers for those areas.

Acknowledgements

Helen Ramsay has supported this project from the outset and her encouragement and interest have been invaluable. We are most appreciative of assistance from The National Herbarium of New South Wales, from Josephine Milne and Niels Klazenga from The National Herbarium of Victoria, Christine Cargill, Judith Curnow and Heino Lepp from The Australian National Herbarium in Canberra and Murray Henwood from The John Ray Herbarium at University of Sydney. We are indebted to participants in the 2001 Australasian Bryological Workshop in the Blue Mountains: Jan Allan, Karen Beckman, Jessica Beever, Graham Bell, Volker Buchbender, Christine Cargill, Kerri Clarke, Wil Cuddy, Judith Curnow, Paddy Dalton, Allan Fife, Aaron Floyed, Reijel Gardiner, Scott Gilmore, Helen Jolley, Niels Klazenga, Heino Lepp, Hannah McPherson, Josephine Milne, Perpetua Turner and Joy Williams. We thank New South Wales National Parks and Wildlife Service for permission to work in the various national parks of the Blue Mountains, Blue Mountains City Council for permission to work in council reserves and Macquarie University for providing laboratory facilities. Figures 1, 2 and 3 were prepared by Dean Oliver.

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Manuscript accepted 24 July 2007