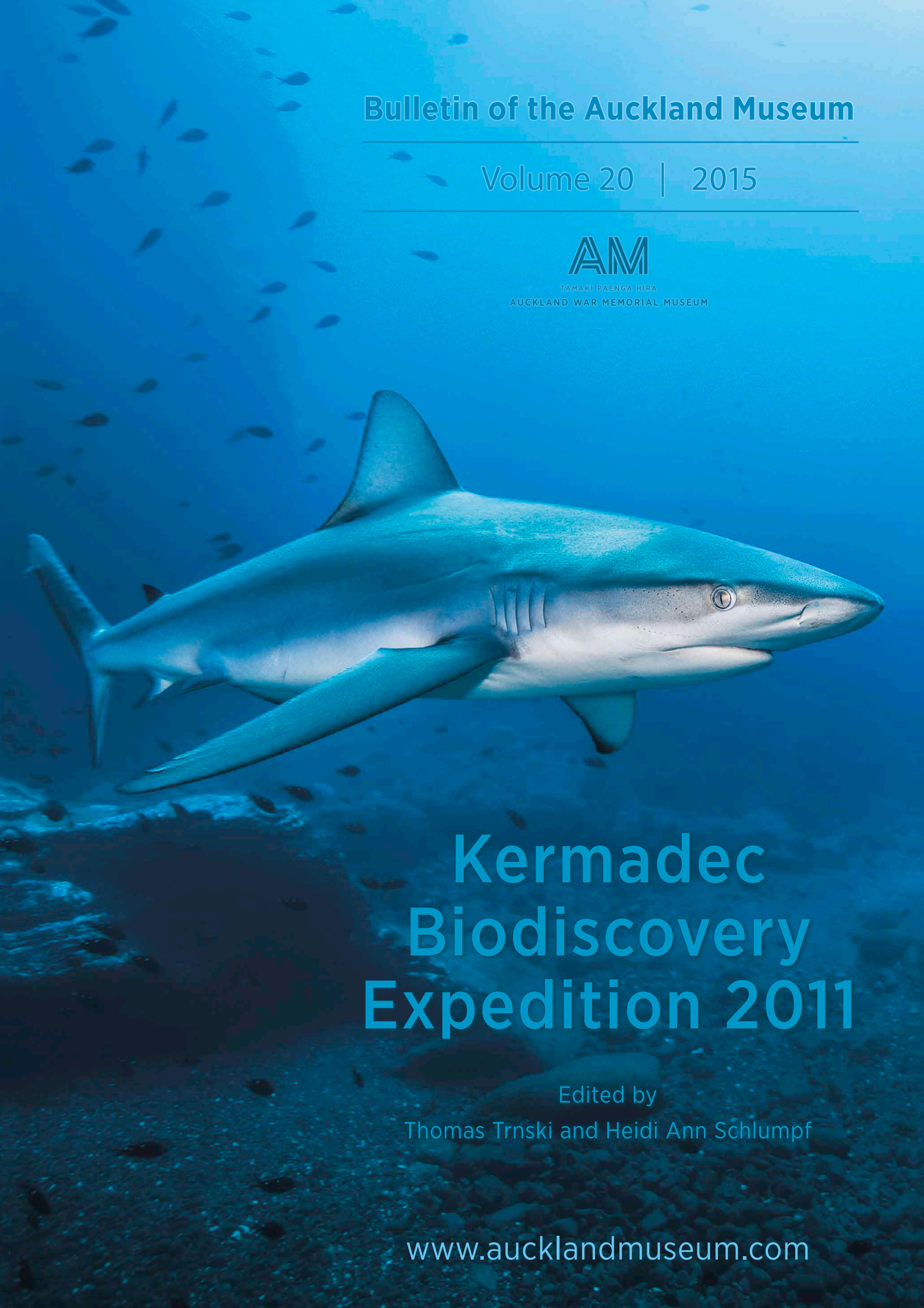




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Recent vegetation succession and flora of Macauley Island, southern Kermadec Islands

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Abstract

A revised listing of the flora of Macauley Island is presented and aspects of its composition discussed. A vascular flora of 92 taxa (including two hybrid combinations and two unnamed entities) and 50 bryophytes is recorded here for the island. Six seaweeds are also recorded from the intertidal zone of the north-eastern coastline of Macauley. Twenty-two taxa (10 Vascular plants, seven liverworts and five mosses) are considered new records for the Kermadec Islands, and 59 taxa (22 vascular plants, 10 liverworts and 27 mosses) are additions to the known flora of Macauley Island. The flora of the island has increased considerably since goats were exterminated from the island in 1970. The vegetation of the island is documented, using broad, empirically derived vegetation associations. Eleven associations are recognised and described and the vegetation succession of the island discussed. While the dominant vegetation cover on the island is still a dense monospecific *Hypolepis* fernland, a treeland of *Homalanthus polyandrus* is now developing. It is suggested that this has happened because kiore (*Rattus exulans*) may have been successfully eradicated from the island in 2006. Notes are made on the condition of the islands vegetation associations in the wake of Tropical Cyclone Bune, which struck the island on 28 March 2011. It is also suggested that the vegetation succession of Macauley Island needs no direct human intervention to make conditions more suitable for sea bird nesting.

Keywords

Kermadec Islands; Macauley Island flora; vascular plants; bryophytes; cyclone-damage; vegetation associations; vegetation succession; *Homalanthus*; rat predation

INTRODUCTION

Macauley Island (c.3 km², 238 m a.s.l., 30° 14' S, 178° 26' W) is the largest and highest of the five islands that make up the southern Kermadec Islands (Fig. 1, 2). The island is roughly circular in shape with a broad gently sloping (rising from north to south) plateau whose surface is broken only by drainage gullies, ravines and a large clearly defined crater just below the south-eastern summit of Mt Haszard. The exposed base is comprised of thick arc tholeiite basalts (Lloyd *et al.* 1996) which dip gently from the south to the north (Fig. 3). These are overlaid by a complex sequence of interbedded pinkish dacitic tephra, followed by a series of pyroclastic dacitic surge deposits (these often admixed with a heterogeneous assemblage of basalt and coarse grained peridotite xenoliths) and finally further dacitic tephra sequences. These dacitic deposits form most of the sheer cliffs which ring the island (a series that is broken only to the south by basalt scoriaceous sequences associated with the heavily eroded and scarcely recognisable northern crater system of Mt Hazard). In places the dacitic cliffs are interrupted either by dark basalt lava flows which seem to be part of the same eruptive sequence that

formed the scoriaceous deposits and lava flows around Mt Haszard; or, by deep erosion gullies and ravines. It is the ravines and gullies that provide the only reliable access paths up to the plateau of Macauley.

The flora of the island was briefly described by Cheeseman (1888) and Oliver (1910) who visited the island in 1887 and 1908 respectively and then again by Sykes (1977) based on two visits there in 1966 and 1970. Subsequent visits by Taylor & Tennyson (1988), Greene *et al.* (2004) and Barkla *et al.* (2008) have added to our knowledge of the islands flora and vegetation associations, adding one new addition to the indigenous flora of the New Zealand Botanical Region (*sensu* Allan 1961) (*Achyranthes velutina* (Fig. 4) (first listed for the island as *A. aspera* in de Lange *et al.* 2004) and also rediscovering the *Homalanthus polyandrus* on the island (Fig. 5). *H. polyandrus* had first been recorded from the island as *Carumbium polyandrum* by Cheeseman (1888), then declared, as a consequence of feral goat browse, extinct by Sykes (1977) only to be rediscovered as a massive, solitary tree in 2006 (Barkla *et al.* 2008). Although the *Homalanthus polyandrus* was the main subject of Barkla *et al.* (2008) in that paper they also provided a revised listing of the vascular flora of Macauley noting 68 vascular taxa

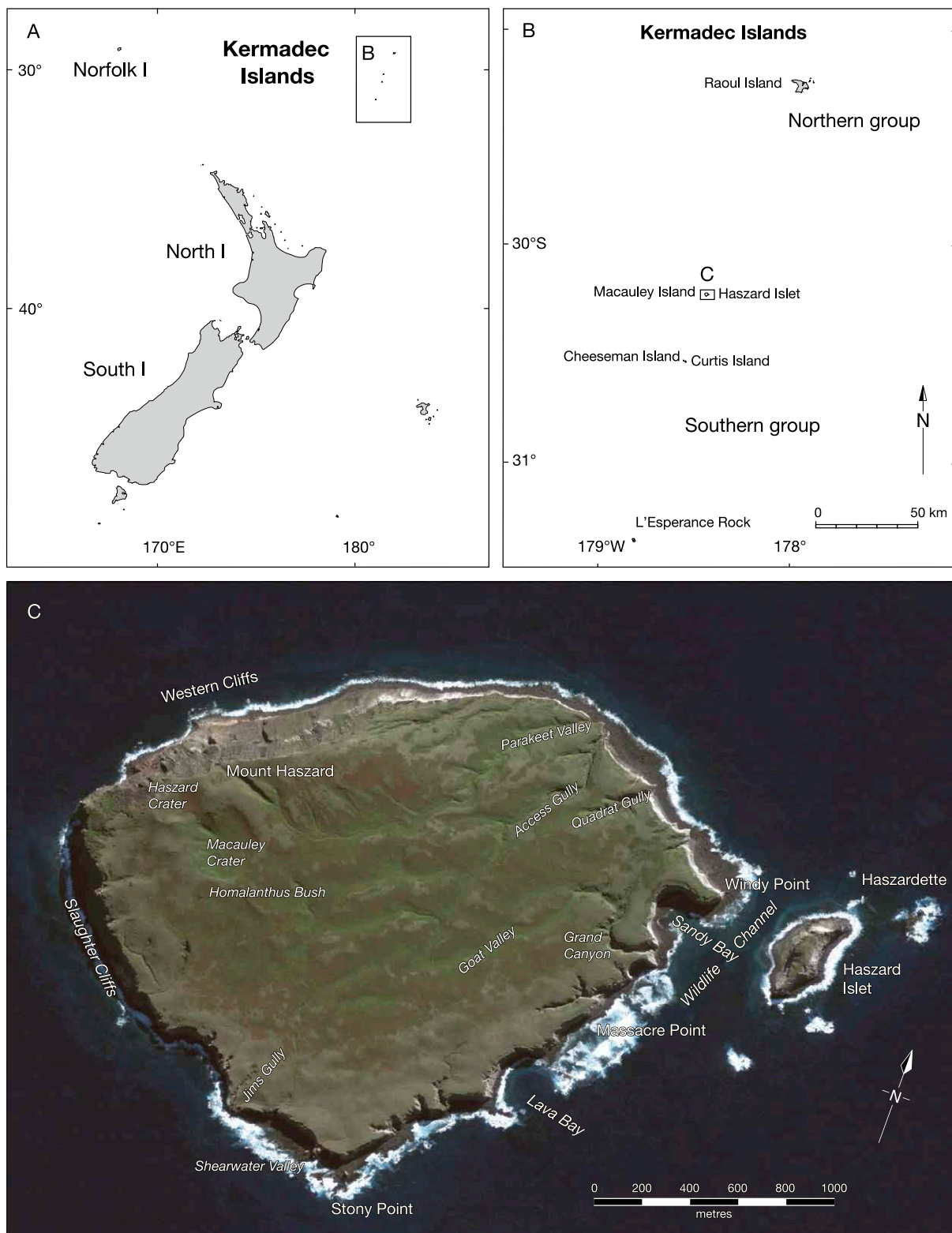


Figure 1. Macauley Island. **A** Location of the Kermadec Islands in the South Pacific, **B** The Kermadec Islands showing the location of the main islands of the northern and southern groups – showing (in box) location of Macauley Island and Haszard Islet, **C** Aerial image of Macauley Island, Haszard Islet and “Haszardette” showing the main geographic features and names used on the island and the location of “Homalanthus Bush”. The aerial image is reproduced courtesy of ‘Digital Globe 2005’ (ID: 10100100046A0F01).

(14 ferns, 38 dicotyledonous, and 16 monocotyledonous plants), 19 of which they regarded as naturalised to the island. No plants were listed as endemic to the island.

The vegetation of Macauley has been severely modified. Polynesians arrived on Raoul Island in the Kermadec Islands c. 700 years ago (Wilmshurst *et al.* 2011). There is so far no archaeological evidence by which to date their arrival on Macauley Island but it is likely that they reached the island at about the same time as reaching Raoul Island, given their rapid patterns of discovery within other Pacific archipelagos of similar size. Kiore or Pacific rats (*Rattus exulans*) are most likely to have been introduced by Polynesians to Macauley Island at the same time (Wilmshurst *et al.* 2011). The first account of the islands's vegetation by Captain W. Sever of the *Lady Penrhyn* in 1788 is of a deforested island (see Oliver 1910). Although Macauley Island was uninhabited at that time, its deforestation is entirely consistent with Polynesian settlement, even periodic, on islands throughout the Pacific, where existing forest was cleared to make way for agriculture (Rolett & Diamond 2004). Sever's description was of an island covered by a "coarse kind of grass...and a great plenty of the wild mangrove" (Oliver 1910). Sykes (1977) interpreted the grass to have been *Cyperus ustulatus* (now referred to *C. insularis* (Heenan & de Lange 2005) and mangrove to *Myoporum obscurum* (now referred to *M. rapense* subsp. *kermadecense* (Chinnock 2007)).

Subsequently pigs (*Sus scrofa*) and goats (*Capra hircus*) were liberated on Macauley Island by whalers sometime in the early 19th century (Sykes 1977; Barkla *et al.* 2008). Due to the cumulative effects of these animals and probably past modification by Polynesians the original flora of the islands was already severely modified by the time it was first properly described by Oliver (1910), by which time the island apparently supported only goats and kiore, the pigs having, it seems, already naturally died out (Oliver 1910). It should be noted that both Sykes (1977) and Barkla *et al.* (2008) provide a more detailed account of the vegetation history of the island than that given above, the salient points of which are that following the eradication of goats between 1966 and 1970 the island has reverted from the goat-induced *Microlaena stipoides* meadow to a landscape dominated by two key vegetation types – a monotonous, monospecific *Hypolepis* fernland (Fig. 6), and a slightly more varied *Cyperus* sedgeland (Fig. 7).

As well as rediscovering *Homalanthus*, Barkla *et al.* (2008) recorded an absence of seedlings and a lack of fruit on the solitary tree. They speculated that the fruits may be destroyed by the islands resident Kermadec Islands kakariki (*Cyanoramphus novaezelandiae cyanurus*) and that this may explain the lack of recruitment. They also (p. 376) rather gloomily noted that the spectacular recovery of *Homalanthus* on Raoul Island following goat eradication from that island would be "unlikely to be replicated on Macauley Island because the vegetation over the plateau...is much more exposed and is still almost totally dominated by herbaceous plants".

Following the 2006 visit described by Barkla *et al.* (2008) an attempt to eradicate kiore was made by

the Department of Conservation (in mid July 2006, K. Baird pers. comm.). Since then the island has not been investigated to see if kiore had been eradicated. Between May 21 and 23 as part of the Auckland Museum led Kermadec Biodiscovery Expedition 2011 I was part of a two person party that landed on Macauley Island to investigate the islands invertebrates, mycobiota and flora. Although our party was not equipped to thoroughly assess whether the attempted kiore eradication had been successful, our task was to make observations that would provide evidence of the presence or absence of kiore.

Although vascular plants were collected during my visit the main focus of the survey was bryophytes, and mycobiota, as these are groups which have scarcely been studied on Macauley, or indeed the Kermadec Islands as a whole (see Sykes 1977; McKenzie 1992; Sykes & West 1996; Beever *et al.* 1996; Renner & de Lange 2011; de Lange & Beever 2015; de Lange & Galloway 2015). During my time on Macauley I also collected intertidal algae and made some observations of the island's vegetation associations.

This paper reports on the findings of that visit, and updates information on the islands flora and vegetation associations.

METHODS

To undertake a survey of the islands intertidal algae, bryophytes, mycobiota and vascular flora during a visit of 3 days meant that there was insufficient time to gather quantitative data on the vegetation associations. I estimate that only about 25% of the actual island was traversed, though because of the terrain much of the island could be visually accessed using binoculars. Faced with these constraints I elected to employ the empirical system of vegetation classification detailed by Atkinson (1985). Specimens collected were treated as follows: Bryophytes, mycobiota were air dried in the field in packets (drying completed during the voyage back to New Zealand), while vascular plants were collected into a solution of three parts concentrated ethanol to one part concentrated acetic acid. Seaweeds were stored in a solution of 1% formalin in seawater. Vascular plants and seaweeds were then sorted, cleaned and air dried at the Auckland War Memorial Museum herbarium (AK). Due to the time of year it was sometimes necessary to take seedlings (especially *Conyza* spp., *Gamochaete* spp. and *Lachnagrostis* spp.) and orchid tubers (e.g., *Microtis*) for cultivation back in Auckland, New Zealand to ascertain their exact identity.

Authorities for all plants seen on Macauley Island are provided in Appendix 1, and in the main body of the text for taxa not noted in the Appendix that are either present on the island (lichens) or not but are discussed. Nomenclature of sea weeds follows that in Harper *et al.* (2012) and Nelson (2012), that for mosses follows that advocated by de Lange & Beever (2015), while that used for liverworts follows Nga Tipu o Aotearoa – New Zealand Plants Database (<http://nzflora.landcareresearch.co.nz/> – accessed 10 May 2012) and for liverwort families, Stotler & Long (2009). Vascular plant nomenclature follows de Lange & Rolfé (2010) with authorities derived from



Figure 2. Macauley Island as viewed off the north-eastern coastline near Haszard Islet looking west to Mt Haszard. In this image the prominent entrance to Access Gully is clearly visible, as is the drainage system that forms Parakeet Valley whose mouth is blocked with a basalt lava flow to the right hand side of this image. *Photo: M. Francis, May 2011*

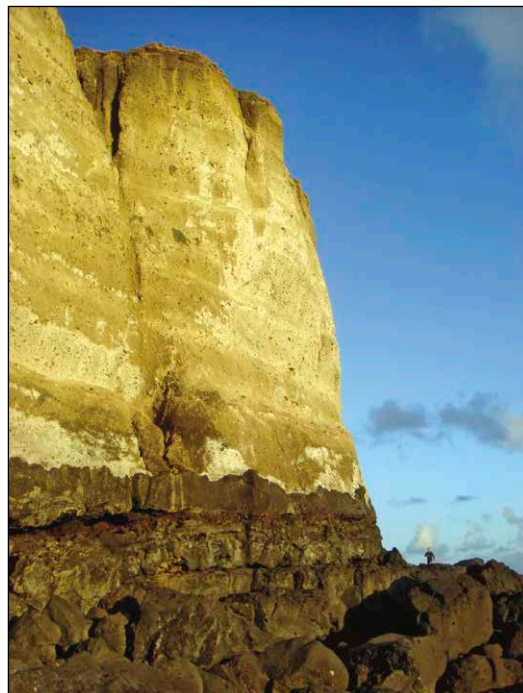


Figure 3. (right) The loosely welded, dacitic pyroclastic cliffs of Macauley Island that lie directly above a dark black shelf of hard tholeiitic basalt. This image, taken at sunrise shows the cliffed northern coastline, rock shelf and boulder beach typical of this part of the island. As an idea of scale note the person on the rock shelf below the cliffs. *Photo: P.J. de Lange, May 2011*



Figure 4. (left) *Achyranthes velutina* in fruit. Mt Haszard Crater cliffs. *Photo: J.W. Barkla, July 2006*



Figure 5. (right) *Homalanthus polyandrus* tree, "Homalanthus Bush", Macauley Island. *Photo: P.J. de Lange, May 2011*



Figure 6. Macauley Plateau looking east toward Haszard Islet showing the dominant *Hypolepis* fernland in the foreground and in the distance *Cyperus* sedgeland. *Photo: P.J. de Lange, May 2011*



Figure 7. *Cyperus* sedgeland, Macauley Plateau looking west to Mt Haszard and Macauley Crater. *Photo: J.W. Barkla, July 2006*

the International Plant Names Index (<http://www.ipni.org/index.html> – accessed 10 May 2012), Australian Plant Census (<http://www.anbg.gov.au/chah/apc/> – accessed 10 May 2012, and Nga Tipu o Aotearoa – New Zealand Plants Database (<http://nzflora.landcareresearch.co.nz/> – accessed 10 May 2012). Exceptions are as follows. For the ferns I have used the family arrangement of Smith *et al.* (2006) and for the *Blechnaceae* that of Perrie *et al.* (2014). For *Sicyos* I have used *Sicyos mawhai* which is a newly described New Zealand Botanical Region endemic (see Telford *et al.* 2012) extending to the Kermadec Islands where it is the only species present (past literature has referred the Kermadec Islands plant to *Sicyos angulatus* L. or *S. australis* Endl. (see Sykes 1977; Sykes & West 1996; Barkla *et al.* 2008)). Similarly the Macauley Island *Lepidium* is now referred to a new Kermadec Islands endemic *L. castellanum* (de Lange *et al.* 2013). For *Nephrolepis* I have followed Hovenkamp & Miyamoto (2005) and referred the Macauley Island *Nephrolepis* to *N. brownii* rather than *N. hirsutula* (G.Forst.) C.Presl (cf. Sykes 1977). *Oxalis thompsoniae* previously regarded as naturalised to the New Zealand Botanical Region (Webb *et al.* 1995) is treated here as indigenous on the basis of comments made by Heenan *et al.* (2009) and Sykes (2009). Vascular plants (excluding lycophytes and ferns) are arranged phylogenetically according to APG III (2009), and then alphabetically by family as per de Lange & Rolfe (2010). Ferns and Bryophytes are also listed alphabetically by family. Herbarium acronyms follow (Thiers 2014).

RESULTS

A total of c.281 plant and fungal gatherings were made, of which 176 (vascular plants, bryophytes, lichens and seaweeds) have been lodged in the Auckland War Memorial Museum Herbarium (AK). One fungus, *Ganoderma* cf. *applanatum* (Pers.) Pat. the first gathering of a fungus for the island, and indeed the southern Kermadec Islands (McKenzie 1992) was lodged with the Plant Diseases Division Herbarium of Landcare Research (PDD). Of the 176 specimens lodged into AK (see Appendix 1), 64 are spermatophytes, 25 pteridophytes, one is a lycophyte (*Lycopodiella cernua*), 66 are bryophytes (15 liverworts and 51 mosses), and seven are seaweeds. So far only 21 lichens (out of the 96 Macauley Island collections) representing 16 taxa have been lodged at AK and UNITEC. As the majority of lichens have yet to be identified they are not listed in this paper though some are discussed in the text.

FLORA OF MACAULEY ISLAND

Intertidal Seaweeds

During my visit to Macauley Island access to the intertidal shoreline was only under taken on the north-eastern portion of the island between Parakeet Valley and Windy Point (Fig. 1) and then only briefly due to the dangerous collecting conditions (de Lange 2012). Nevertheless in this area a limited number of sea weeds were collected, all of which were subsequently identified to genus and/or species level by W.A. Nelson (Table 1). None of the seaweeds seen were common, possibly because of the time of year (C. Duffy pers. comm.), though at the low tide mark within the surge zone two species of *Sargassum*, neither able to be identified to species level, were locally common. The most abundant of these was a small dark-brown fruticose type, and associated with it was an often larger, amber-brown, pendulous type. Both grew in only the most exposed sites on tholeiitic basalt boulders. Admixed within the holdfast of these two *Sargassum* a minute, pinkish, cylindrical red sea weed, possibly *Dasya baillouviana* was also collected. In a few places a third *Sargassum*, *S. aquifolium* was also seen growing within the surge zone but also within a series of very deep rock pools that were present near the low tide mark just east of the Access Gully Entrance (Fig. 1). In these areas *Gelidium isabelae* and *Pterocladia capillacea* were also present, though neither commonly so.

Vascular Flora

Sykes (1977) treated the entire Kermadec Islands vascular flora collectively in his annotated checklist. However, for those plants he regarded as indigenous he gave a listing for each island and islet (Sykes 1977; Table 8). In that Table, 39 indigenous vascular plants were accepted for Macauley Island. However, that Table lists nine “Pteridophytes” (*sensu* Sykes 1977) and 29 (not 30) Spermatophytes, providing a total listing of 38 vascular plants for Macauley Island. Further the listing does not tally fully with the taxa recorded in the annotated portion of the checklist which is in places inconsistent. Thus while Cheeseman’s and Oliver’s published observations (i.e. made without supporting herbarium evidence), of *Homalanthus*, *Pouzolzia australis* (as *Boehmeria australis* var. *dealbata*) and *Solanum aviculare* var. *aviculare* on Macauley Island (Cheeseman 1888; Oliver 1910) were accepted by Sykes (1977), other records of theirs also without supporting herbarium evidence, e.g., *Blechnum kermadecense* (as *Doodia milnei*), *B.*

Table 1. Seaweeds collected from the north-eastern inter-tidal zone of Macauley Island.

? <i>Dasya baillouviana</i> (Gmelin) Mont.	Dasyaceae	AK 327455
<i>Gelidium isabelae</i> W.R.Taylor	Gelidiaceae	AK 327457
<i>Pterocladia capillacea</i> (S.G.Gmel.) Santel. et Hommers.	Gelidiaceae	AK 327459
<i>Sargassum aquifolium</i> (Turner) C. Agardh	Sargassaceae	AK 327453
<i>Sargassum</i> C. Agardh	Sargassaceae	AK 327450
<i>Sargassum</i> C. Agardh	Sargassaceae	AK 327452

norfolkianum, *Carex kermadecensis*, and *Lachnagrostis filiformis* were not. Nor was any explanation offered for why only some of these literature records were accepted for Macauley. Another Cheeseman (1888) Macauley Island observation of the grass *Oplismenus hirtellus* subsp. *imbecillis* (as *O. setarius* Roem. et Schult.), was also not accepted by Sykes (1977) though, on p. 173, as *O. imbecillus* (R.Br.) Roem. et Schult. it was mentioned as “not there in 1966 or 1970”. Notably all of these rejected records were also not supported by a herbarium specimen. Subsequently in Barkla *et al.* (2008) *Blechnum kermadecense*, *Solanum aviculare* var. *aviculare* and *Oplismenus hirtellus* subsp. *imbecillis* were admitted to that islands flora – though again solely on the basis of the published observations by Cheeseman (1888), as they were still without supporting herbarium specimens, yet Cheeseman’s record of *Blechnum norfolkianum* was still not accepted. *Lachnagrostis filiformis* was also admitted to the flora of Macauley Island by Barkla *et al.* (2008) though again without a herbarium specimen, presumably on the basis of its having been recorded from Macauley by Taylor & Tennyson (1988). Finally Oliver’s *Carex kermadecensis* record was also now accepted from Macauley Island, though this record was supported by herbarium evidence (AK 296529!) based on a specimen collected by Taylor during his visit there (Taylor & Tennyson 1988).

Aside from these inconsistencies, Sykes (1977) also recorded a further 13 naturalised vascular plants from Macauley Island. Collectively then and including those Cheeseman and Oliver records of indigenous plants apparently accepted for Macauley Island in the main body of his checklist but not in Table 8, Sykes (1977) recorded 56 vascular plant taxa from Macauley Island (11 “Pteridophytes” *sensu* Sykes 1977, and 45 Spermatophytes).

Barkla *et al.* (2008) increased the vascular flora of Macauley Island to 68 taxa. Aside from those records of Cheeseman (1888) and Oliver (1910) noted above, which they accepted without supporting herbarium specimens, they also admitted a number of vascular plants recorded by Sykes (1977) or observed, though it seems not collected by him during his 1966 visit there (e.g., *Oxalis exilis*). Despite there now being 12 additions to the flora of Macauley Island in Barkla *et al.* (2008), only one of these, *Sonchus asper*, they noted, was a genuinely new discovery stemming from their field work on the island. All the other additions resulted either from taxonomic changes affecting such variable species as *Oxalis corniculata* (see comments on this species by Sykes 1977) or from specimens collected by both G.A. Taylor and A.J.D. Tennyson in 1988 or by T.C. Greene in 2004 and not published. In addition a species of *Achyranthes*, first recorded for the Kermadec Islands from Macauley Island as *A. aspera* (de Lange *et al.* 2004), was treated as *A. velutina* by Barkla *et al.* (2008) on my advice.

In this paper, 92 vascular plants are recorded for Macauley Island (Appendix 1). Sixty-eight of these are regarded as indigenous (this figure includes two hybrid fern combinations, and one fern of uncertain taxonomic status (*Christella* aff. *dentata*), and 24 taxa are regarded

as naturalised. Twenty-two of these vascular plant taxa are new additions to the Macauley Island flora, and of these nine species (four indigenous, five naturalised) and one putative hybrid fern combination (*Asplenium oblongifolium* × *A. shuttleworthianum*) are also new additions to the Kermadec Islands flora (cf. Sykes 1977; Sykes & West 1996; Barkla *et al.* 2008). Four taxa *Blechnum kermadecense*, *B. norfolkianum*, *Pouzolzia australis* and *Solanum aviculare* var. *aviculare* recorded without substantiating herbarium specimens by Cheeseman (1888) and Oliver (1910) were rediscovered.

Bryophytes

Although Sykes (1977, p. 42) considered that bryophytes “have not been properly collected in the Kermadecs” he later stated (p. 49) “the dominant bryophytes on Raoul and Macauley (very few grow elsewhere in the Kermadec Islands) are now known”. Based on the determinations of K.W. Allison, Sykes (1977) listed eight mosses for Macauley Island while the liverworts he gathered from the island were discussed separately by Campbell (1977) who listed four species. Subsequently Campbell (1997) provided a brief update of her listing in which she rejected the Macauley Island record of *Marchantia foliacea* from the liverwort flora of the Kermadec Islands, referring the material she had identified to *M. pileata* instead. This name change aside Campbell (1977, 1997) still only accepted four liverworts for Macauley Island.

Beever *et al.* (1996) revisited the moss flora of the Kermadec Islands but they did not provide a specific island-by-island listing of their distribution (see de Lange & Beever 2015). Nevertheless they examined moss gatherings from Macauley Island, accepting eight for the island, and in the process confirming six of the species listed by Sykes (1977) for that island. They also rejected two listed by Sykes (1977), *Bryum dichotomum* and *Syntrichia phaea* (as *Tortula phaea* (Hook.f. et Wilson) Dixon) referring these gatherings (CHR 163430, CHR 161034) to *Bryum erythrocarpoides* Müll. Hal. et Hampe and *Barbula calycina* respectively. The *Bryum erythrocarpoides* specimen (CHR 163430) was subsequently referred to *B. clavatum* of which it is now regarded as synonym by A.J. Fife (unpublished, notes on CHR 163430) though this synonymy (Beever *et al.* 1996) was not published.

Subsequent visits to Macauley by field parties (see Taylor & Tennyson 1988; Greene *et al.* 2004; Barkla *et al.* 2008) resulted in some moss gatherings (notably *Bryum argenteum*, *Fissidens asplenioides*, *F. linearis* var. *linearis*, mosses which are conspicuous and common on the island). However, none of these were new for the island.

In this paper 14 liverworts are listed for Macauley. Ten of these are additions to the island liverwort flora and seven of these are new additions to the overall Kermadec Islands liverwort flora (see Appendix 1 cf. Campbell 1977, 1997). Furthermore, three liverworts (*Asterella australis*, *Marchantia foliacea* and *Telaranea quinquespina*) are so far only known in the Kermadec Islands from Macauley Island. The discovery of *Marchantia foliacea* on Macauley Island is notable as this species had first been

recorded for the Kermadec Islands by Campbell (1977) only to be later rejected from it (Campbell 1997).

The presence of *Lunularia cruciata* on Macauley is also interesting because this is a widespread naturalised species in New Zealand (see: <http://nzflora.landcareresearch.co.nz/default.aspx?selected=NameDetails&TabNum=0&NameId=9389C2DF-E31F-446B-9143-0E2509017867> and <http://www.virtualherbarium.org.nz/map.3> both accessed 10 May 2012). *Lunularia cruciata* was not recorded for the Kermadec Islands by Campbell (1977, 1997) though it is now very common on Raoul Island (P.J. de Lange unpubl. data). Significantly it was not collected by field parties surveying Macauley Island in the 1980s and 2000s (Taylor & Tennyson 1988; Green *et al.* 2004; Barkla *et al.* 2008). However, these parties did collect conspicuous bryophytes including *Plagiochasma rupestre* which is of a similar size range and has a superficial resemblance to *Lunularia* with which it often grows, so it seems likely that had *Lunularia* been there in any quantity they would have collected it as well. Thus I think it likely that *Lunularia* is a recent arrival to Macauley Island. On Macauley Island it is now locally common, though it was seen only in Quadrat and Access Gullies. As these gullies now provide the main access points to Macauley Island used by shore parties since the 1990s it may be that it has established in these areas in association with human traffic, emanating from either Raoul Island or New Zealand.

The apparent absence of hornworts from Macauley Island is interesting. Possibly the habitat there is too marginal for these plants, though considering the presence of other moisture-loving thalloid liverworts as *Dumortiera hirsuta*, *Marchantia foliacea* and *M. pileata* on the island, hornworts should still be there. Future surveys, ideally during winter should look for these often highly seasonal plants.

Thirty-eight mosses are listed here for Macauley Island of which 29 are new to that island's flora. Of these, five (*Byrum radiculosum*, *Didymodon torquatus*, *Ditrichum difficile*, *Rosulabryum capillare* and *Schistidium apocarpum*) are also new additions to the moss flora of the Kermadec Islands being as yet only known from Macauley Island. One moss, *Weissia* "North Cape" proved common Macauley Island. It is a potentially new species found also in northern New Zealand, whose status is discussed in more detail by de Lange & Beever (2015). As there is nothing singular about the habitats they occupy on Macauley Island it is likely that they will occur elsewhere in the group, most especially on Raoul Island.

Taxonomic Issues

One fern *Christella* aff. *dentata*, and a putative hybrid fern, *Asplenium oblongifolium* × *A. shuttleworthianum*, recorded from Macauley Island require further taxonomic investigation.

On the Kermadec Islands, as in New Zealand proper (see Brownsey *et al.* 1985; Brownsey & Smith-Dodsworth 2000) there are two races of *Christella*. One has widely creeping, usually partially buried rhizomes, and fronds often widely spaced along these, or bunched at growing points (see de Lange *et al.* 2010) while the other has

shortly creeping, exposed rhizomes with plants developing over time a shortly erect caudex the base of which often buds and proliferates so producing over time additional caudices (see comments by Brownsey *et al.* 1985). The first race, currently equated with *C. dentata* (Forssk.) Brownsey et Jermy (see Brownsey & Smith-Dodsworth 2000) is scarce in continental New Zealand being known now only from one site near Kaitia (de Lange *et al.* 2010), while the other is widespread, sometimes even locally common in geothermal sites in the Taupo Volcanic Zone, and, albeit less frequently, also in similar sites on Raoul Island. It is also known from non-thermal sites in Te Paki (P.J. de Lange unpubl. data). It is this race which occurs on Macauley Island. At this stage, no one is actively researching the genus in New Zealand.

One fern hybrid combination, *A. oblongifolium* × *A. shuttleworthianum* recorded here for Macauley Island requires further study. Previously the putative hybrid combination *Asplenium northlandicum* × *A. shuttleworthianum* (as *A. obtusatum* subsp. *northlandicum* Brownsey × *A. shuttleworthianum* Kunze) had been accepted for the Kermadec Islands initially on the strength of a collection made from the Northern Kermadec Islands on the Meyer Islands (Brownsey 1977). The same hybrid was later reported from Boat Cove, Raoul Island (Sykes & West 1996). Of that hybrid, Sykes & West (1996) note that it was in part the basis of the earlier listing in Sykes (1977) of a hybrid swarm that he had attributed to *A. flaccidum* G.Forst × *A. lucidum* G.Forst. (now *A. oblongifolium* Colenso) and/or *A. obtusatum* G.Forst. (Kermadec Islands plants of which are now referred to *A. northlandicum*). Although Sykes (1977) stated he was uncertain as to the exact parentage of these hybrids, he noted that (p. 63) '*A. flaccidum* has not been found on the Meyers'. Since then it has been recognised (see Sykes & West 1996) that Northern Kermadec Islands examples of *A. flaccidum* actually comprise two taxa, *A. flaccidum* s.s. and *A. aff. haurakiense* (Brownsey) Ogle. Of the two, *A. aff. haurakiense* is the more common, especially at lower altitudes and along the coast. So it is more likely to be involved in hybridisation in these areas than the relatively scarce, upland species *A. flaccidum*. For the Meyers specimen, a W.R.B. Oliver gathering (WELT P1967), the belief that *A. flaccidum* (more probably *A. aff. haurakiense*) was absent, the presence of aborted spores and the morphological intermediacy of the hybrid, along with a knowledge of associated *Asplenium* species on the Meyers collected by Oliver at the same time led Brownsey (1977) to suggest a parentage involving *A. northlandicum* (as *A. obtusatum* subsp. *northlandicum*) and *A. shuttleworthianum* for that gathering. Later Sykes & West (1996; p.453) included Raoul Island specimens from Boat Cove within this hybrid combination. Though they gave no compelling reasons for this decision simply stating that the specimens Sykes (1977) had believed were hybrids of unclear parentage 'really belong to this *A. shuttleworthianum* hybrid [i.e. *Asplenium northlandicum* × *A. shuttleworthianum*]'. In any case examination of the Boat Cove gathering in question (CHR 176161!) shows that this parentage was determined not by these authors but by P.J. Brownsey in May 1979. Irrespective, any decision

as to hybrid parentage, based solely on the morphology of the hybrid and its stated association (notably based on herbarium notes and specimens) with other putative parents on the Meyers and Raoul Island is fraught, because at both localities, other than *A. shuttleworthianum*, *A. aff. haurakiense*, *A. northlandicum* and *A. oblongifolium* are all present (cf. Sykes 1977).

Therefore, aside from *A. shuttleworthianum* which is, morphologically speaking almost certainly involved, any of these other species may be involved in the hybrids recorded from these stations. Luckily the situation on Macauley Island seems a little clearer. There, a putative hybrid *Asplenium*, *A. oblongifolium* × *A. shuttleworthianum*, was collected (AK 325824) growing from within a large mass of *A. oblongifolium* on a cliff face in Quadrat Gully. Associated with *A. oblongifolium* and the hybrid were numerous plants of *A. shuttleworthianum*. *Asplenium aff. haurakiense* is absent from the island, and although *Asplenium northlandicum* is present in the general area where the hybrid was collected, it did not grow in the immediate vicinity of the putative hybrid and the postulated parents. So in this case the intimate association of the putative hybrid with *A. oblongifolium* and *A. shuttleworthianum*; along with the stature of the plant, especially the large size of the pinnules all suggest this parentage is more probable than one involving *A. northlandicum*. Of course, *A. northlandicum* may still be involved as it is very common on Macauley Island and it is unlikely that its spores would not have reached the part of Quadrat Gully where the hybrid was found. Interestingly, the Macauley Island hybrid plant is also morphologically very similar to the Boat Cove, Raoul Island *Asplenium* hybrid specimens that I have seen (e.g., AK 242181! CHR 176161!) but not those that I have seen from the Meyers (e.g., AK 292899!, WELT P1967!) which are smaller plants with shorter, much more finely divided pinnules and which I believe are more likely to be *A. northlandicum* × *A. shuttleworthianum*. On that basis it does seem that the Raoul Island (Boat Cove) and Macauley Island *Asplenium* hybrid specimens would be better treated as *Asplenium oblongifolium* × *A. shuttleworthianum*. Nevertheless, the issue of exactly what the parentage is of all these putative hybrids needs more critical evaluation than can be offered here or indeed by Sykes (1977), Brownsey (1977) or Sykes & West (1996).

CYCLONE DAMAGE

On the 28 March 2011 the Kermadec Islands were struck by Tropical Cyclone Bune (de Lange 2011, 2012). The cyclone had a major impact on the forest cover of Raoul Island and the nearby Meyer Islands and Herald Islets, toppling and/or completely defoliating many of these islands' canopy trees (de Lange 2011). Further in many places the understorey and ground cover was stripped bare, resulting in tremendous soil erosion. In the southern Kermadec Islands the impact of Tropical Cyclone Bune was also severe (de Lange 2012) however, because those islands are not forested cyclone damage was not so obvious. On Macauley Island, cyclone damage was most apparent in the taller woody species, thus most

Myoporum and the more isolated *Homalanthus* trees had been severely defoliated, though by the time of my visit these were showing signs of vegetative recovery, mostly as regrowth from epicormic shoots. Cyclone damage was also obvious in such scrambling plants as *Disphyma*, especially where it grew along the exposed cliff faces, boulder and talus slopes and along the small beach on the north eastern coastline leading to Windy Point. Here the majority of the *Disphyma* seen were either dead or nearly so, though beneath and between the dead plants were countless seedlings. Interestingly, the *Hypolepis* fernland and *Cyperus* sedgeland showed no obvious cyclone damage. In the die back areas were numerous dead *Sicyos mawhai* vines and the only specimens seen of this species were seedlings at the cotyledon stage or young vines up to 1 m long. Over all though, by comparison to the vegetation on the other southern Kermadec Islands visited during the 2011 Biodiscovery Expedition, Cheeseman and L'Esperance (see de Lange 2012), Macauley seemed to have suffered the least from Tropical Cyclone Bune.

VEGETATION ASSOCIATIONS

Due to time constraints no quantitative data were obtained to validate the following vegetation associations. Nevertheless using the system of Atkinson (1985) 11 empirically derived vegetation associations could be distinguished, and these are described below, and a generalised vegetation map showing their distribution provided (Fig. 8). The vegetation associations are arranged by order of their occurrence from the coastline of Macauley Island inland. Most of these correlate to those briefly described by Sykes (1977), Greene *et al.* (2004) and Barkla *et al.* (2008). Each vegetation association is numbered (i.e. 1–11) to assist with the interpretation of the vegetation map (Fig. 8).

1. *Disphyma* turf

Along the most exposed cliff tops of the island (Fig. 8), especially toward Windy Point and along the Slaughter Cliffs a dense turf of almost pure *Disphyma australe* subsp. *stricticaule* is present (Fig. 10). This turf also fringed the upper portions of the ravines and gullies draining this area. In places this monotonous turf was broken by plants of *Tetragonia tetragonoides*, *Polycarpon tetraphyllum*, *Ficinia nodosa*, *Scaevola gracilis*, *Cotula australis*, *Microlaena stipoides*, *Parietaria debilis*, *Oxalis exilis*, *O. thompsoniae* and *Solanum nodiflorum*. Active burrows of white-naped petrels (*Pterodroma cervicalis*) and wedge-tailed shearwaters (*Puffinus pacificus*) were common in these areas. Below the cliffs on the northern coastline near Windy Point sand has accumulated behind the shelving rock shore platform. Here, *Disphyma* though still dominant, grows intermixed with *Calystegia soldanella* and *Tetragonia tetragonoides*, forming a small area of vineland that given time and continued sand accumulation may eventually form a distinct vegetation association. In many places Kermadec Islands kakariki were observed nipping the leaf tips of the *Disphyma*, in some places this cropping seemingly causing quite severe damage.

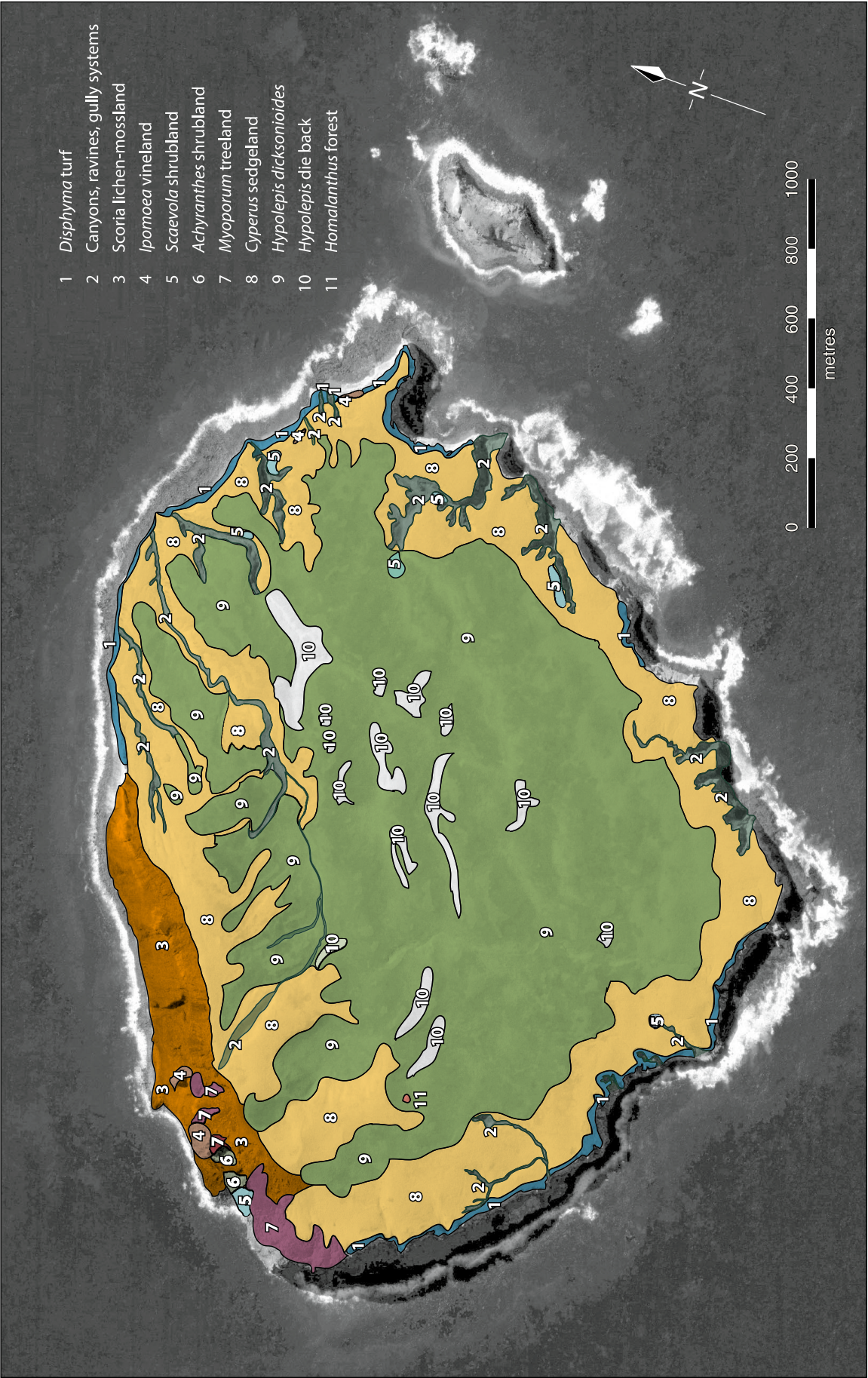


Figure 8. Generalised vegetation map of Macauley Island. Vegetation associations are numbered as per text.

2. Canyons, Ravines and Gully Systems

Much of the Macauley Plateau is dissected by steep-sided ravines and gully systems (Fig. 8. 11A-C) (see also de Lange 2012) which have cut down through the soft dacitic rock and pyroclastic flow material that forms much of the cap rock of this part of the island (Fig. 11B). In a few places, most notably the Grand Canyon several tributary systems have converged to produce a spectacular, deep canyon system whose walls are for the most part vertical. Some of these drainage systems are partially blocked off by basalt lava flows (Fig. 11C) and/or scoriaceous tuff deposits and in places past flows have scoured this material so forming small overhangs and caves. These areas provide a series of slightly damper and more sheltered habitats than those formed by this rock type elsewhere on the plateau, northern or north-western cliffs, and as such they support a range of plants either not common elsewhere on the island, or only seen in these places. Of these plants the ferns *Asplenium oblongifolium*, *Blechnum molle*, *Pellaea falcata* and grass *Poa polyphylla*, were

best developed in the shaded ravines (especially Access and Quadrant Gullies) along the north-eastern end of the island, and here too grew the best examples of *Asplenium oblongifolium* and *A. shuttleworthianum*, and, at one site a putative hybrid between the two. The large thalloid liverwort *Dumortiera hirsuta* first collected from the Kermadec Islands from Raoul and Macauley Island by Sykes (see Campbell 1977), was also rediscovered in this type of habitat in the Grand Canyon. Of the bryophytes the most commonly seen in these areas were *Bryum dichotomum*, *Fissidens linearis* var. *linearis*, and the naturalised *Lunularia cruciata*.

3. Scoria Lichen – Moss Field

The seaward scoriaceous basalt sequences, notably the cliff faces below Mt Haszard and their associated talus slopes (Fig. 8) are often sparsely vegetated or otherwise devoid of vascular plant growth (Fig. 12). In these areas, in a few places such as behind fallen blocks and in sheltered nooks and crannies on the lower



Figure 9. (left) *Lepidium castellanum*. The taller of three plants seen on the cliffs near Windy Point in July 2002 and 2006 all had vanished by 2011. Photo: J.W. Barkla, July 2006

Figure 10. (right) *Disphyma australe* subsp. *stricticaule* in flower. *Disphyma* not only forms a distinct band along the northern cliff faces of Macauley Island but in the few places such as at the entrance to Access Gully and Grand Canyon, and below the northern cliffs near Windy Point where sand has accumulated. It also grows with *Calystegia soldanella* and native spinach. Photo: P.J. de Lange, May 2011



Figure 11. Examples of the Canyon, Ravine and Gully systems of Macauley Island. **A** upper Quadrant Gully floor showing dense, monospecific growth of *Hypolepis dicksonioides*, this fernland dominates the floors of most of the islands drainage systems. **B** entrance to Access Gully, even here, despite the apparently barren conditions virtually the entire gully floor is occupied by the burrows of white-naped petrels and black-winged petrels (*Pterodroma nigripennis*). **C** mouth of Parakeet Valley which is blocked by a large lava flow. Higher up the valley becomes deeper with the lava flow forming the floor. Photo: P.J. de Lange, May 2011

cliff faces a stunted growth of such ferns as *Asplenium northlandicum*, *A. shuttleworthianum*, *Blechnum parrisiae*, *B. molle*, *B. zeelandicum*, *Pellaea falcata*, the grass *Lachnagrostis littoralis* subsp. *littoralis*, and *Polycarpon tetraphyllum* is present. However, in most places the open ground is given over to a rich lichen field comprised of such genera as *Caloplaca* spp., *Heterodermia* spp., *Physcia* spp., *Ramalina microspora*, and *Dufourea ligulata* (Körb.) Frödén, Arup et Søchting. Occasionally, especially where there are large scoria blocks lying about, their south facing sides and overhangs were often clothed in mosses (typically *Bryum argentum*, *B. dichotomum*, *Fissidens linearis* var. *linearis*, *Macromitrium brevicaulis*, *Syntrichia laevipila*, and *Weissia* spp.) and liverworts (mostly *Plagiochasma rupestre* and *Frullania pentapleura*).

4. *Ipomoea* vineland

Along the more exposed portions of the western, scoriaceous cliff faces and slopes near Mt Hazard (Fig. 8), in places where *Myoporum* is absent or sparse *Ipomoea cairica* forms a dense vineland (Fig. 13). Common associates of this vegetation association include *Cyperus insularis*, *Achyranthes velutina*, *Scaevola gracilis* and *Solanum nodiflorum* – most of which are being actively smothered by the *Ipomoea*. Barkla *et al.* (2008) did not distinguish an *Ipomoea* vineland but their notes suggest that they saw the beginnings of this vegetation association because they noted that *Ipomoea* was spreading and that it was a feature of the vegetation along the cliffs near Windy Point (Fig. 14). This is still the case near Windy Point. Barkla (pers. comm.) also noted *Ipomoea* vineland on the southern seaward slopes below Mt Hazard where it formed an almost pure association. By May 2011 the *Ipomoea* vineland had spread north into the main area where Barkla *et al.* (2008) had noted only *Achyranthes velutina* as present.

5. *Scaevola* “shrubland”

Scaevola, is a shrubby scrambling plant which in places can form mounds up to 1.6 m deep. Tangles of pure to almost pure *Scaevola gracilis* “shrubland” (Fig. 15) were noted mostly along the plateau around Windy Point, above the eastern side of Quadrat Gully and along the eastern coastal cliff margins of the island (Fig. 8). The same vegetation type was also sparingly developed on the scoria talus slopes forming the north-western cliffs below the Mt Hazard Crater (Fig. 8). Within the *Scaevola* were numerous petrel-burrows, these at the time of my visit were mostly occupied by black-winged petrels. This association was not reported by either Sykes (1977) or Barkla *et al.* (2008). However, it was seen in 2006 (Barkla pers. comm.) at the head of, for example, tributary gullies feeding into Grand Canyon. Generally *Scaevola* “shrubland” was best developed at the heads of small ravines and gullies or along the ecotones between the *Disphyma* turf and either the *Cyperus* sedgeland or *Hypolepis* fernland. While the “shrubland” usually consisted of a dense tangle of intermeshed *Scaevola*, in places this was broken by

occasional specimens of *Cyperus insularis*, *Ficinia nodosa*, *Hypolepis dicksonioides*, species through which *Scaevola* seemed to an effective invader. In a few places *Scaevola* was itself covered in dense tangles of *Ipomoea cairica*. The overall impression is that *Ipomoea* appears to be displacing *Scaevola*, while *Scaevola* seems to be capable of displacing *Cyperus insularis* and *Hypolepis dicksonioides*. Dense, monospecific patches of *Scaevola* was also occasionally noted draping the cliff faces within the Grand Canyon, Quadrat and Access gullies (Fig. 1B).

6. *Achyranthes* shrubland

On the extensive scoria scree slope along the north-western side of Mt Hazard (Fig. 8), in places devoid of *Myoporum* and *Ipomoea*, a dense dwarf shrubland of *Achyranthes* has now developed (Fig. 16). *Achyranthes velutina* was first noticed on Macauley Island in this general area as a few shrubs in 2002 (de Lange *et al.* 2004). Four years later Barkla *et al.* (2008) noted that it had spread rapidly and was now also present near Windy Point. In May 2011, *Achyranthes* was now sufficiently common to dominate large parts of the scoria slopes below Mt Hazard. In these areas it forms an almost pure vegetation, in places nearly 1 m tall, through which grew occasional tangles of *Ipomoea cairica* and *Sicyos mawhai*, the sedge *Cyperus insularis*, swards of *Poa polyphylla*, and the common autumnal to winter green annual *Cotula australis*. Although widespread, the impression is that this shrubland is now beginning to be displaced by *Ipomoea cairica*.

7. *Myoporum* treeland

Myoporum is still, as noted by Sykes (1977) and Barkla *et al.* (2008) virtually confined to the western, scoriaceous cliff faces and slopes near Mt Hazard (Fig. 8, 17). Here it forms a monospecific often rather open treeland whose sparse canopy ranges from 2–8 m in height. The branches of some *Myoporum* were festooned in shaggy growths of the fruticose lichen *Ramalina pacifica* as well as crusts of *Heterodermia* spp., *Physcia* spp., and *Dufourea ligulata*. Sparse subcanopy associates of this treeland included solitary examples of *Pouzolzia australis* (Fig. 18) and *Solanum aviculare* var. *aviculare*, and a few *Coprosma petiolata*. Overall though, the understorey of this treeland was usually devoid of vegetation. However, in a few places a ground cover of *Cyperus insularis*, *Ipomoea cairica*, *Achyranthes velutina*, *Asplenium northlandicum* and *A. shuttleworthianum* was present, especially in those places where large scoria blocks, collapsed from the cliffs above provided some shade and shelter from the wind. Elsewhere, as noted by Barkla *et al.* (2008) *Myoporum* trees are now a minor component of the plateau and ravine vegetation. While Barkla *et al.* (2008) were the first to record the spread of ngaio back onto the plateau, my limited observations suggest that *Myoporum* is now actively expanding across the plateau (but only in the die back areas) though perhaps not nearly as quickly as that observed for the *Homalanthus*. As with *Homalanthus* I assume the seed of ngaio is being dispersed by Kermadec Islands kakariki.



Figure 12. Open scoria slopes such as seen here are common along the north-western cliff tops and faces of Mt Haszard and the associated Haszard Crater system. Though often devoid of vascular plants (or supporting only stunted *Cyperus insularis* and *Ficinia nodosa*) in places the scoria was covered in a colourful lichen field of mostly crustose *Caloplaca* spp., *Haematomma fenizianum* A.Massal., *Heterodermia tremulans* (Müll. Arg.) W.L.Culb., and *Dufourea ligulata*, and, in places, the fruiticose *Ramalina microspora*. However, where boulders provided some shelter the mosses *Bryum argenteum*, *B. dichotomum*, *B. clavatum* and liverworts *Frullania pentapleura* and *Plagiochasma rupestre* were often locally common. Note on the slopes below an area of *Scaevola* “shrubland” grading into Kermadec Islands ngaio treeland. Photo: P.J. de Lange, May 2011



Figure 14. *Ipomoea* vineland near Windy Point. At this site *Ipomoea* appears to be actively expanding into the surrounding *Cyperus* sedgeland. Associated plants are few but in this image a few specimens of *Sicyos mawhai* can be seen. Photo: P.J. de Lange, May 2011

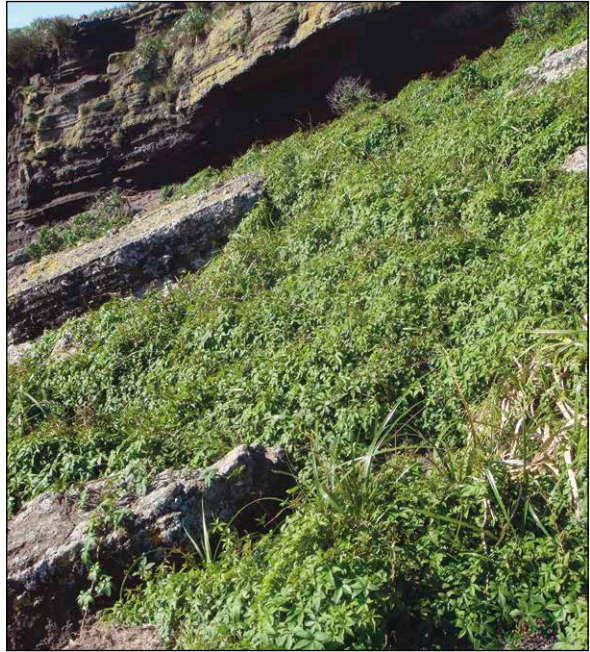


Figure 13. *Ipomoea* vineland on scoria talus slopes below Mt Haszard. Also in this image the sparse cliff vegetation, comprising mostly *Ficinia nodosa*, *Cyperus insularis*, patches of *Poa polyphylla*, cyclone battered Kermadec Islands ngaio (*Myoporum rapense* subsp. *kermadecense*) and dense lichenfield of mostly *Caloplaca* spp., and *Dufourea ligulata* can be seen. Photo: P.J. de Lange, May 2011

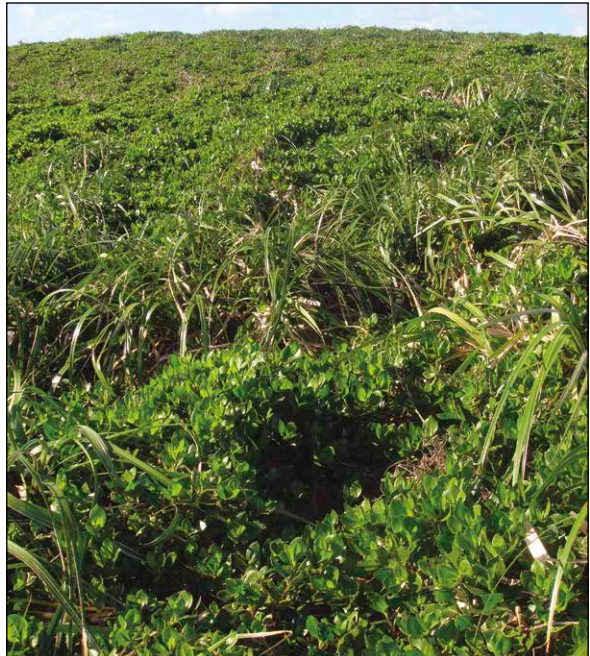


Figure 15. *Scaevola* “shrubland” above Quadrat Gully. At this site *Scaevola* forms dense smothering patches of vegetation in places up to 1.6 m deep. In these areas the associated *Cyperus insularis* plants were all in ill thrift and many were dying. It would appear that *Scaevola* is now actively expanding its range on Macauley Island into the surrounding *Cyperus* sedgeland though notably, not into the *Hypolepis* fernland. Photo: P.J. de Lange, May 2011

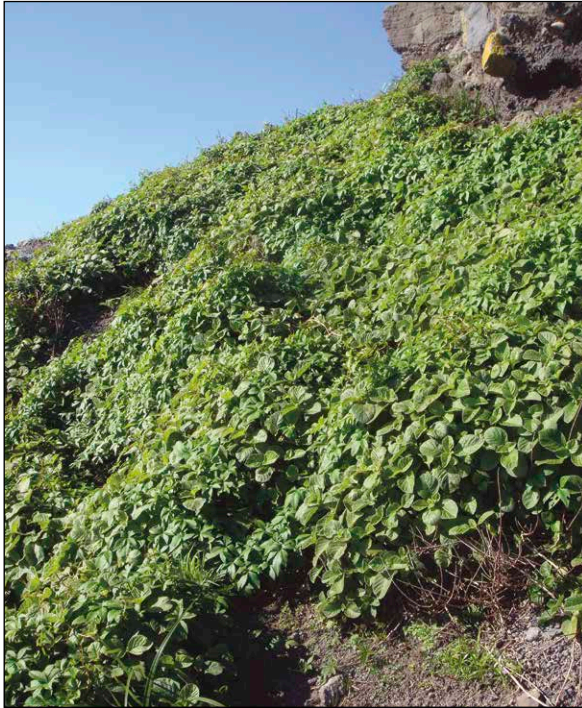


Figure 16. *Achyranthes* shrubland below Mt Haszard.
Photo: P.J. de Lange, May 2011

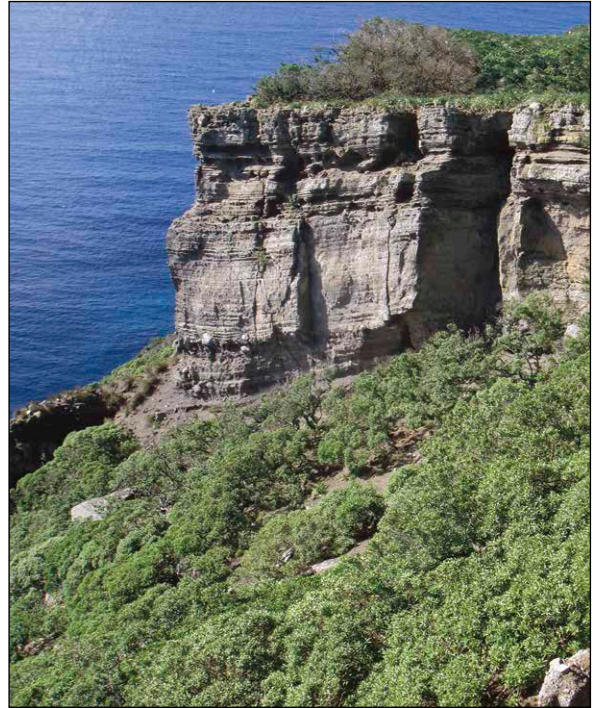


Figure 17. *Myoporum rapense* subsp. *kermadecense* treeland on scoria talus slopes below Mt Haszard.
Photo: P.J. de Lange, May 2011



Figure 18. *Pouzolzia australis* believed extinct on Macauley and rediscovered as a single shrub during the May 2011 visit. Photo: P.J. de Lange, May 2011



Figure 19. White-naped petrels (*Pterodroma cervicalis*) amongst *Cyperus insularis* in *Cyperus* sedgeland. These petrels are virtually endemic to the Kermadec Islands and having gone extinct on Raoul Island their main nesting ground is Macauley Island. Photo: P.J. de Lange, May 2011



Figure 20 A-B. Die Back Area. **A** portion of die back area near source of Goat Valley showing masses of dead, standing *Solanum* and *Eucalyptus sphaericus*, patches of *Hypolepis dicksonioides* while in the foreground young plants of *Carex kermadecensis* and *Cyperus insularis* are establishing. The yellow turf on the left hand side of the die back is *Cyperus brevifolius*. **B** An area of die back dominated by *Solanum* stems and collapsed branches. Note the small vine of *Sicyos mawhai*, and the curving line of dead *Solanum*, caused by tunnel-gully erosion. Photo: P.J. de Lange, May 2011



Figure 21. Dense growth of *Carex kermadecensis* within a die back area. Although the patches of this sedge are still very small it is now common in many die back areas suggesting that in time a distinct sedgeland dominated by this species may yet develop on the island. Photo: P.J. de Lange, May 2011



Figure 22. Dead *Homalanthus polyandrus*, which is all that now remains of the tree recorded from Macauley in 2006 (Barkla et al. 2008). Photo: P.J. de Lange, May 2011



Figure 23. Seedlings of *Homalanthus polyandrus* within "Homalanthus Bush". Photo: P.J. de Lange, May 2011

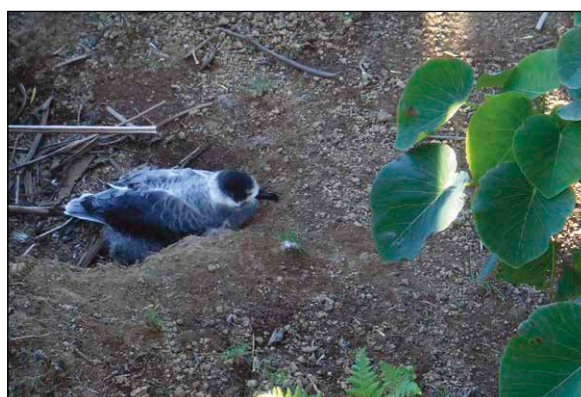


Figure 24. White-naped petrel (*Pterodroma cervicalis*) fledgling in burrow within "Homalanthus Bush". Photo: P.J. de Lange, May 2011

8. *Cyperus* Sedgeland

Sedgeland dominated by *Cyperus insularis* (Fig. 7) forms the next most common vegetation association, occupying perhaps some 15% of the island's plateau, gullies and ravines (Fig. 8). Although *Cyperus* is the main species of the association, in places *Carex kermadecensis* may be locally common. Other sparse associates observed included *Bidens pilosa*, *Cotula australis*, *Sicyos mawhai*, *Ficinia nodosa*, *Achyranthes velutina* and, near the crater, *Homalanthus*. Judging from the observations made by Sykes (1977) and Taylor & Tennyson (1988) *Cyperus* sedgeland was the first vegetation association to replace the *Microlaena stipoides* swards noted in by Sykes during his 1966 visit, and between 1970 and 1988 it may even have been temporarily the dominant vegetation type on the island, after which it was rapidly replaced by the *Hypolepis* fernland. In contrast to the fernland, the sedgeland is extensively petrel-burrowed, and during our visit the burrows were mostly occupied by the near-endemic fledgling white-naped petrels (Fig. 19). Aside from this species other commonly observed birds in the burrows of the sedgeland were black-winged petrels, wedge-tailed shearwaters, and less frequently little shearwater (*Puffinus assimilis kermadecensis*) fledglings as well as adults. *Cyperus* sedgeland also appears to be the preferred habitat for the Kermadec Islands kakariki, birds of which were often flushed from amongst the dead foliage of the *Cyperus* plants during our survey.

9. *Hypolepis* fernland

As reported by Greene *et al.* (2004) and Barkla *et al.* (2008) *Hypolepis* fernland (Fig. 6) now forms the dominant vegetation association on Macauley Island (Fig. 8). The fernland ranges from near sea level along the ravine and gully bottoms to the summit slopes of Mt Haszard, and it entirely blankets the crater below that peak. Although I was unable to accurately assess its percentage cover on the island it is likely to cover more than 70% of the plateau, and it is also the most common vegetation association covering the floors of the larger gullies and ravines (Fig. 8, 11A). The fernland is comprised entirely of a monotonous, dense (100% cover) of actively growing fronds of *Hypolepis dicksonioides*, surmounting a dense layer of dead or dying fronds and rhizomes of this species. During my visit this mass was in places up to 2 m tall though it was more usually within the range of 0.8–1.5 m. With the exception of one place, on a ridgeline running north to the Mt Haszard crater where a few, widely spaced, solitary *Homalanthus* have broken through this fernland, there are no other associated plants. As noted by past ornithological teams this dense fernland is suboptimal habitat for nesting birds (Taylor & Tennyson 1988; Greene *et al.* 2004) and I saw very few petrel burrows; those seen occurring mainly along the ecotone between the fernland and *Cyperus* sedgeland. In the few places where active burrows were present, these were occupied by black-winged petrels and wedge-tailed shearwaters.

10. Die Back Areas

Barkla *et al.* (2008) observed areas of fern die back (Fig. 20A, B) in which they reported a local dominance of *Solanum nodiflorum* (as *S. americanum* subsp. *nutans*). These die back areas, occur in two situations: along drainage lines and depressions and on the interfluves between these. In 2006 (Barkla pers. comm.) die back was restricted to interfluves and probably resulted from storm damage. However, in 2011 die back was mostly observed following drainage lines on the plateau. These areas of die back may be derived from tunnel-gully erosion (see comments by de Lange 2012), a process causing drought stress and death to the taller overlying vegetation. During my visit the extent of these areas of die back appeared to have increased from the c.1 ha Barkla *et al.* (2006) had observed though I was unable to quantify this. In contrast to what was observed by Barkla *et al.* (2008) these areas were now virtually devoid of living *Solanum*. Rather the ground, where it was not covered in dead *Solanum* and *Euchiton sphaericus* stems (Fig. 20B) usually supported a mosaic of vegetation types too interwoven and complex to easily define. Therefore they are collectively described here under the catch all “Die Back Areas”. Probably the most common vegetation observed comprised a dense monospecific turf of *Oxalis thompsoniae*. The die back areas also supported isolated tufts (sometimes grading into dense patches) of up to 1 m tall *Carex kermadecensis* (Fig. 20A, 21) and, in places a dense sward of the much smaller naturalised *Cyperus brevifolius*. Other sparse associates included *Achyranthes*, *Homalanthus* (especially south and east of the Macauley Crater), *Myoporum*, and, at the time of my visit, seen mostly as seedlings, the Asteraceous herbs *Bidens pilosa*, *Gamochaeta calviceps*, *G. coarctata*, *G. simplicicaulis*, *G. subfalcata* and *Pseudognaphalium luteoalbum*. In places *Cyperus kyllingia*, *Euchiton japonicus*, *E. sphaericus*, *Ficinia nodosa*, *Oxalis corniculata*, *O. exilis*, *Pteris tremula*, *Sicyos mawhai*, *Solanum nigrum*, *S. nodiflorum*, and stunted *Sonchus kirkii* and *S. oleraceus* were also noted. Virtually all the *Sonchus* seen had their inflorescences and upper stems ravaged by Kermadec Islands parakeets. Although we saw few living *Solanum* in these areas, it is probably still common in this habitat at other times of the year, as evidenced by the numerous dead specimens (Fig. 20B). Associated with these dead *Solanum* were also many dead *Euchiton sphaericus*, and the dried out plants and inflorescences of the grasses *Lachnagrostis filiformis* and *Vulpia* spp. I suspect that the *Euchiton* and the grasses are probably as abundant as *Solanum* when conditions are suitable.

11. *Homalanthus* Forest

Barkla *et al.* (2008) observed a solitary tree whose dimensions they described as 5.5 m tall, 17 m across, multi-leadered with a short trunk 1.03 m diameter. By the time of our visit this tree had died (Fig. 22), though its trunk and branches were still preserved intact and the bark was in most places still firmly attached suggesting that the tree had probably died within the last year or

so. In its place however were now 65, 5 m tall trees and numerous (uncounted but in the order of 100s) saplings and seedlings (Fig. 23). The understorey within this area was sparse being given over to mostly white-naped petrel burrows (Fig. 24) which had not been seen in this area in July 2006 (J.W. Barkla pers.comm.). Nearer the old tree's trunk were several large swards of *Carex kermadecensis*, a small area of *Hypolepis dicksonioides*, *Lachnagrostis filiformis* and patches of the grass *Oplismenus hirtellus* subsp. *imbecillis*. The dead tree itself sported several large specimens of a bracket fungus (*Ganoderma* cf. *applanatum*), an assortment of lichens (mostly *Heterodermia*, *Parmotrema* and *Physcia* spp.) and sheets of the mosses *Macromitrium brevicaulis* and *Syntrichia laevipila*. This area of *Homalanthus* forms a clearly discernible dark patch on the upper south-eastern slopes of the central Mt Haszard crater (Fig. 25) that can be seen from 1 km off shore and from the air (Fig. 1 – as “*Homalanthus* Bush”). Outside this main area of *Homalanthus* we counted a further 12 trees up to 3 m tall, many multi-leadered (Fig. 26), and some up to 600 m distant from the original “parent tree” described by Barkla *et al.* (2008). Many of these trees had germinated in the areas of die back supporting *Oxalis* turf, though a few were present in the dense *Hypolepis* fernland on the northern slopes of the ridgeline leading up to Mt Haszard crater (Fig. 26). At the time of our visit most of these trees had been semi defoliated, I assume through storm damage caused by Tropical Cyclone Bune (see de Lange 2012). Nevertheless each tree sported dense areas of epicormic regrowth arising from the bases of the main branches and trunks.

GENERAL OBSERVATIONS

Following the removal of goats from Macauley in 1970 (Sykes 1977; Barkla *et al.* 2008) and the subsequent presumably successful rat eradication (see comments by de Lange 2012) a process of natural vegetation recovery has been initiated on Macauley which in this authors opinion should not now be interfered with by human management. Since 1970 there has been a shift from a species poor flora and stark dominant *Microlaena stipoides* grassland (Sykes 1977) to a fernland dominated by *Hypolepis dicksonioides* (Taylor & Tennyson 1988; Greene *et al.* 2004). In 2006 it was noted that in some areas this fernland had died back (Barkla *et al.* 2008), which I attribute mostly to underlying tunnel gully erosion, resulting in moisture loss and drought (de Lange 2012). In these areas, by 2011 occasional saplings of *Myoporum* and *Homalanthus* were recorded.

The rediscovery of *Homalanthus polyandrus* on Macauley 118 years after it was last seen there (Cheeseman 1888) in 2006 is noteworthy (Barkla *et al.* 2008). While one can only speculate as to whether the tree seen germinated from a resident, as yet undiscovered population persisting somewhere on the Macauley cliff faces, or was derived from the soil seed bank, or had arrived by chance via long distance dispersal of seed from Raoul to Macauley ingested by tui (*Prosthemadera novaeseelandiae*), silvereye (*Zosterops lateralis*) or

starlings (*Sturnus vulgaris*), all options given by Barkla *et al.* (2008), this may never be known. Irrespective, it seems likely now that the lack of fruit on the tree or lying on the ground observed by Barkla *et al.* (2008) may not have been completely due to those authors' suggestion of seed predation by resident kakariki. It is now known that kiore have a profound impact on the regeneration of many of New Zealand's offshore island tree species (Campbell & Atkinson 2002). In this context the observation of the recruitment and spread of *Homalanthus* five years after it was rediscovered on Macauley Island and following an attempted rodent eradication on the island in 2006 is interesting. Field observations and herbarium specimens of the related *Homalanthus nutans* Benth. et Hook.f. ex Drake collected from the rat-infested cloud forest of Rarotongan populations, showed that the developing fruits and seeds were so completely annihilated by rats that there was no recruitment (de Lange 2010). Similar observations of rat predation have been recorded for Mauritius Island populations of *H. populifolius* Graham (Strahm 2001). So the fact that 65 mature, fruiting adult *Homalanthus* trees were recorded in and around the now dead tree that had been discovered by Barkla *et al.* (2008), and that a further 12 mature trees were located in die back areas and amongst *Hypolepis* fernland up to 600 m distant from the original 2006 find (dubbed “*Homalanthus* Bush” see Fig. 1. and de Lange 2012) suggests that rats may also have been responsible for the lack of fruits seen on the solitary tree in 2006. Certainly de Lange (2012) thought so, further noting that the widespread presence of an undetermined species of land crab (possibly a species of *Geograpsus*) previously unrecorded for the island (cf. Taylor & Tennyson 1988; Greene *et al.* 2004), and lack of rodent predation of nesting sea birds suggested that the attempted 2006 rat eradication was probably successful.

Of some significance also was the observation of active white-naped petrel burrows under the *Homalanthus* trees (Fig. 24). This strongly suggests that given time and the future spread of *Homalanthus* then parts of the plateau currently unsuitable for ground nesting and burrowing sea birds because of the dense *Hypolepis* fernland will eventually be colonised by these birds as the taller woody vegetation succeeds the fernland.

The observation of the spread of *Homalanthus* into the fernland, and the spread of *Myoporum* across the Macauley plateau is also considerably more encouraging than the pessimistic view expressed by Barkla *et al.* (2008; p. 376) viz “There seems little prospect of recovery of the island's former woody cover in the short term given the lack of woody species propagules and the existing very dense, and perhaps inhibitory, fern and sedge cover”. The rapid spread of *Homalanthus* from one tree in 2006 to 77 adult trees and 100s of seedlings in 2011, five years later is far more encouraging. *Homalanthus* is a well-known, fast growing, short-lived tropical “pioneer” genus (Turnbull 1991), so it will be interesting to see what the plateau vegetation of Macauley Island looks like in another 20 years. In this respect it would seem that *Homalanthus* is behaving on Macauley Island rather like another short-lived, pioneering “tropical” small tree



Figure 25. "*Homalanthus* Bush" as seen from the ridge line leading south-south east from the southern side of Macauley Crater down to the plateau. Photo: P.J. de Lange, May 2011

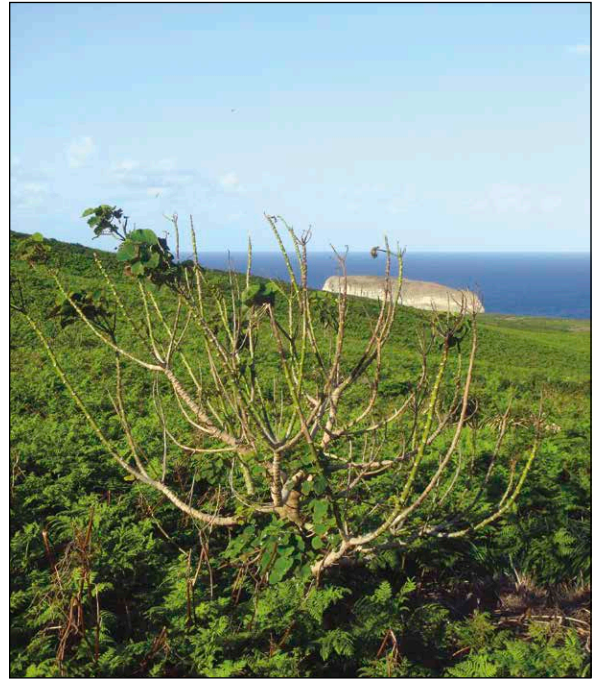


Figure 26. *Homalanthus polyandrus* tree growing within *Hypolepis* fernland on the eastern slopes leading down from Macauley Crater. The tree although mostly defoliated as a result of Tropical Cyclone Bune was at the time of its discovery covered in much regrowth. Photo: P.J. de Lange, May 2011



Figure 27. A young vine of *Sicyos mawhai* trailing up dead *Hypolepis dicksonioides*. During the May 2011 visit to Macauley Island, *Sicyos* was usually seen as small cotyledon stage seedlings and a few young vines such as seen here. However, numerous dead adult vines were also seen, these were apparently killed by Tropical Cyclone Bune. Photo: P.J. de Lange, May 2011

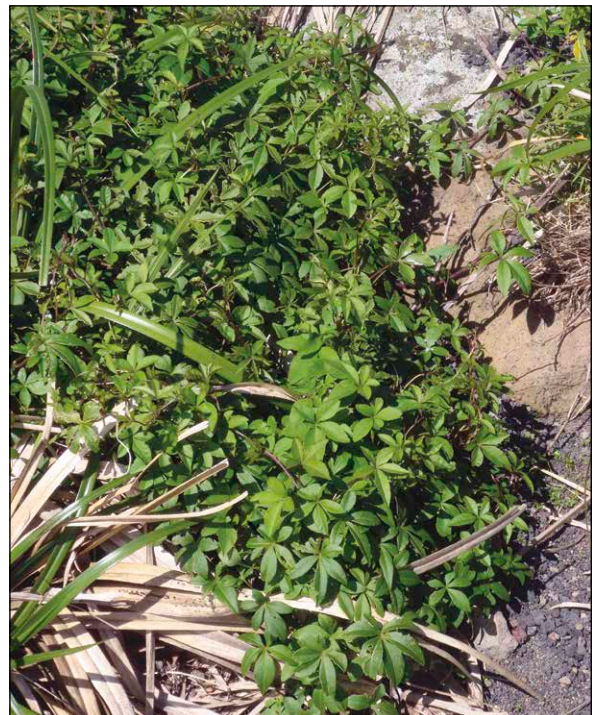


Figure 28. Young vine of *Ipomoea cairica* growing in *Cyperus* sedgeland in margin of deep gully lying just north-east of Mt Haszard and draining east onto the plateau. Photo: P.J. de Lange, May 2011

Meryta sinclairii (Hook.f.) Seem. did on the Three Kings Islands (Bellingham *et al.* 2010). Encouraging too, is the rediscovery of *Pouzolzia australis* and *Solanum aviculare* var. *aviculare*, previously believed extinct on the island, and the confirmation of the persistence and possible spread of *Coprosma petiolata* (a species recorded by Sykes 1977 but not seen by Taylor & Tennyson (1988), Greene *et al.* (2004) or Barkla *et al.* (2008)). These rediscoveries, albeit of single individuals of both *Pouzolzia* and *Solanum* augers well for the future, as well as suggesting that maybe these plants and perhaps the *Coprosma* and *Homalanthus* as well have persisted in as yet undiscovered cliff refuge or refugia somewhere on the island.

Barkla *et al.* (2008; p. 376) also stated that “changes to the island’s pattern of vegetation are likely to be the result of further expansion of the scrambling herbs which are showing a propensity to overtop and displace existing vegetation”. From the 2011 field observations this seems to be true, with two vegetation associations, *Scaevola* shrubland and *Ipomoea* vineland being clear examples. Although neither was distinguished by Barkla *et al.* (2008) they noted an increase in the abundance of *Sicyos mawhai* (as *S. australis*) (Fig. 27) and *Ipomoea cairica* (Fig. 28). Further, although not noted in their paper the *Scaevola* “shrubland” reported here was already developed in 2006 (Barkla pers. comm.).

Collectively, these results suggest that the dominance of the *Hypolepis* fernland on Macauley may be nearing its end. Certainly these observations, coupled with the increasing floral diversity of Macauley Island strongly argue against any future human interference to hasten vegetation succession as a step to secure or improve breeding conditions for the islands sea birds as has been suggested by Taylor *et al.* (2011). Aside from the obvious logistical, financial and biosecurity problems of such an undertaking, the potential damage to the island’s biota and disruption of the sequence of natural vegetation recovery is not justifiable.

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APPENDIX 1: Macauley Island flora, southern Kermadec Islands.

‡ – Addition to the Kermadec Islands Flora (22 taxa), † – Addition to the Macauley Island Flora (59 taxa),
* – denotes taxa naturalised to Macauley Island

Voucher		
Lycophytes (1)		
† <i>Lycopodiella cernua</i> (L.) Pic. Serm.	Lycopodiaceae	AK 325815
Ferns (23)		
<i>Asplenium northlandicum</i> (Brownsey) Ogle	Aspleniaceae	AK 128485
<i>A. oblongifolium</i> Colenso	Aspleniaceae	AK 325821
<i>A. shuttleworthianum</i> Kunze	Aspleniaceae	AK 295719
*† <i>A. oblongifolium</i> Colenso × <i>A. shuttleworthianum</i> Kunze	Aspleniaceae	AK 325824
<i>Blechnum kermadecense</i> Perrie et Brownsey	Blechnaceae	AK 325820
<i>B. mollis</i> (Parris) Christenh.	Blechnaceae	AK 325817
<i>B. norfolkianum</i> (Heward) C.Chr.	Blechnaceae	AK 325825
<i>B. parrisiae</i> Christenh.	Blechnaceae	AK 325812
<i>B. zealandicum</i> Christenh.	Blechnaceae	AK 246196
<i>B. ?parrisiae</i> Christenh. × <i>B. zealandicum</i> Christenh.	Blechnaceae	AK 297572–297574
<i>Hypolepis dicksonioides</i> (Endl.) Hook.	Dennstaedtiaceae	AK 246200
† <i>Nephrolepis brownii</i> (Desv.) Hovenkamp et Miyam.	Lomariopsidaceae	AK 325818
<i>Ophioglossum coriaceum</i> A.Cunn.	Ophioglossaceae	AK 325804
† <i>O. petiolatum</i> Hook.	Ophioglossaceae	AK 325814
† <i>Adiantum cunninghamii</i> Hook.	Pteridaceae	AK 326202
<i>A. diaphanum</i> Blume	Pteridaceae	AK 325806
<i>A. hispidulum</i> Swartz	Pteridaceae	AK 295710
*† <i>Cheilanthes distans</i> (R.Br.) Mett.	Pteridaceae	AK 325810
<i>Pellaea falcata</i> (R.Br.) Fee	Pteridaceae	AK 281415
† <i>Pteris comans</i> G.Forst.	Pteridaceae	AK 325813
<i>P. tremula</i> R.Br.	Pteridaceae	AK 295714
† <i>Christella</i> aff. <i>dentata</i>	Thelypteridaceae	AK 325819
† <i>Macrothelypteris torresiana</i> (Gaudich.) Ching	Thelypteridaceae	AK 325826

		Voucher
Spermatophytes		
Monocots I (2)		
<i>Microtis parviflora</i> R.Br.	Orchidaceae	AK 329822
† <i>M. unifolia</i> (G.Forst.) Rchb.f.	Orchidaceae	AK 329745
Monocots II – Commelinids (18)		
<i>Carex kermadecensis</i> Petrie	Cyperaceae	AK 296529
<i>Cyperus insularis</i> Heenan et de Lange	Cyperaceae	AK 246199
<i>Ficinia nodosa</i> (Rottb.) Goetgh., Muasya et D.A.Simpson	Cyperaceae	AK 325959
* <i>Cyperus brevifolius</i> (Rottb.) Endl. ex Hassk.	Cyperaceae	AK 246171
†* <i>C. kyllingia</i> Endl.	Cyperaceae	AK 325957
* <i>Juncus bufonius</i> L. var. <i>bufonius</i>	Juncaceae	AK 325962
<i>Dichelachne crinita</i> (L.f.) Hook.f.	Poaceae	AK 1521
<i>Lachnagrostis filiformis</i> (G.Forst.) Trin.	Poaceae	AK 329715
<i>L. littoralis</i> (Hack.) Edgar subsp. <i>littoralis</i>	Poaceae	AK 128498
<i>Microlaena stipoides</i> (Labill.) R.Br.	Poaceae	AK 297714
<i>Oplismenus hirtellus</i> subsp. <i>imbecillus</i> (R.Br.) U.Scholz.	Poaceae	AK 325960
<i>Poa polyphylla</i> Hack.	Poaceae	AK 200167
* <i>Polypogon monspeliensis</i> (L.) Desf.	Poaceae	AK 202337
†† <i>Rytidosperma biannulare</i> (Zotov) Connor et Edgar	Poaceae	AK 325953
* <i>R. racemosum</i> (R.Br.) Connor et Edgar	Poaceae	AK 202332
† <i>R. unarede</i> (Raoul) Connor et Edgar	Poaceae	AK 325956
* <i>Vulpia bromoides</i> (L.) Gray	Poaceae	AK 128571
* <i>V. myuros</i> (L.) C.C.Gmel. var. <i>myuros</i>	Poaceae	AK 128571
Core Eudicots (48)		
<i>Disphyma australe</i> subsp. <i>stricticaule</i> Chinnock	Aizoaceae	AK 325932
† <i>Tetragonia implexicoma</i> (Miq.) Hook.f.	Aizoaceae	AK 325945
<i>T. tetragonoides</i> (Pall.) Kuntze	Aizoaceae	AK 3990
<i>Achyranthes velutina</i> Moq.	Amaranthaceae	AK 258040
† <i>Chenopodium trigonon</i> Schult. subsp. <i>trigonos</i>	Amaranthaceae	AK 325854
† <i>Hydrocotyle moschata</i> G.Forst. var. <i>moschata</i>	Apiaceae	AK 329102
* <i>Bidens pilosa</i> L.	Asteraceae	AK 299854
<i>Cotula australis</i> (Spreng.) Hook.f.	Asteraceae	AK 246192
* <i>Conyza bonariensis</i> (L.) Cronq.	Asteraceae	AK 325943
* <i>C. sumatrensis</i> (Retz.) E.H.Walker	Asteraceae	AK 329746
<i>Euchiton japonicus</i> (Thunb.) Holub	Asteraceae	AK 325950
†† <i>E. involucratus</i> (G.Forst.) Holub	Asteraceae	AK 325848
<i>E. sphaericus</i> (Willd.) Holub	Asteraceae	AK 281419
††* <i>Gamochaeta calviceps</i> (Fernald) Cabrera	Asteraceae	AK 325940
††* <i>G. coarctata</i> (Willd.) Kerg.	Asteraceae	AK 325849
* <i>G. pennsylvanica</i> (Willd.) Cabrera	Asteraceae	AK 296533
††* <i>G. simplicicaulis</i> (Willd. ex Spreng.) Cabrera	Asteraceae	AK 325861
* <i>G. subfalcata</i> (Cabrera) Cabrera	Asteraceae	AK 296531
<i>Pseudognaphalium luteoalbum</i> (L.) Hilliard et B.L.Burt	Asteraceae	AK 246194
* <i>Sonchus asper</i> (L.) Hill.	Asteraceae	AK 299859

		Voucher
<i>S. kirkii</i> Hamlin	Asteraceae	AK 247615
* <i>S. oleraceus</i> L.	Asteraceae	AK 128548
<i>Lepidium castellanum</i> de Lange et Heenan	Brassicaceae	AK 297694
* <i>L. didymum</i> L.	Brassicaceae	AK 297700
<i>Rorippa divaricata</i> (Hook.f.) Garn.-Jones et Jonsell	Brassicaceae	AK 223339
<i>Lobelia anceps</i> L.f.	Campanulaceae	AK 296532
<i>Wahlenbergia vernicosa</i> J.A.Petterson	Campanulaceae	AK 128570
†† <i>W. violacea</i> J.A.Petterson	Campanulaceae	AK 325927
††* <i>Cerastium fontanum</i> Baumg.	Caryophyllaceae	AK 325926
* <i>C. glomeratum</i> Thuill.	Caryophyllaceae	AK 295713
* <i>Polycarpon tetraphyllum</i> (L.) L.	Caryophyllaceae	AK 128547
††* <i>Sagina apetala</i> Ard.	Caryophyllaceae	AK 329747
<i>Calystegia soldanella</i> (L.) R.Br.	Convolvulaceae	AK 246190
<i>Ipomoea cairica</i> (L.) Sweet	Convolvulaceae	AK 295717
<i>Sicyos mawhai</i> I.Telford et P.Sebastian	Cucurbitaceae	AK 247562
<i>Scaevola gracilis</i> Hook.f.	Goodeniaceae	AK 128562
<i>Homalanthus polyandrus</i> (Hook.f. ex Müll.Arg.) Cheeseman	Euphorbiaceae	AK 297695
<i>Haloragis erecta</i> (Murray) Oken subsp. <i>erecta</i>	Haloragaceae	AK 325941
* <i>Oxalis corniculata</i> L. var. <i>corniculata</i>	Oxalidaceae	AK 297708
<i>O. exilis</i> A.Cunn.	Oxalidaceae	AK 325886
<i>O. thompsoniae</i> B.J.Conn et P.G.Richards	Oxalidaceae	AK 325890
<i>Coprosma petiolata</i> Hook.f.	Rubiaceae	AK 325951
<i>Myoporum rapense</i> subsp. <i>kermadecense</i> (Sykes) Chinnock	Scrophulariaceae	AK 128572
<i>Solanum aviculare</i> G.Forst. var. <i>aviculare</i>	Solanaceae	AK 325855
* <i>S. nigrum</i> L.	Solanaceae	AK 325946
<i>S. nodiflorum</i> Jacq.	Solanaceae	AK 299863
<i>Parietaria debilis</i> G.Forst.	Urticaceae	AK 3799
<i>Pouzolzia australis</i> (Endl.) Friis et Wilmot-Dear	Urticaceae	AK 325857
Liverworts (14)		
†† <i>Asterella australis</i> (Hook.f. et Taylor) Verd.	Aytoniaceae	AK 325532
<i>Plagiochasma rupestre</i> (J.Forst.) Steph. var. <i>rupestre</i>	Aytoniaceae	AK 325517
† <i>Reboulia hemisphaerica</i> var. <i>australis</i> R.M.Schust.	Aytoniaceae	AK 325589
<i>Dumortiera hirsuta</i> (Sw.) Nees	Dumortieraceae	AK 325535
†† <i>Frullania pentapleura</i> Tayl.	Frullaniaceae	AK 325514
† <i>Lopholejeunea</i> sp.	Lejeuneaceae	AK 325564
†† <i>Siphonolejeunea nudipes</i> (Hook.f. et Taylor) Herzog	Lejeuneaceae	AK 325629
†† <i>Telaranea quinquespina</i> (J.J.Engel et G.L.Sm.) J.J.Engel et G.L.Sm.	Lepidoziaceae	AK 325528
† <i>Chiloscyphus semiteres</i> (Lehm.) Lehn. et Lindenb. var. <i>semiteres</i>	Lophocoleaceae	AK 325516
††* <i>Lunularia cruciata</i> (L.) Dum.	Lunulariaceae	AK 325525
<i>Marchantia berteriana</i> Lehm. et Lindenb.	Marchantiaceae	AK 325520
†† <i>Marchantia foliacea</i> Mitt.	Marchantiaceae	AK 325538
<i>Marchantia pileata</i> Mitt.	Marchantiaceae	AK 325530
†† <i>Targionia hypophylla</i> L.	Targioniaceae	AK 325519

		Voucher
Mosses (37)		
<i>Philonotis tenuis</i> (Taylor) Reichardt.	Bartramiaceae	AK 326972
† <i>Rhynchostegium tenuifolium</i> (Hedw.) Reichardt.	Brachytheciaceae	AK 326967
<i>Bryum argenteum</i> Hedw.	Bryaceae	AK 181747
<i>Bryum clavatum</i> (Schimp.) C.Muell.	Bryaceae	AK 181749
† <i>Bryum dichotomum</i> Hedw.	Bryaceae	AK 326976
‡†* <i>Bryum radiculosum</i> Brid.	Bryaceae	AK 326996
† <i>Bryum sauteri</i> Bruch., Schimp et W.Gümbel	Bryaceae	AK 326995
‡† <i>Rosulabryum capillare</i> (Hedw.) J.R.Spence	Bryaceae	AK 327054
† <i>Campylopus clavatus</i> (R.Br.) Wilson	Dicranaceae	AK 326981
† <i>Trematodon suberectus</i> Mitt.	Dicranaceae	AK 326992
<i>Ceratodon purpureus</i> (Hedw.) Brid.	Ditrichaceae	CHR 449358
‡† <i>Ditrichum difficile</i> (Duby) M.Fleisch.	Ditrichaceae	AK 326984
<i>Fissidens asplenioides</i> Hedw.	Fissidentaceae	CHR 161040
† <i>Fissidens curvatus</i> Hornsch. var. <i>curvatus</i>	Fissidentaceae	AK 325567
<i>Fissidens leptocladus</i> Müll.Hal. ex Rodway	Fissidentaceae	CHR 161333A, 161333B
† <i>Fissidens linearis</i> Brid. var. <i>linearis</i>	Fissidentaceae	AK 326994
† <i>Fissidens megalotis</i> Müll.Hal.	Fissidentaceae	AK 326971
† <i>Fissidens oblongifolius</i> Hook.f. et Wilson	Fissidentaceae	AK 326983
† <i>Fissidens tenellus</i> Hook.f. et Wilson var. <i>tenellus</i>	Fissidentaceae	AK 327884
‡† <i>Funaria hygrometrica</i> Hedw.	Funariaceae	AK 332140
† <i>Macromitrium brevicale</i> (Besch.) Broth.	Orthotrichaceae	AK 326973
<i>Barbula calycina</i> Schwägr.	Pottiaceae	CHR 161034
† <i>Polytrichadelphus magellanicus</i> (Hedw.) Mitt.	Polytrichaceae	AK 326991
<i>Polytrichum commune</i> Hedw.	Polytrichaceae	CHR 499357
† <i>Didymodon australasiae</i> (Hook.f. et Grev.) R.H.Zander	Pottiaceae	AK 330859
‡† <i>Didymodon torquatus</i> (Taylor) Catches.	Pottiaceae	AK 326993
‡† <i>Schistidium apocarpum</i> (Hedw.) Bruch et Schimp.	Grimmiaceae	AK 326970
† <i>Syntrichia antarctica</i> (Hampe) R.H.Zander	Pottiaceae	AK 326974
† <i>Syntrichia laevipila</i> Brid.	Pottiaceae	AK 326982
† <i>Syntrichia phaea</i> (Hook.f. et Wilson) R.H.Zander	Pottiaceae	AK 326989
† <i>Tortella flavovirens</i> (Bruch.) Broth.	Pottiaceae	AK 326975
† <i>Tortula muralis</i> Hedw.	Pottiaceae	AK 327052
‡† ? <i>Trichostomum sciophilum</i> Müll.Hal.	Pottiaceae	AK 332268
† <i>Weissia controversa</i> Hedw.	Pottiaceae	AK 326990
† <i>Ptychomitrium australe</i> (Hampe) A.Jaeger	Ptychomitriaceae	AK 326977
† <i>Sematophyllum subhumile</i> var. <i>contiguum</i> (Mitt.) Tan, Schofield et Ramsay	Sematophyllaceae	AK 326988
† <i>Thuidium sparsum</i> (Hook.f. et Wilson) A. Jaeger	Thuidiaceae	AK 326966

