Flora Values Assessment and Monitoring Report – Macquarie Island Nature Reserve and World Heritage Area – *March 2019*

Natural Values Science Section

2019

Nature Conservation Report Series 19/01

Department of
Primary Industries, Parks, Water and Environment

Tasmanian Government

Flora Values Assessment and Monitoring Report – Macquarie Island Nature Reserve and World Heritage Area – March 2019

Compiled by Micah Visoiu – Ecologist, Natural Science Section, NCH

Acknowledgements
Support and advice for this work was provided by Luke Gadd, Chris Howard and Noel Carmichael of the Tasmanian Parks and Wildlife Service.

Nature Conservation Report 19/01

ISSN: (Electronic): 1838-7403

Published by: Natural Values Science Section, Natural Values Conservation Branch, Natural and Cultural Heritage Division, Department of Primary Industries, Parks, Water and Environment (DPIPWE), GPO Box 44 Hobart, Tasmania, 7001.

Suggested citation:

Visoiu, M. (2019) Flora Values Assessment and Monitoring Report – Macquarie Island Nature Reserve and World Heritage Area – March 2019. *Nature Conservation Report 19/01*, Natural and Cultural Heritage Division, DPIPWE. Hobart.

Cover photo: Double point from Davis Point – Mid west coast.

Table of Contents

Introduction

Macquarie Island is a highly oceanic subantarctic island located approximately 1,500 kilometres SSW of Tasmania and just north of the Antarctic convergence. The island is 32 km long by 5 km at its broadest point and 12,800 hectares in area (Figure 1). It is managed as a Nature Reserve by the Tasmanian Parks and Wildlife Service (PWS) and has been listed as a UNESCO World Heritage Area since 1997. The island is unique within the Tasmanian Reserve system in its geographic isolation, subantarctic climate and unique natural values, very few of which are held in common with mainland Tasmania. The island was the focus of the Macquarie Island Pest Eradication Project (MIPEP). A joint $25 million Australian and Tasmanian Government project to eradicate European rabbit (*Oryctolagus cuniculus*), black rat (*Rattus rattus*) and house mice (*Mus musculus*), from the island. This project was declared a success in 2014, proving to be the largest ever multi-species island eradication project ever attempted. Previously, two other introduced species were eradicated from the island, domestic cats (*Felis silvestris catus*) in 2000 and wekas (*Gallirallus australis*) in 1989.

The Island is the location of one of the Australian Governments four permanent stations which are maintained by the Australian Antarctic Division (AAD). Along with the station which is located at the northern end of the island there is a network of six field huts which are distributed around the island. The Macquarie Island station and field huts are currently in the process of being replaced through the AAD's Macquarie Island Modernisation Project which is expected to be completed by 2027. The AAD support the PWS management of the reserve through the supply of management berths on AAD shipping to and from the island and through support of on-island staff and round trip management personnel on the island. PWS also play a key role in the ongoing biosecurity management of the island.

From the 1970's, PWS began to establish a range of formal monitoring programs focussing on sea birds and vegetation, primarily investigating the impacts and interaction resulting from feral animal control programs that commenced in the 1960's. The custodianship of several of these monitoring programs was transferred from PWS to what is now the Natural and Cultural Division (NCH) with the transfer of scientific specialist staff out of PWS in the late 1990's. These programs have been maintained by NCH in collaboration with PWS since this time. In addition to aspects of these programs being included in the PWS Macquarie island works program, PWS also supplies NCH with management berths to the island on an annual basis.

In past season's flora monitoring has been undertaken on a biennial basis, usually with two staff, or one staff member and a volunteer. The work is undertaken during the AAD's annual Macquarie Island re-supply voyage (V4) which typically occurs between March and May. Usually this affords 5-7 days on the island for work to be undertaken. During the 2019 re-supply V4 was extended due to the Macquarie Island Modernisation Project and only one berth for flora related work was available. Natural Values Science Section ecologist, Micah Visoiu, undertook the work and was provided on-island support by Macquarie Island summer ranger, Luke Gadd. The support provided by PWS including Luke's time and Ranger in Charge, Chris Howard's logistical facilitation enabled a thorough field program to be undertaken during 10 days in the field. This enabled all priority aspects of the monitoring program to be achieved.

Figure 1, Macquarie Island

Program Description

Aims:

- Vegetation monitoring and assessments
    1. Undertake re-scoring of long term vegetation monitoring sites.
    2. Re-photograph long term photo-monitoring points.
    3. Island wide assessment of state of vegetation development post MIPEP.
- *Azorella macquariensis* dieback
    4. Island wide assessment of the current status of dieback in *Azorella macquariensis.*
- Restricted and threatened flora assessments
    5. Opportunistic assessment of restricted and threatened flora sites and populations.
- Biosecurity surveys and weed species assessments
    6. Assessment of treatment sited for invasive exotic grasses *Agrostis capillaceous* and *Agrostis stolonifera.*
    7. Assessment of status of newly identified exotic species *Cerastium glomeratus* on Macquarie Island.
    8. Biosecurity surveys of field hut sites, ex-MIPEP hut sites and Tourism Management Zones for weed incursions.

Objectives

- Vegetation monitoring and assessments
    1. Provide quantitative and qualitative information on the development of the island's vegetation post MIPEP to document the success of the project and state of the Nature Reserve and WHA.
    2. To enable early identification of emerging issues threatening the flora and vegetation values of the reserve.
- *Azorella macquariensis* dieback
    3. To ascertain the current status of dieback in *Azorella macquariensis,* its level of impact, distribution, ongoing impact on the feldmark ecosystem and potential trajectory of the species on the island.
- Restricted and threatened flora species assessments
    4. To increase the understanding of the biogeography of restricted and threatened flora species in the face of rapidly changing vegetation post MIPEP, climate change and the interaction between the two.
- Biosecurity surveys and weed species assessments
    5. To provide an assessment of the efficacy or otherwise of the eradication management of the invasive exotic grasses *Agrostis capillaceous* and *Agrostis stolonifera.*
    6. To confirm the field identification of *Cerastium glomeratus* and survey widely to identify its distribution, likely origin and potential for management.
    7. To survey gateway sited for any new or undetected weed incursion which pose a threat to the natural values of the reserve.

Rationale /Justification

This program feeds into island management and reporting on several levels. Biosecurity is one of the most important issues for the maintenance of the integrity of the Macquarie Island Nature Reserve. Systematic surveys for incursions of new weed species at key gateways and at previous incursion sites on the island provides for early identification and rapid response to any new or persisting incursions.

Assessment of the status of *Cerastium glomeratus* on the island provides information on the potential origin of the species which directly influences any management responses for the species.

Assessment of the island's vegetation condition via structured and unstructured means provides evidence of the efficacy of the MIPEP project which provides information for World Heritage Area reporting and supports management through documenting the condition of natural values.

The dieback in the endemic and Endangered *Azorella macquariensis* has been ongoing since the late 2000's and has been the focus of several research projects and management responses including, the establishment of *Azorella* Special Management Areas, and enhanced biosecurity including the instigation of reverse biosecurity measures for expeditioners and materials returning to Tasmania. Assessment of the status of the dieback provides managers with information on the current state of the species on the island and justification for any direct management actions or otherwise.

The key stakeholders for this program are PWS, NCH and the AAD.

The Natural and Cultural Heritage Division and PWS provide in-kind support for this program in the form of allocated staff time. The AAD, through agreement with PWS provide in-kind support through the provision of shipping berths, field support and on island operating costs.

Vegetation Monitoring and Assessments

There were three levels to this aspect of the field program; to undertake re-scoring of long term vegetation monitoring sites; to re-photograph long term photo-monitoring points; and to undertake an island wide assessment of general state of vegetation development post MIPEP.

Re-scoring of long term vegetation monitoring sites

This objective was the primary aim of the vegetation assessment for this season and is the 18th time this set of 29 quadrats with an additional 29 nested quadrats, across six sites, have been re-sampled in the 38 years since their establishment in the 1980/81 season by former PWS and NCH wildlife biologist Geoff Copson. One quadrat was discontinued in 2016/17 due to its complete loss due to flood damage.

These monitoring sites are critical to assessing long term responses in the vegetation on Macquarie Island to the eradication of rabbits and rodents from the island. They inform the Macquarie Island management plan, the identification of plant species under threat on the island and vegetation community conversion processes. Maintenance of the plots in the longer term will enable continued assessment of the recovery of the vegetation on Macquarie Island following rabbit eradication, monitoring of weed responses to rabbit eradication, and reporting on recovery of plant species at risk from rabbit grazing.

All sites were successfully re-surveyed during the 2018/19 resupply, with no additional landslip or flood damage present in any of the quadrats. Corner markers were replaced at several sites to enable easier location in the rapidly heightening vegetation. Five 1.5m markers are required for the Sandy Bay Site to replace posts in dense tussock grassland that are currently difficult to relocate due to overgrowth.

Limitations or critical issues

N/A

Recommendations

- The sites be re-assessed in the 2020/21 summer season, marking the 40-year anniversary of their establishment and 10 year recovery from rabbit grazing. A full statistical analysis of the data be undertaken and reported on following this survey.
- Following analysis and reporting in 2020/21, assessment of the future trajectory of the program is undertaken.
- Forward planning to enable two flora NVC specialist staff berths be allocated in 2020/21 to allow for knowledge management and capacity for the Macquarie Island flora program into the future.

Re-photograph long term photo-monitoring points

There are a number of photopoints on the island established by Geoff Copson, primarily in the 1980s, with some of these sites based on the location of older images. In the last ten years these photopoints have been maintained and have been undertaken at the same time as the vegetation plot data is collected.

All target photo points were successfully re-photographed during the 2018/19 resupply; the observations made from these are outlined below in the general vegetation assessment.

Limitations or critical issues

N/A

Recommendations

- Photopoints continue to be re-taken on a biennial basis.
- Sites be recorded on the PWS Macquarie Island Scientific Sites Register.

Macquarie Island General Vegetation Assessment

The vegetation on the island has continued to develop at a rapid rate following the initial crash in rabbit populations that occurred in January/February 2011 following the introduction of rabbit calicivirus to the island as a part of MIPEP. Anecdotally and observationally rabbit calicivirus appeared to significantly reduce rabbit numbers over much of the island, probably in the range of over 90% in many areas. Immediately prior populations were estimated at approximately 140 000 island wide, and were decreasing from an estimated historical high of ~220 000 in 2005/2006 (Terauds *et al.* 2014).

The completion of brodificoum bait broadcasting on the island in the winter of 2011 eliminated the remaining rabbits and eradicated both mice and rats from the island. The vegetation of the island has therefore undergone eight full growing seasons in the absence of terrestrial mammals.

General Vegetation Observation

The initial stage of vegetation recovery following the release from rabbit disturbance was a rapid increase in the biomass of the pre-existing communities. The pre-eradication vegetation was a highly modified grazing/ground disturbance disclimax with the majority of the lower slopes of the island dominated by short *Agrostis magellanica* grassland in which regular soil disturbance encouraged the establishment of herbaceous primary colonisers including the two *Epilobium* species, *Cardamine corymbosa*, *Montia fontana* and the introduced grass *Poa annua*. Pure patches of *Acaena magellanica* also occupied large areas due to its relative unpalatability to rabbits and its ability to rapidly vegetatively colonise large areas. The large tussock grass *Poa foliosa* was largely reduced to small pockets or

individual plants mainly on steep slopes, whilst the large megaherb *Stilbocarpa polaris* was confined to very steep coastal slopes.

The initial stage of vegetation recovery was well underway during a visit to the island in February 2013, at that time the biomass of vegetation on the island had increased by a factor of five to ten over 2011 levels, although with a relatively minor change in vegetation composition.

As of April 2015 the vegetation had commenced a second stage of recovery with a dynamic range of species successions having commenced. By March 2017 this succession and vegetation development had progressed, a process which has continued up until March 2019.

After an initial rapid change in the island vegetation up until 2017 the development of the islands vegetation has slowed in inland valleys dominated by short grassland. Occasional *Poa foliosa* tussocks and *Stilbocarpa* plants established in the first five years after MIPEP, however large areas now appear to have reached a stable disclimax. Whilst the *Stilbocarpa* and *Poa foliosa* have the ability to outcompete all of the species in the short grassland once established, the density of the grassland in these areas is such that there appears to be vary limited ability for these species to germinate and therefore spread and expand (Figure 2). Evidence supporting this assessment can be seen in numerous area of landslide that occurred after heavy rains in 2015. At these sites the ground disturbance has allowed the establishment of *Poa foliosa* tussocks, however surrounding undisturbed areas remain largely devoid of this species (Figure 3). This is not the case on steep sloped where ongoing minor disturbance associated with slop processes appears to have allowed the continued rapid expansion of *Poa foliosa* and *Stilbocarpa*.

Figure 2. Established *Stilbocarpa polaris* and *Poa foliosa* in short grassland near Lake Gratitude. Colonisation of these areas by these larger species has now slowed due dense ground cover.

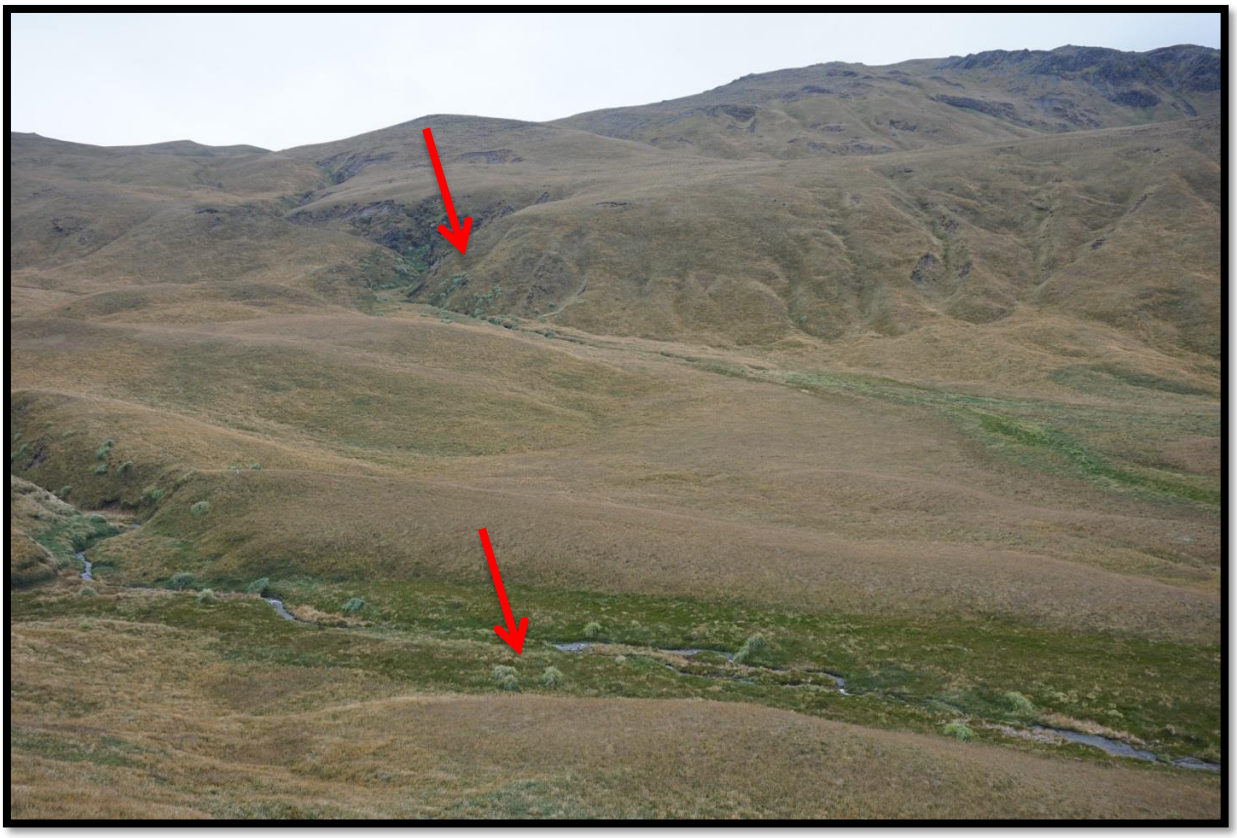

Figure 3, *Poa foliosa* tussocks, in the foreground established on area scoured by a debris flow that occurred in 2015 and in the background establishing in the absence of recent major disturbance on steep banks. Establishment on the flatter undisturbed areas is only occasional. Photo taken March 2019.

Species Specific Observations

The following observations are based on direct observation and interpretation of time series photopoints.

- Progression of the vegetation from 2017 has continued with similar trends in most cases. In areas away from disturbance, primary colonisers (those species, usually short-lived low-stature herbs, which germinate on bare ground and rapidly form a ground cover) have continued to reduce in cover and have virtually disappeared in many areas. The native species which favour these conditions, *Cardamine corymbosa*, *Epilobium brunnescens*, *E. pedunculare* and *Montia fontana* have all greatly reduced in occurrence and cover since the completion of MIPEP.
    - The three common introduced plant species on the island, all of which are early stage primary colonisers, have fluctuated in abundance post-MIPEP although in different ways.
        - *Poa annua* has decreased dramatically in abundance on the island as a whole. This is particularly so in inland areas where it is now largely confined to tracks, bird rookeries and landslide site. On the coastal verge it is still common and often dominant in the inter-tussock spaces frequented by seals and penguins.
        - *Cerastium fontanum* increased in prominence between 2011 and 2013 before decreasing slightly by 2015. In 2017 the species had become a prominent and a highly visible component of the vegetation in many areas that were formerly short grassland. A potential scenario which would explain the abundance in 2017 relates to the life cycle of this species which is a short-lived perennial persisting for several years once established. *Cerastium fontanum* was heavily grazed by rabbits and

consequently was rarely encountered pre-2011, with most plants being in areas inaccessible to rabbits or being ground-hugging chewed-back individuals. Two years without rabbit grazing saw a significant increase in the cover of this species by 2013 as previously grazed plants grew over several seasons and flowered and produced seed. By 2015 this initial generation of mature plants had died off temporarily reducing the visibility of the species however a large cohort of seedlings and less developed smaller plants were already established within the grass sward. By 2017 these plants which had resulted from seed produced in the first flush of vegetation development have grown into large multiyear individuals. It was predicted at the time that the species would gradually decrease in prevalence due to the density of ground layer vegetation preventing establishment of new seedlings in many areas, although it would likely remain a significant element of the flora in some areas.

This situation has been realised to some extent in 2019, the species has decreased in cover in the previously dense sites in the northern part of the island, particularly around the Sandy Bay Track and other mid-altitude tracks through short grassland areas, although it is still highly visible near tracks and other disturbance sources in this area. The wider survey of the island possible in 2019 identified that the species is far less common in the southern part of the island south of Pyramid Peak, with populations in the south generally widely dispersed and localised. It would seem likely that in the absence of rabbit grazing this species will spread more widely in the south of the island and will increase in abundance around sources of disturbance in this area. The track system provides likely corridors for the further spread of the species in this area, through both providing habitat and through unintentional spreading of seed on expeditioners clothing.

- *Stellaria media* is not often observed in the areas traversed during the standard island transit undertaken round trips. The 2019 field program allowed a greater coverage of the island to be surveyed which nevertheless identified very few sites where this species was present. Other work on this species on the island has located large populations which are localised within a few catchments in the north of the island (Williams *et al.* 2019). This species can be considered to be highly localised in its distribution on the island and appears confined to the north where it is only common in certain areas.

- *Acaena magellanica* continues to reduce in total cover on the island. As of 2019 the widescale monocultures of the species appear to have nearly retreated completely to what is likely its core habitat of burrowing seabird rookeries and recent landslide scars (Figure 4). Previously this pattern of distribution was masked by rabbit disturbance, however it is predicted that within the next few years monocultures of *Acaena magellanica* will be highly correlated with burrowing sea bird sites and landslips.
- The megaherbs *Stilbocarpa polaris* and *Pleurophyllum hookeri* and giant tussock grass *Poa foliosa*, are establishing in areas in which they have been absent in the recent past. The final "climax" distribution and interaction between these species is not yet immediately evident, however the continued expansion of all three species on the island is likely to continue.
    - *Pleurophyllum hookeri* continues to increase in occurrence and cover, predominantly on the westerly aspects of the island, but also on low lying eastern aspects. This species is particularly evident in the area along the western edge of the plateau within a few hundred metres of the escarpment. It is also continuing to develop on coastal terrace vegetation on the west coast. This species grows in mineral soils

through to pure peats with the only consistent factor being that it favours permanently saturated environments either due to a lack of competition from taller species or physiological preference.

- *Stilbocarpa polaris* is increasing in cover in several environments on the island and the eventual balance between this species and *Poa foliosa* is not yet clear. Confined only to steep inaccessible coastal slopes incidental to rabbit grazing in the years prior to MIPEP this species is now becoming dominant in numerous areas of coastal slope and also areas of coastal terrace. Individual plants have also become established throughout inland valleys such as Red River and Green Gorge (Figure 2) however this colonisation has now slowed despite the fact that in many areas plants have now reached reproductive size for the first time since mid-1990s.
- *Poa foliosa* continues to expand dramatically on coastal slopes and some inland valleys all over the island. Cover of this species on the slopes and flats around Bauer Bay has gone from <5% in 2011 shortly after the introduction of rabbit calicivirus to approaching 70% cover in 2019 (Figure 5). Seedlings of *Poa foliosa* are beginning to emerge in vegetation throughout the Red River Valley and other inland locations where the species has been completely absent in recent decades.

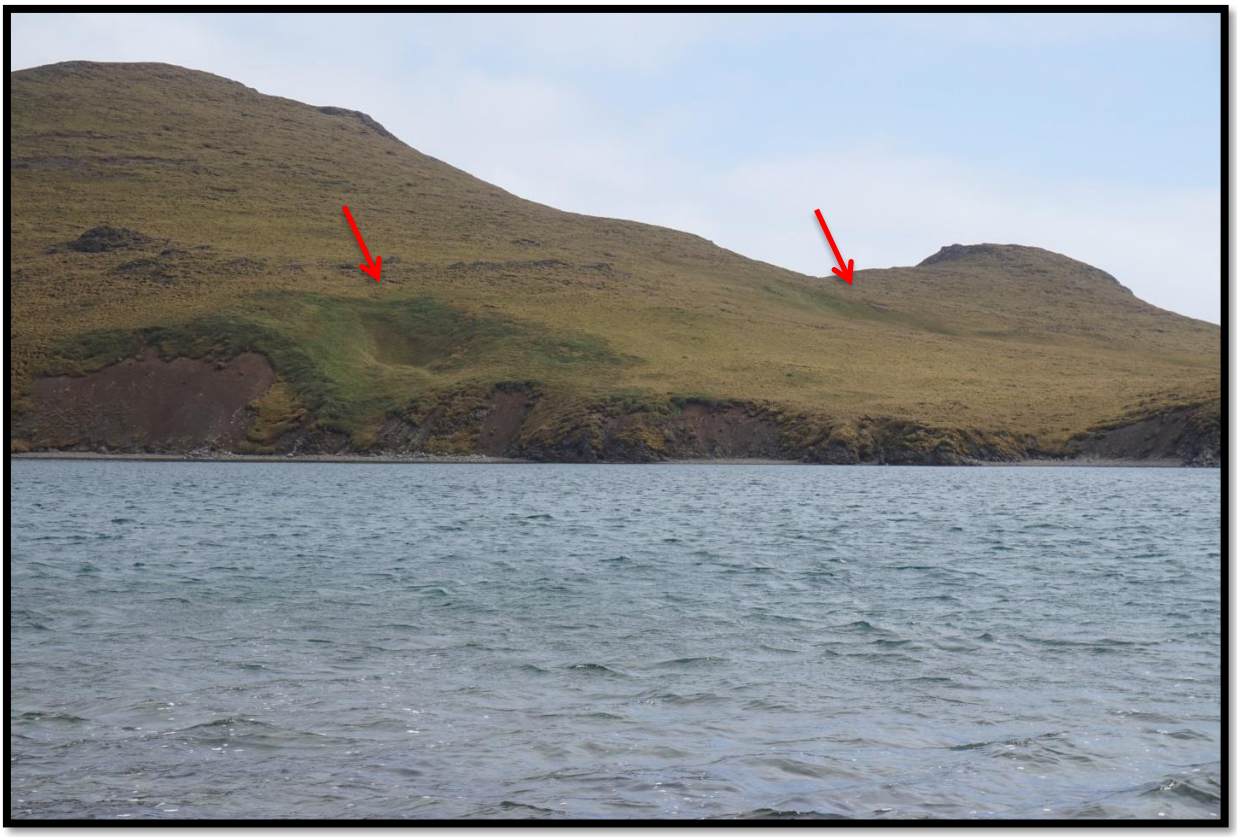

Figure 4. Dense patches of *Acaena magellanica* showing a bright bluish green indicating burrowing sea bird rookeries at Gratitude Lake.

2011

2013

2015

2017

2019

Figure 5, tussock development on the slopes behind Bauer Bay from 2011 shortly before the aerial baiting phase of MIPEP until 2019, seven full growing seasons after rabbit eradication.

- The fern *Polystichum vestitum* is accelerating its expansion, with individuals now establishing extensively in short grassland areas along the eastern slopes of the island. The species is now easily observable at Sandy Bay and Brothers Valley and is expanding rapidly in the Green Gorge area, and east coast slopes near Waterfall Valley amongst other localities. For the first time since the early 1990's it is growing in permanent monitoring plots in the northern part of the green gorge basin. This species is predicted to be a dominant "climax" species in some areas of steep and shaded slopes and unlike the mega herbs and giant tussock grass *Polystichum* has the ability to establish and

grow in dense vegetation swards so is continuing to spread despite the dense vegetation cover over the island, which appears to have slowed the expansion of the aforementioned species.

- *Sphagnum falcatulum* is the only species of sphagnum moss on Macquarie Island and has historically been restricted in its distribution and occurrence is continuing to expand in a wide range of areas on the island. Small localised patches are extensive in the Green Gorge Basin, at numerous waterlogged sites along the overland track and along the featherbed between Bauer Bay and the station.

Limitations or critical issues

- This assessment is informed by knowledge and observations of the island's vegetation gained over six trips to the reserve over a 10 year period. The observations presented are nevertheless inductive and are based on short and discrete periods of time on the island.

Recommendations

N/A

Azorella macquariensis dieback

A rapid dieback event was first observed in the Macquarie Island endemic cushion *Azorella macquariensis* during the summer of 2008/2009, resulting in the listing of the species as critically endangered in 2010. Since this time the dieback which is often typified by a progression of yellow disease front through and between cushions has progressed throughout the habitat of the species on the island (Figure 6). In addition to *Azorella macquariensis* the larger plants of the megaherb *Pleurophyllum hookeri* are also killed by these infection fronts. The symptoms displayed are characteristic of the progression of a pathogenic organism through the soil or root zone. There is often some level of recovery observed in affected cushions; however no areas have been seen to recover to a pre-dieback state. Several research projects have been undertaken on this dieback and are ongoing in one instance – *AASP 4312 Nowhere to hide? Conservation options for a sub-Antarctic keystone species*.

An early assumption was that the dieback was potentially the result of the establishment of a non-native primary pathogen which was being spread around the island. The management response was the increase in border biosecurity measures, introduction of reverse biosecurity to Tasmania, and introduction of on-island biosecurity measures, including the establishment of Azorella Special Management Areas (SMA). Three of these SMA's were established in areas which were thought to be largely free of the dieback at the time.

Subsequent work identified a potential primary cause of the dieback as being climate change related, with any pathogenic organism responding to, and being a secondary symptom to the changing environment (Bergstom et al. 2015). All funded research on the topic has subsequently focused on environmental and climate change research. Unfunded ad-hoc investigation by DPIPWE in conjunction with UTAS did identify a number of potential pathogens the most likely being an unidentified ascomycete soil fungus in the genus *Rosellinia*. This genus of fungus contains several known species that cause root rot diseases some of which cause similar symptoms to those observed on Macquarie Island (ten Hoopen and Krauss 2005).

The dieback phenomena was initially only widespread in the north of the island and was for several seasons sporadic and localised in the south of the island. This situation has since slowly progressed with *Azorella* cushions becoming less abundant in the north of the island and dieback becoming more abundant in the south.

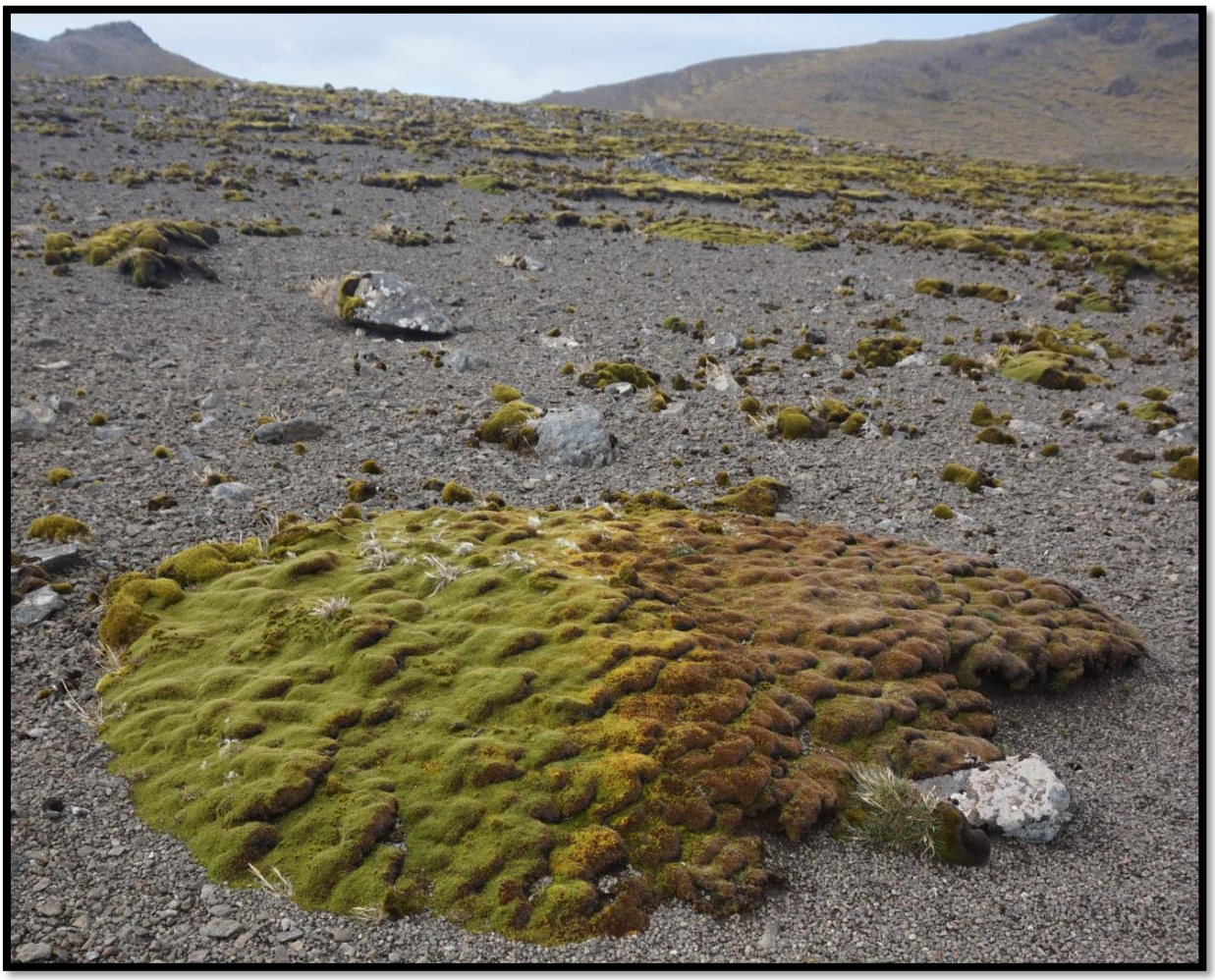

Figure 6, dieback progressing through a cushion of *Azorella macquariensis* in feldmark near Gratitude Lake

Observations of dieback during the 2019 resupply support the notion that the south of the island is currently in the midst of a significant dieback caused decline in *Azorella*. Dieback appeared to be ubiquitous in areas of *Azorella* on the island, although spatially variable in its level of impact. The Mt Ainswoth Azorella SMA was visited and active dieback found to be particularly extensive in this area. It is similarly extensive in the large areas of feldmark in the vicinity of Windy Ridge and Mount Hamilton. Small areas of dieback were evident in inaccessible areas of Azorella cushions on westerly facing cliff lines along the escarpment above Sellick Bay and Davis Bay. Although dieback was still present, the eastern slopes of Mount Blake and northern slopes of Pyramid Peak still support large areas of comparatively healthy cushion dominated feldmark.

The ubiquitous nature of the dieback within the range of *Azorella* and its occurrence in apparently inaccessible and isolated areas suggests that the pathogen causing the mortality of the species is not being actively spread, and is likely a widespread and potentially native component of the soil flora. Whilst this disease outbreak is highly likely a result of changing environmental conditions brought about by climate change, there are other environmental variables which are currently changing and may be implicated to some extent. Rabbit grazing is likely to have artificially advantaged Azorella since their introduction in the late 18th century through preferential gazing of grasses. Rabbits have also highly likely influenced ground level microclimate during this time by reducing vegetation height, reducing dew and fog water inputs by removing foliage etc. All these interactions are now changing since MIPEP.

Limitations or critical issues

- Without definitive identification of the pathogen that is causing mortality in *Azorella* it is not possible to accurately predict the response of this organism under differing conditions.
- There are numerous unresolved interactions taking place that have culminated in the dieback in *Azorella* the require resolution before long term prognosis for the species can be made.

Recommendations

- The *Azorella* Special Management Areas may be revoked if required for other land management purposes as they are not achieving their original objective.
- Representative permanent photopoints be set up on the southern plateau to track the decline of *Azorella* in the fellfield environment.
- Attempts to isolate and positively identify the pathogenic organism responsible for the mortality in *Azorella* and associated *Pleurophyllum* plants resume.

Restricted and Threatened Flora Species Assessments

A number of sites of restricted and/or threatened species on the island were able to be visited during the 2019 re-supply observations of note were:

- *Huperzia australiana* (not-listed) has undergone a dramatic increase in distribution and abundance post-MIPEP. PWS Ranger in Charge, Chris Howard has surveyed and mapped the distribution of this species increasing the known locations from only eight small patches in 2011 to over 520 patches in 2019. This dramatic expansion whilst to a degree representing an increased survey effort has also likely occurred as a direct result of rabbit eradication. The habitat for this species is mid to high altitude fellfield where it grows in moss and *Azorella* cushions and spaces between bolsters. During the 2019 resupply the species was observed on numerous occasions in this habitat, with individuals up to 150mm in diameter not uncommon (Figure 7).

Figure 7, *Huperzia australiana* growing amongst mosses, grasses near Gratitude Lake.

- *Galium antarcticum* (Critically Endangered EPBC, Endangered TSPA) was investigated from the two sites it is known from on the western edge of Skua Lake. The species was found at both sites and is common but localised in the southern site but only occasional in the northern location where it appears to be getting outcompeted by rapidly developing grassland. The fellfield environment at the southern site appears to be the more favourable habitat for this species. There are very extensive areas of suitable habitat elsewhere on the island and it is likely to occur elsewhere. If it is restricted to the current sites then it can only be due to recent colonisation, possibly through human pathways but more likely naturally potentially via bird transportation from another subantarctic island.

Figure 8, *Galium antarcticum* habitat and plant near the western edge of Skua Lake

- The two orchid species in the genus *Corybas* were investigated at three sites on the northwest featherbed – *Corybas dienemus* (Critically Endangered EPBC, Vulnerable TSPA), and at Sawyer Creek north of Pyramid Peak – *Corybas sulcatus* (Critically Endangered EPBC, Endangered TSPA). These are all previously known populations of these species. *Corybas dienemus* was heavily in fruit at one site in on the featherbed near handspike point indicating prolific flowering this season at this site, no evidence of flowering was seen in other populations. Examination of the characteristics of the leaves of the both species suggested that it is possible to distinguish between them when not in flower: a guide is provided below in Figure 9.

  Assessment of the habitat of the species based on known records suggests that the habitat preferences for species may be vary basically modelled (Table 1). An analysis using these parameters produced an indication of areas which have the potential to have suitable habitat for these species is presented in Figure 9.

Table 1, basic habitat modelling parameters identified from Macquarie island orchid records

Species	*Altitude*	*Vegetation assemblages*
Corybas dienemus	< 40m asl	Coastal terrace mosaic (QCT) Mire (QMI) Short tussock grassland/rushland with herbs (QST)
Corybas sulcatus	70-160m asl	Short tussock grassland/rushland with herbs (QST) Mire (QMI)

Limitations or critical issues

- Surveys were only incidental and short and are were not extensive in geographic extent.

Recommendations

- The east coast *Corybas* sites are all visited and identity of the species confirmed.

Corybas sulcatus

cuspidate leaf tip

Flatter distinctively veined finer textured leaf

Corybas dienemus

mucronata leaf tip

Fleshy often cupped leaf, more often forming dense patched

Elongated fruiting bodies in March 2019

Figure 9, *Corybas sulcata* leaves on the left can be distinguished from *C. dienemus* on the right by the distinctive cuspidate tip which is mucronate in *C. dienemus*. The leaf of *C. sulcata* is also less fleshy with distinctive veins and less inclined to be cupped than *C. dienemus*.

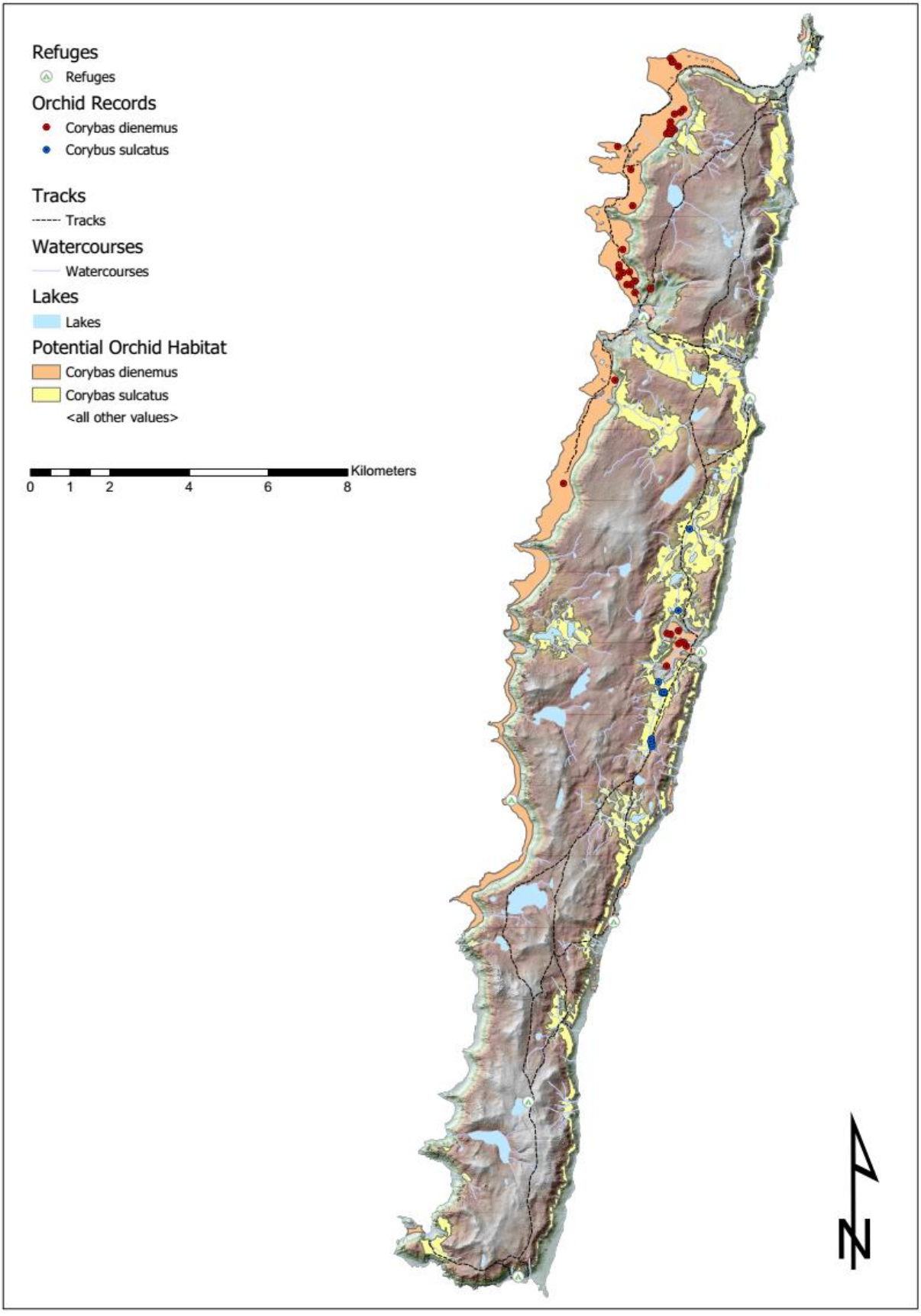

Figure 10, Modelled potential for orchid habitat for both species of *Corybas* on Macquarie Island

Biosecurity surveys and Exotic Species Assessments

Three separate tasks were undertaken as part of this assessment. 1) The survey of potential weed gateways for new weed incursions. 2) The assessment of two known exotic grass sites where eradication focused management has been carried out and; 3) The assessment of the recently identified weed species *Cerastium glomeratum* on the island.

Weed incursion surveys of Field Huts and Tourism Management Areas

All current field huts and two former hut sites were visited on the island and surveyed for novel incursions of exotic plant species. Surveys were conducted within a 10m radius of infrastructure, pallet drop sites, particular attention was paid to graywater outfalls. Sites assessed this way during the 2018/19 resupply were:

- Bauer Bay Hut
- Brothers Point Hut
- Green Gorge Hut
- Waterfall Valley Hut
- Davis Point Hut
- Hurd Point Hut
- The former site of Windy Ridge Hut (removed in 2016/17)
- The former site of Tiobunga Hut (Removed in 2014/15)
- The Sandy Bay Tourism Management Area and Board walk
- The Ridgeback Tourism Management Area and Board walk

No new weed incursions were detected during surveys. The naturalised and widespread weed *Poa annua* was common at all sites surveyed except for the sites of now removed MIPEP huts on the Plateau. The weed *Cerastium fontanum* is also frequent around sites in the northern half of the island. Several native grass species grow with atypically lush growth forms in the eutrofied environment associated with hut graywater and could potentially cause confusion at times.

Limitations or critical issues

- Although surveys were thorough it is possible that very small, low frequency or cryptic weed species may have been missed.

Recommendations

- Specialist staff undertake surveys of potential weed gateways on a semi-regular basis (every 2-4 years).
- Macquarie Island PWS rangers remain vigilant for unfamiliar plants on the island.
- The former site of Windy Ridge Hut and Tiobunga Hut can be accepted as free of novel exotic weed incursion and need not be subject to targeted surveys in the future.

Exotic grass sites in Green Gorge

In 2014 two small patches of exotic grass were found in the vicinity of Green Gorge; subsequently these patches were confirmed as being of different but similar widespread invasive grass species. *Agrostis stolonifera* was confirmed from a single patch (<1 square meter) adjacent to the Green Gorge hut Remote Area Power Supply (RAPS) unit. Following the initial discovery extension surveys identified a second similarly sized patch of exotic grass several hundred meters to the northwest adjacent to a

small creek crossing on the Overland Track in the Green Gorge basin, this second patch was subsequently determined to be a separate but similar species – *Agrostis capillaris*.

Pertierra *et al.* (2016) conducted a risk assessment of the species and found that although it seemed likely that currently the bioclimatic conditions on Macquarie Island are such that the species were unlikely to successfully sexually reproduce in an average season, both species nevertheless pose significant risk as invasive weeds to the island, particularly with ameliorating conditions under climate change. *Agrostis stolonifera* in particular is an invasive on several other sub-Antarctic islands including Auckland and Campbell Islands (Edgar and Connor 2010) and Marion Island (Pertierra *et al.* 2016)

Due to the limited extent of both of the patched at the time, the agreed management response was to mechanically remove the grasses returning all material to the station for incineration. A management plan was developed for the sites specifying follow up mechanical removal of re-sprouting material for a period, and then regular re-survey. After follow up removal was undertaken in early 2015 and mid-2016, the decision was made to fall back on chemical treatment if either species re-emerged. Suitable herbicide was identified and stocked on island and a treatment plan identified to be enacted in the event of re-emergence of either species.

Since mid-2016 no confirmed re-emergence of either species has been detected although in both 2017 and 2018 atypical growth of the native species *Deschampsia chapmanii* and *Agrostis magellanica* has raised concerns from PWS staff.

During the current trip both sites were thoroughly investigated both within the eradication sites and within a 10 meter radius of the sites. No suspect material was detected at either site. The timing of this survey was highly favourable for detection of these species being at the end of the growing season and maximised the chance of detection in the event of either species being present.

At the *Agrostis stolonifera* site near the Green Gorge hut RAPS there is a highly atypical form of the native grass *Deschampsia chapmanii* growing aquatically within the marked confines of the site that could be mistaken for the target species on superficial inspection. Figure 11 and Figure 12 illustrate the form in question. Differences in floret morphology between the species are shown in Figure 13.

Limitations or critical issues

- It is feasible that some small amount of vegetative material may have escaped detection, or that fertile seed was produced at some point prior to summer 2014 and remains within the soil.
- High intensity survey was only carried out within a 10 meter radius of the original detections and it is possible that other incursions of these species occur undetected on the island.

Recommendations

- The site markers at the eradication sites should be maintained and remain on the scientific sites register.
- Assessment by PWS staff can be reduced to once a year in February/March.
- When specialist staff are present on the island an intensive assessment of the sites and surrounding areas should be conducted.

Figure 11. Atypical *Deschampsia chapmanii* growing within the *Agrostis stolonifera* treatment site.

Figure 12. Comparison between the common form (left) and atypical form (right) of *Deschampsia chapmanii*.

Image credits: K.A. Ford - Landcare Research 2015

***Deschampsia chapmanii*, two florets per spikelet, florets greatly exceeding length of glumes on ripening.**

Image credit: Andrea Moro - Creative Commons Attribution Non Commercial Share-Alike 3.0 License

***Agrostis stolonifera*, (*A. capillaris* similar) single floret per spikelet enclosed in glumes following flowering. Toothed keels to glumes.**

Figure 13. Comparison of diagnostic spikelet characteristics between *Deschampsia Chapmanii* and the exotic *Agrostis* species.

The status of *Cerastium glomeratum* on the island

In February 2017 a potential new species record for Macquarie Island was made by summer science field assistant Alex Fergus along the Jessie Nichol Track near Waterfall Valley Hut. The species, *Cerastium glomeratum*, commonly called sticky mouse-eared chickweed, is a small annual or short lived perennial species which is a globally widespread disturbance-requiring herb. The very similar invasive species *Cerastium fontanum* – mouse-eared chickweed, is widespread on the island having been present since at least 1894 (Copson 1984). Botanical specimens were collected and later determined by Caryophyllaceae expert Phil Garnock-Jones, at the herbarium housed at Te Papa Tongarewa, Wellington as *Cerastium glomeratum*. Incidental observation by Alex in the 2017 summer detected a potential second site for the species near Boot Hill on the Overland Track in the north of the Island. Given the similarity of the species to *C. fontanum* and the potential widespread nature of the two potential occurrences it was assumed that the species detection most likely did not represent a new incursion, and was rather the recognition of a cryptic species that has potentially been present on the island for a long time. Since the initial detection there has been limited capacity to assess the status of the species on the island due to problems with identification. During the 2018/19 season the extended time available enabled specialist assessment of the type locality on the island and then incidental survey for addition populations undertaken during a 100+km foot traverse of multiple habitat types on the Island.

The field identification *Cerastium glomeratum* on the island was found to be easily achievable once the growth form and habit were compared with *Cerastium fontanum*. Side by side examples of the species are shown in Figure 15. *Cerastium glomeratum* on Macquarie Island grows as a smaller denser plant than does *Cerastium fontanum*, with the largest individuals seen not exceeding 10 cm in height. It has ovate rather than lanceolate leaves and appears to generally lack and red pigmentation of the stem, whereas *Cerastium fontanum* usually has some reddening of the stems.

Cerastium glomeratum was subsequently positively identified from five widespread sites on the island (Figure 14). The observed habitat of the species on the island was confined to active gravel outflows associated with landslides and fluvial processes where there is little or no competition from other species. The species occurs both on the coast and plateau and populations are generally composed of no more than a few reproductive individuals and a few dozen seedlings. The widespread but highly localised nature of the species on Macquarie Island suggests that it has been present on the island for an extended period of time but is potentially bioclimatically restricted with only individuals that germinate early in the season reaching a reproductive state. Currently the species poses a limited risk to the natural values of the reserve, and the nature of the distribution means that any direct management actions are unrealistic.

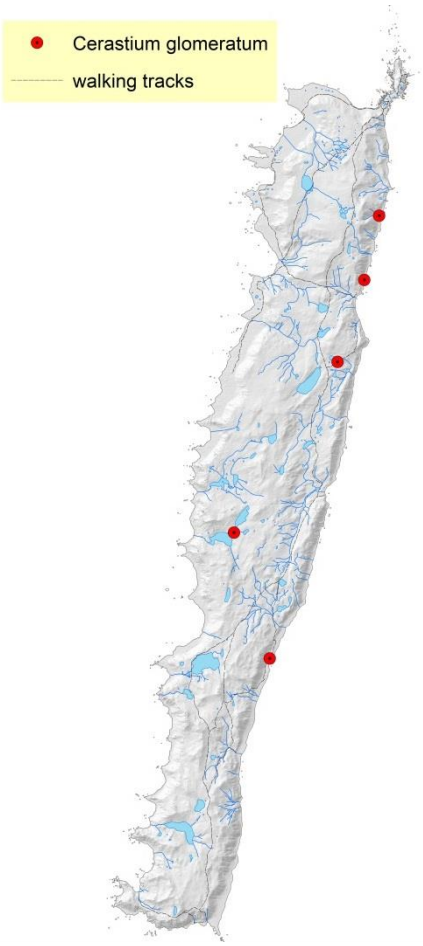

Figure 14. Cerastium glomeratum sites recorded during April 2019 re-supply

Cerastium glomeratum is commonly vary depauperate and present only as seedlings and vary small reproductive individuals

The three introduced chickweeds on the island growing side by side, *Stellaria media* (left), *Cerastium fontanum* (bottom right) and *C. glomeratum* (top right)

Cerastium fontanum (left) and *C. glomeratum* (right)

Cerastium glomeratum habitat on coastal erosion scarp near the nuggets

Cerastium glomeratum habitat on fluvial gravel near Flynn Lake

Cerastium glomeratum habitat in gravel fan outwash on coastal terrace near Waterfall Valley Hut.

Figure 15. *Cerastium glomeratum* examples and habitats observed on Macquarie Island.

Limitations or critical issues

- The survey was not exhaustive; however the nature of the distribution and population structure is likely to be consistent across the island.
- There is potential for climate change to advantage this species and for it to increase in distribution and abundance, nevertheless the apparent preference for areas of low or absent competition suggests that the species is filling a niche that is currently unoccupied on the island.

Recommendations

- There are no realistic management actions to be taken for *Cerastium glomeratus*. It should be considered to be a probable long term naturalised exotic which has hitherto gone undetected due to its low abundance and cryptic nature.

Additional notes and observation

- During November and December 2018 there was an extended period of comparatively dry and fine weather experience on Macquarie island that resulted in extensive drying out of usually saturated soil and partial or complete drying out of numerous lakes and tarns. This has historically been a very rare occurrence. The remainder of the summer has also been reported to be unusually fine.
- Potentially associated with the unusually warm and dry summer there has been an extensive bloom of a green filamentous algae in the many of the creeks and lakes on the island (Figure 16). There was some initial concern that it may be a new incursion of the exotic invasive species Didymo (*Didymosphenia geminata*). However, the characteristics of the algae suggests a green filamentous type (phylum Chlorophyta) rather than the invasive Didymo, which is a colony forming diatom (class Bacillariophyceae). The island wide distribution of the bloom suggests a likely native origin, and it is likely that environmental conditions have favoured it blooming extensively this year. A similar although perhaps smaller scale bloom was noted in the streams going from Waterfall Bay to Pyramid Peak and in Whiskey Creek amongst other places in 2016/17 and to a lesser extent 2017/18 (C. Dickson *pers com*). 2016/17 was also noted to be a particularly dry year.

Figure 16. Filamentous green alga has bloomed extensively across the island in the 2018/19 summer.

- Common redpoll (*Carduelis flammea*) and common starling (*Sturnus vulgaris*) populations remain high after an initial massive population increase after MIPEP. Both species were self-introduced to Macquarie Island in the early 20th century.
    - Large flocks of redpolls can now be reliably seen all over the island usually congregating in slightly wind protected localities. The likely factors contributing to the population are the ready availability of food, with seed set of most species having increased enormously in the absence of rabbit grazing; increased nesting habitat available in regenerating *Poa foliosa* tussocks; and eradication of rats and mice which would have had an unknown, but potentially significant, predatory impact on the breeding success of the species. Facilitated by their breeding biology, redpolls are known to be able to undergo rapid population increases in favourable habitat under good conditions. They are capable of producing two clutches of up to six eggs per season and breed in their first season (Latitude 42, 2011).
    - The common starling population has not increased as much as the redpoll population, however a significant increase in abundance was observed between 2011 and 2017 but has remained at apparently similar levels since. Unlike redpolls, starlings are not often permanent residents of the high latitudes, they have a higher dietary protein (insect) requirement during fledging, and they are hollow nesters. Starlings were observed in small flocks ~10-50 birds on numerous occasions and evidence of their feeding activity was regularly seen.

References

Bergstrom, D. M., Bricher, P. K., Raymond, B. , Terauds, A. , Doley, D. , McGeoch, M. A., Whinam, J. , Glen, M., Yuan, Z., Kiefer, K., Shaw, J. D., Bramely-Alves, J., Rudman, T. , Mohammed, C. , Lucieer, A., Visoiu, M., Jansen van Vuuren, B. and Ball, M. C. (2015), Rapid collapse of a sub-Antarctic alpine ecosystem: the role of climate and pathogens. *J Appl Ecol*, 52: 774-783. doi:10.1111/1365-2664.12436.

Copson, G.R. (1984) An annotated atlas of the vascular flora of Macquarie Island. ANARE Research Notes 18.

Edgar E, Connor H.E. (2010) Flora of New Zealand, volume v, grasses, 2nd ed. Manaaki Whenua Press, Lincoln

Landcare Research (2015) - http://www.nzflora.info/factsheet/Gallery/Deschampsia-chapmanii.html

Latitude 42 (2011) Pest Risk Assessment: Common Redpoll (*Carduelis flammea*). Latitude 42 Environmental Consultants Pty Ltd. Hobart, Tasmania.

Pertierra, L. R., Baker, M., Howard, C., Vega, G. C., Olalla-Tarraga, M. A. & Scott, J. (2016) Assessing the invasive risk of two nonnative *Agrostis* species on sub-Antarctic Macquarie Island. Polar Biol DOI 10.1007/s00300-016-1912-3

ten Hoopen, G.M., & Krauss, U. (2005). Biology and control of *Rosellinia bunodes, Rosellinia nectarix,* and *Rosellinia pepo:* A review. *Crop Protection*, 25: 89-107. http://doi.org/10.1016/j.cropro.2005.03.009

Terauds, A., Doube, J., McKinlay, J., Springer, K. (2014) Using long-term population trends of an invasive herbivore to quantify the impact of management actions in the sub-Antarctic, *Polar Biol*. 37:833–843.

Williams, L.K., Fergus, A.J., Shaw, J.D. et al. (2019) Quantifying site and species factors to inform the feasibility of eradication of alien plants from Southern Ocean Islands: *Stellaria media* on Macquarie Island. *Biol Invasions,* 21: 993. https://doi.org/10.1007/s10530-018-1880-3