

Some new and noteworthy bryophytes from Antarctic Beech (*Nothofagus moorei*) forests of north-eastern New South Wales

Alison Downing^{1,3}, Ross Peacock¹ and Helen Ramsay^{1, 2}

¹ Department of Biological Sciences, Macquarie University, NSW, 2109, Australia

² National Herbarium of New South Wales, Mrs Macquaries Road, Sydney, NSW, 2000, Australia

³ Author for correspondence: alison.downing@mq.edu.au

Abstract

Bryophytes (mosses, liverworts, hornworts) are an abundant and conspicuous component of the World Heritage Gondwana Rainforests of Australia which comprise several discontinuous areas of subtropical forests and woodland along the Great Escarpment of north-eastern New South Wales and south-eastern Queensland. The Gondwana Rainforests are considered to be of exceptionally high conservation value, with more than 200 rare or threatened plant and animal species but, surprisingly, no mention is made of bryophytes in the *statement of outstanding universal values*. Recent studies in Werrikimbe and Willi Willi National Parks using bryophytes as fine-scale indicators of rainforest condition, have identified a number of unusual and interesting bryophytes including the moss *Rosulabryum epiphyticum* (Bryaceae), *Leptodontium viticulosoides*, (Pottiaceae) and several endemic species of *Macromitrium* (Orthotrichaceae). The moss *Fissidens thorsbornei* (synonym: *Nanobryum thorsbornei*) (Fissidentaceae) and the liverwort *Lejeunea gracilipes* (Lejeuneaceae), are reported as new records for New South Wales.

Introduction

Location and environment

The Gondwana Rainforests of Australia World Heritage Area, formerly known as the Central Eastern Rainforest Reserves, is a serial property consisting of numerous discontinuous reserves along the Great Escarpment of north-eastern New South Wales (N.S.W.) and south-eastern Queensland. These areas are considered to be of exceptionally high conservation value, with more than 200 rare or threatened plant and animal species. They were inscribed on the World Heritage List in 1986, renominated in 1992 to include additional reserves, re-listed in 1994 as Central Eastern Rainforest Reserves (Australia) and renamed in 2007 as Gondwana Rainforests of Australia.

The Gondwana Rainforest satisfy three World Heritage criteria (viii, ix and x), relating to the unique biota and landforms across its 42 separate areas. The property provides the major refugia for the remaining Gondwanan rainforest flora and fauna, and its spectacular landforms are outstanding examples of ongoing geological processes. However, the World Heritage nomination documents, current statements of outstanding universal values (Adam 1987, Hunter 2004, Kitching et al. 2010) and proposed extensions (<http://whc.unesco.org/en/tentativelists/5541/>), do not include bryophytes (mosses, liverworts and hornworts) despite numerous references to the significance of other species of primitive and relictual taxa, and the abundance of bryophytes in the rainforest environments.

The current study is focussed on the Hastings-Macleay Group of the Gondwana World Heritage property within the upper reaches of the Forbes and Wilson River catchments. The vegetation of the study area is *Nothofagus moorei* – *Ceratopetalum apetalum* sub-alliance, cool temperate rainforest (Floyd 1990) or microphyll fern forest following the national classification by Webb (1959). The Gondwana Rainforests of Australia World Heritage serial property protects the most extensive areas of subtropical rainforest in the world, large areas of warm temperate rainforest and nearly all of the Antarctic beech (*Nothofagus moorei* (F.Muell.) Maiden) cool temperate rainforest in existence. The reserve consists of ancient vegetation and plant lineages that play a significant role for biodiversity conservation and evolutionary history of the rainforests. *Nothofagus moorei* (Antarctic beech) is considered to be a key species of these forests, and the finest examples of *Nothofagus moorei* – *Ceratopetalum apetalum* forests are considered to be those of Werrikimbe and Willi Willi National Parks which lie within the Hastings-Macleay Group of the Gondwana property north-west of Port Macquarie. Here cool temperate rainforest occupies an altitudinal range of 900 – 1240 m with *N. moorei* forming an open canopy 25–40 m tall over a dense 15–25 m sub-canopy of *Ceratopetalum apetalum* D.Don and *Doryphora sassafras* Endl. Approximately 15 additional sub-canopy rainforest tree species exhibiting strong relictual Gondwanan affinities occur in the rainforest community. There is a continuous understorey cover of ground fern species such as *Blechnum watsii* Tindl. and *Sticherus lobatus* N.A.Wakef. and semi-woody vines such as *Ripogonum discolor* F.Muell. Stand tree basal areas (>10 cm DBH) are high in the study area, ranging from 70–130 m²/ha⁻¹ (mean 83 m²/ha⁻¹, 95% confidence interval around the mean: 77.3, 88.8) creating a large surface area of tree buttresses for bryophyte colonisation in addition to an abundance of fallen log substrates (mean surface area is 709 m²/ha⁻¹) (Peacock and Downing, in prep).

The climate of the study area is cool temperate, with a mean annual rainfall of 2200 mm and mean annual temperature of 14.2°C. Relative humidity usually exceeds 90% with afternoon mists common all year. Rainfall peaks in the summer months with the mean of 197 rain days per year. Since 1960 mean annual maximum temperature has increased by 1.5°C, a rate of increase at the high end of the scenarios outlined in the projected global warming scenarios in IPCC Fifth Assessment Report (<http://www.ipcc.ch/report/ar5>) (R Peacock, unpublished data).

Bryophytes are abundant and conspicuous throughout these Gondwanan rainforests, although they were not included in the World Heritage nomination (Adam 1987) presumably due to a lack of awareness and difficulty of identification. However, bryophytes are plentiful along roadsides, on soil, on roadside banks, on fallen logs and pendant from roadside trees and shrubs. Within the forest, *corticolous bryophytes* are strikingly apparent on the buttresses of most tree species, particularly those of *N. moorei* and *C. apetalum* (Figs 3, 4). On the forest floor, shade tolerant bryophytes colonise soil, rocks, fallen logs, shrubs, vines, tree ferns and palms, even the leaves of some vascular plants (such as *Cryptocarya* and *Ripogonum* spp.) and ferns. A very different suite of bryophytes colonise branches in upper tree canopies (Fig. 5) where they are intermittently exposed to frequent fogs and mists but must also be able to tolerate periods of high light levels and temperatures 3–4°C higher than those of the rainforest understorey.

Bryophytes in *Nothofagus* forests elsewhere in Australia

There have been numerous Australian studies of bryophytes associated with *Nothofagus cunninghamii* (Hook.) Oerst. (myrtle beech) in Tasmania (e.g. Jarman et al.1991, Jarman and Kantvilas 1995, Tng et al. 2009) and in

Victoria (e.g. Ashton and McCrae 1970, Keller et al. 2006, Milne and Louwhoff 1999) but there are relatively few studies of bryophytes associated with *N. moorei*. Franks (2000) and Franks and Bergstrom (2000) described corticolous bryophytes of *N. moorei* forests along the higher peaks of the Lamington Plateau of south-eastern Queensland where they recorded 43 bryophyte taxa from the lower trunks. However, apart from a species list of mosses from Barrington Tops compiled by Heinar Streimann (unpublished), there is no published information on bryophytes of *N. moorei* forests of north-eastern New South Wales.



Fig. 1. Map of Australia showing general location of Gondwana Rainforests of Australia.

Early history of collections from this area

In 1949, Professor Alan Burges and R.D. Johnston surveyed an area of previously unlogged simple notophyll vine forest in the Doyles River State Forest, a section of the forest south of the Oxley Highway. This survey site is approximately 30 km south of Werrikimbe and Willi Willi National Parks and at a much lower elevation (650–700 m ASL, Burges and Johnson 1953). Botany students from the University of Sydney took part in this survey as part of their ecological studies in 1949. The forest here is dominated by *C. apetalum* and *Acradenia euodiiformis* (F.Muell.) T.G.Hartley, but the elevation is too low for *N. moorei*. Although bryophytes were poorly known at this time and identification difficult, fourteen moss taxa were recorded during this study. The area was logged in 1955–1956. In 1981, thirty two years after the Burges and Johnston study, foresters Gary King and William Chapman resurveyed the original study area and described the post-logging recolonisation patterns. Bryophytes were collected as part of this survey by Chapman in March 1981 (the specimen ‘Collector’ recorded as *Forestry Office, Taree*) and in October of the same year by King, and bryologists Helen Ramsay (one of the students involved in the original 1949 project) and Dale Vitt. All specimens were identified by Ramsay and Vitt and included a total of 44 moss taxa for the site (King and Chapman 1983). Additional specimens collected by Chapman which have recently come to light, include two mosses and eight liverworts.

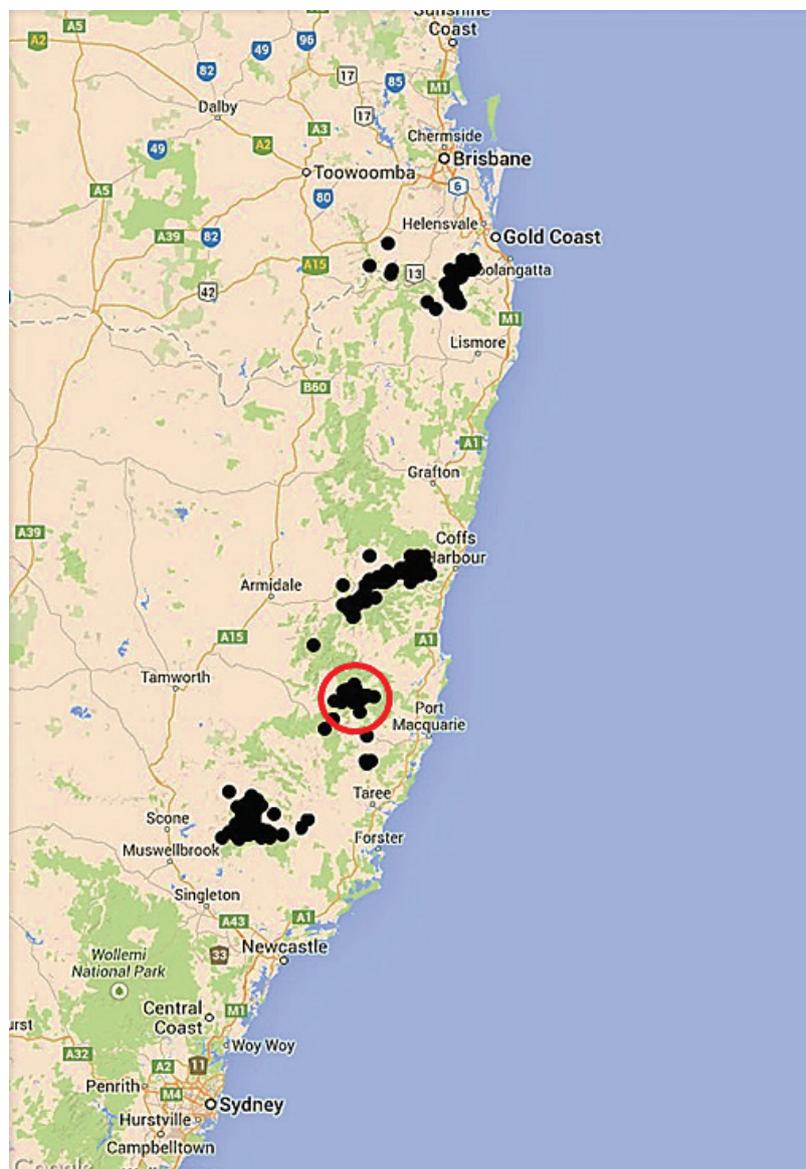


Fig. 2. Location of *Nothofagus moorei* forests in south-eastern Queensland and north-eastern New South Wales. Red circle marks location of Werrikimbe and Willi Willi National Parks. Atlas of Living Australia (ALA) Creative Commons Attribution 3.0 Australia License (www.ala.org.au). Point locality data was sourced also from ALA with cultivated and non-valid records excluded.



Fig. 3. Typical *Nothofagus moorei* - *Ceratopetalum apetalum* forest in Werrikimbe National Park.



Fig. 4. Bryophytes are abundant on tree buttresses in *Nothofagus moorei* forest of Werrikimbe and Willi Willi National Parks.

Notes prepared for the University of New South Wales *Plant Community Ecology* field trips to Mount Boss State Forest from 1973–1983 (unpublished) list 62 mosses. Areas of specific interest on these field trips, and now part of Werrikimbe and Willi Willi National Parks, were Mount Banda Banda (*Nothofagus moorei* – *Ceratopetalum apetalum* – *Sloanea woollsii* rainforest), some lower elevation warm temperate rainforest at Wilson River Picnic Area, and tableland high altitude *Eucalyptus* forest and woodland at the Forbes River Crossing on the Racecourse Trail.

Heinar Streimann from the Australian National Herbarium (CANB) made numerous collecting trips to Werrikimbe and Willi Willi National Parks and surrounding State Forests and Reserves and his collections from the area include 73 moss taxa, 29 liverworts and 1 hornwort.

Many interesting and unusual bryophyte species are present in the Gondwana Rainforests and two new species records are reported here.

Methods

Two approaches were adopted for the sampling strategy: a systematic permanent plot approach to facilitate long term monitoring and a stratified plotless approach which targeted specialised habitats. Sampling was conducted in 2011–2013. The systematic plot based sampling was nested within a larger study undertaken by Macquarie University biologists Ross Peacock, Alison Downing, William Chapman and Suzanne Kinsley, which aims to systematically survey rainforest bryophytes across a disturbance gradient to examine the relationship between compositional and fine scale habitat preferences and past site disturbance. Twenty eight 50 x 2 m² plots were established in Werrikimbe and Willi Willi National Parks, nested within larger 1200 m² rainforest growth dynamic plots. Bias was minimised by using original Forestry Commission 1960 plot markers establishing the boundaries of the growth dynamics plots. The 50 x 2 m² plots were established within each tree growth plot; 1 metre either side of a diagonal line established across the plot axis. Bryophytes were sampled by substrate type, including tree buttresses to 2 m, logs, rocks, soil, fallen branches and leaves.

The stratified plotless sampling approach aimed to gain an insight into species occurring in other specialised habitats not easily sampled in a systematic way. Specialised habitats included abandoned pine plantations, disturbed roadsides and camp grounds, rocky outcrops, swamps and *Eucalyptus* forests. Specimens were

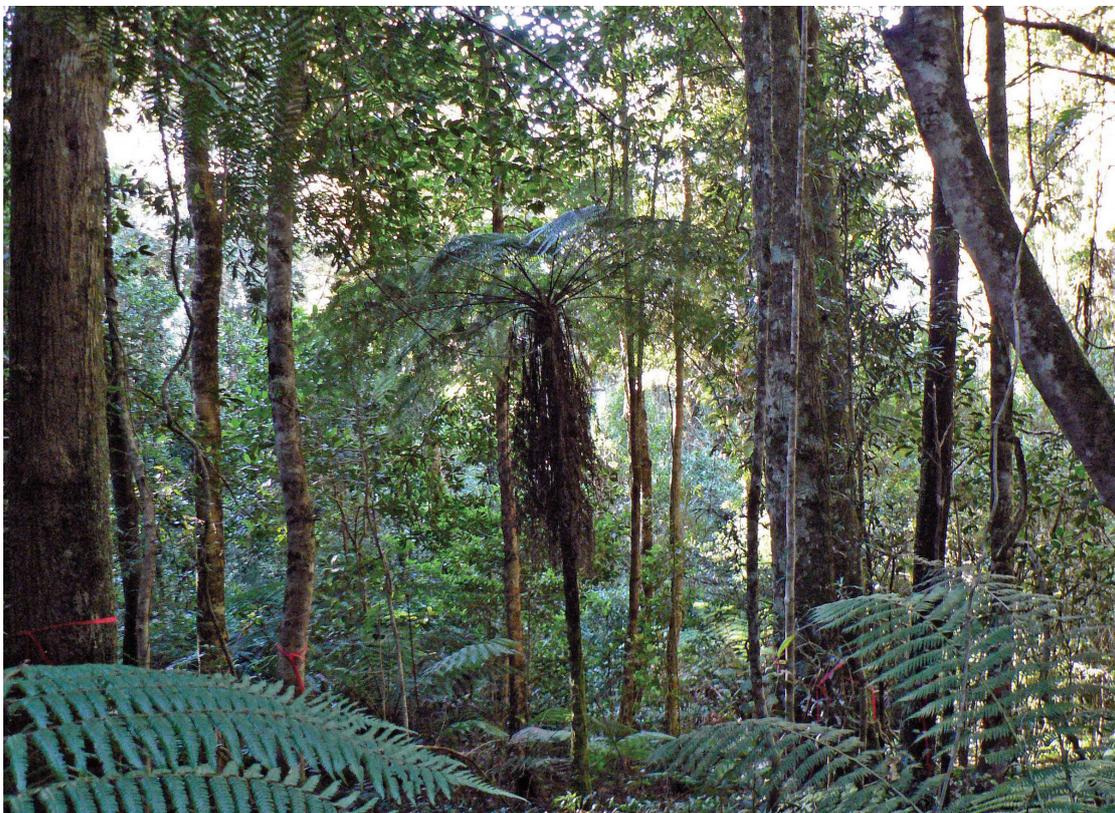


Fig. 5. Bryophytes, ferns (*Pyrrosia*) and orchids (*Dendrobium falcorostrum* Fitzg.) on the upper trunk and canopy branches of *Nothofagus moorei*.

returned to the laboratory where they were identified using published keys, for example Buck et al. (2002), Scott and Stone (1976), Scott (1985) and Beever et al. (1992), and on-line resources, in particular Australian Mosses Online (2014). Small, epiphytic and epilithic liverworts (Radulaceae and Lejeuneaceae) were referred to Dr Matt Renner for determination. Representative collections of each species will be lodged with MQU and NSW.

Information on distribution of the selected species was sought from the Atlas of Living Australia (2014), Australian Mosses Online (2014), Australia's Virtual Herbarium (2014) and from our own records. Specimens which reflected both geographic range and time since collection were examined at CANB, MEL and NSW.

Results and Discussion

More than 120 bryophyte taxa were recorded in the wider study; we considered that the species represented here are of particular interest.

New Records for New South Wales

Lejeunea gracilipes (Taylor) Stephani (Lejeuneaceae)

The type locality of *Lejeunea gracilipes* is somewhat perplexing, recorded simply as *PACIFIC ISLES, Nightingale s.n., ex herb. Hooker, ex herb Taylor: FH* (Renner 2013). This epiphytic leafy liverwort of subtropical and warm temperate rainforests of New Zealand occurs in lowland forests in the northern part of the North Island, and from Raoul Island in the Kermadec Group. In Australia, *L. gracilipes* has been known only from Norfolk Island, recorded variously as *Hygrolejeunea norfolkensis* (Stephani) Stephani and *Lejeunea norfolkensis* Stephani (Renner 2013) until collected by Renner in 2005 from Eungella National Park on the ranges to the west of Mackay in tropical north Queensland (Atlas of Living Australia 2014a).

The Lejeuneaceae is a particularly complex and taxonomically difficult family of almost exclusively epiphytic and epiphyllous leafy liverworts. The extremely small size of most taxa makes identification exceptionally challenging. Other complications are the tendency of many taxa to grow intermixed with other leafy liverworts, or sometimes for a single stem to weave a path through mats of other leafy liverworts, mosses and lichens.

Collections of *L. gracilipes* from Werrikimbe National Park are the first records of this species in N.S.W. Given the relative proximity to Norfolk Island and the North Island of New Zealand, this is not surprising and had been predicted by Renner (2013). *Lejeunea gracilipes* was recorded in two different forest types at Werrikimbe and Willi Willi National Parks: firstly, in the drier (MAR 1471 mm) tableland *Ceratopetalum apetalum* – *Acradenia euodiiformis* dominated forest of Fenwick's Scrub in the western section of Werrikimbe National Parks where it is relatively common on the bark of *Acradenia euodiiformis* (Yellow Satinheart); secondly on a range of tree buttresses including *C. apetalum*, *D. sassafras* and *N. moorei* in *Nothofagus moorei* – *Ceratopetalum apetalum* forest in the areas of highest rainfall at the edge of the escarpment.

Lejeunea gracilipes appears to flourish in very low light levels near the forest floor where substrates are consistently moist. Characteristically, the cells of the leaf lobes are clear and the lobules are described as 'inflated obpyriform' (Renner 2013), not unlike an open baseball glove waiting for a catch (Renner, pers. comm.).

Specimens examined: **New Zealand: Kermadec Islands:** Raoul Island, Kermadec Islands Nature Reserve, *P.J. de Lange K355 & D.C. Howell*, 9 May 2009, on damp ground in deep ravine (NSW875753); **North Auckland:** Waitakere Ranges, Destruction Gully, *M.A.M. Renner1206*, 24 Nov 2004, on trunk of *Rhopalostylis sapida* (NSW889050);

Australia: New South Wales: Northern Tablelands (Jacobs and Pickard 1981): Werrikimbe National Park, Cockerawombeeba Road, *A.J. Downing & S. Kinsley s.n.*, 25 Oct 2011, on *Nothofagus moorei* in dense *Nothofagus moorei* – *Ceratopetalum apetalum* cool temperate rainforest (MQU72002869); Fenwicks Scrub Flora Reserve Werrikimbe National Park, off Cobcroft and Fenwicks Roads, north of Oxley Highway, *A.J. Downing & S. Kinsley s.n.*, 24 Oct 2011, on *Acradenia euodiiformis* in *Ceratopetalum apetalum* – *Doryphora sassafras* cool temperate rainforest (MQU72002868); Werrikimbe National Park, Hastings Forest Road, *A.J. Downing s.n.*, 22 Apr 2013, on *Doryphora sassafras* in cool temperate *Nothofagus moorei* – *Ceratopetalum apetalum* forest, (MQU72002867).

Fissidens thorsbornei (I.G.Stone) Brugg.Nann.

Synonym: *Nanobryum thorsbornei* I.G. Stone (Fissidentaceae)

In 2010 *Fissidens thorsbornei* was collected in Nimbin, north-eastern N.S.W., growing in pure stands on damp, shaded clay roadside banks in a rural area adjoining natural areas of mixed forest. In this location, these

minute plants, ca 1.5 mm high, were emerging from a dense mat of green protonema. The original placement of this species in *Nanobryum* by Stone (1982) has not been without controversy as Pursell and Reese (1980) and Bruggeman-Nannenga and Berendsen (1988) considered it to be more appropriately included in *Fissidens*. Most collections of this species are from tropical north Queensland, between Ingham and Cooktown. However, it was also collected by Ilma Stone from Lamington Plateau in south-eastern Queensland. Nimbin, falling within the Mount Warning erosion caldera, shares many environmental factors with Lamington Plateau (geology, topography, climate, vegetation), so the presence of this species in northern N.S.W. is to be expected.

Specimens examined: Australia: Queensland: Cook (Anonymous 1975): Lions Den, Helenvale, *I.G. Stone 22090*, 07 Jun 1984 (MEL2262604); Emmagen Creek Track, Cape Tribulation, *I.G. Stone 19430*, 26 Jun 1982, on earth, on roots of fallen tree (MEL2245664); **North Kennedy**: Wrights Creek, Lake Eacham National Park, *I.G. Stone 25512*, 22 Jul 1989 (MEL2329012); Kirrama State Forest, *I.G. Stone 16971*, 10 Sep 1980 (MEL2241141); **South Kennedy**: Finch Hatton to Calen, *I.G. Stone 18470*, 09 May 1982 (MEL2243811); **Leichhardt**: Mickeys Creek, Carnarvon National Park, *I.G. Stone 20476*, 27 Jul 1982, on earth bank near *Livistona* (MEL2249797); **Burnett**: Cania, *I.G. Stone 20989*, 5 Aug 1983, on clay bank in rainforest (MEL2258248). **New South Wales: North Coast**: Nimbin, Falls Road, *A.J. Downing, N. Osborne & K.D. Downing s.n.*, 13 Aug 2010, on sticky clay loam of roadside bank (MQU72001800, NSW873819).

New Caledonia: La Cresson, north-east of Koumac, 100 m asl, *Z. Iwatsuki 6334*, 02 Aug 1982, on soil, limestone area (MEL2278692).

Noteworthy Mosses

Rosulabryum epiphyticum J.R.Spence & H.P.Ramsay (Bryaceae)

Rosulabryum epiphyticum was described by Spence and Ramsay (1999) from a collection made by Alison Downing in 1991. This is an unusual epiphytic moss species for which the place of origin was not certain. The type locality has always been somewhat of an enigma as the specimen was collected from an epiphytic orchid, purchased originally from a Port Macquarie nursery, and at the time growing in the glasshouses at Macquarie University.

This endemic species of *Rosulabryum* from the coastal ranges of north-eastern N.S.W. and Queensland is the only known epiphytic *Rosulabryum* species and is also one of the very few epiphytic species of Bryaceae. *Rosulabryum epiphyticum* is readily identified by the unbranched, filiform gemmae in the axils of the upper leaves. Collections by Ilma Stone are recorded from tropical far north Queensland (Ramsay and Cairns 2004) and from south-eastern Queensland where the species is well documented. In 2010, Alison Downing, Neville Osborne and Kevin Downing collected another specimen, again growing amongst epiphytic orchids at Nimbin in north-eastern N.S.W.

A specimen of *R. epiphyticum* growing with the rare epiphytic beech orchid, *Dendrobium falcorostrum*, on a fallen *N. moorei* canopy branch in Werrikimbe National Park was collected in 2011 by Alison Downing and Suzanne Kinsley. The identification was confirmed by the presence of conspicuous gemmae amongst the upper leaves. The occurrence of this species at Werrikimbe appears to confirm the likelihood that the type locality given as Port Macquarie is quite sound. In the last two years, no further collections have been made, despite using every opportunity to search for the moss on fallen branches laden with beech orchid. The type collection was not growing amongst *D. falcorostrum* and it may be that *R. epiphyticum* could be sought more productively amongst other species of epiphytic orchids on branches of trees at lower elevations.

Surprisingly, with one exception (*I.G. Stone 24701*, from Innisfail), all the collections made by Ilma Stone appear to have been from crumbly, friable, sandy soils. Unfortunately, Stone does not record substrates for any collections of this species. So perhaps consideration of the habitat description for *R. epiphyticum*, namely ‘usually on the twigs of trees and shrubs and on orchid roots; sometimes on rocks’ should be reviewed.

Specimens examined: Australia: Queensland: Cook: Mount Haig (Lamb Range), Danbulla State Forest, *I.G. Stone s.n.*, 5 Jul 1984 (MEL2262845); **North Kennedy**: Downey Creek, near Innisfail, *I.G. Stone 24701*, 19 Sep 1987 (MEL2322544); **South Kennedy**: Peases Lookout, Eungella National Park, *I.G. Stone 12505*, 6 Jun 1975 (MEL2213357); **Leichhardt**: Expedition Range, *I.G. Stone 21181*, 8 Aug 1983 (MEL2258503); **Morton**: Mount Nebo, *I.G. Stone 13130*, 14 May 1978 (MEL2216643); Rifle Bird Creek, Binna Burra, Lamington National Park, *I.G. Stone 12919*, 12 Jun 1975 (MEL2219159); Staircase Falls, Lamington National Park, *I.G. Stone 11998*, 26 Oct 1976 (MEL2212294). **New South Wales: Northern Tablelands**: Werrikimbe National Park, Hastings Forest Way, *A.J. Downing s.n. & S. Kinsley*, 1 Mar 2011, epiphytic on fallen branch in *Nothofagus moorei* – *Ceratopetalum apetalum* forest (MQU72002596); **North Coast**: Nimbin, Falls Road, *A.J. Downing s.n., N. Osborne & K.D. Downing*, on epiphytic orchids (NSW873822, MQU72001779); **Central Coast**: Macquarie University glasshouse, cultivated, *A.J. Downing s.n.*, 8 Aug 1991, epiphytic on orchids in pots originally from Port Macquarie (NSW713185 – isotype);

The genus *Macromitrium* Brid. (Orthotrichaceae)

Macromitrium Brid. is an exceptionally large moss genus, including about 350 taxa worldwide, of predominantly epiphytic species from tropical and subtropical regions with a few taxa found in southern temperate locations. Most Australian taxa can be found in rainforests of eastern Australia from sea level to 1500 metres. Eleven of the 22 taxa recorded in Australia are endemic (Vitt and Ramsay 1985a). *Macromitrium* species are often abundant on the branches of tree canopies and margins of rainforest where they have the capacity to tolerate high light levels, high temperatures and periods of desiccation. In Werrikimbe and Willi Willi National Park there are several *Macromitrium* species of particular interest.

In their taxonomic revision of *Macromitrium* in Australasia, Vitt and Ramsay produced a summarised diagram of the habitat preferences of Australian species (Vitt and Ramsay 1985b, fig. 4, p. 459). In this diagram, a number of endemic species are shown to occur in rainforests but are found in different habitats. For example, *M. stoneae* and *M. exsertum* prefer *Nothofagus* dominated forests whereas *M. hortoniae* and *M. hemitrichodes* are most common in ravine rainforests dominated by *C. apetalum*. Two species, the relatively robust *M. stoneae* and the smaller *M. hortoniae*, are of particular interest.

Macromitrium hortoniae Vitt & H.P.Ramsay (Orthotrichaceae)

Macromitrium hortoniae is described by Ramsay et al. (2006) as one of the smallest Australian species of *Macromitrium*, with a distinct, multi-fringed calyptra. The distribution was initially considered to be restricted to the vicinity of the Border Ranges in north-eastern N.S.W. and south-eastern Queensland. However, Atlas of Living Australia (2014b) now shows records of *M. hortoniae* sparsely scattered along the east coast of Australia from Belmore Falls south-west of Sydney to locations in the vicinity of Bulahdelah and Taree. Some additional Queensland collections are from the ranges north-west of Bundaberg and south-west of Gladstone, and from the Bunya Mountains of south-central Queensland. Our collections from Werrikimbe and Willi Willi National Parks, from a range of substrates, including *N. moorei* buttress, *Parsonsia* sp., *Cryptocarya foveolata*, *Cryptocarya meissneriana* and fallen branches, fill a discontinuity in the species distribution between the few southern N.S.W. collections and those from the Richmond River and Border Ranges region of N.S.W.

Specimens examined: Queensland: Burnett: Kalpowar, Scrub Creek, 30 km NE Monto, 400 m, *H. Streimann* 9921, 17 Jun 1980, on tree trunk in dry semi-tropical scrub forest (CBG 8002464); Bunya Mountains National Park, south-west of Kingaroy, 800 – 1000 metres, *D.H. Norris* 35689, 9 Mar 1974, in open rainforest (NSW767406); **Moreton:** Lamington National Park, 25 km SW of Canungra on road to O'Reilly's Guest House, *D.H. Vitt* 28150 & *H.P. Ramsay*, 7 Nov 1981, in open shrubby montane rainforest (NSW748831 – isotype); Border Track, Lamington National Park, *I.G. Stone* 4247, 18 Aug 1969, (mixed with *M. stoneae*) (MEL2140570); Lamington National Park, road to O'Reilly's, *D.H. Vitt* 28183, 7 Nov 1981, on trees in rainforest (NSW444399). **New South Wales: Northern Tablelands:** Werrikimbe National Park, Cockerawombeeba Road, *A.J. Downing* & *S. Kinsley* s.n., 2 Mar 2011, on liane in dense *Nothofagus moorei* – *Ceratopetalum apetalum* cool temperate rainforest (MQU72002870); Werrikimbe National Park, Cockerawombeeba Road, *A.J. Downing* & *S. Kinsley* s.n., 2 Mar 2011, on *Nothofagus moorei* coppice, in dense *Nothofagus moorei* – *Ceratopetalum apetalum* cool temperate rainforest (MQU72002871); **North Coast:** Foot of Mount Lindsay, *W. Forsyth* 852, Sept 1900 (NSW767165); S. Beach Scrub opposite Ballina, *W.W. Watts* 8148, 31 Dec 1902 (NSW767183); near Bulga Creek, *W.W. Watts* 10812, April 1915 (NSW767179); Wiangaree State Forest, 30 km NE Kyogle, 920 m, *H. Streimann* 6115, 3 Sep 1978, on fallen dead branch in *Nothofagus* dominated forest (CBG 7902000); **Central Tablelands:** Belmore Falls, *W.W. Watts* 9816, 5 Oct 1908 (NSW767182).

Macromitrium stoneae Vitt & H.P.Ramsay (Orthotrichaceae)

Macromitrium stoneae is an uncommon epiphytic moss from montane rainforests (Vitt and Ramsay 1985a, 1985b, Ramsay et al. 2006) It has an unusual disjunct distribution, with a cluster of collections from the Atherton tablelands north-west of Cairns in tropical north Queensland, a second cluster from the Border Ranges of south-eastern Queensland and north-eastern N.S.W. and a third which includes collections from Werrikimbe and Willi Willi National Parks (Atlas of Living Australia 2014c). The type locality, *Plateau Beach Preserve* (sic), *Mount Boss State Forest* is now *Plateau Beech Reserve* and part of Werrikimbe National Park. In N.S.W., *M. stoneae* grows as an epiphyte in the canopies of *N. moorei*. In this study, *M. stoneae* was collected from buttresses of *N. moorei*, from young stems of *Callicoma serratifolia* and from fallen logs. In their taxonomic revision Ramsay et al. (2006) describe the distinctive capsules and multi-split calyptrae, pattern of leaf cell shape and anatomy as the most distinctive characteristic of *M. stoneae*, in particular, upper leaf cells which are densely pluripapillose with low branched papillae and smooth, elongate basal cells.

Specimens examined: Queensland: Cook: Mount Lewis, end of road, 28.1 km, from junction with road between Mount Molloy and Mossman, 1036 m, *D.H. Vitt* 28014 & *H.P. Ramsay*, 3 Nov 1981, montane tropical rainforest with abundant epiphytes (NSW748821); Mount Father Clancy, from road to Souita Falls, 800 – 1100 m, *D.H. Norris* 43251, 28 May 1981,

on moist sunny limbs of fallen tree in partially cut-over rainforest on northern slopes (NSW770583); **North Kennedy:** Mount Bellenden Ker, *I.G. Stone 17944*, 23 Sep 1981 (MEL2243185); **Moreton:** South of Boonah, State border, on ridge trail northward from the pass on road north of Wilsons Peak, ca 600 m, *D.H. Norris 37124*, 23 Mar 1974, on moist, diffusely lit limbs high in tree in cut-over rainforest (NSW771078); Border Track, Lamington National Park, *I.G. Stone 4247*, 18 Aug 1969, (mixed with *M. hortoniae*) (MEL2140570); Scrub opposite track to Morans Falls, road below O'Reillys, Lamington National Park, *I.G. Stone 20534*, 14 Feb 1983 (MEL2249847); Lamington National Park, Python Rock Lookout, west of O'Reilly's Guest House, *D.H. Norris 34943*, 26 Feb 1974, on moist sunny boulder in *Eucalyptus* forest (NSW771085). **New South Wales: Northern Tablelands:** north-west of Wauchope, Plateau Beach Preserve, Mount Boss State Forest, 823 m, *D.H. Vitt 27483*, *H.P. Ramsay & G. King*, 10 Oct 1981, collection from canopy area of felled trees, actively logged *Nothofagus moorei*, *Doryphora sassafras*, *Ceratopetalum apetalum* temperate rainforest (NSW748596 – isotype); Mount Boss State Forest, Forbes River, 1060 m, *H. Streimann 7173*, 20 Oct 1978, On fallen *Eucalyptus* branch, in *Eucalyptus* scattered grassland with shrubs (CBG 7906119); Werrikimbe National Park, Cockerawombeeba Road, *A.J. Downing s.n. & S. Kinsley*, 23 Oct 2011, on buttress of *Nothofagus moorei* in dense *Nothofagus moorei* – *Ceratopetalum apetalum* cool temperate rainforest (MQU72002873); Fenwicks Scrub Flora Reserve Werrikimbe National Park, off Cobcroft and Fenwicks Road, north of the Oxley Highway, 1114 m, *A.J. Downing s.n. & S. Kinsley*, 24 Oct 2011, on fallen log in *Ceratopetalum apetalum* – *Doryphora sassafras* cool temperate rainforest surrounded by *Eucalyptus* forest and woodland (MQU72002872); **North Coast:** Wingham-Comboyne Road, 24 km NNW of Taree, *H. Streimann 60451*, 17 Apr 1998, on semi-shaded tree trunk, in wet sclerophyll forest on steep slope (CBG9906481.1);

***Leptodontium viticulosoides* (Beauv.) Wijk & Marg. var. *viticulosoides* (Pottiaceae)**

The epiphytic moss, *Leptodontium viticulosoides* var. *viticulosoides*, has a widespread distribution, including many South and Central American countries (e.g. Argentina, Bolivia, Brazil, Mexico, Peru), sub-Saharan Africa, Madagascar, Mauritius and Reunion, although, curiously, it has not been reported from New Zealand in spite of its strong representation in the southern hemisphere. The first published report of this species in Australia appears to be that of Ilma Stone, from Mount Kiangarow, Bunya Mountains, *I.G. Stone 13334 & N. Ludke*, 24 May 1978, from an old branch (*sic*) of *Xanthorrhoea* sp., MEL22178373 (Stone 1982) but there is an earlier collection from Barrington Tops (*R. Pullen 3796*, 4 Feb 1963, CANB156843) later determined by Zander.

However, in Australia, this species appears to be restricted to rainforests of north-eastern N.S.W. and south-eastern Queensland (Atlas of Living Australia 2014d). *Nothofagus moorei* appears to be the most commonly recorded substrate although collections in CANB include one specimen growing on a boulder, one on *Banksia* and one on *Acacia*. The most southerly collection was made by A Newton (MO90175103) from Mount Wilson in the Blue Mountains north-west of Sydney. There are a few collections from Barrington Tops, from New England National Park and from south-eastern Queensland. The actual localities of several Queensland colonies are unclear but appear to be in the rainforests of the Border Ranges.

In 1999, a recommendation was made that *L. viticulosoides* var. *viticulosoides* should be recorded as a rare species, classified as 1R (Scott et al. 1999). '1' signifies known only from a single Australian collection if the type locality is overseas and 'R' (Rare) signifies that the species is recorded from either the type locality or from very few localities (Briggs and Leigh 1988). The latter is true for this species but not the first criterion. In Werrikimbe and Willi Willi National Parks, this species is not uncommon, sometimes occurring in abundance, often with *Dicranoloma dicarpum*, on large fallen branches of *N. moorei*. In contrast, sometimes few stems are found mixed with epiphytic mosses (eg *Eucamptodon muelleri*, *Macromitrium* spp.), and liverworts (*Frullania* spp.) on smaller fallen branches. The habitat appears to be similar to that of other Australian collections, namely rainforest or closed forest at the edge of the escarpment of the eastern ranges, above 900 metres in elevation.

In his revision of the genus *Leptodontium*, Zander (1972) describes the habitat for *Leptodontium* species as middle to high altitude, in mountainous regions of the tropics and subtropics, frequently in mossy forests in high rainfall areas. In terms of climate change, does this mean that this particular species may well be at risk in Australia in a warming climate where there are no suitable habitats at higher altitude?

Nomination of a species as threatened, rare or endangered, is a detailed and time-consuming process. In view of the records now available on line, and our own collections, perhaps a more appropriate classification for *L. viticulosoides* would be 3RC [3 – geographic range in Australia greater than 100 km; R – rare in Australia but currently without an identifiable threat; C – species with at least one population within a national park] (Briggs and Leigh 1995).

Specimens examined: Australia: Queensland: Burnett: Mount Kiangarow, Bunya Mountains, *I.G. Stone 13334 & N. Ludke*, 24 May 1978, on old branch (*sic*) of *Xanthorrhoea* sp., (MEL22178373); **Darling Downs:** Killarney, Moss garden, Spring Creek Road, *I.G. Stone 13185*, 16 May 1978 (MEL2217754). **New South Wales: Northern Tablelands:** New England National Park, Weeping Rocks Track, 1500 m, *H. Streimann 65181 & T. Pocs*, 11 Sep 1999, on crown branches of fallen

Nothofagus in *Nothofagus* – *Elaeocarpus* dominated forest along escarpment (CANB609671); Werrikimbe National Park, Hastings Forest Road, 1100 m, A.J. Downing s.n., 22 Apr 2013, on recently fallen branch of *Nothofagus moorei*, NE aspect, mesic, part shade, slope, in medium forest (MQU72002860); Werrikimbe National Park, Cant's Trail of Cockerawombeeba Road, R.J. Peacock s.n., 2 Feb 2014, on upper limb of veteran *Nothofagus moorei* recently fallen in January 2014 windstorm, in *Nothofagus moorei* – *Ceratopetalum apetalum* sub-alliance cool temperate rainforest (MQU72002859); Werrikimbe National Park, Hastings Forest Road, A.J. Downing s.n., 22 Apr 2013, on recently fallen branch of *Nothofagus moorei*, in cool temperate *Nothofagus moorei* – *Ceratopetalum apetalum* forest (MQU72002866); Barrington Tops, 64 km N of Singleton, ~1370 m, R. Pullen 3796, 4 Feb 1963, corticolous on upper trunk of *Nothofagus* (CANB156843); Dilgny River, Barrington Tops State Forest, 40 km WNW of Gloucester, 1160 m, H. Streimann 44626, 26 Apr 1990, on shaded granite boulder in *Nothofagus* dominated temperate forest (CBG 9010575); Gloucester Tops, 37 km WSW of Gloucester, ~1300 m, H. Streimann 1568 (CBG 056730).

South Africa: Transvaal: Mariepskop, 1970 m, P. Vorster 1110, 20 Oct 1969, mountain summit, eastern facing kloof, on stone, Podocarpus (CANB873242).

Zaire: massif du Kahuzi, 2180 m, J.L. de Sloover 12554, 22 Dec 1971, en bordure du marais de Musisi, talus de schiste fortement délité (CANB873243).

Madagascar: Ranomafana National Park, 1110 m, R.E. Magill 9465/EQ, 27 Sep 1994, montane rainforest, on high branches of tree at forest edge (CBG9710870).

La Réunion: cirque de Cilaos, près de cascades du Bras de Benjoin, 1600 m, J.L. De Sloover 17.967, 1 Jan 1974, sur vieux tronc (CANB873244).

Mexico: Distrito Federal: Cerro Xitle, vertiente NE del Ajusco, A. Cárdenas S. 4427, 5 Feb 1986, bosque mezclado de *Pinus* y *Quercus* etc., tronco de encino, lugares expuestos y secos (CANB873245).

Costa Rica: Province San Jose, Valle de Copey, c. 30 km al sur de Cartago, 2000 m, D. Griffin III B90-a & M.I. Morales, 4 Nov 1979, bosque primario montano bajo, muy húmedo y con potreros, plantas en roca seca a pleno sol (CBG9205747).

Peru: Vicinity of Cuzco, 1200 – 3000 m P. Jay, Oct 1893, humid slope (CBG8207625).

Bolivia: vicinity of Yungas and La Paz, 1200 – 3000 m, P. Jay s.n., Jun & Jul 1893, humid slope, (CBG8207624).

Argentina: Prov. Tucumán: Valle de los Sosas, road between Tafí del Valle and Tucumán, W.C. Steere 60-322, 4 Dec 1960, at lower, drier end of valley, on moist bank (CBG8207626).

Conclusion

Providing a threat or risk assessment of the new records in this paper is challenging as the IUCN Red List of Threatened Species criteria (IUCN 2001) are difficult to apply to bryophytes without specific adaptation (e.g. Hallingbäck et al. 1998, González-Mancebo et al. 2012). In Australia we lack data on rates of decline; populations are difficult to quantify in terms of number and local extent; our continental extent data is patchy and dependent on survey and databasing effort; and defining a population across sexual and asexual life stages is extremely problematic. For extinction risk to be assessed using the IUCN Red List Categories and Criteria (IUCN 2001, 2012) at a minimum the species must be threatened globally, confined to a threatened habitat and have a narrow distribution range (Hallingbäck and Hodgetts 2000). In the absence of such information a pragmatic approach incorporating criteria such as the presence of declining, threatened, or rare taxa and apparent or reported species richness is recommended (Hallingbäck and Hodgetts 2000).

Establishing bryophyte distribution and population status will always be difficult. Bryophytes are small, difficult to see, often growing in mixed populations and frequently with single stems intertwined amongst numerous other epiphytic fern, bryophyte and lichen taxa. Identification can be difficult for the non-specialist and is always time consuming. Bryophyte collections can be quite minimal and patchy, often garnered from readily accessible locations, such as roadsides and along walking tracks while those of challenging terrain or canopy habitats may go unheeded. Collections of canopy bryophytes from fallen trees, while possible, in our experience need to be made within weeks of the tree fall before desiccation and herbivory set in. Bryologists themselves are sparsely distributed, most are located in Australian capital cities. Werrikimbe and Willi Willi National Parks consist of remote and challenging terrain, and are almost equidistant between Sydney and Brisbane, but still a long way from both centres, in comparison to the distance of Victorian and Tasmanian beech forests from Melbourne and Hobart respectively. These parks represent the largest and least disturbed examples of Gondwana *Nothofagus moorei* dominated cool temperate rainforests in existence and it is only through systematic studies such as this, with both permanent plot sampling of sites remote from roads and stratified sampling of other specialised habitats such as rock outcrops and creek banks that we can advance our

knowledge of the distribution and habitat preferences of unusual or uncommon bryophytes. However, studies in less accessible locations should be encouraged as collections of unusual species and new regional records are essential for our understanding of bryophyte distribution and assessment of their conservation status.

Acknowledgments

We have been exceptionally fortunate to have had the opportunity to work with Dr Elizabeth Brown. We would like to acknowledge her contribution to Australian bryological studies, her passion for bryophytes, her wry sense of humour, her generosity, and her encouragement and support of our many and varied bryological ventures.

We thank Josephine Milne (MEL), Christine Cargill and Judith Curnow (CANB), and Matt Renner (NSW) for access to collections in those herbaria, and we are also most appreciative of assistance from Matt Renner (NSW) for his patience and assistance with identification of our Lejeuneaceae specimens.

Andrew Marshall, National Parks and Wildlife Service Ranger, Manning-Hastings Area, arranged for accommodation and site access. Plant collections were made using a National Parks and Wildlife Act (1974) Section 132c licence # 101239.

References

- Adam P (1987) *New South Wales rainforests – nomination for the World Heritage List*. (National Parks & Wildlife Service, Sydney)
- Anonymous (1975) [untitled map] *Contributions of the Queensland Herbarium* 19: end paper
- Ashton DH, McCrae RF (1970) The distribution of epiphytes on beech (*Nothofagus cunninghamii*) trees at Mount Donna Buang, Victoria. *Victorian Naturalist* 87: 253–261.
- Atlas of Living Australia (2014a) *Lejeunea gracilipes* (Taylor) Spruce <http://bie.ala.org.au/search?q=lejeunea+gracilipes>. (accessed 27 May 2014)
- Atlas of Living Australia (2014b) *Macromitrium hortoniae* “Vitt & H.P.Ramsay” <http://bie.ala.org.au/search?q=Macromitrium+hortoniae> (accessed 20 May 2014)
- Atlas of Living Australia (2014c) *Macromitrium stoneae* “Vitt & H.P.Ramsay” <http://bie.ala.org.au/search?q=Macromitrium+stoneae> (accessed 20 May 2014)
- Atlas of Living Australia (2014d) *Leptodontium viticulosoides* “(P.Beauv.) Wijk & Margad.” <http://bie.ala.org.au/search?q=Leptodontium+viticulosoides> (accessed 8 June 2014)
- Australian Mosses Online*, Australian Biological Resources Study, Canberra. http://www.anbg.gov.au/abrs/Mosses_online (accessed 8 June 2014)
- Australia's Virtual Herbarium (2014) Council of Heads of Australasian Herbaria, <http://avh.chah.org.au> (accessed July 2014)
- Beever J, Allison KW, Child J (1992) *The Mosses of New Zealand* (University of Otago Press, Dunedin, New Zealand)
- Briggs JD, Leigh JH (1988) *Rare or Threatened Australian Plants*. (Australian National Parks and Wildlife Service Special Publication No. 14: Canberra)
- Briggs JD, Leigh JH (1995) *Rare or Threatened Australian Plants*, revised edition. (CSIRO Publishing, Australia)
- Bruggeman-Nannenga MA, Berendsen W (1988) *On the peristome types found in the Fissidentaceae and their importance for the classification in systematic studies on Fissidens (Musci)*. Doctoral thesis, Instituut voor Systematische Plantkunde 135–171.
- Buck WR, Vitt DH, Malcolm WM (2002) *Key to the Genera of Australian Mosses*. Flora of Australia Supplementary Series No. 15, Australian Biological Resources Study, Canberra.
- Burges A, Johnson RD (1953) The structure of a New South Wales subtropical rainforest. *Journal of Ecology* 41 (1): 72–83.
- Floyd AG (1990) *Australian Rainforests in New South Wales, Volume 2*. (Surrey Beatty and Sons Pty Limited, Chipping Norton, New South Wales)
- Franks AJ (2000) Biogeographical distribution of corticolous bryophytes in microphyll fern forests of south-east Queensland. *Proceedings of the Royal Society of Queensland* 109: 49–57.
- Franks AJ, Bergstrom DM (2000) Corticolous bryophytes in microphyll fern forests of south-east Queensland: distribution on Antarctic beech (*Nothofagus moorei*). *Austral Ecology* 25: 386–393.
- González-Mancebo JM, Dirkse GM, Patiño J, Romaguera F, Werner O, Ros RM, Martín JL (2012) Applying the IUCN Red List criteria to small-sized plants on oceanic islands: conservation implications for threatened bryophytes in the Canary Islands. *Biodiversity and Conservation* 21(14): 3613–3636.

- Hallingbäck T, Hodgetts NG, Raeymaekers G, Schumacker R, Sérgio C, Söderström L, Stewart N, Váňa J (1998) Guidelines for application of the revised IUCN threat categories to bryophytes. *Lindbergia* 23: 6–12.
- Hallingbäck T, Hodgetts N (compilers) (2000) *Mosses, Liverworts, and Hornworts. Status Survey and Conservation Action Plan for Bryophytes*. (IUCN/SSC Bryophyte Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK) 106 pp.
- Hunter RJ (2004) *World Heritage and associative natural values of the Central Eastern Rainforest Reserves of Australia*. (NSW National Parks and Wildlife Service, Sydney) (First published 2003, revised 2004)
- IUCN (2001) IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. (IUCN: Gland, Switzerland and Cambridge, UK)
- IUCN (2012) *Guidelines for Application of IUCN Red List Criteria at Regional and National Levels: Version 4.0*. (IUCN, Gland, Switzerland and Cambridge, UK) iii + 41 pp.
- Jacobs, SWL, Pickard J (1981) *Plants of New South Wales* (D West, Government Printer, Sydney)
- Jarman SJ, Kantvilas G (1995) *A floristic study of rainforest bryophytes and lichens in Tasmania's myrtle-beech alliance*. (Tasmanian NRCP Report No. 14. Forestry Tasmania and Department of the Environment, Sport and Territories, Canberra, Hobart)
- Jarman S, Kantvilas G, Brown MJ (1991) *Floristic and ecological studies in Tasmanian rainforest*. (Tasmanian NRCP Technical Report No. 3. Forestry Commission. Tasmania and the Department of the Arts, Sport, the Environment, Tourism and Territories, Canberra, Hobart)
- Keller C, Short M, Milne J (2006) Epiphytes on *Nothofagus cunninghamii* and *Eucalyptus regnans* in a Victorian cool temperate rainforest. *Victorian Naturalist* 123(4): 222–229.
- King GC, Chapman WS (1983) Floristic composition and structure of a rainforest area 25 years after logging. *Australian Journal of Ecology* 8: 415–423.
- Kitching R, Braithwaite R, Cavanaugh J (2010) *Remnants of Gondwana: a natural and social history of the Gondwana Rainforests of Australia* (Surrey Beatty & Sons, Chipping Norton).
- Milne J, Louwhoff S (1999) Vertical distribution of bryophytes and lichens on a Myrtle Beech, *Nothofagus cunninghamii* (Hook.) Oerst. *Hikobia* 13: 23–30.
- Peacock RJ, Downing AJ (In prep.) Bryophytes as fine scale indicators of vegetation condition in *Nothofagus moorei* rainforest of Werrikimbe National Park.
- Pursell RA, Reese WD (1980) The taxonomic status of the Nanobryaceae (Bryopsida). *The Bryologist* 82: 58–64.
- Ramsay HP, Cairns A (2004) Habitat, distribution and the phytogeographical affinities of mosses in the Wet Tropics bioregion, north-east Queensland, Australia. *Cunninghamia* 8(3): 371–408.
- Ramsay HP, Vitt DH, Lewinsky-Haapasaari L (2006) Orthotrichaceae. Pp.187–244 in *Flora of Australia* Volume 51, (Australian Biological Resources Study, Canberra & CSIRO Publishing, Melbourne)
- Renner MAM (2013) A new subspecies of *Acrolejeunea arcuata*, and notes on typification, synonymy, and distribution of other Australian Lejeuneaceae. *Phytotaxa* 83(1): 39–53.
- Scott GAM (1985) *Southern Australian Liverworts* (Australian Government Publishing Service, Canberra)
- Scott GAM, Entwisle TJ, May TW, Stevens GN (1999) A conservation overview of Australian non-marine lichens, bryophytes, algae and fungi. Environment Australia <http://www.environment.gov.au/node/14679> (accessed 4 May 2014)
- Scott GAM, Stone IG (1976) *The Mosses of Southern Australia* (Academic Press, London)
- Spence JR, Ramsay HP (1999) Three new species of *Rosulabryum* (Bryopsida, Bryaceae) from Australia. *Telopea* 8(3): 325–335.
- Stone IG (1982) *Nanobryum thorsbornei*, a remarkable new moss from Australia. *Journal of Bryology* 12: 199–208.
- Stone IG (1982) Some new and noteworthy records of mosses, mostly from Queensland, Australia. *Austrobaileya* 1(5): 511–520.
- Tng DYP, Dalton PJ, Jordan GJ (2009) Does moisture affect the partitioning of bryophytes between terrestrial and epiphytic substrates within cool temperate rain forests? *Bryologist* 112(3): 506–519.
- Vitt DH, Ramsay HP (1985a) The *Macromitrium* complex in Australasia (Orthotrichaceae, Bryopsida). Part I. Taxonomy and Phylogenetic Relationships. *Journal of the Hattori Botanical Laboratory*. 59: 325–451.
- Vitt DH, Ramsay HP (1985b) The *Macromitrium* complex in Australia. Part II. Distribution, ecology and palaeogeography. *Journal of the Hattori Botanical Laboratory*. 59: 453–468.
- Webb LJ (1959) A physiognomic classification of Australian rain forests. *Journal of Ecology* 47: 551–570.
- Zander R (1972) Revision of the genus *Leptodontium* (Musci) in the New World. *Bryologist* 75: 213–280.