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4000 m^2 in extent (Devine 1975).At Low Flat shore hibiscus is extensive in the south-western corner of the flat.

In 1993 one small plant was found growing above the strand line at Coral Bay and the same plant was first seen in 1991 (Clapham 1991b). This plant may have established from seed as shore hibiscus is a common strand plant in the Pacific (Merrill 1940). What is uncertain, though, is where the seed originated from. Seedlings have only occasionally been recorded under the large stands on Raoul Island (Clapham 1991b), and seed set has not been observed. It is possible that the Coral Bay plant germinated from seed dispersed from elsewhere in the Pacific. Alternatively, the plant at Coral Bay could have established from a stem fragment washed around the coast from Denham Bay or Low Flat. However, given that all known stands are some distance from the sea, this explanation is less likely.

At the start of the weed eradication programme, shore hibiscus was listed as a category A plant (Devine 1977). In 1980, Sykes noted that the plants at Low Flat and Denham Bay had not increased much and because they were only slightly increasing through vegetative layering should be accorded low priority in the eradication programme.

7.3.2 Ecology

Shore hibiscus is a sprawling shrub up to 4 m tall belonging to the mallow family (Malvaceae). Leaves are densely hairy below and velvety to touch, almost circular and c. 10-30 cm diam. Yellow flowers with dark purple centres are c. 30-70 mm long. Flowers are produced from November to December. Fruit have not been recorded on Raoul.

On Raoul, shore hibiscus grows as pure stands covering areas up to 50 x 50 m in old plantation sites. The dense stands expand gradually through layering of branches and they virtually exclude all other species. Thus, this species is an effective competitor and is impeding regeneration of native species, as well as restricting the growth of other adventive species, such as aroid lily. However, it does not grow under the forest canopy as it is a light-demanding species. The one plant at Coral Bay is in full light at the strand line. Shore hibiscus could spread further into the clearings it occupies but will not spread into forest. Thus it poses a lesser threat than those vines which invade the forest canopy, or those trees and shrubs which grow within small light gaps in the forest.

7.3.3 Control methods

Various chemicals, including Tordon 2G and 520, have been used on the plant at Denham Bay without much success (Sykes 1980). In 1975 some stems were ring-barked and painted with a 50:50 mixture of Tordon 520 and diesel (Champness 1975) and this appeared to be successful (Anon. 1976). Selby (1980) commented that poisons have no effect on this species and suggested that the only feasible method of eradication was cutting and burning. Clapham (1991b) planned to cut the single plant at Coral Bay and spray the stump with Escort. If he did, the plant was resistant.

7.3.4 *Future work*

Detailed observation of the existing clumps of shore hibiscus to discover if viable seed is set would help to unravel the history of this species on Raoul. The clump by Denham Bay hut should be checked monthly from November through to April to record flowering and fruit set.

7.4 *Brugmansia suaveolens* - NIGHT BELLS

Previously *Datura suaveolens*

7.4.1 *History*

Although not recorded by Cheeseman (1888) or Oliver (1910), this species was presumably introduced by Thomas Bell as a garden plant (Sykes 1977x), as Nightbell Gully is referred to by Morton (1964). Sorensen (1944) photographed "trumpet plant" which is this species (Figure 24). Sykes (1977x) recorded night bells only from the mouth of Nightbell Gully, in 1966-67. In 1993, however, the species was seen near the road at Bell's Ravine and scattered along the forest edge and in the open in the central part of the Orchard, immediately east of Nightbell Gully. Sykes (pers. comm.) recalls that night bells was present in the Orchard in 1966-67 although that location was not recorded in his Flora.

7.4.2 *Ecology*

Night bells is a softly woody perennial shrub up to 3 m tall and is in the nightshade family (Solanaceae). The leaves are large (25 x 12 cm) and papery. During most of the year, large, white, trumpet-shaped flowers are produced. The flowers are sweetly scented at night. Fruit production has not been noted.

Figure 24 Nightbells in a sea of *Ageratum houstonianum*, 1944 (Photo: J.H. Sorensen).

This species is light demanding and currently grows in the open or at the forest edge. It is apparent that this species might be spreading. Sykes (1977x) has never recorded fruit from the plants on Raoul. Fruit production may not have been observed, or it is possible that the species could be spread by vegetative fragments from machinery. The grass in the orchards has in the past been periodically cut and it is likely that bits of the night bells have been caught up in the mower blade or tractor wheels and dropped off along the road or farm tracks.

7.4.3 *Control methods*

Grub out plants and hang in nearby trees to desiccate.

7.4.4 *Future work*

Observe those plants at Bell's Ravine, every two weeks for a year to see whether fruit are set.

7.5 *Araucaria heterophylla* – NORFOLK PINE

(Adults of historic significance only)

Control of this species is described in section 5.9.3. Only the 12 trees assumed to have been those originally planted by Thomas Bell are to be left standing. All progeny, including the trees at Denham Bay are to be destroyed, given the potential this species has to invade and alter the structure of the forest on Raoul Island, albeit slowly. The trees planted by Bell are in poorer condition than their nearby offspring, and most suffer from central stem rot. As they die out, no replacements should be allowed to grow. However, if there are unisexual trees present, these could be cloned as suggested in section 5.9.4, and used to perpetuate the specimens of historic significance on the island.

7.6 *Prunus persica* – PEACH

7.6.1 *History*

Peaches were introduced to Raoul by the earliest settlers (Haigh 1968) and were noted both by Smith (1887) and Cheeseman (1887 unpub.). According to Venables (1937), Bell cultivated three varieties of peach. Sorensen (1944) photographed peach blossoms. Sykes (1977a) records that both clingstone and freestone varieties are present in old plantations on the Terraces and at Denham Bay. In 1993 peaches were recorded from Denham Bay, the Terraces, Low Flat, in groups along the Boat Cove Road and near Boat Cove Hut. Peaches were naturalising freely, especially in the vicinity of Boat Cove Hut. At Low Flat, what is probably a recent dwarf cultivar grows on the edge of the bracken at the eastern end of the flat.

7.6.2 *Ecology*

Peach trees (family Rosaceae) are deciduous on Raoul and grow up to 4 m tall. Pale pink flowers are present through winter and spring and green fruit are evident from late winter (Figure 25). Sykes (1977a) records that "fruits are generally small and tend to rot as they ripen, apparently because of disease and high humidity".

People have assisted the spread of peaches around Raoul Island by carrying fruit and throwing away the stones. The clumps of peach trees have arisen from one or a few trees establishing at a site and seedlings establishing as the progeny of those trees. All of the infestations are in areas frequently accessed by people, e.g., along Boat Cove Road. The species is light-demanding, so persists in old cultivation sites and establishes in clearings or along the road edge.

Figure 25 Young peach fruits on trees at Low Flat, October 1994.

Peach stones were not common in 1993, and rat chewed stones were not observed. It is possible, though that rats could cache peach stones, but they would most likely be put in places which are too dark for germination or seedling establishment.

7.6.3 Control methods

Cut and paint stumps with Tordon. Cut stumps may sucker if not adequately poisoned.

7.6.4 Future work

The peaches on Raoul probably do not have much horticultural value as they are prone to fruit rot. They do have historical significance, but the only trees which are likely to be original plantings are those at the northern end of the swamp in Denham Bay and those immediately west of Bell's Ravine, in the vicinity of the date palms. All other peach trees should be removed.

7.7 *Vitis vinifera* – GRAPE

7.7.1 *History*

Grapes are one of the earliest recorded exotic fruit crops from Raoul Island. In 1836-37 the earliest settlers on the Island, the Reeds and Bakers, sold grapes to passing whalers (Haigh 1968). In 1887 Cheeseman (unpub.) and Smith (1887) noted grapes as being used by the Bells. Large (1888) quotes Thomas Bell as saying that grapes do not succeed well on Raoul Island "from some cause or other". Grape vines were established in association with various settlements on Raoul. During the Coastwatch years of World War II a vine was grown outside the Coastwatchers Hut on Trig V (Expedition Hill) and this was still growing rampantly in 1966-67 (Sykes 1977a). Attempts have been made to destroy the vine on Trig V and it may now be absent from this location. Elsewhere grapes are still known from three sites in Denham Bay - at the northern end of the swamp, by the hut, and near the grove of cherimoya behind the Norfolk pines. A large vine occupies most of a clearing of low-growing shrubs and ferns on the western side of the vehicle track to Low Flat beach. Grapes are also recorded from the Orchard and from an old orchard area west of Bell's Ravine.

7.7.2 *Ecology*

Grape vines (family Vitaceae) are deciduous woody climbers with coarsely toothed leaves to c. 18 cm diam. Forked tendrils enable the vines to climb high into the canopy of surrounding trees (see Figure 19). The small, green, fragrant flowers are clustered in long clumps and are present from October through to December. Two types of fruit have been recorded on Raoul. Most have small black fruit (Sykes 1977a) but others have green fruit (S. Uren pers. comm.).

Grape vines have a similar effect on the forest canopy as Mysore thorn and black passionfruit but, because they are deciduous and native trees and shrubs of Raoul can grow all year, do not have as much impact. However, the weight of grape foliage and stems built up over the years is sufficient to smother all but pohutukawa.

Various workers on Raoul have reported seedling grape vines, but none of these records have been substantiated. Instead these reports relate to lateral branches formed from prostate stems buried in the soil or covered with dense grass or deep litter. New shoots of grape are very soft and can easily be mistaken for seedlings.

7.7.3 *Control methods*

Trace back stems, many of which will have rooted in contact with the ground, and pull out. Scatter Tordon 2G granules in areas where stems can't be pulled up.

7.7.4 *Future work*

Only the plants in the Orchard and on Trig V (if still present) should be eradicated. For the plants at Low Flat, at Denham Bay and west of Bell's Ravine, cut down the stems to keep the foliage out of the tree canopy but do not eliminate from each site. These plants are likely to be the oldest and may be of horticultural significance. Live material has been taken for propagation in New Zealand to identify the types of grape present. Thus, the plants on Raoul should not be eradicated until the results of these investigations are known.

7.8 *Phoenix dactylifera* - DATE

7.8.1 *History*

Date palms have been on Raoul at least since the time of the Bells as a sketch by Carver of "Bells kitchen garden" on the Northern Terraces in 1892 clearly shows date palms as well as Norfolk pines (Johnson 1991). Dates are still present in the vicinity of the Bell settlement at this site and are most likely to be the ones illustrated by Carver. A taller growing clump of dates grows near Denham Bay hut, and is presumed to be older than those on the Northern Terraces. There is a large clump of date palms behind the foxway winch shed at Fishing Rock and small plants lacking trunks and with fronds up to 2 m long are scattered along the crater rim adjacent to Boat Cove Road.

7.8.2 *Ecology*

Date palms (family Arecaceae) are slow-growing trees which, on Raoul, have attained a height of 12 m. Fronds on mature trees are up to 4 m long. Small plants are produced by suckering at the base of the trunks but the species has not spread by this method. Large clumps of small flowers are produced below the fronds on large trees. Flowering was recorded in August 1993 and many flies were attracted to the flowers. Fruit production has never been recorded on Raoul and Sykes (1977a) suggests that fruiting is unlikely because of the humid oceanic climate. The young plants along the crater rim are suckers planted many years ago which are growing slowly (Sykes pers. comm.).

7.8.3 *Control methods*

Control of dates has never been undertaken on Raoul. In the first instance, removal of young plants could be attempted by digging them out.

7.8.4 *Future work*

The dates at Denham Bay and on the Northern Terraces west of Bell's Ravine should be left alone. They are of historic significance as they are relics of European settlement in the 19th century. These dates should also be observed to discover whether fruit are produced on Raoul. Monthly observations of the trees from August onwards should suffice.

8. Discussion

The first botanists to visit Raoul - Cheeseman in 1887 and Oliver in 1908 - recorded all naturalised exotic species present then. Only one of the species listed in Category A (castor oil plant) was naturalised then, and was noted by Oliver (1910). Both guava species were listed by Cheeseman (unpub.) as crops grown by the Bells but none of the other species were recorded, although some are surmised to have been cultivated then. All of the earliest botanical observers on Raoul, from Cheeseman through to Sorensen, saw weeds of cultivation as the most prolific introduced plants. Oliver recorded two "introduced formations" on Raoul: the "*Ageratum* meadow" which occupied all clearings in Denham Bay; and the "buffalo grass meadow" which extended from the northern terraces to Low Flat and the crater rim nearby, as well as in one place on the east coast. These are weeds of cultivated and open ground and do not pose a long-term threat to forest cover, although the dense buffalo grass swards greatly slow down the rate of forest recolonisation. *Ageratum houstonianum* is still common today as a weed in open, disturbed ground. Guthrie-Smith (1936) mentioned both of these species, too, in relation to the Meyer Islets which he stated were fortunate ". . . in being waterless, therefore not fouled with humanity and therefore goatless, pigless and innocent of such iniquities as ageratum and buffalo grass." Unfortunately, these islets are not so weed-free today.

It was only when the settlements in Denham Bay and on the northern side of the Island were abandoned that the species which were to pose a threat to the forest on Raoul became apparent as they were no longer kept in check by harvesting and cultivation. The first warning bells were sounded in 1944 by Sorensen when he saw the impact of Mysore thorn in Denham Bay but other, more widespread species attracted more attention, e.g., *A. houstonianum*, *Sicyos australis* and aroid lily. At this stage there was no weed control undertaken but caution was exercised with regard to importation of plants to the Island. By then, though, most of the species listed in Category A were already present on the Island and were beginning to spread. More than 20 years later when Sykes first visited Denham Bay, Mysore thorn was even more firmly entrenched. At this point eradication of this species was recommended. Other species were also recommended for eradication because, even though they were not particularly widespread and were having less obvious impact on the forest, experience on other Pacific islands had shown the enormous impact these species could have, in time, e.g., African olive and purple and yellow guava.

Weed eradication has been a goal of operations on Raoul Island for the past 20 years. In that time, only one species, ragwort, can be clearly identified as having been eradicated. Ragwort was recorded as a single plant and was killed before it flowered. Other species which have not spread beyond their known, limited ranges have been able to persist because of seeds in the seed bank or vegetative propagules. Examples are pampas grass, Mauritius hemp, fennel and swan plant. For the species which had much greater initial abundances, great progress has been made on eradication of most. Reduction in the extent of

Mysore thorn provides the clearest example of progress towards eradication of one of the worst weeds on the Island. Instead of solid curtains of this vine climbing up and killing pohutukawa a walk through Denham Bay reveals nothing of the existence of this species, and it is only by searching diligently through the clearings, on the cliffs, and beside the stems of trees and shrubs that young Mysore thorn plants are found. Species such as Brazilian buttercup have extended their range during the period of the eradication programme, but the numbers of mature seeding plants have been reduced substantially.

One of the difficulties of the weed eradication programme is continuity of effort. When teams are present on the Island for one-year periods and there is limited time during the changeover period for exchange of information and familiarisation by the new team, some time can be lost or information not fully appreciated while the new team is learning about the eradication programme and the Island. Record-keeping in relation to site details for specific weed species continues to improve and this, combined with the commitment of staff to follow up on all records, should reduce the incidence of previously treated sites becoming reinfested with target species. Thus, situations such as currently experienced with Brazilian buttercup should not recur.

Some workers have commented on the apparently poor job done by previous weed teams or individuals. In most cases, though, this perception relates more to the fast growth rates of the weed species on Raoul than a lack of effort by staff. Growth rates on Raoul are much faster than in most places on the New Zealand mainland, which is the experience base of most staff on the Island. As indicated earlier in this report several species of both shrubs and vines can be of sufficient size to flower and set seed within two years. One of the reasons for providing a history of each target weed was to indicate the level of control which has been exerted over the years.

There has been a change in the type of effort required for each species as the eradication programme has progressed. In the initial stage of eradication the greatest effort is expended on destruction of the existing, usually dense populations of the target species. However, within a relatively short time (and with the current exception of Madeira vine) the initial populations are reduced substantially. The effort then switches to most time being spent searching for individuals or small groups of the target species. Once found, destruction is usually quick and easy. Most of the category A(i) species fall into this latter stage. Effective searching and documentation of sites are the most critical factors in this phase of weed eradication as the aim is to stop any further seeding of plants and therefore the earlier termination of the weed eradication programme.

Several of the weed species are much easier to find when they are flowering (e.g., Mysore thorn, Brazilian buttercup). Others are easier to see as adults as their stems look quite different from the native species in the forest (e.g., purple and yellow guava) but some others are easier to find as juveniles because their foliage is a different colour or form from most native species yet the adult trunks blend in with the trunks of native species (e.g., African olive). There is usually some characteristic of the target species which enables it to be distinguished from the surrounding vegetation.

Grid searching is the most effective way of finding target species, and the distance between search lines must be varied according to the density of the

vegetation. In forest with a slight understorey 10 m spacing would be sufficient but in dense areas, 5 m spacing would be more appropriate. On subsequent searches of each site, the search pattern must be changed, e.g., rotated by 90 ϒ each time to avoid familiarity of approach and improve the chances of finding target species.

On Raoul, the invasive weeds all have greatest impact on the dry forest and most are not known to grow above 300 m altitude. It is possible that the wet forest is less vulnerable to invasion because the understorey and canopy are generally more dense. Also, for species with seeds dispersed by explosion of the pods (e.g., Brazilian buttercup) or by vegetative propagules (e.g., Mauritius hemp) dispersal uphill takes much longer than dispersal downhill, and the initial sites of establishment of all of the target species was in the inhabited lowlands. However, recent teams have recorded greater altitudinal ranges for species such as black passionfruit, African olive and Brazilian buttercup (Fastier 1994, Uren 1995b).

The majority of the weeds targetted for eradication on Raoul are of tropical as opposed to temperate origin and this reflects the warm climate on Raoul. The native vegetation of the Island grows much more rapidly than the temperate species introduced there, but the introduced subtropical species can grow just as fast as the native vegetation and infiltrate or dominate the native communities. Although the climate is not warm enough for sexual reproduction of some of the subtropical target species (e.g., Madeira vine, Para grass), vegetative reproduction is sufficiently aggressive to warrant their eradication.

Most of the species targetted for eradication are light-demanding. They were initially established in plantations or gardens and have been able to spread into the forest by taking advantage of light gaps which are continually formed on Raoul. There are four main ways in which light gaps are created on the Island: tree falls during cyclones; slips caused by earthquakes; slips caused by flash floods (e.g., the downpour which caused the Bells to finally desert Raoul - Bell 1911); and destruction of vegetation by volcanic eruptions (see Sykes 1977a). Given the dynamic nature of the Island there will always be light gaps forming and being recolonised. Some of the native species regenerate best in light gaps too (e.g., *Homalanthus polyandrus)* but can be outcompeted by adventive species.

New slip sites should be checked for weed species, especially where they are near known previous infestation sites as seeds may have been buried in the soil for many years. As soon as dormant seed is exposed to higher light levels it will germinate and the high light environment of slips will favour the growth of light-demanding weed species. Similarly, light gaps formed after cyclones should also be checked, especially along the northern side of the Island, in the crater and in Denham Bay. Eruptions are far less frequent (fortunately) and are also less likely to promote weed growth as the most effective coloniser of ground bared by eruptions appears to be Kermadec pohutukawa. However, many of the target weed species are capable of invading the pohutukawa forest once it has re-established.

Germination of seed from the seed bank can be speeded up by increasing the light levels reaching the ground in areas where parent plants have been removed. In the early 1980s controlled burns in Denham Bay were used to accelerate germination of Mysore thorn seeds buried in the the soil but shaded by a fern canopy. Sykes (1980) suggested this strategy and Selby (1982b)

reported that it was working well. In 1994, Sykes (1994) recommended removing surrounding ground-cover vegetation from sites where parent plants of Brazilian buttercup had seeded recently. This would achieve the same effect and, because only a small area is cleared, would not greatly enhance the potential for erosion.

Weed species which are not so light-demanding and grow densely beneath the pohutukawa canopy pose a significant threat even though they may be limited to vegetative spread (e.g., Para grass, bamboo). In this situation the forest canopy remains only for the life of the existing trees. Once they fall or die, the weeds will persist at the site as they are usually tolerant of high light conditions. It should be noted, however, that Kermadec pohutukawa is virtually indestructible (except by volcanic eruptions and smothering vines) and continues to grow once felled by cyclones or slips. Regeneration by seed, of course, is impeded by dense ground cover.

Invasive weeds generally affect native vegetation in one of two ways: the most obvious impact is by those species which smother the canopy, eventually killing the host trees and then the subcanopy and ground cover layers as the canopy trees disintegrate; less obvious impact comes from those species which grow densely in the subcanopy or as ground cover and inhibit forest regeneration. As mentioned in the paragraph above, the effect of these species is not noticed for much longer, until the canopy begins to disintegrate naturally. All of the shrub and tree species targetted for eradication on Raoul will inhibit forest regeneration by occupying sites which would otherwise be inhabited by native species. They will not generally occupy all sites and most native species would be able to regenerate but to a lesser extent. Over time, the forest would change from one dominated by native species to one dominated by exotics, and the rarer elements of the native flora (including a number of endemic species) would be lost first.

Vines are the greatest canopy killers (although parasitic plants such as mistletoes can be just as effective) and several species are targetted in the weed eradication programme for Raoul (e.g., Mysore thorn, black passionfruit, Madeira vine). The native flora of Raoul lacks woody vine species, and has, therefore, evolved in their absence. This could have resulted in a flora which is less able to grow in the presence of vines and is subsequently more susceptible to their effects. Sicyos australis is the only native tree-climbing vine on Raoul, but it is non-woody and short-lived and has no lasting effect on the forest edge shrubs that it scrambles over.

Not only are the weeds targetted for eradication subdivided into vines and others but they can also be subdivided into those that affect forest vegetation versus coastal communities. Most of the category A species threaten the forest but a few (e.g., pampas grass, fennel) pose a greater threat to coastal shrublands and herb communities. In forest they are readily overtopped and die slowly through lack of light but in the lower growing, more open coastal communities they are aggressive competitors. Pampas also springs up readily on slip sites and in large light gaps and, being wind-dispersed, the seeds are readily transported to remote locations. Madeira vine poses a threat to coastal communities and also threatens forest.

A further subdivision of target weeds relates to their mode of dispersal: predictable vs unpredictable. Fortunately, many of the species are usually dispersed only short distances by explosion of seed pods (e.g., Mysore thorn, Brazilian buttercup), by wind dispersal of seeds (e.g., Norfolk pine) or by gravitational dispersal of vegetative propagules (e.g., Mauritius hemp, Madeira vine). Thus, they spread incrementally from existing infestations and their pattern of spread is generally predictable. For those species relying on gravity and pod explosion most dispersal will be downhill of existing infestations whereas lateral and uphill dispersal will be less significant. Most spread of wind-dispersed species is in the direction of the prevailing wind.

Species with fleshy fruits tend to be dispersed by birds. Either the fruit containing the seed is taken whole by the bird (e.g., African olive) or the seeds are picked out of the fruit (e.g., black passionfruit, yellow guava). Generally, birds disperse seeds in an unpredictable fashion as they move from the weed species they are feeding on to a roosting or perching site. Despite black passionfruit being bird-dispersed, it has tended to spread incrementally from foci associated with human activity. However, it and all other bird-dispersed species could potentially appear in any suitable habitat around the island.

Whether the dispersal pattern of species is predictable or unpredictable, effective invasion by these species relies on seeds being able to germinate in the sites to which they are dispersed. In many instances conditions are not right for seed germination, but most of the target weed species on Raoul have seeds which can lie dormant in the soil for many years, as part of the seed bank. When conditions improve (usually high light associated with soil movement or tree fall) the seeds germinate and a new weed infestation arises.

Also, species which are generally dispersed in a predictable fashion occasionally do turn up in unexpected places. Two examples from Raoul illustrate this point. Firstly, species which are primarily terrestrial can also grow epiphytically, e.g., Mauritius hemp. It is not inconceivable that other target species could establish epiphytically and this possibility should be borne in mind when grid-searching. Secondly, chance dispersal by seeds being transported in mud adhering to birds' feet or feathers, or in the clothing or on boots of people is probably responsible for most of the remote dispersal of some species. Brazilian buttercup has been on the Meyer Islets for many years and its method of introduction is not known but is not likely to have been deliberate. Aroid lily is also present on the Meyers and will have been taken across by birds. With regular movement of birds between Raoul and the Meyers seeds of fleshy fruited species in particular will be moved between the two places. It is, therefore, important that eradication efforts on Raoul continue to include the Meyers so that these two islands do not act as a source of weed re-infestation to Raoul. The Meyers themselves are a very valuable part of the nature reserve and should have the weeds eradicated as a priority for their own sake anyway.

Longer distance dispersal of Madeira vine becomes more likely the longer the infestations remain untreated as the number and size of the tubers builds up. Inevitably, tubers will fall into the sea and be dispersed around the coast of Raoul, or to the Meyers, and have the potential to start new infestations. I cannot stress strongly enough the urgency with which this plant must be dealt with. Any species which is as difficult to eradicate as this one is in its current,

limited locations, is going to be orders of magnitude more difficult to deal with once it has dispersed to many, more remote locations.

In order to enable areas remote from currently known infestations of the target weed species to be checked, it is suggested that helicopter surveillance be used at least every two years. Areas which should be checked are the Mahoe ridge down to sea level on both sides, the eastern side of the Island from Rayner Point around to Boat Cove and both sides of Hutchisons Ridge from Denham Bay and Western Spring westwards. This request was made by Fastier (1994) also, and while helicopter surveillance might be difficult to organise, it will be essential to the success of the weed eradication programme. Species which could profitably be searched for by helicopter are Mysore thorn and Brazilian buttercup (when they are flowering), black passionfruit, Madeira vine and African olive. The flowering times of Mysore thorn and Brazilian buttercup barely overlap (in November) so it may be necessary to do separate runs for these species. Brazilian buttercup, however, is higher priority given its greater abundance and current range.

The species currently targetted for eradication are those which are causing significant threats to the native vegetation of Raoul Island in the presence of two species of rat: kiore *(Rattus exulans)* and Norway rat (R. *norvegicus).* However, it is expected that some species might become significant weeds once rats are eradicated (eradication of rats and cats is currently programmed for 1998). Species such as macadamia, puriri, papaya and possibly grapes, dates and some citrus could increase in abundance in the absence of rats. There are two reasons why some of these introduced species might increase in abundance and range. Firstly, rats eat large amounts of seed, e.g., all nuts produced by the macadamias on Raoul are eaten by rats - the ground beneath the trees is littered with opened shells. When kiore were eradicated from Tiritiri Matangi Island in the Hauraki Gulf, puriri seedlings grew under the one tree in the main bush area for the first time in recorded history (pers. obs.). Secondly, eradication of rats and cats will allow bird populations to increase. Some of these bird species will be effective seed dispersers. As bird numbers increase, so too will dispersals, and some of the currently restricted exotic species could increase substantially, to the detriment of the native forests of Raoul. It would be prudent to remove species such as macadamia and puriri before the rat eradication commences. However, reclassification of these species is more appropriate closer to the time of the rat eradication programme. Closer observation of some species may be required also.

In summary, considerable progress has been made towards eradication of all weeds which significantly threaten the natural plant communities of Raoul Island (and the Meyer Islets). This assessment serves to illustrate the progress which has been made and also gives an indication of the work which has yet to be done. The length of the eradication programme increases with every individual weed that disperses viable seeds or vegetative propagules. Thus, searching for and destroying all individuals before they can reproduce is the target. Bearing in mind the unknown seed longevity of all target species and given the tenacity of even the most restricted category A weeds, it is probably realistic to predict that the weed eradication programme on Raoul Island will run for a further 20 years.

9. Recommendations

9.1 *That the three categories encompassing the entire introduced flora be adopted.*

9.2 *That the assignation of species in each category be accepted.*

9.3 *That the lists of species in each category be revised regularly, as more is known about the species themselves, and that a revision be undertaken before the rat eradication operation.*

9.4 *That the actions suggested for each of the species be undertaken.*

9.5 *That particular effort be put into hand removal of Madeira vine at Fishing Rock and in Bell's Ravine.*

9.6 *That monitoring of seed formation be undertaken for shore hibiscus, night bells, and date.*

9.7 *That the rate of spread of air plant be monitored.*

9.8 *That every effort be made to undertake aerial surveillance of remote parts of Raoul Island as soon as possible, and regularly thereafter as long as weed eradication remains a goal of management on the Island.*

9.9 *That weed eradication on the Meyer Islets proceeds in tandem with that on Raoul.*

10. Acknowledgements

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Appendix 1

RAOUL WEED PEOPLE

1972	Len McConnell
1973	Chris Smuts-Kennedy
1974	Arthur Taylor
1975	Graham Champness, Sonny Biddle
1976	John Trotter, Ian Thorne, Rob Selby
1977	John Ombler, Kim Morrison, Dick Kennett, John Gardiner, Bob Selby
1978	Paul Dale, Darryl Morrow, Chris Garton
1979	Ben Adlam, Gilly Adam, Tony Woods
1980-81	Bob Selby, Dave Hancock, Pat Riddett
1981-82	Dave Rees, Bob Selby, Dicey Davidson
1982-83	Dick Cropp, Alf Blundell
1983-84	Darryl Morrow, Rob Wall, Paul Chandler
1984-85	Mark Davies, Jon Maxwell, Paul Chandler, Paul McGahan
1985-86	Mike Fowler, Paul Chandler, Alan Johnston
1986-87	Mark Bracefield
1987-88	Simon Gardner, Lance Cane
1988-89	no staff
1989-90	Simon Gardner
1990-91	Martin Clapham
1991-92	Ant Clark
1992-93	Barry Samson
1993-94	Al Fastier, Grant Harper, Dave Moulder, Len Webb
1994-95	Simon Uren, Blair Ewington, Sean Husheer
1995-96	Jenny Steven, Georgie Hedley, Keith Springer, Gary Lewis

Appendix 2

NOTES ON DISTRIBUTION, PHENOLOGY, AND DATES OF FIRST KNOWN RECORDS OR COLLECTIONS OF PLANTS OF NO KNOWN HISTORIC SIGNIFICANCE

Category B

Adventives resulting from accidental or deliberate introduction which have no historic significance and which pose a minimal or no threat to the forest ecosystem of Raoul Island. First records are derived from the literature or from herbarium collections.

GYMNOSPERMS
PINACEAE
Pinus radiata
Date of introduction not known. When observed in 1970s appeared unthrifty. All trees were felled in 1978 but one was left in the orchard. Not seen recently and is probably no longer present. Cultivated relic.

ANGIOSPERMS
DICOTYLEDONS
APIACEAE
Apium graveolens - wild celery
Recorded by Cheeseman 1887 and not reported since then.

Ciclospermum leptopbyllum - slender celery
First recorded by Sorensen 1944. Widespread in open places along the Terraces, e.g., airstrip, road side. Also on the dune crest at Denham Bay.

Daucus carota ssp. *sativus* - carrot
Recorded by Cheeseman 1887. Probably extinct as an adventive - Sykes.

Pastinaca sativa - wild parsnip
Probably died out as an adventive - Sykes.

APOCYNACEAE
Catharantbus roseus
First recorded by Oliver 1908.
Denham Bay - DB8 and scattered towards the coast. One outlier clump in the dune slack just north of the Norfolks.

ASTERACEAE
Achillea millefolium - yarrow
Only reported in 1944, by Sorensen.

Arctotheca calendula - Cape weed
Collected in 1972, only, by Veitch and reported by Sykes 1977.

Aster subulatus - sea aster
First collected by Cooper 1956. Widespread, e.g., Denham Bay, Western Spring, but often not abundant. Dense stands at the south-eastern corner of Blue Lake on

damp ground and in the dune slack at Denham Bay. Plants vary considerably in size. Some at Denham Bay flowering and fruiting in July.

Bidens pilosa - cobblers' pegs
Collected by McGillivray 1854. Recorded by Cheeseman 1887 as plentiful in open and rocky places. Widespread in open areas in dry and wet sites at all altitudes, e.g., Western Spring, Rayner Pt, Boat Cove, north end of Denham Bay. Some plants flowering in winter. Plenty of ripe fruit by the end of October.

Carduus tenuiflorus - winged thistle
First collected by Sorensen 1944. Last seen 1974 near the Met station.

Conyza bonariensis - wavy-leaved fleabane
Recorded by Cheeseman 1887 and Oliver 1908.
Juvenile plants seen in scattered locations on the Terraces.

Crepis capillaris - hawksbeard
Only reported in 1944, by Sorensen, and once in 1969.

Galinsoga quadriradiata - galinsoga
First collected by Sykes 1966-67. Common in cultivated ground around the Hostel, and on freshly bared earth at the airstrip.

Gnaphalium subfalcatulum
First collected by Cooper 1956.

Gnaphalium pensylvanicum
First collected by Sorensen 1944. Now growing in mown grass behind the Met. Station.

Hypochoeris glabra - smooth catsear
Only reported by Sykes in 1964 from Green Lake shore, one day before the eruption.

Hypochoeris radicata - catsear
Recorded by Cheeseman 1887 and Oliver 1908.

Lapsana communis - nipplewort
First collected by Sykes 1966-67. Currently along mown tracks on Low Flat and at edge of paddocks at back of Farm Terrace.

Leontodon taraxacoides - hawkbit
First collected by Sykes 1964. Common at Denham Bay in the first dune slack and along the dune crest.

Senecio vulgaris - groundsel
Recorded by Cheeseman 1887 and Oliver 1908.
Two small seedlings may have been seen on steep descent into Denham Bay in 1993.

Sigesbeckia orientalis
Recorded by Cheeseman 1887 as common in open, sunny places in bush.
Not seen, although looked for at Coral Bay and on North Meyer.

Sonchus oleraceus - sow thistle
Recorded by Cheeseman 1887 (as *S. oleraceus* var. *asper)* as common on cliffs and by Oliver 1908.

In coastal areas on cliffs, on the airstrip, and in other open sites, e.g., by the *Hebe* on Hutchisons ridge. Common along the Denham Bay dune crest and in the dune slack. Leaves thicker and more sharply pointed near the coast.

Tagetes erecta - African marigold
First collected by Sykes 1966-67 and not seen since.

Taraxacum officinale - dandelion
First recorded by Oliver 1908.
Scattered around Met. Station, at the top of Ravine 8 track and Denham Bay track. A few plants flowering in July, more in August.

BORAGINACEAE
Cynoglossum amabile
First collected by Sorensen 1944. Known from Boat Cove Road just past the Rayner Point turnoff, but not seen recently - presumed died out.

BRASSICACEAE
Capsella bursa-pastoris - shepherd's purse
Recorded by Cheeseman 1887. Not reported since the 1960s.

Coronopus didymus - twin cress
Recorded by Cheeseman 1887 and Oliver 1908.
Abundant in coastal areas on cliffs. Also abundant around the Hostel and on disturbed soil, e.g., new airstrip. Common in other open, waste places. Also on North Meyer.

Lepidium byssopifolium
Recorded by Oliver 1908.

Lobularia maritima - alyssum
Recorded by Cheeseman 1887 and not reported wild since then.

Raphanus sativus - radish
First collected by Sykes 1966-67. Died out.

Rapistrum rugosum - turnip weed
Only reported in the 1966-67 by Sykes.

Sisymbrium officinale - hedge mustard
Recorded by Oliver 1908 (as *Brassica adpressa).*
A group of plants grows on the Low Flat track with *Lapsana communis.* Also beside Blue Lake.

CARYOPHYLLACEAE
Cerastium fontanum ssp. *vulgare* - mouse-ear chickweed
Recorded by Cheeseman 1887 (as *C. vulgatum).* Recorded by Oliver 1908 (as *C. viscosum*).
Along mown tracks from Low Flat to the airstrip and around the Met. Station.

Cerastium glomeratum - annual mouse-ear chickweed
First collected by Sorensen 1944.

Dianthus barbatus - Sweet William
First collected by Sykes 1966-67.
Died out - from seed deliberately scattered in crater.

Dianthus caryophyllus - carnation
First collected by Sykes 1966-67.
Died out - from seed deliberately scattered in crater.

Polycarpon tetraphyllum - allseed
First recorded by Oliver 1908.
Very common around the coast on cliffs.

Silene gallica - catchfly
First recorded by Oliver 1908.

Spergula arvensis - spurrey
Only reported by Sorensen in 1944.

Stellaria media - chickweed
Recorded by Cheeseman 1887 and Oliver 1908.
Common on cultivated ground around Hostel and in waste places further afield.

CHENOPODIACEAE
Chenopodium album - fathen
Only reported in 1944, by Sorensen.

CONVOLVULACEAE
Calystegia sepium - pink bindweed
Recorded by Cheeseman 1887 as rare.

Ipomoea alba - moon flower
Growing on fern and grass outside Denham Bay Hut and near the *Tibouchina.*

EUPHORBIACEAE
Euphorbia hirta - asthma plant
Recorded by Oliver 1908.
Grows on heated ground in the Green Crater.

Euphorbia peplus - milkweed
Recorded by Cheeseman 1887 and Oliver 1908.
Common along mown tracks and road edges on the northern side of the island, at Denham Bay, and also along Blue Lake track.

FABACEAE
Lotus pedunculatus - lotus
First collected by Sykes 1967. Probably has died out - Sykes.

Lotus suaveolens - hairy birdsfoot trefoil
First collected by Sorensesn 1944. Noted growing in two places on the track from Fleetwood Bluff to Low Flat.

Medicago arabica - spotted bur medick
First collected by Sykes 1967. Not common.

Medicago lupulina - black medick
First collected by Sykes 1967. One plant seen near woolshed, by Chas Parker's grave.

Medicago nigra - bur medick
Recorded by Oliver 1908 (as *M. denticulata).*
Growing along road edge near Met. Station. More plants apparent in August, scattered along road edge. On track to Fishing Rock.

Medicago sativa - lucerne
First recorded by Sykes 1978. Near the hostel and on the Terraces.

Phaseolus lunatus - sieva bean
First collected by Cooper 1955. Presumed died out.

Trifolium dubium - suckling clover
Recorded by Oliver 1908 (as *T. procumbens).*
Common on Fishing Rock track.

Trifolium pratense - red clover
Recorded by Cheeseman 1887 and Oliver 1908.
Seen in the orchard. Flowering in October.

Trifolium repens - white clover
Recorded by Cheeseman 1887.
Common on mown and grazed areas on the Terraces and in the lawn around the hostel. Flowering in October and visited constantly by bees.

Trifolium subterraneum - subclover
No CHR record of collection. Probably has died out - Sykes.

FUMARIACEAE
Fumaria muralis - scrambling fumitory
Recorded by Cheeseman 1887 and Oliver 1908.
On cultivated ground around the Hostel and around the Met Station. Flowering in July. Abundant in coastal petrel burrow areas on the western side of North Meyer.

GERANIACEAE
Geranium dissectum - cut-leaved cranesbill
Recorded only by Cheeseman 1887 and then not common.

Geranium molle - dove's foot cranesbill
Recorded by Cheeseman 1887 and Oliver 1908 but not reported since then.

LAMIACEAE
Lamium purpureum - red dead nettle
First recorded by Sorensen 1944. Common in cultivated ground around the Hostel.

Stachys arvensis - staggerweed
First collected by Sorensen 1944 and has been recoded from near the hostel since then.

LINACEAE
Linum trigynum - yellow flax
First collected by Sykes 1966-67 and noted as common on the old landslips at the western end of Denham Bay.

MALVACEAE
Hibiscus rosa-sinensis - hibiscus
First collected by Sykes 1967 from the hostel garden. Several plants of the orange flowered form grow around the Hostel. There is also a plant with entirely red petals at the bus stop (behind the Hostel), favoured by tui in the early morning. Cultivated.

Malva parviflora - small-flowered mallow
First collected by Sorensen 1944 and noted by Sykes as near the hostel in 1966-67. In October 1994 not seen on Raoul but abundant on North Meyer on soft petrel-burrowed earth.

Modiola caroliniana - creeping mallow
First collected by Sorensen 1944. Noted in the back cow paddock on the Terraces. Also on the Ravine 8 track near the turn off to Western Spring. Scattered in open areas on the northern side of Raoul.

Sida rhombifolia - paddy lucerne
Reported by Oliver 1908.
Distributed along roads and tracks, e.g., Low Flat, Rayner Pt, Boat Cove Rd, Denham Bay. Some of the biggest plants are beneath the *Brugmansia suaveolens* in Bell's Ravine. Seedlings common in August.

OROBANCHACEAE
Orobanche minor - broomrape
First collected by Sorensen 1944. One plant seen in 1994, growing with *Trifolium repens* and *Anthoxanthum odoratum* in mown grass in front of the Met. Station.

OXALIDACEAE
Oxalis thompsoniae
Recorded by Cheeseman 1887 as common.
Common in open places where there is little other vegetation, e.g., bush edge, base of cliffs. Generally in dryish sites. Also on coastal cliffs in loose soil, e.g., Rayner Pt. Beginning to flower in late July.

Oxalis latifolia - fishtail oxalis
Fist collected by Sykes 1966-67. Common around the Hostel, Met Station area and Low Flat on mown tracks. Some plants flowering in July.

PASSIFLORACEAE
Passiflora mollissima - banana passionfruit
Only known from one leaf collected by Sorensen in 1944.

PLANTAGINACEAE
Plantago lanceolata - narrow-leaved plantain
Recorded by Cheeseman 1887 and Oliver 1908.
Common on mown tracks and other open vegetation of short stature. Also on coastal cliffs in loose soil, e.g., Rayner Pt, and dunes, e.g., Denham Bay. Some plants are more hairy than others.

Plantago major - broad-leaved plantain
Recorded by Cheeseman 1887 and Oliver 1908.
Common on the new airstrip and occurs on edges of mown tracks. Also growing in boggy ground on the southern edge of Blue Lake. Some plants are very large - leaves > 10 cm broad - and flowering stems to 60 cm tall.

POLYGONACEAE
Polygonum aviculare - wireweed
Only reported in 1944 by Sorenson.

Rumex acetosella - sheep's sorrel
Recorded by Oliver 1908 and last reported in 1944 by Sorensen.

Rumex brownii - hooked dock
Recorded by Cheeseman 1887 (as *R. flexuosus*).
Growing at the airfield and scattered around the Hostel and Met. Station. Also seen in open areas in wet forest.

Rumex obtusifolius - broad-leaved dock
Recorded by Cheeseman 1887 and Oliver 1908.

PORTULACAECEAE
Portulaca oleracea - purslane
First recorded by Sorensen 1944. Noted at Fishing Rock and the Green Lake crater. Also at Rayner Pt on coastal rocks. Also on North Meyer.

PRIMULACEAE
Anagallis arvensis ssp. *arvensis* var. *arvensis* - scarlet pimpernel
First collected by Sykes 1966-67. Common on coastal talus. Noted on the north coast and at Boat Cove. Also abundant on the dune crest at Denham Bay near the Norfolk pines.

PROTEACEAE
Hakea salicifolia - willow-leaved hakea
First collected by Cooper 1956 and has since died out - Sykes.

RUBIACEAE
Sherardia arvensis - field madder
First collected by Sykes 1966.

SCROPHULARIACEAE
Verbascum thapsus - woolly mullein
Not reported since 1944 by Sorensen.

Veronica arvensis - field speedwell
Recorded by Cheeseman 1887 and Oliver 1908.
Growing in lawn near Met Station, and in race beside cow paddocks.

Veronica persica - scrambling speedwell
Recorded by Oliver 1908 (as *V. agrestis*).

SOLANACEAE
Datura stramonium - thornapple
Recorded by Oliver 1908 and not seen since 1966.

Lycopersicon esculentum - tomato
First recorded by Sykes 1967. Widely naturalised beneath coastal cliffs, e.g., Lava Point - roosting starlings? Noted on the foreshore at Coral/Turtle Bay.

Nicotiana tabacum - tobacco
Recorded by Cheeseman 1887 and Oliver 1908.

Physalis peruviana - cape gooseberry
Recorded by Cheeseman 1887 and Oliver 1908.
Scattered along the northern terraces and along the northern edge of Blue Lake. Large, spreading bushes in flower and fruit in winter 1993.

VERBENACEAE
Verbena bonariensis - purple-top

First collected by Sorensen 1944. A common weed of open areas and one of the few that can grow in the dense buffalo grass swards. Widespread around farm and airstrip.

MONOCOTYLEDONS

CYPERACEAE

Kyllinga brevifolia

First recorded by Oliver 1908. Grows on warmed ground at western end of Green Lake. Has a dense green head.

Kyllinga nemoralis

First recorded by Sykes 1966-67. Noted near flax at Denham Bay.

Cyperus rotundus - nut grass

First recorded by Cooper 1956. This is the small, broad-leaved species with brown, open heads and of short stature, <15 cm tall. Grows densely at the airstrip.

Pycreus polystachyos

First collected by West 1993. This is a new record for Raoul Island and is the tall, thin species found often in buffalo grass. Widespread along northern terraces, esp. among buffalo grass. Also at Denham Bay and along the swamp edge at Blue Lake.

IRIDACEAE

Gladiolus x hortulanus - florist's gladiolus

First collected by Sykes 1966-67. This species has red and yellow flowers. There is a clump near the Hostel. At Denham Bay, an extensive clump grows south of the Norfolk pines and the coconut. There is also a clump near the poison shed north of the lagoon. Both were in active new growth, with healthy-looking corms in winter 1993. Also a clump by the gate to the woolshed. Most colonies flowering in October 1994.

Gladiolus cv.

Clumps grow on either side of the Met Station and these have cream flowers with purple stamens and pink markings on the lower petals, or pink flowers.

JUNCACEAE

Juncus flavidus

First collected by Sykes 1967. Has died out from Low Flat - Sykes.

POACEAE

Anthoxanthum odoratum - sweet vernal

Recorded by Oliver 1908.

Noted in mown areas around the Met Station and at Low Flat. Also at the northern end of Denham Bay.

Avena sativa - oat

Only reported in 1944 by Sorensen.

Axonopus affinis

First collected by Sykes 1964. Grows in Green Lake crater on open ground. Slender stems.

Bothriochloa bladhii

First collected by Sykes 1966-67. Has died out from Low Flat - Sykes.

Briza minor - small shivery grass
Recorded by Oliver 1908.
Scattered along tracks and road edges on northern side of the island.

Bromus diandrus
Only reported in 1944 by Sorensen.

Bromus hordeaceus
First collected by Sykes 1966-67 in mainly coastal sites.

Bromus willdenowii - prairie grass
Recorded by Oliver 1908.
Scattered along road edges. Also in the dune slack at Denham Bay and on North Meyer.

Calamagrostis epigeios
Only reported in 1944 by Sorensen.

Chloris gayana - Rhodes grass
First collected by Cooper 1956. Grows in tall grass at the end of the older airstrip. Also at edge of mown tracks near the Met. Station.

Cynodon dactylon - Indian doab
Recorded by Cheeseman 1887 and Oliver 1908.
Growing near Met. Station and at Denham Bay - long runners, prostrate.

Dactylis glomerata - cocksfoot
Recorded by Cheeseman 1887 and Oliver 1908.

Digitaria ciliaris
Recorded by Cheeseman 1887 (as *Panicum sanguinale*).

Digitaria sanguinalis - crab grass
First collected in 1994 from Hostel steps.

Digitaria setigera
Recorded by Cheeseman 1887 (as *Panicum sp.*).
Growing with other grasses at road edge in dry pohutukawa forest.

Echinochloa utilis
Only reported in 1944 by Sorensen.

Eleusine indica
Recorded by Cheeseman 1887.
Noted in the middle of Boat Cove Road in dry forest before Rayner Point.

Holcus lanatus - Yorkshire fog
Recorded by Oliver 1908.
Very rare - Sykes.

Hordeum murinum subsp. *leporinum*
First collected by Sorensen 1944. Very rare - Sykes.

Lolium perenne - perennial ryegrass
Recorded by Cheeseman 1887 and Oliver 1908.

Oplismenus hirtellus subsp. *hirtellus*
Recorded by Cheeseman 1887 (as *O. compositus*).

Common in dry forest, usually at lower altitudes than *O. imbecillus.* Often grows alongside this other species.

Oplismenus hirtellus subsp. *imbecillus*
Collected by McGillivray 1854 and recorded by Hooker 1856 (as *O. aemulus*).
Recorded by Cheeseman 1887 (as *O. setarius*).
Often carpets the forest floor in dry forest, more widespread than the former species, and often at higher altitude.

Paspalum conjugatum - T grass
First collected by Sykes 1966-67. This is the very widespread, yellow-green grass with the bifurcate inflorescence (hence the name T grass) which grows extensively around Blue Lake, and is common along tracks, especially in open areas.

Paspalum dilatatum - paspalum
Recorded by Oliver 1908.
Grows in the dune slack near Denham's grave at Denham Bay. Also grows around the Hostel and Low Flat with buffalo grass and *Digitaria.*

Paspalum distichum - Mercer grass
Recorded by Sykes 1984 from a collection on the farm in 1978.

Paspalum urvillei - Vasey grass
Recorded by Sykes 1978 although first collected in by Cooper in 1956. Scattered along the road from Ravine 8 to Boat Cove Hut.

Phalaris minor
Only reported in 1944 by Sorensen.

Poa annua
Recorded by Cheeseman 1887 and Oliver 1908.
Some plants flowering on rock outcrops at the northern end of Denham Bay. Suddenly became apparent and increased in prominence in August as befits this late winter to spring annual.

Poa pratensis
Recorded by Cheeseman 1887 and last reported by Oliver in 1908.

Polypogon fugax
Recorded by Oliver 1908.

Sacciolepis indica
First collected by Sykes 1966-67.

Setaria pumila subsp. *pallidifusca* - millet
First collected by A.C.S. Wright 1949.
Common around the hostel, cow paddocks and along the road towards the airstrip.

Sporobolus indicus var. *capensis* - ratstail
Recorded by Oliver 1908.
Common along roads and in recently mown or open areas, e.g., airstrip, Turtle Bay.

Vulpia bromoides
Recorded by Oliver 1908.

Vulpia myuros
Recorded by Oliver 1908.

Vulpia myuros var. *megalura*
First collected by Sykes 1966-67. Abundant in Green Lake crater in open areas.

Appendix 3

NOTES ON DISTRIBUTION, PHENOLOGY, AND DATES OF FIRST KNOWN RECORDS OR COLLECTIONS OF PLANTS OF HISTORIC SIGNIFICANCE

Category C

Persistent relics of cultivation of historic significance or providing edible fruit which may be protected. First records are derived from the literature or from herbarium collections.

DICOTYLEDONS

ANACARDIACEAE

Mangifera indica - mango

First collected by West 1993. One large tree near the Kalona Plot felled when hit by a falling pohutukawa during Cyclone Sarah - still alive though. Cultivated relic.

ANNONACEAE

Annona cherimola - cherimoya, custard apple

Noted by Cheeseman 1887 (notebook).

A group of 5 trees, one of which has smaller leaves than the others, grows east of the Norfolk pines at Denham Bay. Appeared to have slight-moderate salt spray damage. Cultivated relic.

ARALIACEAE

Polyscias guilfoylei

First collected by Sykes 1974. A clump of 6 slender stems from a prostrate stem beneath pohutukawa and near an avocado grows just off the main road on the Terraces. There are two more trees further under the pohutukawa. Leaves are pinnate. Cultivated relic.

APOCYNACEAE

Nerium oleander - oleander

First collected by Sykes 1966-67. Persists around Bell's house site near the woolshed and planted around Hostel. Cultivated relic.

ASTERACEAE

Ageratum houstonianum - ageratum

Recorded by Cheeseman 1887 as abundant especially in abandoned cultivations. Recorded by Oliver 1908.

Very common in open places throughout the island in both wet and dry forest. In the clearing around Hutchisons Hut, Mahoe Hut, around the edge of Blue Lake, Rayner Pt, on rock outcrops at the northern end of Denham Bay. On bluffs above the Terraces. One isolated plant on Pukekohu was pulled out on 28/7/93.

Colonies beginning to flower abundantly from early July. Abundant on North Meyer on open slopes on western side.

CARICACEAE

Carica pubescens - mountain pawpaw

First recorded by Sorensen 1944. One mountain pawpaw found adjacent to a grove of peach trees in the central part of the orchard. Cultivated relic.

Carica papaya - pawpaw

No specimen in CHR. Several clumps of trees around the Hostel. Seedlings develop from fallen fruit. Some stems produced tightly bunched fruit, the others have fruit on a peduncle c. 50 cm long. Cultivated.

CONVOLVULACEAE

Ipomoea batatas - kumara

Noted by Cheeseman 1887 (notebook).

Not seen. Recorded and collected by Wynne Spring-Rice in 1990 from near Boat Cove Hut. She says it is "Owairaka Pink".

EUPHORBIACEAE

Acalphya wilkesiana

First recorded by Sykes 1966-67. Some plants persist by the Hostel but most are being overtaken by bamboo. One plant noted at the forest edge in the orchard. Cultivated relic.

FABACEAE

Sophora microphylla - kowhai

First recorded by Harper 1994. One fallen tree grows near the Braithwaite tanks. Cultivated.

Grant Harper has grown a plant from seed washed up on the beach. Potted up by glasshouse.

LAURACEAE

Cinnamomum camphora - camphor tree

First recorded by Bacon 1926-27. Tree died - Sykes.

Persea americana - avocado

First recorded by Sykes 1966-67. One small tree just off the main road near the Met. Station. One very large tree in the Kalona plot (damaged by pohutukawa which fell during Cyclone Sarah, but still alive) and on the other side of the track, one tall seedling. Leaves wind-damaged. Young plants in hostel gardens. Cultivated.

MELASTOMATACEAE

Tibouchina urvilleana

First recorded by Sorensen 1944. Covers a large area north-west of the dates by Denham Bay hut. Flowering in the fern clearing in early August.

MORACEAE

Ficus carica - fig

First recorded by Morton 1964. Four trees in a clump at Denham Bay by the poison shed at the northern end of the lagoon. One tree near the lime behind the Met. Station. One noted amongst grapevines at the head of Low Flat beach road. Not seen at Rayner Point. Entirely leafless in July.

Ficus macrophylla - Moreton Bay fig

First collected by Cooper 1956. One large tree with numerous prop roots grows back from the road behind the Met Station.

Morus alba - mulberry
First recorded by Oliver 1908. A large thicket grows directly behind the implement shed. Fruit ripening in August (1993) and being eaten by birds. Many ripe fruit in October 1994.

MYRTACEAE
Eucalyptus globulus
First collected by Sykes 1966-67. May no longer exist.

Eucalyptus maculata
First collected by Sykes 1966-67. Large tree with fallen trunks grows by the Hut at Denham Bay.

Syncarpia glomulifera - turpentine tree
First collected by Sorensen 1944. Large fallen trunk with numerous upright leaders seen flowering and fruiting on 4/8/93. Grows beside the eucalypt. New foliage very hairy.

PROTEACEAE
Macadamia tetraphylla - macadamia
First collected by Sykes 1974. A group grows at the back of the Terraces, past the burning pit. Some of these, including the largest, fell during Cyclone Sarah - still alive. All nuts seen were eaten by rats. A single tree grows near the small avocado just off the main road near the Met. Station.

ROSACEAE
Eriobotrya japonica - loquat
Plant died recently - Sykes.

RUBIACEAE
Coffea arabica - coffee
First recorded by Davison 1938 and collected by Sorensen 1944. Cheeseman 1887 in his notebook records: "a rubiaceous plant, evidently an outcast from some garden, was also not uncommon" in Denham Bay.

RUTACEAE
Citrus aurantifolia - lime
Noted by Cheeseman 1887 (notebook).
One layered tree grows on the Terraces at the side of a track south of the Met. Station. At Denham Bay, a group north of the hut were flowering and fruiting in July/August. One further clump grows north of Route 77 near an old hearth and with *Cordyline fruticosa.* This was also flowering and fruiting. Cultivated relic.

Citrus limon - lemon
Noted by Cheeseman 1887 (notebook).
Trees by the Hostel. Cultivated.

Citrus medica - citron
Noted by Cheeseman 1887 (notebook).
One tree seen on Low Flat. Fruit on it in winter. A group grows near the turpentine tree at Denham Bay. The fruit of these are more knobbly and orange than those at Low Flat. Also, the aroma of the fruit is less lemony - more soapy - the pith is not so thick, and it has seeds. Cultivated relic.

Citrus paradisi - grapefruit, shaddock
Noted by Cheeseman 1887 (notebook).
At least one tree on the Terraces, fruiting at this time of year. One tree grows at Denham Bay about halfway between Denham Bay Hut and the Norfolks and c. 30 m back from the forest edge. The fruits of this tree are very large with thick pith. Cultivated relic.

Citrus reticulata - mandarin
First collected by Sykes 1984. One small tree on the Terraces with small, firm-skinned flesh on the fruit. Cultivated relic.
First collected by West 1994. One large tree just east of Ravine 8 and south of the road with large, loose-skinned fruit. This was almost defoliated by salt spray in a storm in winter 1993. By October 1994, the tree had recovered by producing epicormic shoots. One ripe fruit present in the middle of the tree then.

Citrus sinensis - orange
Noted by Cheeseman 1887 (notebook).
Many trees on the Terraces and two tall trees on Low Flat. A small group of trees at Denham Bay near the hut. A windfallen tree in this group has upright growth with fierce spines. Two further trees grow near the poison shed at the north end of Denham Bay lagoon. One tree below Devastation Ridge plot (c. 18 cm d.b.h.) in forested gully near edge of Blue Lake. One tree opposite storage shed on Fishing Rock road and 2-3 trees on the ski slope (near the sign) and one on Judith above the road (not seen by me - Len Webb).

VERBENACEAE
Vitex lucens - puriri
First collected by Davison 1937. One tree grows in forest just behind the Braithwaite tanks. The diameter at breast height of this tree was 43.0 cm on 12/7/93. Two more trees grow near this large one. A small, multi-stemmed tree is c. 5 m north-west of this one and the other was not seen by me. According to Wynne Spring-Rice's records, there are possibly two more trees on the terraces, inland from the airstrip. Cultivated relic.

MONOCOTYLEDONS
ARACEAE
Colocasia esculenta - taro
Noted by Cheeseman 1887 (notebook).
Seen at Lava Point spring from the sea.

Xanthosoma sagittifolium - taro tarua
First collected by Sykes in 1967 beside the road near Low Flat turn-off. Also grows down Low Flat gully nearby.

ARECACEAE
Cocos nucifera - coconut
One plant 4-5 m tall grows just south of the Norfolk pines at Denham Bay. It has a trunk 1-1.5 m tall and c. 25 cm d.b.h. In October 1994 this tree looked rather storm-ravaged. There is also a plant at the Kalona plot which has a trunk c. 1.5 m tall. This tree managed to escape the falling pohutukawa from Cyclone Sarah. Cultivated relic.

CANNACEAE

Canna indica - Indian shot

No specimen in CHR. Grows in Denham Bay on or near the site of the old Bell homestead. Until recently was covered by Mysore thorn. In June 1993 one plant in flower was seen in the vicinity of the poison shed at the northern end of the lagoon, by John Dodgson.

MUSACEAE

Musa sp. – banana

Noted by Cheeseman 1887 (notebook).

Growing around the Hostel and in Bell's Ravine. A planting at Mahoe Hut does not appear to have survived although plants apparently bore fruit up there. Cultivated relic.

PHORMIACEAE

Phormium tenax - NZ flax, harakeke

First recorded by Sorensen 1944. A planted semicircular line of harakeke is just back from the beach at the southern end of Denham Bay and is visible from the beach behind *Coprosma petiolata* and ngaio. The plants are tall and straight with no sign of flower stalks, old or new, either in 1993 or 1994.

Appendix 4

DIAMETER AT BREAST HEIGHT AND CONDITION OF THE 48 NORFOLK PINES IN THE VICINITY OF THE WOOLSHED IN 1993.

Original trees

D.B.H.	CONDITION
188.0	heartrot, low branching
184.0	heartrot
174.5	heartrot
169.0	heartrot
166.0	heartrot
164.0	heartrot
161.0	heartrot
160.0	heartrot
156.5	heartrot
155.0	heartrot, wire
151.0	heartrot
147.5	heartrot, wire

Progeny

D.B.H.	CONDITION
124.5	sound
122.5	sound, low branching
110.0	sound, low branching
105.0	sound, low branching
98.0	sound, low branching
98.0	sound
94.0	sound
92.5	sound
89.0	sound
86.0	sound
83.0	sound
82.5	sound
82.0	sound
82.0	sound
79.5	sound
79.0	sound
78.5	sound
76.0	sound
74.5	sound
72.0	sound
71.0	sound
69.5	sound
65.0	sound

D.B.H.	CONDITION
64.0	sound
60.0	sound
56.0	standing dead
50.0	sound
50.0	sound
44.0	standing dead
43.5	sound
41.0	sound
35.5	sound
35.0	sound
33.5	sound
29.0	sound
21.0	sound