AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITIONS

ANARE RESEARCH NOTES 18

An Annotated Atlas of the Vascular Flora of Macquarie Island

G.R. Copson

ANTARCTIC DIVISION
DEPARTMENT OF SCIENCE AND TECHNOLOGY

AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITIONS

A N A R E

R E S E A R C H

N O T E S

18

An Annotated Atlas of the Vascular Flora of Macquarie Island

G.R. Copson

ANTARCTIC DIVISION
DEPARTMENT OF SCIENCE AND TECHNOLOGY

ANARE RESEARCH NOTES (ISSN 0729-6533)

This series complements ANARE Reports and incorporates the functions of the now discontinued series of Technical Notes and Antarctic Division Technical Memoranda. The series will allow rapid publication in a wide range of disciplines. Copies of ANARE Research Notes are available from the Antarctic Division.

Any person who has participated in Australian National Antarctic Research Expeditions is invited to publish through this series. Before submitting manuscripts authors should obtain a style guide from:

The Publications Office
Antarctic Division
Channel Highway
Kingston
Tasmania 7150
Australia.

Published May 1984
ISBN: 0 642 87546 4

CONTENTS

FIGURES

TABLES

MAPS

AN ANNOTATED ATLAS OF THE VASCULAR FLORA OF MACQUARIE ISLAND

by

G.R. Copson

National Parks and Wildlife Service,
Magnet Court, Sandy Bay, Tasmania, 7005

ABSTRACT

The atlas shows the known distribution and abundance of each vascular species on Macquarie Island immediately prior to the commencement of control measures against rabbits in 1978. It gives a baseline against which changes in the vegetation can be monitored. The effects of the introduced vertebrates on the vegetation are discussed. Additional data are given on the habitat, gregarious performance and phenology of some species.

11/7/1810	Macquarie Island discovered by the brig Perseverance, Capt. Hasselborough. Sealing and oil gathering commenced.
1820's	First botanical collections made by Bellingshausen and Raine. Cats and dogs running wild on island.
1825	The "Macquaries" proclaimed part of Van Diemens Land.
1870's	Rabbits and wekas released on the island as a source of food for sealers.
1880	Dr Scott made a botanical collection. Rabbits well established at the northern end of the island.
1894	A. Hamilton made a collection of 32 vascular plants including two endemics and three alien species. The endemic races of the landrail and parakeet were not sighted on this visit or by any subsequent visitor.
1911-13	The Australasian Antarctic Expedition established a station on the island and carried out scientific studies. H. Hamilton made a botanical collection of 34 species of vascular plants including the third endemic.
1919	The sealers and oil gatherers finally left the island.
1933	Macquarie Island proclaimed a Wildlife Sanctuary.
1948	An ANARE station was established on the island and scientific studies have been carried out there ever since.
1950	Taylor carried out a detailed study on the flora.
1971	The island proclaimed a Tasmanian State Reserve.
1978	Myxomatosis introduced to control rabbit numbers.

Table 1. Historical events relating to the vascular flora of Macquarie Island.

1. INTRODUCTION

The initial European discovery of subantarctic Macquarie Island in 1810 led directly to the commercial exploitation of its biological resources. The exploitation, firstly of fur seals for their skins, then elephant seals and penguins for oil, continued intermittently until 1919 when the last oil gathering gang left the island (Cumpston 1968). In 1933 the Tasmanian Government declared the island a Wildlife Sanctuary and in 1971 it was made a State Reserve, i.e. a fully protected area under the Tasmanian National Parks and Wildlife Service (NPWS) Act 1970. Brief resumes of historical events and botanical collections for the island are given in Tables 1 and 2.

With the establishment of the sealing industry came the inevitable introduction of alien species, many of which have remained to become major problems for biological conservation on the island (Jenkin et al. 1981). From the botanical point of view the most serious problem was the European rabbit (Oryctolagus cuniculus L.) which was introduced in the 1870's (Scott 1881). The deleterious effects of rabbits on the vegetation of the island have been documented by Taylor (1955), Costin and Moore (1960), and Jenkin and Ashton (1979).

In the mid 1960's the Antarctic Division, CSIRO and Tasmanian Agricultural Department began to investigate means of controlling rabbits on the island. This work was taken over by the NPWS in 1972 and culminated in the introduction of myxomatosis in December 1978, (Brothers et al. 1982). The myxoma virus has been reintroduced on several occasions and detailed monitoring of its effects is continuing. In conjunction with the rabbit control programme studies are being carried out into the effects of rabbits on other fauna on the island, particularly burrowing birds, skuas, feral cats. Programs are also in train to monitor effects of individual vascular plant species as well as gross changes in vegetation.

The detailed studies on vegetation changes are being carried out on 20 m x 20 m control plots, set up on two hectare replicate count areas for rabbits, and will not be discussed further here.

The present annotated atlas records information collected on the distribution and abundance of individual vascular plant species on Macquarie Island immediately prior to the introduction of myxomatosis in 1978. A few records of rare species, one new species and one quadrant not visited in 1978 were added later to give a more complete picture. It is intended to use these data as a baseline from which gross changes in the vegetation can be monitored, particularly in relation to changes in the rabbit population. The island was divided into 1 km grid squares and the abundance of each species recorded in each square is shown on individual species maps. Notes accompanying each map give details of species distribution, flora alliances, preferred habitat and the effects of the rabbits (see Section 5.1).

In the past few years it has become increasingly apparent that a review of the taxonomy of the vascular plant species on the island is warranted. Although recent work has indicated several changes, for the purposes of the present atlas the nomenclature given in Greene and Walton (1975) is used, except where noted in Table 2.

The plant communities as described by Taylor (1955) are becoming increasingly difficult to locate in the field due to the activity of rabbits. Section 3 enlarges on this problem and amends some of his notes on individual species in the light of further observations.

? 1824	Scott 1881	Hamilton 1894
Lycopodium selago		*Lycopodium billardieri*
	Lomaria alpina	*Lomaria alpina*
Aspidium aculeatum var. vestitum	*Aspidium aculeatum var. vestitum*	*Aspidium vestitum*
	Polypodium australe	*Polypodium australe*
	Ranunculus (acaulis?)	*Ranunculus cressipes*
		Cardamine hirsuta var. corymbosa
	Stellaria decipiens	*Stellaria decipiens*
		Stellaria media
		Cerastium triviale
	Colobanthus muscoides	*Colobanthus muscoides*
		Colobanthus billardieri
		Montia fontana
Acaena adscendens	*Acaena adscendens*	*Acaena adscendens*
Acaena sanguisorbea	*Acaena (buchanani?)*	*Acaena sanguisorbea*
	Tillaea sinclairii	*Tillaea moschata*
		Callitriche antarctica
		Epilobium linnaeoides
		Epilobium nummularifolium
Azorella selago	*Azorella selago*	*Azorella selago*
	Stilbocarpa polaris	*Stilbocarpa polaris*
	Coprosma repens	*Coprosma repens*
Pleurophyllum criniferum	*Pleurophyllum criniferum*	*Pleurophyllum hookeri*
Cotula plumosa	*Cotula plumosa*	*Cotula plumosa*
Luzula crinita	*Luzula campestris*	*Luzula crinita*
		Uncinia nervosa
		Agrostis antarctica
		Deschampsia hookeri
		Deschampsia penicillata
Poa foliosa	*Poa foliosa*	*Poa foliosa*
		Poa hamiltoni
	Poa annua	*Poa annua*
	Festuca duriuscula	*Festuca contracta*

Table 2. Historical collections of vascular plants of Macquarie Island giving author and publication date.

Cheeseman 1919	Taylor 1955	Greene and Walton 1975
Lycopodium varium	*Lycopodium saururus*	*Lycopodium sp.* [2]
		Hymenophyllum peltatum
Lomaria penna-marina	*Blechnum penna-marina*	*Blechnum penna-marina*
Aspidium vestitum	*Polystichum vestitum*	*Polystichum vestitum*
Polypodium australe	*Polypodium billardieri*	*Grammitis poeppigeana* [2]
Ranunculus biternatus	*Ranunculus biternatus*	*Ranunculus biternatus*
Cardamine corymbosa	*Cardamine corymbosa*	*Cardamine corymbosa*
Stellaria decipiens	*Stellaria decipiens*	*Stellaria decipiens*
Stellaria media	*Stellaria media*	*Stellaria media*
Cerastium triviale	*Cerastium triviale*	*Cerastium fontanum*
Colobanthus muscoides	*Colobanthus muscoides*	*Colobanthus muscoides*
Colobanthus billardieri	*Colobanthus crassifolius*	*Colobanthus quitensis*
Montia fontana	*Montia fontana*	*Montia fontana*
Acaena adscendens	*Acaena adscendens*	*Acaena magellanica*
Acaena sanguisorbea	*Acaena anserifolia*	*Acaena minor*
Tillaea moschata	*Crassula moschata*	*Crassula moschata*
	Myriophyllum elatinoides	*Myriophyllum triphyllum* [2]
Callitriche antarctica	*Callitriche antarctica*	*Callitriche antarctica*
Epilobium linnaeoides	*Epilobium linnaeoides*	*Epilobium linnaeoides*
Epilobium nummularifolium var nerterioides	*Epilobium nerterioides*	*Epilobium nerterioides*
	Hydrocotyle sp.	*Hydrocotyle sp.*
Azorella selago	*Azorella selago*	*Azorella selago*
		Rumex crispus [1]
Stilbocarpa polaris	*Stilbocarpa polaris*	*Stilbocarpa polaris*
Coprosma repens	*Coprosma pumila*	*Coprosma pumila*
Pleurophyllum hookeri	*Pleurophyllum hookeri*	*Pleurophyllym hookeri*
Cotula plumosa	*Cotula plumosa*	*Cotula plumosa*
		Corybas macranthus [1]
Juncus scheuchzerioides	*Juncus scheuchzerioides*	*Juncus scheuchzerioides*
Luzula campestris	*Luzula campestris*	*Luzula campestris*
Scirpus aucklandicus	*Scirpus aucklandicus*	*Scirpus aucklandicus*
	Uncinia riparia	*Uncinia compacta*
Carex trifida	*Carex trifida*	*Carex trifida*
Agrostis magellanica	*Agrostis magellanica*	*Agrostis magellanica*
Deschampsia chapmani	*Deschampsia chapmani*	*Deschampsia chapmani*
	Deschampsia penicillata	*Deschampsia penicillata*
Triodia macquariensis	*Puccinellia macquariensis*	*Puccinellia macquariensis*
Poa foliosa	*Poa foliosa*	*Poa foliosa*
Poa hamiltoni	*Poa hamiltoni*	*Poa hamiltoni*
Poa annua	*Poa annua*	*Poa annua*
Festuca erecta	*Festuca erecta*	*Festuca contracta*

1. New record.
2. Alteration since 1975.

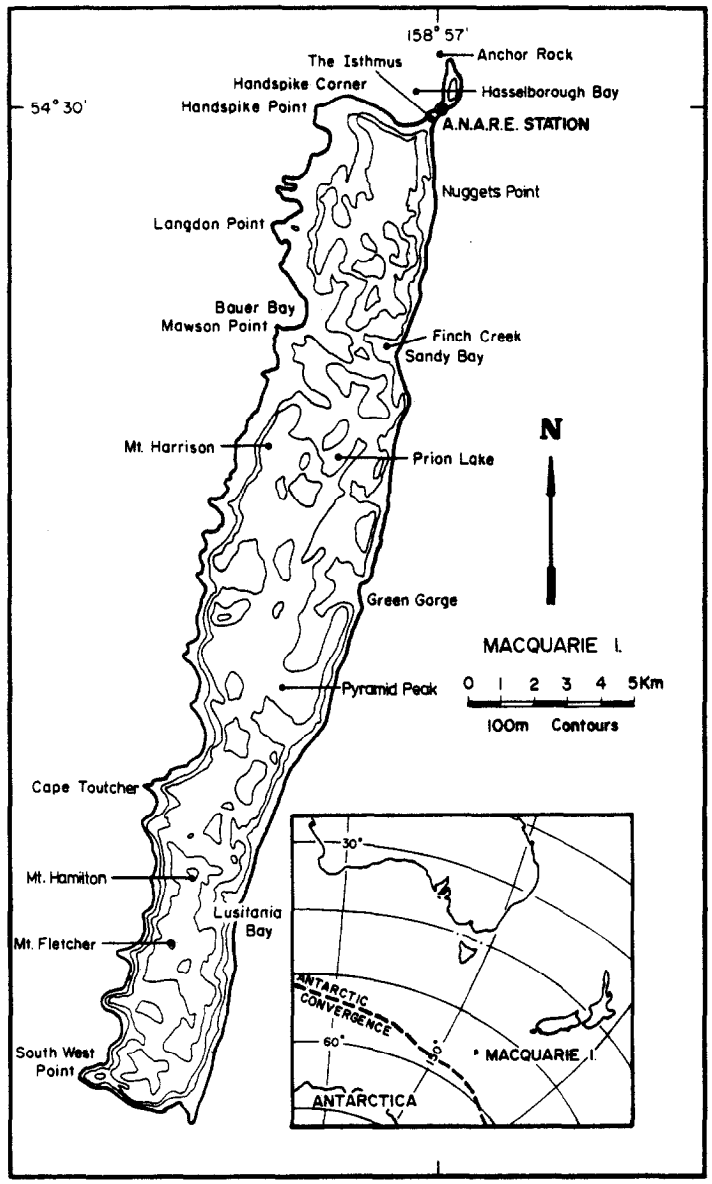


Figure 1. Map of Macquarie Island showing places mentioned in the text.

2. GEOGRAPHY

2.1 GEOGRAPHY AND PHYSICAL FEATURES

Macquarie Island 54°30'S, 158°57'E lies approximately 1500 km SSE of Tasmania and 1100 km SSW of New Zealand (Figure 1). There are several sea stacks immediately adjacent to the main island besides two group of islets, Judge and Clerk (11 km to the north) and Bishop and Clerk (37 km to the south). The New Zealand groups of the Auckland Islands (640 km) and Campbell Island (700 km) are the nearest land masses to Macquarie Island.

The island and the outlying islets form the exposed crest of the Macquarie Ridge (Varne and Rubenach 1972). Quilty, Rubenach and Wilcoxon (1973) consider it to be composed of oceanic crust material of the early to middle Miocene. Tectonic movements along the Macquarie Ridge are thought to have elevated the island to its present position in the mid to late Pleistocene (Colhoun and Goede 1973). The emergence time was estimated on an average uplift movement of between 1.5 m and 4.5 m per 1000 years, assuming a continuous rate of uplift.

The islands to the south of New Zealand and the Campbell Plateau, on which they stand, are separated from Macquarie Island by a deep trough.

Macquarie Island has an area of approximately 12,700 ha being 34 km long and 5.5 km wide at its broadest. The island rises steeply from the sea with slopes of over 40° in many places. A raised beach terrace occurs along somewhat less than half the coastline, being most extensive in the norwestern part of the island where it reaches widths of over 0.75 km. The main body of the island is an undulating plateau which varies in altitude from 180 m to 300 m. Isolated peaks rise above the general plateau surface to a maximum altitude of 433 m (Mt. Hamilton).

It has been suggested by Blake (Mawson 1943) that during the last ice age an ice sheet formed on an exposed rock shelf to the west of the island. He considered that almost the entire island was glaciated. However, Colhoun and Goede (1974) state that the maximum extent of the ice cover was less than 40%. They feel that the limited glaciation could be accounted for by a movement of the Antarctic Convergence from its present position (150-200 km south of Macquarie Island, Figure 1) to north of the island, concomitant with a mean temperature reduction at sea level of 3-4°C. At the same time the general lowering of the sea level may have exposed part of the shallow shelf which lies to the west of the island but no ice sheet formed upon it.

Loffler and Sullivan (1980) have concluded that, in the northern part at least, the ice and permanent snow cover was almost continuous with only small areas particularly in the west and north having escaped glaciation. These conclusions were drawn from studies of aerial photographs taken in 1976 and subsequent ground observations. They state, "The (rock) shelf was unglaciated as were many of the steep plateau escarpments to the north and west and some of the escarpments to the east and these areas may have been sufficient to serve as refuge areas and ensure the survival of the Island fauna and flora".

The question still remains however whether climatic conditions during the Pleistocene permitted the survival of any or all of the present flora of the Island.

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL MEAN
Mean Windspeed (Knots)	16.9	18.3	19.2	18.2	17.4	17.6	16.8	18.3	19.8	18.6	16.0	15.0	17.7
Mean Temperature (°C)	6.7	6.6	6.1	5.1	4.2	3.3	3.1	3.3	3.5	3.8	4.4	5.9	4.7
Mean Maximum Temperature (°C)	8.5	8.3	7.7	6.7	5.6	4.9	4.7	4.8	5.1	5.5	6.3	7.7	6.3
Mean Minimum Temperature (°C)	5.5	5.0	4.5	3.4	2.4	1.5	1.4	1.4	1.3	1.8	2.6	4.2	3.0
Mean Rainfall (mm)	78.7	74.4	87.3	85.4	74.8	70.6	62.6	59.0	71.4	65.8	63.2	68.1	861.3
Mean Sunshine (Hours)	97.9	95.6	78.2	50.8	29.7	16.2	24.5	41.3	59.9	77.7	89.4	90.8	752.0
Mean Daily Sunshine (Hours)	3.5	3.7	2.8	1.7	1.0	0.6	0.9	1.4	2.2	2.8	3.3	3.2	2.2

Table 3. Summary of meteorological data (1948-1975) for Macquarie Island

2.2 CLIMATE

The first meteorological station on Macquarie Island was run by the Australasian Antarctic Expedition (AAE) from January 1912 to November 1913. It was then taken over by the Commonwealth Bureau of Meteorology (CBM) until its closure in November 1915. Since March 1948 the CBM has run a station, at the same site as the 1912-15 one, as part of the Australian National Antarctic Research Expeditions (ANARE).

The meteorological station is situated on The Isthmus, altitude approximately 6 m, at the northern end of the Island with the ANARE station. All data included here are from the CBM records from March 1948 to January 1975 unless stated otherwise.

The outstanding features in the weather at Macquarie Island are the constant strong winds, very narrow average temperature range and the high average humidity. The climate is extremely oceanic.

2.2.1 Wind

The mean wind speed at 0900 hours is 17.7 knots; the range of mean monthly windspeeds is 15 to 19.8 knots (Table 3). On 289 days per year the maximum gust recorded is over 30 knots (De Lisle 1965) from data between 1948 and 1960. The wind direction is predominantly west to north-west (Figure 2), based on data from De Lisle (1965). He states, "The reported winds are affected by topography ... the main plateau on Macquarie Island (c 1000 ft. asl) shelters the station from winds between SSW and WSW. Except for further light sheltering from winds between NNE and NE the flow is uninterrupted".

Studies carried out on the plateau, 1.5 km from the station at 235 m altitude, show the wind run (i.e. miles of wind per day) to be approximately 30% greater than at the station (Jenkin 1972). The increase in wind in localised areas, particularly the top of the western escarpment, mountain and ridge crests is reflected by the floristic alliances. Changes from herbfield with 100% cover to feldmark with less than 20% cover can occur in 2-3 m at these crests.

2.2.2 Temperature

Troll (1960) describes the climate at Macquarie Island as isothermic. There is very little variation in either the diurnal or annual temperatures. The mean temperature is 4.6°C. The difference between the mean of the warmest and coldest months is 3.8°C. Monthly means are shown in Table 3. The extreme maximum and minimum temperatures recorded are 12.6°C and -8.9°C, a range of only 21.5°C.

A series of temperature readings taken at elevated points on the island show an average drop of approximately 1°C per 100 m in elevation (Taylor 1955). This would give mean temperatures on the highest peaks (over 400 m) of around freezing point.

2.2.3 Precipitation and humidity

The mean annual precipitation is 861 mm. On average, precipitation occurs on 312 days per year. Heavy rainfalls are rare and the greater part of the precipitation is in the form of mist or light rain. It is evenly spread throughout the year (Table 3).

Snow may occur at any time of the year. It rarely lies for more than a few days on the plateau or a few hours at sea level.

The annual mean relative humidity is 89%. There is little variation in the monthly means.

2.2.4 Photoperiod and sunshine

The photoperiod varies from 9 to 19 hours per day, including civil twilight (Aitken 1974). The average sunshine is 2.24 hours per day. The mean daily sunshine duration for each month is shown in Table 3. The main concentration is in the six month period October to March when approximately 70% of the sunshine is recorded (Table 3). Records are not available for the period January 1954 to April 1964.

The average number of hours of sunshine per year is 17% of the maximum possible. The number of days per year with a given number of hours of sunshine is shown in Figure 3.

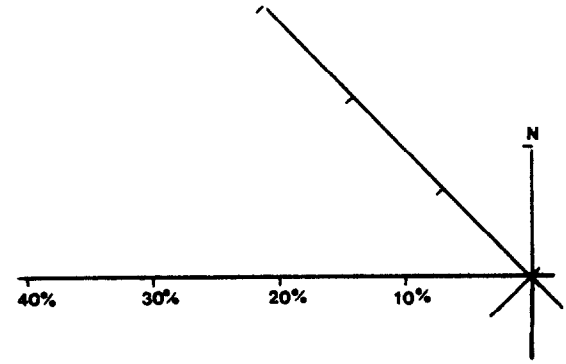


Figure 2. Wind rose showing percentage frequency from given directions at the ANARE station.

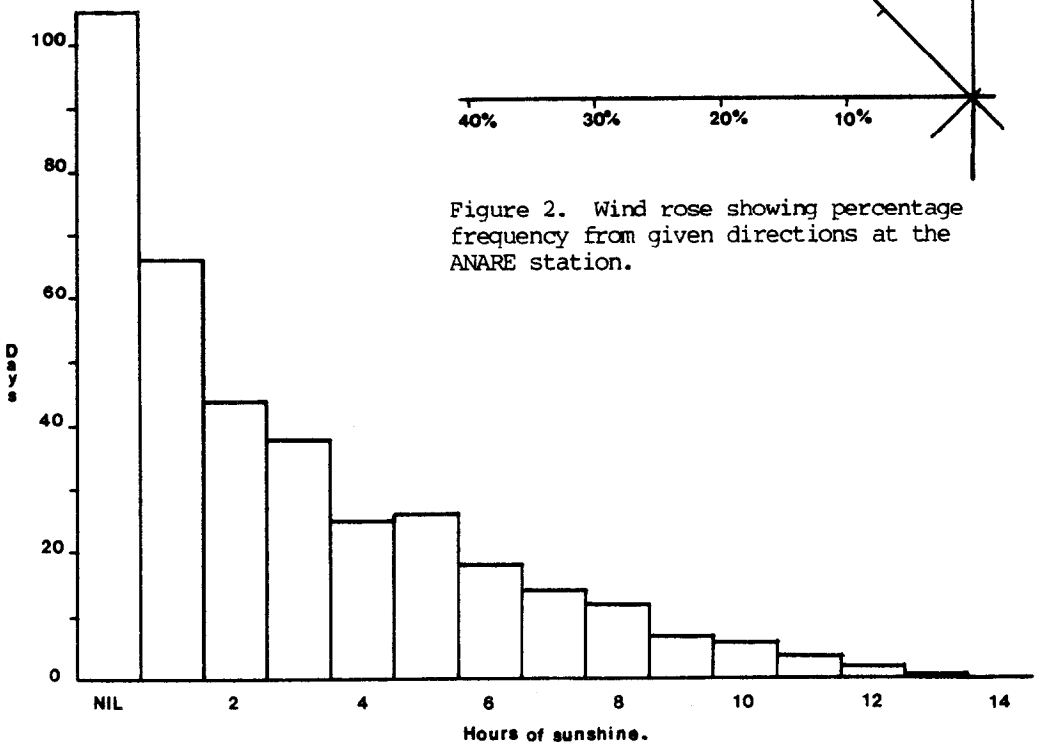


Figure 3. The number of days per year with a given period of sunshine in hours.

3. RECENT CHANGES TO THE VEGETATION

The Macquarie Island vegetation alliances and associations described by Taylor (1955) have become increasingly difficult to identify in the field. This is almost entirely due to the activities of rabbits. The problem was apparent to Taylor during his field work (1950-51); he states, "The natural vegetation of long-grazed areas in the south has frequently to be inferred ... This inference has been done by comparison with identical sites which support natural or little grazed vegetation. The resultant communities now growing on a once uniform vegetation type are extremely varied".

The rabbits on Macquarie Island during 1950-51 were almost entirely south of a line between Sandy Bay and Bauer Bay although they did extend their range slightly northwards in 1951 (Taylor 1955). Taylor's description of the rabbits being introduced at Lusitania Bay and spreading slowly northwards over the next 70 years is unfortunately incorrect. However it led him to believe that the vegetation at the northern end of the island was largely untouched by rabbits. Cumpston (1968) gives a detailed history of the island from which it is possible to obtain the following picture of the spread of the rabbit over the first 40 years.

The rabbits were introduced in 1877-78. After visiting the island in 1880 Dr Scott (1881) reports, "The ubiquitous rabbit was introduced a few years ago, and now swarms at the northern end". By 1889 they were reported as being at the northern end and Sandy Bay but not at Lusitania Bay (Cumpston 1968). The picture had changed by 1894, as Hamilton (1895) reports, "I may say that rabbits are fairly numerous in the south-east, they have disappeared from the north owing to the wild cats". Subsequent reports up until Taylor's stay indicate major fluctuations in the rabbit population at the northern end of the island. In 1905-6 and 1918 they appear to have been plentiful around the Nuggets Point area, whereas in reports from 1909-10 and 1923 no rabbits were reported there. Their numbers appear to have been low at the northern end during the AAE in 1911-14 (Mawson 1915). In contrast, rabbit numbers around the Lusitania Bay area appear to have remained quite high throughout the same period (Cumpston 1968).

Rapid fluctuations in the rabbit population were recorded during the NPWS studies of their biology on Macquarie Island, 1972-78 (Copson et al. 1981). It appears that one of the main causes of mortality among rabbit kittens on the island is the wet burrow conditions. A drier than average breeding season allows a high survival rate of kittens and a very rapid build up of the population. This was seen in the 1977-78 season when population increases of between two and ten-fold were recorded on several of the 2 ha replicate count areas which had been monitored since 1974 (Copson et al. 1981). It is therefore unfortunate that Taylor's first visit followed at the end of eleven of the driest months on record. It is likely that he saw devastation to the vegetation caused by a higher than usual rabbit population.

3.1 ALTERATIONS IN VEGETATION FORMATIONS

3.1.1 Wet tussock grassland alliances

In general the tussock alliances have been reduced in area and almost eliminated from inland sites. In many places only remnants of Poa foliosa (in

places inaccessible to rabbits such as steep outcrops or islands in lakes) indicate the former extent of the tussock alliance.

Work carried out in 1980 indicates that Poa hamiltoni is grazed in preference to P. foliosa. It is very probable therefore that the extent of this association has been reduced and that the frequency of the P. hamiltoni in the remaining areas is also lessened. Small patches of the association can be found in places away from penguin rookeries in the proximity of burrowing bird colonies. These colonies have been reduced in number and size directly by rabbit activity reducing cover or by competition for burrows. It is therefore possible that the P. foliosa - P. hamiltoni association was not necessarily associated only with penguin rookeries and was more extensive in the past.

On the west coast the P. foliosa - Polystichum vestitum association no longer exists, only two small plants of P. vestitum have been found there. The stands on the eastern side of the island are still quite extensive although there is little recruitment of seedlings as these are readily eaten by rabbits.

The Poa foliosa - P. annua association described by Taylor (1955) appears to be a purely seral community. It is formed by animals (elephant seals, rabbits or gentoo penguins) opening up the tussock alliance areas allowing P. annua to rapidly colonise the bare surface. Continued animal activity, particularly rabbit grazing at the edge of the tussock, is required to maintain the association and if this ceases one of the more stable P. foliosa associations will rapidly predominate.

The maritime communities can be affected locally by rabbit grazing, particularly on the accessible coastal rocks and sea stacks. The main species affected are P. foliosa, Stilbocarpa polaris and Pleurophyllum hookeri. The species which are wholly or mainly confined to the maritime assocation (Puccinellia macquariensis, Crassula moschata, Cotula plumosa and Colobanthus muscoides) are largely unaffected by rabbits and are not endangered.

3.1.2 Sub-glacial herbfield

The herbfield associations have probably been modified more than any of the others. Jenkin and Ashton (1979) comment on the vulnerability of these associations to continued grazing and how their study sites have been affected over the course of their work.

Of the nine species which Taylor (1955) records as either abundant, locally abundant, dominant or co-dominant in the herbfield associations all are grazed and five are locally endangered (Pleurophyllum hookeri, Festuca contracta, Stilbocarpa polaris, Coprosma pumila and Blechnum penna-marina). The former distribution of these five species frequently has to be inferred from damaged remnants or small patches left in inaccessible places. Prolonged grazing will result in the eradication of the five vulnerable species from local areas.

Severe rabbit grazing results in vegetation less than 50 mm in height, the bryophytes becoming dominant and the vascular plants being restricted to a few unpalatable species, such as Ranunculus biternatus and Cardamine corymbosa, or species which can reproduce in a low mat form like Agrostis magellanica and Epilobium linnaeiodes. Acaena sp. will also survive under these conditions and with a slight reduction in grazing pressure can dominate large areas. The secondary vascular species in those situations depend on the height of the watertable.

Three of the introduced species (Poa annua, Stellaria media and Cerastium fontanum) are early colonisers of eroded areas. P. annua and S. media may dominate early seral stages but they become minor components or disappear altogether from the associations if succession proceeds without further disturbance.

3.1.3 Fen and bog alliances

Taylor (1955) considered the fen and bog communities to be unattractive to rabbits. However, there is ample evidence that rabbits regularly feed on fens and bogs, sometimes at distances of over 200 m from the nearest possible burrowing sites. Two of the major components of the associations (Juncus scheuchzerioides and Scirpus aucklandicus) are eaten by rabbits. In areas under light grazing the J. scheuchzerioides and S. aucklandicus benefit by the reduction in vegetation height and a rise in the water-tables. With severe and prolonged grazing J. scheuchzerioides becomes rare, S. aucklandicus locally common and C. muscoides and/or the bryophytes dominant. When this stage is reached even light grazing will maintain the new association.

3.1.4 Feldmark alliances

The feldmark alliances support a very small rabbit population with average densities of less than one per hectare (Copson et al. 1981). Even at these low densities they can have a quite significant effect due to their selective grazing of a few species. Pleurophyllum hookeri, Stilbocarpa polaris and Festuca contracta are particularly vulnerable and are soon removed from the associations.

The dominant species in the association (Azorella selago and the bryophytes) are not grazed but can suffer from mechanical damage. In some areas if the profiles of the A. selago cushions are opened up by rabbit burrows wind erosion can rapidly destroy the rest of the cushion.

3.2 AMENDMENTS TO THE STATUS OF INDIVIDUAL SPECIES

The amendments are to the autecology of the vascular flora and are based on data collected over seven consecutive summers and three winters.

Stellaria decipiens

Gregariousness. Taylor describes this species as, "Slightly gregarious ... but dense patches never form."

In some areas where rabbits have completely destroyed tussocks S. decipiens can dominate the degraded tussock pedestals. This appears to be a first seral stage and the S. decipiens is reduced in abundance as other species become established. In these areas the S. decipiens is in the tussock alliance before the degradation by the rabbits and is not introduced after it.

Stellaria media

Habitat. Found in sheltered places at altitudes of up to 200 m. Also found on the west coast and on the plateau away from old settlements.

Phenology. Flowers from early August to the end of June.

Cerastium fontanum

Habitat. It has extended its range into fen and bog areas on the west coast raised beach terrace and the flats behind Green Gorge.

Communities

Azorella selago alliance. It can be locally common in this alliance where several small plants are often found in a few square metres.

Fen and bog alliances. Rarely found in these alliances it occurs between Handspike Point and Bauer Bay on the west coast and on the flats behind Green Gorge.

On South Georgia, Greene and Greene (1963) record C. holosteoides (amended to C. fontanum, Greene and Walton 1975) as present on seepage areas. The closed nature of the fen and bog alliances on Macquarie Island may prevent its ready establishment in these areas. Rabbit activity in these alliances is largely confined to grazing and rarely exposes the substratum.

Crassula moschata

Distribution. Recorded in three areas between the ANARE station and Sandy Bay where Taylor (1955) states, "None could be found during dozens of trips". This appears to be a recent extension of its range.

Phenology. Flowers from January to March.

Cotula plumosa

Phenology. Flowers from October to March.

Azorella selago

Communities.

Pleurophyllum hookeri. In one valley (altitude 50 m) A. selago was found to be locally common along the banks of a stream. The surrounding alliances were P. hookeri and fen but the stream banks were well drained where the A. selago was growing.

Rock communites. Cushions were found on rock outcrops at low altitudes on both the east coast (below 10 m) and Handspike Corner. Where it occurs the interspecific competition is low.

Phenology. Flowers from November to February.

Stilbocarpa polaris

Communities.

Pleurophyllum hookeri. Its frequency in this alliance has been reduced to the degree where it is either rare or absent over large areas. In

areas where the rabbit population has been reduced S. polaris re-establishes rapidly often from seeds.

Floral biology. The introduced ships rat (Rattus rattus L) removes seedheads from the umbels and stores them in caches. This would provide a means of local dispersal.

Pleurophyllum hookeri

Phenology. It flowers from September to January. Its flowering is not regular and on some years it was estimated that less than 2% of the mature plants flowered.

Luzula campestris

Communities.

Fen alliance. It occurs in the fen alliance at Green Gorge and sites on the west coast raised beach terrace. Some of these latter sites are impossible to fit into any of Taylor's (1955) associations as within a 1 metre diameter circle the association not only contains L. campestris but also Pleurophyllum hookeri (which he excludes from fen and bog communities) and Scirpus aucklandicus (which is only in fen and bog communities). Also in these sites the water-table was from 100 mm below to surface level.

Scirpus aucklandicus

Habitat. Widespread and locally common on the plateau and two sites on the east coast. This appears to be a recent extension of its range as Taylor (1955) states, "It is only found on the west coast raised beach terrace".

Floral biology. Indoor tests have shown that S. aucklandicus grows readily from root sections with shoots with an overall length of less than 25 mm. This provides a local means of dispersal along stream and lakes as well as from wind dispersal.

Uncinia compacta

Gregariousness, performance. It forms dense clumps up to 300 mm in diameter. Two areas of herbfield (approximately 20 m x 40 m and 20 m x 20 m) at Green Gorge were dominated by U. compacta.

Carex trifida

Habitat. The main distribution is between Handspike Point and Handspike Corner but it is also establishing along the Hasselborough Bay sections of the raised beach terrace. The water-table can be at the surface. On better drained banks the growth is less vigorous.

Puccinellia macquariensis

Effect of biotic factors. In areas where rabbits have invaded coastal rocks P. macquariensis is eaten but it is not a favoured food.

Poa annua

Communities.

Pleurophyllum hookeri alliance. It can be locally common in this alliance and is particularly conspicuous in front of rabbit burrows. Fen and bog alliances occasionally occur in these alliances.

Polystichum vestitum

Communities.

Poa foliosa alliance. It was only found at two sites on the west coast. One plant at the foot of the slope was in a gully, the P. vestitum being 500 mm high and surrounded by Poa foliosa and Stilbocarpa polaris. The other site, about 100 m from the first, had four plants 300 mm high and was surrounded by herbfield with P. foliosa 4-5 m away. Rabbits were common in the area.

Grammitis poeppigeana

Habitat. Found growing in moss cushions in the spray of a waterfall at Green Gorge, altitude 50 m. In this sheltered position the fronds were up to 21 mm by 3 mm.

Hydrocotyle sp.

Habitat. Taylor (1955) states that is is only found on the west coast raised beach terrace and one valley on the plateau at an altitude of 300 feet. It is now locally common to altitudes of over 200 m and on the eastern side of the watershed.

4. EFFECTS OF INTRODUCED VERTEBRATE FAUNA

4.1 RABBITS

The distribution of the rabbits within various plant alliances is very selective. Their effects on these alliances have been discussed above (3.1).

Rabbit activities can have both adverse and beneficial effects on individual plant species. The effects may be either direct, i.e. grazing and digging (burrows, squats or scrapes to mark territories), or indirect by alterations to habitats, including erosion, reduced interspecific competition and dispersal of selected species. The effects on individual species are shown in Table 4.

All the species which are endangered in any way, and two of the three species whose status is unknown, are eaten by rabbits. Of the 13 species in the endangered, locally endangered and status unknown groups six are classified as local and rare and two as widespread but rare in distribution. In the cases of Lycopodium sp. and Coprosoma pumila there are indications of much wider distribution in the past.

The majority of the species whose conservation status is either not endangered or is enhanced are also grazed. Most of these are either rarely grazed or able to grow and reproduce as a low mat. Only in the case of Myriophyllum triphyllum (which is an obligate aquatic) could the habitat give complete protection from rabbit grazing throughout its range.

Most species are affected, to a greater or lesser extent, by rabbits digging. The only exceptions would be a few species restricted to very wet habitats. Two feldmark species, Azorella selago and Grammitis poeppigeana which are not grazed by rabbits, are adversely affected by their digging (above 3.1). Several species including the introduced Poa annua, benefit by colonising the exposed soil surfaces left by digging.

The seeds of three of the species (the two Acaena spp. and the Uncinia) are well adapted for dispersal by animals. In the case of the Acaena spp. there is evidence indicating that they now dominate areas formerly occupied by other species, remnants of which still occupy places inaccessible to rabbits in the area. In these areas rabbits are common to abundant. The suitability of Acaena seeds for dispersal by rabbits together with the fact that the plants are not a favoured food would help to establish and maintain their dominance in these areas.

Reduction in interspecific competition, alterations to the water-table level (usually a general rise) and exposure of bare soil surfaces can all result from rabbit activities. These alterations to habitats, either singly or in various combinations, have resulted in alterations to the conservation status of over half the species on the island.

Two species (Stellaria decipiens and Uncinia compacta) are adversely affected by rabbit induced alterations in their habitats. Both suffer from a rise in the water-table. Stellaria decipiens is also adversely affected by the reduction in cover due to elimination of taller plants, particularly Poa foliosa. In some cases it will dominate the bare tussock pedestal which has been killed but it does not appear to thrive for long in this situation.

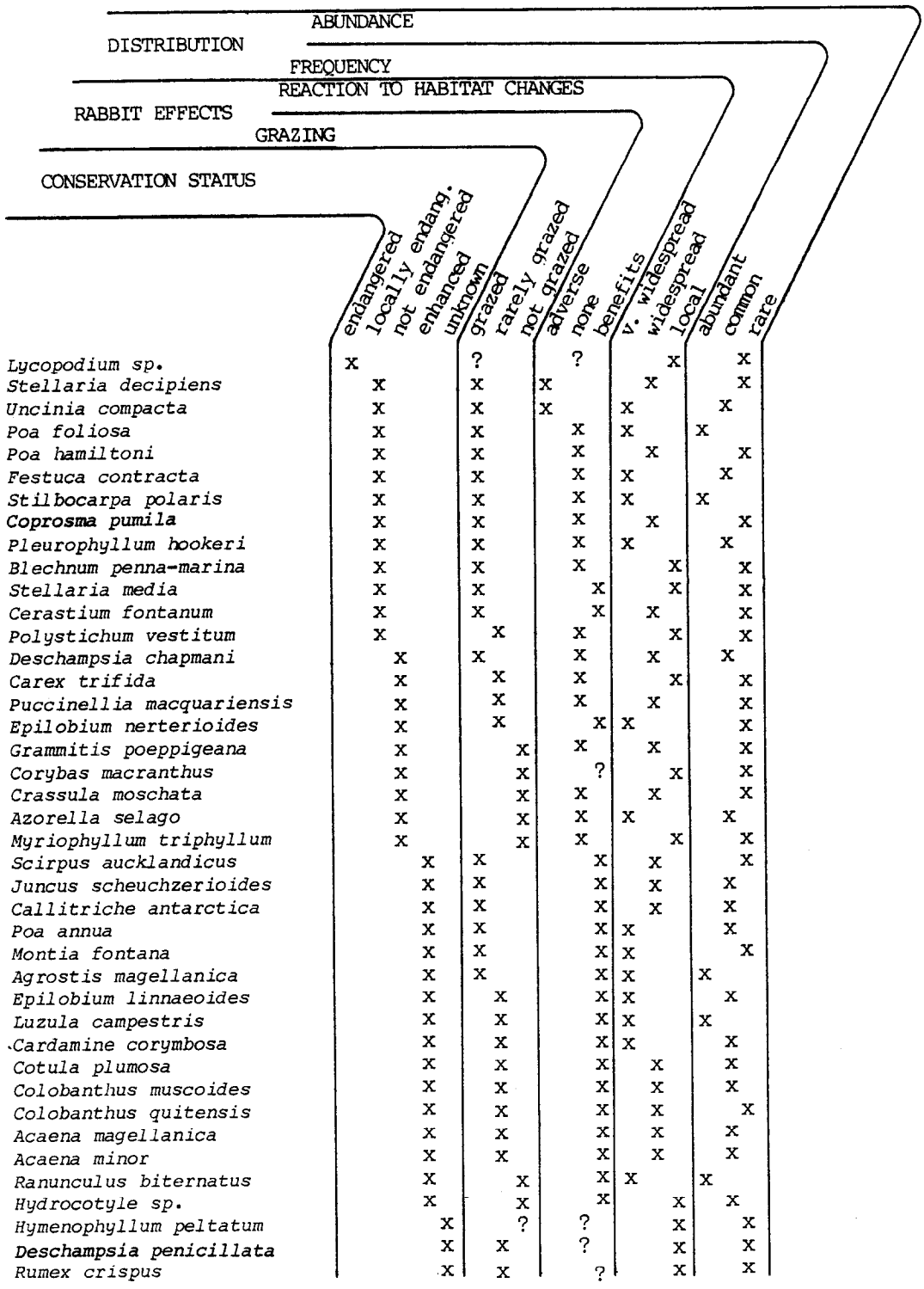


Table 4. Conservation status, distribution and effects of rabbits on the vascular plants of Macquarie Island.

Eighteen species are not generally affected by changes within their habitat. The remaining twenty one species all benefit to a greater or lesser extent. Three of the introduced species occur in the early seral communities on landslip and erosion areas.

The extent to which rabbits affect the natural erosion patterns on the island has not been clearly defined.

Taylor (1955) and Costin and Moore (1960) consider that if the dominant species (Poa foliosa and Stilbocarpa polaris) are eradicated on the steep coastal slopes there are no deep rooted species to replace them. Costin and Moore state that this leads to instability in the peat cover resulting in soil slips and that further slips may then occur in immediately adjacent areas even when the original vegetation is still intact. However subsequent observations (Griffin 1980) and comparisons of early photographs with present conditions indicate that this trend of irreversible soil loss does not generally take place.

Costin and Moore (1960) suggest that rabbit burrows provide water channels and add to the instability of the peat on the slopes. Burrowing birds including the sooty shearwater (Puffinus grisus Gmelin), white-headed petrel (Pterodroma lessoni Garnet) and the blue petrel (Halobeana caerulea Gmelin) nested on these slopes prior to the introduction of the rabbit. In the colonies of shearwaters and white petrels (which still breed on the slopes), and blue petrel (now found only on the offshore islets), the concentration of burrows is far greater than in rabbit warrens on the Island. Any influence burrows may have in causing soil slips on the slopes would therefore be greater in the bird colonies and have been present before the introduction of the rabbits.

In some local areas rabbit burrowing can be seen to have directly contributed to wind erosion. These areas are mainly in the feldmark where the Azorella selago cushions have been damaged and on the raised beach terrace of the west coast where burrows have exposed shallow peat layers on old seastacks.

In other places areas of several hectares are being stripped by wind erosion. The fact that they may be of fairly recent origin is indicated by the surface being either exposed peat or being of small particle size and not having a high proportion of stone cover as seen in the established feldmark alliances. These areas are mainly on the western side of the Island between Langdon Point and Mt. Harrison.

A detailed study would be required to ascertain to what extent, if any, this erosion may be attributed to rabbit activities.

4.2 RATS AND MICE

The ship rat (Rattus rattus L.) and the house mouse (Mus musculus L.) were recorded as being on Macquarie Island at the end of the last century (Cumpston 1968). It is likely that there were several introductions associated with sealing activities and wrecks throughout the period of operations.

A study was carried out in 1978 of the rats and mice on Macquarie Island. A preliminary study of stomach contents showed that plant materials are included in both diets. Field observations revealed caches of seedheads; Stilbocarpa polaris seedheads associated with rats and Acaena spp. and various grasses

found with mouse droppings. One mouse nest inspected was constructed of grasses including seedheads which subsequently sprouted when kept in the biology laboratory.

Threre is no evidence of either rats or mice ever having increased to plague proportions on Macquarie Island. Their direct effects on the vascular vegetation would appear to be the moderate usage of seeds and vegetation of a small number of species for feeding and nesting materials and the limited dispersal of seeds. As the mice in particular also feed on invertebrate fauna there could be indirect effects but these have not been documented.

4.3 AVIFAUNA

Four aliens species of avifauna are established on Macquarie Island, the Stewart Island weka (Gallirallus australis scotti, Ogilvie-Grant), common starling (Sturnus vulgaris, L.) redpoll (Acanthis flammea, Mueller) and the mallard (Anas platyrhynchos, L.). The weka was introduced to Macquarie Island in the 1870's by sealers. The other three are northern hemisphere species which were introduced to New Zealand and Australia (except the redpoll) in the last century and have spread to Macquarie Island from one or both of these countries. The numbers of these species are not very large on the island.

The four species all feed to some extent on plant materials but little work has been undertaken on the diets of starlings, redpolls or mallards on Macquarie Island. The wekas are the only ones which leave obvious signs of damage to plant communities. They systematically pick over areas (up to 2-3 m^2) of the fen and bog alliances while feeding on plant and/or invertebrate materials. The stomach contents of wekas collected in a study carried out in 1979 contained plant material including the seeds of several species, but this material is yet to be identified (Brothers, personal communication). Brown et al. (1978) documented effects of the wekas on the orchid Corybas macranthus on Macquarie Island.

It is unlikely that there is a generally adverse effect on the vegetation of Macquarie Island by the four alien species (weka, redpoll, starling and mallard) feeding upon it. It is possible that one of the alien birds could endanger a rare plant species if it fed heavily on it or disturbed the plant's habitat extensively, but there is no indication of this occurring. No work has been done on the indirect effect the birds may have on the vegetation by their feeding on the invertebrate fauna.

The area where the alien birds may have the greatest effect is in the introduction and/or local dispersal of plants. Taylor (1955) states, "It is significant that all the (plant) species on Macquarie Island fit into one or more of the groups of seed which could conceivably be carried by birds". The starlings, redpolls and mallards frequently move around, on and between the coastal flats and the plateau providing opportunities for local dispersal of seeds and plant materials.

5. SURVEY AND ATLAS OF VASCULAR PLANTS

The survey was carried out between February 1978 and February 1979. In collecting the data particular note was made of the effects of rabbit activity on the flora.

Additional data was collected in 1980-81 including several extra records of Lycopodium sp. and Hymenophyllum peltatum, also one new species record for Macquarie Island (Copson and Leaman 1981). It was then possible to observe changes in the flora in areas where the control program had resulted in a major drop in the rabbit population. Observations in these areas indicated a greater degree of grazing of some species than had previously been suspected.

The survey is part of a long term monitoring program. It should be possible to repeat the survey, as a whole or in selected areas, and so monitor gross changes with a good degree of accuracy. It is intended to continue collecting data concerning endangered and rare species on the island.

5.1 METHODS AND DEFINITIONS

The Island was divided on a 1 km square grid. For the atlas work, 153 grid squares were used. Some small coastal strips were combined with the square adjacent to them. This was only done if the same flora alliance extended into both of them. As each grid square was traversed the track was recorded on a master map and a separate coverage map. The track had to be at least 0.75 km long to be recorded on the coverage map (Figure 4).

Notes were made on the presence and abundance of each species found in a grid square. These were added to if the square was traversed again. More detailed notes were made of any unusual occurrences.

In the field the abundance was estimated on a four grade scale; sparse, locally common, common and abundant. In the notes frequency is defined as:

Local	found in less than 25 grid squares;
Widespread	found in 26-100 grid squares;
Very Widespread	found in 101 or more grid squares.

Abundance is defined as:

Rare	abundant or common in less than 10% of its range;
Common	abundant or common in 10% - 50% of its range;
Abundant	abundant or common in over 50% of its range.

Part 1 of the notes records frequency and abundance of the species; the figure in brackets give the number of squares in which the species was found, and the number in which it is abundant or common. Part 2 gives flora alliances and preferred habitats. Part 3 gives details on the effects of the rabbits.

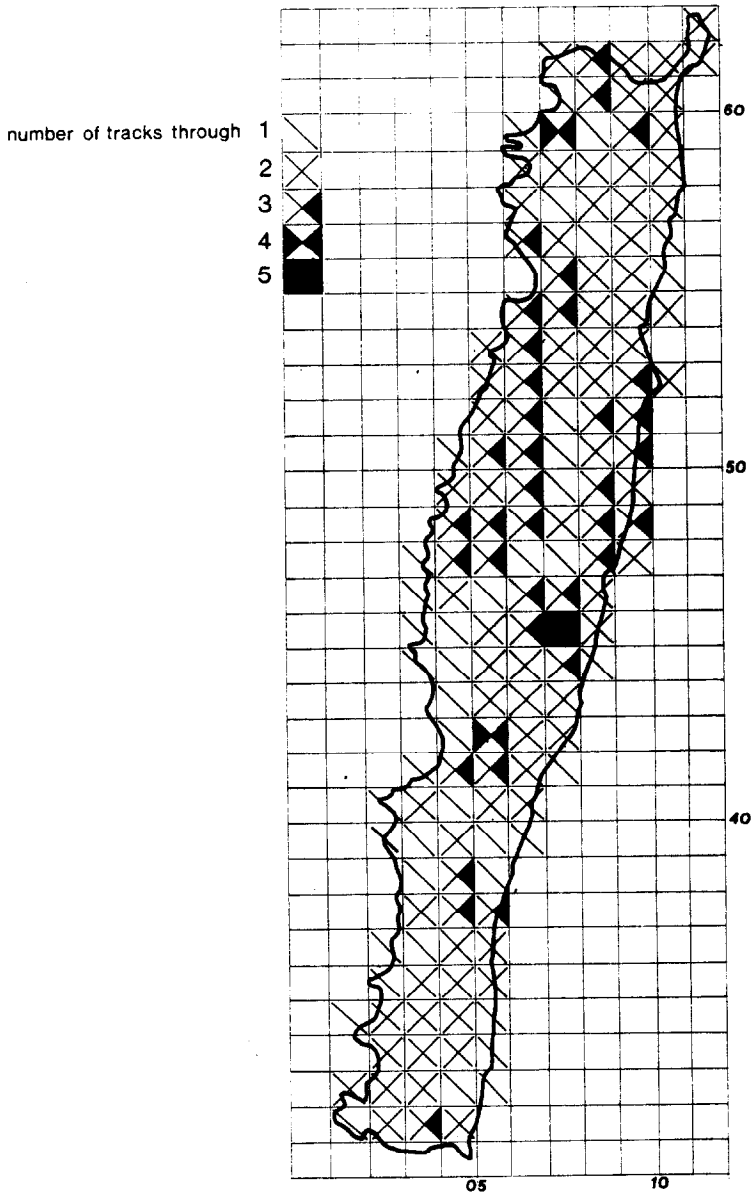


Figure 4. Coverage in 1978-79 flora survey.

ATLAS OF VASCULAR FLORA

Key to the maps:

NOT FOUND

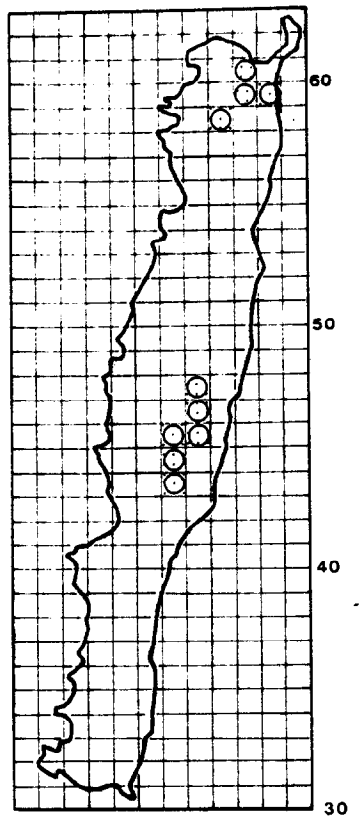
SPARSE

LOCAL

COMMON

ABUNDANT

MAP 1



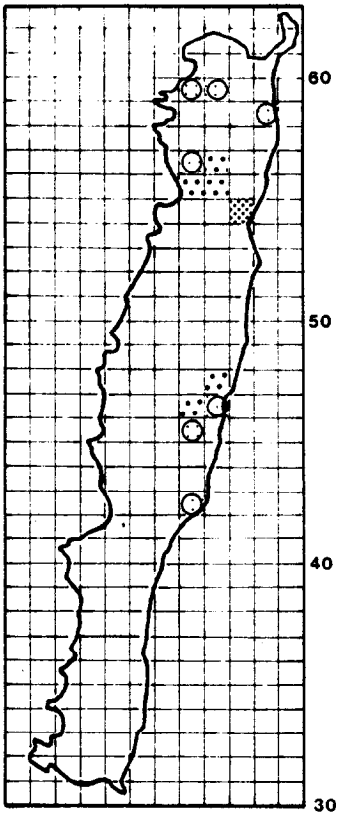
Hymenophyllum peltatum (Poir) Desv.

1. Local and rare (10/0).

2. Recently discovered on Macquarie Island (Hnatiuk 1972). Known only from the feldmark.

3. Effect of rabbits and conservation status unknown.

MAP 2



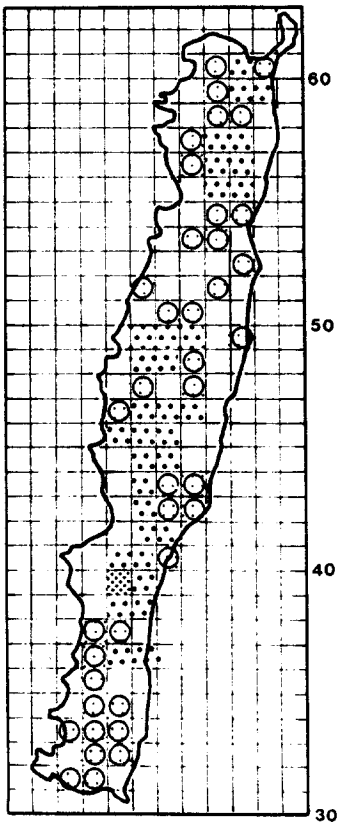
Blechnum penna-marina (Poir) Kuhn.

1. Local and rare (13/1).

2. Limited to sheltered and better drained sites in the herbfield. Also found amongst open tussocks of Poa foliosa adjacent to herbfield at Sandy Bay.

3. No evidence of grazing was seen during the survey. In the 1980-81 summer inspections of some areas where the rabbit populations had been reduced by control measures showed a marked increase in B. penna-marina. This may have been due to the removal of direct grazing pressure or to the growth of B. penna-marina being encouraged by the increased cover from surrounding herbfield plants. Locally threatened.

MAP 3



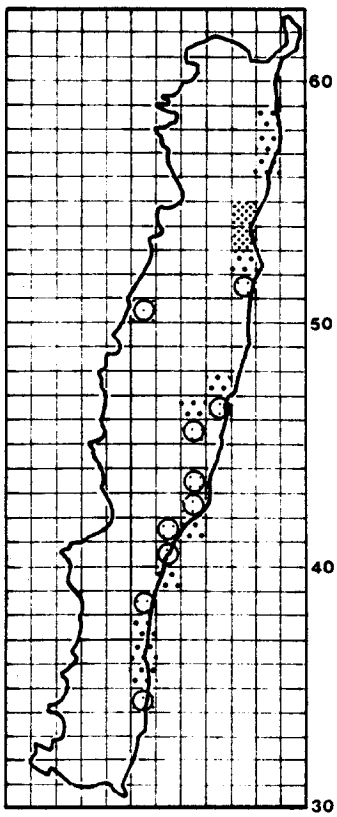
Grammitis poeppigeana Pichi Sermolli et Bizzarri

1. Widespread but rare (73/1).

2. Grows in the feldmark in cushions of Azorella and bryophytes. Also found growing in mosses beside a waterfall at Green Gorge at 50 m altitude.

3. Not eaten by rabbits, but suffers mechanical damage along with the cushions on which it grows. Not threatened.

MAP 4



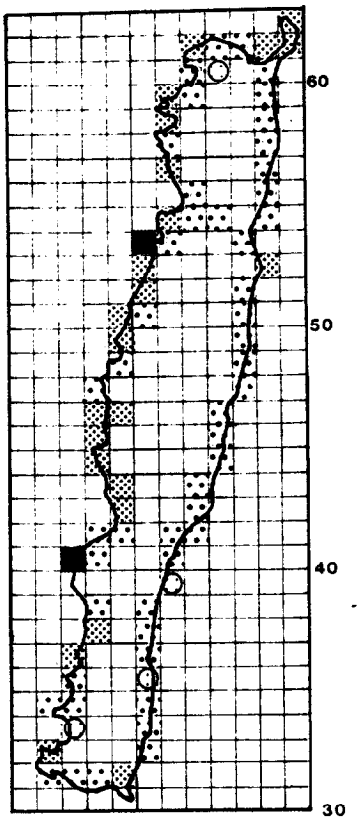
Polystichum vestitum Forst. f.

1. Local and rare (22/0). Coastal and inland valleys on the eastern side of the island. The only record from the west coast was of 5 small (20-25 cm) plants in two sites 100 m apart. Taylor (1955) recorded it as occasional on the west coast.

2. Confined mainly to slopes supporting the Poa foliosa alliance.

3. Eaten by rabbits and locally endangered.

MAP 5



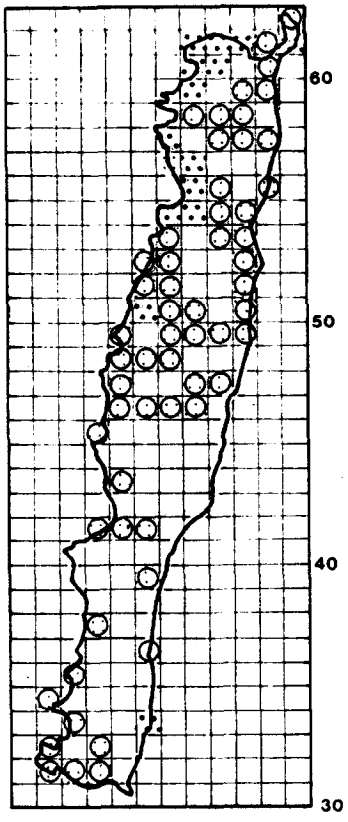
Colobanthus muscoides Hook. f.

1. Widespread and common (78/25) around the coastline.

2. In sea spray zone of maritime communities. Also forms large mats (of several hundred m^2) in bog communities. Has colonised and now dominates some areas formerly occupied by Poa foliosa tussocks (Mawson Point, Cape Toutcher and a bay NW of Mt. Fletcher).

2. Unaffected by rabbits through most of its range, but rabbit activity probably beneficial.

MAP 6



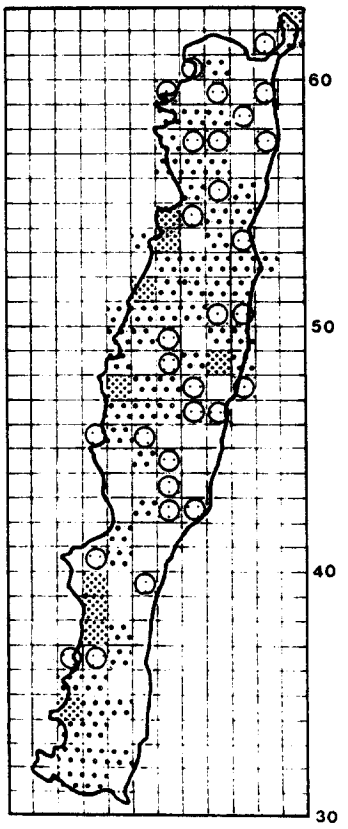
Colobanthus quitensis (Kanth.) Bartl.

1. Widespread but rare (73/10).

2. Forms mats in bog communities. Scattered individual plants found elsewhere. Often found in seral communities on eroded areas.

3. Rarely eaten by rabbits, but suffers some mechanical damage. Probably benefits from raised water-table and from reduction in cover of other species associated with rabbit grazing.

MAP 7



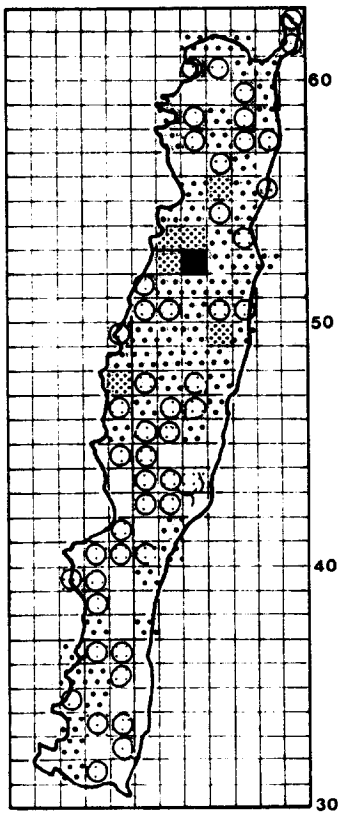
Stellaria decipiens Hook. f.

1. Widespread and common (98/10).

2. Limiting factors are high wind exposure and wet soils (Taylor 1955). Apparently prefers sheltered situations amongst taller growing plants of the herbfield and wet tussock - herbfield ecotone.

3. Eaten by rabbits. Probably adversely affected by raised water-table associated with intensive rabbit grazing. Locally threatened.

MAP 8



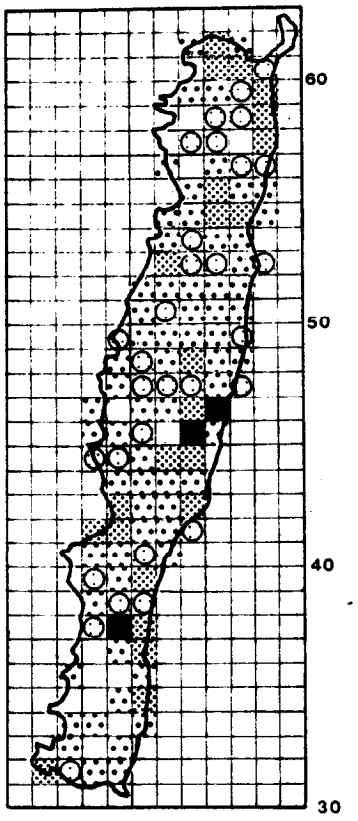
Montia fontana L.

1. Very widespread but rare (109/7).

2. Most common in Juncus scheuchzerioides alliance in fens where it may form large mats. Also found in small clumps or as individuals in bogs and wetter sites of the herbfields and feldmark communities. Found in seral communities and in rabbit scrapes.

3. Eaten by rabbits, but survives as a low growing mat. Probably benefits from rabbit activity.

MAP 9



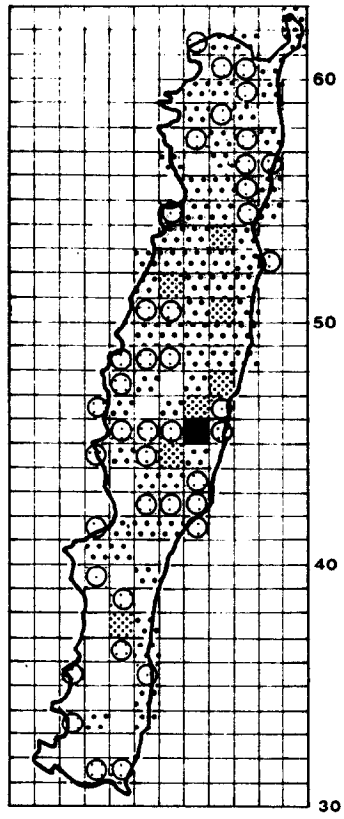
Epilobium linnaeoides Hook. f.

1. Very widespread and common (122/26).

2. Most common in the herbfield, but also occurs in maritime, feldmark, fen and bog communities. It occurs in seral communities where rabbits have cleared the other vegetation.

3. Eaten by rabbits, but not favoured. It can form low mats and is plentiful in rabbit-grazed areas of the Pleurophyllum hookeri alliance. Probably benefits from rabbit activity.

MAP 10



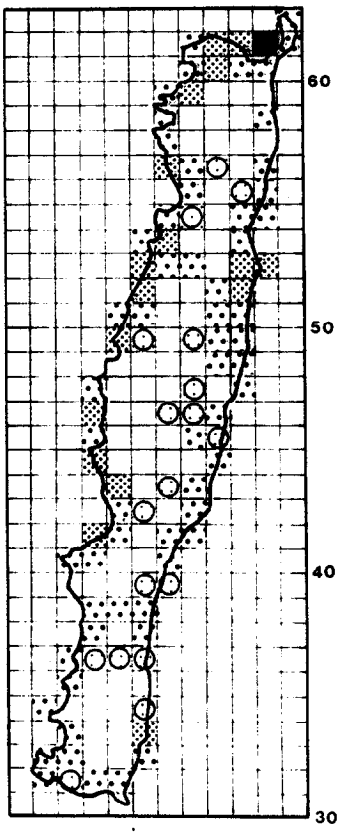
Epilobium nerterioides A. Cunn.

1. Very widespread but rare (110/8).

2. Habitat and range similar to E. linnaeoides, but is more abundant than that species in wind-exposed areas.

3. Occasionally eaten by rabbits. Not threatened.

MAP 11



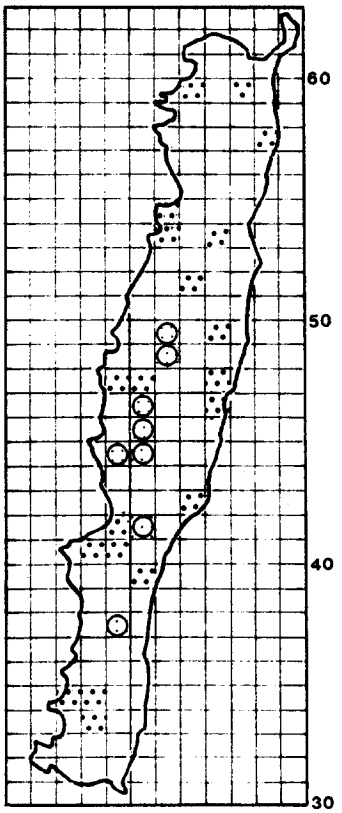
Callitriche antarctica Engelm.

1. Widespread and common (95/18).

2. Commonly occurs in open tussock and aquatic communities of the raised beach terrace, where it forms large mats. Found in wet sites elsewhere. "Limited by low water availability, high wind velocities and by competition from taller growing species" (Taylor 1955).

3. Grazed by rabbits, but persists as a short mat and is favoured by the reduction in competition from associated plants. Probably benefits from rabbit activity.

MAP 12



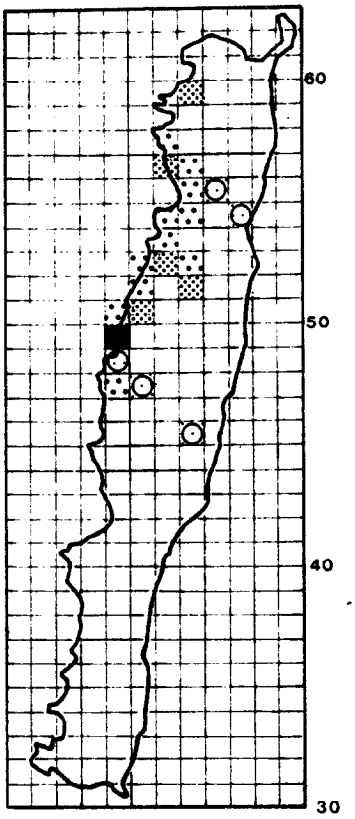
Myriophyllum triphyllum Orchard

1. Local and rare (28/0). First recorded by Taylor (1955), who found it only above 300 ft. (ca 100 m). Now found at altitudes of from 5 - 250 m, but is most vigorous at elevations below 50 m.

2. Aquatic, occurs in lakes and streams.

3. Unaffected by rabbit activities. Not threatened.

MAP 13



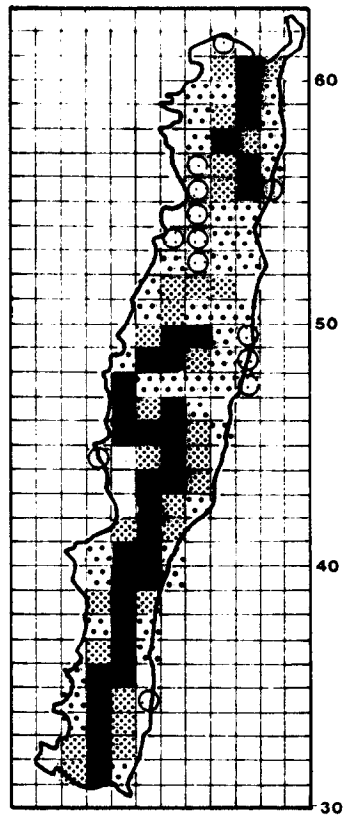
Hydrocotyle sp.

1. Local and common (22/6).

2. Mainly fen and bog alliances but will spread into adjacent herbfield if the inter-specific competition and cover is low (i.e. areas cropped by rabbits with less than 100 mm cover). Taylor (1955) records the main distribution as the raised beach terrace on the west coast, and only one location on the plateau at 300 ft. It is now found at several inland sites, to over 200 m by Prion Lake and on the eastern side of the drainage divide at Finch Creek and Green Gorge.

3. Not known to be eaten by rabbits. Probably benefits from reduction in associated vegetation by grazing. Not threatened.

MAP 14



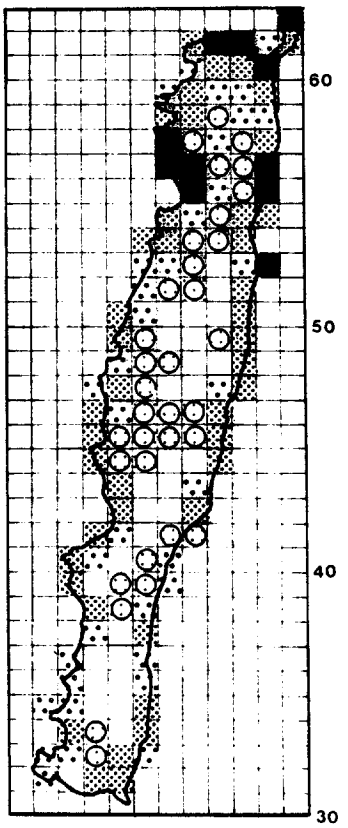
Azorella selago Hook. f.

1. Very widespread and abundant (116/62). Usually on the plateau, but on occasions extending to sea level on the east coast, where it occurs on large rocks where inter-specific competition is low.

2. Dominant in the feldmark, which is the largest alliance on the island.

3. Not known to be eaten by rabbits, but extensive mechanical damage results from rabbit scrapes in some areas. Once the profile of the Azorella cushion is broken, the strong winds ensure its ultimate destruction. Not threatened.

MAP 15



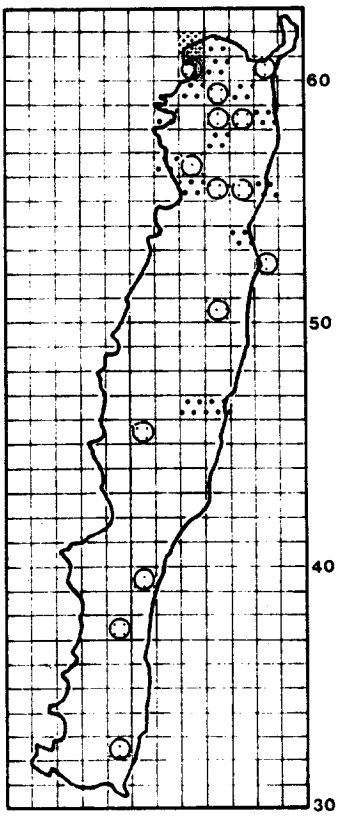
Stilbocarpa polaris A. Gray

1. Very widespread and abundant (125/55).

2. Forms pure stands or is co-dominant with Poa foliosa. Also present in the Pleurophyllum and Azorella alliances.

3. Extensively grazed by rabbits; completely eradicated in patches. The eradication can lead to erosion of the underlying peat in areas where the species occurs as a pure stand. Seeds and petioles also eaten by rats, which bite individual peduncles from the flower head. Locally threatened.

MAP 16



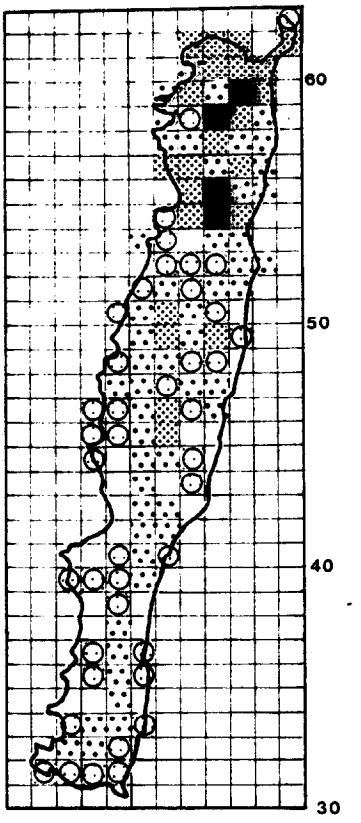
Coprosma pumila Hook.f.

1. Local and rare (28/1). Most extensive on the raised beach terrace of the west coast. More widespread in small patches on inaccessible rock outcrops and steep slopes which may indicate a reduction in abundance.

2. Co-dominant in the Pleurophyllum hookeri - Coprosma pumila subassociation of the herbfield, also common in Azorella selago alliance (Taylor 1955). Now found in this alliance only in the north of the island, where the co-occurrence of Pleurophyllum hookeri indicates a lack of intensive rabbit grazing.

3. Eaten but not favoured by rabbits. Range reduced, locally eradicated.

MAP 17



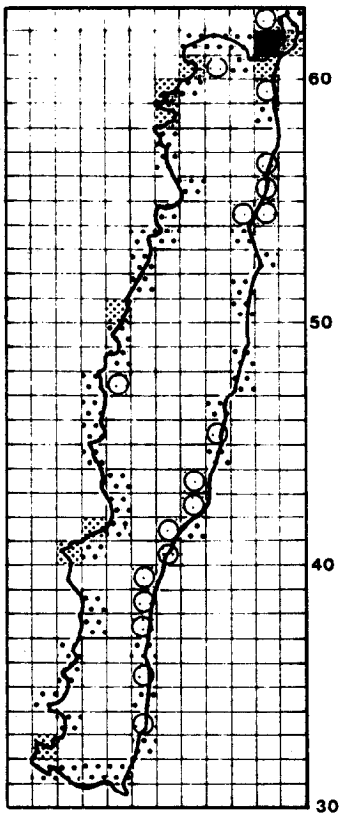
Pleurophyllum hookeri Buch.

1. Very widespread and common (118/26).

2. Dominant in parts of the herbfields; also present in the Azorella selago alliances.

3. Favoured food of rabbits, particularly during winter. Plants usually recover in spring but do not reproduce. Prolonged grazing results in elimination. There is considerable evidence of a reduction in range, e.g. relict dense patches on islands in lakes and other places inaccessible to rabbits. Preserved material present in peat cores and sections in areas where living plants are no longer present. Locally threatened.

MAP 18



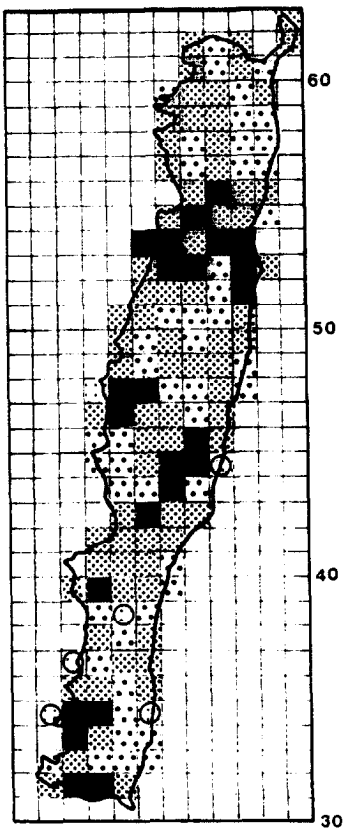
Cotula plumosa Hook. f.

1. Widespread and common (74/10).

2. Common in maritime communities. Also forms a sub-alliance with Poa foliosa where tussocks opened up by animals (seals, penguins). One record from 150 m altitude, 1 km inland on eroded peat surface. Recorded by Taylor (1955) as rare in the Azorella selago alliance. Found also on Anchor Rock (Horning and Poore, personal communication).

3. Eaten but not favoured by rabbits (Taylor 1955). No evidence for this was found in the survey. Benefits from grazing of associated taller vegetation.

MAP 19



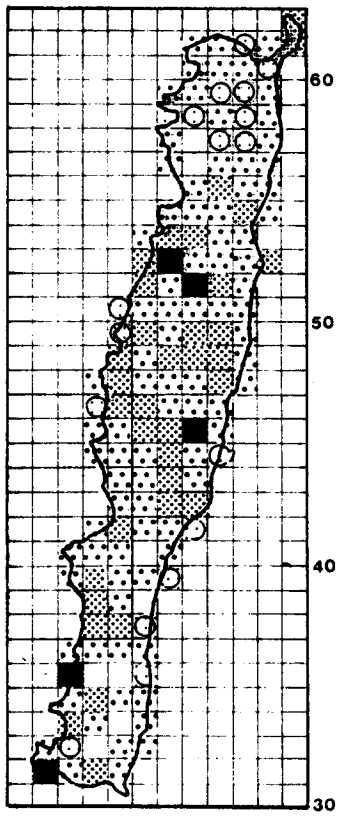
Ranunculus biternatus Sm.

1. Very widespread and abundant (150/84).

2. Found in all floristic alliances on wet sites, and is an early coloniser of eroded areas.

3. Not known to be eaten by rabbits (many Ranunculaceae are toxic to animals). Probably benefits from rabbit activity.

MAP 20



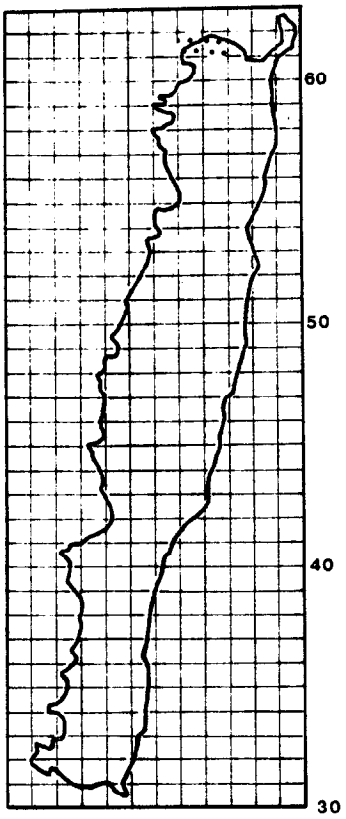
Cardamine corymbosa Hook. f.

1. Very widespread and common (144/40).

2. Found in all floristic alliances, usually in sheltered sites. Occasionally found as only other vascular species in stands of Stilbocarpa. Forms a low mat on exposed sites.

3. Eaten by rabbits, but not favoured. One of the few species to survive intense and sustained grazing. Often found in abandoned burrow entrances. Benefits from rabbit activity.

MAP 21



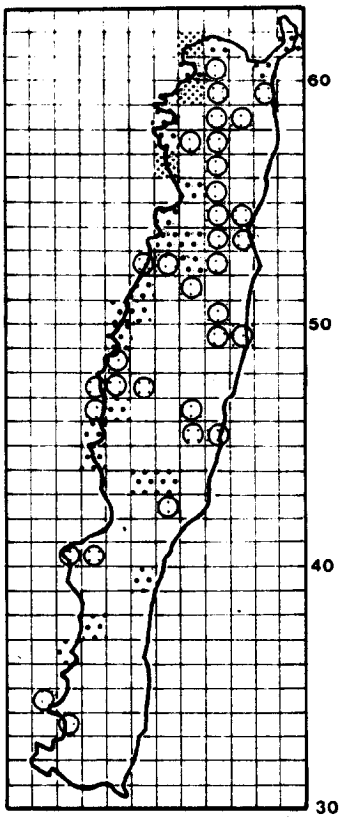
Carex trifida Cav.

1. Local and rare (2/0). Confined to Handspike Point. May be a late arrival on the island (Taylor 1955).

2. Occurs in the Pleurophyllum hookeri alliance. Also associated with Poa foliosa, where tussocks of this are small.

3. Grazed by rabbits (J. Jenkin, personal communication) but grazing is apparently rare; e.g. in 1978 Poa foliosa had been eaten, but associated Carex was untouched. Not threatened by rabbits.

MAP 22



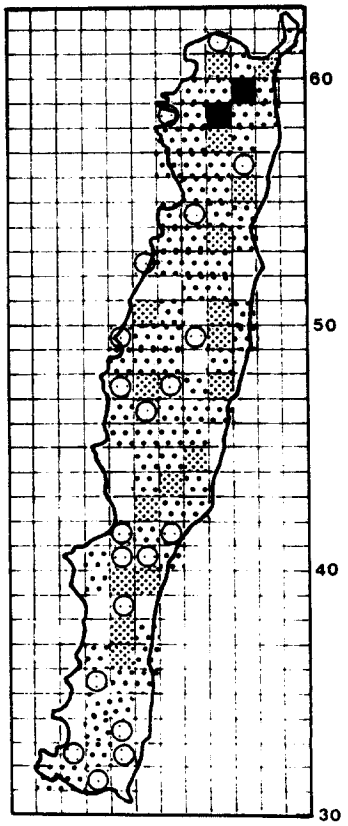
Scirpus aucklandicus (Hook. f.) Boeck.

1. Widespread but rare (60/4). Once restricted to the raised beach terrace on the west coast (Taylor 1955), it is now also found on the plateau.

2. Occurs in fen and bog alliances where the water-table is at or near the surface and where taller species are absent.

3. Grazed by rabbits, occasionally extensively damaged, but usually survives to reproduce in low growing form (less than 20 mm). Probably benefits from rabbit activity, e.g. by extension of range.

MAP 23



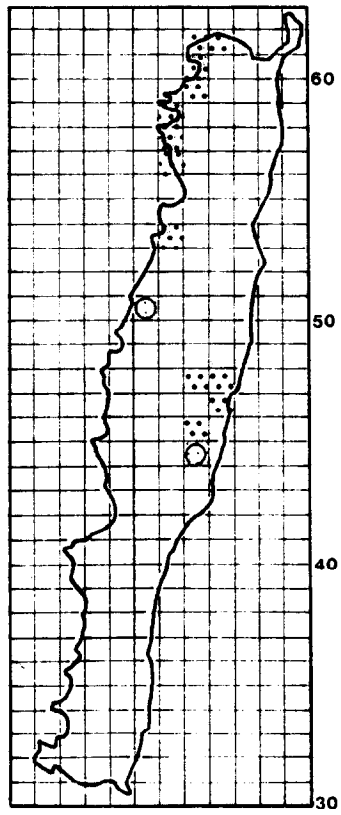
Uncinia compacta R. Br.

1. Very widespread and common (103/19).

2. Occurs in better drained areas of the Pleurophyllum hookeri alliances and in sheltered parts of feldmark.

3. Eaten by rabbits and is absent from areas of prolonged grazing. Locally threatened.

MAP 24



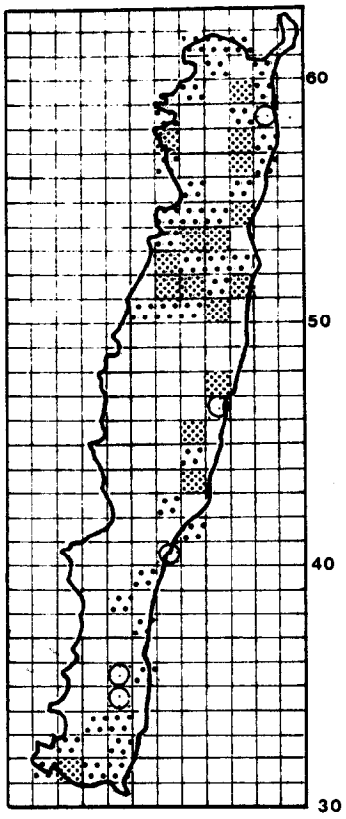
Corybas macranthus (Hook. f.) Reichb. f.

1. Local and rare (14/0).

2. Occurs in fen and bog alliances. At Handspike Point they are also found under Stilbocarpa polaris leaves on dry banks adjacent to the fen and bog communities. Flowering period early November to mid December (1980 data only).

3. Apparently unaffected by rabbits. Uprooted plants have been found in several areas and may be used as a food source by the wekas or kelp gulls.

MAP 25



Acaena minor (Hook. f.) Allan

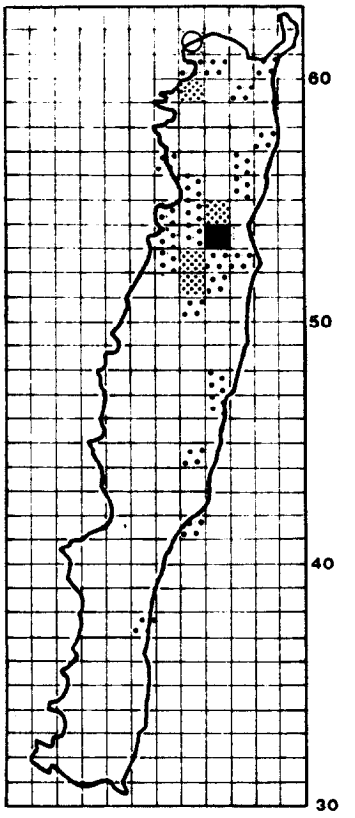
1. (60/16). Survey incomplete.

2. Occurs at all elevations in herbfield and feldmark alliances. Restricted by wet conditions and shading.

3. Eaten by rabbits but not favoured. Benefits from dispersal of seeds and reduction in interspecific competition. One of the few vascular species to survive in heavily and continually grazed areas.

Note:
The data on the Acaena spp. contained in the atlas is not complete. Difficulties arose in differentiating between the two known species through much of the year and there is a possibility of hybridisation which is being

MAP 28



Acaena magellanica (Lam.) Vahl.

1. (28/5). Survey incomplete.

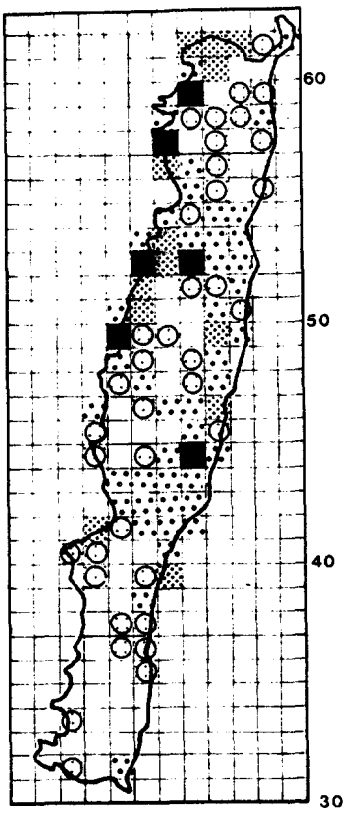
2. Occurs in fen, bog and wet herbfield alliances, also rarely in feldmark. Requires a high water-table.

3. Eaten by rabbits but not favoured. Seeds dispersed by rabbits and can become locally dominant in some rabbit grazed areas.

---

investigated at present. The information shown here is only from data where a positive identification was made and both species are more abundant and widespread than shown in the atlas.

MAP 27



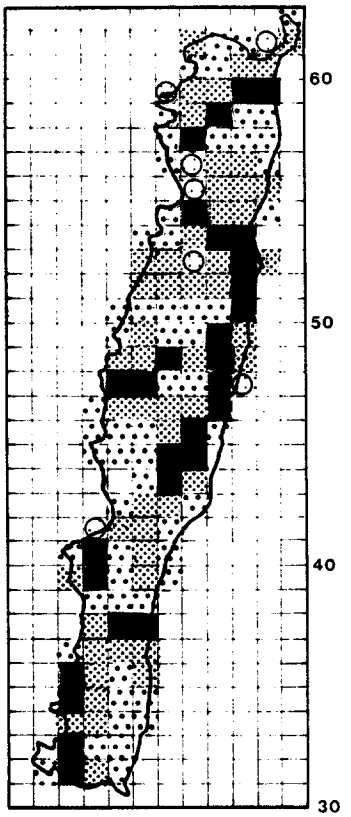
Juncus scheuchzerioides Gaud.

1. Widespread and common (100/19).

2. Wide-ranging, dominant in fen associations, common in bogs. Found also in wet areas of herbfield.

3. Eaten by rabbits, sometimes heavily cropped. The species is favoured by a high water-table, and has had its range extended by rabbits. Rabbits probably beneficial.

MAP 28



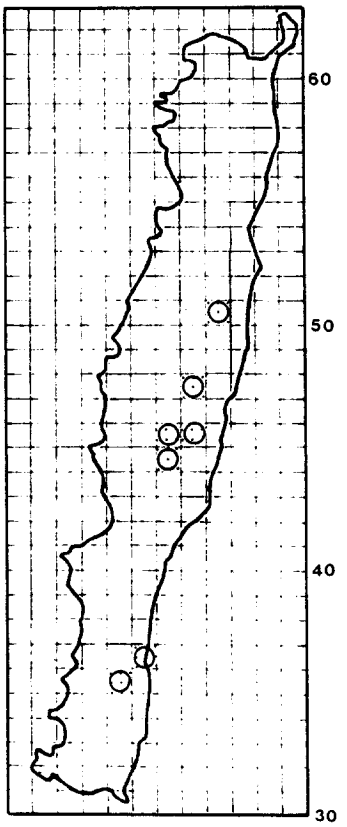
Luzula campestris (L.) DC. in Lam. et DC.

1. Very widespread and abundant (145/80).

2. Common in herbfields and feldmark communities.

3. Eaten by rabbits, though not favoured. The species has been eliminated in some areas of prolonged and heavy grazing, but benefits from reduction of associated vegetation. Rabbits probably beneficial.

MAP 29



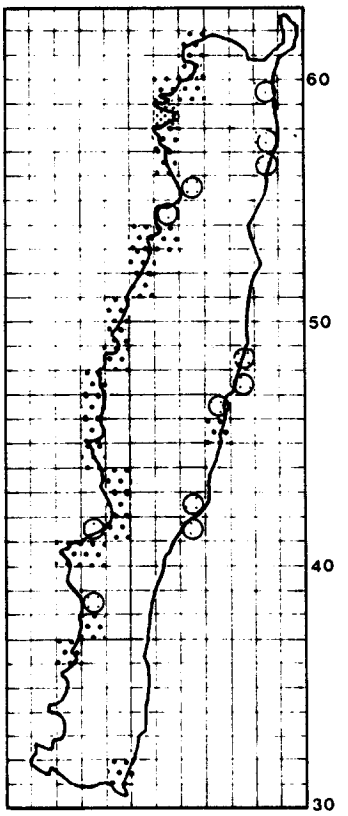
Lycopodium sp.

1. Local and rare (7/0). Only one plant was found during the survey. Six further sites were found in the two following summers. Cumpston (1968) records that one specimen accompanied Azorella material sent to Kew Gardens in 1824, indicating that it may have been more common then. Laird (1949 unpublished) records it as being "widely distributed over the island at plateau levels and in deep gorges below plateau level". Taylor (1955) found about 100 plants in 12 sites. Jenkin (personal communication) found 5 plants near Green Gorge in 1977 and one south of Pyramid Peak.

2. Sheltered sites of the Azorella selago alliance.

3. Apparently in danger of complete elimination.

MAP 30



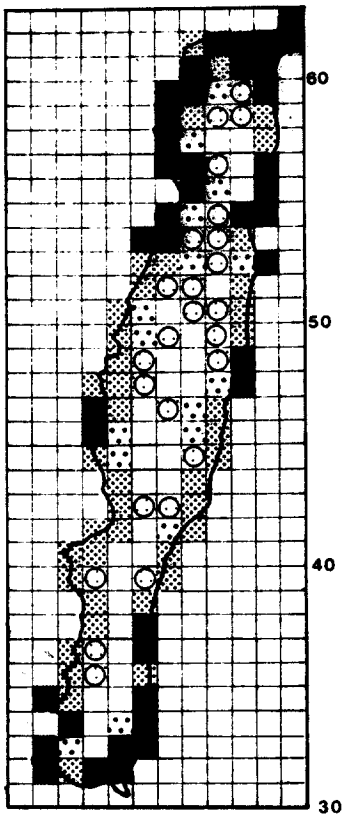
Crassula moschata Forst. f.

1. Widespread but rare (39/1), most frequently on the west coast. Three occurrences recorded between the ANARE Station and Sandy Bay where it was previously thought to be absent (Taylor 1955).

2. Found in sheltered parts of the maritime community where it is most common on broad ledges subject to salt spray but not wave action.

3. Apparently not grazed by rabbits, but plants have been observed to be subject to mechanical damage. Not threatened.

MAP 31



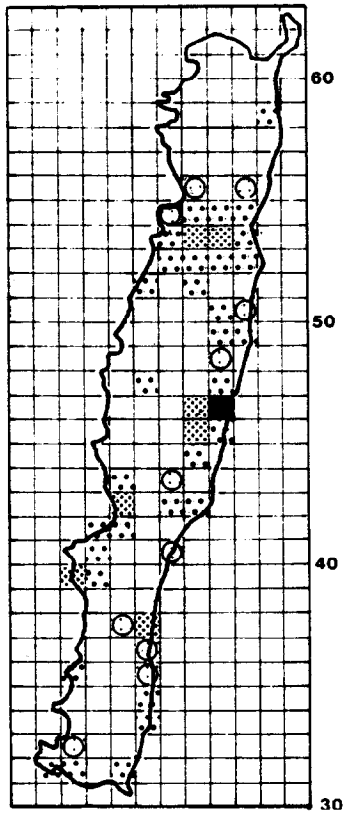
Poa foliosa Hook. f.

1. Very widespread and abundant (123/82).

2. Dominant in wet tussock grassland, rarely found elsewhere.

3. Grazed by rabbits and may be eradicated locally. Relict populations in inaccessible areas (rock outcrops and islands in lakes) indicate a previously broader distribution. Costin and Moore (1960) have attributed accelerated erosion of the coastal slopes to the removal of this species. Locally threatened.

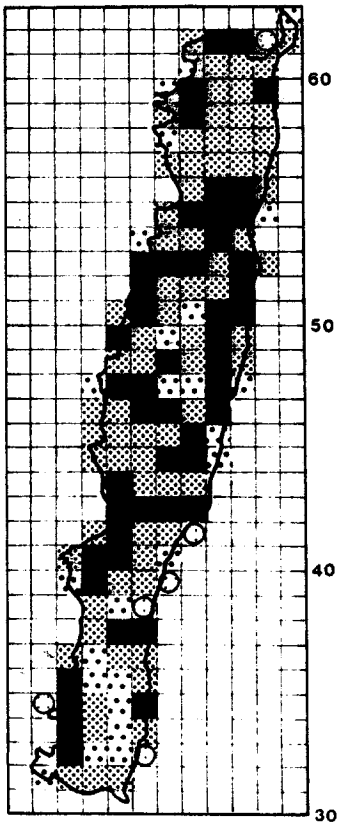
MAP 32



Deschampsia chapmani Petrie

1. Widespread and common (51/8), but has a patchy, irregular distribution.
2. Occurs in sheltered parts of the herbfields.
3. Eaten by rabbits but withstands moderate grazing and remains common in areas where rabbits numbers are high.

MAP 33



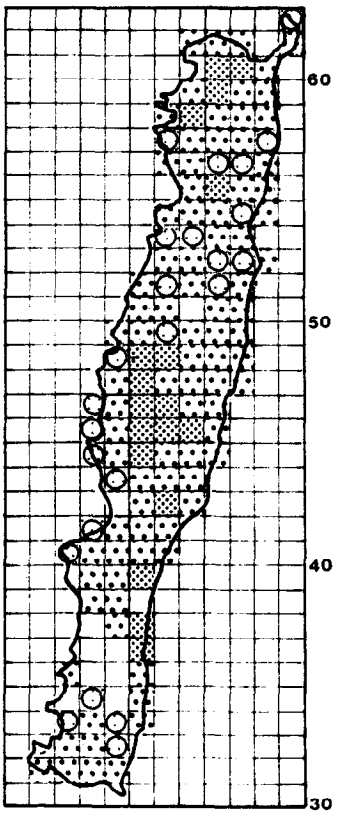
Agrostis magellanica Lam.

1. Very widespread and abundant (153/120).

2. Found in most floristic associations, but rarely in dense stands of Poa foliosa. Common in later stages of seral colonisation of bare areas.

3. Heavily grazed by rabbits in some areas, but can grow and reproduce in mat form. Its range is extended by degradation of the Poa foliosa alliance by rabbits. Rabbit activities probably beneficial.

MAP 34



Festuca contracta T. Kirk

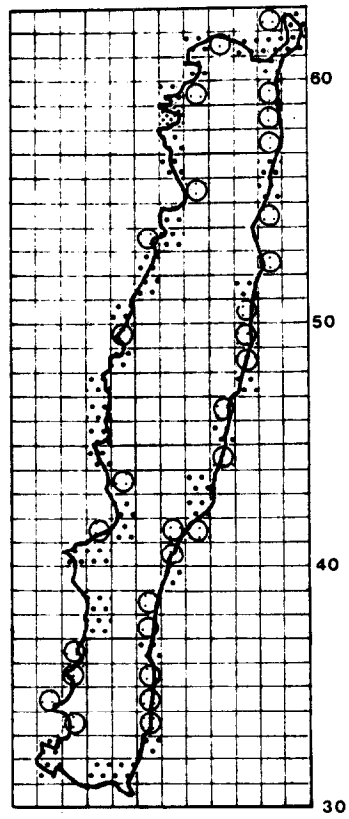
1. Very widespread and common (129/18).

2. Occurs in the Pleurophyllum hookeri alliance of the herbfields and Azorella selago alliance of the feldmark.

3. Eaten by rabbits. Eradicated locally by intensive grazing in the herbfields. Rapidly reduced or eliminated from the feldmark. Locally threatened.

Species endemic to Macquarie Island

MAP 35



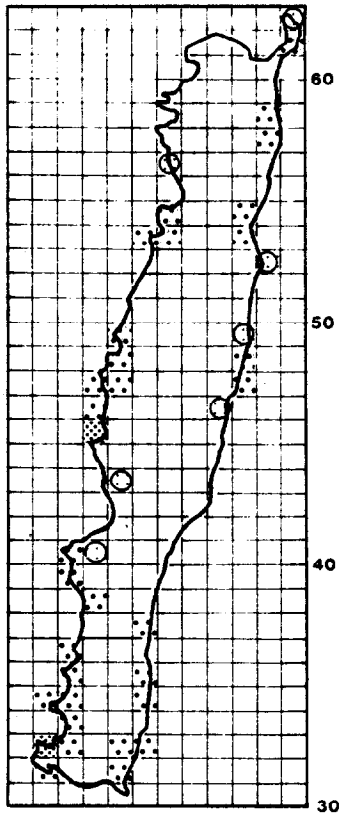
1. Puccinellia macquariensis Allan et Jan.

   1. Widespread but rare (70/1) (Has been recorded from Campbell Island in recent years).

   2. Restricted to maritime communities. Found also on Anchor Rock (Horning and Poore, personal communication). One record from South West Point at 50 m altitude, where subject to salt spray.

   3. Eaten, but not favoured by rabbits; not endangered.

MAP 36



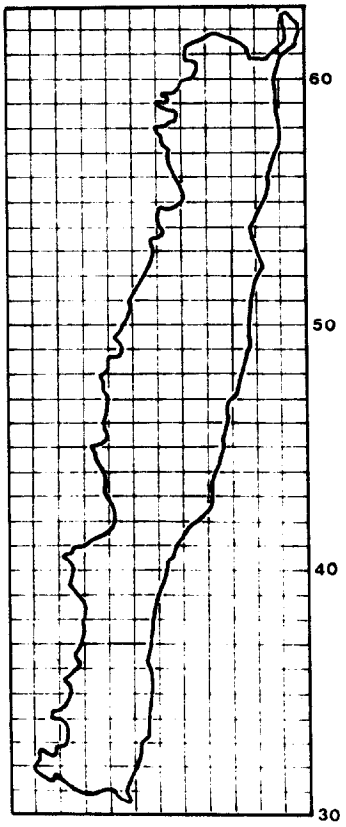
2. Poa hamiltoni T. Kirk

   1. Widespread but rare (40/2).

   2. Confined largely to wet tussock grasslands on the margins of permanent penguin rookeries. Four small colonies were found remote from rookeries.

   3. Eaten by rabbits, sometimes in preference to P. foliosa. Locally threatened.

MAP 37



3. Deschampsia penicillata T. Kirk

   1. Not found in survey.

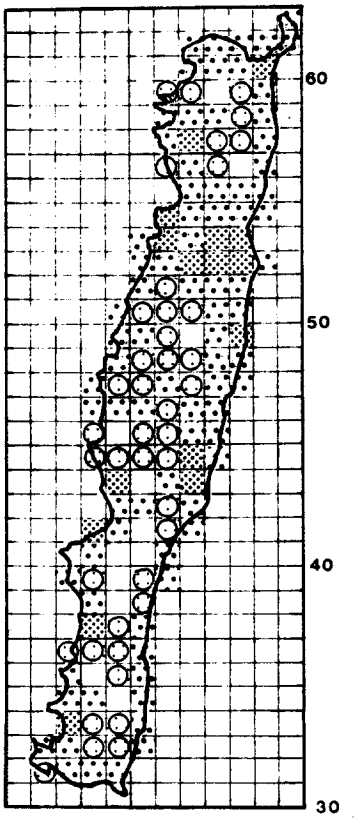
   2. Confined largely to the Juncus - Agrostis - Deschampsia association in small soaks which are wind exposed (Taylor 1955).

   3. Rarely eaten by rabbits (Taylor 1955). Present conservation status unknown.

Species Introduced to Macquarie Island

Several species have been introduced to the island both accidentally and intentionally. Four cosmopolitan species have become established. Three were first collected in the the last century and thought to have been introduced by sealers and oil gatherers in packing materials. The fourth Rumex crispus L. was found in December 1980.

MAP 38



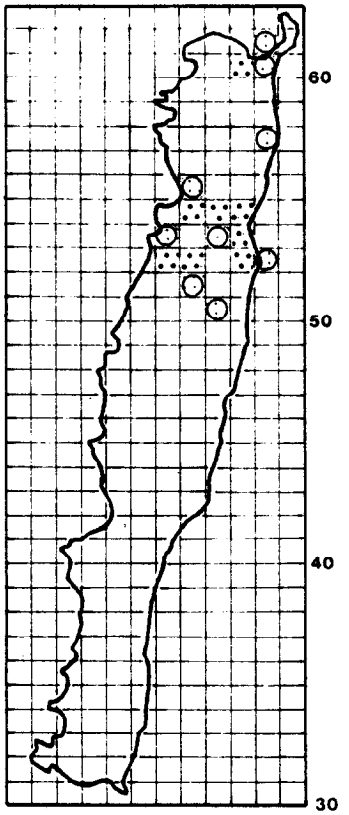
Poa annua L.

1. Very widespread and common (139/18). Introduced by sealers in the last century.

2. Present in all floristic alliances, especially disturbed areas. It is an early coloniser of eroded areas.

3. Eaten by rabbits, but is well able to withstand intensive grazing. The rabbits probably have been a major factor in its spread around the island. Benefits from rabbit activity.

MAP 39



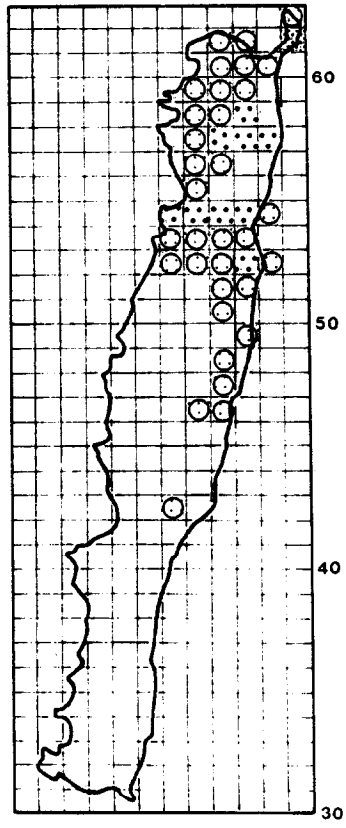
Stellaria media (L.) Vill.

1. Local and rare (17/0). First collected near the sealers' huts at Lusitania Bay by A. Hamilton in 1894. Taylor (1955) only found it close to sealers' huts of the east coast and isthmus. Now found on the plateau and west coast, but not recorded from the southern half of the island.

2. Confined to Poa foliosa alliance below 120 m (Taylor 1955). Now found in Poa foliosa alliance and in herbfield to altitudes over 200 m. The species is an early coloniser of eroded sites.

3. Eaten by rabbits, but benefits by changes in habitat due to rabbit activity.

MAP 40



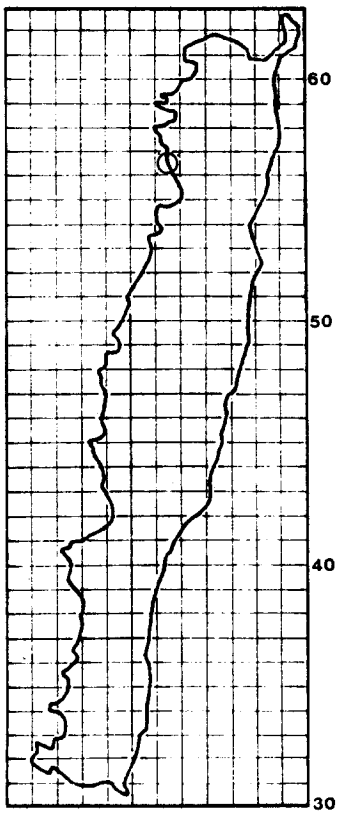
Cerastium fontanum Baumg.

1. Widespread but rare (43/1). It was first collected by A. Hamilton at Lusitania Bay in 1894. Now frequent on the northern end of the island it was only recorded from one location in the southern half, 5 km north of Lusitania Bay.

2. Tayor (1955) records it as present in tussock, herbfield and feldmark alliances. It is now also found in fen and bog alliances on the west coast.

3. Eaten by rabbits but benefits from changes in habitat due to rabbit activity.

MAP 41



Rumex crispus L.

1. Local and rare (1/0). First collected on Macquarie Island in December 1980.

2. Found in a bog alliance on the west coast raised beach terrace.

3. Eaten by rabbits but not favoured, present status unknown.

ACKNOWLEDGEMENTS

I would like to thank the Tasmanian National Parks and Wildlife Service and the Antarctic Division, Department of Science and Technology for making my stays on Macquarie Island possible; Dr M.J. Brown for his assistance and encouragement throughout the work; Dr R.D. Seppelt, Dr P.M. Selkirk and J.J. Scott for data on the distribution of some species.

REFERENCES

Aitken, Y. (1974). Flowering time, climate and genotype. Melbourne University Press.

Brothers, N.P.; Eberhard, I.H.; Copson, G.R. and Skira, I.J. (1982). Control of rabbits on Macquarie Island by myxomatosis. Australian Wildlife Research 9:477-485.

Brown, M.J.; Jenkin, J.F.; Brothers, N.P. and Copson, G.R. (1978). Corybas macranthus (Hook. f.) Reichb. f. (Orchidaceae), a new record for Macquarie Island. New Zealand Journal of Botany 16:405-7.

Cheeseman, T.F. (1919). The vascular flora of Macquarie Island. Australasian Antarctic Expedition Scientific Reports, Series C 7 Part 3.

Colhoun, E.A. and Goede, A. (1973). Fossil penguin bones, 14C dates and raised marine terraces of Macquarie Island: some comments. Search 4(11):499-501.

Colhoun, E.A. and Goede, A. (1974). A reconnaissance survey of the glaciation of Macquarie Island. Papers and Proceedings Royal Society of Tasmania 108:1-19.

Copson, G.R.; Brothers, N.P. and Skira, I.J. (1981). Distribution and abundance of the rabbit, Oryctolagus cuniculus (L.), on subantarctic Macquarie Island. Australian Wildlife Research 8:597-611.

Copson, G.R. and Leaman, E.G. (1981). Rumex crispus L. (Polygonaceae) - a new record for Macquarie Island. New Zealand Journal of Botany 19:401-404.

Costin, A.B. and Moore, D.M. (1960). The effects of rabbit grazing on the grasslands of Macquarie Island. Journal of Ecology 48:729-732.

Cumpston, J.S. (1968). Macquarie Island. Australian National Antarctic Research Expeditions Scientific Reports, Series A(1) 93:1-380.

De Lisle, J.F. (1965). The climate of the Auckland Islands, Campbell Island and Macquarie Island. New Zealand Ecological Society Proceedings 12:37-44.

Greene, S.W. and Greene, D.M. (1963). Check list of the sub-antarctic and antarctic vascular flora. Polar Record 11(73):411-418.

Greene, S.W. and Walton, D.W.H. (1975). An annotated check list of the sub-antarctic and antarctic vascular flora. Polar Record 17(110):473-484.

Griffin, B.J. (1980). Erosion and rabbits on Macquarie Island: some comments. Papers and Proceedings Royal Society of Tasmania 114:81-83.

Hamilton, A. (1895). Notes on a visit to Macquarie Island. Transactions of the New Zealand Institute 27:559-579.

Hnatiuk, R.J. (1972). Hymenophyllum peltatum (Poiret) Desvaux, a new Macquarie Island record. New Zealand Journal of Botany 10:701.

Jenkin, J.F. (1972). Studies on plant growth in a subantarctic environment. Ph.D. Thesis, University of Melbourne.

Jenkin, J.F. and Ashton, D.H. (1979). Pattern in Pleurophyllum herbfields on Macquarie Island, subantarctic. Australian Journal of Ecology 4:47-66.

Jenkin, J.F.; Johnstone, G.W. and Copson, G.R. (1981). Introduced animal and plant species on Macquarie Island. In: Colloque Sur Les Ecosystemes Subantartiques, Paimpont 1981. CNFRA 51:301-313.

Loffler, E. and Sullivan, M.E. (1980). The extent of former glaciation on Macquarie Island. Search 11(7-8):246-247.

Mawson, D. (1915). The home of the blizzard. London: Heinemann.

Mawson, D. (1943). Macquarie Island: its geography and geology. Australasian Antarctic Expedition Scientific Reports, Series A 5.

Quilty, P.G.; Rubenach, M.J. and Wilcoxon, J.A. (1973). Miocene ooze from Macquarie Island. Search 4:163-164.

Scott, J.H. (1881). Macquarie Island. Royal Society of New Zealand 15:484.

Taylor, B.W. (1955). The flora, vegetation and soils of Macquarie Island. Australian National Antarctic Research Expeditions Reports, Series B(II) 1-92.

Troll, C. (1960). The relationship between the climates, ecology and plant geography of the southern cold temperate zone and of the tropical high mountains. Proceedings of the Royal Society, Series B 152(949):529-540.

Varne, R. and Rubenach, M.J. (1972). Geology of Macquarie Island and its relationship to oceanic crust. American Geophysics Union Antarctic Research Series 19:251.

ANARE RESEARCH NOTES (ISSN 0729-6533)

1. John M. Kirkwood (1982). A guide to the Euphausiacea of the Southern Ocean.

2. David O'Sullivan (1982). A guide to the Chaetognaths of the Southern Ocean and adjacent waters.

3. David O'Sullivan (1982). A guide to the Pelagic Polychaetes of the Southern Ocean and adjacent waters.

4. David O'Sullivan (1982). A guide to the Scyphomedusae of the Southern Ocean and adjacent waters.

5. David O'Sullivan (1982). A guide to the Hydromedusae of the Southern Ocean and adjacent waters.

6. Paul J. McDonald (1983). Steam aided curing of concrete in Antarctica.

7. Richard Williams, John M. Kirkwood, David O'Sullivan (1983). FIBEX cruise zooplankton data.

8. David O'Sullivan (1983). A guide to the Pelagic Tunicates of the Southern Ocean and adjacent waters.

9. Rosemary Horne (1983). The distribution of Penguin breeding colonies on the Australian Antarctic Territory, Heard Island, the McDonald Islands, and Macquarie Island.

10. David O'Sullivan (1983). A guide to the Pelagic Nemerteans of the Southern Ocean and adjacent waters.

11. John M. Kirkwood (1983). A guide to the Decapoda of the Southern Ocean.

12. John M. Kirkwood (1983). A guide to the Mysidacea of the Southern Ocean.

13. T.H. Jacka (1983). A computer data base for Antarctic sea ice extent.

14. G.B. Burns (1983). The variation of Southern Hemisphere atmospheric vorticity around interplanetary magnetic field sector crossings.

15. Suzanne E. Stallman (1983). Gazetteer of the Australian Antarctic Territory.

16. Peter Keage (1984). Resource potential of the Australian Antarctic Territory.

17. Damien Jones (1983). Snow stratigraphy observations in the katabatic wind region of Eastern Antarctica.

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

19. J.S. Boyd (1983). Invariant geomagnetic co-ordinates for Epoch 1977.25.

ISBN: 0 642 87546 4

ANARE RESEARCH NOTES (ISSN 0729-6533)

1. John M. Kirkwood (1982). A guide to the Euphausiacea of the Southern Ocean.

2. David O'Sullivan (1982). A guide to the Chaetognaths of the Southern Ocean and adjacent waters.

3. David O'Sullivan (1982). A guide to the Pelagic Polychaetes of the Southern Ocean and adjacent waters.

4. David O'Sullivan (1982). A guide to the Scyphomedusae of the Southern Ocean and adjacent waters.

5. David O'Sullivan (1982). A guide to the Hydromedusae of the Southern Ocean and adjacent waters.

6. Paul J. McDonald (1983). Steam aided curing of concrete in Antarctica.

7. Richard Williams, John M. Kirkwood, David O'Sullivan (1983). FIBEX cruise zooplankton data.

8. David O'Sullivan (1983). A guide to the Pelagic Tunicates of the Southern Ocean and adjacent waters.

9. Rosemary Horne (1983). The distribution of Penguin breeding colonies on the Australian Antarctic Territory, Heard Island, the McDonald Islands, and Macquarie Island.

10. David O'Sullivan (1983). A guide to the Pelagic Nemerteans of the Southern Ocean and adjacent waters.

11. John M. Kirkwood (1983). A guide to the Decapoda of the Southern Ocean.

12. John M. Kirkwood (1983). A guide to the Mysidacea of the Southern Ocean.

13. T.H. Jacka (1983). A computer data base for Antarctic sea ice extent.

14. G.B. Burns (1983). The variation of Southern Hemisphere atmospheric vorticity around interplanetary magnetic field sector crossings.

15. Suzanne E. Stallman (1983). Gazetteer of the Australian Antarctic Territory.

16. Peter Keage (1984). Resource potential of the Australian Antarctic Territory.

17. Damien Jones (1983). Snow stratigraphy observations in the katabatic wind region of Eastern Antarctica.

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

19. J.S. Boyd (1983). Invariant geomagnetic co-ordinates for Epoch 1977.25.

ISBN: 0 642 87546 4