A restoration plan for Mangere Island, Chatham Islands group

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Te Papa Atawhai

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ABSTRACT

Mangere and Rangatira (South East) Islands are the only sizeable islands in the Chatham Is group that are free of introduced mammals and introduced weka. Mangere was not greatly altered until the latter part of the nineteenth century when it suffered impacts from rabbits and cats, and was used as a sheep run for more than 50 years. The island supports populations of a number of rare plants and animals including one of the most genetically distinct parakeets in the New Zealand region. With expansion of the current restoration programme, a significant part of the biological diversity present in the late nineteenth century can be regained. This plan provides a timetable for re-establishing forest in additional parts of the island during the period 2003 to 2013 and details species likely to be suitable for the island's site conditions. The plan also summarises requirements for recovery of some threatened plant and animal species, protection measures that need to be continued or strengthened on the island, and monitoring and research needs.

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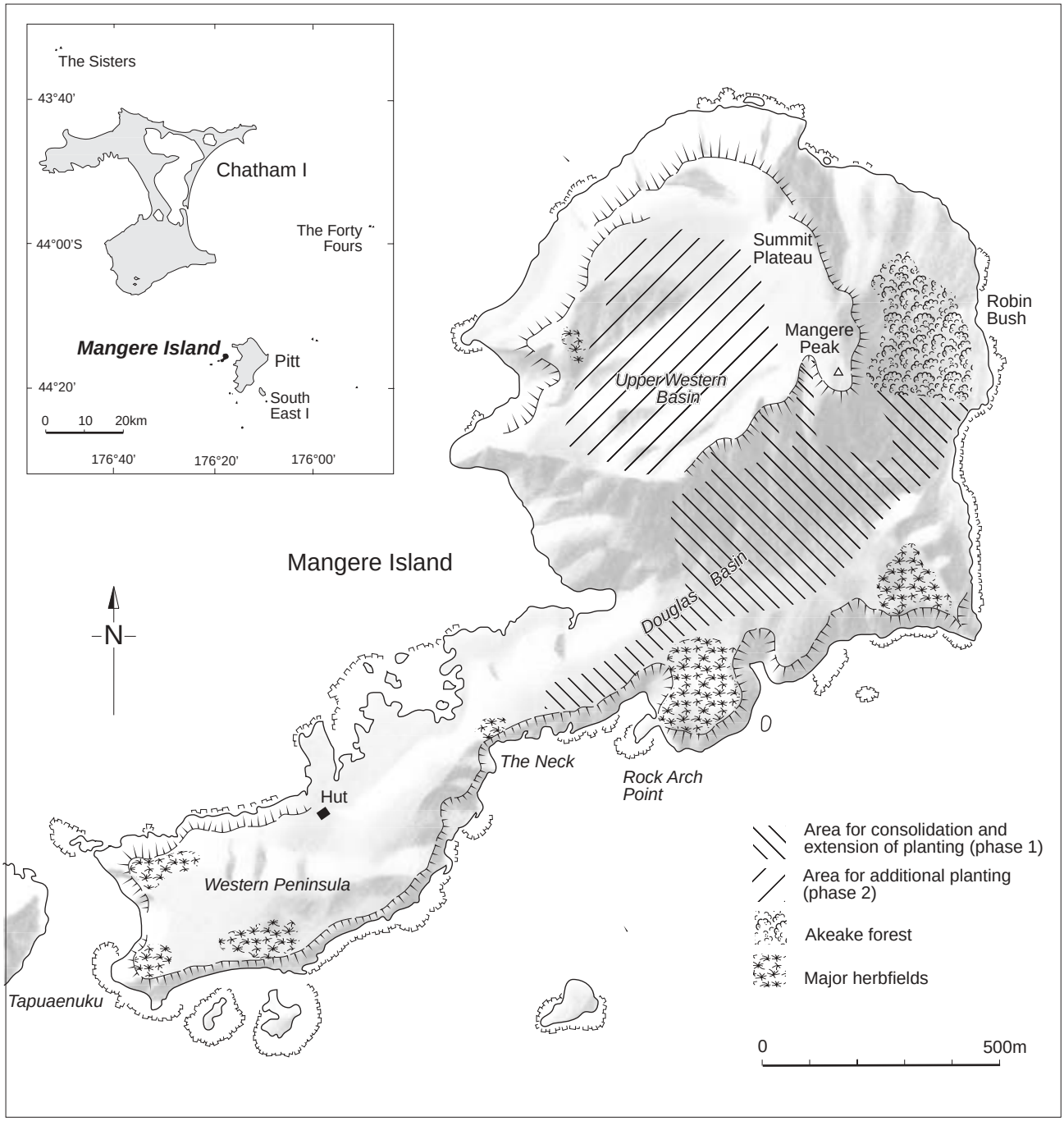

Figure 1. Map of Mangere Island in the Chatham Islands, showing geographical features and areas for management. Phases of planting are discussed in Section 6.3.

1. Introduction

This plan is based on observations made during visits to Mangere Island[1] in October 1973, January 1998 and February 2000. It draws on relevant publications and unpublished reports as well as on numerous discussions with individuals who have local knowledge of the island. Its purpose is to outline a course of action that can be taken during the next 10 years that will, as far as possible, allow the island to be restored in a comprehensive and effective manner.

Mangere (Fig. 1) appears to have been largely forested until the 1890s when, after extensive burning, sheep and rabbits were put on the island to be followed soon afterwards by cats. The island was used as a sheep farm until 1966 by which time the idea of reforesting it as a habitat for native birds of the Chatham Is was being actively promoted. Mangere was then purchased with funds raised by the Royal Forest & Bird Protection Society, the New Zealand Wildlife Service and the Department of Lands and Survey. It was gazetted as a Nature Reserve in 1967 and the last sheep were removed in 1968. Brian Bell of the Wildlife Service took a leading role in initiating restoration, and following publication of a report by Atkinson et al. (1973), planting began in November 1973. This was of 30 young plants of Chatham Island akeake (*Olearia traversii*) in the lower Douglas Basin (Baird 1989). These plantings have been extended in almost every year since that time, at first through propagation of akeake cuttings at the NZ Forest Service nursery at Kaitaia and the Ministry of Works and Development nurseries at Wellington and Christchurch. Subsequently the Motukarara nursery in Canterbury became a mainstay for raising the plants, and in recent years plants have been raised in nurseries on Chatham and Pitt Is. Early plantings were funded by the Wildlife Service. Since 1987 funding has come from the Department of Conservation with substantial assistance from the Forest Heritage Fund. Chatham Island snipe were re-established on the island in 1970, black robins between 1976 and 1989, and Chatham Island tomtits between 1987 and 1989.

The Department of Conservation maintains a hut on the island that is used as a base for planting, and for various monitoring and research studies related directly to either recovery of threatened species or restoration of the island as a whole.

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[1] To avoid the constant use of 'Island' throughout the text, the second part of the official geographic placename 'Mangere Island' has been dispensed with, except in section headings and running footers. Other occurrences of 'Island' have been abbreviated to I. (singular) or Is (plural) except within species' common names.

2. Characteristics of Mangere Island

2.1 CLIMATE

No climate records are available for the island. In common with other islands of the Chatham group, Mangere has a cool windy climate. The prevailing wind direction is south-west but north-west winds are also very frequent. Meteorological data recorded at Waitangi, Chatham I., for the period 1951–80 show a mean annual rainfall there of 895 mm. The driest months were October through to February (monthly means of 57 mm in November and January) and the wettest were May to August (mean of 114 mm in May). The average number of raindays (1 mm or more) for the 1956–80 period was 133 per annum with the highest number of raindays recorded in any one month being 18 in July (NZ Meteorological Service 1981).

Air temperatures recorded by the Meteorological Service at Waitangi for the period 1956–80 show a mean of 11.2°C with the warmest month January averaging 14.5°C and the coolest month July averaging 7.8°C. Frosts are probably absent on Mangere and snow is rare. The island is affected by occasional hailstorms.

Mean annual sunshine hours recorded at Waitangi for the period 1957–80 was 1430 hours. The sunniest month during this period was January (183 hours) and the most overcast month was June with 64 hours of sunshine.

Probably the most significant climatic factor for plant growth on Mangere is the high incidence of salt storms: strong winds of less than 70% relative humidity pick up aerosol salt from waves breaking far out at sea. Wind then drives the salt particles through the leaf surfaces of exposed plants and the salt is translocated to shoot apices, leaf tips and margins where it blackens and kills shoots and foliage (cf. Boyce 1954). The most severe salt storms are associated with south-westerly gales but there are no systematic records of this aspect of the Chatham Is climate.

From a management viewpoint, the most significant aspect of the island's climate is the high frequency of rough seas that prevent safe landings and departures from the island.

2.2 GEOLOGY AND PHYSIOGRAPHY

Mangere (113 ha) and neighbouring Little Mangere I. (Tapuaenuku) are the eroded remnants of an ancient volcano of Pliocene age (Campbell 1996). Mangere lies 2.3 km north-west of Pitt I. at its nearest point. The high eastern block of the island is composed of massive coarse-grained agglomerate and trachyte, similar to that of Waihere Head and Rangiauria Point on the west coast of Pitt I. (Hay et al. 1970). The relatively low western peninsula has a basement of similar agglomerate but this is overlain by freshwater sediments that

TABLE 1. LANDFORMS, SOILS AND FUTURE VEGETATION OF MANGERE ISLAND.

LANDFORM	DIAGNOSTIC CRITERIA	DISTRIBUTION ON ISLAND	SOIL FEATURES	FUTURE VEGETATION
Plateau	Gently sloping (<15°) uppermost slopes	Summit plateau of E. block	Shallow loams with weak structure	Koromiko scrub; open communities; ?royal albatross colony
Ridgetops	Gently sloping (<15°) to flat areas on ridges or small hills	Broad ridges of W. peninsula and hills and ridges of S. coast	Shallow and deep friable dark reddish brown loams	Koromiko scrub; akeake forest; flaxland; herbfields
Residual hillslopes	Slopes (8–25°) where soil is largely from *in situ* weathering	Lower Douglas Basin; upper west catchment	Firm reddish brown loams on very compact B horizon	Matipo-akeake forest and scrub
Colluvial hillslopes	Slopes (8–25°) where soil is product of creep and mass-movement	Upper Douglas Basin; northern slopes of W.peninsula	Shallow reddish brown loam on compact B horizon	Matipo-akeake forest with karamu and ribbonwood; koromiko scrub
Colluvial steeplands	Slopes mostly 26–55° produced by mass-movement of soil, stones and boulders	Upper Douglas Basin; south-eastern slopes	Shallow (<12 cm) reddish brown loam on firm B horizon	Matipo-akeake forest and scrub; herbfields
Landslides	Deposits of rocks, soil and debris produced by slumps and sliding	South-eastern slopes	Soils without horizon development	Akeake shrubland, flaxland and herbaceous vegetation depending on site
Rockfalls	Deposits of rocks produced by free fall from higher ground	Eastern slopes	Accumulations of organic debris between boulders	Akeake-ribbonwood forest and scrub
Cliffs	Slopes >55°usually formed in hard rock	Surround the island on all sides	Soil material only in crevices	Vegetation similar to that of present day

probably accumulated in a crater lake (Hay et al. 1970; Campbell 1996). The high eastern block is bounded on northern and eastern sides by nearly vertical cliffs that rise to a summit plateau with the highest point, Whapaka (292 m), at its south-eastern corner. This plateau falls gently towards the west with moderate slopes that form an upper basin extending further westwards to the cliff edge at 150 m altitude. The northern cliffs skirting the plateau fall 250 m directly to the sea. A 190-metre cliff forms the eastern edge of the plateau, terminating in an extensive rockfall of huge boulders that tumble seawards to the shoreline. The southern margin of the plateau is a line of rocky bluffs below which moderately steep slopes grade into the easier slopes of the Douglas Basin. Much of the remaining coastline is bounded by steep or overhanging cliffs but a large shore platform along the northern coast of the peninsula makes landings possible in suitable weather.

2.3 LANDFORMS AND SOILS

The island's landforms were classified using the method of Atkinson (1992). This is a convenient way of relating site, soil and vegetation data to restoration planting and acknowledges the strong linkages that exist between landforms, soils and vegetation (Chavasse 1962; Atkinson 1981, 1994; Stewart & Harrison 1987). Details of the landforms distinguished, together with their associated soils, are listed in Table 1.

The landforms forming the greater part of the island are residual hillslopes, colluvial hillslopes and steeplands. Together these form practically the whole of the Douglas Basin, the elevated catchment west of the summit plateau, some northern slopes of the western peninsula and the south-eastern slopes opposite Pitt I. The distribution of other landforms is also given in Table 1.

Soils of the island cannot be related directly to those mapped on Chatham I. by Wright (1959), probably because of differences in soil parent materials. They are typically dark reddish brown (5YR 3/2–3/4) loams, some shallow, but most of depths greater than 50 cm. A diagnostic feature of a mature soil on the island is the very compact B horizon of clay loam texture which is very difficult to dig. However, these soils, together with most others examined on the island, are well drained. No chemical analyses of soils from Mangere are available but their long and continuing use by burrowing seabirds, as well as the use of the island last century as a sheep run, suggests that soil nutrient levels are likely to be high.

2.4 FLORA

Common and scientific names for plants known from Mangere are listed in Appendix 2. The vascular flora of the island, as presently known, totals 92 taxa consisting of 70 indigenous taxa and 22 adventive species. The total includes five ferns, 15 trees and shrubs, five lianes and other climbing plants, 11 grasses, eight rushes and sedges, four other monocotyledonous herbs and 44 dicotyledonous herbs (Appendix 3). Among the indigenous taxa there are 22 that are endemic to the Chatham Is, just over half the total of 42 plant taxa listed by Crisp et al. (2000) as endemic to the region.

2.5 VEGETATION

Qualitative diagnostic criteria used in naming the vegetation types recognised here follow the system of Atkinson & Blaschke (1995). Classifications of vegetation in the Chatham Is (Cockayne 1902; Kelly 1983; Given & Williams 1984) have been based largely on the vegetation of main Chatham I. and by authors who did not visit Mangere.

2.5.1 Shoreline vegetation

Shoreline vegetation is well developed only along the eastern coast where a series of rockfalls, stony and gravel fans have provided sites for herbaceous and some woody plants to establish. Sites regularly exposed to wave splash are dominated by glasswort (*Sarcocornia quinqueflora*) and ice plant (*Disphyma papillatum*). On less exposed sites, carpets of ice plant and mats of Mercury Bay weed are abundant as are Chatham Island scurvy grass (*Lepidium* aff. *oleraceum*), Chatham Island groundsel (*Senecio radiolatus*), and the grass *Festuca coxii.* Fathen (*Chenopodium album*), glasswort and the sedge *Carex trifida* are locally abundant. Low-growing shrubs of Chatham Island koromiko (*Hebe chathamica),* or those intermediate in appearance between this species and Dieffenbach's koromiko (*H. dieffenbachii),* have established in many places.

2.5.2 Herbfields

These are most often associated with ridgetops and seaward facing slopes, particularly those of north-west to south-west aspect. They are characterised by four herbaceous plants: ice plant forming extensive mats, dense growths of Chatham Island geranium, clumps and individuals of Dieffenbach's speargrass (*Aciphylla dieffenbachii*), and tussocks of *Festuca coxii.* Occasional clumps of Chatham Island forget-me-not (*Myosotidium hortensia*) are present. Mats of *Pratia arenaria* are widespread in the herbfields and both southern nettle (*Urtica australis*) and Scotch thistle (*Cirsium vulgare*) are locally abundant. The herbfields are frequently margined by tussocks of *Carex trifida* or, on the western peninsula, stands of Chatham Island flax (*Phormium* aff. *tenax*).

2.5.3 Grasslands

Grassland of Yorkshire fog (*Holcus lanatus*) and cocksfoot (*Dactylis glomerata*), sometimes mixed with prairie grass (*Bromus willdenowii*), creeping bent (*Agrostis stolonifera*), ryegrass (*Lolium perenne*), barley grass (*Hordeum murinum*) or Kentucky bluegrass (*Poa pratensis*) is the most widespread kind of vegetation on the island. Grassland covers much of the summit plateau and adjacent western basin. It is still widespread on hillslopes and steeplands of the Douglas Basin, where there are now extensive plantings of Chatham Island akeake (*Olearia traversii*). It forms a mosaic with other communities on the shallow soils of the western peninsula. This grassland is a relic of the sheep-farming days and, when moisture is adequate, forms rank growth that tends to exclude invasion by other plants. In a few places, however, it has been invaded by fast-growing patches of muehlenbeckia (*Muehlenbeckia* aff. *australis*).

A second kind of grassland is also widespread, particularly on the upper colluvial steeplands. It is composed almost exclusively of deep swards of *Poa chathamica* often forming large patches within Yorkshire fog-cocksfoot grassland. Apparently the poa has spread since sheep were removed from the island.

2.5.4 Tussocklands and flaxlands

Although localised, *Carex trifida* is widespread on the island forming single-dominant tussocklands on seaward-facing slopes and ridge crests. Chatham Island flax forms dense thickets on parts of the western peninsula as well as in the lower Douglas Basin. Much of this flaxland has developed from flax plantings that have subsequently flowered and seeded into the adjacent grassland.

2.5.5 Shrublands and scrub

The northern slopes of the western peninsula are now covered in many places by shrubland (50–80% cover of woody plants) or scrub (> 80% cover of woody plants with diameters at breast height (dbh) < 10 cm) and composed of Dieffenbach's koromiko. This community is associated with the often shallow and sometimes powdery soils weathered from ancient lake deposits mentioned above (Section 2.2). In one or two basins of the western peninsula, koromiko scrub appears in process of replacement by taller trees but these stands were not examined. Elsewhere on the island, there are many small stands of koromiko scrub that, like those of the peninsula, have developed almost entirely since sheep were removed.

The oldest plantings of Chatham Island akeake are in the south-western corner of the Douglas Basin and are now 30 years old. These young trees have closed their crowns to form a continuous salt-furrowed canopy at a height of 3.7 to 4.0 m. However, trunk dbh are still in the range of 6–9 cm so that, using a 10 cm dbh threshold for forest, this akeake community is still only at a scrub stage.

A third kind of scrub on Mangere is dominated by compact rounded bushes of keketerehe (*Olearia chathamica*), less than 2 m high, which have been shaped by the effects of wind-driven salt. This community is most strongly developed on the very exposed and steep western slopes of the high eastern block of the island.

2.5.6 Akeake-ribbonwood forest (Robin Bush)

About 5 ha of this forest survived the sheep-farming period by reason of its position on the rockfall below the eastern cliffs of the island. Regeneration and planting along the southern boundary of the forest has increased its area to about 8 ha. Chatham Island ribbonwood (*Plagianthus chathamicus*) is concentrated in the upper half of the forest. A point analysis of canopy cover (n=100 points), conducted throughout both upper and lower slopes of the forest, gave akeake 70%; ribbonwood 19%; muehlenbeckia 4% and gaps in the canopy 5%. Chatham Island matipo (*Myrsine chathamica*) and hoho (*Pseudopanax chathamicus*) are also present in the forest as well as ngaio (*Myoporum laetum*), the latter species not seen by the author. The only major understorey plant was Chatham Island mahoe (*Melicytus chathamicus*).

Canopy height varied between 7 and 11 m and, judged by the range in trunk diameters (8–110 cm dbh), many trees are young. This is a consequence of the frequency with which new rockfalls are tumbling onto the site from the cliffs above and leaving swathes of broken or buried trees. Rocks on the ground vary in plant cover from those encrusted with mosses or lichens to those that are freshly broken or cracked and lacking in moss or lichen cover. Openings in the forest appear to be quickly re-colonised by akeake and to a lesser extent by mahoe.

Associated with this forest are extensive areas of muehlenbeckia vineland, particularly on the boulder slopes between the upper margin of the forest and the foot of the cliffs. In some places muehlenbeckia is present on the ground within the forest but, although climbing trees, it does not become a major component of the canopy (see point analysis results above).

2.6 ANIMAL LIFE

2.6.1 Invertebrates

Several threatened species of invertebrates endemic to the Chatham Is have survived on Mangere. The Rangatira spider (*Dolomedes schauinslandi*), one of the largest New Zealand spiders, is now restricted to South East I. (Rangatira) and Mangere. On Mangere their 'nursery webs' are widespread, from near the shoreline to the upper slopes. In the Douglas Basin these spiders have frequently been found in the bases of large flax clumps (D. Bell, pers. comm. 2000).

The largest population known of coxella weevil (*Hadramphus spinipennis*) is on Mangere (R. Emberson, pers. comm.). This is a consequence of the island also holding the largest remaining population of Dieffenbach's speargrass. The dependence of the weevil on the speargrass as well as its effects on the speargrass population have been studied intensively by Schöps et al. (1999) and Schöps (2000).

The Chathams giant click beetle (*Amychus candezei*), another species restricted to the smaller islands, has been found in Robin Bush on Mangere. The flightless carabid beetle *Mecodema alternans* is common in forest and coastal vegetation on the island. The nocturnal and flightless stag beetle *Geodorcus capito*, now very rare on Chatham and Pitt Is, is present on Mangere (Emberson 1998). Emberson recorded 65 beetle species from Mangere although he collected less intensively there than on Rangatira (139 beetle species).

Other components of the island's invertebrate fauna are still inadequately known. There are giant slugs living in some of the flax communities. Two species of cave weta are present on the island. Among the Lepidoptera there are certain to be endemic species associated with particular endemic plants. Examples found by J. Dugdale (pers. comm.) on Rangatira include an undescribed species of noctuid moth (*Tmetolophota* sp.) associated with *Carex* spp., two species of geometrid moth (*Austrocidaria*) associated with *Coprosma arborea,* and another geometrid moth, *Asaphodes chlorocapna*, that eats fallen muehlenbeckia leaves. The fact that there are a significant number of flightless, often nocturnal, endemic invertebrate species on Mangere can be attributed directly to the absence of rats and mice.

2.6.2 Lizards

Skinks (*Oligosoma nigriplantare nigriplantare*) are abundant on the island and show considerable colour variation. This skink is unlikely to be conspecific with *Oligosoma n. nigriplantare* of mainland New Zealand (C.H. Daugherty, pers. comm. 2001). Diagnosis of its taxonomic position awaits further genetic analysis.

2.6.3 Birds

Common and scientific names for birds known from Mangere are listed in Appendix 4. Seabirds recorded as breeding on Mangere during the past 30 years are sooty shearwater, fairy prion, broad-billed prion, black-winged petrel, grey-backed storm petrel and blue penguin (Tennyson 1991; Tennyson & Millener 1994). Shorebirds breeding during the same period are Pitt Island shag, Chatham Island oystercatcher, red-billed gull and white-fronted tern.

Birds breeding in the forest or open land include Chatham Island snipe, brown skua, Chatham Island red-crowned parakeet, Forbes' parakeet, Chatham Island pipit, blackbird, Chatham Island warbler, Chatham Island tomtit, black robin, Chatham Island tui, starling and probably silvereye. Visitors to the island include Australasian harrier, Chatham Island fantail and redpoll. The shore plover was re-introduced in January 2001 and bred successfully in the 2001/02 summer. Further introductions of this bird were made in January of 2002 and 2003.

3. Mangere Island in pre-historic time

A picture of what the island may have been like in pre-historic time can be constructed using information from several sources: published historical information; scientific studies combined with personal knowledge of the native plant/animal communities of Pitt I., Rangatira and Tapuaenuku; composition of the surviving native communities of Mangere; and relating this information to the landforms and soil pattern of the island.

Mangere is unlikely to have been permanently settled by Moriori. No field evidence of permanent occupation has been found, and bracken, which on Chatham I. was cultivated for food by Moriori (Richards 1962), has not been found on the island. Fresh water is apparently limited to one permanent but fluctuating supply. Fyfe (1978) remarks that there appear to be no sources of stone suitable for artefact manufacture on the island. He gives details of two archaeological sites, one a midden in the Douglas Basin (C240/717) and the other a rock shelter on the east coast that has been destroyed by livestock (C240/718). On neighbouring Pitt I. the Moriori population was estimated to have numbered 300 in 1790 (Richards 1972), and so it is highly probable that the island was visited to collect forest birds or seabirds and their eggs. Although there may have been no seal colony on the island, seals were eaten there; Fyfe found large numbers of seal bones in the Douglas Basin midden. He noted that 'early European cadastral maps (1898 series) show reasonably large areas of Mangere under forest cover'. However, Travers & Travers (1872) describe the island in 1871 as 'nearly covered with low rigid scrub'. Clearly both kinds of vegetation were present, canopy height varying in different parts of the island according to the degree of exposure. While making a limited survey of the soils of the island for this plan, I was unable to find charcoal in soil pits that would have indicated widespread burning of forest or scrub during the Moriori period. Although some bird species may have been extinguished by hunting during this time, it seems reasonable to conclude that Mangere escaped major modification until the second half of the nineteenth century.

The most obvious evidence of the nineteenth century forest is the presence of large akeake logs scattered unevenly over much of the island. The trunk diameters of these trees can often be estimated: they are mostly between 25 and 70 cm dbh. Judged by the shape and sizes of the remaining upper branches, heights of these trees ranged from 3.7 to 7 m. In 1968 a few of the akeake trees in the Douglas Basin were still alive. Ritchie (1970) states: 'isolated stems of *Olearia traversii* still supported tufts of leaves and a few flowers on the sheltered side'. The persistence of the logs for 50 or more years can be attributed to the hardness and water-resistance of akeake wood; other kinds of tree originally present have long since decayed.

The probable composition of this forest can be inferred from the remaining stands on volcanic soils of Pitt I., from bird-burrowed forest stands on Rangatira, from the very small stand surviving on the heavily bird-burrowed soil of Tapuaenuku and from the rockfall forest of Mangere itself (Robin Bush). It

was probably a matipo-akeake forest with a minority proportion of akeake that fluctuated according to the frequency of windthrows, landslides, rockfalls and, not least, salt storms that occasionally kill both akeake and other tree species. Akeake does not regenerate well in shade but establishes and grows rapidly in light gaps that result from disturbance events. Chatham Island mahoe, which would have been prominent in the understorey but less important in the canopy, would also have contributed towards filling of canopy gaps. In the absence of further disturbance at a particular site, the more shade-tolerant and slower growing Chatham Island matipo would gradually re-establish and become the leading dominant again. On sites where disturbance was continual, such as the rockfall at Robin Bush, recurring rockfalls promote successive cycles of akeake growth that allow this species to remain continuously dominant.

Other tree species were present in the nineteenth-century forest, their distribution being controlled by site conditions. On fertile sites that were sheltered from salt storms, Chatham Island ribbonwood would have been prominent. Moister soils less subject to drought would have supported Chatham Island karamu (*Coprosma chathamica*) particularly the colluvial hillslopes and steeplands of the upper Douglas Basin. Hoho is still present on the island and could have contributed to the canopy on a range of different sites, its exact distribution probably influenced by the flight paths of parea (*Hemiphaga chathamensis*). With present knowledge, the former distribution and numbers of ngaio, which is still present, are difficult to assess. How much Chatham Island nikau (*Rhopalostylis* aff. *sapida*) was present on the island is also unknown although there appears to be no reason why it would not have grown on moister sites. Supplejack (*Ripogonum scandens*) would have contributed to the forest canopy as did muehlenbeckia. The general lack of peaty soils do not suggest that tarahinau (*Dracophyllum arboreum*) was ever important in the original forest but there may have been a few trees as there are today on Rangatira. Another question is whether any tree fern species were present. If so, it is very surprising that none have been recorded, even young ones recently blown as spores from Pitt I. Kawakawa would have been a major component of the forest understorey as well as mahoe. I think it unlikely that kopi was present on the island, at least in pre-human times.

On very exposed westerly sites subject to high wind-runs with frequent salt-storms, forest would have graded into a low-growing scrub in which flax, keketerehe and Dieffenbach's koromiko were the most prominent species. It is likely that hokataka (*Corokia macrocarpa*), still present on the island, grew on these sites, particularly on stony soils.

Where wind-driven salt reached extremes on exposed ridges, knolls and cliff edges, scrub would have been replaced by herbfields similar in composition to those described above (Section 2.5.2). These herbfields would always have been in a state of continual change with respect to their site boundaries and their plant/animal composition at any one place. These changes are likely to have been more rapid than those affecting the forest.

Animal life of this pre-historic community would have been dominated by birds: at least 11 species of seabird, mostly burrow-nesters, 7 species of shorebirds and 19 species of birds inhabiting forest or more open habitats. Up to 22 bird

species have been lost from the island since the arrival of humans. They include diving petrel, Chatham petrel, an unnamed species of gadfly petrel, an unnamed species of crested penguin, two species of rail, a snipe distinct from the species now on the island, an unnamed species of shelduck, parea, Chatham Island kaka, Chatham Island fernbird and Chatham Island bellbird (Tennyson & Millener 1994).

4. Restoring Mangere Island

4.1 WHY RESTORE RATHER THAN SIMPLY MANAGE WHAT IS LEFT?

Reasons for restoring an island are: (1) to provide habitats for threatened plant or animal species and (2) to replace or repair plant/animal communities that have either been lost or greatly altered in structure and function. These two imperatives are closely linked. Providing habitat for a threatened species depends on reconstructing, as far as possible, the physical and biological conditions necessary for that species to maintain itself with minimum human intervention; i.e. restoring the kind of community (or communities) of plants and animals in which the threatened species had become adapted to live at an earlier time. These aims can often not be met safely by protecting what is left on an island. Without intervention, some kinds of habitat may not re-develop within a time frame that is useful for supporting a threatened species. Species lost from an island may have to be replaced in some way. Earlier physical or biological conditions necessary for survival of a particular species may need to be reinstated. For these reasons this plan advocates:

- Continuing the replacement of rank pasture, inherited from the sheep-farming period, by extensive planting of tree species native to Mangere (begun in the 1970s)
- Removing flax or native trees locally to protect indigenous herbfields
- Continuing the culling of an endemic subspecies of bird to protect an even more distinctive endemic bird species (begun in the 1980s) and
- Introducing two native bird species as substitutes for two extinct species.

The question must therefore be asked: 'Are these kinds of intervention compatible with the island's status as a Nature Reserve?'

In answering this question it must be recognised that Mangere is an extremely modified island, more so than any other island reserve in the Chatham group. This is a consequence of species' extinctions following introduction of rabbits and cats, and extensive habitat destruction associated with use of the island as a sheep farm for more than half a century.

The Reserves Act (1977) outlines primary management objectives for a Nature Reserve. These include (1) 'It shall be preserved as far as possible in its natural state' (2) 'Except where the Minister otherwise determines, the indigenous flora and fauna, ecological associations and natural environment shall as far as possible be preserved…'

Both tree planting and protection of herbfields are aimed at converting the present rank grassland to native vegetation similar to that of the nineteenth century. Increasing the area of forest will increase the area of habitat suitable for the small populations of both black robin and Forbes' parakeet on the island. It will also provide needed additional habitat for Chatham Island tui, parea, Chatham Island fantail, Chatham Island tomtit and Chatham Island snipe. Culling of a native parakeet on Mangere is designed to secure the survival of an

extremely threatened parakeet species (with which it hybridises) without putting survival of the culled species (which is on other islands) at risk. The culled species favours grassland while the threatened species favours forest. Thus it is expected that culling can be phased out as grassland is replaced by forest.

The powers, duties and functions of the administering body (Department of Conservation) under the Reserves Act 1977, as they relate to Nature Reserves, include certain guidelines:

(1) 'Area should be large enough to ensure the integrity of its ecosystems...' and (2) 'Area should be significantly free of direct human intervention and capable of remaining so.'

With respect to (1), the extinction, late in the nineteenth century, of several bird species on Mangere adversely affected the integrity of this island ecosystem. The proposed substitutions of two bird species, closely related to two of the extinct species, would be a step towards restoring the integrity of the system. For example, by re-activating processes such as particular predator-prey, seed dispersal or pollination relationships between these birds and other organisms on the island.

Guideline (2), relating to direct human intervention contains an apparent contradiction; none of the necessary management objectives discussed above can be achieved without 'direct human intervention.' It is clear, however, that all the intervention discussed, either in train or proposed, will not be continued indefinitely if it is successful in achieving its goals. Put another way, all management intervention should be directed towards building an island ecosystem that is self-maintaining to a level at which further intervention is minimised.

4.2 WHAT KIND OF COMMUNITY SYSTEM SHOULD WE RESTORE TO MANGERE ISLAND?

Without a clear answer to this question there is real danger that planting programmes and those for recovery of threatened plant and animal species will be pursued in isolation from each other.

The most widespread community originally present on Mangere was forest and many plant and animal species depended on it for survival. But other kinds of community were also present (e.g. herbfields, shrublands and scrub) and a very widespread and species-diverse array of burrow-nesting seabirds (cf. Tennyson & Millener 1994) exerted a continuing influence on the whole system. Although we are aiming to restore forest to the greater part of Mangere we should remember that the specific target is restoration of a seabird-plant-invertebrate-forest bird system.

The next question is: 'What kind of forest in terms of tree species?' Some people may consider it sufficient to plant any kind of forest that will grow on the island and provide cover and/or food for threatened species of concern. Such an approach might be sensible if we understood all the dependencies of these species. In fact, in many cases we are still in extreme ignorance of the factors that determine whether or not a particular plant or animal species will survive on an island. Any kind of *ad hoc* community will not necessarily be self-

maintaining; nor can we assume that it will provide the key resources needed by a species that we particularly wish to protect, such as Forbes' parakeet (see Section 5.4.1).

A safer strategy is to attempt to reconstruct the forest community (plants and animals), and associated communities, *that we know from historical evidence once supported the threatened species of concern.* The sheep farm of last century, or the earlier state of the island when inhabited by cats and rabbits, are clearly not suitable as restoration targets because so many of the island's native species either declined or became extinct during this period. Restoring the island to a condition as close as possible to that of the middle nineteenth century, *before* the introduction of these mammals, is an identifiable and achievable goal for restoration.

Descriptions of the island's vegetation and wildlife at that time are limited (see Chapter 3, and Tennyson & Millener 1994 and references therein) but there is more information available than at any earlier period. This is sufficient to draw inferences and build a useful model of what the island was like. It would certainly not have been in a pre-human condition but nevertheless much less modified by humans than the main islands of the Chatham group. A number of the extinct species that were present in the early nineteenth century cannot be replaced by substituting other taxa (see Section 6.6). But re-assembling many of the plant and animal species that were present will increase our chances of providing conditions for sustaining populations of some species currently threatened. In particular, we can expect that reconstructing these conditions will ultimately, even if not immediately, reduce the amount of management intervention required to maintain these threatened species.

4.3 PRIMARY GOALS AND RESTORATION TARGETS

The primary goal for restoring Mangere is to *reinstate the island's vegetation and wildlife to a condition, as similar as our understanding and available plant and animal species will allow, to that prevailing during the middle part of the nineteenth century.* This goal must acknowledge that plant and animal numbers were never static during this period any more than at any other time. Therefore restoration targets must accommodate normal ecological processes that change plant and animal numbers. This primary goal does not preclude secondary targets, in which localised and site-specific modification of vegetation or substrate is done to increase breeding opportunities for a threatened species that is either already present on the island, or whose habitat is very restricted elsewhere in the Chatham Is.

4.4 KEY PLANT AND ANIMAL SPECIES REQUIRED FOR RESTORING MANGERE ISLAND

Akeake has been the mainstay of the planting effort on Mangere and must remain so until all the area to be re-forested has some cover of woody vegetation. No other forest plant of the Chatham Is has the same pioneer

qualities. On more exposed sites where soils are deep enough to support woody vegetation, flax and keketerehe should be considered for planting. On the most exposed sites, where only herbaceous plants can tolerate salt input, Chatham Island iceplant and Dieffenbach's speargrass are suitable for herbfield communities.

To attain a forest that begins to approach the composition of the nineteenth century more closely, extensive plantings of matipo and mahoe need to begin as soon as possible. Both trees produce fleshy fruit and would assist the establishment of several threatened bird species, particularly parea and the Chatham Island tui.

Whether any animal should be considered as a key or 'keystone' species for restoring Mangere is debateable. Certainly the burrowing-petrel population, taken as a whole, should be seen as a probable major controlling and therefore 'keystone' influence on the composition and dynamics of forest communities, even if these processes are not yet properly understood. In the herbfields of the island, the study of Schöps (2000) demonstrates how the dynamics of speargrass is influenced by the coxella weevil. But there is no reason to think that the speargrass population would not survive in the absence of the weevil.

5. Targets for recovery of threatened species

5.1 PLANTS

Recovery action on Mangere is needed for several plant species endemic at the specific or sub-specific level. Some of these are already present on the island and a case should be prepared for those that are not. All indigenous plant species of the Chatham Is region were considered in compiling this section of the plan.

5.1.1 Chatham Island nikau (*Rhopalostylis* aff. *sapida*)

Taxonomically indeterminate and classified as 'Nationally vulnerable' by Hitchmough (2002). Nikau is likely to have been on Mangere originally (Chapter 3). The nikau population on Pitt I. is declining steadily (Walls 2000) and, even though this palm is regenerating satisfactorily in some reserves on Chatham I., a second population of Pitt I. stock is desirable. Nikau can be planted on moist sites in developing akeake forest that is at least 3 m tall. Given the value of nikau fruit to birds, they could be established on several sites as the akeake forest matures.

5.1.2 Barker's koromiko (*Hebe barkeri*)

Classified as 'Nationally vulnerable' by Hitchmough (2002). Although not known from Mangere, it has survived on Chatham and Pitt Is and Rangatira. Pitt I. could be used as a seed source. Walls (in press) reports finding about 200 plants on Pitt, particularly in one gully-head but also in a variety of other sites. Establishment of some tree ferns on Mangere, particularly *Cyathea dealbata* or *Dicksonia squarrosa,* would facilitate epiphytic establishment of this koromiko.

5.1.3 Chatham Island astelia (*Astelia chathamica*)

Classified as 'Nationally endangered' by Hitchmough (2002). Whether this was once present on Mangere is not known. An additional population to those on Chatham and Pitt Is would increase security for the species. Whether there are sufficient moist sites on the island to support a population could best be tested with trial plantings; the availability of suitable sites is likely to increase as forest develops on the island.

5.1.4 Chatham Island sow thistle (*Embergeria grandifolia*)

Classified as 'Nationally endangered' by Hitchmough (2002). Although not immediately threatened on Mangere, this plant is currently known from only three sites on the island. I examined only the largest of these, a steep coastal herbfield in the upper western basin where the soil is shallow and loose, and heavily burrowed by seabirds. A rough estimate indicated that in February 2000 the site was supporting between 70 and 100 plants. A study should be made to establish whether the thistle population of the island is viable or whether it

should be established on additional sites. Another question that needs to be resolved is whether the establishment or growth of the sow thistle is influenced significantly by introduced thistles.

5.1.5 Chatham Island button daisy (*Leptinella featherstonii*)

Classified as 'Nationally vulnerable' by Hitchmough (2002). This rare plant is particularly associated with surface-nesting or burrowing seabirds. Its variation between different islands in the Chatham group is considered by Lloyd (1982) to reflect the history of marine submergence of the islands. It has not been recorded from Mangere but a small population exists on the summit plateau of Tapuaenuku. This would be the most satisfactory source for establishing the plant on Mangere.

5.1.6 Chatham Island rauhuia (*Linum monogynum* var. *chathamicum*)

Taxonomically indeterminate but classified as 'Nationally critical' by Hitchmough (2002). In six days of walking over much of the island during February 2000, our party saw only two plants of rauhuia. A. Baird (pers. comm.) reports that it is rare on other islands in the Chatham group. Intensive searching, both on Mangere and on other islands, is needed to identify its habitat requirements and factors limiting its numbers with the purpose of developing a recovery plan. Its requirements are not necessarily the same as those of New Zealand mainland populations of rauhuia.

5.1.7 Other threatened species

Another threatened species that could be considered for establishment on Mangere, if suitable habitat can be found, is the Chatham Island woollyhead (*Craspedia* aff. *minor*). This is taxonomically indeterminate and is classified as 'Range restricted' by Hitchmough (2002). At present it is not clear why this plant is apparently confined to the south coast of Chatham I. Chatham Island scurvy grass (*Lepidium* aff. *oleraceum*) is apparently not threatened on Mangere but requires regular monitoring. This taxonomically indeterminate plant is classified as 'Nationally critical' by Hitchmough (2002).

5.1.8 Species for which recovery action on Mangere Island is inappropriate

Provided the island's herbfields are maintained (Section 6.5), viable populations of Dieffenbach's speargrass (*Aciphylla dieffenbachii*, classified as 'Nationally vulnerable' by Hitchmough (2002)) and Chatham Island forget-me-not (*Myosotidium hortensia*, classified as 'Nationally endangered' by Hitchmough (2002)) are likely to persist without particular recovery action. Although the Chatham Island speargrass (*Aciphylla traversii*, classified as 'Nationally endangered' by Hitchmough (2002)) has been recorded once (Appendix 3), this plant is primarily a peat species; it is doubtful whether there are suitable habitats for it on the island. Notwithstanding the single record of shore spurge (*Euphorbia glauca* (classified as in 'serious decline' by Hitchmough (2002)), the general absence of sand and other unconsolidated debris along the coast make it unlikely that a viable population of this species would persist on the island.

5.2 INVERTEBRATES

5.2.1 Coxella weevils and Dieffenbach's speargrass

Schöps et al. (1999) and Schöps (2000) have shown that coxella weevils can cause local (patch) extinctions of Dieffenbach's speargrass by eating leaves, shoots and roots. They recorded seven such patch extinctions on Mangere between 1990 and 2000 and measured minimum distances of 200 to 480 m moved by marked female weevils to other speargrass patches. The collapse of local plant and weevil populations was a common event. As pointed out by Taylor (1990) and others, asynchrony in local population dynamics is essential for maintaining the stability of such a system. If all speargrass on Mangere was lost to weevils in one season, the weevil (whose females live little more than 2 years) could also become locally extinct. At present, speargrass patches on the island appear to be sufficiently far apart for this not to happen.

Coxella weevil is classified as 'Range restricted' by Hitchmough (2002). Given that there are only two viable populations left of the coxella weevil, on Mangere and Rangatira, it is essential to ensure that an adequate number of the herbfields that support these two species on Mangere are maintained. Areas where herbfields containing the speargrass are best developed are shown on Fig.1. It is recommended that within these areas there should be periodic intervention to remove young trees that threaten to replace parts of these herbfields. On some sites it may also be necessary to cut back the advancing margins of flax stands and possibly *Carex trifida* as well. No tree planting within herbfields should be attempted. This intervention should be treated as a temporary measure until such time as the distribution and areas of herbfield induced by normal climatic processes (e.g. wind-driven salt) become clear.

No invertebrate species on Mangere has been studied as intensively as the coxella weevil; there may well be other native invertebrate species that are dependent on herbfield communities for their survival. The re-establishment of forest of mixed plant composition on the island will provide suitable habitat for a greater diversity of invertebrates than is possible at present. As pointed out by J. Dugdale (pers. comm.), when considering herbivorous insects, re-establishment of their host plants will make it highly probable that these specialists will also re-establish.

5.3 REPTILES

On the basis of existing knowledge, no particular recovery action is needed for the skinks on Mangere.

5.4 LANDBIRDS

The possible value of Mangere as a habitat was considered for all endemic landbirds (refer Section 2.6.3) of the Chatham Is. Only those for which Mangere is likely to be suitable are discussed below.

5.4.1 Forbes' parakeet (*Cyanoramphus forbesi*)

The recent genetic and field study of Forbes' parakeet by Boon et al. (2000) appears to have resolved the long-running debate concerning the taxonomic status of this bird (Rothschild 1893; Oliver 1930; Fleming 1939; Triggs & Daugherty 1996). Boon et al.'s mitochondrial DNA data show that Forbes' parakeet carries a unique genotype deserving recognition as a distinct species, a conclusion reached earlier by Triggs & Daugherty using allozyme evidence. Boon et al.'s molecular data for this parakeet show a very high level of divergence from all other *Cyanoramphus* species. They found that 'the genetic distances between Forbes' parakeet and either red or yellow-crowned parakeets are three to four times greater than between red and yellow-crowned parakeets.' This suggests that Forbes' parakeet may be one of the most ancient *Cyanoramphus* taxa. The fact that they readily hybridize with the Chatham Island red-crowned parakeet indicates that they have not evolved an effective pre-mating isolating mechanism other than that of habitat preference (see below).

With its small breeding population confined to Mangere and Tapuaenuku, Forbes' parakeet is endangered; it is classified as 'Nationally endangered' by Hitchmough (2002). By the 1920s the species had disappeared from Mangere (Archey & Lindsay 1924). Fleming (1939) was informed that when the island was still forest-covered, this bird was the commonest parakeet present. Available evidence suggests that it prefers dense unbroken forest and scrub although it is well able to feed in non-forest habitats (Thurley 2000; pers. obs.). On Tapuaenuku, Taylor (1975, 1985) found that Forbes' parakeets are strongly territorial and that their diet includes a large proportion of invertebrates as well as flowers and seeds. Food was taken from the canopy and from the forest floor. Nixon (1994) observed that Forbes' parakeets ate greater amounts of leaf material when feeding on Mangere.

In contrast to Forbes' parakeets, Taylor (1975) found that Chatham Island red-crowned parakeets were not territorial and ate only insignificant amounts of invertebrates. Destruction of the original forest on Mangere and its replacement by pasture had favoured red-crowned parakeets. Once cat numbers declined, the grassland habitat allowed hybridization between the two species, as pointed out by Taylor. In 1973 he estimated the total parakeet population of Mangere at 'about 100, of which 6% were classed as *forbesi*, 47% as *chathamensis,* and 47% as hybrids.' (Taylor 1975). Culling of hybrid and red-crowned parakeets began in 1976 (Aikman et al. 2001). Numbers of Forbes' parakeets had increased to 25 to 30 birds by 1980 (Merton & Bell 1975) and reached 250–300 birds in 1992 (Munn & Page 1992). Subsequent counts of Forbes' parakeet on Mangere show large fluctuations, the high counts apparently following periods when Chatham Island red-crowned parakeets and hybrids had been culled (Aikman et al. 2001). The most recent count (Thurley 2000) gave a 'crude estimate' of 550 adults and 185 juveniles.

Culling of red-crowned parakeets and red-crowned/Forbes' hybrids will need to continue on Mangere until Forbes' parakeet has established a substantial population with a low incidence of hybrids.

Whatever its original distribution, breeding populations of Forbes' parakeet were apparently restricted to Mangere, Tapuaenuku and part of Pitt I. by the

early part of the twentieth century (Fleming 1939). If it is primarily a forest species, the question arises as to why it has never been recorded from Rangatira. Was there something about the structure or composition of the Mangere forest that provided unique but essential habitat conditions, or did this forest provide some pre-mating isolating barrier that minimised hybridization between the two parakeet species? Such speculations underline the importance of trying to provide every opportunity for forest on Mangere to develop along pathways determined by local site conditions. This means ensuring that a variety of appropriate tree species are planted at widely dispersed localities as future seed sources on the island. This will help to ensure that the proportions of different species among the next generation of trees will more closely reflect variation in site conditions rather than human preference (Section 6.1).

5.4.2 Chatham Island red-crowned parakeet (*Cyanoramphus novaezelandiae chathamensis*)

Classified as 'Range restricted' by Hitchmough (2002). The analysis of Boon et al. (2000) supports the current sub-specific classification of this bird; it remains a taxon endemic to the Chatham Is. Although culling of both red-crowned parakeets and red crowned/Forbes' hybrids may have to continue for some time on Mangere, protection for the red-crowned parakeet will be essential on other islands in the Chatham group (Aikman et al. 2001).

5.4.3 Black robin (*Petroica traversi*)

Classified as 'Nationally critical' by Hitchmough (2002). Breeding of black robins on Mangere is at present restricted to Robin Bush where there is a closed canopy but an open understorey. This forest is apparently suitable habitat for robins. Up to at least 1997, the density of territories, productivity and survival of Mangere birds surpassed that of Rangatira birds (Kennedy 1997). In the 2001/02 season, black robins on Mangere produced 14 fledglings from 22 pairs; census results for the previous three years indicate a stable population of about 50 birds (C. Miskelly, pers comm., January 2003). At present robins appear to make no significant use of the planted akeake shrubland and scrub on the island, presumably because a forest structure is not yet sufficiently developed. Monitoring the population for robin/tomtit hybrids and removing them is necessary; but continuing the effort to increase the area of planted akeake, and ultimately of forest, will be the most effective way of securing the viability of the Mangere population.

5.4.4 Chatham Island tomtit (*Petroica macrocephala chathamensis*)

Classified as 'Nationally endangered' by Hitchmough (2002). Tomtits were re-established on Mangere between 1987 and 1989 and, in contrast to robins, they are using the planted akeake to some extent. They also make use of the muehlenbeckia and shrubland communities that extend between the upper margin of Robin Bush and the base of the cliffs (Amey & Studholme 1996). No particular conservation action seems needed for tomtits at present but every effort should be made to identify the kind of habitat associated with any robin-tomtit hybrids that may appear.

5.4.5 Chatham Island warbler (*Gerygone albofrontata*)

Classified as 'Range restricted' by Hitchmough (2002). The Mangere population of this Chatham I. endemic species appears to be healthy and no intervention is needed.

5.4.6 Chatham Island fantail (*Rhipidura fuliginosa penita*)

Classified as 'Not threatened' by Hitchmough (2002). Fantails were present on the island in the nineteenth century but do not appear in published records since that time. However, there have been several recent sightings (D. Fastier pers, comm. to C. Miskelly). It appears likely that fantails will re-establish on the island when conditions are suitable.

5.4.7 Chatham Island tui (*Prosthemadera novaeseelandiae chathamensis*)

The Chatham Island tui has declined to a threatened status since 1990: the species is classified as 'Nationally endangered' by Hitchmough (2002). Their main breeding place is now Rangatira. They sometimes visit Mangere during the period of flax flowering. One pair has been regularly recorded in both the 1998/99 and 1999/00 seasons in and around Robin Bush. Dave and Mike Bell saw two fledglings in c.1998, that they consider could only have been bred on the island (D. Bell, pers. comm.). Dilks & Bell (1998) point out that the amount of breeding by tui varies widely from year to year, one factor being the extent of flax flowering. Mangere must be seen as a future place for a permanent breeding population but until a more invertebrate- and plant-diverse forest develops, permanence seems unlikely.

5.4.8 Parea (*Hemiphaga chathamensis*)

Classified as 'Nationally critical' by Hitchmough (2002). Parea were reported as breeding on Mangere in 1871/72 (Travers & Travers 1872) but have apparently not been seen on the island since. Restoration of the island's forest may enable a viable population to be re-established. A study of foods taken by this fruit pigeon on Chatham I. (Powlesland et al. 1997) found the diet consisted mainly of fruit, particularly matipo in autumn and hoho in winter and spring. Heavy fruiting of matipo and hoho promoted early nesting and prolonged nesting, including nesting during winter. It is essential that substantial numbers of these two trees are incorporated into the planting program for Mangere if a breeding population of parea is to be restored to the island.

5.4.9 Chatham Island snipe (*Coenocorypha pusilla*)

Classified as 'Range restricted' by Hitchmough (2002). Following re-establishment of snipe on Mangere in 1970 they have become widespread on the island as well as established on Tapuaenuku. No particular conservation action is required.

5.4.10 Shore plover (*Thinornis novaeseelandiae*)

Classified as 'Nationally critical' by Hitchmough (2002). A small population of shore plover was present on Mangere until 1898 (Fleming 1939) but probably

disappeared at that time when cats were introduced. Three attempts were made to re-establish shore plover on Mangere between 1970 and 1973. The transferred birds either returned to Rangatira or disappeared. A single female bird stayed on the island for just over a year in 1998.

Establishing new populations of shore plover on islands in the Chatham group is part of the preferred option for recovery given in the species' recovery plan (Aikman et al. 2001). A recent discovery on Western Reef (c. 6 ha) revealed an apparently reproductively isolated population of 21 birds (Bell & Bell 2000a). The habitat here is a rocky shore platform with little terrestrial vegetation (O'Connor *in* Aikman et al. 2001: Recovery Plan 44); this suggests that re-establishing a small population of shore plovers on Mangere may be feasible.

A 1999/2000 attempt to establish plover on the island's shore platform failed when the holding aviary was severely damaged by a storm. Juvenile shore plover have been transferred to Mangere in January of 2001, 2002 and 2003. One pair raised a fledgling in 2001/02.

5.4.11 Chatham Island oystercatcher (*Haematopus chathamensis*)

This endemic species, the rarest oystercatcher in the world and classified as 'Nationally critical' by Hitchmough (2002), was formerly present on Mangere (Fleming 1939). Two breeding pairs of oystercatchers were present on Mangere in February 2000 together with a third pair that did not breed. It is uncertain whether the numbers of oystercatchers breeding on the island could be increased with any kind of intervention.

5.4.12 Chatham Island shag (*Leucocarbo onslowi*)

Classified as 'Range restricted' by Hitchmough (2002). No breeding colonies of this shag are established in any protected area at present and there are no colonies on Mangere or Tapuaenuku. The nearest is on Rabbit I., off Pitt I., where Bell & Bell (2000b) recorded a colony of 83 nests in 1997/98. Their census showed that there were only 10 colonies of this Chatham I. endemic bird in the whole region. They feed in the waters around Mangere and consideration should therefore be given to establishing a colony on the island. Pitt Island shags currently breed on Mangere as well as on islands around Chatham and Pitt Is. Chatham Island shags dive more deeply for food than Pitt Island shags which are shallow divers (B.D. Bell, pers. comm.). Thus competition for the same food is not likely to be a limiting factor to the establishment of a colony.

5.5 SEABIRDS

Several factors are likely to have changed the numbers of seabird species breeding on Mangere since the prehuman period. These include predation by cats, loss of forest and consequent increased predation by skuas, harvesting by humans, removal by bird collectors and changes in food supply. Seabirds known to be breeding on Mangere at present are sooty shearwater, fairy prion, broad-billed prion, black-winged petrel, grey-backed storm petrel and blue penguin.

With the exception of the storm petrel and black-winged petrel, these seabirds are now abundant on the island but fossil deposits examined by Tennyson & Millener (1994) suggest they may have been much less abundant in the past. Some seabirds that have apparently been lost from the island altogether include the Chatham petrel and diving petrel.

All seabirds breeding in the Chatham Is region were considered in this section but only those for which the island is potentially important are discussed. No immediate recovery action appears to be needed for seabirds currently breeding on the island. There is, however, a necessity to systematise monitoring of their populations to gain understanding of what factors are most significant in affecting their numbers on the island. In the longer term, as outlined below, a case can be made for translocating three or four species of Chatham seabirds to Mangere. This, however, should only be attempted after (1) a detailed analysis of the difficulties inherent in such action and (2) expansion of the source populations to a sufficiently large size.

5.5.1 Chatham petrel (*Pterodroma axillaris*)

Classified as 'Nationally critical' by Hitchmough (2002). Tennyson & Millener (1994) found bones of this petrel at the two sites they examined representing a minimum number of eight individuals. The species may have been eliminated by cats in the early 1900s. The only known population is on Rangatira. which is estimated to be between 800 and 1000 birds (Taylor 2000a). A second population that can be fully protected is needed. Using techniques similar to those developed by Bell (1995), 41 chicks were transferred to the Ellen Elizabeth Preece conservation covenant on Pitt I. in 2002. All chicks fledged (C. Miskelly, pers. comm.) but it will be several years before any returns can be expected. Translocation of birds from Rangatira to Mangere may be feasible using these and other techniques for moving nestlings such as those developed by Priddel & Carlile (1999), or methods for attracting seabirds to new nesting sites (Podolsky 1990). Successful establishment on Mangere is likely to involve localised culling of broad-billed prions to reduce competition for burrows unless this can be avoided through careful selection of sites free of prions. Additional information on the biology of the bird may be needed including seasonal changes in the frequency with which the chicks are fed, and site conditions—particularly forest characteristics—that are favoured by the birds for burrowing. Other critical information needed is the minimum number of chicks required to establish a new colony, and the size that the breeding population on Rangatira must reach before it can sustain removal of chicks (cf. Aikman et al. 2001). With respect to burrow competition from broad-billed prions, it will be necessary to determine the population size, distribution and current rate of prion increase on the island.

5.5.2 Taiko (*Pterodroma magentae*)

Classified as 'Nationally critical' by Hitchmough (2002). Bones of taiko have been recovered from Pitt I. (P.R. Millener, pers. comm. 1993) but so far not from Mangere where only two fossil sites have been examined. Whether the island would have been suitable for taiko is not clear but establishment of a second population, free from predation or interference by cats, rats, wekas, pigs and cattle, would help to secure the species. Given the extremely small

size of the taiko population, any attempt to establish a population on Mangere is much further into the future than establishing the Chatham petrel. This gives more time for gathering the information on taiko biology that is essential for a successful transfer.

5.5.3 Chatham Island mollymawk (*Diomedea cauta eremita*)

Classified as 'Serious decline' by Hitchmough (2002). The breeding population of this albatross is restricted to The Pyramid in the Chatham Is. They are seldom seen at sea in the Chatham region as, after leaving the island, they apparently fly eastwards to feed (D. Bell, pers. comm.). The most recent classification recognises this population as a distinct species: the Chatham Island albatross, *Thalassarche eremita.* Robertson et al. (2000) point out that this endangered species is vulnerable to habitat change at the Pyramid, sporadic illegal harvesting of chicks, and various kinds of fisheries by-catch in New Zealand, Chile and Peru.

A second breeding population, in a fully protected area, would increase the long-term security for this magnificent seabird. Mike Bell (pers. comm. 1998) has suggested a steep north-facing slope on the western peninsula of Mangere as a possible site for a new mollymawk colony. With present knowledge, such an attempt appears formidable but the question should be addressed seriously. Techniques for establishing a mollymawk colony need not be restricted to translocation of chicks. Methods of attracting albatrosses to new potential nesting sites, such as those explored by Podolsky (1990), should be investigated. The recent success achieved by the Department of Conservation in hatching grey-faced petrel (*Pterodroma macroptera*) eggs and raising the chicks to a point where they could fly and be released from a different island, raises new possibilities for translocating seabirds. Moving eggs and raising chicks at specially selected sites may circumvent the problem of adult birds returning to their natal site instead of the new site selected.

5.5.4 Northern royal albatross (*Diomedea sanfordi*)

Classified as 'Nationally vulnerable' by Hitchmough (2002). The major breeding colonies of this bird are on the nearby islands The Sisters and The Forty Fours, although a small colony has established at Taiaroa Head, Otago Peninsula, since 1926. Breeding success on the islands has been adversely affected in recent years by depletion of plant cover and loose debris used as nesting material. This is possibly related to increased moisture deficits in the Chatham Is region since the early 1970s (Robertson & Sawyer 1994). Although royal albatrosses are apparently not affected by long-line fishing in the way some species have suffered, several factors including food supply are impacting negatively on albatrosses world-wide. Royal albatross bones indicative of a former colony have been recovered from Paramata, northern Pitt I. (P.R. Millener, pers. comm.). Another population of this albatross, established in a protected area of the Chatham region, would increase security for the species. The summit plateau of Mangere may be a suitable site for such an endeavour. An area near the cliff edge could easily be maintained free of woody vegetation and nesting material there would be adequate. The challenge of developing a method of establishing such a colony parallels that for the Chatham Island mollymawk.

5.5.5 Northern giant petrel (*Macronectes halli*)

Classified as 'Not threatened' by Hitchmough (2002). Taylor (2000b) has recommended investigating the possibility of establishing a new colony of this petrel on Mangere or Rangatira.

5.6 TAXON SUBSTITUTIONS

It may be possible to partially substitute for an extinct species by use of a related living species. Such action aims to establish a functional surrogate for the extinct taxon that is capable of re-activating trophic relationships and other interactions that formerly operated when the extinct taxon was alive (Atkinson 1988, 1990, 2001). Atkinson (2001) makes specific suggestions for possible substitutions in the Chatham Is. Two of these are discussed below.

5.6.1 Chatham Island fernbird (*Bowdleria rufescens*)

The Chatham Island fernbird was discovered on Mangere by H.Travers who remarked that it was 'not uncommon' and that it 'appears to live exclusively on insects' (Travers & Travers 1872). New Zealand fernbirds are not usually forest birds. It is possible that the Mangere population lived mainly in scrub where areas of dense petrel burrows would have been a source of invertebrate food. For example, the Snares Is fernbird frequently enters burrows to take invertebrates below ground (Best 1979). Both the Snares and Codfish Island fernbirds could be considered as a possible substitute for the Chatham Island fernbird. However, a comprehensive survey of the invertebrate fauna of Mangere is necessary before such action so that any potentially vulnerable species of invertebrate, already in very low numbers, can be identified and measures taken for its protection.

5.6.2 Chatham Island bellbird (*Anthornis melanura melanocephala*)

In 1871 H. Travers found bellbirds on all islands in the group but mostly on Mangere (Travers & Travers 1872). It survived on Mangere to at least 1892 (Forbes 1893) and became extinct on Pitt I. in 1906 (Fleming 1939). Cats are likely to have been the main reason for the loss of bellbirds from both islands. In comparison to New Zealand bellbirds, the Chatham Island bellbird had a reduced sternum and thus reduced powers of flight (P.R.Millener, pers. comm.). Possible source populations for a substitute taxon should be an island where food resources are limited, e.g. bellbirds from the Auckland Is or Codfish I. Again, given the probable importance of invertebrates in the diet of Chatham Island bellbirds, a survey of the invertebrates of Mangere and their habitat distribution should precede any decision to re-establish bellbirds there.

Establishing appropriate related taxa to replace two of the extinct birds of the Chatham Is on Mangere would be another significant step towards a comprehensive restoration of the biodiversity of the Chatham Is region.

6. Targets for restoring the Mangere Island ecosystem

6.1 ACHIEVING THE PRIMARY GOAL

The primary restoration goal is identified in Section 4.3 as that of re-instating the plant/animal communities of the island that were present in the middle part of the nineteenth century before the arrival of rabbits and cats. To the extent that this is possible, it will maximise the chances of establishing self-maintaining populations of some of the threatened species of concern and thus minimise the need for intervention. This goal can be achieved by replacing most of the remaining grassland with forest, scrub, shrubland and herbfield communities. Some communities have already recovered significantly since sheep were removed so that planting is unnecessary, e.g. keketerehe scrub and shrubland, and coastal herbfields.

The proportions of each plant species in the original communities may never be known with any certainty. However, variation in site conditions on the island will be the final arbiter of community composition; any planted species that is unsuitable for a particular kind of site will not survive there. This sieving process will determine the distribution pattern of all plant (and animal) populations on the island. If the process can be accelerated, the 'final' meta-stable pattern of changing communities will be reached more quickly. To this end, seed sources of the plants required for restoration should be established at sites that are both well dispersed throughout the island and, to the best of our knowledge, ecologically appropriate.

6.2 SOURCES FOR PLANTING STOCK

The geographic pattern of genetic variation in plant species of the Chatham Is has not been studied, except for the button daisy (Lloyd 1982). If proximity is used as a criterion for close relationship, the first choice for propagation material is Mangere then Tapuaenuku, Pitt I. and Rangatira. But each case should be judged on its own merits: taking account of its historical distribution, present site distribution, morphological variation and genetic information when available.

Some of the early Wildlife Service plantings of akeake originated from cuttings taken from a farm at Kaingaroa, Chatham I. Following that, and up to 1989, propagation material of flax, akeake, the two koromikos, keketerehe and *Carex trifida* was predominantly from Rangatira with some akeake seed collected from Mangere.

6.3 AREAS FOR FOREST ESTABLISHMENT AND A TIMETABLE FOR RESTORATION ACTIONS

Continued planting is necessary to break the tight sward of pasture grasses inherited from the sheep-farming days. It might have been expected that burrowing by nesting petrels would have largely broken through this grassland cover by now. This has happened in only a few places: predation of petrels by skuas is a possible explanation. Substantial areas of rank grassland remain: when flowering or seeding this is attractive to red-crowned parakeets and therefore may hinder recovery of Forbes' parakeet (see Section 5.4.1). Grassland must be reduced in area as quickly as possible.

Areas of the topographic sectors discussed below are given in Table 2. Planting of trees is envisaged in two phases (see Fig. 1 and Table 3). When tree-planting is completed, with areas added to existing forest in Robin Bush, parts of the western peninsula and naturally regenerating parts of the eastern seaward slopes, nearly half the island will be forest-covered.

6.3.1 Archaeological sites

Fyfe (1978) described two sites, one of which has been destroyed by rockfalls and sheep. The other is located towards the edge of the Douglas Basin (see Chapter 3). Tennyson & Millener (1994) also described two sites, both containing fossil bone deposits and both located toward the margins of the Douglas Basin.

Any archaeological site likely to contain information that elucidates the history of Mangere should not be planted in trees. Unfortunately, the boundaries of none of the sites mentioned above has been demarcated and even the exact positions of some sites are not indicated in the relevant reports. A more comprehensive survey, identification and demarcation of archaeological sites on the island is needed.

TABLE 2. AREAS OF TOPOGRAPHIC SECTORS MAPPED ON MANGERE ISLAND.

TOPOGRAPHIC SECTOR	AREA (ha)*
Western peninsula	20
The Neck	0.3
Corridor Ridge and Arch Rock spur	11
Upper western basin	13
Douglas Basin and upper gullies	11
Slumps on the eastern faces	3
Summit plateau	3
Robin Bush	4
Steep cliffs, rockfalls and basins skirting eastern block of the island (herbfields, partly vegetated debris, coastal scrub and low forest)	48
Total area of island	**113**
Northern shore platform exposed at mid to low tide (not included in total area of island)	5.5

* Areas calculated by weighing after cutting up each of the mapped sectors and relating their weights to that for the whole island and using the surveyed area of the island (113 ha) as the reference point.

TABLE 3. TIMETABLE FOR KEY RESTORATION AND RECOVERY ACTIONS ON MANGERE ISLAND (2000–10).

RESTORATION ACTION	2000–02	2002–04	2004–06	2006–08	2008–10
Akeake planting	Continue in Douglas Basin	Complete Douglas Basin	Begin in upper west catchment	Continue in upper west catchment	Complete upper west catchment if possible
Matipo/mahoe/hoho/ karamu/ribbonwood planting*	Plant in widely dispersed areas	Continue in Douglas Basin and elsewhere	Continue in Douglas Basin and elsewhere	Continue in all areas except upper west catchment	Begin in upper west catchment and complete other areas
Additional shelterbelt planting: akeake, ?tarahinau	Begin	Complete	—	—	—
Archaeological site survey		Complete	—	—	—
Invertebrate survey		Complete	—	—	—
Herbfield study incl. *Embergeria*	Begin	Complete			
Establish seabirds e.g. Chatham petrel	Begin research on analogue trials and initiate more passive techniques (vocals, speakers, whitewash) before 2004				
Establish fernbird and bellbird	Complete feasibility studies		Initiate as soon as sufficient habitat is available		
Recovery for threatened plants	Action all completed recovery plans; initiate research for additional plans		Action all recovery plans for all threatened plant species		

* Begin diversified planting when akeake have reached a height of 1.5 m.

6.3.2 Douglas Basin and upper gullies (11 ha)

Planting of this basin should continue up to the 190 m contour at which level the endemic grass *Poa chathamica* is almost completely dominant. Consideration could be given to planting the three narrow gullies leading up to the summit plateau above the 190 m contour. It would also be possible to construct drinking pools for future birdlife in these gullies. To the west, planting can extend to a line where exposure to westerly gales is favouring keketerehe scrub and shrub-flaxland communities. Plantings along the eastern boundary are already partly connected to Robin Bush through earlier plantings on the eastern faces. Continuing to plant gaps on these faces will put a future Douglas Basin forest in complete continuity with Robin Bush. The lower (southern) boundary of the Douglas Basin plantings should stop short of the herbfield communities that have developed on the southern headlands and basins above the cliffs. This will allow a spatial transition to develop from the forest, through scrub, to the herbfields. The area of these proposed plantings is shown in Fig. 1 as Phase 1 of the planting programme. Assuming that two-thirds of the Douglas Basin is already planted, a further 36 600 trees will be needed to complete this basin (using a planting rate of 10 000 trees/ha at 1×1 m spacing).

6.3.3 Slumps on the eastern faces (3 ha)

Slumps have occurred here both in soft unstable grey mudstone and in reddish brown weathered volcanic rock. Excepting one mudstone face that is continuing to erode, plantings of akeake, flax and hokataka, together with some mahoe, have been successful in helping to stabilise these slumps. Some of the earliest New Zealand Wildlife Service akeake plantings here (c. 1974–75) have reached a height of 6 m. If it is assumed that about half this area has been planted, then a further 9000 trees are needed to complete the area.

6.3.4 Upper western basin (13 ha)

Soil depth and structure in the rank grassland here is adequate for forest growth both in the basin and on the slopes leading up to the summit plateau. Remains of dead akeake trees confirm that most of this basin and part of the summit plateau were once forest-covered—though many trees were stunted by wind-carried salt.[2] Planting of this basin can be seen as Phase 2 of the planting programme after planting of the Douglas Basin is complete (see Fig. 1). Akeake shelterbelts were established in the western basin by the Wildlife Service in the 1970s and advantage can be taken of these when planting of the area begins. The summit plateau can be left in the meantime to develop its own plant cover. Planting of the western basin requires at least 78 000 trees. If planting is spread over a period of seven years, as suggested in Table 2, the basin would need to be planted at a rate of approximately 11 150 trees per year.

6.3.5 Western peninsula (20 ha)

The soils of this peninsula are generally shallow and more powdery than in other parts of the island. There is a vegetation mosaic here of grassland,

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[2] In February 2000 Allan Ross and John Mason discovered a tiny stand of forest that had survived the farming period, just below the cliff edge at the northern margin of the summit plateau.

flaxland, *Hebe dieffenbachii* shrubland, planted akeake, *Carex trifida* tussockland, and herbfields. Some of the early Wildlife Service akeake plantings have died in recent years, possibly a result of drought. The north slope of the peninsula is unstable where strata of sedimentary mudstone or sandstone are eroding but some more stable parts have developed a semi-continuous cover of Dieffenbach's koromiko. Patches of forest are developing in small basins on the south side of the peninsula. Forbes' parakeets are quite capable of flying directly from Tapuaenuku to the Douglas Basin; therefore there is no urgency to establish a continuous corridor of woody vegetation along the full length of the peninsula. Unless compelling reasons become apparent, no extensive planting is recommended on this peninsula.

6.3.6 Corridor Ridge and Arch Rock spur (11 ha)

This E–W trending ridge, connecting the western peninsula with the Douglas Basin, is one of the most exposed parts of the island. It is traversed for most of its length by an akeake shelterbelt planted in the early 1970s. Trees in this belt, after 25 years growth, have reached a height of 3 m towards the lower (western) end and only 2 m at the upper (eastern) end. The belt has been shaped on both northern and southern sides as a result of die-back associated with north-westerly and south-westerly salt storms. The greater part of the vegetation on the ridge is Yorkshire fog grassland which, during flowering or seeding, can be attractive to red-crowned parakeets. The parts of this sector where it is appropriate to plant trees are unlikely to exceed 4 ha; remaining areas are better suited to support herbfields or shrublands. Thus planting of this sector is likely to require 24 000 trees.

To re-forest this ridge, three types of restorative action are recommended:

- The existing shelterbelt is widened on both its downslope (northern) and upslope (southern) sides by plantings of matipo, mahoe and akeake (and possibly tarahinau, see Section 6.6.7). These plantings can be progressively widened year by year as plants become available.
- The grassland cover is broken by planting *small* clumps of flax (for partial shelter) and surrounding them with circles of akeake planted at a distance that is great enough to protect them from abrasion by flax leaves flapping in the wind.
- Further attempts are made to establish areas of Dieffenbach's koromiko in places where the grass-cover has been destoyed mechanically (rotary hoe?) or chemically with spot-spraying.

6.4 AREAS FOR SCRUB, SHRUBLAND AND FLAX COMMUNITIES

Substantial areas of scrub (≥ 80% woody cover), shrubland (< 80% woody cover) and flaxland are already widespread on the island. Some of these communities may in time develop into a low forest that remains stunted owing to site conditions. Leaving aside the localised planting of koromiko (see Section 6.3.6), there does not appear to be any need at present to actively restore any scrub, shrubland or flax communities. It is recognised that flax may still be needed for special shelter purposes.

6.5 AREAS FOR HERBFIELD COMMUNITIES

Herbfield communities are described in Sections 2.5.2 and 4.2.1. These communities provide habitats for populations of the Chatham Island sow thistle, Chatham Island forget-me-not, Dieffenbach's speargrass, Chatham Island geranium, Chatham Island groundsel, the coxella weevil and a number of other species less well known. Areas of herbfield were identified as weevil habitats in Section 5.2.1. In view of the number of species endemic to the Chatham Is that these communities support, it is recommended that at least six separate areas should be given protection to secure herbfield habitats (Fig.1). The distribution and exact boundaries of these areas can be determined more precisely when the local effects of exposure and substratum have been studied.

6.6 SELECTION OF SITES FOR PLANTED SPECIES

Where forest is being established on the island there is an important secondary objective of increasing species diversity within the forest that develops. As indicated in Section 6.1, if some plantings of any one species are as widespread on the island as suitable sites permit, it will shorten the time to re-establish a more diverse community

6.6.1 Chatham Island akeake

This species, with its superior growth rates, is likely to remain the most effective plant for replacing the grassland over a wide range of sites. However, it may be of value to trial tarahinau for special purposes (see 6.6.7 below).

6.6.2 Chatham Island matipo

Matipo should become the most widespread planted species within akeake stands that have reached 2–3 m in height. Like akeake, matipo is exceptionally resistant to wind-carried salt and, judged by its behaviour on Tapuaenuku, may be more resistant to droughts.

6.6.3 Chatham Island mahoe

Planting of this salt-resistant species should also be widespread in developing akeake stands.

6.6.4 Hoho

This species is tolerant of a wide range of site conditions but is probably not as resistant to wind-driven salt as either akeake or matipo.

6.6.5 Chatham Island karamu

Sites selected for this species should be basins or at least concave-shaped slopes, if looked at in cross-section, where there is both some shelter and the soils are not prone to droughts. The upper slopes of the Douglas Basin represent one such place.

Note: Collection and sowing of seeds of matipo, mahoe, hoho and karamu should be trialled within young akeake stands, directly into places bared of vegetation.

6.6.6 Chatham Island ribbonwood

Ribbonwood requires shelter for satisfactory growth. It also responds to elevated soil fertility: it will achieve its fastest growth on a sheltered site where there is continual input of nutrients brought by burrowing petrels. Examples of rapid ribbonwood growth can be seen on Rangatira.

6.6.7 Tarahinau

This tree has been found neither on Mangere nor Tapuaenuku, although it is widespread on southern Pitt I. and some plants are present on Rangatira. It is extremely resistant to wind-driven salt and has a rapid growth rate in its early stages. It appears worthwhile to test this species as a shelterbelt plant on Mangere. It may prove possible to use tarahinau along the margins of very exposed akeake stands where growth has been slow. Extensive planting of tarahinau is not recommended. Its highly resinous wood burns strongly, even when damp, and the thick layers of litter it forms are also easily ignited in dry periods (Wright 1959). Thus stands of tarahinau on the island would pose a significant fire risk.

6.6.8 Hokataka

Like tarahinau, hokataka is very salt-resistant as well as able to grow on shallow stony soils. It could be used on stony sites where drainage is excessive or on other difficult sites around forest margins where it would help to increase the diversity of the planted stands.

6.6.9 Ngaio

Ngaio apparently grows naturally on the island but is rare. Early plantings of ngaio have not lived up to the expectations expressed by Atkinson (1988). However, before use of the plant is abandoned, it should be tried again in sheltered sites with the particular objective of repressing grass growth.

6.6.10 Supplejack

This vine, though not recorded from the island, was almost certainly once present in moister sites. Re-establishing it would increase the range of fruit available for animals.

6.6.11 Chatham Island nikau

This palm should be established in moister sites, similar to those selected for supplejack, using seed from Pitt I.

6.6.12 Kopi

If kopi had been present on the island earlier in the twentieth century, one would have expected it to have survived (at least in sheltered sites) within the

rockfall forest of Robin Bush. The kopi presently in Robin Bush are very young trees that have apparently been planted. P.T. Nielsen (pers. comm.), who farmed the island for many years, could not recall ever seeing kopi on the island. The sapling kopi in the Douglas Basin plantings originate from seeds sown by Wildlife Service in the 1970s.

Although the evidence for kopi having been introduced to the Chatham Is by the early Moriori settlers is not strong, such an introduction is very probable. Unlike the other major tree species of the Chatham Is (with the possible exception of ngaio), kopi is apparently not distinguishable from its New Zealand counterpart, karaka. This suggests a recent origin for kopi in the Chatham Is. Dispersal of such a large seed by a bird flying from New Zealand, presumably a pigeon, is unlikely because of the short passage time of the seed through the bird in relation to the time needed to fly to the Chatham Is.

I recommend that kopi be removed from Mangere and that no more is planted. Planting of kopi cannot be justified as food for parea because the diet study by Powlesland et al. (1997) shows that kopi fruit or foliage are not essential for successful breeding of this bird. Should new evidence come to light showing that kopi is natural to the Chatham Is, the option of planting it on Mangere would still be open.

6.7 PARTICULAR RESTORATION PROBLEMS ON MANGERE ISLAND

6.7.1 Breaking the grass cover

Possible methods of breaking the grass cover have been mentioned above (Section 6.3.6). Spraying with herbicides has already been used successfully to kill dense stands of *Poa chathamica* (see Appendix 1). These methods could be compared for effectiveness with mechanical methods such as rotary hoeing, or with killing the grass by covering it with a layer of cut flax leaves. Mechanical or covering methods have the advantage that there is no delay before planting while waiting for toxic effects of herbicide to subside.

6.7.2 Muehlenbeckia growth

Concern is sometimes expressed about the extent to which muehlenbeckia is able to climb over planted trees and suppress them. Close observation suggests that suppression is only partial. On Tapuaenuku this vine forms heavy tangles over the crowns of young matipo and mahoe as well as almost impenetrable masses between taller trees. However, if the muehlenbeckia tangles are carefully cut away from the matipo or mahoe crowns, foliage of the trees beneath is found to be healthy (Atkinson, unpubl. data). At this stage of growth the young trees are protected from serious salt damage by the muehlenbeckia cover. Sooner or later, the muehlenbeckia itself is partly killed by a salt storm. Even in a relatively sheltered site where muehlenbeckia is abundant, as at Robin Bush, it is of interest to see how little muehlenbeckia persists in the canopy (4%, Section 2.5.6).

Nevertheless, in the absence of data, it appears likely that in many circumstances muehlenbeckia will reduce the growth rates of plants it covers. It is therefore recommended that, where muehlenbeckia is overtopping young *planted* trees, it is carefully cut and removed except on very exposed sites. Patches of muehlenbeckia have also established in a few places in grassland; these can be grubbed out or sprayed before planting of trees.

6.7.3 Flax spread

The natural spread of flax from the planted shelterbelt flax has resulted in a mosaic patchwork of developing forest and tall flaxland, in which the flax is likely to persist for decades before being replaced by trees. These flax stands, particularly those in the Douglas Basin, encourage continued use of the area by red-crowned parakeets and substantially reduce the area of forest that can be established quickly in what may be the most sheltered part of the island. Remaining patches of grassland within the flax stands are being filled rapidly by flax.

Recent very labour-intensive efforts to combat this problem by cutting swathes through the flax and grubbing out the root stocks, have demonstrated that the stands can be opened sufficiently for tree-planting. It is worth continuing this effort if labour is available. The highest priority for containing this problem, however, is to weed out young flax plants from the many small patches of grassland within the flax stands and plant with akeake and matipo. When young, flax plants are comparatively easy to dig or pull out.

An alternative approach to this problem is to treat individual flax plants with herbicides such as Velpar or Tordon and subsequently plant trees into the areas of dead flax.

6.7.4 The Neck (0.3 ha)

This is a very exposed, narrow and steep-sided unstable ridge that forms the narrowest part of the western peninsula, where it connects with Corridor Ridge. For safety reasons, the ridge is now traversed by a narrow path flanked on both sides by a post, wire and rope fence. The unstable material forming the upper part of the ridge is a soft mudstone that erodes easily in heavy rain and readily crumbles under the pressure of feet. It is apparently part of a sequence of lake sediments mentioned in Section 2.2. This unstable layer is underlain by much harder sandstone sediments that, on the southern side of the peninsula, give way (nearer sea level) to hard agglomerate.

The erosion associated with the Neck has been cause for concern for some time. In reporting on the problem, Bell (1996) recommended establishing ice plant on the bare slopes. He suggested driving in stakes behind driftwood logs laid across the slope to provide temporary platforms for the ice plant to establish. I support this recommendation and suggest that, as soon as the ice plant has established, planting of the tussock sedge *Carex trifida* is carried out. Once the carex has established, then Dieffenbach's koromiko should be planted. The koromiko would develop a network of roots over the unstable slopes and provide a better protection against erosion. Near the crest of the ridge, where wind and wind-driven salt reach maximum velocities, it may not be possible to cover the ground with anything taller than the carex.

7. Continuing protection for Mangere Island

7.1 GENERAL

The future success of the Mangere restoration is dependent on the degree of protection that we give the island against alien influences. This protection is a matter of unrelenting vigilance. The range of threats to the island may increase as more plant and animal pests establish in the Chatham Is. *Preventing* introductions of these pests to the island is extremely cost-efficient in terms of savings to the country and to the Mangere environment.

7.2 WEEDS

There appear to be no major weed problems affecting Mangere at present, leaving aside the grasslands of Yorkshire fog, cocksfoot and other grasses that have persisted since the time when sheep were present. None of the weeds currently being dealt with in pest-plant control plans for the Chatham Is (Walls unpubl. report) are present on Mangere. It is clear that the grassland problem will be overcome as more and more of the island is restored to native vegetation. Introduced thistles have been mentioned as a potential problem and they certainly would be if it were shown that they were excluding the giant sow thistle (*Embergeria grandifolia*).

One of the most likely ways for transport of weed seeds to the island is on muddy boots or caught in socks; all individuals travelling to the island should carefully check their footwear for seeds. A second likely mode of weed entry is in any soil that is brought to the island with young plants.

The key to excluding weeds from the island is early detection of their presence. A thorough inspection of the island should be made annually by a management party at least one member of which has knowledge of problem weeds in the Chatham Is region. This person should know what kinds of site on the island are most vulnerable to particular weed species likely to reach the island. *On these inspection visits, equipment (tools, herbicides, etc.) should be taken that is sufficient to eradicate any small infestations of problem weeds that are found.* Searches for weeds can be integrated with other management tasks in the island's work programme (Atkinson 1997). Should any weed problem eventuate on Mangere, it will be necessary to refer to the Department's Weed Surveillance Plan (Braithwaite 1999) for details of procedures to be used.

7.3 INVERTEBRATE PESTS

No invertebrate pests have been recorded from Mangere but whether any pests are present cannot be determined without a comprehensive invertebrate survey. The white butterfly (*Pieris rapae*) and the cabbage aphid (*Brevicoryne*

brassicae) are established on Chatham I. Both are capable of flying the distance from Chatham to Mangere (A. Heath, pers. comm.). Presumably these organisms could pose a threat to Cook's scurvy grass on Mangere.

If any introduced species of social wasp (*Vespula* spp., *Polistes* spp.) established in the Chatham Is they would pose a serious new threat to some of the invertebrates of Mangere, as well as those of other protected islands. A solitary hunting species (Pompilidae, spider-hunting species) has been found on Pitt I. (Kennedy 1992). Wasps, as well as moths such as the white-spotted tussock moth (*Orgyia thyellina*) and gypsy moth (*Lymantria dispar*), or their eggs, can be carried by ships. Mangere is distant from major shipping routes but cruise ships from New Zealand or overseas ports should be discouraged from passing or anchoring close to the island.

A third type of threat centres on the introduction of invertebrate pests with plant material propagated in nurseries on islands such as Chatham and Pitt Is. A high level of plant hygiene in these nurseries, together with rigorous inspection of all plants as they are packed for shipment to Mangere, is an effective way to prevent pests such as introduced snails, slaters and aphids from reaching the island. This threat raises the question of whether establishing a small nursery for cuttings and seedlings in a sheltered part of the Douglas Basin should not be considered. It could be watered by piping water from polythene tanks further upslope, trickle-fed from one or more of the ephemeral streams draining the bluffs that surround the summit plateau. Apart from greatly reducing the pest risk, a nursery in this location would reduce the labour of transporting young plants to the island and planting sites.

7.4 VERTEBRATE PESTS

Among the introduced birds on the island, starlings have been identified as a potential predator of black robins and possibly other small birds. One incidence of starling predation of a black robin nestling was recorded in the 1998/99 breeding season (C. Miskelly, pers. comm.) and the capacity of starlings to transmit diseases is documented (Feare 1984). Wekas on Pitt I. pose a slight risk of reaching Mangere by swimming but the distance between these islands (2.3 km minimum) makes this unlikely.

Other vertebrates that might be introduced to Mangere from islands in the Chatham group, or from ocean-going boats, are rats, mice, dogs, cats and possibly farmstock. Rats and mice pose by far the greatest risk. Mice are on Pitt I. but all three species of rat as well as mice are on Chatham I. Procedures for preventing rats or mice from establishing on Mangere, together with procedures for dealing with such an arrival if it happened, are given in the Chatham Is Rodent Contingency Plan (Couchman 2000). Key points of this plan, as they relate to Mangere are:

1. Care must be taken to exclude mice and rats from food, equipment and other stores being taken to the island, particularly on the night before departure. Storage in a rodent-proof room immediately after packing is the most satisfactory way of meeting this requirement.

2. Upon landing, all provisions, containers and equipment must be unpacked in the hut with all doors and windows closed to ensure that no rodent can escape beyond the confines of the hut.
3. The position of the rodent contingency kit stored on the island must be known to the party and inspected annually to ensure that all items are in good condition and ready for use.
4. Both tracking tunnels and permanent bait stations are in use on the island as means of detecting or killing any rodent that arrives.
5. *Any shipwreck or grounding of a vessel must be treated as a rodent invasion* until inspection of the boat, and trapping, bait stations and tunnel tracking of the surrounding area show otherwise.

7.5 PEOPLE (VISITORS, FIELD WORKERS AND RESEARCHERS)

The Chatham Islands Conservation Management Strategy (1999) outlines the policy adopted for minimising visits to Mangere by people (pp. 93, 94). No 'tourism' visits are permitted but occasional filming visits are allowed. There is probably no more effective way of communicating the value of Mangere to the wider public than a high-quality nature film. Without public support it is not possible to gain the funding that the island's conservation requires. Allowing such visits, however, does place a responsibility on the Department to be selective of the film crews that visit Mangere. Not all film crews are sensitive to the environment in which they work.

'Open days' on which, once a year, local people have an opportunity to visit a highly protected island reserve is an excellent principle, even if sometimes difficult to administer. It has been applied for some years to Rangatira. Unfortunately, the risks of landing people not used to small boats, on a rocky unsheltered coast where sea conditions can change rapidly, make open days impractical for Mangere.

Generally, the sleeping capacity of the hut will determine the number of people that can work on the island. Careful scheduling of the various tasks to be done avoids having too many people on the island at one time. There will always have to be flexibility because weather can play havoc with the best-designed schedules.

With respect to scientific research on Mangere, many projects could be identified. The questions that must always be asked about a particular proposal are: 'What benefit will it bring to the island?' 'How will it help the position of a threatened species?' Or, if it relates to assisting conservation in the Chatham Is in general: 'Is it a project that can only be carried out on Mangere?'

Chatham Islanders are already heavily involved in the planting work on Mangere All opportunities should continue to be taken to involve competent individuals from the Chatham community in any aspect of the restoration work for which they are suited.

7.6 PROTECTING THE MANGERE ISLAND ECOSYSTEM

We must remain clear about the nature of what it is we are trying to protect: a very complex interacting system. If we pursue any one of our restorative actions on the island to a point where its effects on other actions are forgotten, we risk damaging or undermining the way in which this system functions. The consequences of planting must be related to effects on animals, including invertebrates. The need to provide habitat for threatened species cannot be the only criterion for what planting is done. The need to have people on the island will inevitably result in some effects that would not have occurred in their absence. We are not restoring individual 'ecosystems' when we restore a herbfield or a forest; there are numerous connections between these communities. The island should be looked upon as a whole system with strong connections to the sea through wind-carried salt and input of nutrients by seabirds; and the further movement of some of those nutrients back to the sea through leaching and erosion. The effects of the latter process on the marine community immediately surrounding the island have not been studied but such effects are real (cf. Hutchinson 1950). There are further connections, through the movement of birds and seeds, with Tapuaenuku; connections with other islands such as Pitt I. are less strong. We need to be aware of all these interactions if we are to make our protective action truly effective.

8. Monitoring and research needs

There is a wide range of monitoring and research needs that could be identified for Mangere. Those listed here require, in the opinion of the author, the highest priority for attention. Monitoring and research are grouped together because monitoring that is not scientifically based may yield data of limited value. Equally, many research projects are dependent on monitoring for their raw data. Most of the needs listed below have already been identified earlier in this plan.

8.1 ARCHAEOLOGICAL SITES

There is an immediate need to carry out a comprehensive archaeological reconnaissance of Mangere to ascertain the location and boundaries of any important sites that should not be planted with trees (see Section 6.3.1).

8.2 INVERTEBRATES

One of the largest gaps in our knowledge of the island is that of the invertebrates, native and introduced, that are present. A comprehensive invertebrate survey is needed.

8.3 VEGETATION CHANGES

8.3.1 Progress with restoration

To measure the progress made in restoring forest and other communities to the island, a series of photo-points should be set up with details kept of photography dates and the focal length of the lens used for each photograph. In selecting these photo-points it is important to anticipate the future height of the vegetation so that the camera's view will not be blocked with the passing of time.

8.3.2 Herbfield dynamics

Although there is now an understanding of the population dynamics of Dieffenbach's speargrass within the herbfields, no other plant population has been studied in these communities. Studies are needed of the sow thistle and forget-me-not as well as several of the more abundant plants in the herbfields. The role of burrowing seabirds in maintaining particular plant species within these herbfields may be important. In addition, we need to gain an understanding of the factors that govern the boundaries of these herbfields. For example, are the herbfield/carex boundaries static or are these boundaries shifting in favour of one or the other kind of vegetation? If so, what is the

driving mechanism? Is it a result of climatic effects, interactions between plant species, or between animals and plants? Charting, in combination with photographs from fixed points, would help to resolve these questions.

8.4 THREATENED SPECIES

8.4.1 Chatham Island sow thistle

A detailed study of this plant is required to determine the factors that are controlling its numbers (including possible negative interactions with introduced thistles or other weeds) and thus ascertain whether intervention is needed to maintain a viable population on the island.

8.4.2 Rauhuia (*Linum monogynum* var. *chathamicum*)

Valuable ecological information for this species has been recorded by Walls (in press). Dopson et al. (1999) suggest that on Mangere this species is being excluded by competition from flax. A profile of the plants' habitat requirements, distribution and abundance should be put together. From this it may be possible to determine what kind of recovery action is needed for rauhuia on Mangere

8.4.3 Forbes' parakeet

The relationship between genetic constitution and external appearance of parakeets in the Chatham Is has been studied by the Victoria University of Wellington, School of Biological Sciences genetics group (Boon et al. 2000). This information will improve our capacity to separate hybrids from their parents and thus provide a better basis for identifying the environmental circumstances when hybridisation is likely. Other monitoring for this species is determined by the parakeet recovery plan (Aikman et al. 2001).

8.4.4 Black robin

Monitoring of this species on Mangere is determined by the black robin recovery plan (Aikman et al. 2001). A necessary component of this monitoring is to locate any robin/tomtit hybrids that may appear and, if possible, determine the environmental circumstances associated with a hybridization event.

8.5 SEABIRDS AND SHOREBIRDS

A programme that integrates the various, somewhat *ad hoc,* monitoring studies of seabirds on Mangere is needed. Questions relating to both numbers of breeding birds and their distribution on the island need to be answered. Among threatened seabirds (Taylor 2000a), the southern white-fronted tern (*Sterna striata aucklandorna*), a category C species, requires annual monitoring of the breeding population (Aikman et al. 2001). Of the non-threatened seabirds, recommendations are made for colonies of fairy prion (*Pachyptila turtur*), broad-billed prion (*P. vittata*) and black-winged petrel (*Pterodroma*

nigripennis) on Mangere to be monitored every five years and for the colony of grey-backed storm petrels (*Oceanites nereis*) to be monitored every 10 years (Taylor 2000a, b; Aikman et al. 2001).

8.6 MONITORING OF PLANTING METHODS AND TREATMENTS

There will be an ongoing need to monitor the results of planting various species, differing planting methods and various kinds of aftercare (see Appendix 1). Ensuring that there are always adequate control areas for comparison is essential to reach reliable conclusions about the effects of different treatments.

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Appendix 1

DETAILS OF PLANTING METHODOLOGY: 1973–99

Species planted: The mainstay species used in the early plantings of 1973 through to 1977 were flax and akeake. Several ngaio were planted in 1975 and some Dieffenbach's koromiko were planted around the hut in 1983. A greater diversity of tree species was advocated for planting by Baird (1989): (1) area around Robin Bush: mahoe, matipo, karamu, ribbonwood, koromiko and teteaweka in addition to further flax, akeake and ngaio; (2) Douglas Basin: koromiko, korokio and mahoe in addition to flax, akeake and ngaio. All but the keketerehe were planted in the 1990–99 period as were ribbonwood and karamu in the Douglas Basin.

Use of seeds, seedlings and cuttings: Few trees have been established by artificial spreading of seed. About 45 kg of kopi fruit were scattered along the freshly planted flax lines in the 1970s (Baird 1989) and some of these have survived in the western margin of the Douglas Basin plantings. Seedlings have a greater chance of survival than unrooted cuttings in the Mangere environment. In April 1974, 4000 unrooted cuttings were planted between Robin Bush and the Douglas Basin. A survival of 6–10% was recorded for these plants in January 1975 (Baird 1989).

Use of herbicides: Herbicides were not used until February/April 1998. Planting into the very deep grass swards dominated by *Poa chathamica* is difficult and time-consuming, particularly on the higher slopes of the Douglas Basin. In 1998, Roundup mixed with dye was applied 2–3 months before planting, to kill grass in the immediate area of the planting hole. A small number of holes were treated with Gardoprim and Roundup. (Gardoprim is used to kill the grass and suppress germination for 12–18 months; it has been found that Roundup alone will not kill the *Poa*). Planting was done 2 months after spraying. Preliminary observations indicate that this procedure may result in unacceptably high levels of mortality for the plantings. The procedure for 1999 and 2000 has been modified so that the patches of dead grass are not planted until 12–14 months after spraying with Roundup and Gardoprim. It is at present too early to assess the effectiveness of the new treatment: areas sprayed in 1999 have begun to be planted in March–April 2000.

Planting technique: Both spades and mattocks have been used for planting but details of the exact methods used by planters are not available. It is apparent, however, that there is considerable variation between planters in the depth of planting and degree of firming that plants receive. This is not a new development as failure of some of the early plantings (Atkinson 1988) can be attributed in part to this cause. A more reliable method of planting is that of cutting out a triangular shaped hole with a spade and placing the plant in the apex of the triangle, thus bracing it against wind with two sides of the hole. This gives the plant a much better start than heeling it into a hole filled with loose soil.

Use of clean-rooted seedlings: Since 1991 all akeake plants used in the Mangere Island restoration have been raised from seed, grown in trainers and then

shaken free of soil to provide clean-rooted plants for transport to the island. Survival has generally been high. A. Baird (pers. comm. 15 May 2000) reported survival of clean-rooted akeake seedlings from two areas of 1999 plantings as follows: in the upper Douglas Basin survival was 97.6% (n=1568) and of unshaken plants: 99.2% (n=524). In the 'top triangle' survival of clean-rooted seedlings was 99.4% (n=1790) and of unshaken plants: 99.2% (n=384). However, these survival rates do not reveal any differences in growth rate that may be present during the first 1–2 years of establishment. Clean-rooted seedlings reduce the number of boat-loads of plants between Chatham and Mangere Is and reduce the weight and therefore time required to carry the plants from shore to the planting site. Faster growth rates of akeake may be achievable in the first year or two after planting, if soil is not removed in this way; but the increase in planting cost would be considerable and may not justify a change in the present procedure.

With other species such as mahoe, matipo, karamu and ribbonwood, it appears that use of clean-rooted stock does increase mortality after establishment. Data collected by A. Baird (see above) shows that survival of the 1999 plantings of clean-rooted mahoe in the upper Douglas Basin was 85.4% (n=760) and 89.3% (n=242) for unshaken plants. In the 'top triangle', survival of clean-rooted mahoe was 78.2% (n=476) and 96.8% (n=187) for unshaken plants. With respect to clean-rooted karamu, Baird found that after a year of growth, plant size is invariably reduced (compared with seedlings where the soil is retained), much of the original shoot having died back and leaving growth to be resumed from basal or lateral buds.

Small numbers of matipo, ngaio, karamu and akeake have been raised in planter bags (PB2s, mainly) before planting. As a general principle, one would expect that any planting that minimises disturbance of young roots is likely to be more effective than shaking the plants free of soil. Testing of this expectation is required for a wider range of species but certainly any widespread use of PBs would greatly increase the cost of planting.

Aftercare of seedlings: Trials were begun on Mangere in 1992 to determine the influence of several treatments on the survival, growth and health of akeake (Baird 1994). It was found that on poorer shallower soils, the growth rate of first year plants was improved significantly by fertilising and weeding. On rich deep soils, the growth rate of first-year plants showed a profound response to weeding. Weeding in the second growth season confered little advantage to plants in terms of growth rate though there was an improvement in vigour. Overall first-year survival was good in the absence of aftercare on sites where there was little competition. In contrast, 'on rich sites planting success is abysmal in the absence of aftercare' (Baird 1994). Baird's main recommendations from these trials are (1) obtain taller planting stocks (30–40 cm) for continuing work in the Douglas Basin; (2) weed and mulch plantings in the Douglas Basin in the spring following planting and if possible weeded again in year 2; (3) use fertilisers where soils are poor; (4) expand the trials to other species and (5) continue to use seedlings in preference to clones (e.g. cuttings); the former appear to be hardier and faster growing.

Further aftercare trials were established in 1998. These are comparing the use of Roundup, Gardoprim and grubbing as methods of reducing grass competition (see Use of herbicides, above).

Appendix 2

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED IN THE RESTORATION PLAN

barley grass	*Hordeum murinum*
Chatham Island akeake	*Olearia traversii*
Chatham Island flax	*Phormium* aff. *tenax*
Chatham Island forget-me-not	*Myosotidium hortensia*
Chatham Island groundsel	*Senecio radiolatus*
Chatham Island ice plant	*Disphyma papillatum*
Chatham Island karamu	*Coprosma chathamica*
Chatham Island koromiko	*Hebe chathamica*
Chatham Island mahoe	*Melicytus chathamicus*
Chatham Island matipo	*Myrsine chathamica*
Chatham Island nikau	*Rhopalostylis* aff. *sapida*
Chatham Island ribbonwood	*Plagianthus chathamicus*
Chatham Island scurvy grass	*Lepidium* aff. *oleraceum*
Chatham Island sow thistle	*Embergeria grandifolia*
cocksfoot	*Dactylis glomerata*
creeping bent	*Agrostis stolonifera*
Dieffenbach's koromiko	*Hebe dieffenbachii*
Dieffenbach's speargrass	*Aciphylla dieffenbachii*
fathen	*Chenopodium album*
glasswort	*Sarcocornia quinqueflora*
hoho	*Pseudopanax chathamicus*
hokataka	*Corokia macrocarpa*
kawakawa	*Macropiper excelsum*
keketerehe	*Olearia chathamica*
Kentucky bluegrass	*Poa pratensis*
muehlenbeckia	*Muehlenbeckia australis*
ngaio	*Myoporum laetum*
praire grass	*Bromus willdenowii*
ryegrass	*Lolium perenne*
rauhuia	*Linum monogynum* var. *chathamicum*
Scotch thistle	*Cirsium vulgare*
shore spurge	*Euphorbia glauca*
southern nettle	*Urtica australis*
supplejack	*Ripogonum scandens*
tarahinau	*Dracophyllum arboreum*
Yorkshire fog	*Holcus lanatus*

Appendix 3

CHECKLIST OF VASCULAR PLANTS RECORDED FROM MANGERE ISLAND

Ian Atkinson and Amanda Baird

This list is incomplete. It is included as a useful starting point for anybody wishing to make a comprehensive plant species list for the island. Scientific names of indigenous plants follow those used by de Lange, Sawyer et al. (1999) and common names mostly follow those of Crisp et al. (2000). Symbols used:

* non-indigenous adventive

(e) endemic to the Chatham Islands

a widespread and abundant over the island

la abundant in localised areas

m many individuals but restricted in distribution

\+ present in fewer than five sites

(1) bracketed numbers refer to number of individuals

– not seen by authors

FERNS			
Asplenium chathamense (e)	Chatham Island spleenwort	a	
A. oblongifolium		a	
Blechnum durum		+(1)	
B. penna-marina		la	higher slopes
Polystichum aff. *vestitum* (e)	Chatham Island shield fern	+	plantings; Robin Bush
TREES AND SHRUBS			
Coprosma chathamica (e)	Chatham Island karamu	+	seedlings; no adults seen; planted
C. propinqua martinii (e)	swamp karamu	m	
Corokia macrocarpa (e)	hokataka	+	natural and planted
Corynocarpus laevigatus	kopi	+	introduced and planted (seed)
Hebe chathamica	Chatham Island koromiko	m	
H. dieffenbachii	Dieffenbach's koromiko	a	natural and planted
H. chathamica × *H. dieffenbachii*		a	
Macropiper excelsum	kawakawa	m	Robin Bush
Melicytus chathamicus (e)	Chatham Island mahoe	la	natural and planted
Myoporum laetum	ngaio	+(1)	adult (Robin Bush); seedlings and planted
Myrsine chathamica	Chatham Island matipo	m	natural and planted
Olearia chathamica (e)	keketerehe	la	western slopes and cliffs
O. traversii (e)	Chatham Island akeake	a	natural and planted
Plagianthus chathamicus (e)	Chatham Island ribbonwood	la	Robin Bush; also planted
P. divaricatus	saltmarsh ribbonwood	+(1)	Douglas Basin: natural
Pseudopanax chathamicus (e)	hoho	+	Robin Bush

LIANES AND SCRAMBLING PLANTS			
Calystegia soldanella	shore bindweed		
C. turguriorum		m	
Disphyma papillatum (e)	Chatham Island ice plant	a	
Muehlenbeckia australis	muehlenbeckia	a	forest, grassland, plantings
Tetragonia implexicoma	native spinach	a	
GRASSES			
**Agrostis stolonifera*	creeping bent	m	grassland
**Bromus willdenowii*	prairie grass	m	grassland
**Dactylis glomerata*	cocksfoot	a	grassland
Festuca coxii (e)	Cox's fescue	a	herbfields, rocky sites
**Holcus lanatus*	Yorkshire fog	a	grassland
**Hordeum murinum*	barley grass	m	grassland
**Lolium perenne*	perennial ryegrass	m	grassland
**Poa annua*	annual poa	+	plantings
P. chathamica (e)		la	Douglas Basin
**P. pratensis*	Kentucky bluegrass	m	Douglas Basin
Rytidosperma sp.		+	
RUSHES AND RELATED PLANTS			
Luzula banksiana	coastal woodrush	+	
Triglochin striata	arrow-grass	+	seepage, NW basin
SEDGES			
Carex trifida		a	grassland, herbfields
C. ventosa (e)		+	Robin Bush
Elaeocharis acuta		+	damp hollows; seepages
Isolepis cernua		+	seepages
I. distigmatosa		m	clearings in plantings
I. nodosa		a	coastal cliffs
MONOCOTYLEDONOUS HERBS (EXCLUDING GRASSES, RUSHES AND SEDGES)			
Microtis unifolia		a	
Phormium aff. *tenax* (e)	Chatham Island flax	a	
Pterostylis ?banksii	tutukiwi	+	
Thelymitra longifolia		m	bare ground in herbfield
DICOTYLEDONOUS COMPOSITE HERBS			
**Carduus tenuiflorus*	winged thistle	+	plantings
**Cirsium vulgare*	Scotch thistle	a	grassland, herbfields, slips
Embergeria grandifolia (e)	Chatham Island sow thistle	+	only three sites known
Helichrysum filicaule	slender everlasting	+	plateau grassland
Lagenifera pumila	papataniwhaniwha	+	western slopes
Pseudognaphalium aff. *luteoalbum*	native cudweed	a	
Senecio lautus var. *lautus*	shore groundsel	+	plantings; herbfield
S. radiolatus subsp. *radiolatus*	Chatham Island groundsel	a	herbfields; burrowed areas
**Sonchus oleraceus*	puha	a	
**Taraxacum officinale*	dandelion	m	
DICOTYLEDONOUS HERBS (EXCLUDING COMPOSITES)			
Acaena anserinifolia	bidibid	a	grassland, coastal slopes
A. novae-zelandiae	bidibid	m	grassland, coastal slopes
Aciphylla dieffenbachii (e)	Dieffenbach's speargrass	la	herbfields
A. traversii (e)	Chatham Island speargrass	–	south side, steep gully (Ritchie, M.A. & I.M. 1968)

**Anagallis arvensis*	scarlet pimpernel	m	plantings, slips
Apium prostratum	native celery	la	shoreline
**Cerastium glomeratum*	annual mouse-ear chickweed	a	
**Chenopodium album*	fathen	la	shoreline
C. glaucum	coastal goosefoot	+	shoreline
Dichondra repens	Mercury Bay weed	la	
Disphyma papillatum	Chatham Island ice plant	a	shoreline; exposed slopes
Einadia trigonos subsp. *trigonos*		la	coastal slopes
Epilobium pedunculare		+	seepage, NW basin
Euphorbia glauca	shore spurge	–	Horgan, K. (CHR 178530)
Geranium traversii (e)	Chatham Island geranium	a	herbfields
Haloragis erecta	toatoa	m	
Lepidium aff. *oleraceum* (e)	Chatham Island scurvy grass	m	herbfields
Linum monogynum var. *chathamicum*	rauhuia	+(3)	herbfields, grassland
Lobelia anceps		+	herbfield
Myosotidium hortensia (e)	Chatham Island forget-me-not	m	herbfields
Parietaria debilis		+	shoreline
**Plantago lanceolata*	narrow-leaved plantain	a	grassland
Potentilla anserinoides	silverweed	+	grassland: NW basin
Pratia arenaria		a	herbfields, grassland
**Rumex acetosella*	sheep's sorrel	la	plateau (1991)
**Rumex* sp.	dock	+	herbfield
**Sagina procumbens*	pearlwort	m	plantings
Samolus repens		la	shoreline
Sarcocornia quinqueflora	glasswort	la	exposed shoreline
Selliera radicans		+	?shoreline
Solanum americanum	small-flowered nightshade	m	burrowed areas: shrubland
**Trifolium dubium*	suckling clover	m	grassland
**T. repens*	white clover	m	grassland; plantings
Urtica australis	southern nettle	a	
**Vicia sativa*	vetch	a	

Appendix 4

COMMON AND SCIENTIFIC NAMES OF BIRDS MENTIONED IN THE RESTORATION PLAN

Australasian harrier	*Circus approximans*
blackbird	*Turdus merula*
black robin	*Petroica traversi*
black-winged petrel	*Pterodroma nigripennis*
blue penguin	*Eudyptula minor*
broad-billed prion	*Pachyptila vittata*
brown skua	*Catharacta skua lonnbergii*
Chatham Island albatross	*Thalassarche eremita*
Chatham Island bellbird	*Anthornis melanura melanocephala*
Chatham Island diving petrel	*Pelecanoides urinatrix chathamensis*
Chatham Island fantail	*Rhipidura fuliginosa penita*
Chatham Island fernbird	*Bowdleria rufescens*
Chatham Island kaka	*Nestor* sp.
Chatham Island mollymawk	*Thalassarche eremita* (=*Diomedea cauta eremita*)
Chatham Island oystercatcher	*Haematopus chathamensis*
Chatham petrel	*Pterodroma axillaris*
black-winged petrel	*Pterodroma nigripennis*
broad-billed prion	*Pachyptila vittata*
Chatham Island pipit	*Anthus novaeseelandiae*
Chatham Island red-crowned parakeet	*Cyanoramphus novaezelandiae chathamensis*
Chatham Island shag	*Leucocarbo onslowi*
Chatham Island snipe	*Coenocorypha pusilla*
Chatham Island tomtit	*Petroica macrocephala chathamensis*
Chatham Island tui	*Prosthemadera novaeseelandiae chathamensis*
Chatham Island warbler	*Gerygone albofrontata*
fairy prion	*Pachyptila turtur*
Forbes parakeet	*Cyanoramphus forbesi*
grey-backed storm petrel	*Oceanites nereis*
grey-faced petrel	*Pterodroma macroptera*
northern giant petrel	*Macronectes halli*
northern royal albatross	*Diomedea sanfordi*
parea	*Hemiphaga chathamensis*
Pitt Island shag	*Stictocarbo featherstoni*

red-billed gull	*Larus novaehollandiae*
redpoll	*Carduelis flammea*
shore plover	*Thinornis novaeseelandiae*
silvereye	*Zosterops lateralis*
southern white-fronted tern	*Sterna striata aucklandorna*
starling	*Sturnus vulgaris*
sooty shearwater	*Puffinus griseus*
taiko	*Pterodroma magentae*
white-fronted tern	*Sterna striata*