# Status of Kermadec red-crowned parakeets and the likely effects of a proposed kiore eradication programme

## Macauley Island expedition July 2002

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## Macauley Island expedition July 2002

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## ABSTRACT

Macauley Island in the Kermadec Group, northeast of New Zealand, was visited in July 2002 to investigate the potential risk to the resident population of Kermadec red-crowned parakeets *Cyanoramphus novaezelandiae cyanurus* of a proposed kiore *Rattus exulans* eradication programme. Ecological and behavioural observations were made of the Macauley Island parakeet population and feather samples collected. The status of kiore and seabirds on Macauley Island and Haszard Islet was assessed, and plant communities monitored. To simulate an eradication operation, 50 kg of non-toxic cereal baits containing pyranine biotracer were spread by hand over 6 ha at a concentration of 8 kg/ha. Parakeets were then observed and / or captured and examined for any evidence of bait ingestion. None was found. The parakeet population on Macauley Island was estimated at 8000–10 000 birds despite a perceived contraction in suitable habitat. Kiore numbers were very low on Macauley Island and there was little evidence for their presence on nearby Haszard Islet. Vegetation on Macauley Island was dominated by the fern *Hypolepis dicksonioides,* a dramatic change from the vegetation observed in 1988. Notable botanical finds included the discovery of *Achyranthes aspera* and *Lepidium oleraceum* on Macauley Island. It was concluded that risks to the Macauley Island parakeet population from the proposed kiore eradication programme were negligible and that kiore eradication should proceed, providing a number of conditions are met. More regular monitoring of the vegetation changes and of their impact on the ecology and communities of Macauley Island is recommended.

Keywords: red-crowned parakeets, *Cyanoramphus novaezelandiae cyanurus*, kiore, *Rattus exulans*, eradication, monitoring, seabirds, vegetation, succession, Kermadec Islands, Macauley Island, New Zealand.



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# 1. Introduction

The eradication of introduced mammalian pests from Macauley Island and Raoul Island in the Kermadec group was scheduled for the winter months of 2002. However, several concerns were raised by Friends of the Earth over the proposed aerial application of toxic baits containing brodifacoum on Macauley I. Firstly, Macauley I. is the major population stronghold for the Kermadec red-crowned parakeet *Cyanoramphus novaezelandiae cyanurus*, which could be at risk during the kiore *Rattus exulans* eradication programme. Secondly, there was no information on the diet and foraging behaviour of the parakeets during the period of the year proposed for the aerial operation. Finally, the current numeric and taxonomic status of the parakeets was uncertain or unknown.

Although there has been no detectable effect on the resident parakeet populations following a number of similar aerial poisoning operations on numerous offshore islands since 1989 (McFadden & Greene 1994; Towns et al. 1994; Empson & Miskelly 1999; Towns & Broome 2003), it was agreed to postpone the eradication of kiore on Macauley I. until these concerns could be addressed.

A visit to Macauley I. was planned for the winter of 2002. During this visit the authors aimed to:

- Assess the likelihood of cereal pellet bait ingestion by Kermadec red-crowned parakeets and other non-target species.
- Record the winter diet and foraging behaviours of Kermadec red-crowned parakeets on Macauley I.
- Estimate the population size of Kermadec red-crowned parakeets on Macauley I.
- Collect parakeet feather samples for genetic analysis.
- Assess bait palatability to kiore on Macauley I.
- Attempt to visit Haszard Islet and assess its rodent status and that of its native flora and fauna.
- Assess the presence and abundance of seabird species on Macauley I.
- Assess the status of terrestrial bird species on Macauley I.
- Monitor changes in plant communities on Macauley I.
- Collect invertebrates on both Macauley I. and Haszard Islet.

# 2. Itinerary and study areas

Transportation to the southern Kermadec Islands was provided by the vessel *Braveheart*, and a Robinson R22 helicopter. We left Auckland at 1700 h on 18 July 2002. Extremely fine and calm conditions were experienced on the trip north, resulting in a course deviation to L'Esperance Rock which was reached about 1500 h on 20 July 2002. About an hour was spent sailing around the islet in flat calm conditions before sailing on to Curtis and Cheeseman Is. These islands were reached about 2130 h with the remainder of the night spent anchored off Curtis I. near the mouth of the active crater. By 1000 h on 21 July 2002 the Institute of Geological and Nuclear Science (IGNS) team visiting Curtis I. had been successfully offloaded by helicopter and by about 1200 h we had reached Macauley I. In a very calm sea Paul Scofield, Terry Greene and Peter Dilks were flown from the *Braveheart* onto Macauley I. to the only place between Access Gully and Sandy Bay that the helicopter could be set down. A suitable site for a campsite amongst dense fern was located nearby and all remaining gear delivered to this point (Fig. 1). Fine weather and the calm sea allowed the Macauley I. party to then be landed on the top and the lower slopes of Haszard Islet between 1400 h and 1545 h before being returned to Macauley I. After securing the helicopter, *Braveheart* then departed for Raoul I. We remained on Macauley I. until 26 July 2002 when we were flown back onto the *Braveheart* between 0830 h and 0900 h. Curtis I. was reached at 1130 h with our departure occurring at about 1500 h. During this time the transfer of IGNS staff and equipment from Curtis I. was completed and about 40 min was spent ashore on Cheeseman I. by Paul Scofield and Terry Greene. After a very rough trip we arrived back at Auckland at 1100 h on 29 July 2002.

## 2.1 MACAULEY ISLAND—ACCESS AND CAMPSITES

Macauley I. (30°13′S, 178°33′W) is the remnant (282 ha) of an extinct basaltic volcano bounded on all sides by vertical coastal cliffs (Fig. 1). The top of the island is a sloping plateau which steadily climbs from the relatively low eastern cliffs about Windy Head to the summit of Mt. Haszard (240 m) in the northwest. The plateau itself is heavily dissected by numerous erosion gullies, some of which have developed into vertical-sided ravines where they exit through the sea cliffs. Only a few of these ravines provide practical and safe access from the coast to the interior of the island.

Previous expeditions to Macauley I. have usually been landed by sea and had therefore chosen to base themselves at Sandy Bay—the only sandy beach in an otherwise unbroken rocky coastline (Williams & Rudge 1969; Taylor & Tennyson 1988). A talus platform caused by the collapse of the tuff cliff behind the beach was usually used for a campsite. By 1988 this platform was being actively eroded by the sea (Taylor & Tennyson 1988). By the time of our visit the entire remaining talus platform had been washed away, rendering Sandy Bay unsuitable as a campsite. We spent very little time on the coast during our visit, but other visitors might find a possible campsite at the mouth of Access Gully, although exposure to high winds and seas from the north and east as well as flooding during heavy rain would make this a risky option. Our ability to utilise a helicopter to transport team members and equipment to the top of the island rather than landing by sea proved essential to the success of this short visit.

Access to the coast was achieved via Access Gully, Quadrat Gully and the Lava Cascade (Fig. 1). Unlike the situation in 1988, Quadrat Gully was easily negotiated both to and from the coast. This gully is, however, very deeply entrenched and only just wide enough for a person to fit through, thereby

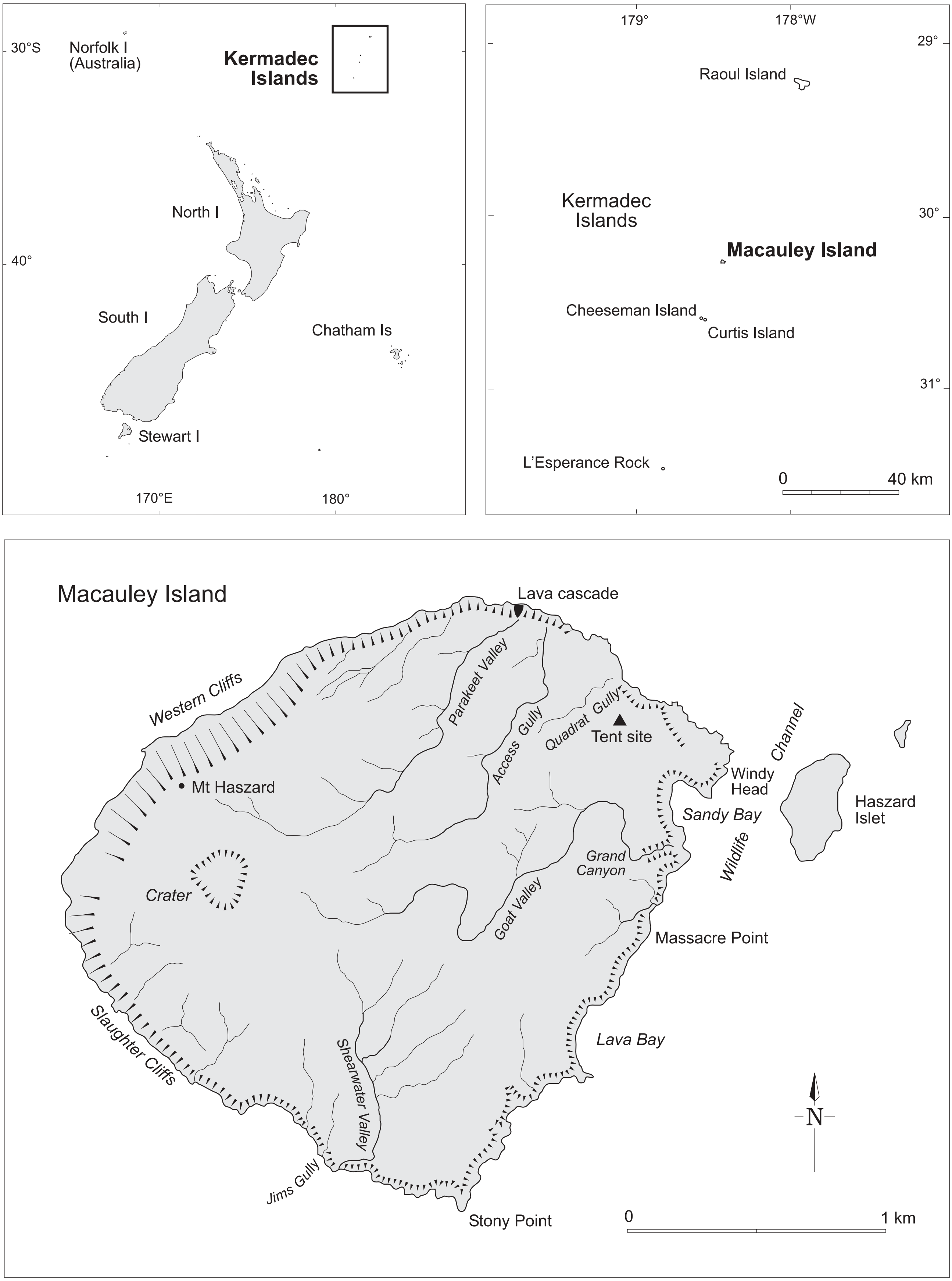



Figure 1. Location map of Macauley Island (tick marks denote cliffs).

limiting its usefulness as a main thoroughfare. These changes since 1988 seem to reflect the continued active erosion of the island by water (Williams & Rudge 1969; Taylor & Tennyson 1988) and the geological instability of the area (one small earthquake was felt during our visit). The lava cascade is very steep and probably too dangerous for anything other than emergency access, given the available alternatives. Such access points and campsites should not be taken for granted on future visits.

Although the top of Macauley I. is relatively flat, particularly on the lower slopes, locating a suitable campsite was a challenge. A decision was made to site the campsite in an area of *Hypolepis dicksonioides* fern about 1.5 m high south of Quadrat Gully. The fern was easily trampled to provide a flat area in which our tents could be pitched and a helicopter landed. The depth of the vegetation and the very friable soil made standard tent pegs useless. Sections of mist net pole were required to secure our tents and withstand gale-force winds and rain.

## 2.2 HASZARD ISLET—ACCESS

Haszard Islet lies about 300 m East of Windy Head and Sandy Bay (Fig.1). The island is about 300 m long and 100 m across at its widest point and is entirely cliff-bound. The eastern face is almost vertical and completely inaccessible. The western side has a large sparsely vegetated talus slope resulting from a collapse of the tuff cliffs above. Access to the summit from the lower slopes appears impossible.

Although a landing could be made on this island from the sea, conditions would have to be very calm to avoid the influence of large ocean swells that tend to be funnelled through the channel between Macauley I. and Haszard Islet (Fig. 1). On arrival at Macauley I. we took advantage of the presence of the helicopter and the settled weather and sea conditions to visit Haszard Islet. As far as we are aware, this was the first landing on this island and the first visit to the summit plateau.

## 2.3 CHEESEMAN ISLAND—ACCESS

Cheeseman I. is a small (7.6 ha) rocky island lying approximately 20 km south-southwest of Macauley I. (Fig. 1). Apart from a small section of its western coastline, Cheeseman I. is almost entirely cliff-bound with very limited access from the sea. Landing on this island from the sea could only be accomplished in the calmest of sea conditions. The island is predominantly rocky with steep slopes descending into a small central gully that exits on the western coast. Very little woody vegetation is present and areas where soil has accumulated are heavily burrowed by seabirds.

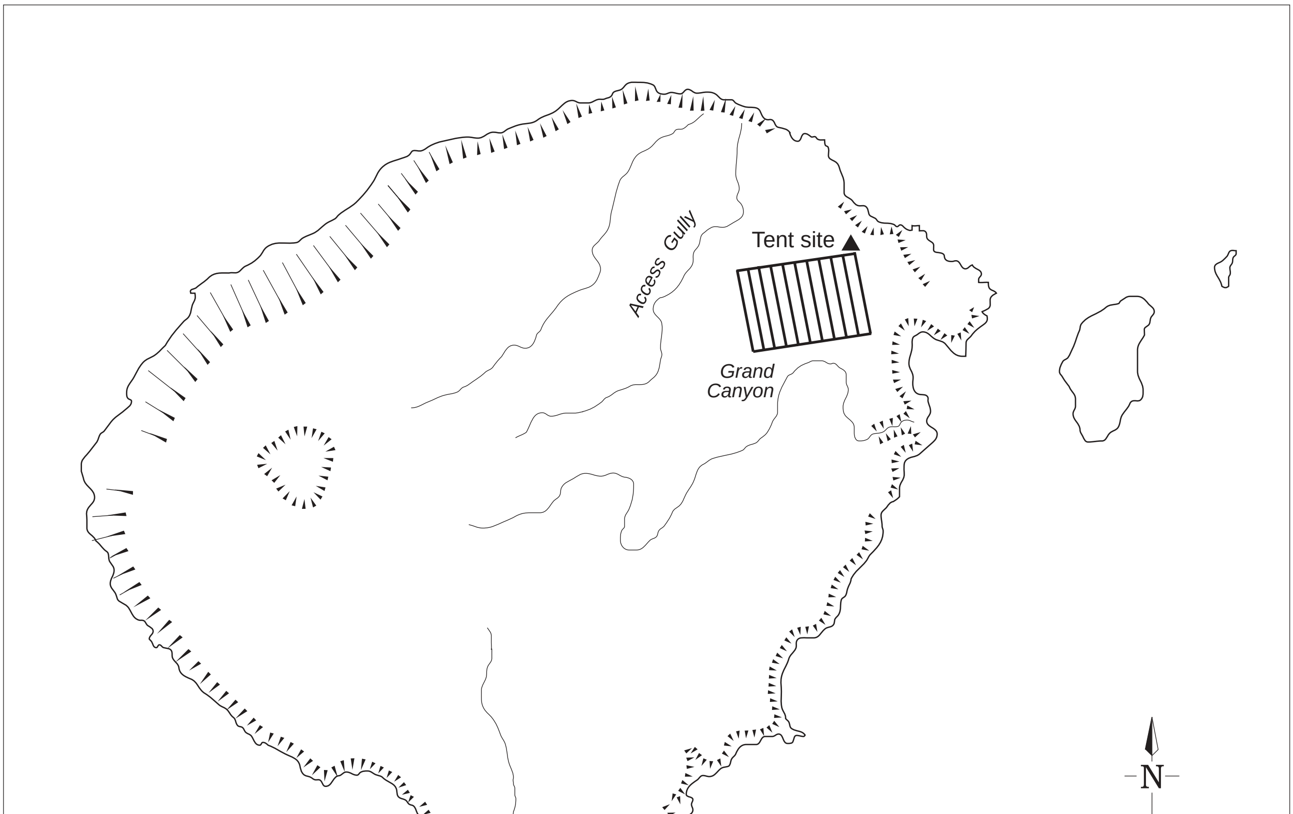
A short visit of about 40 min was only possible because of the presence of the helicopter and the need to remove IGNS staff and equipment from Curtis I. during the return voyage. As far as we are aware, this is the first visit to Cheeseman I. for about 20 years.

# 3. Methods

## 3.1 ASSESSMENT OF THE RISKS OF KIORE ERADICATION TO KERMADEC RED-CROWNED PARAKEETS

Fifty kilograms of non-toxic bait was provided for this operation. Pestoff 20R baits, 12 mm in diameter and weighing approximately 2 g, were used. These baits contained pyranine (at a concentration of 0.4% w/w) as a biotracer (it also dyed the baits pale green) but no lure, wax coating or Bitrex®. During the voyage to Macauley Island, we measured the bait into 500-g lots. On arrival, a study area was chosen between our campsite and the Grand Canyon (Fig. 2). This contained dominant vegetation types (*Cyperus ustulatus*, *Scaevola gracilis* and *Hypolepis dicksonioides*). To simulate an aerial bait operation, a grid of 11 lines running north / south and 25 m apart was established using a compass and two rangefinders. The location of the end of each line was recorded using a handheld GPS. At 25-m intervals along each line, a 500-g bag of bait was spread by hand around each point as evenly as possible. On 22 July 2002 a total area of about 6 ha received bait coverage at the recommended 8 kg/ha density. Application of the bait took three people 5 h.

Figure 2. Location of bait grid (vertical lines) on Macauley Island.



Strong winds and squalls severely hampered attempts to directly observe or capture parakeets' response to the baits until 24 July 2002. The return of the fine weather enabled us to erect four mist nests toward the eastern boundary of our bait grid. This area was chosen mainly because of the abundance of *S. gracilis*, upon which numerous parakeets fed. Despite the breezy and bright sunny conditions encountered, a total of 31 parakeets (19 female and 12 male, all adults) were captured. All birds captured were weighed, measured and had feather samples removed. They were banded with a single metal band and examined for traces of the fluorescing pyranine biotracer using a UV light source in darkened conditions. Birds were checked for pyranine about the bill and cloaca. The inside of catch bags and other faecal material were also checked for traces of pyranine (Appendix 1).

## 3.2 DIET AND FORAGING BEHAVIOUR OF KERMADEC RED-CROWNED PARAKEETS ON MACAULEY ISLAND

There was insufficient time to make systematic feeding observations of Kermadec red-crowned parakeets on Macauley I. Instead, foraging observations were recorded opportunistically and only the 'first food' seen consumed (Greene 1998) was recorded. The records are, therefore, heavily biased toward the areas most frequently visited by observers and the foods most commonly eaten at the time of year the records were made.

## 3.3 ESTIMATION OF THE POPULATION SIZE OF KERMADEC RED-CROWNED PARAKEETS ON MACAULEY ISLAND

During the July 2002 visit we attempted to estimate the density and abundance of the red-crowned parakeet population on Macauley I. using distance sampling methods (Buckland et al. 2001). In summary, this technique involves measurement of the distance of a target object (in this case a parakeet or group of parakeets) from a sampling line or point and then attempting to model the observed decline in detectability using program DISTANCE (Barraclough 2000; Buckland et al. 2001).

On arrival at Macauley I., it was immediately apparent to us that a random or systematic survey design over representative habitats would not be possible given the limited amount of time available. For this reason most of the sampling was either conducted in the immediate vicinity of the campsite where we had established a rat-trapping grid or in areas where access was reasonable, such as gullies and near the edges of cliffs (Fig. 3). A total of 16 line transects totalling 3152 m were surveyed within an approximate area of 73 ha. Groups of Kermadec red-crowned parakeets were recorded as clusters and distances (perpendicular to the line) measured to the centre of these clusters. The size of each cluster was also recorded. Parakeets flying into or over the count area were excluded from the analysis. Every effort was made to record the perpendicular distance from the line to the point from which birds were flushed. All distances were recorded to the nearest metre (to a maximum of 50 m) using a laser rangefinder.

## 3.4 STATUS OF KIORE ON MACAULEY ISLAND AND HASZARD ISLET

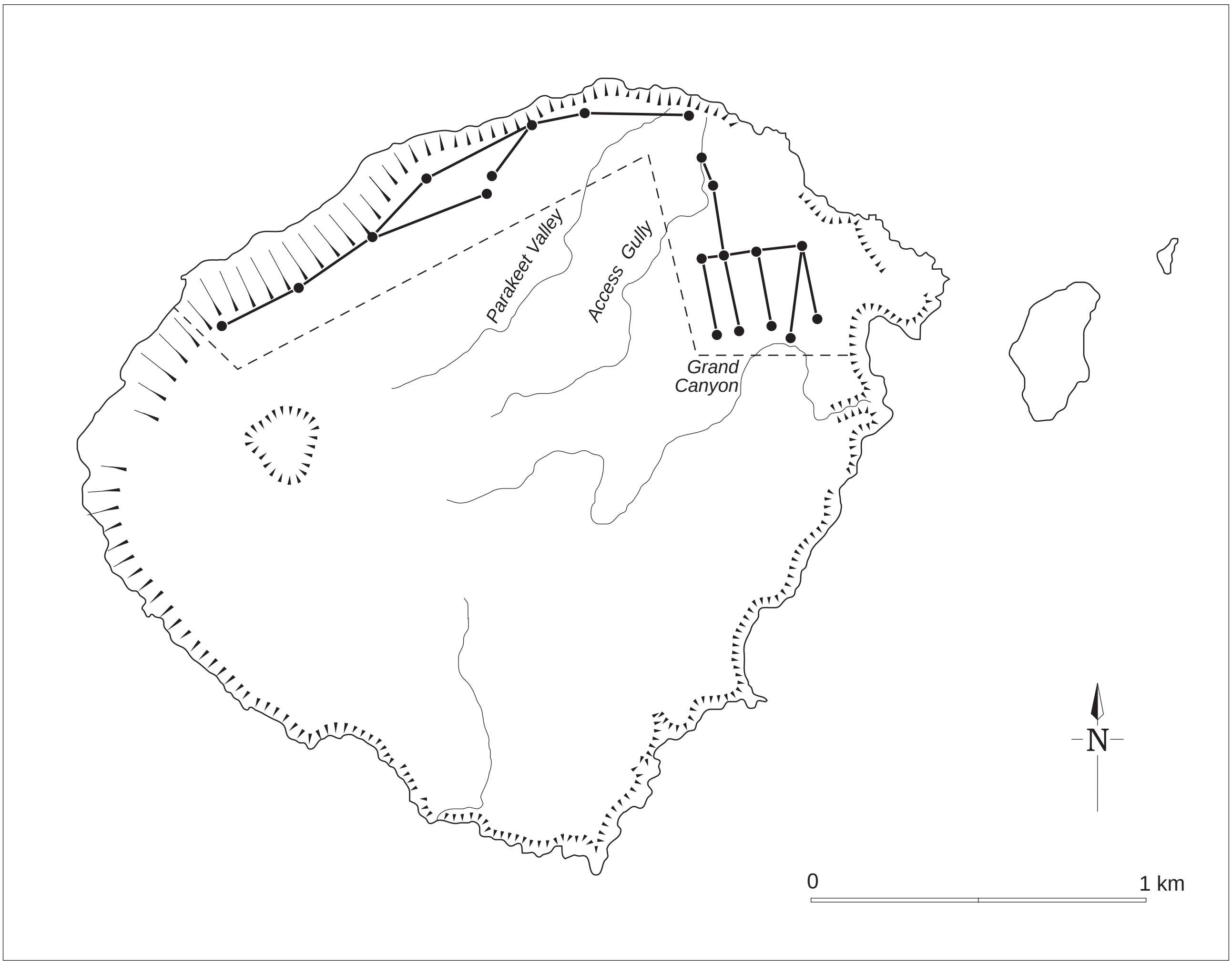
To assess kiore status and abundance as well as the palatability of the non-toxic baits to kiore on Macauley I., standard snap traps were set around the campsite and within the bait grid (four lines of eight traps, 25 m apart). Traps were baited with a mixture of peanut butter and sardines and checked daily for 104 trap nights following the spread of non-toxic baits.

During our short visit to Haszard Islet a basic search was made for evidence (faeces, feeding sign, corpses, etc.) of kiore.

## 3.5 OBSERVATIONS OF BIRDS, PLANTS AND INVERTEBRATES SEEN ON THE SOUTHERN KERMADEC ISLANDS

Given the infrequent number of visits to the islands of the southern Kermadec group, every opportunity was taken to record general observations that we thought might be of interest. In particular, notes were made on all birds encountered and a rough estimate made of their numbers and / or size of their colonies. Dead birds were also collected for museum (Canterbury) collections

Figure 3. Location of parakeet sampling transects (n = 16) on Macauley Island.



and a list of these can be found in Appendix 2. Feather samples from captured Kermadec red-crowned parakeets were also collected and have been forwarded to the School of Biological Sciences, Victoria University of Wellington for analysis as part of an ongoing taxonomic revision of the genus *Cyanoramphus*.

Notes were also made on the flora of the three islands visited, with particular attention paid to current vegetation patterns and species records of interest. Plant specimens collected have also been deposited in a museum (Auckland) and a list of these can be found in Appendix 3.

Invertebrates were collected on an *ad hoc* basis whenever and wherever the opportunity presented itself. Efforts were made to collect samples on both Macauley I. and Haszard Islet in all of the habitats we visited. All samples were placed directly into alcohol and forwarded to Chris Green, an entomologist working for the Department of Conservation in Auckland.

# 4. Results and discussion

## 4.1 RISKS OF KIORE ERADICATION TO KERMADEC RED-CROWNED PARAKEETS

None of the birds examined showed any traces of pyranine, nor were any parakeets seen foraging directly on baits. Direct foraging observations, however, were difficult to record in dense vegetation. It is possible that some parakeets fed on baits then moved out of the area undetected and uncaptured. Poor weather immediately following bait distribution may have also compromised the palatability of baits. In addition, the area over which baits were spread was small and only in one part of Macauley I. Some habitats, such as bare scoriacious slopes in gullies, cliffs and very low littoral vegetation (e.g. *Disphyma australe*), could not be sampled given the quantity of bait provided, the logistics involved in spreading bait by hand, and the short visit to the island.

By far the bulk of the bait penetrated the vegetation and was immediately lost to sight. Most parakeets were observed feeding on top of the vegetation (see Section 4.2). This would reduce the chance of parakeets encountering aerially applied baits over much of the island. Exceptions to this would be relatively small areas of very short vegetation on the littoral / cliff edge and amongst exposed scoria 'soils'. It should be noted that parakeets are also likely to be encountered in these areas (see Section 4.2) and, as such, will be at increased risk from toxic baits.

Macauley I. is covered in low, dense sedges and ferns with few trees. This vegetation is similar to that of other islands from which kiore have been eradicated. Burgess Island (in the Mokohinau group), for example, has few large trees but large areas of dense, low *Cyperus* sp., buffalo grass *Stenotaphrum secundatum* and rank pasture grasses. Kiore were successfully eradicated from Burgess I. following an aerial bait drop (at 30 kg/ha) in 1994, and there was no detectable impact on its red-crowned parakeet *C. n. novaezelandiae* population (McFadden & Greene 1994). Similarly, aerial application of toxic baits over significant areas of mowed and rank pasture grasses on Tiritiri-Matangi Island had negligible effect on the resident red-crowned parakeet population, despite this being a favoured foraging habitat (Greene 1998).

## 4.2 DIET AND FORAGING BEHAVIOUR OF KERMADEC RED-CROWNED PARAKEETS ON MACAULEY ISLAND

Table 1 summarises observations of plant species and food types consumed by parakeets and provides a subjective assessment of their dietary importance. It is worth noting that we never saw parakeets eating any part of *Hypolepis dicksonioides,* despite its dramatic increase in abundance over the top of the island.

## 4.3 ESTIMATION OF THE POPULATION SIZE OF KERMADEC RED-CROWNED PARAKEETS ON MACAULEY ISLAND

Analysis of the data collected (following truncation of the distance data to only include recorded distances between the transect line and parakeets of less than 13 m) using program DISTANCE (Buckland et al. 2001) suggested that both half-normal and uniform models described the data well ($\Delta AIC_c$ = 1.21 and high Goodness of Fit (GOF), Table 2)[1]. Model averaging and the derivation of unconditional variances (see Burnham & Anderson 1998) provided the estimates of density and abundance presented in Table 2.

TABLE 1. OPPORTUNISTIC OBSERVATIONS OF KERMADEC RED-CROWNED PARAKEET FOOD ITEMS AND SUBJECTIVE ASSESSMENT OF DIETARY IMPORTANCE.

| PLANT SPECIES | FOOD TYPE | IMPORTANCE |
|---|---|---|
| *Myoporum kermadecense* | Flowers | Rare |
| *Cyperus ustulatus* | Leaves | Some |
| *Scaevola gracilis* | New leaves / leaf buds | Common |
| | Flowers | Rare |
| *Solanum americanum* | Berries | Some |
| | Flowers | Some |
| *Leptinella australis* | Flowers | Common |
| *Pseudognaphalium luteoalbum* (?) | Flower buds (?) | Rare |
| *Oxalis corniculate* | Seeds | Rare |
| *Lepidium oleraceum* | Leaves (?) | Possibly common on Haszard Islet; rare / nonexistent elsewhere |
| *Ipomea cairica* | Leaves | Some—restricted to relatively small area |
| *Bidens pilosa* | Flowers and seeds | Common |
| *Polycarpon tetraphyllum* | Seeds | Common |
| *Disphyma* spp. | Leaves | Common |
| *Sicyos angulata* | Flowers / buds | Some |

[1] $\Delta AIC_c$ refers to the difference in Akaike Information Criterion adjusted for small sample sizes. The larger the $\Delta$ value (> 2 units), the less support there is for the model.

Although model fit was good, the variance estimates were very high. This was probably a function of the number of transect lines (only 16—as opposed to a minimum of 20 recommended by Buckland et al. 2001), the short length of some, the lack of independence between lines, the poor distribution of sampling effort (i.e. line placement) over the island and the large variation in encounter rates of parakeets between these lines.

Encounter rate ($n$/L; where $n$ is the number seen and L the length of the line) varied from a high of 0.2 parakeets/m (in *Cyperus ustulatus* / *Solanum* / Grass spp. habitats) to a low of 0.006 (in *Hypolepis dicksonioides* ferns with small patches of *C. ustulatus*). The average encounter rate across all transects was 0.03 parakeets/m (95% CI = 0.02–0.05). This suggests that those habitats comprising virtual monocultures of *C. ustulatus* and *H. dicksonioides*, or a mix of both, supported very low densities of parakeets. Our disproportionate sampling of coastal, gully and cliff habitats, however, effectively skewed the sampling frame toward those areas with greatest botanical diversity and an apparent high density of parakeets. Given the large areas of Macauley I. now covered by low-diversity habitats (see Section 4.6.1), any attempt to extrapolate our results to the rest of the island would be inappropriate. However, using this information and making allowance for the sampling bias, we estimate the parakeet population at 8000–10 000 birds, similar to that recorded in 1980 (Taylor 1985).

Previous estimates of the parakeet population have usually been little more than informed guesses (Taylor 1985). In 1966, a population of about 1000 parakeets was estimated (Taylor 1985). Subsequently, more robust estimates were calculated by counting all parakeets within 'representative' quadrats of known size, then extrapolating this figure over the rest of the island (Taylor & Tennyson 1988). Using this method, the parakeet population was estimated at between 17 000 and 20 000 birds during September 1988. Two months later, using the same method, the parakeet population was estimated at between 1700 and 2000 birds (Tennyson et al. 1989). The driving forces behind such massive fluctuations remain unknown, although seasonal drought and food shortages on the island have been implicated (G. Taylor, DOC, pers. comm.; Tennyson et al. 1989).

This result confirms the status of Kermadec red-crowned parakeets on Macauley I. as locally abundant. However, whether this estimate is indicative of an actual decline in the population since 1988 (perhaps mediated by significant changes in vegetation) and / or sampling error is unknown. More accurate assessments of the population size will only be possible given appropriate time scales and a more representative sampling regime.

TABLE 2. DENSITY AND ABUNDANCE ESTIMATES FOR KERMADEC RED-CROWNED PARAKEET.

| | ESTIMATE | CV[1] (%) | 95% CI[2] | GOF[3] | NO. OF OBSERVATIONS |
|---|---|---|---|---|---|
| Density (birds/ha) | 41.9 | 23.0 | 26.2 – 66.1 | 0.60 | 96 |
| Abundance[4] | 3059 | 23.0 | 1908 – 4824 | | |

[1] CV = Coefficient of variation

[2] CI = Confidence interval

[3] GOF = Goodness of fit

[4] Parakeet abundance within the 73 ha sampled

Future sampling of the Macauley I. parakeet population should continue to be based on distance sampling methods (or some other relatively 'unbiased' estimator) using clusters as the sampling units so that absolute measures or density and abundance (rather than indices such as 5 min counts) can be derived and compared over time. Every effort should also be made to sample as representative an area of the island's habitats as possible. Although a minimum of 20 independent line transects arranged systematically with a random start is recommended (see Buckland et al. 2001), we acknowledge this is likely to be logistically difficult to put into practice.

## 4.4 STATUS OF KIORE ON MACAULEY ISLAND AND HASZARD ISLET

As on previous winter visits to Macauley I., we saw very little evidence for the presence of kiore. One fresh, partly eaten rat corpse, presumably killed by one of the Australasian harrier hawks *Circus approximans* on the island, was found near the Grand Canyon soon after our arrival. A second, mummified corpse was subsequently located within Quadrat Gully. Both rat corpses have been deposited with the Canterbury Museum.

No rats were captured nor were any traps sprung during the period spent trapping on Macauley I. No evidence for live kiore was seen until the last night on the Island, when two kiore were seen fighting adjacent to the campsite. Whether kiore on Macauley I. find the type of baits to be used for the rat eradication operation palatable remains unknown, although evidence from elsewhere suggests that palatability is unlikely to be a significant concern (McClelland 2002).

No evidence for the presence of kiore on Haszard Islet was found. We saw numerous intact fruits and seeds on the ground (particularly under ngaio *Myoporum kermadecense* scrub), many small centipedes and Hawaiian beet moths *Spoladea* (*Hymenia*) *recurvalis* that were uncommon on Macauley I., and small petrel burrows (most probably the Kermadec white-faced storm petrel *Pelagodroma marina albiclunis*). Given the islet's small size and its close proximity to Macauley I., it would be prudent to assume that kiore may be present in low numbers on Haszard Islet. Any future attempt to eradicate kiore from Macauley I. should, therefore, include sufficient bait to treat Haszard Islet, as a precautionary measure, as well.

## 4.5 ANNOTATED LIST OF BIRDS SEEN ON THE SOUTHERN KERMADEC ISLANDS

### Kermadec petrel (*Pterodroma neglecta*)

One pale-phased bird was seen flying close to L'Esperance Rock on 20 July and one near Curtis I. on 21 July. Two dark-phased birds were seen on the ground on inaccessible cliffs on the eastern side of Haszard Islet. An adult dark-phase bird on an egg in an area of *Cyperus ustulatus* behind the beach on the western side of Haszard Islet was photographed by PJD. We saw six birds of the three known colour phases flying over Haszard Islet and around Sandy Bay cliffs on 21

July and three on 22 July. A corpse was found on the Perpendicular Cliffs but no breeding birds were located during our quick survey. We saw a single chick (nearly fledged, probably of the intermediate phase) on the ground on Cheeseman I. On 26 July, between leaving Macauley I. and arriving at Cheeseman I., we saw 20–30 Kermadec petrels of all three colour phases.

**Providence petrel (*Pterodroma solandri*)**

On 26 July, between leaving Macauley I. and arriving at Cheeseman I., we saw at least five providence petrels.

**Black-winged petrel (*Pterodroma nigripennis)***

Our subjective estimates of burrow density and corpse numbers, when compared with similar estimates made by RPS on Macauley I. in 1988, suggest that the increase in fern cover has not affected the huge numbers of this species breeding on Macauley I. The large number of corpses, and burrows of a size made by black-winged petrels, suggest this species is also the dominant summer nester on Cheeseman I. and Haszard Islet.

**White-naped petrel (*Pterodroma cervicalis*)**

Similarly, our subjective estimates and comparisons of them with those made by RPS in 1988 suggest that the increase in fern cover has not drastically affected the numbers of white-naped petrels breeding on Macauley I. This species appears to be most common at the eastern side of the island. Large numbers of corpses (> 50) in Access and Quadrat Gullies suggest healthy populations there. The loss of the talus slope in Sandy Bay has meant the loss of nesting sites for the c. 200 pairs that nested here in 1988. If this loss occurred during the summer (i.e. during a tropical cyclone) it may have been detrimental to the population. However, if it was during the winter, then most birds would probably have moved up onto the plateau. The large size of a number of burrows and the finding of an egg confirm this species is present in small numbers on Haszard Islet.

**Wedged-tailed shearwater (*Puffinus pacificus*)**

Comparison of our estimates of burrow density and corpse numbers with those made by RPS in 1988 suggests that the increase in fern may have adversely affected the numbers of this species breeding on Macauley I. Few corpses were found (< 10) and large-shearwater-type burrows were restricted to within 20–50 m of the cliff edge. Corpses and burrow sizes suggest that wedged-tailed shearwaters are present in small numbers on Haszard Islet, but no direct evidence was found of them being on Cheeseman I.

**Kermadec little shearwater (*Puffinus assimilis kermadecensis*)**

We spotlighted or heard about 20 birds flying overhead at night on Macauley I. None were captured. The loss of the talus slope in Sandy Bay has probably meant the loss of breeding sites for some of the 50 pairs that nested here (Taylor & Tennyson 1988). If the talus slope was lost during the winter, it may have been detrimental to the population. However, if the storm that destroyed the slope occurred during the summer (i.e. a tropical cyclone), then most birds would probably have moved elsewhere. Little-shearwater-sized burrows and the finding of a broken egg confirm this species is present in very small numbers on top of Haszard Islet. None were captured during our short stay. Little shearwaters were an abundant breeding species on Cheeseman I.

The majority of burrows on this heavily burrowed island appeared to be of this species. We found at least 20 incubating birds by putting our hands into burrows. Eggs were at an advanced stage of incubation.

**White-bellied storm petrel (*Fregetta grallaria*)**

We spotlighted five birds and heard three calling on Macauley I. None were caught. We were unable to find any nests on Cheeseman I., but the discovery of one corpse suggests that they are probably present. The timing of our visit may have been too late in the breeding season for the species to be detected in significant numbers.

**Kermadec white-faced storm petrel (*Pelagodroma marina albiclunis*)**

Three birds, believed to be the Kermadec subspecies of the white-faced storm petrel, were spotlighted by us on three separate nights on Macauley I. None were caught. The presence of this species on the island in mid-winter suggests it may be an early breeder. Between 50 and 100 small burrows in bare ground on top of Haszard Islet and the apparent absence of *Rattus exulans* (as indicated by the presence of *Lepidium*) are strongly indicative that this species may nest on top of the islet.

**Sooty tern (*Sterna fuscata*)**

A dark-plumaged immature bird was seen by us off L'Esperance Rock. We found eggs or desiccated corpses at six sites on Macauley I. The available area for sooty terns to nest in the *Microlaena* sward on Macauley I. has considerably reduced since 1988 (Taylor & Tennyson 1988). The IGNS Curtis I. party reported large numbers of corpses of this species in the crater of Curtis I. that they suspected of being killed by poisonous gasses from volcanic activity (C. de Ronde, IGNS, pers. comm.). Several corpses and eggs suggest that a large colony of this species may also occur on the northern point of Cheeseman I. in the summer. We found six desiccated sooty tern corpses on Cheeseman I. and one above Access Gully on Macauley I.

**Masked booby (*Sula dactylatra*)**

Two nest sites appear to be occupied by masked bobbies on L'Esperance Rock. This is the first record of this species here. The IGNS party reported about 100 occupied nests on Curtis I. They saw many nests with one egg and some with two eggs. No chicks were seen. On Macauley I., masked boobies are now entirely restricted to within 20 m of the cliffs surrounding the island. During a walk from our camp to the summit of Mt Haszard on 25 July, we observed 48 occupied nest sites. Of these, nine had one egg, two had two eggs and one had a newly hatched single chick. It is RPS's opinion that the size of the population is similar to that seen in 1988, but that the birds are now distributed closer to the coast. Five banded birds were seen. Of these, three were captured. Band numbers and places captured were: M-38883 Haszard Islet; M-38885 Macauley, above Sandy Bay; M-38853 Macauley, halfway up Mt Haszard. All birds were banded in 1988 on Macauley Island as juveniles / immature (Taylor & Tennyson 1988).

**Grey ternlet (*Procelsterna cerulea*)**

We saw more than 2000 birds roosting and flying around L'Esperance Rock. The cavernous hole in the centre of the island was white with ternlet guano, suggesting this may be a large colony. L'Esperance Rock may have one of the densest colonies of grey ternlets anywhere. We observed more than 1000 birds roosting and flying around the coasts of Curtis and Cheeseman Is; and more than 500 around the short piece of the coastline of Macauley I. that we explored. Between 100 and 200 birds were roosting and preparing nest sites in caverns, and on cliff faces in Quadrat Gully, and c. 50 were seen in Access Gully. We did not see any birds on eggs, nor any banded birds. One bird was seen carrying nest material. A freshly eaten, still warm ternlet corpse was found on Cheeseman I.—we suspect it was a victim of harrier hawk predation.

**White-capped noddy (*Anous tenuirostris*)**

No white-capped noddies were seen by us on any island. This species appears to be absent from the Kermadec Is during the non-breeding season.

**Common noddy (*Anous stolidus*)**

We saw two common noddies off L'Esperance Rock and two off Curtis I. on 21 July amongst feeding grey ternlets. The presence of this species suggests it may nest on L'Esperance Rock.

**Red-tailed tropic bird (*Phaethon rubricauda*)**

We found one red-tailed tropic bird chick, near fledging, on the cliffs on the east side of Haszard Islet, and at least three other potential nest sites. Ten chicks near fledgling, all with little or no down, were found whilst we walked around Macauley I. On 25 July, we saw more than 20 adults, possibly all feeding chicks, flying and landing along the northeastern cliffs of Macauley I. Recent corpses of three fledglings that appeared to have crash-landed in the tall fern and been unable to recover were found. We estimate that the winter breeding population of red-tailed tropic birds on Macauley I. is between 200 and 300 pairs. None were seen by our or the IGNS party on Curtis or Cheeseman Is or L'Esperance Rock.

**Pacific golden plover (*Pluvialis fulva*)**

Two Pacific golden plovers were seen flying north over our campsite on 22 July.

**Turnstone (*Arenaria interpres*)**

A small flock of six turnstones was disturbed from the coastal lava platform near the mouth of Access Gully in the late afternoon of 25 July.

**Kermadec red-crowned parakeet (*Cyanoramphus novaezelandiae cyanurus*)**

Kermadec red-crowned parakeets were ubiquitous on Macauley Island—by far the most common terrestrial bird species observed by us (see Section 4.3). Large flocks of 20 to 30 were commonly seen flying about our campsite early in the morning and in the late afternoon. Large groups were seen foraging throughout the day, particularly on lower vegetation and in or near large ngaio trees. No parakeets were seen on the coast. They were common on the top of Haszard Islet, but were not seen on either Curtis or Cheeseman Is.

**Australasian harrier (*Circus approximans*)**

Single, adult harrier hawks were seen over Curtis I. during both visits and one was seen each day over Macauley I.

**Blackbird (*Turdus merula*)**

Blackbird alarm calls were heard on 23 July in Access Gully. A female was seen on 24 July at the head of Grand Canyon, and a male was seen flying between Sandy Bay and Grand Canyon on 23 July.

**Song thrush (*Turdus philomelos*)**

One song thrush was seen on the beach between Access Gully and Quadrat Gulley on 23 July.

**Starling (*Sturnus vulgaris*)**

Two starlings were seen by us on L'Esperance Rock. A flock of 12 was seen above Haszard Islet on 21 July. The cliffs and gullies of Macauley I. were home to furtive pairs of starlings and the total population could be as large as 100 birds. We observed a flock of 12 starlings and 8 swallows flying around Cheeseman I. on 26 July.

**Welcome swallow (*Hirundo tahitica*)**

At least 8 swallows were present on Macauley I. and were seen by us each day. Another 8 were seen above Cheeseman I. in a mixed flock with starlings. We identified at least some of this flock as welcome swallows, as they had long tails, whitish under-parts and liberally-spotted upper tails.

We also saw smaller swallows with shorter, squarer tails than welcome swallows. These birds had grey underparts and little (if any) spotting on the uppersides of the rectrices. They were seen by us most days on Macauley I. In our opinion these were the Pacific subspecies of the welcome swallow, but it will be necessary to capture some of them to confirm the identification.

**Omissions**

No silvereyes or introduced finches were seen (c.f. Taylor & Tennyson 1988; Tennyson et al. 1989)

## 4.6 NOTES ON THE FLORA OF THE SOUTHERN KERMADEC ISLANDS

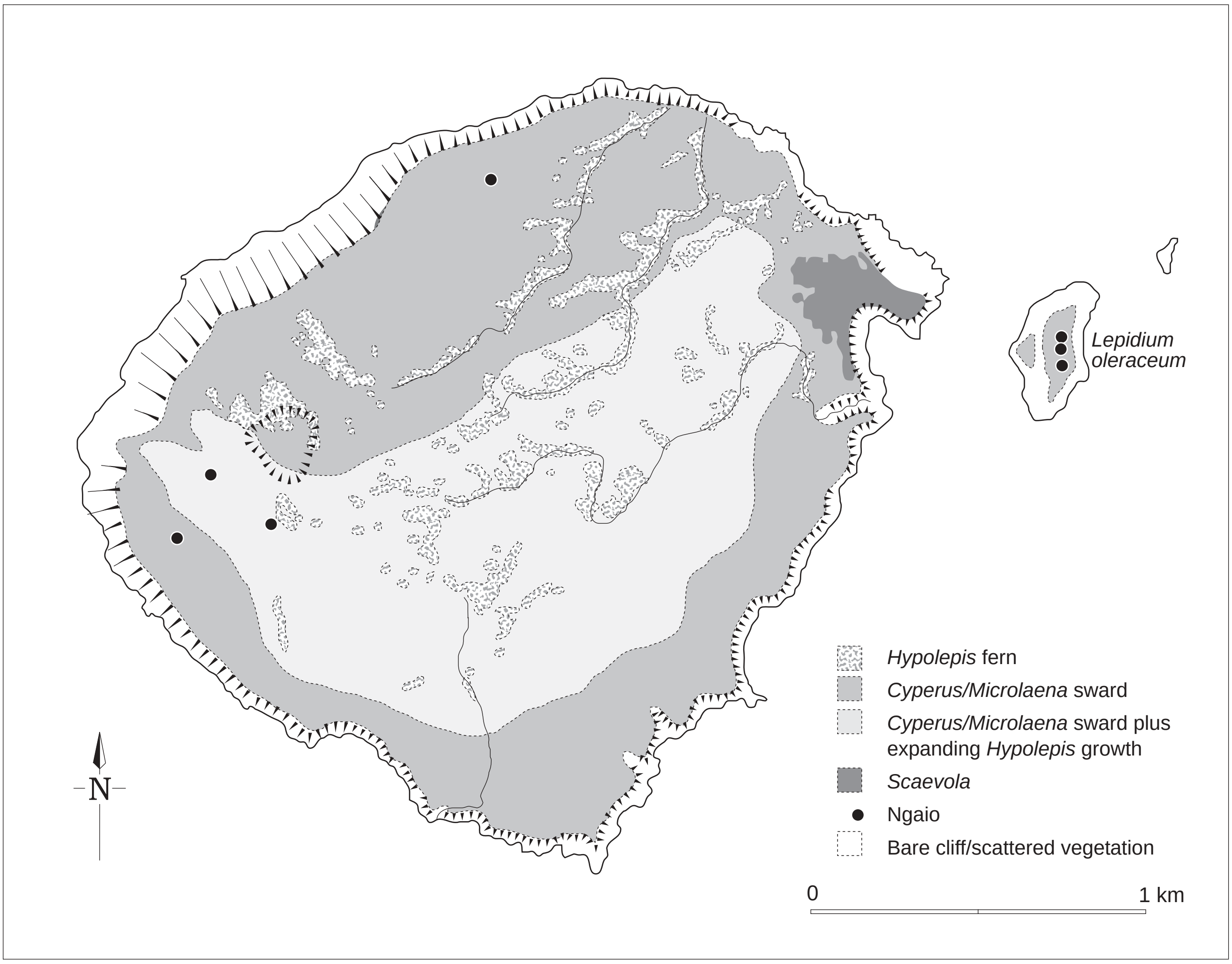
### 4.6.1 Macauley Island

Although there is no direct archaeological evidence, it is likely that Macauley Island was visited by early Polynesian or Melanesian peoples (Anderson & McFadgen 1990). The presence of kiore certainly suggests early Pacific people visited this island, but whether they had any impact on the vegetation is unknown. The first discovery of the island by Europeans was by Captain Sever aboard the Lady Penrhyn on 30 June 1788. The surgeon on this vessel—Arthur Bowes-Smith—stated that the plateau was 'covered with a coarse kind of grass' (Fidlon & Ryan 1979). Sykes (1977) suggests this 'grass' was probably *Cyperus ustulatus* which is still a dominant part of the flora. It is not clear when ungulates were introduced, but in 1836 Captain W.B. Rhodes recorded that Macauley I. 'abound[ed] with goats and pigs' (Straubel 1954). Pigs S*us scrofa* have not been reported since. By 1966 goats *Capra hircus* had reached large numbers; and an expedition in 1966 killed a minimum of 3200 (O'Brien, 1966). A further 18 were killed in 1970 (Bell 1970).

The vegetation was severely affected by the goats but has recovered remarkably since 1966. However, concerns have been expressed about the effects of the rapid regrowth and the apparent successional trajectory on various plant and animal species (Taylor & Tennyson 1988; Tennyson et al. 1989).

The most significant change since 1988 (Taylor & Tennyson 1988) has been the spread of the fern *Hypolepis dicksonioides*. In 1988 this fern was largely restricted to the floor of all major gullies (presumably where it was wetter) with several large patches present on the middle and upper slopes of Mt. Haszard. A 1992 aerial photograph (Air Logistics (NZ) Ltd. aerial photograph 224407) showed a similar pattern, although there was an increasing density of what look like small fern clumps over much of the central lower slopes. This general pattern is summarised in Fig. 4. This distribution has changed dramatically in the subsequent 10 years. About 70% of the island, particularly the central part, is now covered in dense areas of *H. dicksonioides* up to 2.5 m high (Fig. 5). Although the reasons for this change in the vegetation are not clear, it is possible that climatic changes resulting in increased rainfall have aided the spread of the fern (P.J. de Lange, DOC, pers. comm.).

Figure 4. Vegetation on Macauley Island in 1992, derived from Air Logistics (NZ) Ltd aerial photograph 224407.



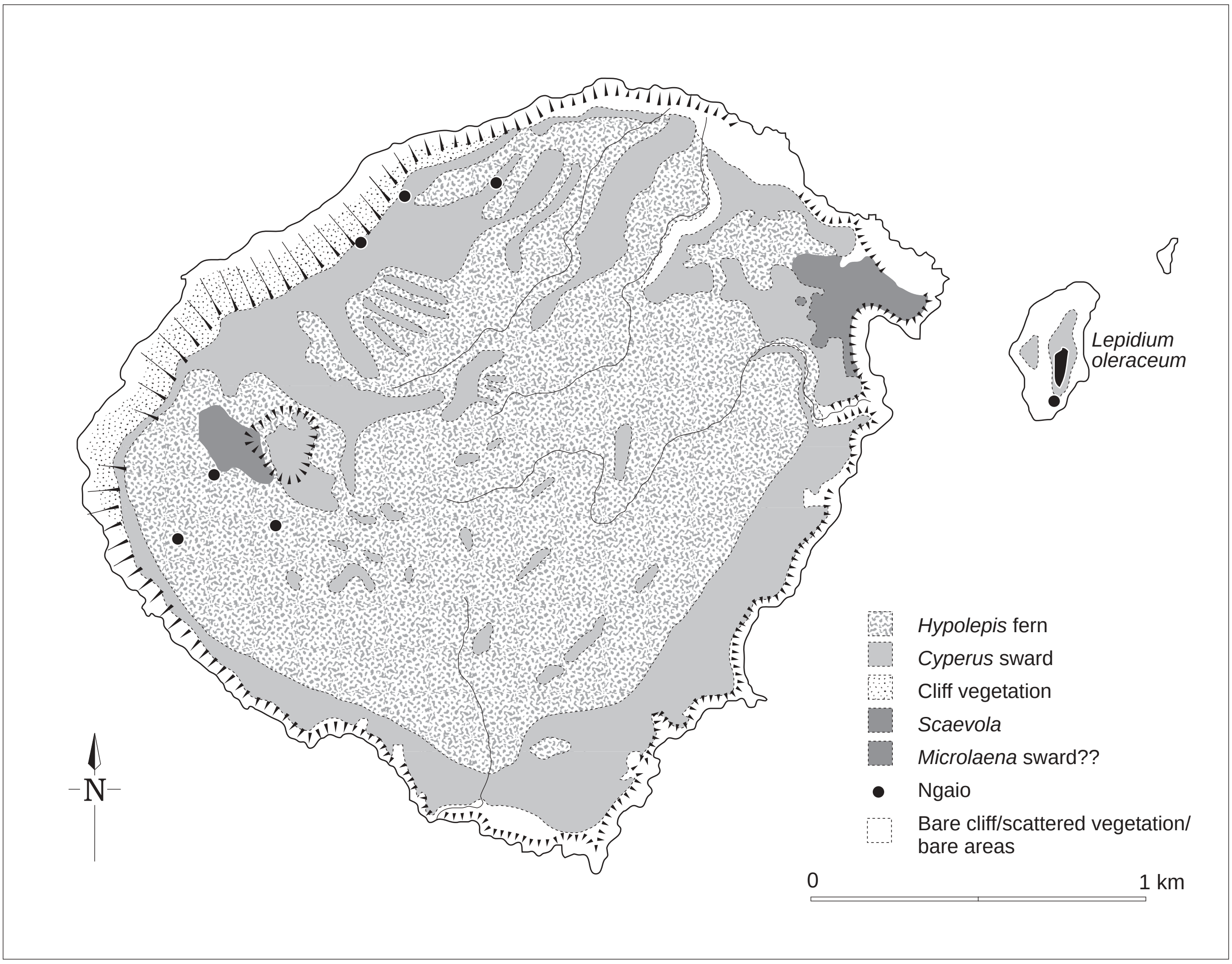
The expansion of ferns has markedly reduced the abundance of other formerly common plant species. *Cyperus ustulatus* is now estimated to cover 25% of Macauley I. and is only common around the outer edge of the island and as patches within a sea of fern in central areas. This is a significant change from 1988 when up to 70% of Macauley Island was estimated to be covered in *C. ustulatus*.

We found no evidence of the *Microlaena stipoides* grassland that once covered most of the plateau (Sykes 1977) in the 1960s and 1970s, and 30% of the plateau in 1988 (Taylor & Tennyson 1998). Perhaps the only substantial area of this species left is restricted to the vicinity of the main crater below Mt. Haszard.

*Scaevola gracilis* was still locally abundant on the north-eastern corner of the island. Little change in the distribution of the species seems to have occurred since the 1988 expeditions (Taylor & Tennyson 1988) and the 1992 aerial photograph. Similarly, *Ipomoea cairica* and *Calystegia soldanella* are still largely restricted to Windy Head and the slopes and plateau immediately adjacent to Sandy Bay.

The distribution of *Sicyos angulata* has increased markedly from the observation of a single patch recorded on the ridge north of Mt. Haszard (Taylor & Tennyson 1988). It was common along the vegetated edge of much of the northern cliffs and was also very abundant along the edges of the Grand Canyon

Figure 5. Vegetation on Macauley Island in 2002, derived from terrestrial and helicopter observations.

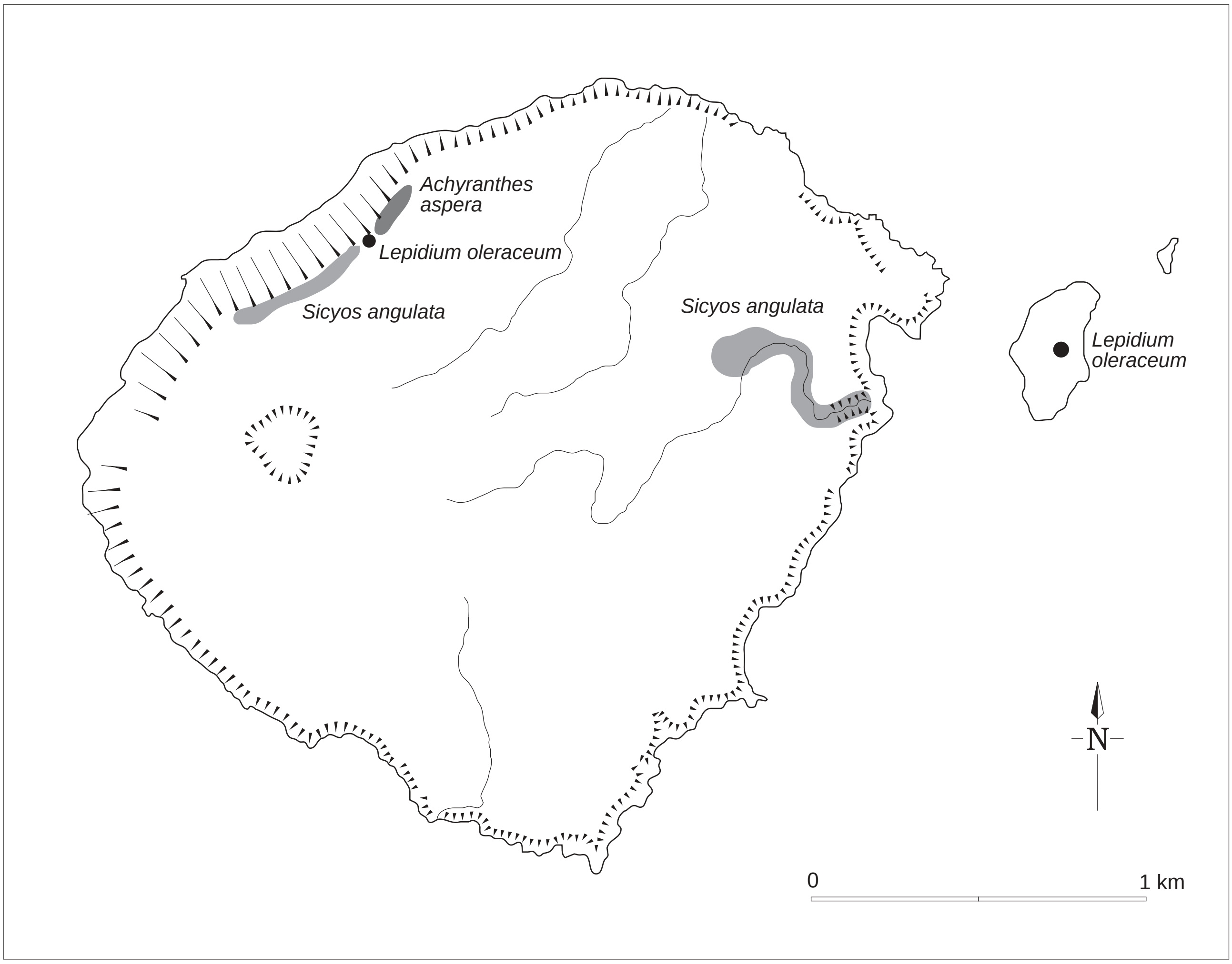


and was scattered in patches through the vegetation on the cliffs above Sandy Bay (Fig. 6). Of interest were the large numbers of damaged leaves of this species that were observed (suggestive of disease).

On the northern cliffs, vegetation has continued to re-establish on the more stable slopes. Large numbers of young ngaio are present, some of which have reached a height of 2 m. Other vegetation seen on the cliffs included *Parietaria debilis*, *Juncus* spp., *Achyranthes aspera* (see Section 5) and a small amount of *Cyperus ustulatus*. No young or seedling ngaio were seen on the flatter parts of the island that we were able to access.

Two new plant species were recorded from Macauley Island. A single, 7-cm-high seedling of *Lepidium oleraceum* was found near a large ngaio tree on the cliff edge northeast of Mt. Haszard (Fig. 6). The second important find was significant numbers of *Achyranthes aspera*, again on the northern cliffs, approximately 50 m northeast of the *L. oleraceum* specimen (Fig. 6). This appears to be a new indigenous species for the New Zealand flora and is very similar to plants from Norfolk Island (de Lange et al. 2004). This species' spiny seeds are well suited to avian dispersal. Possible vectors include Kermadec petrels and masked boobies, both of which breed on these cliffs and are known to visit Norfolk Island.

Figure 6. Notable botanical discoveries, Macauley Island 2002.



### 4.6.2 Haszard Islet

A number of distinct vegetation types occurred on the top of Haszard Islet, despite its small size. The northern end and the cliff edges surrounding the top of the islet were dominated by *Disphyma australe* with patches of *Parietaria debilis* and native spinach *Tetragonia tetragonioides*. The remainder of the island was covered in *Cyperus ustulatus* with scattered clumps of ngaio. Gaps between clumps of *C. ustulatus* (where there were no petrel burrow entrances) were filled with *Parietaria debilis*, spinach, *Leptinella australis*, *Gnaphalium* spp., scurvy grass, *Scaevola gracilis*, *Polycarpon tetraphyllum*, *Microlaena stipoides*, *Solanum* spp., *Sonchus* spp. and *Apium australis*. Ngaio plants were generally prostrate and not higher than 1.5 m. The entire surface was heavily burrowed by seabirds.

Of particular interest were the large numbers of *Lepidium oleraceum* plants in very poor condition (Fig. 6). Most leaves appeared to have been extensively browsed back to the mid-rib, but the immediate cause of this (invertebrate or parakeet?) was unclear. Subsequent examination of the invertebrates on the island revealed that the Hawaiian beet moth prefers to forage on brassicas and is classified as a pest of brassica crops where it occurs overseas. *Lepidium oleraceum* is a brassica and it would, therefore, seem likely that caterpillars of this moth were the main cause of the poor condition of *L. oleraceum* plants on Haszard Islet. Whether this moth is native to the Kermadec group is not known, but it is conceivable that it may pose a significant threat to the few *L. oleraceum* plants that remain on the southern islands of the group and the future recovery *of L. oleraceum* on Macauley I.

The vegetation on the accessible western face at the base of the islet was dominated by iceplant *Disphyma australe* and spinach with small patches of *Cyperus ustulatus*, *Solanum* spp., *Sonchus* spp. and *Gnaphalium* spp. in more sheltered places. A small number of stunted ngaio plants were also present.

### 4.6.3 Cheeseman Island

This island has a relatively small flora. The central valley between the two high points of the island was almost entirely dominated by *Cyperus ustulatus*. With the exception of a few scattered plants on the surrounding slopes, this species was largely restricted to this gully. The bulk of the remaining sloping and rocky area was dominated by a mix of *Parietaria debilis* and iceplant with the more exposed areas dominated by the latter. Interspersed amongst these dominant species in relatively sheltered places were individual plants of *Asplenium obtusatum*, *Sonchus* spp., *Leptinella australis*, *Lachnagrostris littoralis*, something resembling a *Stellaria* or *Polycarpo*n spp. and both *Solanum americanum* and *S. nodiflorum*. A last-minute discovery was the presence of two or three *Lepidium oleraceum* plants. A layered part of one of these plants was collected as a live specimen.

## 4.7 NOTES ON THE INVERTEBRATES OF THE SOUTHERN KERMADEC ISLANDS

The following is a brief summary of the invertebrates encountered.

### 4.7.1 Macauley Island

Blowflies (species not identified) were extremely common on Macauley I. and considerable care was required to keep them out of tents and food supplies. Hawaiian beet moths were also present on Macauley I., but at much lower densities to those seen on Haszard Islet and then only about the cliffs above Sandy Bay. It was thought the distribution of these moths may reflect the proximity of Haszard Islet to Macauley I. (Sandy Bay) and the almost complete absence of *L. oleraceum* on the latter. The small dark crickets seen on Haszard Islet were also extremely common on Macauley Island and their high-pitched 'calls' could be heard night and day. Both adult and juvenile crickets were collected. Much larger orthopterans were also present on Macauley I. and although none could be collected, they were thought to be *Locusta migratoria*.

A number of spiders, several very small dark brown beetles, a click beetle and what appeared to be a small vinegar fly were also collected. Of some note was the large number of very small snails (1–2 mm) that were found foraging on the damp, non-toxic baits following two days of poor weather. These were extremely common and a number were collected for identification. We were also able to collect a very large specimen of a convolvulous sphinx moth *Agrius convolvuli*. A single yellow-admiral butterfly *Bassaris itea* was seen on the summit of Mt. Haszard.

### 4.7.2 Haszard Islet

The top of this islet was extremely dry which undoubtedly influenced the invertebrates we were able to observe and collect. Given the high density of petrel burrows and surface-nesting boobies, blowflies of at least two species (not identified) were particularly common. Small black- and yellow-striped hoverflies were also common about flowering ngaio plants, as were Hawaiian beet moths (see Section 4.6.2). On the ground and beneath what litter was present there were numerous late instar nymphs of a small dark cricket species and small (1 cm) red / brown centipedes, both of which were able to be collected. A specimen of a very small ant and a number of spiders were also collected.

# 5. Conclusions

We view the eradication of kiore as essential to the ecological recovery of Macauley I. Although such an operation undeniably poses a risk to the large population of Kermadec red-crowned parakeets, we still expect any negative impacts to be localised (possibly to those few areas of remaining open ground) and minimal in terms of the status of the overall population. Total extirpation of the Macauley I. parakeet population is extremely unlikely. Evidence from previous rat eradication operations in similar environments, our bait trials during this visit (despite their limitations), parakeet foraging behaviours and diet during this time of year, and the overall density of vegetation on Macauley I. give us considerable confidence in our assessment, providing conditions (food plant phenology, vegetation types, parakeet numbers, water availability, etc.) remain broadly similar to those experienced in July 2002.

In the unlikely event that significant mortality of parakeets occurs as a direct result of kiore eradication, we would expect to see rapid population recovery typical of that noted for this species and its close relatives. However, if any of these factors have altered significantly prior to the eradication attempt, then our appraisal of the risks to the parakeet population will require reassessment. In particular, the timing of the eradication operation is important given the uncertain cause of the mass mortality event observed for parakeets between September and November 1988—especially if such events are a regular phenomenon. Food shortages have been suggested as a cause of this event (C. Miskelly, DOC, pers. comm.), but a severe drought was known to have occurred in October and November 1988 (G. Taylor, pers. comm.). For this reason, every effort should be made to assess the status of the parakeet population on Macauley I. immediately prior to any rat removal operation. If the number of parakeets is found to be much lower than current estimates (< 5000), it may be prudent to consider either postponing the operation, holding birds on Macauley I. or considering the transfer of parakeets to Raoul I.—dependent on its status as a rat-free island[2]. If the latter course of action is an option, then it would be prudent to collect feather samples from the remnant Kermadec red-crowned parakeet population inhabiting the Meyer Is (northwest of Raoul I.). This would confirm the current supposition that these and the Macauley I. parakeets are of the same genetic provenance and any interbreeding would not be deleterious to the genetic integrity of the Meyer Is birds.

Any eradication attempt should be timed to coincide with the period of least risk to the Kermadec red-crowned parakeet population. From late autumn until winter, food and water are likely to be abundant for parakeets (*Cyperus ustulatus* is thought to flower from November to February, with seeds ripening from February to April; G. Taylor, pers. comm.), and seabirds are largely absent, making this period the ideal time in which to attempt kiore eradication.

The historical impacts of kiore occupation of Macauley I. are likely to have been severe. Although the vast seabird population suggests that kiore have little direct impact on the major species, the current distribution of the Kermadec little shearwater, grey ternlets, white-bellied storm petrel and Kermadec white-faced storm petrel suggests a significant effect on the breeding success of these smaller species. More insidious is the potential for impacts on the successional pathway of the island's flora as it continues to recover from the past depredations of goats. Experience from elsewhere in New Zealand suggests that kiore have a significant destructive impact on fruits and seeds of a wide variety of plants (Campbell & Atkinson 2002). This may be a contributing factor to the much slower than predicted colonisation of the plateau by ngaio and other plant species such as *Scaevola gracilis* and *Lepidium oleraceum* (Taylor & Tennyson 1988). Given recent research, it seems likely that kiore have also had a significant impact on the larger invertebrate species (Green 2002).

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2. It should be noted that Raoul Island is likely to be declared rodent-free in 2004 and it may be more expedient to catch and transfer parakeets to this island.

Whether the reason for the dramatic expansion of *Hypolepis dicksonioides* ferns has had anything to do with the continued presence of kiore and / or is the result of larger-scale climatic change (i.e. wetter conditions over the last 20 years) is uncertain. Whatever the reason, this fern is now dominant over much of the island, markedly reducing the distribution of *Cyperus* and leading to the possible elimination of the *Microlaena stipoides* sward previously reported. An obvious impact of these changes has been a marked reduction in the distribution of nesting masked boobies. Nesting pairs of this species are now only found about the cliff margins, having been forced from the centre of the island. It seems likely that other surface-nesting seabirds such as sooty terns have also experienced reductions in available nesting habitat. Although previous measurements of petrel burrow density in areas of *Cyperus ustulatus*, *Scaevola gracilis* and *H. dicksonioides* showed that the density of petrel burrows was much lower than that in open areas (Taylor & Tennyson 1988), the spread of the *H. dicksonioides* ferns does not seem to have drastically affected the numbers of either black-winged petrels or white-naped petrels. It also seems likely that the change in population estimates for Kermadec red-crowned parakeets—from 17 000–20 000 in 1988 (Taylor & Tennyson 1988) to our estimate of 8000–10 000—is entirely explicable in terms of the large changes in vegetation composition and the availability of suitable foods.

The continued spread of *H. dicksonioides* over much of the plateau has probably had a significant impact on the Kermadec red-crowned parakeet population. It is unlikely that *H. dicksonioides* produces much, if anything, of food value for these parakeets, particularly when compared with the large seed heads of the formerly much more common *Cyperus ustulatus* and *Microlaena stipoides*. During our visit, no parakeets were seen foraging in areas of fern and very few were even seen in these patches. It is likely that parakeet density has declined significantly since 1988 and will continue to do so as the fern continues to spread. Nevertheless, considerable suitable habitat is likely to persist and should begin to increase again following the removal of kiore and the projected regeneration of ngaio trees.

The long-term implications of the appearance of *Achyranthes aspera* on the western cliffs are unknown. If the species continues to spread along these cliffs it may well begin to impact on the breeding sites of Kermadec petrels. Whether *A. aspera* is capable of competing with either *C. ustulatus* or *H. dicksonioides* on the main plateau of Macauley I. is, as yet, unknown.

# 6. Recommendations

Based on our investigations, as reported in this paper, we make the following recommendations:

- Kiore should be eradicated from Macauley I. and Haszard Islet between May and September as soon as possible. The long-term benefits of kiore eradication outweigh the perceived negative impacts and would do much to ensure the survival of the Kermadec white-faced storm petrel and assist the revegetation of Macauley I.

- A serious attempt should be made to obtain useful GPS (preferably Differential GPS) position fixes so that aerial photos are able to be accurately geo-referenced and accurate maps drafted. This could be achieved during the kiore eradication operation using the DGPS system onboard helicopters used for eradication.
- A small team of observers should be sent to Macauley I. immediately prior to and during any kiore eradication operation to assess the status of the Kermadec red-crowned parakeet population.
- If a significant decrease in numbers of parakeets on Macauley I. is observed (< 5000), planned kiore eradication should be postponed or consideration given to maintaining a group of birds in captivity. However, it should be noted that Raoul I. is likely to be declared rodent free in 2004 and it may be more expedient to catch and transfer parakeets to this island.
- To enable genetic comparison with samples already taken from Macauley I., feathers should be collected from Kermadec red-crowned parakeets resident on the Meyer Is as soon as possible.
- Regular aerial and / or satellite photos be taken so that vegetation changes can be monitored over time. Regular physical visits of longer duration also need to be made to Macauley I. so that regular and more systematic population assessments of parakeets, surface-nesting seabirds and burrowing petrels can be made and related to any changes in vegetative cover.
- The continued spread of *Hypolepis dicksonioides* and the recently arrived *Achyranthes aspera* should continue to be closely monitored.
- If possible, a night visit to the top of Haszard Islet should be made in the month of October to confirm the presence of Kermadec white-faced storm petrels. A night trip is also desirable to Cheeseman I. (between March and June) to confirm the presence of white-bellied storm petrels.
- The impact of Hawaiian beet moths on *Lepidium oleraceum* should be investigated.
- Alternative coastal camp sites should be identified following the loss of the site at Sandy Bay.

# 7. Acknowledgements

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# Appendix 1

**Kermadec red-crowned parakeet measurements and biotracer presence (table overleaf)**

| BAND | LEG | DATE | SEX | AGE | BILL (mm) L | W | D | TARSUS (mm) | TAIL (mm) | WING (mm) | WEIGHT (g) | FEATHERS COLLECTED | PYRANINE DETECTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D105847 | R | 24/07/02 | M? | Ad. | 16.5 | 10.0 | 8.5 | 21.0 | 145 | 133 | 66 | Yes | No |
| D105848 | L | 24/07/02 | F | Ad. | 14.1 | 9.7 | 8.7 | 21.2 | 151 | 132 | 67 | Yes | No |
| D105849 | L | 24/07/02 | F | Ad. | 14.9 | 10.0 | 8.5 | 21.4 | 150 | 130 | 75 | Yes | No |
| D105850 | R | 24/07/02 | M | Ad. | 18.2 | 12.1 | 10.2 | 21.8 | 165 | 146 | 89 | Yes | No |
| D105851 | R | 24/07/02 | M | Ad. | 20.3 | 12.9 | 10.0 | 22.0 | 150 | 141 | 89 | Yes | No |
| D105852 | L | 24/07/02 | F | Ad. | 15.6 | 10.4 | 8.6 | 20.3 | 149 | 133 | 76 | Yes | No |
| D105853 | R | 24/07/02 | M | Ad. | 17.9 | 11.0 | 9.9 | 22.6 | 165 | 136 | 93 | Yes | No |
| D105854 | L | 24/07/02 | F | Ad. | 14.6 | 10.1 | 8.1 | 20.6 | 151 | 136 | 67 | Yes | No |
| D105855 | L | 24/07/02 | F | Ad. | 15.3 | 9.6 | 8.4 | 22.3 | 151 | 135 | 73 | Yes | No |
| D105856 | L | 24/07/02 | F | Ad. | 14.2 | 10.9 | 8.5 | 20.0 | 149 | 136 | 67 | Yes | No |
| D105857 | R | 24/07/02 | M | Ad. | 19.1 | 11.8 | 10.6 | 23.7 | 160 | 139 | 88 | Yes | No |
| D105858 | R | 24/07/02 | M | Ad. | 19.2 | 12.0 | 10.4 | 24.6 | 158 | 147 | 109 | Yes | No |
| D105859 | L | 24/07/02 | F | Ad. | 15.0 | 10.0 | 8.6 | 22.0 | 150 | 132 | 67 | Yes | No |
| D105860 | L | 24/07/02 | F | Ad. | 15.0 | 9.7 | 8.4 | 21.0 | 153 | 134 | 68 | Yes | No |
| D105861 | L | 24/07/02 | F | Ad. | 14.8 | 9.9 | 8.8 | 21.5 | 154 | 134 | 56 | Yes | No |
| D105862 | L | 24/07/02 | F | Ad. | 15.6 | 10.3 | 9.0 | 21.6 | 158 | 135 | 77 | Yes | No |
| D105863 | L | 24/07/02 | F | Ad. | 15.2 | 9.9 | 8.5 | 22.0 | 146 | 132 | 69 | Yes | No |
| D105864 | R | 24/07/02 | M | Ad. | 17.5 | 11.0 | 9.5 | 22.8 | - | 141 | 71 | Yes | No |
| D105865 | L | 24/07/02 | F | Ad. | 13.9 | 10.0 | 8.5 | 20.0 | 146 | 129 | 78 | Yes | No |
| D105866 | L | 24/07/02 | F | Ad. | 15.2 | 10.2 | 8.5 | 22.3 | 144 | 132 | 71 | Yes | No |
| D105867 | R | 24/07/02 | M | Ad. | 18.6 | 12.5 | 10.1 | 23.0 | 165 | 143 | 99 | Yes | No |
| D105868 | R | 24/07/02 | M | Ad. | 17.8 | 10.5 | 9.7 | 21.3 | 149 | 131 | 79 | Yes | No |
| D105869 | R | 24/07/02 | M | Ad. | 18.5 | 11.9 | 10.3 | 21.7 | 164 | 144 | 98 | Yes | No |
| D105870 | R | 24/07/02 | M | Ad. | 19.9 | 12.2 | 10.6 | 23.0 | 158 | 145 | 102 | Yes | No |
| D105871 | L | 25/07/02 | F | Ad. | 14.3 | 10.0 | 8.4 | 21.3 | 156 | 133 | 79 | Yes | No |
| D105872 | L | 25/07/02 | F | Ad. | 14.3 | 10.0 | 8.1 | 21.5 | 125 | 131 | 65 | Yes | No |
| D105873 | L | 25/07/02 | F | Ad. | 13.9 | 9.4 | 7.9 | 20.1 | 146 | 132 | 70 | Yes | No |
| D105874 | R | 25/07/02 | M? | Ad. | 16.1 | 10.0 | 9.8 | 21.8 | 147 | 136 | 70 | Yes | No |
| D105875 | L | 25/07/02 | F | Ad. | 15.3 | 9.7 | 8.4 | 20.5 | 154 | 136 | 65 | Yes | No |
| D105876 | R | 25/07/02 | M | Ad. | 19.3 | 12.9 | 10.5 | 23.6 | 163 | 145 | 89 | Yes | No |
| D105877 | L | 25/07/02 | F | Ad. | 14.9 | 10.1 | 8.6 | 19.6 | - | 136 | 71 | Yes | No |

Ad. = adult
M = male
F = female

# Appendix 2

## Bird specimens collected

Desiccated corpses of the following species were collected from Macauley I., Haszard Islet and Cheeseman I. for skeletal material and deposited within the Canterbury Museum's collection:

Black-winged petrel (n = 5)
Kermadec petrel (n = 1)
White-naped petrel (n = 1)
Sooty tern (n = 4)
Red-tailed tropic bird (n = 2)
Little shearwater (n = 1)

# Appendix 3

## Plant specimens collected

**Live plant specimens**
*Cyperus ustulatus* (Macauley I.) (n = 1)
*Lepidium oleraceum* (Cheeseman I.) (n = 1)
*Lachnagrostris littoralis* (Cheeseman I.) (n = 1)

**Specimens in alcohol**
*Sicyos angulata* (Macauley Island) (n = 1)
*Lepidium oleraceum* (Haszard Islet) (n = 1)
*Achyranthes aspera* (Macauley Island) (n = 1)

**Pressed plant specimens**
A selection of pressed specimens has been passed on to the Auckland Museum herbarium.