

Flora and vegetation of Montagu Island – past and present

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Abstract: Montagu Island (36°15'S; 150°14'E) is situated about 10 km east of Narooma on the New South Wales South Coast. The paper presents evidence about the changes in the terrestrial vegetation of the island since it was first seen by Europeans, provides a floristic inventory and gives a perspective on the effects of introduced species.

Flinders (1814) mentions that the island 'produced small trees.' This is the only record of what grew on the island until in 1880 annotations on a map, made at the time of the construction of the lighthouse, mentioned the presence of scrub, trees and rank grass. This is confirmed by photographic evidence, but by 1932, when the botanist F. A. Rodway visited the island, the trees had disappeared. In 1973, during a land use survey of the South Coast, a team of CSIRO described the vegetation as a distinct series of dune communities belonging to the *Lomandra longifolia* – *Pteridium esculentum* – *Phragmites australis* complex. Vegetation mapping in the late 1980s confirmed the prevalence of these species, except that *Pennisetum clandestinum* then covered a large area along the west side of the island.

Excluding taxa used for ornamental or culinary purposes, nearly 200 species of vascular plants have been recorded since 1932 of which about 140 were still present in the late 1990s. There are ten species of ferns e.g. *Pteridium esculentum*, widespread and sometimes codominant with *Lomandra longifolia*, and *Asplenium obtusatum*, frequently found among the rocks along the east side of the island. The only taxon unique to Montagu Island is a hybrid of this species and *Asplenium australasicum*. Among the flowering plants there are about 110 native species and about 70 species naturalised in Australia. About 85 and 40, respectively, are still present today. Many of these have a wide distribution in Australia and only about 25 have a more restricted coastal distribution. The species that have disappeared include many that were weeds in the vegetable gardens or around the chicken sheds. Several naturalised species still present are notorious for their capacity to overrun existing vegetation. Foremost among these is *Pennisetum clandestinum*, which now covers about one-third of the island; *Acetosa sagittata* is a close second. Other contenders are *Dipogon lignosus* and *Delairea odorata*. It is now apparent that these species were kept in check by the feral goats that roamed the island before it was declared a Nature Reserve in December 1987.

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Introduction

Montagu Island (36°15'S; 150°14'E) is situated about 10 km offshore from Narooma on the New South Wales South Coast. It has a north-south orientation, is nearly 2 km long, up to about 700 m wide and reaches an elevation of about 50 m asl (Fig. 1). Seen from an approaching ship, the lighthouse, together with large rounded rock outcrops set in a low vegetation of green and reddish brown hues, dominates the scenery. In 1790 the master of the supply ship 'Surprize' discovered that Cook's 'Cape Dromedary' was actually an island and named it after George Montagu Dunk, Earl of Halifax (Reed 1969). This name, together with the Aboriginal name Barunguba, is still used on the charts published by the Admiralty. The spelling 'Montague Island,' sanctioned by the Geographical Names Board of New South Wales, originated from a mistake on Flinders's chart (Flinders 1814).

The aim of the paper is to document what is known about the terrestrial vascular flora of Montagu Island. It presents evidence about changes in the vegetation since the island was first seen by Europeans, updates and expands earlier papers

(Heyligers & Adams 1989, Heyligers 1993) and provides a perspective on the effects of introduced species at a time that considerable changes in flora and vegetation can be expected as a consequence of the management regime implemented by NSW National Parks and Wildlife Service.

Environmental factors: climate, geology and soils

The Narooma area (average annual rainfall 887 mm) is a relatively dry region in comparison with other areas in coastal southern New South Wales. Median annual rainfall is only 803 mm with annual extremes between 426 and 1769 mm (Kalma & McAlpine 1978). Average rainfall on Montagu Island is 909 mm per year, while the median value is 908 mm. Monthly averages range from 122 mm in March and 118 mm in June to 49 mm in July and 60 mm in August. Rainfall data for the mainland show a moderate summer maximum, but no such trend is apparent in the data for Montagu Island. Average maximum and minimum temperatures for February, the warmest month, are 23.6 and 17.8°C, those for July, the coldest month, 15.3 and 9.7°C (Anon. 1988). Minimum temperatures below 6.0°C are rare; however, on 22 July 1983,

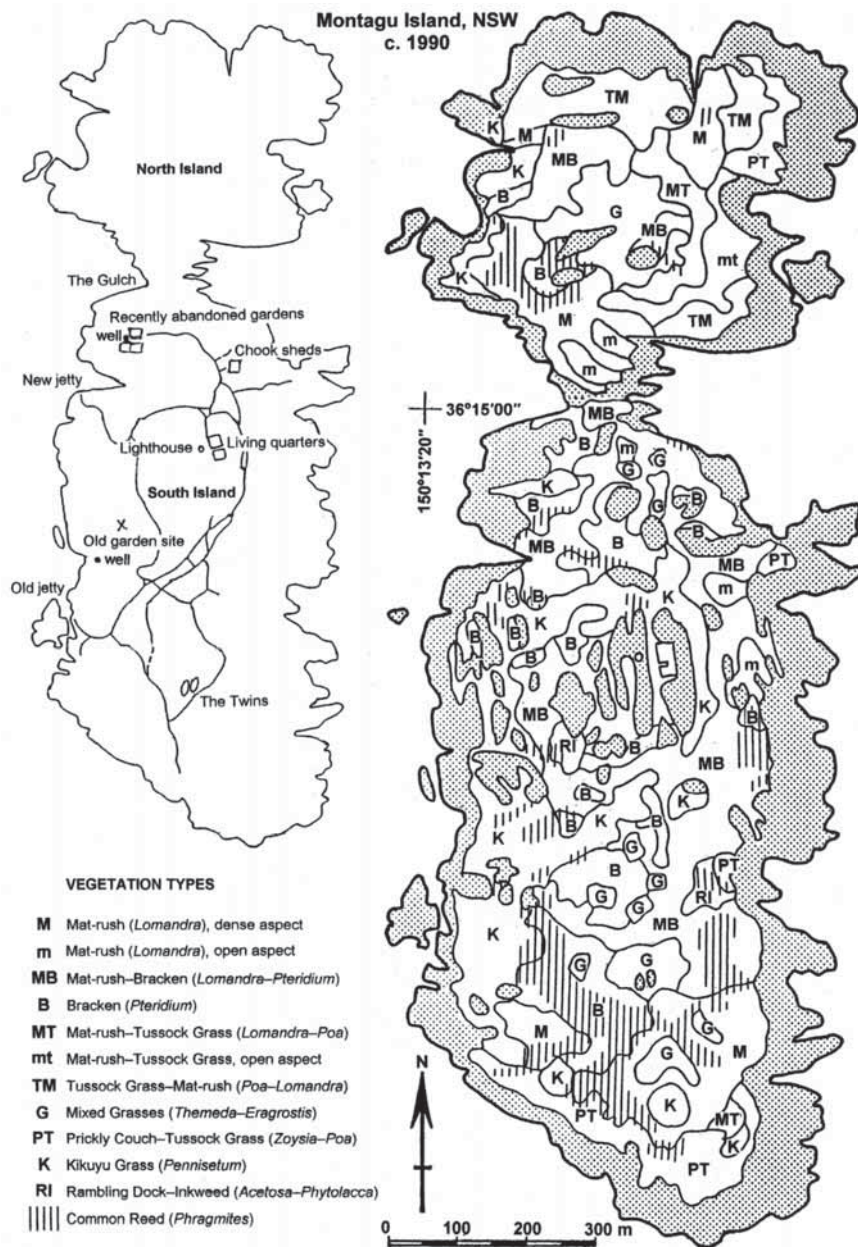


Fig. 1. Montagu Island as it was in the late 1980s. Vegetation and major rock outcrops (stippled) are shown at the right, buildings and other features, including tracks, at the left. (The vegetation map is based on Heyligers 1993 with permission from the Eurobodalla Natural History Society, the map with geographic features on Fullagar & Heyligers 1992.)

when in the screen a minimum temperature of 6.6°C was recorded, there was 'frost on island near chookpen' according to an annotation in the logbook.

The island's northern section is shaped by basaltic rocks, its southern by granite (Brown 1930). The junction between the two rock types formed a zone of weakness and has eroded to below present-day sea level. The gap between the sections is variously known as 'The Gulch,' 'The Gorge' or 'The Gut.' It is filled with large boulders, but at the western side a beach of shellgrit connects the northern section, usually called 'North Island', with the southern one, about twice as large and known as 'South Island.' North Island is plateau-like with a gently bulging centre. It has steep slopes at the western side and cliffs at the eastern and southern sides. The northern and north-eastern sides of South Island are also steep, but the remainder is fringed by staggered, shelving rock platforms giving way to large, rounded outcrops towards the crest. Joints

formed lines of weakness and have eroded into cliff-sided canyons cutting into the periphery of the island.

Soils on the island are invariably coarse-textured as they have developed in wind-blown sands overlying bedrock. They are moderately deep, medium acid throughout and imperfectly drained. Their colours grade from black to very dark grey in the surface horizons to dark brown or reddish brown beneath (Gunn 1978). Coffee-rock, a dark reddish brown massive hardpan cemented by iron and organic compounds due to impeded drainage, occurs at variable depths and in its turn provides another impermeable layer.

European history of the island

In the early 1880s a lighthouse was built on the highest rock outcrop of the South Island (Higgins 1990, Pacey 2001). After Federation the island came under the jurisdiction of the Commonwealth and in 1953 was gazetted as a Wildlife

Reserve to protect seabirds breeding on the island and seals hauling out on the rocks along the northern shore. After automation of the light in the 1980s, the jurisdiction over the island was transferred to the State of New South Wales and it became a Nature Reserve administered by the National Parks and Wildlife Service (Pacey 2001). This resulted in a drastic change in management regime. Under Commonwealth rule the lightkeepers, although adapting to changing circumstances in the outside world, lived by and large in traditional style and the management of natural assets was largely a matter of laissez-faire (Higgins 1990). The only livestock kept on the island at the time of the transfer were chickens. Horses, pigs, sheep, milking goats, dairy cows, geese and ducks were already a thing of the past, but goats had turned feral and rabbits, already introduced to the island before the lighthouse was built, were still present. So were some of the courtyard and outside gardens, which were used for growing ornamental plants as well as vegetables (Pacey 2001). When the National Parks and Wildlife Service took over, an active natural resources management regime was put in place, which started with the immediate eradication of the goats. However, no special efforts were made to eradicate the rabbits, as these were already subject to periodic outbreaks of myxomatosis. Recently, experiments have been put in place to push back invasive introduced plant species and establish a cover of native species instead (N. Klomp, pers. comm.).

Methods

To discover the history of vegetation change an extensive search for early descriptive and photographic material was undertaken in libraries and archives in the late 1980s and early 1990s. This search was underpinned by information presented by Higgins (1990) and Pacey (1991). In addition, we visited people who had ties with Montagu Island and were able to help with information and often with photographs as well. These sources are documented in the Acknowledgements.

The species list in our earlier paper (Heyligers & Adams 1989) was updated with later collections made by Heyligers, while identifications, where necessary, were checked and names brought up to date by Adams. Also, the computer databases at the Australian National Herbarium (CANB) and at the National Herbaria of New South Wales (NSW) and Victoria (MEL) were searched for collections from Montagu Island. As not all collections in these herbaria have as yet been entered, we expect that in due course some further collections will come to light. Details on distribution for plant-geographic analysis were obtained from Jacobs and Pickard (1981), Harden (1990–1993) and Walsh and Entwisle (1994–1999), while field experience and field notes were used to assess abundance and habitat preferences on the island. Nomenclature follows Harden (1990–1993), and Walsh and Entwisle (1994–1999) for later changes.

Early botanical records

Montagu Island has a long history of use by indigenous people (Pacey 2001) and this may well have had a profound

influence on the vegetation. Flinders (1814) mentions that the island ‘produced small trees,’ but this is the only record of what grew on the island in the early days of colonisation. A map of South Island, made at the time the lighthouse was built, has annotations about topography and vegetation: ‘Scrub Trees and rank Grass,’ ‘Scrub and Trees,’ ‘Scrub and Stunted Trees,’ ‘Coarse rank Grass’ (Anon. 1883).

A.F. Basset Hull (1908) walking up from the jetty at the western side of South Island to the lighthouse in September 1907 described the vegetation as: ‘A few very ragged and dwarfed banksias (*Banksia integrifolia*) and Pigeon-berries (*Monotoca elliptica*) scattered at wide intervals, were the only trees on the island, but the sandy soil between the granite boulders was thickly overgrown with masses of the red-flowering pea-creeper (*Kennedia rubicunda*). Under these creepers, tangled up with tussock grass, rushes and stinging nettles, the Penguins’ runs and burrows extended in every direction.’

Higgins (1990) consulted much primary source material such as newspaper articles and lightkeepers’ logbooks and found that in newspaper reports from the late 19th century ‘island oaks’ were mentioned as well as remarks on the disappearance of ‘the historic Bear.’ From this one may assume that casuarinas and, if the bear is indeed a koala, eucalypts were present on the island.

In May 1921 F. A. Rodway, a medical practitioner and keen amateur botanist living in Nowra, asked the Montagu lightkeeper for a sample of the island flora. The lightkeeper, M. A. Williams, obliged by sending samples of ten species and in the covering letter wrote: ‘There is not much variety, in fact the Island is practically covered with the ordinary coastal tussock’ (Rodway archive; Royal Botanic Gardens, Sydney). Rodway sent one of the creepers to the Government Botanist, J.H. Maiden, for identification and received the following answer dated 30 June, 1921.

Dear Dr. Rodway,

The climber with opposite leaves appears to be *Marsdenia rostrata*, but flowers are required to confirm the determination. The flora of the small islands which skirt our coast are worthy of record, imperfect as the present collection obviously is. It seems desirable that a botanist should visit as many of these islands as possible; if that cannot be done, then it is desirable that local residents should do the work as well as they are able. As, so far as I am aware, no note has been made of the vegetation of Montague Island, I will cause a note of them to be put in the Australian Naturalist, if you approve.

Yours faithfully,

(J. H. Maiden.)

However, no such note was published until eleven years later after Rodway had visited Montagu Island on 4 April 1932 (Rodway 1932). In his diary Rodway listed 46 species of which he made collections. Twelve of these were introduced.

His annotations are scant and mostly refer to 'foliage' or 'old flowers.' However, *Kennedia rubicunda* is 'luxuriant,' and *Phytolacca octandra* 'plentiful, luxuriant.' There were only a 'few plants, S. end' of *Monotoca elliptica*, from which only 'foliage' was collected (and hence, earlier mis-identified as '*Leucopogon Richei*'). In 1953 there was still one 3 m high *Monotoca elliptica* left, the only tree present on the island (Higgins 1990). '*Phragmites communis*' occurred in '2 patches in wet places on S. portion.' *Stenotaphrum secundatum* was found 'at landing place & at lighthouse.' This species had been introduced in 1916 to develop lawns around the quarters to prevent further erosion of the sandy soils (Higgins 1990). Rodway's other notes refer mostly to the plants cultivated by the keepers; however, he also saw 'a few rotten stumps of *Banksia* (?) *integrifolia*' and 'a photo of opening of lighthouse [in 1881] showing a large *Banksia*,' while 'one of staff said a small wattle tree on the Island.' Most likely this referred to an *Acacia longifolia* var. *sophorae* shrub (Rodway archive; Royal Botanic Gardens, Sydney).

Some of the remarks Tom Paddon, keeper from 1934 to 1937, made during a taped interview in 1979 are relevant here: 'There used to be big trees all over the island ... then they introduced the rabbits to the island and the rabbits undermined all the trees and they fell over...' 'I've seen stumps 3 ft across, big trees of all kinds...' 'There was only one tree (when he was there), what we'd call a blackwood tree, that the goats used to nibble the bark off ... leaves ... killed everything' (L. Pacey pers. comm. 1992).

Early photographic evidence

The lighthouse was built at a time when photography had come 'of age.' Pacey (1991) shows several early pictures from which some information on the vegetation can be gained. Further searching has uncovered more pictures, including panoramic views taken from passing ships. All of these confirm that trees were present on both North and South Island, but they generally appear to be stunted and at best to occur in small groups (Fig. 2). A photograph similar to the picture referred to by Rodway indeed shows branches of a *Banksia integrifolia* (Fig. 3), but species recognition on other photographs is at best guess work (Fig. 4). Also, shrubbery was widespread. On the pictures bushes appear compact and sometimes wind-shorn. Again, species identification is impossible (Fig. 5). However, *Lomandra longifolia* was undoubtedly an important component of the ground cover, but generally appears to be interspersed with other herbaceous vegetation. Later photographs attest to the gradual disappearance of the woody plants; for instance, a picture of the lighthouse taken around 1900 shows that the *Banksia integrifolia* tree was no longer there. A couple of *Metrosideros excelsa* trees now occupy that position (Fig. 3).

Basset Hull (1914) took pictures of Silver Gull (*Larus novaehollandiae*) colonies, then located on North Island, showing a herbaceous vegetation outside the colonies, most likely dominated by *Lomandra longifolia* (Fig. 6). In 1990 the positions from which the three published photographs were

taken, were relocated. Silver gulls no longer breed there, but the aspect of the vegetation had hardly changed. Even the rock fragments lying on a gently sloping rock outcrop were still in the same position.

Oblique aerial views of Montagu Island taken in 1936 by Stanley Fowler of CSIRO's Fisheries Investigation Section, leave no doubt that by that time all trees had gone and that only a few patches of shrubbery remained (Figs. 7 and 8). They also show widely spaced *Lomandra longifolia* tussocks, and vegetable gardens on the west side of South Island at a site since overrun by *Pennisetum clandestinum*.

Later botanical work

Little botanical activity took place between 1932 and 1973, when in April a team of CSIRO's Division of Land Use Research visited the island for two days. The floristic inventory was carried out by L.G. Adams; 44 collections were made and many more species were listed. Austin and Sheaffe (1976) characterised the vegetation as follows:

A distinct series of dune communities [belonging to the *Lomandra longifolia* – *Pteridium esculentum* – *Phragmites australis* complex] occurs on Montague Island. The island is covered with drifted sand to varying depths. These communities, dominated by *Lomandra longifolia*, appear to reflect both the disturbance and eutrophication effects of the bird colonies and the soil moisture drainage patterns across the underlying rock. They form a complex continuum along an apparent moisture gradient from *Lomandra* dominated areas to those dominated by *Phragmites australis*.

In the early 1960s it was discovered that three shearwater species, the Wedge-tailed Shearwater (*Puffinus pacificus*), the Sooty Shearwater (*Puffinus griseus*) and the Short-tailed Shearwater (*Puffinus tenuirostris*) bred on Montagu Island (Fullagar 1973). Since breeding success of these species has been monitored annually in late March by teams of volunteers (Fullagar et al. 1991). On most occasions since 1988 P.C. Heyligers has been a member of this team, and during these visits and additional ones in the spring he mapped the vegetation and documented the flora by collecting voucher specimens. Heyligers and Adams (1989) published a floristic inventory for the island based on collections and observations up to and including 1988, whilst Heyligers (1993) published a map, which recorded the distribution of the vegetation in the late 1980s. During four transect surveys in the 1990s to assess the population size of Little Penguins (*Eudyptula minor*), dominant plants were recorded, in addition to nesting details. This information, together with additional fieldwork, has been used by Trezise (1999) and Weerheim et al. (2003) to assess the spread of *Pennisetum clandestinum*.

We have not found any publication on the marine algae of Montagu Island. However, since 1995 Dr Alan Millar of the Royal Botanic Gardens, Sydney, has collected many

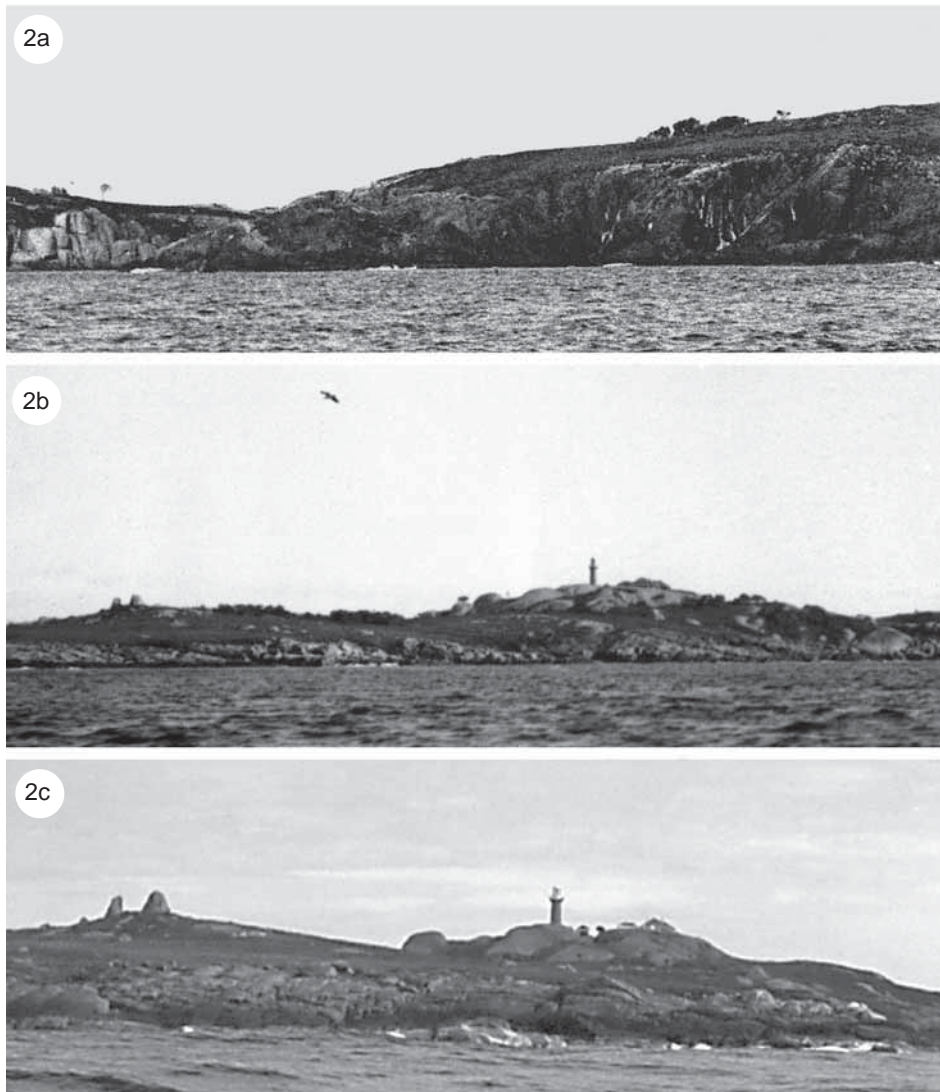


Fig. 2. Views of the east coast of Montagu Island, taken from coastal steamers shortly after the lighthouse was built compared with 1988.

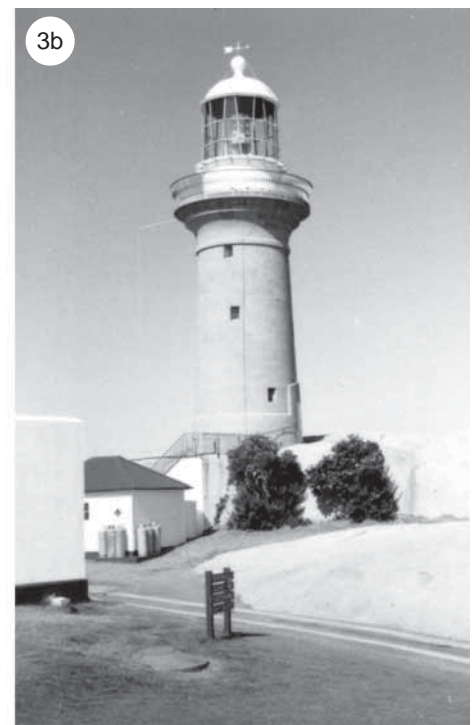
(a) Shows a stand of trees on the highest part of North Island. (Detail from a photograph in A. Searcy's SLA: PRG 280/1/ 'Albums of photographs of Australian Scenes' p. 17 (1902), used with permission of the State Library of South Australia.)

(b) Shows stands of woody vegetation and an isolated tree in the area between The Twins and the lighthouse. (Detail from a photograph taken around the turn of the century held by, and used with permission from, the State Records of New South Wales, catalogued as CGS 4483 Glass Negatives 1870–1988 [Aperture Card no. 1994.]

(c) Picture taken in 1988.

Fig. 3. The picture on the left (a) (courtesy of Mrs B. Debus), taken shortly after the lighthouse was opened in 1881, shows branches of a *Banksia integrifolia* tree. During the next fifty years all trees disappeared and during his visit in 1932 Rodway saw only a few rotten stumps, possibly from banksias.

The *Metrosideros excelsa* trees on the photograph at the right (b), taken in 1993, now grow on about the same spot as the banksia. Pohutakawas, or New Zealand Christmas trees, were introduced to the island in the early 1960s.



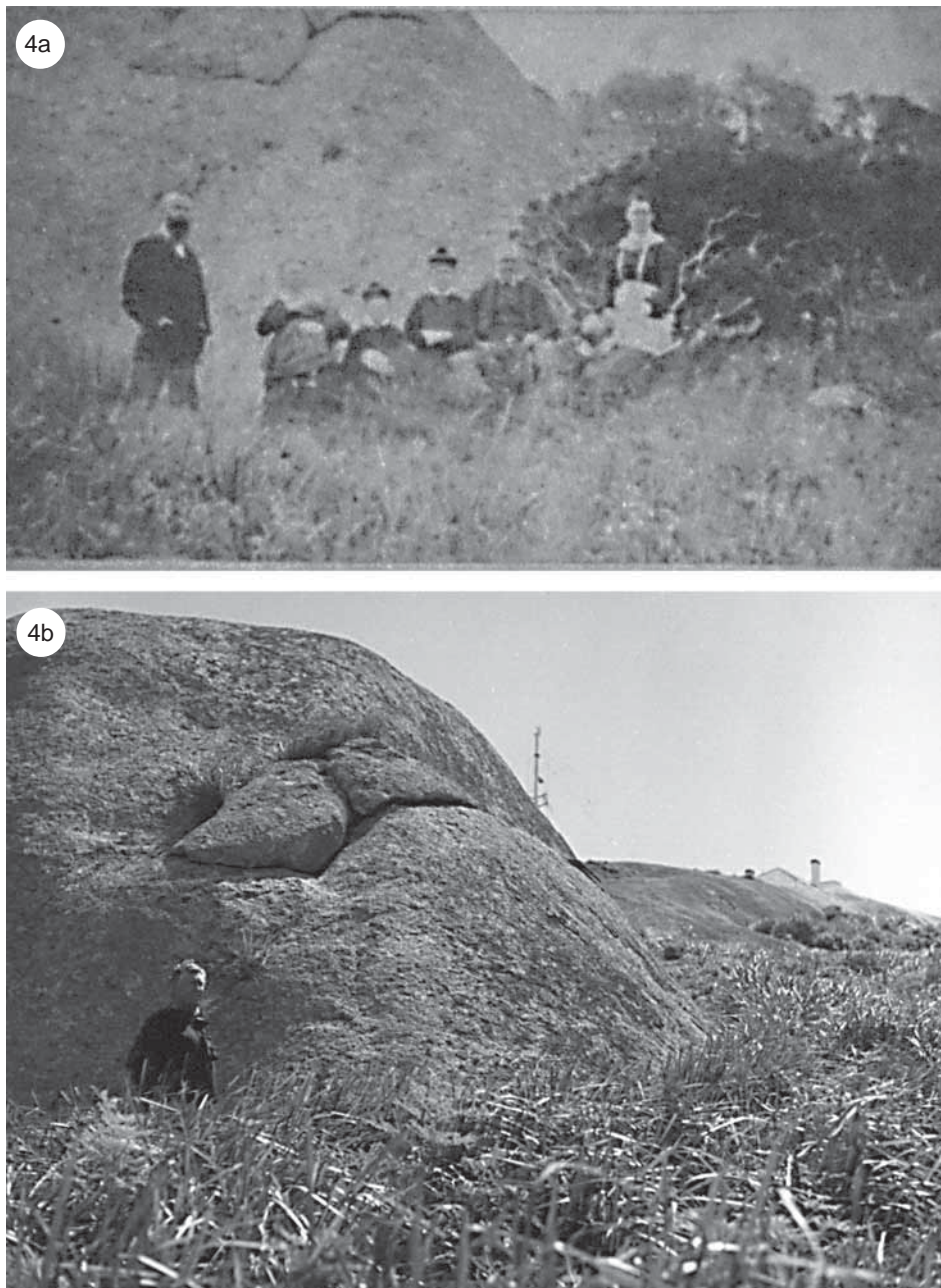


Fig. 4.

(a) A photograph taken in 1882 (courtesy Mrs B. Debus) against the background of an isolated rock outcrop south-west of the lighthouse quarters features members of head lightkeeper John Burgess's family seated on what appears to be the flattened trunk of a windshorn tree, with more trees in the background. Unfortunately, species identification is at best guess work.

(b) In 1993 the vegetation surrounding this outcrop was dominated by *Lomandra longifolia*.

specimens around the island but a good deal more taxonomic work needs to be done before the results are ready for publication (Millar, in lit. 2003).

The present vegetation of Montagu Island

Dominant communities

After the disappearance of most woody plants, a few herbaceous species, notably *Lomandra longifolia*, *Pteridium esculentum* and *Poa poiformis*, became the dominant elements in the vegetation (Heyligers 1993). The map depicting the situation at the end of the 1980s (Fig. 1) shows that seven mapping units were based on differences in the co-dominance of these three species and the overall density of the vegetation, the height of which is generally between 0.8 m and 1.2 m.

Besides the dominant species, the twiners *Marsdenia rostrata* and *Kennedia rubicunda* are locally common and, in more open vegetation, *Isotoma axilaris* and *Einadia hastata* are frequently seen. *Solanum vescum* occurs as scattered individuals and reaches a height of about 1.5 m. In places there is a groundcover of *Commelina cyanea*. *Phragmites australis* occurs as an added element where drainage is impeded by the configuration of the underlying impermeable substrate. This species may be found in unexpected situations, for instance near the crest of North Island.

On some Victorian, Tasmanian and Western Australian islands with breeding colonies of little penguins and short-tailed shearwaters, marked effects on the vegetation have been found, characterised by an increase of succulent plants at the expense of species like *Lomandra longifolia* and *Pteridium*

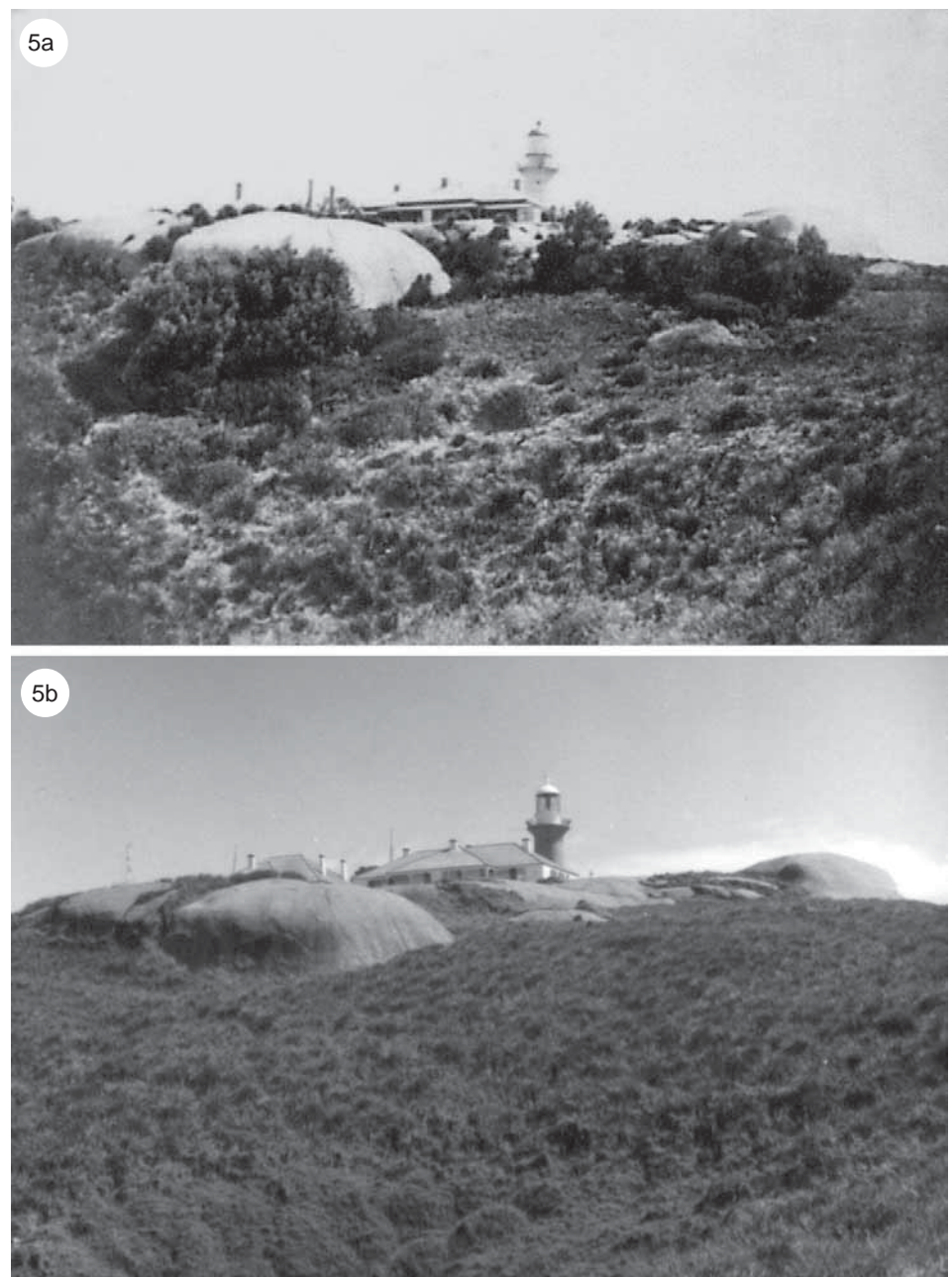


Fig. 5.

(a) In the early days shrubbery was widespread, as shown on this picture (courtesy Ms L. Pacey) of the area to the northeast of the lighthouse quarters.

(b) This area is now dominated by dense *Lomandra longifolia* vegetation.

esculentum which occur in the undisturbed dune vegetation (Gilham 1960, 1961, Rippey et al. 2002, Walsh et al. 1997). We have observed this phenomenon on Gabo Island, but the only effect we have noticed on Montagu Island is that, due to nitrification, the grass around penguin burrow entrances, along paths with a cover of regularly mown *Pennisetum clandestinum*, is often greener than elsewhere. This may be due to chicks spending time at the entrance rather than to adults, which defecate when preening after leaving the water and during their long hikes over the rocks before they reach the vegetation.

The very shallow soils found over and among fractured rock outcrops on higher parts of the island carry a lower, more mixed vegetation, in which, apart from *Lomandra longifolia*, *Pteridium esculentum* and *Poa poiformis*, grasses such as

Themeda triandra, *Eragrostis leptostachys*, *Imperata cylindrica* and *Zoysia macrantha*, and the sedge *Isolepis nodosa* can be found. The only *Ozothamnus diosmifolius* shrub on the island occurs in this vegetation. *Crassula sieberiana* and the ferns *Cheilanthes austrotenuifolia* and *Cheilanthes sieberi* grow in small crevices of the rocks.

Vegetation dominated by *Zoysia macrantha* and *Sporobolus virginicus* occupies a wide fringe at the southern end of South Island, which is often subject to heavy saltspray. It also occurs in smaller patches elsewhere on the east side of both North and South Island. This vegetation is low, rather carpet-like and interspersed with many small rock outcrops (Fig. 9). *Lobelia alata*, *Dichondra repens* and *Tetragonia tetragonoides* occur scattered amongst the grasses. The name used for the mapping unit, namely *Zoysia-Poa*, would be more

**Fig. 6.**

(a) Basset Hull (1914) took pictures of silver gull colonies, then located on North Island, which show little vegetation among the rocks. (Reproduced from the first issue of *Australian Zoologist*, with permission from the Royal Zoological Society of New South Wales.)

(b) Now the luxuriant vegetation is dominated by *Lomandra longifolia*. Some rocks in the foreground have broken up, while the trees on the distant skyline have gone.

appropriate for these smaller areas where patches of *Poa poiformis* and *Isolepis nodosa* are more prevalent.

In 1990 vegetation dominated by *Pennisetum clandestinum* occurred at several locations on the western side of the island. Patches on North Island were small, but on South Island *Pennisetum clandestinum* covered a considerable area that extended to the crest along the tracks leading up from the old and new jetties. Around the lighthouse complex it mixed with or replaced *Stenotaphrum secundatum*. One of the lighthousekeepers, who did several tours of duty between 1970 and 1986, 'has noticed just how rapidly the kikuyu has taken over on the island. He recalled none at the southern end of the island earlier' (Higgins 1990). In 1990 *Pennisetum clandestinum* vegetation occupied 16% of the vegetated area of the island (Fig. 10). However, as was to be expected (Crooks & Soulé 1999), released from grazing pressure of the goats, *Pennisetum clandestinum* spread even more rapidly and by 2001 covered an area of 37% (Weerheim et al. 2003). This process may have been assisted by intensified track maintenance. While previously tracks were merely rough paths through the *Lomandra*-dominated vegetation (Fullagar pers. comm.; Fig. 7), when the island was foreshadowed to become a Nature Reserve and a tourist destination, the

vegetation on the tracks was at first regularly slashed and when *Pennisetum clandestinum* became established, mown. It is likely that *Pennisetum clandestinum* seeds and stolon fragments were spread through these activities.

Another mapped category is vegetation dominated by species which take hold after severe disturbance, the more important of these being *Acetosa sagittata* and *Phytolacca octandra*, together with *Solanum chenopodioides*, *Urtica incisa*, *Commelina cyanea*, and twiners, especially *Stephania japonica*. In 1990, on the east side of South Island, there was a large patch at the rear of a cove, where some years before the vegetation was killed by a seawater surge through the cove. It is now dominated by *Pennisetum clandestinum*.

Minor communities

There are various minor vegetation communities on the island, occupying only small areas due to specific habitat requirements and too small to be mapped. Examples include beach vegetation, stands of *Stipa stipoides* on the margin of high cliffs, shrub communities on cliff faces, areas influenced by groundwater seepage and the vegetation of small bodies of water in rock hollows.

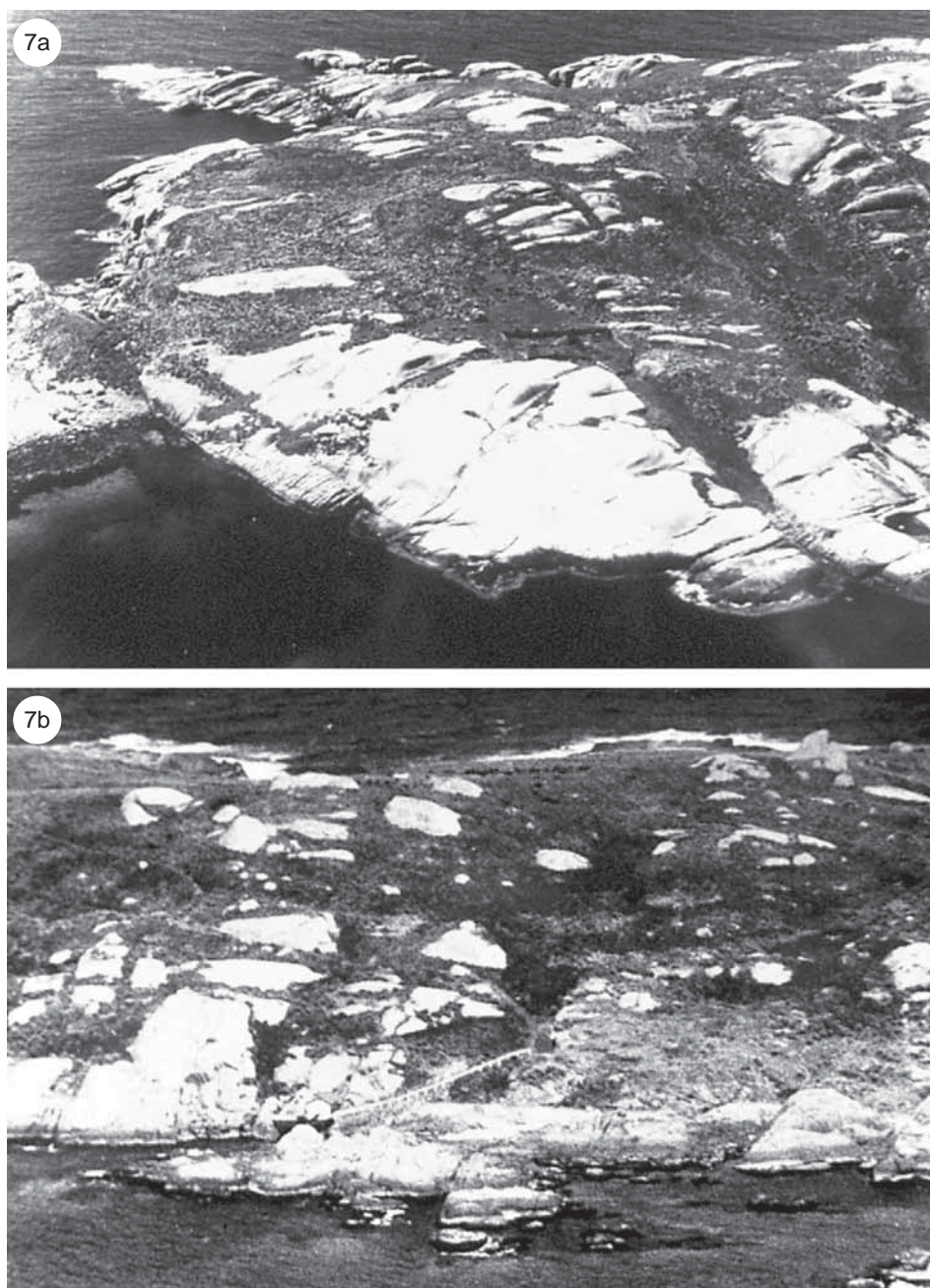


Fig. 7. Aerial views of South Island taken by Stanley Fowler on 31 October 1936.

(a) Shows the northern end of the island. The vegetation appears to be dominated by *Lomandra longifolia* interspersed with patches of lower vegetation, possibly caused by grazing. Vegetable gardens with an overgrown fence can be seen in the middle foreground, situated in a valley position with better soil moisture conditions. The gardens are now abandoned and sprawling *Dipogon lignosus*, *Acetosa sagittata* and *Pennisetum clandestinum* dominate much of the surrounding vegetation.

(b) Shows the section between the lighthouse rocks and The Twins, with the Old Jetty in the foreground. The vegetation appears to be more open than at the northern end, while in the background a band of shrubs, most likely *Breynia cernua*, can be seen. On both pictures one can barely discern the tracks leading to the lighthouse quarters, a situation very different from today with regularly mown paths, often dominated by *Pennisetum clandestinum*. (Fowler's photos A 2/72 & A2/119 reproduced with permission from CSIRO Archives.)

Beaches, deposits of shell and rock fragments, occur on flatter areas along the shore protected by rock outcrops in the tidal zone. The Gulch has the largest beach, but there are many smaller beaches especially on the less exposed west side of the island. Species typically found there are *Tetragonia tetragonioides*, *Enchylaena tomentosa*, *Einadia nutans*, *Atriplex hastata*, *Chenopodium glaucum*, *Spergularia marina* and *Sagina procumbens*, as well as introduced species which have arrived more recently along the South Coast, namely *Cakile maritima*, *Euphorbia paralias* and *Hydrocotyle bonariensis* (Heyligers 1998, 2002).

A large suite of species can be found in the wetter parts of the island, such as seepage zones at the head of coves and around rock pools. These species grow in various combinations, but

it would be difficult to define plant associations due to the variability in microhabitats. A representative sample of the species found in seepage and rock pool vegetation are *Mimulus repens*, *Lobelia alata*, *Ranunculus rivularis*, *Elatine gratioloides*, *Samolus repens*, *Rumex brownii*, *Limosella australis*, *Lilaeopsis polyantha*, *Centella asiatica*, *Triglochin striata* and *Cotula coronopifolia*, as well as *Paspalum dilatatum*, *Sporobolus virginicus*, *Zoysia macrantha* and several Cyperaceae and Juncaceae. A large patch of the liverwort *Marchantia berteriana* was found in one of the seepages and the fern *Histiopteris incisa* is dominant in some gully heads. An interesting community of small herbs, notably *Hydrocotyle hirta*, *Portulacca oleracea*, *Chenopodium murale* and *Cotula australis* occurred in the



Fig. 8. A recent view of *Breynia cernua* patches growing south of the lighthouse rocks



Fig. 9. (a) Goats used to shelter from northwesterly winds at the lee side of South Island. In the top picture, taken in 1959, the rock outcrops appear to be surrounded by *Zoysia* – *Sporobolus* vegetation. (Picture courtesy Dr A.B. Costin.)

(b) When this site was rephotographed in April 1991 many rock outcrops were partly or completely hidden in *Lomandra longifolia*, *Zoysia macrantha* and *Pennisetum clandestinum*; hence, the picture had to be taken from an elevated position to show at least some of the outcrops.

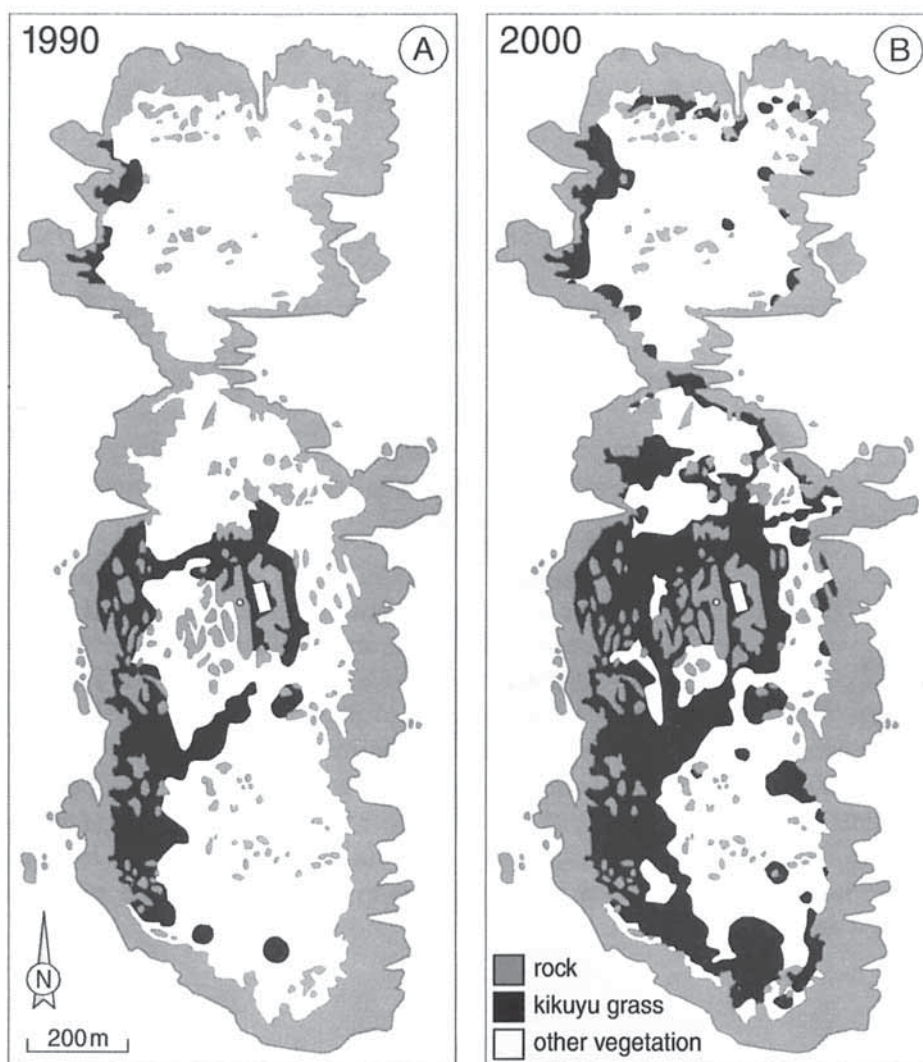


Fig. 10. Maps showing the spread of *Pennisetum clandestinum* on Montagu Island between (A) 1990 and (B) 2000, in which period the area covered by kikuyu grass increased from 16% to 37% (Weerheim et al. 2003, reproduced with permission of CSIRO Publishing).

area with *Phragmites australis* on the lower section of the track to the southern end of the island. It is no longer there, as it became overgrown by a dense low mat of regularly mown *Pennisetum clandestinum*.

Sections of cliff faces inaccessible to goats provided a refuge for several shrubs, namely *Westringia fruticosa*, *Correa alba*, *Rhagodia candolleana* and a few *Alyxia buxifolia*. Two shrubs of *Acacia longifolia* var. *sophorae* were the only woody plants that occurred away from the cliffs. *Westringia fruticosa* and *Rhagodia candolleana* bushes that were in reach of the goats have recovered and are now slowly spreading onto the upper slopes, while *Acacia longifolia* became established in at least one other site. *Pelargonium australe* is rare on Montagu Island; its occurrences are restricted to cliffs of North Island. The fern *Asplenium obtusatum* is common in crevices between, and sheltered by, taller rock outcrops around the periphery of the island.

Lichens usually cover exposed rock surfaces. Those on the rocks along the periphery show the grey, orange and yellow banding characteristic of seashores. A community of several species covers rocks further inland and, especially on

southerly aspects, its growth can be luxuriant. If occurring on a steep face and after being saturated by heavy rain, the lichen cover may give way and accumulate at the foot of the outcrop. Few collections of lichens have been made and none have as yet been identified.

The role of fire

Higgins (1990) mentions that 'the 1917 lightkeepers' instructions emphasized the danger of fire and instructed keepers to burn off around the stations.' Logbooks show that this was carried out on at least six occasions, with the last recorded burn-off in 1962. It is possible that fire was more frequently lit, as there are some large gaps between the dates, especially for the early years. It remains an open question how important fire has been in shaping the vegetation. A visitor to the island in the 1930s 'walked up to the lighthouse through low shrubby heath which must have recently been on fire and where we saw many dead penguins' (B. Ferguson, quoted in Pacey 2001). A large fire on 21 December 1953, caused by embers from bushfires on the mainland, burnt most of the vegetation of South Island and killed the last specimens of *Monotoca elliptica*: a small mature tree and 'a

promising seedling' (Pacey 2001). *Lomandra longifolia* and *Pteridium esculentum* both resprout after (Benson & McDougall 1993). We witnessed this after a lightning strike hit North Island in December 1991 and set fire to an area of about 150 square metres of *Lomandra-Pteridium* vegetation. The effects of this fire were still visible in March 1992, but a year later had disappeared.

In 2001 a fire that escaped from a small burn-off around the well above the cove near the old gardens, went through a large area with *Lomandra-Pteridium* and *Pennisetum* vegetation on the central west side of South Island (C.J. Tiller, pers.comm.). Observations in March 2003 showed that *Coryza* sp. had sprang up all over the burnt area. *Solanum chenopodioides* and *Tetragonia tetragonioides* were almost as abundant, while *Lomandra longifolia*, *Pteridium esculentum*, *Pennisetum clandestinum* and *Acetosa sagittata* were regenerating from charred stumps or underground parts.

The past and present flora of Montagu Island

218 vascular plants have been recorded for Montagu Island. Appendix 1 shows four groups (189 taxa), subdivided by whether they are native or naturalised and whether or not they were still present in the late 1990s i.e. about ten years after the island was declared a Nature Reserve. The fifth group brings together the 29 taxa known to have been introduced for horticultural reasons. Undoubtedly, other vegetables and garden plants will have been cultivated as well, but have remained unrecorded.

Geographic distributions of native and naturalised species have been categorised according to three criteria: native or naturalised, restricted to coastal districts or extending inland, and range size starting with the smallest (Table 1).

Native taxa

Ten species of ferns have been recorded for the island. *Pellea falcata* is only known from one location and *Cyathea australis* from two sites. Normally associated with forests, they represent relicts from a vegetation that has now disappeared. *Asplenium obtusatum* is characteristically found in crevices among the rocks around the periphery of the island. With their tough, leathery leaves the plants appear to be little affected by salt spray. It is known to hybridize with other *Asplenium* species (Walsh & Entwisle 1994) and in one location on Montagu Island a plant identified as a hybrid between *Asplenium obtusatum* and *Asplenium australasicum* (J. Croft pers. comm.) occurs next to one of *Asplenium obtusatum*. *Cheilanthes sieberi* was collected by Rodway in 1932. It may still be present on the island, as in habit it closely resembles *Cheilanthes austrotenuifolia* and may have been overlooked by other botanists.

Few surprises have turned up among the 120 native flowering plants as most of them have a wide distribution, at least in southern Australia (Table 1). *Isotoma axillaris*, when flowering, is an eye-catching species quite widespread through the more open aspects of the various *Lomandra*-dominated

Table 1. Statistical and geographic summary for the native and naturalised vascular flora of Montagu Island.

Filicopsida: Ferns, 10 species and 1 hybrid (all native).
Magnoliopsida: Flowering Plants: 178 species (109 native).
Magnoliidae: Dicotyledons, 120 species (70 native).
Liliidae: Monocotyledons: 58 species (39 native).

Geographic ranges have been coded with a capital letter and a number. C stands for coastal, in the sense that in New South Wales the species is confined to one or more of the coastal ecogeographic regions of that State (see map in Harden 1990–1993), N for: not only coastal, but also occurring in one or more of the inland ecogeographic regions.

The numbers indicate geographic ranges. For native species the numbers following C and N have different meanings, but for introduced species their meaning is the same. The numbers following the code specify the overall number of species recorded for the island and, in parentheses, the number of species still present at the end of the 1990s.

Native taxa 120 (95)

Coastal taxa 21 (18)

- C 1: hybrid, restricted to Montagu Island, 1 (1)
- C 2: species restricted to NSW, 1 (1)
- C 3: species reaching its southern limit on Montagu Island, also occurring in Queensland, 1 (0)
- C 4: species of the east coast, including East Gippsland, 2 (1)
- C 5: species of southern NSW and southeastern coasts, 5 (5)
- C 6: species of NSW and southern coasts, 5 (5)
- C 7: widespread species, 4 also found outside Australia, 6 (5)

Species not restricted to coastal districts 99 (77)

- N 1: species found in southeast Australia, 3 (3)
- N 2: species found in southern Australia, 2 also in NZ, 4 (2)
- N 3: species found in NSW and Queensland, 10 (8)
- N 4: species found in NSW and southern States, some extending to the Pacific, 10 (7)
- N 5: eastern Australian species, some not in Tasmania, 14 (12)
- N 6: species extending to South Australia, 10 (6)
- N 7: species in all States, some not in Northern Territory, 14 (9)
- N 8: species widespread in Australia, also in New Zealand or further into the Pacific, some to America, 18 (14)
- N 9: species with more extensive overseas links, usually to several continents, 16 (16)

Naturalised species 69 (39)

Coastal species 8 (6)

- C 10: species occurring in both the Old and New World, 1 (1)
- C 11: species only occurring in America, 3 (1)
- C 12: European species, 1 (1)
- C 15: Asian-African species, 1 (1)
- C 17: African species, 2 (2)

Species also found inland 61 (33)

- N 10: species occurring in both the Old and New World, 19 (12)
- N 11: species only occurring in America, 14 (6)
- N 12: European species, some also in New Zealand, 16 (10)
- N 13: Eurasian species, 6 (1)
- N 14: European-African species, 1 (0)
- N 15: Asian-African species, 2 (2)
- N 16: Asian species, 1 (1)
- N 17: African species, 2 (1)

vegetation types. *Einadia hastata*, growing as compact, low bushes with dark green foliage, is also found in these vegetation types. However, the *Lomandra*- and *Pteridium*-dominated vegetation types are relatively poor in species. The variety of restricted, specialised habitats makes a much larger contribution to the species diversity of the island (Appendix 1).

Twenty-five species have either disappeared since the early 1920s or have become so rare that their presence has not been apparent (Appendix 1). Notable among the first group are *Banksia integrifolia*, *Monotoca elliptica* and *Leucopogon parviflorus*, while the latter comprises several grasses, for instance *Dichelachne crinita* and *Eragrostis elongata*. These may have disappeared due to more intensive track maintenance.

Naturalised species

Sixty nine naturalised species, naturalised in Australia, have been collected, or reported from, Montagu Island. Only a few of these are typically coastal in their distribution (Appendix 1). Most foreign species reached the island accidentally, for instance on clothing, in contaminated seed, with fodder or through seabirds. Species with buoyant propagules or wind-dispersed seeds could have arrived independently. *Stenotaphrum secundatum* was introduced for a utilitarian purpose, namely to stabilise the sand around the quarters. It is possible that some other species listed in Appendix 1 under this category, namely *Anredera cordifolia*, *Dipogon lignosus*, *Delairea odorata*, *Ipomoea cairica* and *Nothoscordum borbonicum* were introduced as garden plants, but there is no explicit evidence for this.

The occurrence of several species has been transient, as 15 were not among the collections made in the late 1980s. Since the change-over from 'homesteading' by lightkeepers to management as a Nature Reserve another 14 species have disappeared, due partly to demolition of the chicken yards and partly to more intensive track maintenance concomitant with the spread of *Pennisetum clandestinum*.

Pennisetum clandestinum is one of the naturalised species that has become a problem on the island. It smothers the vegetation into which it spreads and there is evidence that when over time it increases in volume, the area thus covered becomes unsuitable as nesting habitat for penguins (Trezise 1999, Weerheim et al. 2003). So far, the shearwater colonies are still largely free of *Pennisetum clandestinum* and no deterioration of breeding conditions has as yet been detected (Fullagar & Heyligers pers. comm. 2003). The species was introduced into Australia from the Belgian Congo and grown from seed at the Botanic Garden in Sydney in 1919. During the early 1920s it was promoted as an excellent fodder plant (Whittet 1921) and later in the same decade was introduced to the South Coast by a member of the Bates family, who returned with cuttings from the Sydney Agricultural Show (N. Hoyer, pers. comm. May 1992). How it reached Montagu Island is not known, but maybe it was carried across by court-judging silver gulls (G. F. van Tets pers. comm. 1988).

Unfortunately, *Pennisetum clandestinum* is not the only species that is enlarging its territory. *Acetosa sagittata*, *Dipogon lignosus* and to a lesser degree, *Delairea odorata* and *Ipomoea cairica* are in the same league. In 1988 *Acetosa sagittata* occurred over a moderately large area of mainly *Lomandra*-*Pteridium* vegetation to the west and south-west side of the lighthouse rocks. Its wind-dispersed fruits established new foci for spread, often at the foot of rock outcrops, especially on South Island, where it is now widespread. While the stems scramble through the vegetation, the roots form woody tubers, which can grow into the size of footballs and give the species the capacity to resprout after high intensity fires (Benson & McDougall 1999). *Dipogon lignosus*, which in 1988 grew only in a few spots on the north-west side of South Island, has rapidly expanded and now covers a substantial area at that side of the island. Together with *Pennisetum clandestinum* it hides most of the abandoned gardens and their fences. The occurrences of *Delairea odorata* are scattered throughout South Island. Its presence in various *Lomandra* and *Pteridium* vegetation types was never obvious until June 1999, when the species was profusely flowering and the many patches stood out from the rest of the vegetation. Benson & McDougall (1993) mention that in 1891 it was reported as 'a major weed carpeting the ground and covering shrubs on Gooseberry Island' in Lake Illawarra. 'Recommended control was to use goats' (sic). *Ipomoea cairica* with its showy flowers is mainly found on the rocks and in the vegetation along the track from the new jetty to the lighthouse. It is present in only a few other areas e.g. on the cliff margin of one of the coves at the east side of North Island. *Ipomoea cairica* is reported to be 'a prolific seeder and germinator' and to resprout from the base after high intensity fire (Benson & McDougall 1995). *Anredera cordifolia*, which presents problems elsewhere along the coast of New South Wales, is only known from two small patches on South Island, one of which is decreasing rather than increasing in size.

Horticultural introductions

The lightkeepers established vegetable gardens where groundwater was easily accessible. These were generally surrounded by screens to protect the plants from the salt-laden winds as well as from goats and rabbits. Rodway's list of 1932 includes vegetables as well as ornamentals (Appendix 1). Ornamentals and some vegetables were also grown in the courtyards of the living quarters (Pacey 2001). The *Pelargonium* hybrids, growing at a few spots near the quarters, would be survivors from discarded plants, but *Gladiolus* hybrids, still present in the early 1990s, have now disappeared.

Attempts in 1943 to introduce ornamental trees and shrubs were unsuccessful, but the planting in the early 1960s of New Zealand Christmas bush, *Metrosideros excelsa*, in the yard between the quarters fared better (Higgins 1990). They are now 4 m tall and, together with some other specimens in the relatively sheltered space between the quarters and the lighthouse, provide protection for vagrant or migrating Passerines (e.g. Fullagar et al. 2003, Heyligers et al. 2002). Christmas

bush seeds that lodged in rock crevices have produced small wind-shorn plants, others, landing in more favourable situations, some substantial shrubs. Early in the 1980s the last lightkeeper planted a couple of *Melaleuca armillaris* shrubs at the east side of the quarters, which have grown only slowly and are still less than 2 m tall.

Few horticultural species can still be found today. Apart from the pelargoniums, there is still a wind-shorn, but fruit-bearing fig 'shrub' tucked away in a rock hollow near the quarters, and a banana plant, vegetative and only 2 m tall, survives in one of the former gardens on the north-west side of South Island. A miserable little stonefruit 'tree' and a very gnarled remnant of *Coprosma repens* are still present near where the chicken sheds used to be.

Conclusion

We would like to conclude with some thoughts on possible future changes. There is evidence that *Pennisetum clandestinum* adversely affects the breeding possibilities for penguins (Trezise 1999) and it cannot be ruled out that in the future this may happen for shearwaters too. Thus far, few areas of their colonies have been invaded by *Pennisetum clandestinum* or *Acetosa sagittata*, but over the last decade both species have markedly increased their presence in one of the sites monitored for shearwater breeding success. Montagu Island is especially important for shearwaters, as it is the only island in Australia where three species breed in mixed colonies. Management, in our view, should be directed towards maintaining suitable breeding habitat.

One of the first measures taken by the NSW National Parks and Wildlife Service after Montagu Island was declared a Nature Reserve in December 1987, was to eradicate the mob of about 60 feral goats. Goats, which had been on the island for more than a century, sometimes in more than twice the numbers present in the mid-1980s, were regarded inappropriate in a Nature Reserve (Pacey 2001). It soon became apparent that the goats had had a profound effect on the vegetation (Fig. 9). Not only were there noticeable changes in the native vegetation e.g. the expansion of creepers such as *Kennedia rubicunda* and the recovery of shrubs which had survived on largely inaccessible cliffs, but several naturalised plant species, notorious for invading existing vegetation, began to spread. Foremost among these was *Pennisetum clandestinum*, which now covers more than one-third of the island (Fig. 10). *Acetosa sagittata* is a close second, followed by *Dipogon lignosus* and *Delairea odorata*. Attempts to stem the spread of *Pennisetum clandestinum* through herbicide application were not successful as *P. clandestinum* soon bounced back. It also became apparent that rabbits, which suffer periodic outbreaks of myxomatosis, had no effect on the spread of *Pennisetum clandestinum*, as they prefer to graze the closely cropped grass on the paths. In 2000 experiments were set up by researchers from Charles Sturt University to find ways to suppress *Pennisetum clandestinum* and replace it with appropriate native woody and herbaceous species (N. I. Klomp, pers. comm.). Other invading species have been given little attention.

The accidental fire that burned a large area on the central west side of South Island in 2001, provided an opportunity for an additional experiment. In March 2002 the burnt area was planted with *Acacia longifolia* var. *sophorae*, *Banksia integrifolia*, *Westringia fruticosa* and *Lomandra longifolia*, all except *Banksia integrifolia* grown from local stock and also used in the plots of the Charles Sturt University experiment (C. J. Tiller pers. comm. 2003). In this area re-growing *Pennisetum clandestinum* is kept under control through spot application of a herbicide, but as at March 2003 no attention had been paid to *Acetosa sagittata*.

We are of the opinion that before long *Acetosa sagittata* will present problems of the same magnitude as *Pennisetum clandestinum*. The areas where *Dipogon lignosus* and *Delairea odorata* occur are still relatively small, but these species will no doubt present similar problems in the future if no immediate efforts at eradication are made.

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Appendix 1: Inventory of the vascular plants of Montagu Island, New South Wales

Families, genera and species are listed alphabetically in four groups, based on whether they are native or naturalised and whether they were still present or not in the late 1990s. Species that were used in horticulture are listed as a fifth group.

Each species has a code indicating its geographic range. These codes are defined in Table 1.

Abundance refers to how common a species is in a particular habitat or vegetation type. If the species occurs in a variety of situations, its occurrence has been indicated as widespread. The following abbreviations have been used:

v co: very common; co: common; ra co: rather common; unco: uncommon; loc co: locally common (found in good numbers where it occurs); loc: localised (only a few individuals or small patches); occ: occasional (unpredictable in occurrence); rare: rare in specified vegetation type or habitat; gone: extinct on Montagu Island; gone?: not seen recently, likely to be extinct.

Lomandra vegetation encompasses the various vegetation types in which *L. longifolia* is dominant or codominant. *Zoysia–Sporobolus* vegetation is the revised name of the *Zoysia–Poa* vegetation type (see Fig. 1).

The last column documents whether the species is represented by a collection (capital letter of collectors name) or was only seen (lower case letter). Names, year or years of collecting, and the herbarium where the specimen or, in the case of duplicate collections, the primary specimen is located are as follows:

A,a: L.G. Adams, 1973, CANB; Ca: J. Cassell, 1949, 1964, NSW; Co: A.B. Costin, 1959, NSW; F: L. Fraser, 1935, NSW; H, h: P.C. Heyligers, 1988–2003, CANB, but *Carpobrotus* collections are at AD; J: L.A.S. Johnson, 1950, NSW; M: A. Melvaine, 1935, NSW; R, r: F.A. Rodway, 1921 (collected by W.H. Williams, lightkeeper), 1932, NSW; S: H. Schröter, 1935, NSW; W: A. Warner, 1958, CANB.

Floristic list

	Geog.	Abund.	Comments	Collectors
Native species (95) and one hybrid still present				
Aizoaceae				
<i>Tetragonia tetragonoides</i>	N 9	co	Upper beaches, also opportunistic, e.g. tracks	R A H
Amaranthaceae				
<i>Alternanthera denticulata</i>	N 7	rare	Opportunistic, a favoured rabbit food	R a H
Apiaceae				
<i>Apium prostratum</i> var. <i>filiforme</i>	N 8	ra co	Moist areas	a H
<i>Centella asiatica</i>	N 9	ra co	Moist areas	H
<i>Hydrocotyle hirta</i>	N 7	unco	Moist areas around periphery	H
<i>Lilaeopsis polyantha</i>	N 4	rare	Around rock pools	H
Apocynaceae				
<i>Alyxia buxifolia</i>	C 5	rare	Cliff faces and margins	H
<i>Parsonsia straminea</i>	N 3	loc co	Northwest facing slope of South Island	H
Asclepiadiaceae				
<i>Marsdenia rostrata</i>	N 5	co	Throughout <i>Lomandra</i> vegetation	R W H
Aspleniaceae				
<i>Asplenium flabellifolium</i>	N 8	co	Shaded cliffs and steep slopes	A H
<i>Asplenium obtusatum</i>	C 5	ra co	Crevices in rock outcrops of the periphery	R M Ca H
<i>A. obtusatum</i> × <i>A. australasicum</i>	C 1	rare	In crevice next to an <i>A. obtusatum</i> plant	H
Asteraceae				
<i>Centipeda minima</i> subsp. <i>minima</i>	N 5	unco	Seepage areas over rock outcrops	A H
<i>Cotula australis</i>	N 7	unco	Shallow sandy areas, usually moist	A H
<i>Cotula coronopifolia</i>	N 7	loc	Around and in rock pools	R a H
<i>Ozothamnus diosmifolius</i>	N 3	rare	Shallow soil near crest of North Island	H
<i>Pseudognaphalium luteo-album</i>	N 9	occ	Tracks and open vegetation	R W a H
<i>Senecio minimus</i>	N 4	rare	In steep alcove head	H
Callitricaceae				
<i>Callitriche sonderi</i>	N 7	unco	Around rock pools	A H
Campanulaceae				
<i>Wahlenbergia gracilis</i>	N 5	unco	Tracks and open vegetation	R H
<i>Wahlenbergia stricta</i>	N 5	unco	Tracks and open vegetation	R H
Caryophyllaceae				
<i>Spergularia marina</i>	C 7	unco	Beaches, damp sites in <i>Zoysia–Sporobolus</i> veg.	A H
Centrolepidac.				
<i>Centrolepis strigosa</i>	N 8	loc	Sandy area between rock outcrops on South Is.	A
Chenopodiaceae				
<i>Atriplex australasica</i>	C 5	ra co	Beaches	A H
<i>Chenopodium glaucum</i>	N 4	occ	Beaches	A
<i>Einadia hastata</i>	N 5	ra co	Open <i>Lomandra</i> , and other vegetation	a H
<i>Einadia nutans</i> subsp. <i>nutans</i>	N 6	unco	Moist areas e.g. sheltered cliff faces	R F A H
<i>Einadia trigonos</i> subsp. <i>trigonos</i>	N 1	unco	Moist areas e.g. sheltered cliff faces	Co A H
<i>Enchylaena tomentosa</i>	N 4	ra co	Beaches	R F J a H
<i>Rhagodia candolleana</i> subsp. <i>candolleana</i>	C 6	co	Cliff faces, margins and lower slopes	A H

Commelinaceae					
<i>Commelina cyanea</i>	N 3	co	Widespread		R A H
Convolvulaceae					
<i>Dichondra repens</i>	N 8	rare	Moist situations		R a H
Crassulaceae					
<i>Crassula peduncularis</i>	N 1	rare	Damp sandy soil overlying granite		A
<i>Crassula sieberiana</i>	N 8	co	Crevices in rock outcrops		R H
Cyatheaceae					
<i>Cyathea australis</i>	N 5	rare	South-facing slope on North Is, crevice on South Is.	a	H
Cyperaceae					
<i>Carex appressa</i>	N 8	unco	Margins of rock pools		a H
<i>Cyperus brevifolius</i>	N 9	ra co	Moist areas		H
<i>Cyperus gracilis</i>	N 3	rare	Seepage areas		a H
<i>Isolepis cernua</i>	N 9	co	Margins of rock pools		a H
<i>Isolepis inundata</i>	N 9	loc	Seepage areas along cliffs		H
<i>Isolepis nodosa</i>	C 7	v co	Widespread <i>Lomandra</i> , and mixed grasses veg.		R A H
<i>Lipocarpa microcephala</i>	N 8	loc	Moist area in <i>Stenotaphrum</i> sward near quarters		H
<i>Pycurus polystachyos</i>	N 9	loc	Moist areas, mainly near rock pools		R A H
Dennstaedtiaceae					
<i>Histiopteris incisa</i>	N 9	loc co	Moist areas in alcove heads		A H
<i>Hypolepis amaurorachis</i>	C 5	rare	In <i>Phragmites australis</i> vegetation		H
<i>Pteridium esculentum</i>	N 8	v co	A major element of the vegetation		R a H
Dicksoniaceae					
<i>Calochlaena dubia</i>	N 5	rare	Rock crevices in crestral area of North Island		H
Elatinaceae					
<i>Elatine gratioloides</i>	N 6	ra co	Rock pools		A H
Euphorbiaceae					
<i>Breynia cernua</i>	N 3	loc co	Scrub patches in <i>Lomandra</i> vegetation		A H
Fabaceae					
<i>Acacia longifolia</i> var. <i>sophorae</i>	C 7	rare	Wide rock crevices, road cutting on South Island	r	H
<i>Glycine microphylla</i>	N 6	rare	<i>Lomandra</i> vegetation		H
<i>Kennedia rubicunda</i>	N 5	co	<i>Lomandra</i> , and rank Pennisetum vegetation	b	R a H
Geraniaceae					
<i>Pelargonium australe</i>	N 7	rare	Cliff ledges on North Island		R a H
Hypoxidaceae					
<i>Hypoxis hygrometrica</i>	N 5	loc	Periodically wet sandy patches on flat rocks		R a H
Juncaceae					
<i>Juncus bufonius</i>	N 9	unco	Moist areas in <i>Zoysia-Sporobolus</i> vegetation		a H
<i>Juncus pallidus</i>	N 4	rare	<i>Lomandra</i> vegetation on North Island		H
<i>Juncus pauciflorus</i>	N 2	loc	Seepage area in alcove head, North Island		H
<i>Juncus usitatus</i>	N 8	rare	<i>Poa-Lomandra</i> vegetation, North Island		H
<i>Juncus vaginatus</i>	N 6	occ	<i>Lomandra</i> - and Pennisetum vegetation		R H
Juncaginaceae					
<i>Triglochin striata</i>	C 7	occ	Moist areas around rockpools		H
Lamiaceae					
<i>Plectranthus graveolens</i>	N 3	ra co	Rock outcrop fringes in <i>Lomandra</i> vegetation		R a H
<i>Westringia fruticosa</i>	C 2	ra co	Cliff faces and rock outcrops at cliff margins		R A H
Lobeliaceae					
<i>Isotoma axillaris</i>	N 5	ra co	Open <i>Lomandra</i> vegetation		A H
<i>Lobelia alata</i>	N 8	co	Moist areas, also <i>Zoysia-Sporobolus</i> vegetation		a H
Lomandraceae					
<i>Lomandra longifolia</i>	N 6	v co	Widespread, often dominant or co-dominant		R a H
Menispermaceae					
<i>Stephania japonica</i> var. <i>discolor</i>	N 3	co	Widespread		R Ca A H
Oxalidaceae					
<i>Oxalis corniculata</i>	N 9	unco	Gritty rock crevices		R A H
Phormiaceae					
<i>Dianella longifolia</i>	N 7	rare	Mixed grasses vegetation		H
Poaceae					
<i>Agrostis avenacea</i> var. <i>avenacea</i>	N 8	occ	Opportunistic, beaches		A H
<i>Austrostipa stipoides</i>	C 5	loc	Cliff margins and scree slopes		a H
<i>Echinopogon ovatus</i>	N 8	occ	Opportunistic		H
<i>Entolasia marginata</i>	N 5	ra co	Rocky areas with mixed grasses vegetation		H
<i>Eragrostis leptostachya</i>	N 3	ra co	Rocky areas with mixed grasses veg., crevices		R a H

<i>Imperata cylindrica</i> var. <i>major</i>	N 9	ra co	Mixed grasses vegetation and other dry areas	r a H
<i>Microlaena stipoides</i> var. <i>stipoides</i>	N 4	ra co	Mixed grasses vegetation, tracks	a H
<i>Phragmites australis</i>	N 9	co	Seepages, periodically wet areas	R a H
<i>Poa poiiformis</i>	C 6	co	A major element of the vegetation	R S W Co H
<i>Sporobolus virginicus</i> var. <i>minor</i>	C 7	co	Dominant in <i>Zoysia</i> – <i>Sporobolus</i> vegetation	H
<i>Themeda triandra</i>	N 7	ra co	Mixed grasses vegetation	R a H
<i>Zoysia macrantha</i>	C 4	co	<i>Zoysia</i> – <i>Sporobolus</i> and mixed grasses vegetation	a H
Polygonaceae				
<i>Rumex brownii</i>	N 8	unco	Moist to wet areas	R a H
Portulacaceae				
<i>Portulaca oleracea</i>	N 9	ra co	Moist areas; favoured rabbit food	R a H
Primulaceae				
<i>Samolus repens</i>	C 6	co	Near rock pools and in seepage areas	A H
Ranunculaceae				
<i>Ranunculus amphitrichus</i>	N 1	occ	Seepage areas	a H
Rutaceae				
<i>Correa alba</i>	C 6	ra co	Cliff faces	W A H
Scrophulariaceae				
<i>Limosella australis</i>	N 2	unco	Near rock pools	A H
<i>Mimulus repens</i>	C 6	ra co	Damp and wet areas	H
<i>Veronica plebeia</i>	N 7	rare	Rock crevices	H
Sinopteridaceae				
<i>Cheilanthes austrotenuifolia</i>	N 4	ra co	Crevices in ‘flat’ rock outcrops	A H
<i>Pellaea falcata</i> var. <i>falcata</i>	N 9	one site	Rocky crest with <i>Lomandra longifolia</i>	H
Solanaceae				
<i>Solanum americanum</i>	N 9	ra co	Widespread, open vegetation	H
<i>Solanum prinophyllum</i>	N 5	rare	Opportunistic, flotsam	a H
<i>Solanum vescum</i>	N 6	ra co	Open <i>Lomandra</i> vegetation	H
Typhaceae				
<i>Typha</i> cf. <i>domingensis</i>	N 9	rare	Around well and rock pools	h
Urticaceae				
<i>Urtica incisa</i>	N 8	ra co	In <i>Lomandra</i> vegetation	R A H
Introduced species still present (40)				
Alliaceae				
<i>Nothoscordum borbonicum</i>	N11	loc	Rank <i>Pennisetum</i> vegetation near lighthouse	H
Apiaceae				
<i>Hydrocotyle bonariensis</i>	C11	loc co	At rear of alcoves, around well	H
Asteraceae				
<i>Conyza bonariensis</i>	N11	occ	Opportunistic, disturbed areas	R a h
<i>Delairea odorata</i>	C17	ra co	In <i>Lomandra</i> vegetation	A H
<i>Dittrichia graveolens</i>	N12	occ	Sand-filled crevasses in flat rocks	H
<i>Gamochoa pennisylvanica</i>	C11	occ	In <i>Poa</i> – <i>Lomandra</i> vegetation	H
<i>Hypochoeris radicata</i>	N12	occ	Ruderal	a H
<i>Sonchus asper</i> subsp. <i>glaucescens</i>	N12	rare	Ruderal	H
<i>Sonchus oleraceus</i>	N12	rare	Ruderal	H
Basellaceae				
<i>Anredera cordifolia</i>	N11	loc	<i>Pennisetum</i> veg. at quarters and former gardens	H
Brassicaceae				
<i>Cakile maritima</i> subsp. <i>maritima</i>	C10	ra co	Beaches of South Island and Gulch	H
Caryophyllaceae				
<i>Polycarpon tetraphyllum</i>	N12	unco	Moist situations	a H
<i>Sagina procumbens</i>	N10	unco	Moist situations	A H
<i>Stellaria media</i>	N10	rare	Seepage areas in alcoves	Co a H
Chenopodiaceae				
<i>Atriplex prostrata</i>	N12	unco	Sandy rock crevices of periphery	H
Convolvulaceae				
<i>Ipomoea cairica</i>	C15	loc co	Rock outcrops, cliffs, rank <i>Pennisetum</i> veg.	a H
Cucurbitaceae				
<i>Cucumis myriocarpus</i> subsp. <i>leptodermis</i>	N16	occ	Ruderal, flotsam lines	A H
Euphorbiaceae				
<i>Euphorbia paralias</i>	C12	loc co	On two beaches, among boulders	H

Fabaceae					
	<i>Dipogon lignosus</i>	C17	loc co	Disturbed sites at north side of South Island	H
	<i>Trifolium cernuum</i>	N12	rare	Damp sites on shallow soil	r a H
Phytolaccaceae					
	<i>Phytolacca octandra</i>	N11	co	Ruderal, open <i>Lomandra</i> vegetation	R a H
Poaceae					
	<i>Bromus catharticus</i>	N10	occ	Opportunistic	a H
	<i>Cynodon dactylon</i>	N10	unco	<i>Zoysia-Sporobolus</i> vegetation	R W a H
	<i>Digitaria ciliaris</i>	N10	occ	Opportunistic	R a H
	<i>Eleusine indica</i>	N10	occ	Opportunistic	H
	<i>Lagurus ovatus</i>	N12	unco	Open areas on tracks	a H
	<i>Paspalum dilatatum</i>	N11	occ	Opportunistic	H
	<i>Paspalum distichum</i>	N10	ra co	Margins of rock pools	H
	<i>Pennisetum clandestinum</i>	N15	v co	Opportunistic	H
	<i>Poa annua</i>	N10	unco	Opportunistic	a H
	<i>Polypogon monspeliensis</i>	N12	loc co	<i>Zoysia-Sporobolus</i> vegetation	H
	<i>Sporobolus indicus</i> var. <i>capensis</i>	N15	unco	Ruderal, usually on tracks	R A H
	<i>Stenotaphrum secundatum</i>	N10	ra co	<i>Lomandra</i> veg. in central area of South Island	R a H
	<i>Vulpia bromoides</i>	N13	occ	Ruderal	a H
	<i>Vulpia myuros</i> f. <i>myuros</i>	N10	occ	Ruderal	H
Polygonaceae					
	<i>Acetosa sagittata</i>	N17	v co	Widespread, especially on South Island	H
Primulaceae					
	<i>Anagallis arvensis</i>	N12	unco	Damp areas, ruderal	a H
Solanaceae Disturbed lower slopes, flotsam					
	<i>Solanum chenopodioides</i>	N11	ra co	Widespread ruderal	H
	<i>Solanum nigrum</i>	N10	occ	Ruderal	R a H
Native species of doubtful presence or gone (25)					
Aizoaceae					
	<i>Carpobrotus glaucescens</i>	C 4	gone?	Sandy spot between rocks, cliff ledge	a H
Asclepiadiaceae					
	<i>Tylophora barbata</i>	N 4	gone		A
Asteraceae					
	<i>Cymbonotus lawsonianus</i>	N 6	gone	Near lighthouse quarters	R
	<i>Gnaphalium involucreatum</i>	N 2	gone		a
	<i>Senecio biserratus</i>	N 4	gone	Near lighthouse quarters	H
	<i>Senecio hispidulus</i>	N 4	gone		a
Chenopodiaceae					
	<i>Chenopodium carinatum</i>	N 3	gone		R a
	<i>Chenopodium pumilio</i>	N 7	gone		R
	<i>Salsola kali</i>	N 7	gone		A
Epacridaceae					
	<i>Leucopogon parviflorus</i>	C 7	gone		a
	<i>Monotoca elliptica</i>	N 5	gone		R Ca
Fabaceae					
	<i>Glycine clandestina</i>	N 6	gone?		R a
Juncaceae					
	<i>Juncus planifolius</i>	N 8	gone		a
Oxalidaceae					
	<i>Oxalis thompsoniae</i>	N 6	gone		R
Plantaginaceae					
	<i>Plantago ?debilis</i>	N 7	gone		a
Poaceae					
	<i>Elymus scaber</i>	N 8	gone?		H
	<i>Dichelachne crinita</i>	N 8	gone?	Opportunistic	a H
	<i>Eragrostis elongata</i>	N 7	gone?	Opportunistic	H
	<i>Poa labillardieri</i>	N 6	gone?	Near lighthouse	H
	<i>Sporobolus diander</i>	C 3	gone		a
	<i>Sporobolus elongatus</i>	N 3	gone		a
Portulacaceae					
	<i>Calandrinia eremaea</i>	N 7	gone?	Deposition hollows and crevices on rocks	H
Proteaceae					
	<i>Banksia integrifolia</i>	N 5	gone		r

Scrophulariaceae					
	<i>Veronica calycina</i>	N 2	gone?	Track through dense, low <i>Pennisetum</i> vegetation	A H
Sinopteridaceae					
	<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	N 8	gone?	Crevices in 'flat' rock outcrops	R
Introduced species of doubtful presence or gone (29)					
Amaranthaceae					
	<i>Amaranthus viridis</i>	N11	gone?	Ruderal, a favoured rabbit food	H
Asteraceae					
	<i>Aster subulatus</i>	N11	gone		R a
	<i>Cirsium vulgare</i>	N12	gone?	Ruderal	r H
	<i>Gnaphalium purpureum</i>	N11	gone		a
	<i>Hypochoeris glabra</i>	N13	gone		R
	<i>Soliva anthemifolia</i>	N11	gone		a
	<i>Tagetes minuta</i>	N11	gone		A
	<i>Taraxacum officinale</i>	N13	gone		R a
Caryophyllaceae					
	<i>Cerastium glomeratum</i>	N12	gone		a
	<i>Paronychia brasiliiana</i>	N11	gone		a
Chenopodiaceae					
	<i>Chenopodium album</i>	N13	gone		a
	<i>Chenopodium murale</i>	N10	gone?	Ruderal	R A H
Fabaceae					
	<i>Trifolium glomeratum</i>	N12	gone		a
	<i>Trifolium repens</i>	N13	gone		a
Juncaceae					
	<i>Juncus effusus</i>	N12	gone		a
Malvaceae					
	<i>Malva parviflora</i>	N12	gone		a
	<i>Modiola caroliniana</i>	N11	gone	Opportunistic	a h
Oxalidaceae					
	<i>Oxalis debilis</i> var. <i>corymbosa</i>	C11	gone?	Among <i>Pennisetum</i> vegetation near quarters	H
Papaveraceae					
	<i>Argemone ochroleuca</i> subsp. <i>ochroleuca</i>	N11	gone	At abandoned chook sheds	H
Poaceae					
	<i>Aira caryophyllea</i>	N10	gone		a
	<i>Briza minor</i>	N10	gone?	Moist sandy depressions on rocks near quarters	H
	<i>Holcus lanatus</i>	N10	gone	<i>Stenotaphrum</i> sward near quarters	H
Polygonaceae					
	<i>Acetosella vulgaris</i>	N10	gone	Opportunistic	R a
	<i>Rumex crispus</i>	N13	gone?	<i>Pennisetum</i> vegetation on runoff area	H
Rosaceae					
	<i>Rubus discolor</i>	N12	gone?	Alcove head near New Jetty	H
Scrophulariaceae					
	<i>Verbascum virgatum</i>	N12	gone	At abandoned chicken sheds	H
Solanaceae					
	<i>Lycium ferocissimum</i>	N17	gone	One shrub in rock crevice, eradicated	H
	<i>Solanum sarrachoides</i>	N10	gone?	Opportunistic, Gulch beach	H
Urticaceae					
	<i>Urtica urens</i>	N14	gone?	Ruderal	A
Horticultural taxa (29)					
Agavaceae					
	<i>Agave americana</i>		gone	One plant; destroyed	h
Alliaceae					
	<i>Allium porrum</i>		gone	Few plants in abandoned garden in late 1980s	h
Amygdalaceae					
	<i>Prunus</i> sp. cf. <i>persica</i>		loc	A small tree surviving in lee of storage shed	h
Apiaceae					
	carrots		gone	Vegetable gardens (Rodway's diary)	r
Araceae					
	<i>Zantedeschia aethiopica</i>		loc	In seepage area near abandoned garden	H

Brassicaceae			
<i>Lobularia maritima</i>	gone	Grew in courtyard garden	H
cabbages	gone	Vegetable gardens (Pacey 2001)	
cauliflowers	gone	Vegetable gardens (Pacey 2001)	
Cannaceae			
small cannas	gone	Vegetable gardens (Rodway's diary)	r
Chenopodiaceae			
silverbeet	gone	Vegetable gardens (Rodway's diary)	r
Convolvulaceae			
sweet potatoes	gone	Vegetable gardens (Pacey 2001)	
Cucurbitaceae			
<i>Cucurbita pepo</i> (marrow)	gone	Grew on former chicken-shed site	H
Fabaceae			
peas	gone	Vegetable gardens (Rodway's diary)	r
beans	gone	Vegetable gardens (Pacey 2001)	
Geraniaceae			
<i>Pelargonium domesticum</i> (hybrids)	loc	Two varieties, in sheltered positions near quarters	r, H
Iridaceae			
small iris	gone	Vegetable gardens (Rodway's diary)	r
<i>Crococsmia crocosmiflora</i> (hybrid)	gone	Grew in seepage area near quarters	H
<i>Gladiolus</i> sp. (hybrids)	gone	Grew in seepage area near quarters	H
Lamiaceae			
rosemary	gone	Vegetable gardens (Rodway's diary)	r
Moraceae			
<i>Ficus cairica</i>	loc	Sheltered position in deep crevice near quarters	r, h
Musaceae			
<i>Musa acuminata</i> × <i>M. balbisiana</i>	loc	Abandoned garden in northwest of South Island	h
Myrtaceae			
<i>Melaleuca armillaris</i>	loc	2 shrubs planted at east side of quarters in c.1985	H
<i>Metrosideros excelsa</i>	loc	Several planted near quarters in the early 1960s	H
Rubiaceae			
<i>Coprosma repens</i>	occ	A shrub in lee of shed; few seedlings elsewhere	H
Solanaceae			
tomatoes	gone	Vegetable gardens (Rodway's diary)	r
<i>Nicotiana tabacum</i>	gone	A wildling on steep alcove slope on North Island	H
<i>Physalis peruviana</i>	gone	Vegetable gardens (Pacey 2001)	H
<i>Solanum tuberosum</i>	gone	Few plants in abandoned garden in late 1980s	h
Violaceae			
violets	gone	Vegetable gardens (Rodway's diary)	r