

Mosses, Liverworts and Hornworts of Mount Canobolas, New South Wales

Alison Downing, Ron Oldfield and Eleanor Fairbairn-Wilson

Downing, Alison¹, Oldfield, Ron¹ and Fairbairn-Wilson, Eleanor² (¹Department of Biological Sciences, Macquarie University NSW 2109; ²Orange Agricultural Institute, Forest Road, Orange NSW 2800) 2002. Mosses, Liverworts and Hornworts of Mount Canobolas, New South Wales. *Cunninghamia* 7(3): 527–537.

A surprising number of endemic species of plants and animals are found within Mount Canobolas State Recreation Area (33°21' S, 148°59' E, 1395 m asl) 15 km SW of Orange in the Central West of New South Wales. During this survey of bryophytes on Mount Canobolas, 75 species, including 60 moss species, 13 liverwort species and two hornwort species were identified. Although no endemic bryophyte species were recorded, the assemblage included an unusual combination of alpine, arid zone and rainforest species. Areas of exposed rock on the upper flanks of the mountain are particularly species rich. The geology of the area is complex and the presence of certain species at particular locations is probably determined by the chemical composition of the substrate rock. *Polytrichastrum alpinum*, a rare species in New South Wales previously recorded only above 1500 metres in alpine areas of Kosciuszko National Park, was collected on Mount Canobolas at 1206 m asl. A number of uncommon species were recorded in Mount Canobolas State Recreation Area, including the mosses *Bryoerythrophyllum jamesonii*, *Leptodontium paradoxum*, *Hymenostomum microstomum* var. *brachycarpa*, *Orthotrichum assimile*, *Tortula anderssonii*, *Tortula rubella* and *Tortula ruralis*, the liverwort *Riccia crozalsii* and the hornwort *Anthoceros* cf. *punctatus*.

Introduction

Mosses, liverworts and hornworts together comprise the three Classes of the Division Bryophyta of the Plant Kingdom. They are often referred to as 'lower plants' and are regularly overlooked in biological surveys although they are usually an important component of the vegetation. This study documents the bryophytes that occur in the Mount Canobolas State Recreation Area in central-western New South Wales. Mount Canobolas is most unusual in the many endemic species of a wide range of organisms that are found in its vicinity. The unique *Xanthoparmelia* lichen flora of rocky outcrops has recently been listed as an Endangered Ecological Community under the New South Wales *Threatened Species Conservation Act 1995*.

Mount Canobolas is located approximately 15 km southwest of Orange in the Central West of New South Wales (Fig. 1). The summit is 1395 m asl, approximately 500 m higher than Orange and the surrounding area. The State Recreation Area has an area of 1673 hectares, incorporating much of the natural vegetation of the mountain. Rather than one mountain, the area comprises a complex of peaks made up of both volcanic and intrusive rocks. Volcanic activity occurred over about 700 000 years, from Middle

Miocene to Late Miocene. Numerous volcanic vents — Young Man Canobolas, Old Man Canobolas, The Pinnacle, Mount Towac and Johnsons Pinnacle — erupted at different times; Old Man Canobolas was the last to erupt and is the youngest volcanic vent of the complex. The lavas vary from trachytes to andesitic basalts to basalts; the intrusive rocks include porphyries and dolerites. There are also large quantities of agglomerate and tuff associated with the various lava flows (Branagan & Packham 2000).

Meteorological data is available from several local observatories, Orange (Post Office, 33°28' S, 149°10' E, 863 metres asl) has warm to hot summers and cold winters. The mean annual rainfall is 878 mm, distributed relatively evenly throughout the year, but with slightly higher recordings during the cooler months. The temperature recordings for Mount Canobolas State Forest (33°39' S, 149°02' E, 987 metres asl), are cooler year round than those of Orange, and the rainfall (1097.5 mm per annum) is higher than that of Orange. Since Mount Canobolas is higher than the surrounding countryside, the summit is likely to have temperatures significantly cooler than Orange, and rainfall significantly higher. Snow is not uncommon on Mount Canobolas in winter. (Bureau of Meteorology 2002).

Mount Canobolas is located near the western boundary of the Central Tablelands Botanical Division. The vascular flora has been well documented, for example by Kenna, Medd and Bower (1998) and includes a surprising number of species with affinities to the alpine flora of southern New South Wales, Victoria and Tasmania. Much of the summit of Mount Canobolas has been cleared and is now topped by communications installations, public car parks and lookouts. Naturally occurring rock rubble and rocky outcrops surround these constructions. Soil in the crevices in and between the rocks support grasses, herbs and low shrubs. The open area of the summit is adjoined by sub-alpine *Eucalyptus pauciflora* (Snow Gum) woodland with a dense cover of *Poa sieberiana* (Snow Grass). Further down the mountain there is a mixed *Eucalyptus* woodland, merging into tall *Eucalyptus* forest on the moist and sheltered eastern and southern flanks of the mountain. There are occasional broad expanses of rock, for example at Orange View Lookout and at the Walls Nature Trail, on which there are low heaths associated with rich lichen communities.

There is very little information available on the distribution of bryophytes in this western sector of the Central Tablelands Botanical Division. The closest area for which there is a comprehensive bryophyte collection is in the vicinity of the Abercrombie River, well to the south-east, made by Robert Coveny in 1995 and held by the National Herbarium of New South Wales. Eldridge & Tozer (1997) have contributed significantly to the knowledge of bryophytes from the drier areas of semi-arid western New South Wales, but their collections held at the National Herbarium of NSW do not include specimens from Mount Canobolas. Many of the species documented by Eldridge and Tozer in semi-arid western New South Wales also occur on Mount Canobolas. Downing (1993) collected bryophytes from numerous, small, isolated limestone outcrops between Wellington and Molong, and more recently in 2000 and 2001, collected bryophytes at Borenore Caves, west of Orange (Downing, unpublished records).

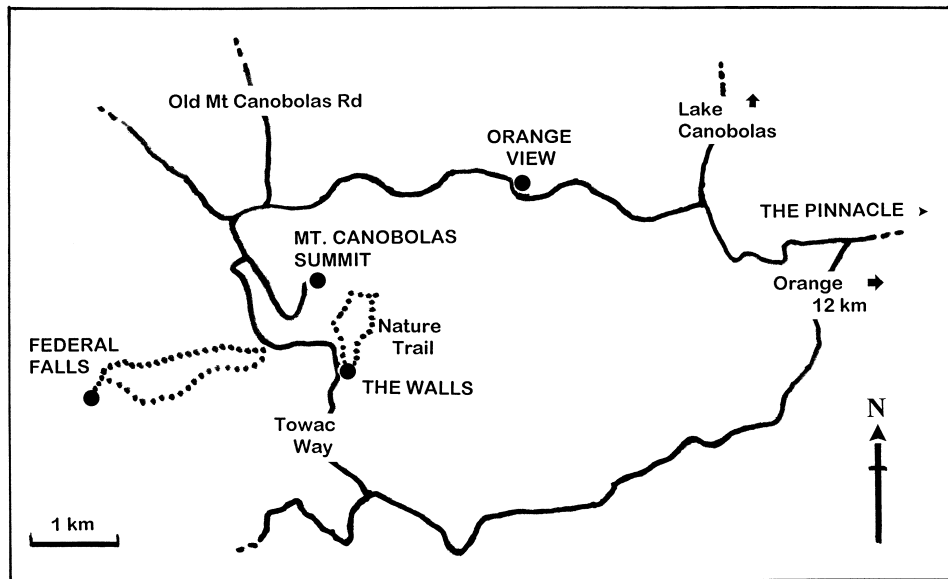


Fig. 1. Mt. Canobolas – bryophyte collecting sites.

Methods

In November 2001, mosses, liverworts and hornworts were collected from within the Mount Canobolas State Recreation Area, from sites reflecting differences in altitude, aspect, vegetation type and substrate. These collection sites included rocky outcrops, constructed car parks, stone walls and paths of the summit, *Eucalyptus* woodland and forest of the flanks of the mountain, and areas of low heath on exposed rock. Additional collections were made in the vicinity of The Pinnacle Lookout, an Orange City Council reserve close to the boundary of the State Recreation Area.

The collections were returned to the laboratory and identified using references, including Scott and Stone (1976), Beaver, Allison and Child (1992), Catcheside (1980) and Scott (1985). Authorities for species mentioned in the text for the most part follow the Index of Mosses Database (W³MOST) which is part of the TROPICOS data base of the Missouri Botanical Garden (2002) and are included in Table 1.

Judith Curnow from Australian National Botanic Gardens Herbarium in Canberra provided a list of species from Mount Canobolas from their records. These are marked # in Table 1. The Canberra collections of Heinar Streimann, August, 1979, came from two sites: *Eucalyptus* woodland (at 1390 m asl just below the summit) of Mount Canobolas and from Federal Falls, a moister area of *Eucalyptus* woodland at 910 m asl. Only one record from Mount Canobolas was found in the National Herbarium of NSW, *Bryum creberrimum*, collected in 1988 by Brooks & Pilgrim.

Vouchers for each species collected from Mount Canobolas have been lodged with the National Herbarium of NSW, Mrs Macquaries Road, Sydney, NSW 2000. Duplicates of unusual species have been lodged with Macquarie University Herbarium, Department of Biological Sciences, Macquarie University, North Ryde, NSW 2109.

Table 1 Bryophytes collected from the Mount Canobolas State Recreation Area

Summit = species collected above 1380 m asl. Walls = Walls Nature Trail, Towac includes a number of locations in the vicinity of the junction of the Towac Road with the Summit Road, Pinnacle = The Pinnacle, an isolated knoll east of the State Recreation Area, OrangeV = Orange View Lookout, Old Rd = Old Mount Canobolas Road, Fed Falls = Federal Falls.

= Records of Australian National Herbarium, Canberra.

MOSSES	Summit	Walls	Towac	Pinnacle	OrangeV	Old Rd	Fed Falls
Bartramiaceae							
<i>Bartramia hampeana</i> Müll. Hal.	*		*				
<i>Bartramia ithyphylla</i> Brid.	#						
<i>Breutelia affinis</i> (Hook.) Mitt.	*	*	*	*	*	*	
<i>Philonotis scabrifolia</i> (Hook.f. & Wilson) Braithw.							#
<i>Philonotis tenuis</i> (Taylor) Reichardt		*	*			*	
Brachytheciaceae							
<i>Brachythecium rutabulum</i> (Hedw.) Schimp.		*	*				
<i>Brachythecium paradoxum</i> (Hook.f. & Wilson) Jaeger			*	*			
Bryaceae							
<i>Bryum apiculatum</i> Schwaegr.	#						
<i>Bryum argenteum</i> Hedw.	*,#				*	*	
<i>Bryum caespiticium</i> Hedw.	*						
<i>Bryum campylothecium</i> (Taylor) J.R.Spence		*					
<i>Bryum creberrimum</i> Taylor		*			*		
<i>Bryum dichotomum</i> Hedw.			*		*	*	
<i>Bryum radiculosum</i> Brid.	#						
<i>Rosulabryum billarderi</i> (Schwaegr.) J.R.Spence	*						#
<i>Rosulabryum torquescens</i> (Bruch ex De Not) J.R.Spence	*						
Dicranaceae							
<i>Campylopus australis</i> Catches. & J.P.Frahm	#						
<i>Campylopus introflexus</i> (Hedw.) Brid.		*			*	*	

MOSSES	Summit	Walls	Towac	Pinnacle	OrangeV	Old Rd	Fed Falls
Ditrichaceae							
<i>Ceratodon purpureus</i> (Hedw.) Brid.	*			*	*	*	
<i>Ditrichum difficile</i> (Duby) M.Fleisch.		*		*			
<i>Eccremidium pulchellum</i> (Hook.f. & Wilson) Müll. Hal.					*		
<i>Pleuridium nervosum</i> (Hook.) Mitt.		*	*				
Encalyptaceae							
<i>Encalypta vulgaris</i> Hedw.						*	
Fabroniaceae							
<i>Fabronia australis</i> Hook.	#						
Fissidentaceae							
<i>Fissidens asplenioides</i> Hedw.	#	*					#
<i>Fissidens leptocladus</i> Müll. Hal. ex Rodway				*			
<i>Fissidens megalotis</i> (Hook. & Wilson) Stone					*		
<i>Fissidens pungens</i> Hampe & Müll. Hal.							#
<i>Fissidens taylorii</i> Müll. Hal.		*	*			*	#
Funariaceae							
<i>Entosthodon muhlenbergii</i> (Turner) Fife			*				
<i>Entosthodon subnudus</i> (Taylor) Fife var. <i>gracilis</i>		*					
<i>Funaria apophysata</i> (Taylor) Broth.			*				
Grimmiaceae							
<i>Grimmia laevigata</i> (Brid.) Brid.						*	
<i>Grimmia longirostris</i> Hook.			*				
<i>Grimmia pulvinata</i> (Hedw.) Sm.	*,#				*		
<i>Grimmia trichophylla</i> Grev.	#	*		*			
<i>Schistidium apocarpum</i> (Hedw.) Bruch & Schimp.	*		*		*	*	
Hedwigiaceae							
<i>Hedwigidium integrifolium</i> (P.Beauv.) Dixon		*		*			

MOSSES	Summit	Walls	Towac	Pinnacle	OrangeV	Old Rd	Fed Falls
Hypnaceae							
<i>Hypnum cupressiforme</i> Hedw.		*		*	*		
Orthotrichaceae							
<i>Orthotrichum assimile</i> Muell. Hal.	#						
<i>Zygodon intermedius</i> Bruch & Schimp.	#						#
Polytrichaceae							
<i>Polytrichastrum alpinum</i> (Hedw.) G.L.Sm.		*					
<i>Polytrichum juniperinum</i> Hedw.	*	*		*	*	*	
Pottiaceae							
<i>Barbula calycina</i> Schwaegr.	*				*		
<i>Barbula crinita</i> Schultz	*				*		
<i>Bryoerythrophyllum jamesonii</i> (Taylor) H.A.Crum			*				
<i>Didymodon subtorquatus</i> (Müll. Hal. & Hampe) Catches.			*				
<i>Hymenostomum microstomum</i> (Hedw.) R.Br. var. <i>brachycarpa</i>			*				
<i>Leptodontium paradoxum</i> I.G. Stone & G.A.M. Scott		*				*	
<i>Tortula anderssonii</i> Ångström	#						
<i>Tortula antarctica</i> (Hampe) Wilson	*	*			*	*	
<i>Tortula muralis</i> Hedw.	*		*				
<i>Tortula pagorum</i> (Milde) De Not.	*				*		
<i>Tortula papillosa</i> Wilson ex Spruce	*						
<i>Tortula rubella</i> Hook. & Wilson	#						
<i>Tortula ruralis</i> (Hedw.) P. Gaertn, B. Mey & Scherb.	#						
<i>Triquetrella papillata</i> (Hook.f. & Wilson) Broth.	*	*		*		*	
Racopilaceae							
<i>Racopilum cuspidigerum</i> (Schwaegr.) Ångström			*				#

MOSSES	Summit	Walls	Towac	Pinnacle	OrangeV	Old Rd	Fed Falls
Splachnaceae							
<i>Tayloria octoblepharum</i> (Hook.) Mitt.		*					
Thuidiaceae							
<i>Thuidium sparsum</i> (Hook.f. & Wilson) Jaeger	*						
LIVERWORTS							
Aytoniaceae							
<i>Asterella drummondii</i> (Hook.f. & Taylor) R.M.Schust.		*	*		*		
Cephaloziellaceae							
<i>Cephaloziella exiliflora</i> (Taylor) R.M.Schust.		*					
<i>Cephaloziella arctica</i> Bryhn & Douin subsp. <i>subantarctica</i>					*		
Codoniaceae							
<i>Fossombronia</i> sp.			*				
Frullaniaceae							
<i>Frullania pentapleura</i> Taylor	#						#
<i>Frullania wildii</i> Stephani	#						
<i>Frullania probosciphora</i> Taylor				*			
Geocalyceae							
<i>Chiloscyphus fissistipus</i> (Hook.f. & Taylor) Taylor ex Gottsche et al.				*			
<i>Chiloscyphus semiteres</i> (Lehm.) Lehm. & Lindenb.		*		*	*		
Metzgeriaceae							
<i>Metzgeria decipiens</i> (C.Massal.) Schiffner		*					
<i>Metzgeria furcata</i> (L.) Dumort.							#
Ricciaceae							
<i>Riccia crozalsii</i> Levier					*		
<i>Riccia rorida</i> Na –Thalang		*					
HORNWORTS							
Anthocerotaceae							
<i>Anthoceros</i> cf. <i>punctatus</i> L.			*	*			
<i>Phaeoceros laevis</i> L.			*				

Results and Discussion

Seventy-five bryophyte species were recorded from Mount Canobolas, including 60 species of moss from 18 families, 13 species of liverworts from seven families, and two species of hornworts from one family (Table 1). New records for the Central Tablelands Botanical Division of NSW are: the mosses, *Polytrichastrum alpinum*, *Eccremidium pulchellum*, *Hymenostomum microstomum* var. *brachycarpa*, *Leptodontium paradoxum*, *Orthotrichum assimile*, *Tortula anderssonii*, *Tortula rubella* and *Tortula ruralis*, the liverwort *Riccia crozalsii* and the hornwort *Anthoceros* cf. *punctatus*.

It would be helpful to compare the bryophyte species richness at Mount Canobolas with surrounding areas, but the lack of collections from the western slopes of the Great Dividing Range casts doubt on the validity of such comparisons. Many of the bryophytes that grow on Mount Canobolas are also found in the Blue Mountains and the hills of the Great Dividing Range to the east. Coveny collected 53 bryophytes (39 mosses and 14 liverworts) along the Abercrombie River; of these, 28 mosses and five liverworts, were also recorded on Mount Canobolas. However, just a few kilometres further west of Mount Canobolas in the Central Western Slopes Botanical Division, there are significantly fewer bryophyte species.

A particularly unusual aspect of the distribution of mosses, liverworts and hornworts on Mount Canobolas has been the difficulty in assigning species to particular habitats. On the sandstones of the Sydney area and the Blue Mountains, it is relatively easy to predict where certain species will occur. Some species occur only on the ridge tops, others on the valley sides, and yet others occur only in the shelter of closed forest in gullies. However, on Mount Canobolas it was almost impossible to predict occurrences and we have had to review our findings carefully. It seems probable that distribution of many species is very closely related to the chemical composition of the substrate rock — rather than to altitude, aspect, or vegetation type. The geology of the area is quite complex, and it appears likely that bryophyte distribution can be correlated with the considerable acidic/basic variability of the underlying rock. For example, a small, rocky outcrop in *Eucalyptus* woodland on the Old Mount Canobolas Road yielded an unusual combination of two species, *Encalypta vulgaris*, a calcicole (i.e. a species found only on calcareous substrates), and *Campylopus introflexus*, a calcifuge (i.e. a species never found growing on calcareous substrates). The occurrence of these two species growing in such close proximity suggested that species distribution could be more closely correlated with the chemical nature of the substrate rock rather than with any other factor.

Bryophytes on rock exposures

Mosses and liverworts are most conspicuous in areas of bare rock or soil, in particular the rocky areas of the summit, and in the heath/lichen communities on broad rock exposures. Thirty species of mosses and two liverworts were collected on or just below the Mount Canobolas summit. Here they grow in abundance on rock and on soil, both in the developed areas of roads, walking tracks, car parks and buildings, and also in the adjoining open areas of naturally occurring rock rubble and bare rock.

Ramsay et al. (1986) document *Grimmia laevigata*, *Grimmia pulvinata* and *Schistidium apocarpum* as alpine species in NSW, although all three are found elsewhere in Australia at much lower altitude. Mosses from the family Pottiaceae are abundant on and near the summit. Some rare finds include *Tortula anderssonii*, *Tortula ruralis* and *Tortula rubella*. *Tortula anderssonii* was until recently known in Australia only from Yarrangobilly Caves in the northern end of Kosciuszko National Park. *Tortula ruralis* and *Tortula rubella* are also not common and more usually collected at higher altitudes. *Orthotrichum assimile* and *Zygodon intermedius*, both from the family Orthotrichaceae, are also more usually collected at higher altitudes in southern NSW. Some more common species including *Barbula crinita*, *Tortula antarctica*, *Tortula pagorum*, *Tortula papillosa* and *Triquetrella papillata*, probably reflect the occasional aridity of the summit, as they are a common component of arid and semi-arid areas of southern Australia (Eldridge & Tozer 1997) They have anatomical characteristics that enable them to survive extreme desiccation resulting from high temperatures, lack of moisture, exposure to wind, and damage to photosynthetic tissue from high light intensities.

Another group of mosses, including *Bryum argenteum*, *Ceratodon purpureus*, *Polytrichum juniperinum* and *Tortula muralis* are cosmopolitan, with a worldwide distribution. Although they occur naturally in Australia, and are present elsewhere on Mount Canobolas in undisturbed areas of natural vegetation, their abundance at the summit appears to be associated with the construction of the roads, parking areas, stone walls and buildings.

The Walls Nature Trail is another very rich area; 20 species of moss and five species of liverwort were collected along the trail. Here species richness is probably related to the diversity of habitats — including both wet and dry heath/lichen communities on the exposed metamorphosed sandstone, wet, seeping, trackside banks at the junction of the heath and *Eucalyptus* woodland, and a cool, moist and shaded gully with terrestrial ferns. *Metzgeria decipiens*, a thallose epiphytic liverwort more usually associated with rainforest gullies of the coast and coastal ranges, was found along this gully. *Metzgeria furcata* from Federal Falls, is also more usually associated with rainforests.

The presence of *Polytrichastrum alpinum* on Mount Canobolas was unexpected. This species was collected at the start of the Walls Nature Trail (1206 m asl) growing through clumps of other mosses and lichens. It is recorded by Scott and Stone (1976 p. 68) as 'almost exclusively alpine in habitat ... a rare plant, growing on bare soil and in wet crevices mostly above about 5000 ft' (about 1500 metres). The National Herbarium of NSW holds two specimens of *Polytrichastrum alpinum* (as *Polytrichum alpinum* L. ex Hedw.) both collected in 1899 from Mount Kosciuszko.

On exposed rock, in microphytic soil crusts a few mm deep, tiny mosses such as *Pleuroidium nervosum* and the minute liverwort *Cephaloziella exiliflora* were collected. Also present are *Riccia rorida* and *Asterella drummondii*, thallose liverworts more usually associated with arid and semi-arid areas of southern Australia. *Breutelia affinis* is abundant on damp seepage areas over the rock, forming dense, golden banks.

Another area of particular interest is the heath community on exposed rock at the Orange View Lookout, on the north-eastern side of the mountain (1154 metres asl); 20 species were recorded, including 16 mosses and four liverworts. On seepage areas on the broad, rocky exposures, there is an abundant growth of *Breutelia affinis*, together with *Bryum creberrimum* and *Campylopus introflexus*.

Bryophytes in Eucalyptus woodland and forest

Where grasses grow as a dense ground cover in *Eucalyptus* woodland or forest, bryophytes are virtually non-existent. However, bryophytes do successfully colonise roadside banks, the margins of walking trails, rough basal bark of eucalypts, fallen logs and exposed rocks. The ubiquitous *Breutelia affinis* forms golden cushions along some sections of road. Both hornworts, *Anthoceros* cf. *punctatus* and *Phaeoceros laevis* were collected from a damp, roadside bank in *Eucalyptus* forest with a south-easterly aspect. Some unusual species are also present, including *Bryoerythrophyllum jamesonii*, *Didymodon subtorquatus* and *Hymenostomum microstomum* var. *brachycarpa*. *Bryoerythrophyllum jamesonii* (syn. *B. binnsii*) is a rare species, recorded by Scott and Stone (1976) from Tasmania and Victoria; however, a small population was recently reported from a volcanic outcrop at Mount Wilson in the Blue Mountains (Graham Bell, pers. comm.). *Leptodontium paradoxum* is not uncommon along the southern coast of Australia, from Western Australia through South Australia to Victoria, but there are no records at the National Herbarium of NSW of this species occurring in the Central Tablelands. *Hymenostomum microstomum* var. *brachycarpa* is listed by Catcheside (1980) as rare in South Australia and Victoria and this is the first record of its occurrence in NSW.

Bryophytes at The Pinnacle

The Pinnacle Lookout is not included within the Mount Canobolas State Recreation Area. However, the bryophyte flora is particularly interesting and includes a number of species either not recorded from, or not common in, the State Recreation Area. These are the liverworts *Frullania probosciphora* and *Chiloscyphus fissistipus*, and the moss *Fissidens leptocladus*. *Brachythecium paradoxum* is a bryophyte frequently found in alpine and sub-alpine environments; it is common and abundant on the rough bark at the base of snow gums in the sub-alpine *Eucalyptus pauciflora* woodlands of Kosciuszko National Park. *Chiloscyphus fissistipus* and *Frullania probosciphora* are both species more usually associated with moist, rainforest gullies of the coast and coastal ranges.

Conclusion

The bryoflora of Mount Canobolas is an unusual assemblage of moss, liverwort and hornwort species. The distribution of bryophytes is unpredictable and the presence of certain species at particular locations can probably be correlated with the chemical composition of the substrate rock. The bryoflora includes some species with alpine affinities, others more common in the arid or semi-arid areas of Australia, and some species more usually associated with rainforest environments. Areas of exposed rock, at the summit, in the vicinity of the Orange View Lookout, and at the beginning of the Walls Nature Trail, are particularly species rich. *Polytrichastrum alpinum*, collected at

1206 m asl on Mount Canobolas, is a rare species in New South Wales where it has previously only been recorded from alpine areas above 1500 metres. The bryoflora of The Pinnacle Reserve includes a number of species that do not commonly occur within the Mount Canobolas State Recreation Area.

Time constraints limited the number of locations that could be visited during the course of this survey, and further collections from the Federal and Hopetoun Falls could add significantly more species. Collections at other times of the year may well include other annual and/or ephemeral species.

The lack of bryophyte collections and the paucity of information available on bryophyte distribution in areas west of the Great Dividing Range has highlighted the urgent need for bryological surveys of the natural areas of the western sector of the Northern, Central and Southern Tablelands Botanical Divisions, and the North Western, Central Western and South Western Botanical Divisions of New South Wales.

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