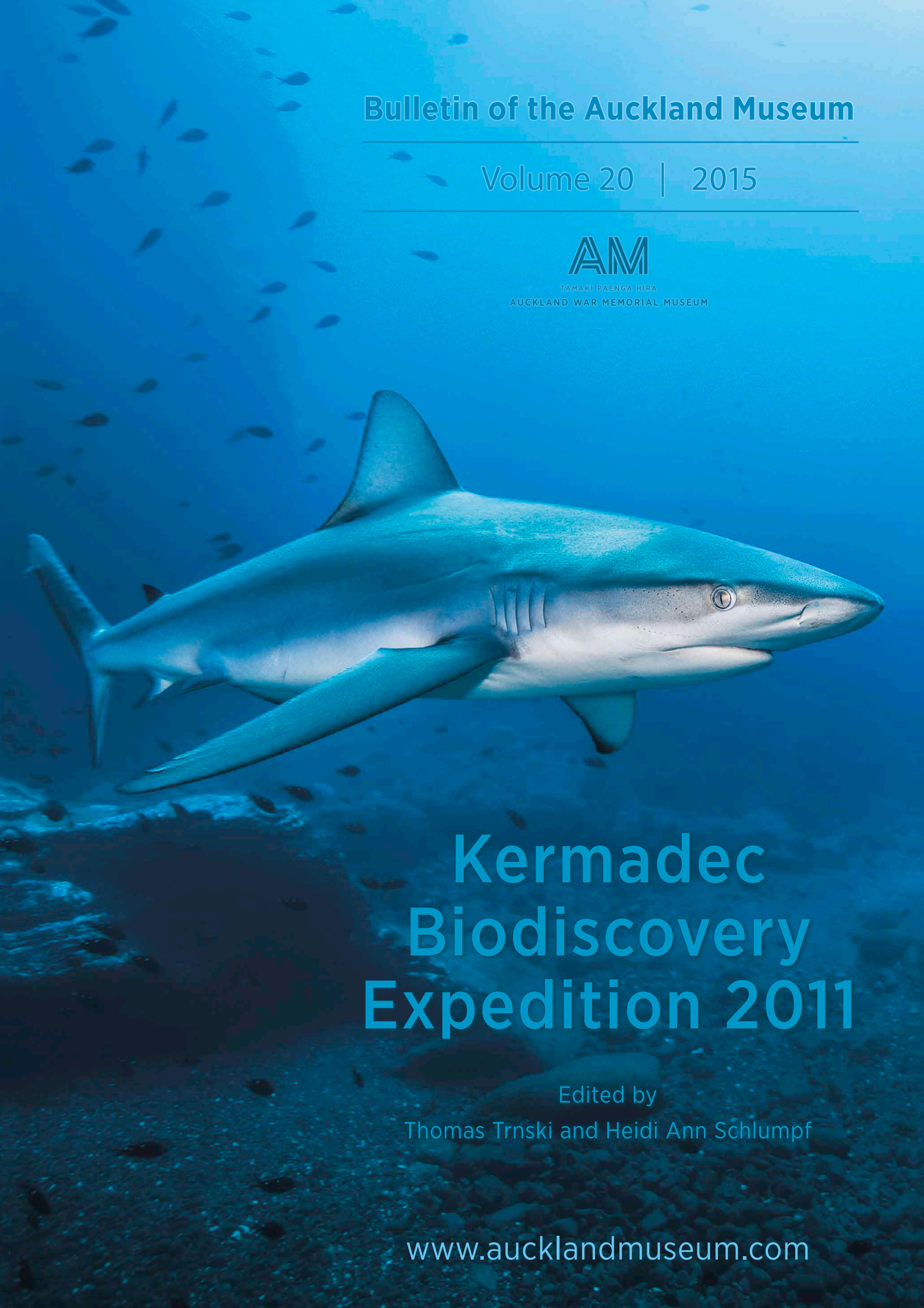




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The flora and vegetation of Cheeseman Island, southern Kermadec Islands

Peter J. de Lange Department of Conservation

Abstract

The flora and vegetation of Cheeseman Island, southern Kermadec Islands, is described. Cheeseman Island has a small flora of 24 vascular plants (3 pteridophytes, 21 spermatophytes) and 11 bryophytes (one liverwort and ten mosses). There are also six naturalised vascular plant species. Limited observations on the island's lichenized fungi are made and two subtidal marine algae recorded. Four plant associations are recognised: bare rock and cliff faces, lichen field, *Disphyma* turf and *Cyperus* sedge-land. Prior to visiting Cheeseman Island (May 2011), the island had been severely damaged by Cyclone Bune (March 2011). Cheeseman Island has a richer flora than the two geologically comparable southern Kermadec Islands, Curtis and Haszard. This most likely reflects a lack of recent botanical investigation on these similar sized islands.

Keywords

Kermadec Islands; southern Kermadec Islands; Cheeseman Island; flora; lichens; marine algae; bryophytes; pteridophytes; angiosperms; plant associations; cyclone damage; island biogeography

INTRODUCTION

Cheeseman Island (8.09 ha, 60.96 m a.s.l., 30° 32' 13.8" S, 178° 34' 3.92" W) is the third smallest of the five islands that make up the southern Kermadec Islands (Fig. 1, 2). The island is named after Thomas Fredric Cheeseman (1846–1923) who participated in the New Zealand expedition to annex the Kermadec Islands in 1887 (de Lange & Galloway 2015). The island is roughly tabular in shape, aligned north-west to south-east, with cliffed northern, eastern and southern sides and a mostly cliffed western side (Fig. 2, 3), which gently slopes toward the sea in one area (the only place where a sea landing is possible (Fig. 4)). The geology of the island has not been investigated properly (I. Smith *pers. comm.*), though the island is volcanic (Latter *et al.* 2010), and based on my observations appears to be made of dacitic pyroclastic deposits, much of which appears to have been hydrothermally altered. In places, particularly on the ridgeline leading to the southern summit of the island there are extensive areas of what appears to be fossil sinter, in most places weathered to a razor-sharp edge. Much of the island is criss-crossed with faults, several of which seem to have contributed to the development of the broad trench-like area informally named here '*Cyperus* gully'.

A detailed account of the flora and plant associations of Cheeseman Island does not seem to have been provided

in past accounts of the Kermadec Islands. Sykes (1977), referring to the island as 'Cheeseman Islet', provided a few short notes on the vegetation and flora based on a five hour visit on 19 November 1970 (W.R. Sykes *pers. comm.*). During which he collected specimens from 12 species, including one lichenized fungus (hereafter lichen) (a species of *Dufourea* Ach. [probably *D. ligulata* (Körb.) Frödén, Arup et Søchting]) and two naturalised species (*Conyza bonariensis* and *Solanum nigrum*) from which the primary specimens were lodged in CHR.¹ The only other formally sanctioned visit that I am aware of that made notes on the flora and vegetation of the island, including the collection of a few plant specimens (lodged in AK), was one made by a Department of Conservation sponsored ornithological party, the participants of whom visited the saddle between the northern and southern summits using a helicopter on 26 July 2002 (Greene *et al.* 2004).

During the Auckland Museum lead Kermadec Biodiscovery 2011 Expedition I, and entomologist Warren Chinn, made landfall on the western side of Cheeseman Island on 24 May 2011 (de Lange 2012) (Fig. 2). We spent five hours on the island, during which time I examined all of the accessible vegetated parts of the island, collected the lichenized mycobiota and flora, and made empirical observations on the plant associations.

This paper discusses the flora and provides a first account of the plant associations of Cheeseman Island.

1. Herbarium acronyms follow Thiers (2013)

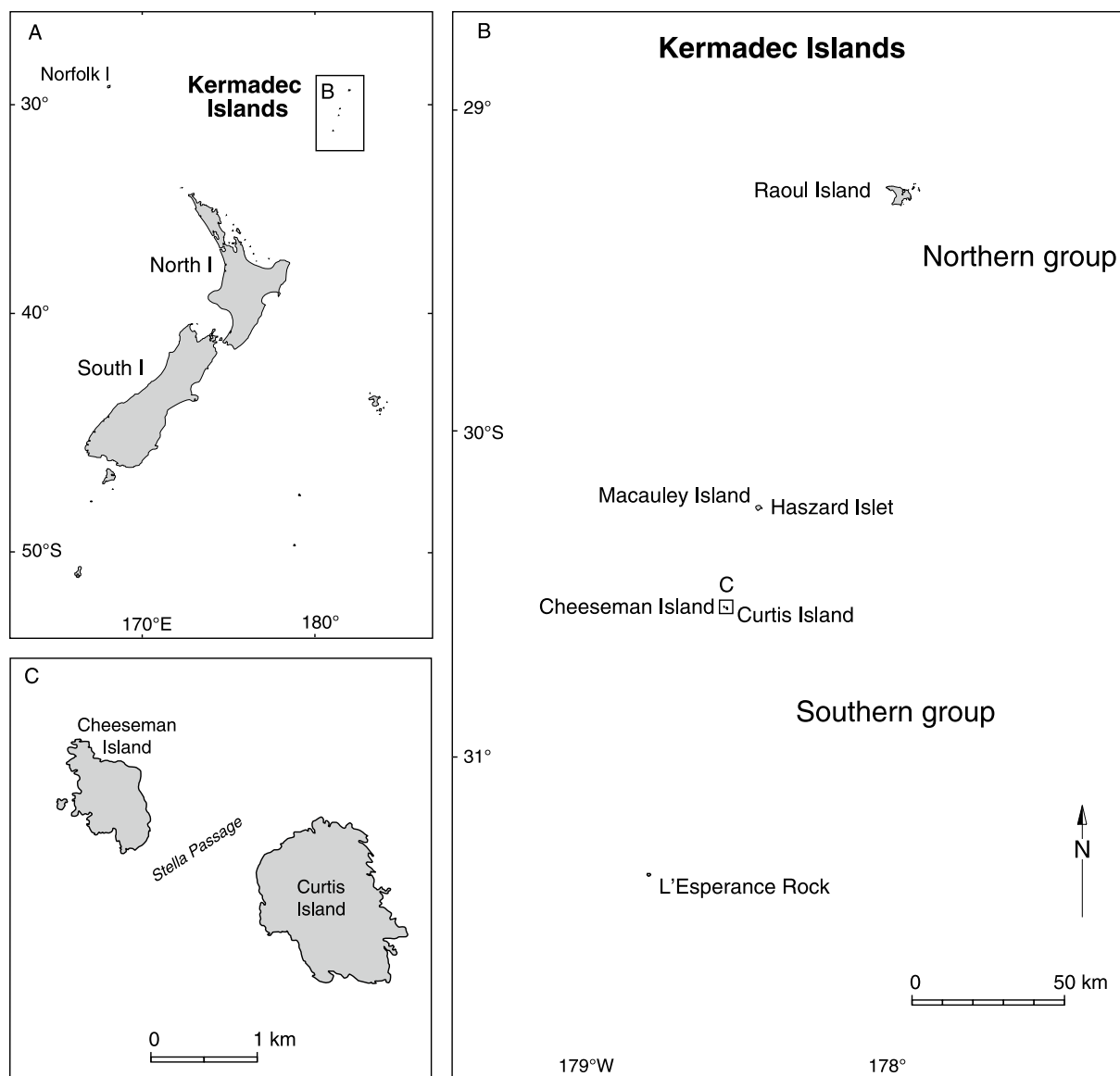


Figure 1. Location of the Kermadec Islands showing **A**, the position of the Kermadec Islands with respect to Norfolk and the main New Zealand Islands, **B**, location of the northern and southern Kermadec Islands, and **C**, showing the position of Cheeseman Island the subject of this paper.

METHODS

During my visit to Cheeseman Island I traversed c. 85% of the islands and undertook a full survey of the intertidal algae, bryophytes, lichenized mycobiota, vascular flora and avifauna (for avifauna see de Lange 2012). The vegetation associations described here were devised using the non-quantitative method of Atkinson (1985). Further observations to supplement those on land were made using binoculars during several circumnavigations of the island by boat.

Herbarium specimens collected were treated as follows: bryophytes and lichens were collected into packets and air dried in transit to New Zealand, while vascular plants were collected into a solution of three parts concentrated ethanol to one part concentrated acetic acid. Marine algae were stored in a solution of 1%

formalin in seawater. Back in New Zealand the vascular plants and marine algae were then sorted, cleaned and dried at AK. In one situation, live seedlings of a *Conyza* species uplifted from Cheeseman Island were cultivated in Auckland, New Zealand until flowering and fruiting to ascertain their identity (*C. bonariensis*).

Authorities for all lichens and plants seen on Cheeseman Island are either provided in Appendix 1, or within the main body of this paper. Nomenclature and families of marine algae follows Harper *et al.* (2012), while for mosses I follow de Lange & Beever (2015), and for the sole liverwort seen (*Frullania pentapleura*) Ngā Tipū o Aotearoa – New Zealand Plants Database (<http://nzflora.landcareresearch.co.nz/> – accessed 12 December 2012) and Stotler & Long (2009). Authorities for lichens follow de Lange *et al.* (2012) and Blanchon *et al.* (2012). Angiosperms are arranged phylogenetically



Figure 2. Cheeseman Island viewed from the north on 23 May 2011. Here the cliffed western and northern portion of the island as well as the northern and southern summits can be seen (visible on the left hand side of the image (east)). Here also the massive north-west trending boulder-slide that comprises the northern third of the island and which is terminated by a series of intact rock pinnacles can be seen.

Figure 3. Cheeseman Island viewed from the western side looking east. The fault bounded saddle in which 'Cyperus Gully' lies can be seen as a broad saddle to the left of which is the northern summit and to the right, the southern summit.

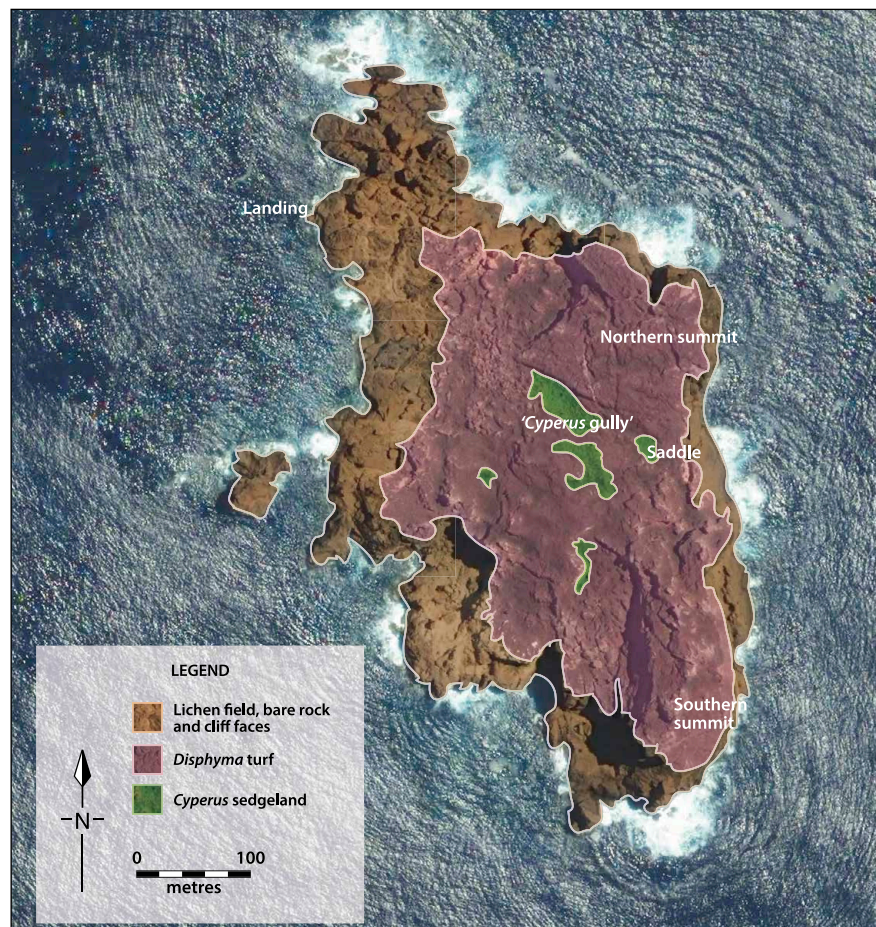


Figure 4. Cheeseman Island, southern Kermadec Islands, showing key areas discussed in the text and the distribution of the bare rock, cliff faces and vegetation types. Image courtesy of the New Zealand Department of Conservation.

according to APG III (2009), and then alphabetically by family as per de Lange & Rolfe (2010) with authorities derived from the International Plant Names Index (<http://www.ipni.org/index.html> – accessed 12 December 2012). The sole exception is *Lepidium castellanum* which is a newly described Kermadec Islands endemic (de Lange *et al.* 2013). Ferns and bryophytes are also arranged alphabetically by family. For fern families, I follow Smith *et al.* (2006) and Rothfels *et al.* (2012).

RESULTS

Three pteridophytes, 21 angiosperms, 11 bryophytes (one liverwort, 10 mosses) and two intertidal marine algae (*Sargassum* sp., and *Caulerpa racemosa* (Forssk.) J.Agardh.) were collected from Cheeseman Island on 24 May 2011. Ten packets of saxicolous lichens were also collected, however, at the time of writing (8 March 2013) only two lichens from within these packets had been identified, *Heterodermia tremulans* (Müll. Arg.) W.L.Culb. and *Ramalina microspora* Kremp.

Flora and Mycobiota of Cheeseman Island

I accept 24 vascular plants (three pteridophytes, 21 angiosperms) and 11 bryophytes for Cheeseman Island (Appendix 1; Table 1). Of the 19 vascular plant species (three pteridophytes and 16 angiosperms) that I recorded during the May 2011 visit (all with voucher records, Appendix 1), nine are additions to previous accounts of the vascular flora of Cheeseman Island. In addition I made the first collections of bryophytes and intertidal marine algae from island.

Intertidal Algae

Large portions of the intertidal zone of the western coastline were exposed during my visit, and in places these were sparsely vegetated by green and brown algae.

However, I could only collect two species because of the strong swell: these were the green alga *Caulerpa racemosa* and another of an unidentified *Sargassum* sp. (W.A. Nelson *pers. comm.*). Based on observations made by the dive team (comprising the major part of the Kermadec 2011 Biodiscovery Expedition), seaweeds were not common anywhere on Cheeseman Island below the intertidal zone, possibly because of the scouring effect of the storm surges created by Cyclone Bune (de Lange 2012).

Lichens

Crustose lichens are a feature of the bare rock of Cheeseman Island. However, although widespread, they reach their greatest abundance only in sheltered sites, particularly higher up the island in the labyrinth of rock outcrops, spires and cliff faces leading to the southern summit area (Fig. 2). At this stage few of the lichens collected have been identified, however, a number of genera appear to be well represented, including *Buellia* De Not., *Caloplaca* Th.Fr., *Heterodermia* Trevis., *Lecanora* Ach., and *Verrucaria* Schrad. Probably the most conspicuous lichen seen on Cheeseman Island during my visit was, because of its colour, the dark orange *Dufourea ligulata* which appears to dominate many of the rocks and cliff faces. However, near the southern summit, on sheltered north-facing rocks the fruticose *Ramalina microspora* was locally dominant.

Bryophytes

Only one liverwort, the foliose *Frullania pentapleura* was noted, growing on a rock overhang in ‘Cyperus Gully’ in a site sheltered by plants of *Cyperus insularis*. *Frullania pentapleura* (here including the morphologically similar New Zealand endemic *F. solanderiana* Colenso), is a variable Australasian species complex that is being actively investigated (M.J. von Konrat *pers. comm.*).

Table 1. Area, elevation and flora of the vegetated islands and islets of the southern Kermadec Islands (data from Sykes 1977; Sykes & West 1996; de Lange 2015; and P.J. de Lange unpubl. data).

	Macauley Island	Haszard Islet	Curtis Island	Cheeseman Island	L'Esperance Rock
Area (ha)	323.75	9.4	52.6	8.09	4.86
Elevation (m)	238	84	137	61	70
Bryophytes	51	2	4	11	2
<i>Liverworts</i>	14	–	–	1	1
<i>Mosses</i>	37	2	4	10	1
Vascular Plants	92	10	22	24	10
<i>Lycophytes</i>	1	–	–	–	–
<i>Pteridophytes</i>	23	1	2	3	1
<i>Spermatophytes</i>	68	9	20	21	9
Total Flora	143	12	26	35	12

Eleven mosses were collected from Cheeseman Island, of which ten were identified to genus and/or species level. One specimen, a sterile collection made from 'Cyperus Gully' (Fig. 1) near an ephemeral brackish pond, growing under some overhanging boulders within an area of black-winged petrel (*Pterodroma nigripennis*) burrows, could only be assigned to the family Ditrichaceae. Of the remaining ten, none were common, nor were any found on the island that had not been recorded from elsewhere in the Kermadec Islands (de Lange & Beever 2015).

The greatest diversity of mosses occurred on the petrel-burrowed ground amongst the *Cyperus insularis* and associated boulders of 'Cyperus gully' where *Bryum dichotomum*, an unidentified species of *Campylopus*, *Ceratodon purpureus*, *Didymodon australasiae*, *Fissidens leptocladus*, *Trematodon suberectus*, and *Weissia controversa* were found. Higher up the island, nearer the southern summit, on the more sheltered rock ledges and overhangs *Bryum argenteum* and *Grimmia pulvinata* var. *africana* were found, though again these were only in areas sheltered by *Cyperus insularis*. In the same general area, *Trematodon suberectus* was locally common growing within the saprolite accumulated at the bases of deep (up to 1 m) rock ledges that were often utilised by black-winged petrels and red-tailed tropic birds (*Phaethon rubricauda*). In much the same habitats grew *Fissidens leptocladus* occasionally occurring admixed with *Didymodon weymouthii*.

Vascular Plants

Disphyma australe subsp. *stricticaule*, is the dominant plant of the island, as it was 41 years earlier (Sykes 1977). It ranges from just above the spray zone to the island's summit.

Aside from *Disphyma*, *Cyperus insularis* was also a conspicuous, though much less common, component of the island's vegetation. *Cyperus* was mostly confined to 'Cyperus gully' and in several sheltered sites within amphitheatre's and basins leading south up from the saddle between northern and southern summits, and on the western side of the southern summit.

There were numerous seedlings, and a few flowering or fruiting adults of *Cotula australis*, *Lachnagrostis littoralis* subsp. *littoralis*, *Parietaria debilis*, and *Sonchus kirkii*. In one sheltered depression (c. 3 m²) close to the landing site, *Sonchus kirkii* formed an almost pure blue-grey mass of seedlings and sub-adults. Otherwise this species was scarce on the island.

Three ferns were recorded during the visit. Of these *Asplenium northlandicum* was locally common. While no ferns were recorded for Cheeseman Island by Sykes (1977) he made the point that the absence of *Asplenium northlandicum* (reported there as *A. obtusatum* G.Forst.) was significant, as this was the one fern seen on all the other islands and islets of the southern Kermadec Islands. It is therefore highly unlikely that Sykes missed this fern, and I assume that it has colonised Cheeseman Island (possibly from nearby Curtis Island) sometime after his 1970 visit.

A single *Asplenium shuttleworthianum* was also found growing in a deep fissure within a heavily

weathered rock overhang in the amphitheatre just south of the island saddle (Fig. 1). This plant grew with *Asplenium northlandicum* and *Ramalina microspora*. This is now the southern-most occurrence of this fern in the Kermadec Islands (if not the world), the previous station having been Macauley Island (Barkla *et al.* 2008).

The third fern collected was *Christella* aff. *dentata* (seen also in the southern Kermadec Islands on Macauley Island (de Lange 2015)). This also grew in a sheltered site, tucked back within an overhanging cliff face forming the northern wall of 'Cyperus gully'.

A few plants of *Isolepis cernua* var. *cernua* occurred at the base of 'Cyperus gully' on the margins of a brackish pond at the bottom end of the gully. These plants were fertile, thus confirming this sedge for the Kermadec Islands; the previous record was a sterile collection, the identity of which was uncertain (Sykes & West 1996).

One notable find was of a few decumbent shrubs of *Coprosma repens* growing on the western side of the southern summit. Previously this shrub had been accepted for the Kermadec Islands on the basis of a single collection made by Thomas Cheeseman from the east coast of Raoul Island (Sykes 1977) and, which was, unusually for Cheeseman, lodged at K. During the Kermadec 2011 Biodiscovery Expedition *Coprosma repens* was also collected from the Herald Islets (on Dayrell Island), *P.J. de Lange* K896, AK 326588). Morphological distinction between *C. repens* and the Kermadec endemic *C. petiolata* Hook.f. is difficult, as noted by Sykes (1977). However, in common with most *C. repens* seen in New Zealand, Cheeseman Island and Dayrell plants had glabrous rather than pubescent stems, and, in the case of the Cheeseman Island, one of the plants was a fruiting female, the pyrenes of which had the tuberculate and ridged opercula typical of *C. repens* (those of *C. petiolata* being smooth) (Webb & Simpson 2001).

Eight of the nine vascular plants (seven indigenous, one naturalised) recorded in 1970 by Sykes (1977) were seen during the 2011 visit except the naturalised *Solanum nigrum* was not found. The absence of *Solanum nigrum* is interesting as this was the only species of *Solanum* that Sykes (1977) recorded for Cheeseman and Curtis Islands; he did not record *S. nodiflorum* which I found in 2011. Four additional taxa were added to Sykes's listing by Greene *et al.* (2004) (the indigenous *Ipomoea cairica*, and naturalised *Bidens pilosa*, *Oxalis corniculata* and *Sonchus oleraceus*) but I did not relocate any of these (Appendix 1). Of these the *Bidens* was possibly eradicated when it was collected, as the notes on the collection (AK 281406) state 'one plant'. In contrast, the *Oxalis* and *Sonchus* were described as 'common'; the abundance of the *Ipomoea* was not described. At the time of my visit the vegetation of Cheeseman Island was still recovering from the effects of Cyclone Bune (de Lange 2012) and the only *Sonchus* seen, *S. kirkii*, was mostly observed as very young (10–30 mm) seedlings, so it is possible that *S. oleraceus* was also present but either overlooked or confused with *S. kirkii* juveniles (see comments by de Lange & Cameron 1999). The absence of *Oxalis* and *Ipomoea* is less easily explained,

as both are long persistent, rhizomatous or stoloniferous, hardy plants unlikely to have been eliminated by the cyclone. Further, although the collections do not state where they were sampled, they were most likely to have been gathered from the vicinity of the saddle between northern and southern summits (Fig. 2) as this was where the field team briefly landed, and the only place from where they were able to explore and collect plants (T. C. Greene *pers. comm.*). This was also the area least affected by Cyclone Bune, and so one would have expected that the *Ipomoea* and *Oxalis* should still have been present, the *Ipomoea* because of its rhizomatous growth habit, and the *Oxalis* because it had been described as ‘common’. It is possible that I overlooked both species but I believe this is unlikely because of the duration of my visit and the area searched, so perhaps they have naturally died out.

The two naturalised species, *Polycarpon tetraphyllum* and *Portulaca oleracea* are new to Cheeseman Island. Of these *Polycarpon* is already well known from Macauley Island (de Lange 2015a) but not it seems from Curtis Island, while *Portulaca* is otherwise unknown from the southern Kermadec Islands (Sykes 1977; Sykes & West 1996; de Lange 2015a). Both species are common in the northern Kermadec Islands on the sea bird dominated Meyer Islands and Herald Islets, where they are typically associated with active sea bird nests and burrows. On Cheeseman Island neither species was widespread giving the impression of recent establishment, with the *Polycarpon* being the more common (though mostly as small seedlings) and the *Portulaca* confined to a single site growing on bare earth amongst *Cyperus insularis*. That both species are bird dispersed is likely (Sykes 1977) but whether the plants seen were those that had germinated from a soil seed bank exposed through cyclonic disturbance or had resulted from recent dispersal from Macauley Island (*Polycarpon*) and/or the northern Kermadec Islands (*Polycarpon* and *Portulaca* (only)) is unclear.

Taxonomic Issues

Only the fern *Christella* aff. *dentata* requires further taxonomic investigation. The plants on Cheeseman Island match the race of *Christella dentata* with shortly creeping, exposed rhizomes and shortly erect caudices (often with the base covered in proliferating buds (see comments by Brownsey *et al.* 1985; Brownsey & Smith-Dodsworth 2000)). This race is common in the crater area on Raoul Island, and otherwise widespread (sometimes even locally common) in geothermal sites in the Taupo Volcanic Zone, North Island, New Zealand (Brownsey & Smith-Dodsworth 2000; P.J. de Lange *pers. obs.*). It is also known from non-thermal sites in Te Paki (P.J. de Lange unpubl. data) and was discovered during the Kermadec 2011 Biodiscovery Expedition on Macauley Island (de Lange 2015a). Like the Te Paki occurrences, neither the Macauley Island nor the Cheeseman Island plants were associated with active volcanic vents.

Cyclone Damage

At the time of survey Cheeseman Island was still recovering from the passage of Cyclone Bune which had struck the Kermadec Islands on the 28 March 2011 (de Lange 2012). The most obvious impacts of the cyclone on the island were: the virtual absence of nesting and burrowing seabirds (de Lange 2011a); a conspicuous band of scoured and/or bare rock encircling the lower portion of the island; pools of brackish water and flood deposits lying at the base of ‘*Cyperus* gully’; and the presence of large areas of dead or dying plants of *Disphyma* and *Cyperus*. Intact, ‘fresh’, greenish *Cyperus insularis* plants were also recovered by the expedition dive team in several places lying on ledges at 20m depth below the cliffs of Cheeseman Island (de Lange 2012; S. Keable and M. Reid *pers. comm.*). These, I assume, were plants that had been dislodged during the passage of Cyclone Bune (de Lange 2012).

At the time of my visit, while much of the established vegetation was in a battered condition, numerous seedlings of a range of plants were seen, and many of the damaged *Disphyma* mats were starting to resprout or flower. At the bottom of ‘*Cyperus* gully’ amongst a series of large boulders flowering *Solanum nodiflorum* were also seen.

Plant Associations

I distinguished four plant associations, and provide here a generalised map showing their distribution (Fig. 2). The vegetation types are arranged in an approximate altitudinal sequence.

1. Bare Rock and Cliff Faces

Occupying an estimated 20% of Cheeseman Island most of the exposed rock and cliff faces of the island are devoid of vascular plants. The fern *Asplenium northlandicum* is locally common in a few places along the western side of the island. Occasional patches of *Bryum argenteum* occur along the northern side of ‘*Cyperus* Gully’, especially where the rock had differentially weathered so leaving sheltered ledges along which saprolite and loess had accumulated. Macro-lichens though mostly scarce (as noted above), in places occur in sufficient density to be distinguished as their own vegetation type (see below).

2. Lichen field

While an estimate of the area occupied by lichens is not possible (they occur interdigitated with the bare rock and cliff faces segregated above), lichens are a common feature of the more sheltered sites within the upper tidal zone and portion of the island subjected to periodic wave wash and salt spray. The dominant genera are *Buellia*, *Caloplaca* and species, *Dufourea* and *Heterodermia*. Higher up the island, lichens are also feature of areas of bare rocks, especially on sheltered cliff faces. Near the southern summit of Cheeseman the fruticose macrolichen *Ramalina microspora* (Blanchon *et al.* 2012) is especially conspicuous, forming a dense turf on the jagged rock faces.

3. *Disphyma* turf

An almost monospecific *Disphyma* turf, covering c. 75% of the island, is the dominant vegetation of Cheeseman Island, from the spray zone to the summit. Associated species are generally sparse, though in sheltered sites *Sonchus kirkii* can be locally – though probably seasonally – co-dominant. Other sparse associates of the *Disphyma* turf include *Cotula australis*, *Chenopodium trigonon* subsp. *trigonon*, *Lachnagrostis littoralis* subsp. *littoralis*, *Lepidium castellanum*, *Polycarpon tetraphyllum*, *Parietaria debilis*, *Tetragonia tetragonoides*, and *Solanum nodiflorum*. Within suitable areas of deeper soil and saprolite, the *Disphyma* turf is frequently broken by petrel burrows (*Pterodroma* and *Puffinus* spp.), and it is in these areas especially that *Lachnagrostis*, *Lepidium*, *Parietaria* and *Solanum* can be locally common, probably promoted by an interaction between nutrient-rich seabird guano and seabird disturbance that may locally suppress *Disphyma*.

4. *Cyperus* Sedgeland

Cyperus insularis forms a sedgeland that occupies c. 5% of Cheeseman Island. This sedgeland is mostly found within a small fault bounded depression on the western side of Cheeseman Island ('*Cyperus* Gully' of de Lange 2012) (Fig. 2) that runs between the northern and southern summits. The depression slopes at about 25° from east to west, with the lower lying western end of the depression terminated by a boulder choke, and at the time of the survey a series of brackish ponds (see de Lange 2011). Here, in the lower two thirds of

this depression *Cyperus* sedgeland forms the dominant vegetation. At the time of the survey the only associates of the sedgeland were scattered 0.6–1.0 m tall plants of *Solanum nodiflorum*, while the ground between the sedges was mostly occupied by *Disphyma* and, in places *Chenopodium trigonon* subsp. *trigonon*, *Polycarpon tetraphyllum*, *Tetragonia tetragonoides* and nearer the western end, a single tuft of *Ficinia nodosa* and a large patch of *Isolepis cernua* var. *cernua*. In places numerous seedlings of *Cotula australis* and *Parietaria debilis* grew, especially where petrel burrows were present. On the northern margin of the depression, along the main fault scarp, the uplifted cliff face had been heavily weathered along the base, leaving a series of overhangs, and in these, amongst the *Cyperus* a few stunted plants of *Asplenium shuttleworthianum* and *Christella* aff. *dentata* were found. Along the base of this cliff face occasional hummocks of – mostly dead – *Bryum dichotomum*, *Didymodon australasica* and *D. weymouthii* were seen. At the time of the survey seabird activity within this area was minimal due to the destruction caused by Cyclone Bune (see de Lange 2012). However, numerous burrows were present amongst the *Cyperus*, and a few supported black winged petrels (*Pterodroma nigripennis*).

Higher up the island leading to the southern summit, smaller areas of *Cyperus* sedgeland grew within sheltered 'basins' and ledges. In these sites, (all extensively petrel burrowed due to the deeper accumulation of soil and saprolite) *Cyperus* grew with *Disphyma*, *Parietaria debilis*, and occasional luxuriant examples of *Lepidium castellanum*.



Figure 5. Curtis Island viewed from the apex of the saddle between the northern and southern summits of Cheeseman Island. Here the narrow Stella Passage separating both islands can be seen. In the foreground the dense mass of *Cyperus insularis* that represents the terminal end of the '*Cyperus* sedgeland' vegetation type can be seen, followed by a band of heavily petrel burrowed *Disphyma* turf. Photo: W. Chinn

DISCUSSION

Clearly comparison of the flora of Cheeseman Island with Macauley Island is of little value, because of the latter island's much greater size, altitude, diverse geology and thus range of habitats (Table 1; see also de Lange 2015). Similarly, L'Esperance Rock, though included for reference in Table 1, is excluded from this discussion due to its extreme isolation from the other southern Kermadec Islands (Fig. 1), and because of its very different hard basaltic-andesite rock composition (de Lange 2015b). Instead the following comparisons are confined to Haszard Islet and Curtis Island, because of their comparable geology, in the case of Haszard Islet its similar size and elevation, and for Curtis Island, its proximity to Cheeseman Island (Fig. 1, 5).

Cheeseman Island has for its size a larger flora (from nearby Curtis by nine species, and more distant Haszard by 12 taxa). Considering the much larger size and elevation (52.6 ha, 137 m a.s.l.) of the "sister" island to Cheeseman Island, Curtis Island (see Fig. 1, 5, and Table 1.), the paucity of that island's flora when compared to Cheeseman Island seems erroneous. I was unable to examine Curtis Island, due to high seas (de Lange 2012). However, the island was extensively surveyed during an ornithological visit undertaken during the late 1980s by G.A. Taylor (pers. comm.), during which only a small number of additions were made to the flora reported by Sykes (1977) (see Sykes & West 1996). Well-established relationships between island vascular floras and area (MacArthur & Wilson 1967) suggest that Curtis Island should have a larger flora than nearby Cheeseman Island, which is 6.5 times smaller and of lesser altitude (Table 1). However it is possible that these figures are accurate. One key difference between both islands is that Curtis Island is volcanically active, and much of the island's area occupied by an active crater and in addition, fumaroles and heated ground. These areas are unsuitable for colonisation by most vascular plants and so may account for Curtis Island having a much smaller flora than could be expected for its area. Further surveys of the Curtis Island flora are needed to be certain of its size. Similarly, the flora reported for Haszard Islet is unlikely to be comprehensive. This islet is only accessible by helicopter and has been visited twice (2002 and 2008), both times by ornithologists, during which only a few plant collections were made only around the general summit area. Further observations by Sykes (1977) and myself, are of those plants that could be seen by boat or from nearby Macauley Island (de Lange 2015). Thus, whilst Table 1 serves as a useful tabulation of the floras of the southern Kermadec Islands, as currently understood, it would be unwise to use it as a basis for biogeographic inferences. Similarly comparisons between these islands and the much larger, taller and geologically distinct northern Kermadec Islands also seems unwise, and for this reason, beyond making the obvious statements that the flora of the southern Kermadec Islands is smaller than its northern neighbours, little more could be said.

Nevertheless the result that seems to be more interesting comes from the comparison between the actual flora (here reported) and previous surveys. Having data collected over a wide temporal interval

allows us to better understand the dynamicity of a flora. The present study clearly shows that Cheeseman Island had a species turnover during the last 40 years, that was caused by several factors. In fact not only is the species richness in an island related to island area, its distance from 'mainland' seed sources, and its environmental heterogeneity (MacArthur & Wilson 1967) but the species assemblage on an island is dynamic not static. Stochastic dispersal, local extinctions, human influence, and environmental disturbance can have a pivotal role in driving the arrival, permanence, diminution and/or disappearance of insular micropopulations.

The impact of Cyclones on the vegetation of Cheeseman is a case in point and worth further study. If as suggested by de Lange & Galloway (2015), cyclones may help seed the Kermadec Islands with propagules uplifted from north-eastern Australia, New Caledonia and Fiji, then this deserves critical investigation. Equally the stochastic role of the cyclones in rejuvenating the seemingly 'closed' *Disphyma* turf (broken only where the depth of soil and saprolite permits petrel burrowing) by mass disturbance is a field little investigated in northern New Zealand offshore island ecology. It is likely that the dense turf of *Disphyma* is a barrier to colonisation by other species. Cyclones cause mortality and damage in these turfs, which in turn may create opportunities for local colonisation by other plant species, from seed banks or seed dispersal. This disturbance, may too account for the increase in the flora of Cheeseman Island, and if this is correct, then the size of the flora should decline the longer the island is undisturbed by cyclones.

These findings suggest that we should consider small islands such as Cheeseman Island as systems strongly dependent on external factors such as disturbance and casual dispersal of propagules to maintain and augment their flora. Further studies will be necessary to better understand the role of external factors in determining the dynamics and turnover of species assemblages and plant communities in such remote insular systems. Cheeseman Island seems to be an excellent example of such a system and would well repay further study.

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Peter J. de Lange, Science and Policy Group, Private Bag 68908, Department of Conservation, Newton, Auckland, New Zealand. Email: pdelange@doc.govt.nz

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APPENDIX 1: Flora of Cheeseman Island, southern Kermadec Islands.

* denotes naturalised to the Kermadec Islands, † denotes addition to flora of Cheeseman Island.

Taxon	Family	Voucher	Abundance
Bryophytes (11)			
Liverworts (1)			
† <i>Frullania pentapleura</i> Taylor	Frullaniaceae	AK 325537	scarce
Mosses (10)			
† <i>Bryum argenteum</i> Hedw.	Bryaceae	AK 327000	scarce
† <i>Bryum dichotomum</i> Hedw.	Bryaceae	AK 327885	scarce
† <i>Campylopus</i> sp.	Dicranaceae	AK 327067	scarce
† <i>Ceratodon purpureus</i> (Hedw.) Brid.	Ditrichaceae	AK 326999	scarce
† <i>Didymodon australasiae</i> (Hook. et Grev.) R.H.Zander	Pottiaceae	AK 327070	scarce
† <i>Didymodon weymouthii</i> (R.Br.bis.) R.H.Zander	Pottiaceae	AK 327003	scarce
† <i>Fissidens leptocladus</i> Müll.Hal. ex Rodway	Fissidentaceae	AK 327002	scarce
† <i>Grimmia pulvinata</i> var. <i>africana</i> (Hedw.) Hook.f. et Wilson	Grimmiaceae	AK 326998	scarce
† <i>Trematodon suberectus</i> Mitt.	Bruchiaceae	AK 326997	locally common
† <i>Weissia controversa</i> Hedw.	Pottiaceae	AK 327887	scarce
Ferns (3)			
† <i>Asplenium northlandicum</i> (Brownsey) Ogle	Aspleniaceae	AK 325982	locally common
† <i>Asplenium shuttleworthianum</i> Kunze	Aspleniaceae	AK 325987	scarce
† <i>Christella</i> aff. <i>dentata</i>	Thelypteridaceae	AK 325984	scarce
Spermatophytes (21)			
Monocots II (4)			
<i>Cyperus insularis</i> Heenan et de Lange	Cyperaceae	AK 325999	common
† <i>Ficinia nodosa</i> (Rottb.) Goetgh., Muasya et D.A.Simpson	Cyperaceae	AK 325998	scarce
† <i>Isolepis cernua</i> var. <i>cernua</i>	Cyperaceae	AK 325996	scarce
<i>Lachnagrostis littoralis</i> (Hack.) Edgar subsp. <i>littoralis</i>	Poaceae	AK 281413	common
Core Eudicots (17)			
<i>Disphyma australe</i> subsp. <i>stricticaule</i> Chinnock	Aizoaceae	AK 326006	dominant
<i>Tetragonia tetragonoides</i> (Pall.) Kuntze	Aizoaceae	AK 325993	scarce
<i>Chenopodium trigonon</i> Schult. subsp. <i>trigonon</i>	Amaranthaceae	AK 326004	locally common
*† <i>Bidens pilosa</i> L.	Asteraceae	AK 281406	not seen
† <i>Cotula australis</i> (Spreng.) Hook.f.	Asteraceae	AK 325991	locally common
* <i>Conyza bonariensis</i> (L.) Cronquist	Asteraceae	AK 329716	scarce
<i>Sonchus kirkii</i> Hamlin	Asteraceae	AK 325989	locally common
*† <i>Sonchus oleraceus</i> L.	Asteraceae	AK 281414	not seen
<i>Lepidium castellanum</i> de Lange et Heenan	Brassicaceae	AK 326009	locally common
*† <i>Polycarpon tetraphyllum</i> (L.) L.	Caryophyllaceae	AK 326001	locally common
† <i>Ipomoea cairica</i> (L.) Sweet	Convolvulaceae	AK 281422	not seen
*† <i>Oxalis corniculata</i> L.	Oxalidaceae	AK 281410	not seen
*† <i>Portulaca oleracea</i> L.	Portulacaceae	AK 326556	scarce
† <i>Coprosma repens</i> A.Rich.	Rubiaceae	AK 326012	scarce
<i>Solanum nigrum</i> L.	Solanaceae	CHR 211796	not seen
† <i>Solanum nodiflorum</i> Jacq.	Solanaceae	AK 326003	scarce
<i>Parietaria debilis</i> G.Forst.	Urticaceae	AK 326002	common