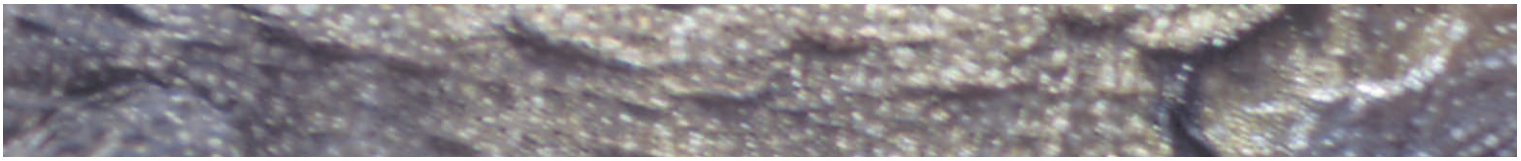

Mana Island ecological restoration plan

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Department of Conservation
Te Papa Atawhai

Mana Island ecological restoration plan

Department of Conservation
P.O. Box 5086
Wellington, New Zealand

Prepared by:
Colin Miskelly

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Executive summary

This plan provides a philosophical basis for the planning and implementation of ecological restoration on 217 ha Mana Island. The primary goal of the restoration programme is to maintain those threatened species and communities that have survived on Mana Island within self-sustaining ecosystems similar to what are likely to have existed on the island before human contact. Secondary restoration goals (where compatible with the primary goal) are to:

- recreate coastal forest, shoreline, cliff and wetland plant communities typical of the Wellington coast and similar to those expected to have occurred on the soils and landforms present on Mana Island, using seed sources as close as possible to (if not on) Mana Island
- establish self-maintaining populations of threatened plants of the Wellington coast of Cook Strait appropriate to the habitats present on Mana Island, using seed sources as close as possible to the island (but further afield if the species are extinct in the Wellington region)
- reintroduce or encourage colonisation by all native animal species known to have previously occurred on Mana Island
- introduce (or reintroduce) threatened and locally extinct vertebrates of the southern North Island that are not able to exist in the presence of introduced mammals, and are likely to have occurred in coastal habitats in the Wellington region
- where previously occurring vertebrate taxa are extinct, introduce an ecologically similar conspecific or congeneric taxon (if one exists within New Zealand) to restore trophic processes and lost evolutionary potential
- as far as possible, restore invertebrate communities typical of the plant communities created
- introduce (or reintroduce) threatened macroinvertebrates appropriate for an island in eastern Cook Strait.
- eradicate/control animals and plants which would severely compromise other restoration goals
- maintain grassland at priority archaeological sites to enhance interpretation and site preservation

Implementation of this suite of restoration goals should collectively restore the natural processes necessary to recreate functional ecosystems representative of the exposed Wellington west coast before human disturbance. However, it is recognised that Mana Island may be required to provide habitat for a select few critically endangered bird species that probably or definitely never occurred on the island in the past. Species that will or may require Mana Island to achieve short or medium term restoration goals include takahe, kakapo and large kiwi. Such "unnatural" introductions must not jeopardise the survival of resident and restored threatened animals and plants, and the species must be able to be removed totally from the island when other more suitable (mainland or island) sites become available.

The six key tasks required to restore viable ecosystems on Mana Island analogous to what may have existed prior to human disturbance are: restore coastal forest; attract nesting seabirds; restore the wetland; reintroduce avian pollinators and seed dispersers; introduce a diversity of forest-dwelling invertebrates;

and weed control. Introductions of other plants and animals will increase the island's potential for maintaining indigenous biodiversity, but these six actions are fundamental to restoring ecosystem viability because of the species and processes that are dependent on their successful implementation.

Forest cover will be artificially restored to about a third of the island using a mix of about 45 tree and shrub species considered appropriate for the landforms and soils on Mana Island. All source populations will be on the island (preferably) or from the adjacent mainland coast. Predominant canopy species will be kohekohe, tawa and karaka. About 400,000 further plants are required to complete revegetation of 72 ha, and planting of canopy and subcanopy species should be complete by 2007 A.D.

Restricting planting of woody species to 72 ha will create a mosaic of habitats that will provide a variety of habitats suitable for the range of plant and animal species that are either resident on the island or considered appropriate for introduction. It is anticipated that the combined effects of the planting programme and natural regeneration will produce about 76 ha of coastal broadleaved forest and 84 ha of shrublands within the next 30-40 years, leaving about 57 ha of grassland. Natural succession will continue to reduce the area of open grassland over time. The only sites where regeneration of native shrub and tree species will be actively prevented is on archaeological sites unless Mana Island remains a key site for the conservation of takahe.

The main wetland (Waikoko) on Mana Island will be restored to provide habitat free of mammalian predators and browsers for brown teal, North Island fernbird, brown mudfish and a variety of threatened wetland plants of the Cook Strait and Wellington Ecological Districts. About 80 regionally threatened vascular plant species (both terrestrial and wetland) are recommended for introduction. Priority species include *Acaena juvenca*, *A. pallida*, Jersey fern, *Atriplex buchananii*, *A. cinerea*, *Clematis afoliata*, *Convolvulus verecundus*, *Coprosma acerosa*, matagouri, akeake, *Euphorbia glauca*, *Ileostylus micranthus*, *Leptinella nana*, *L. pusilla*, rohutu, *Muehlenbeckia astonii*, *M. ephedroides*, *Pimelea aridula*, *Rhabdothamnus solandri*, *Rytidosperma petrosum*, kowhai (Kapiti Island form), *Tetragonia tetragonioides* and *Tupeia antarctica*.

Thirty-three animal species are recommended for introduction or attraction to Mana Island: 18 birds, seven reptiles, one fish and seven macroinvertebrates. Of these, nine will be sourced from the eastern Cook Strait Ecological District (mainly Kapiti Island; little spotted kiwi, New Zealand pigeon, kaka, whitehead, robin, bellbird, tui, Whitaker's skink, speargrass weevil) and 16 will be sourced from elsewhere in the Sounds-Wellington Ecological Region (fluttering shearwater, fairy prion, diving petrel, gannet, banded rail, yellow-crowned parakeet, Cook Strait tuatara, speckled skink, spotted skink, Duvaucel's gecko, Wellington green gecko, flax weevil, *Lissotes reticulatus*, giant pill millipede, *Rhytida greenwoodi*, *Wainuia urnula*). Six species are no longer present in the ecological region and will be sourced from further afield (brown teal, shore plover, North Island fernbird, robust skink, brown mudfish, *Powelliphanta traversi*). The two remaining recommended introductions (Chatham Island snipe and rock wren) will replace extinct taxa.

Restoration of diverse invertebrate communities will require mass translocation techniques rather than a species-by-species approach. It is recommended

that litter samples, decaying timber and malaise trap samples be collected in appropriate forest types on Kapiti Island and transferred to Mana Island. Thorough screening during transfer will check for the presence of injurious adventive species, and allow documentation of the species transferred.

Control of animal and plant pests is a crucial component of ecological restoration on Mana Island. Current management issues for animal pests include limiting the impacts of the large black-backed gull and pukeko populations, and contingency measures to prevent colonisation by rodents and vespulid wasps. Weed control currently focusses on boxthorn and karo, but equal or higher priority should be given to eradicating those weed species that have not yet become widely distributed on the island (especially brush wattle, bone-seed, broom, blackberry, holly-leaved senecio, wandering Jew and gorse).

The ecological restoration plan has made allowance for protection of known historic sites, and is considered compatible with a high level of public visitation and participation. Indeed, the close involvement of the local community and iwi is and will be essential for the ecological restoration of Mana Island to succeed.

1. Introduction

Mana Island is a 217 ha Scientific Reserve administered by Wellington Conservancy, Department of Conservation. Mana Island lies about 4 km offshore from Titahi Bay, and is 2.5 km from Green Point, the nearest part of the North Island coast. The island has resident Department of Conservation staff. Ngati Toa are the tangata whenua.

Mana Island has a long history of Maori and European occupation (Jones 1987) and was farmed from 1832 until the last stock were removed in 1986. This 154 years of intensive pastoralism created a highly modified and degraded ecosystem, with indigenous vegetation confined almost entirely to the cliffs and one small catchment (Timmins et al. 1987a). The human history of the island has been well summarised by Day (1987).

Given the long period that Mana was farmed, it is surprising that mice[1] were the only mammals present when farming ceased. Mice were eradicated from Mana by poisoning in 1989/90 (Todd & Miskelly in press); the island is considered to have been totally free of introduced mammals since February 1990. The island is a significant habitat for three resident threatened animal species (Cook Strait giant weta, McGregor's skink and goldstripe gecko) and is a breeding site for seven species of sea and coastal birds. Mana Island is also an important site for several nationally and regionally threatened plant taxa including Cook's scurvy grass, large-leaved milk tree, rengarenga and *Melicytus obovatus*.

The relative accessibility of Mana Island has allowed considerable public involvement in restoration there, particularly the ongoing revegetation programme. Restoration on Mana Island to date has been guided by a variety of management documents, including: Department of Lands & Survey 1981 & 1986; Timmins et al. 1987b; and Nicholls 1989. All these were written prior to mouse eradication, and none established an overall restoration goal. This report is based on a workshop held at Wellington Conservancy in July 1992, and is intended as a basis for restoration action on Mana Island for the next thirty years, after which minimal ecological management should be required. It is expected that this restoration plan will continue to evolve as we learn from each stage, and so the conclusions and actions outlined here should not be considered the final word.

This restoration plan provides an overall strategic framework for ecological restoration on Mana Island, but further levels of operational planning will be required before new conservation actions occur on the island. For example, species introductions will each require completion and approval of a species transfer proposal, the planting programme requires planning and co-ordination of seed collection, propagation and community structure appropriate for each planting site, and restoration of the wetland will require detailed surveying, production of a development plan and granting of resource consents. However, as all future restorative actions on the island will be carried out within the philosophical framework outlined here, establishing priorities for resourcing and obtaining approvals for the next tier of operational plans should be considerably streamlined.

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1 Scientific names of animals and plants are given in appendices.

2. Restoration options

Ecological restoration can be defined as active intervention to restore lost species or lost physical conditions in order to recreate a biotic community that previously existed (Atkinson 1988). This definition separates ecological restoration from *ecological protection* which may involve removing or excluding unwanted species or threats, and from *natural restoration* which involves processes such as regeneration and succession (Atkinson 1995). Ecological protection and natural restoration are extremely important components of the ecological management of an area, and are often the only cost-effective means to restore conservation values over large land areas. However, where ecological systems have been badly damaged, and component species and processes have been lost, ecological restoration may be necessary (alongside ecological protection and natural restoration) if a previously existing biotic community is to be recreated. Ecological restoration implies that only those plant and animal species that would have occurred previously at the site are introduced; this contrasts with revegetation or rehabilitation planting, where a mix of local plus indigenous plants from other Ecological Districts and alien plant species could be used. On New Zealand islands where introduced mammals have been eradicated the usual goal of ecological restoration is to recreate a biotic community that may have existed before human contact occurred (Atkinson 1990).

This rather restrictive definition of ecological restoration can rarely be achieved in the real world because: (a) we do not usually know the exact composition and structure of the community we are aiming to recreate, (b) some of the species originally present are likely to be extinct, (c) there are likely to be introduced birds, invertebrates and plant species present that either cannot be eradicated or will continue to colonise, (d) environmental conditions have changed through the global effects of industrialisation, and (e) there may be demands for mammal-free islands for critically endangered species that did not occur naturally at that site. These and other constraints on ecological restoration were discussed by Simberloff (1990) and Atkinson (1990). Simberloff suggested that ecological restoration could be considered a success if the structure and function of the system produced cannot be shown to be outside the bounds generated by the normal dynamic processes of communities and ecosystems. With respect to Mana Island, this would mean that the ecosystem produced by ecological restoration should be indistinguishable from one that may have occurred if the island had never been cleared and mice and stock never introduced. This approach allows considerable latitude during restoration, as proof of previous existence is not required (as long as there is sufficient evidence that the species in question is likely to have been present), and local extinctions and immigration are likely to alter community composition naturally over time. However, it is still essential to identify the goal of the restoration programme (Atkinson 1988 & 1990).

Extinction of a previously existing taxon may not preclude restoration, as replacement with an extant closely related species or subspecies (see Atkinson 1988 & 1990) may fill the triple roles of establishing a further population of a threatened species, restoring some of the trophic processes formerly

present, and restoring lost evolutionary potential. This surrogate species concept was developed by Atkinson to support the introduction of rock wren to Matiu/Somes and/or Mana Islands to attempt the re-establishment of a lowland, forest-dwelling wren to replace the extinct bush wren. A similar case could be argued for the introduction of Chatham Island snipe to Mana Island to replace the extinct North Island form of New Zealand snipe.

Introductions of surrogate species to restore lost evolutionary potential have not yet been attempted in New Zealand, but there have been many examples of introductions of threatened species to islands (including Mana Island) where there is little likelihood that the species ever occurred previously. The introductions of, e.g., takahe and kakapo to islands are in direct conflict with ecological restoration programmes as, even if there is evidence for their previous existence within the relevant Ecological District, it is doubtful whether small islands could support viable populations of species with such large space requirements. There are many New Zealand animal and plant species that are critically endangered by the presence of introduced mammal species and for which introduction to predator-free islands may be the only option for retaining a viable wild population. However, the increasing efficiency with which islands are being cleared of rodents and other pests (Table 2.1) means that predator-free habitats are being created within appropriate Ecological Districts for many threatened taxa, reducing the need for inappropriate introductions.

TABLE 2.1 NEW ZEALAND ISLANDS OVER 100 ha IN SIZE THAT ARE CURRENTLY THOUGHT TO BE FREE OF INTRODUCED MAMMALS (OUTLYING ISLAND GROUPS NOT INCLUDED).

ISLAND	AREA (ha)	HISTORY OF MAMMAL ERADICATIONS AND LAND USE
Great (Three Kings)	408	Goats eradicated 1946. Regenerating forest.
Tawhiti Rahi	163	Introduced mammals never present. Forested.
Aorangi	110	Pigs eradicated 1936. Forested.
Whatupuke	102	Kiore eradicated 1993. Forested.
Tiritiri Matangi	196	Kiore eradicated 1993. Part forested. Formerly farmed.
Cuvier	170	Goats eradicated 1961, cats 1964, kiore 1993. Forested. Part formerly farmed.
Red Mercury	225	Kiore eradicated 1992. Forested.
Stanley	100	Kiore & rabbits eradicated 1991. Forested.
Moutohora	173	Goats eradicated 1977, Norway rats 1986, rabbits 1987. Formerly farmed.
Kapiti	1966	Axis deer eradicated 1906, cattle 1917, goats 1928, cats 1934, sheep 1969, possums 1986. Kiore and Norway rat eradication attempted 1996. Forested.
Mana	217	Mice eradicated 1990. Formerly farmed.
Stephens	150	Cats eradicated 1925. Formerly farmed.
Nukuwaiata	242	Pigs eradicated 1963, kiore (and weka) eradicated 1993. Forested.
Maud	309	Stoats eradicated 1983 & 1993. Part forested. Formerly farmed.
Breaksea	170	Norway rats eradicated 1988. Forested.
Solander	100	Introduced mammals never present. Weka present. Part forested.
Ulva	259	Norway rats eradicated 1995. Forested.

There are a few critically endangered species (e.g., kakapo, takahe and some kiwi taxa) for which their may be no ecologically or biogeographically appropriate islands available, and where there will inevitably be conflicts between species recovery programmes and island restoration programmes. For these taxa it is essential that there is national co-ordination of suitable islands where there are sufficiently few conflicts between existing conservation values and the species proposed for introduction. In such an analysis it is inevitable that islands with a previous history of extreme modification (e.g., Tiritiri Matangi, Cuvier, Moutohora, Mana and Maud Islands) are likely to be selected for "extralimital" introductions over islands that have retained largely unmodified ecosystems.

Atkinson & Towns (1990) described a scheme for classifying islands of conservation significance into functional categories on the basis of the presence or absence of endemic species, introduced mammals and indigenous habitats, vulnerability to human interference, degree of habitat modification, and opportunities for habitat restoration (Table 2.2). These categories are points on a continuum, but Atkinson & Towns specifically mentioned Mana as an example of a restoration island. The key difference between restoration islands and open sanctuary islands is whether the ecosystem created is an approximation of an ecosystem that formerly existed, or whether the primary purpose is to create habitat for threatened species that may not have formerly existed at that site. As Mana Island has retained nationally significant populations of threatened animals, and regionally significant populations of threatened plants, it is more appropriate to use these as a basis for restoring a former Mana Island ecosystem, rather than creating an artificial biotic assemblage.

TABLE 2.2 CRITERIA FOR CLASSIFYING ISLANDS OF CONSERVATION SIGNIFICANCE INTO FUNCTIONAL CATEGORIES (AFTER ATKINSON 1990).

FUNCTIONAL CATEGORY	CRITERIA FOR RECOGNITION
Minimum impact islands	Presence of island endemics; freedom from introduced mammals; significant areas of indigenous habitat; high vulnerability to human interference; all sizes of islands, both modified and largely unmodified
Refuge islands	Presence of mainland endemics as island survivors; introduced mammals sometimes present; significant areas of indigenous habitat; moderate vulnerability to human interference; all sizes of islands; all degrees of modification except those largely unmodified
Restoration islands	Opportunities for restoring habitats of threatened species and for restoring threatened communities, both those of islands and those of the mainland; modified and extremely modified islands of all sizes
Open sanctuary islands	Opportunities for providing habitats for rare and threatened species; opportunities for public education; medium and large islands, both modified and extremely modified
Multiple use islands	Conservation values secondary to other uses such as farming, forestry and recreation. Mostly extremely modified islands that are sometimes farm parks or privately owned

Atkinson & Towns' (1990) management suggestions for restoration islands are given in Table 2.3. Note that they specifically mention the introduction of selected species of nationally endangered animals as appropriate for restoration islands, even though this may conflict with the overall goal of restoring a biotic community that may have previously existed at that site. The potential for

conflict between species recovery programmes and strict island restoration on Mana Island has been discussed extensively by Timmins et al. (1987b), Atkinson (1988 & 1990) and Towns et al. (1990).

The most widely accepted conceptual framework for guiding ecological restoration in New Zealand is the Ecological Region/Ecological District system (McEwen 1987). On the basis of soil, vegetation, climate, landform and cultural modification, New Zealand is divided into 268 Ecological Districts which are grouped into 85 Ecological Regions. Many island restoration programmes identify species or communities from the relevant Ecological District or Ecological Region as appropriate for restoration, even if there is no definite evidence of their former presence on the island (e.g., Timmins et al. 1987b; Atkinson 1988; Smale & Owen 1990; McGlynn 1990). Under the current system, Mana Island is part of the Cook Strait Ecological District within the Sounds-Wellington Ecological Region. Cook Strait Ecological District incorporates Kapiti and Mana Islands, the exposed coast and adjacent slopes between Paekakariki and Owhiro Bay, plus Stephens, Rangitoto, Trio, Chetwode, Titi and Brothers Islands, and headlands of the outer Marlborough Sounds. Sounds-Wellington Ecological Region is comprised of four Ecological Districts that include the Hutt Valley, Matiu/Somes Island, the Wellington peninsula, and the entire Marlborough Sounds.

TABLE 2.3 MANAGEMENT ACTIONS APPROPRIATE FOR A RESTORATION ISLAND (FROM ATKINSON & TOWNS 1990).
Note that for Mana Island "introduced" refers to species from beyond the eastern Cook Strait Ecological District and local species that are unlikely to have naturally occurred on a small island.

Primary conservation function	Recovery of viable populations of threatened species and restoration of particular communities
Protective action for species communities	Precautions against establishment of introduced plants and animals (with certain and biotic exceptions, see below) and against illegal visits and fires
Protective and restorative action for archaeological sites	Sites of archaeological value protected with restoration of selected sites where there will be minimal diruption to existing or restored biotic communities
Restorative action for biotic communities	Restoration of communities formerly present and extension of some still existing
Translocation of plants not natural to the island*	Not permitted except for providing temporary cover or, in exceptional circumstances, to provide food for a nationally endangered animal species
Translocation of animals not natural to the island*	Permitted for selected species of nationally endangered animals
Habitat manipulation for particular species	Choice of communities to be restored sometimes influenced by habitat requirements of threatened species
Scientific activity	Experimentation using carefully monitored trials to measure progress of programme
Education and interpretation	(i) Low impact activities not possible in an open sanctuary (ii) Permitted visitors to a few selected islands with interpretation/supervision by rangers (iii) Volunteer help with restoration work on some islands

**i.e., species unlikely to have been present on the island originally*

Cook Strait Ecological District was defined on the basis of its climate (exposure to severe gales) topography and vegetation: "the boundaries recognise ecological and floristic affinities between the very exposed, steep coastal escarpments, terraces, headlands and islands on either side of Cook Strait" (McEwen 1987).

However, there is a very marked faunal discontinuity across Cook Strait (discussed below under "Birds" and "Reptiles") and there is considerable disagreement over whether the two sides of Cook Strait should be included in the same Ecological District (Ogle 1989a; Atkinson 1992). Botanists have long argued that seed sources as close as possible to the restoration site should be used (Godley 1972; Timmins & Wassilieff 1984; Timmins et al. 1987b), therefore there are compelling floral and faunistic reasons for not using the entire Cook Strait Ecological District (or Sounds-Wellington Ecological Region) as a model for restoring Mana Island. Some species that are locally extinct on Mana Island and the southern North Island may have to be sourced from the Marlborough Sounds (e.g., tuatara, Duvaucel's gecko and several species of burrowing petrels), but this is a separate issue from using, e.g., the Brothers Islands or Stephens Island as models for restoring biotic communities on Mana Island.

Ian Atkinson (in lit. July 1992) suggested that for the purposes of ecological restoration on Mana Island, Mana and Kapiti Islands and the coast between Paekakariki and Sinclair Head should be included in an expanded Wellington Ecological District (i.e. including Wellington peninsula, the Hutt Valley, and islands in Port Nicholson). This would still leave the boundaries of the Sounds-Wellington Ecological Region to draw attention to the important ecological similarities between the North and South Islands in the Cook Strait region.

3. Restoration goals

The primary restoration goal for Mana Island is to maintain those threatened species and communities that have survived on Mana Island within self-sustaining ecosystems similar to those likely to have existed on the island before human contact.

Secondary restoration goals (where these are compatible with the primary goal) are:

- recreate coastal forest, shoreline, cliff and wetland plant communities typical of the Wellington coast and similar to those expected to have occurred on the soils and landforms present on Mana Island, using seed sources as close as possible to (if not on) Mana Island
- establish self-maintaining populations of threatened plants of the Wellington coast of Cook Strait appropriate to the habitats present on Mana Island, using seed sources as close as possible to the island (but further afield if the species are extinct in the Wellington region)
- reintroduce or encourage colonisation by all native animal species known to have previously occurred on Mana Island
- introduce (or reintroduce) threatened and locally extinct vertebrates of the southern North Island that are not able to exist in the presence of introduced mammals, and are likely to have occurred in coastal habitats in the Wellington region
- where previously occurring vertebrate taxa are extinct, introduce an ecologically similar conspecific or congeneric taxon (if one exists within New Zealand) to restore trophic processes and lost evolutionary potential
- as far as possible, restore invertebrate communities typical of the plant communities created
- introduce (or reintroduce) threatened macroinvertebrates appropriate for an island in eastern Cook Strait
- eradicate/control animals and plants which would severely compromise other restoration goals
- maintain grassland at priority archaeological sites to enhance interpretation and site preservation

This suite of restoration goals should collectively restore the natural processes necessary to recreate a functional ecosystem representative of the exposed Wellington west coast before human disturbance. However, it is recognised that Mana Island may be required to provide habitat for a select few critically endangered bird species that probably or definitely never occurred on the island in the past. If taxa that are not likely to have ever occurred on Mana must be introduced to ensure their survival, they must (a) not jeopardise the survival of resident and restored threatened animals and plants, and (b) be able to be removed totally from Mana when other more suitable (mainland or island) sites are available.

The close involvement of the local community and iwi is and will be essential for the ecological restoration of Mana Island to succeed.

4. Progress with restoration

Over 250,000 plants of at least 50 species have been planted on Mana since 1987 as part of the revegetation programme. Plantings have mainly been confined to valley sides and floors. Survival in the first year of planting averaged about 80% before pukeko became numerous (P. Todd pers. comm.), but has since declined due to extensive damage by pukekos.

The eradication of mice has resulted in dramatic increases in populations of all three threatened animal species known to be present: Cook Strait giant weta, McGregor's skink and goldstripe gecko (Whitaker 1993; Newman 1994; Todd & Miskelly in press). Anecdotal evidence indicates that several species of native invertebrates in addition to the giant weta have increased since mouse eradication; this was investigated further during surveys in November 1993 & February 1994.

Three species of endangered native landbirds have been introduced to Mana (takahe, kakapo and little spotted kiwi), but none has yet established a self-sustaining population. There are currently no kakapo on Mana. North Island robins were reintroduced to Mana Island in 1995 and 1996, when 68 were transferred from Kapiti Island.

Breeding success and population size of sooty shearwaters at the southern colony (c.100 pairs) are being monitored annually. The northern colony (< 10 pairs) was recently rediscovered 18 years after it was last recorded as being active. An attempt has been made to attract other species of burrowing petrel to the island at one site using continuous broadcast of recorded calls at night, and an attempt to attract gannets to an artificial colony commenced in 1997.

The suitability of Mana Island for the release of captive-reared and captive-bred shore plover was the subject of a study in 1993/94 (Miskelly & Aikman 1993). The main factor that was considered likely to jeopardise establishment of shore plover was the high density of breeding black-backed gulls. Gull control was initiated on Mana Island in 1994/95 in preparation for shore plover release.

Weed control on Mana Island has been a major focus since 1994, with a dedicated team working on boxthorn removal each summer since then. Colonising weed species are also targeted to prevent new weed species becoming established.

5. Revegetation

5.1 CURRENT SITUATION

The vegetation of Mana Island was described by Timmins et al. (1987a) based on surveys between 1984 and 1986. The shoreline and cliffs are mainly covered in regenerating *Muehlenbeckia complexa – Coprosma propinqua* shrubland. Taupata, tauhinu, *Tetragonia trigyna* and *Melicytus crassifolius* are also common, and boxthorn is a major component of shrub communities on the north and north-east coasts. The valleys are mainly covered in exotic grasslands dominated by cocksfoot, Yorkshire fog, prairie grass, rye grass and white clover. Weta Valley, Tauhinu Valley and the top of Forest Valley have some shrub cover of tauhinu, manuka and kanuka. In Forest Valley this grades into 6–7 m tall kanuka with an understorey of native shrubs, then a small (< 1 ha) area of kanuka forest up to 12 m tall containing a narrow band of broad-leaved trees (karaka, two large-leaved milk trees and one each of kohekohe and wharangi). The plateau is almost totally covered in rank exotic grasses and clover. Shelterbelts of pine and macrocarpa were planted earlier this century, and more recent shelter belts of toetoe, pampas grass, flax and Tasmanian ngaio were planted when the island was being run as a quarantine research station by the Ministry of Agriculture and Fisheries in the 1970s.

Timmins et al. (1987a) recorded 325 vascular plant species from Mana Island, of which 171 (53%) were native. Only 40 species of native trees and shrubs were recorded (Table 5.1) and, of these, 17 species were recorded at fewer than five sites. The native flora of Mana Island is thus very restricted and unlikely to include the full diversity once present.

5.2 WHAT WAS MANA ISLAND'S ORIGINAL PLANT COVER?

The original vegetation of Mana Island is not known. Palynological studies revealed a predominantly manuka/kanuka community from 560 ± 160 years BP until European settlement (Chester & Raine 1990; Chester 1991). This manuka/kanuka community (similar to that found in the one forested catchment on the island) was probably a seral community established after the original forest was burnt, although earlier pollen sequences have not been located. Mixed broadleaved/podocarp forest is more typical of small islands (Chester 1991), and some of the likely canopy species (akiraho, karaka, kohekohe, large-leaved milk tree, wharangi and kaikomako) are present on Mana in small numbers (Timmins et al. 1987a).

5.3 IS ACTIVE REPLANTING NECESSARY ON MANA ISLAND?

Active revegetation is necessary on Mana because the landscape is so extensively modified, and because there is a low diversity of native woody plant species on the island. Natural regeneration of the forest and scrub vegetation on Mana would take many decades, if not centuries, and is unlikely to produce a diverse broadleaved/podocarp forest such as was likely to have been present originally. Revegetation will also provide habitat for forest- and scrub-dwelling species more rapidly than natural regeneration.

TABLE 5.1 NATIVE TREE AND SHRUB SPECIES PRESENT ON MANA ISLAND IN 1984–86, WITH NOTES ON DISTRIBUTION AND ABUNDANCE (FROM TIMMINS ET AL. 1987a).

SPECIES	COMMENT
Titoki	One seedling recorded 1975
Rangiora	Abundant in Forest Valley
New Zealand broom	Many in Forest Valley
Tauhinu	Abundant on shore, cliffs and valleys
Coprosma areolata	One in Forest Valley
C. lucida	Many in Forest Valley; present on cliffs
C. propinqua	Abundant on shore, cliffs and valleys
C. rhamnoides	Abundant in Forest Valley; present on cliffs
Taupata	Abundant on shore and cliffs and as plantings
Karamu	Many in Forest Valley; elsewhere as plantings
Tree tutu	One plant recorded 1911
Cabbage tree	One on south-east cliff face; elsewhere as plantings
Karaka	Many in Forest Valley; present on cliffs; elsewhere as plantings
Prickly mingimingi	Many on cliffs and on rocky outcrops in valleys
Kohekohe	One tree and many seedlings in Forest Valley
Puka	One at mouth of Tauhinu Valley and one on northern cliffs
Koromiko	Many on cliffs
Lacebark	Present on shore; elsewhere as plantings
Kanuka	Many on cliffs and in valleys; abundant in Forest Valley
Manuka	Abundant on cliffs and in valleys
Patotara	Many on cliffs and in valleys
Kawakawa	Abundant in Forest Valley; present on cliffs
Wharangi	One tree in Forest Valley; seedlings in Forest Valley and nearby cliffs
Melicytus crassifolius	Abundant on shore and cliffs; present in valleys
M. obovatus	Eight on cliffs, one on shore
Mahoe	Many in Forest Valley; present on cliffs and shore
Northern rata	One on south-east cliff

SPECIES	COMMENT
Ngaio	Recorded in 1975 on south-east cliffs; elsewhere as plantings
Mapou	Two trees in Forest Valley; 16 saplings on shore, cliffs and valleys
Akiraho	Many on cliffs and in Forest Valley
Coastal tree daisy	Two on south-east cliffs; patch in Aston Valley, plus two others in valleys
Large-leaved milk tree	Two trees and many seedlings in Forest Valley; one tree on cliffs and one in valley
Kaikomako	Nine on shore, four on cliffs, many in northern valleys
Pinatoro	Many on cliffs and in valleys
Karo	Widely planted
Shore ribbonwood	One on south-east shore in 1986
Five finger	Recorded in 1911; more recently as plantings
Solanum aviculare	Many on shore and valleys; few on cliffs
S. laciniatum	Many on shore and valleys; few on cliffs
Ongaonga	Many in valleys; few on shore

However, there are many plant and animal species on Mana Island that do not thrive in forest habitats,, e.g., *Melicytus obovatus*, speargrass, giant weta and takahe, and restoring forest to the entire island would also limit restoration opportunities for species such as *Muehlenbeckia astonii*, shore spurge, fernbird, brown teal and snipe. For these reasons, active planting of tree and shrub species is planned for only about 72 ha (33%) of Mana Island (Figure 5.1). Areas to be specifically excluded from the main revegetation programme are: (a) the shore line and cliffs (61 ha) which have extensive native shrub, herb and grass communities, (b) the south side of Weta Valley and the lower reaches of Forest and Tauhinu Valleys (19 ha) where natural succession is restoring shrub and forest communities, (c) archaeological sites (c.5 ha) where woody vegetation could obscure surface features and disturb subsurface strata, (d) the middle reaches of Astons Valley and Tauhinu Valley (25 ha) as control areas to assess natural regeneration of grassland in sheltered sites, (e) rocky outcrops and steep slopes with thin soils (c. 1 ha) within the main planting area, where native shrubs and herbs are already establishing, (f) most (35 ha) of the plateau grasslands where strong salt-laden winds and dry summer conditions will restrict establishment of shrub and forest cover, and (g) windows of grassland on valley floors and lower slopes to provide feeding areas for takahe.

Restricting planting of woody species to 72 ha will create a mosaic of habitats that is both appropriate for the local landforms, soils and microclimates on the island, and will provide a variety of habitats suitable for the range of plant and animal species that are either resident on the island or considered appropriate for introduction. It is anticipated that the combined effects of the planting programme and natural regeneration will produce about 76 ha of coastal broadleaved forest and 84 ha of shrublands within the next 30–40 years (Figure 5.2), leaving about 57 ha of grassland. Natural succession will continue to reduce the area of open grassland over time, but the only sites

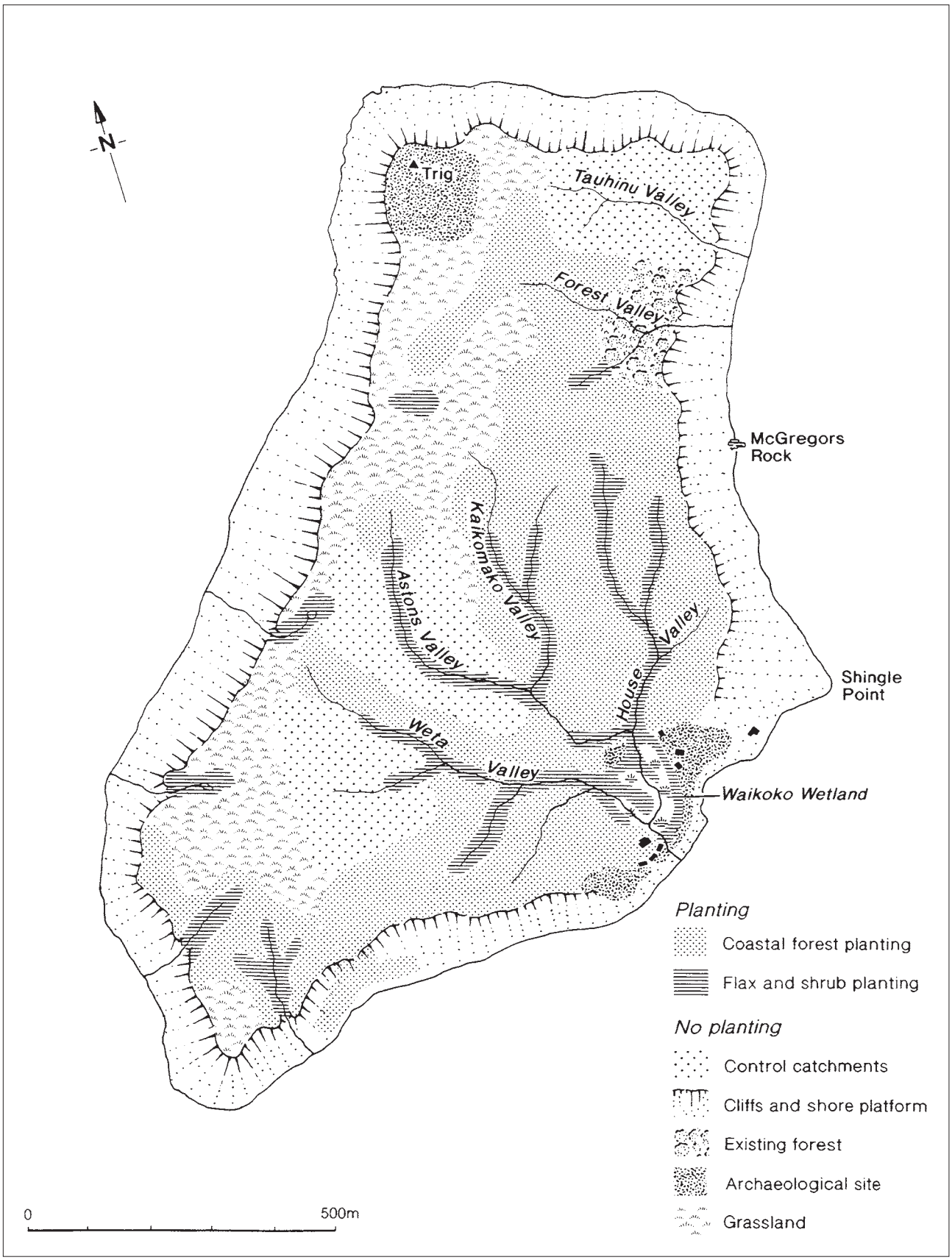

Figure 5.1 Areas of Mana Island planned for planting of tree and shrub species as part of the restoration programme.

where regeneration of native shrub and tree species will be actively prevented is on archaeological sites, unless Mana Island remains a key site for takahe conservation beyond the medium term.

5.4 PROGRESS WITH REVEGETATION TO DATE

The emphasis of the revegetation programme is on recreating plant communities appropriate to the island's location, climate, soils and landforms. Seed is collected on the island or on the adjacent coast (all within Cook Strait Ecological District). All seed is collected from sites below 200 m asl, and from areas with similar soils to those of Mana Island. Mainland seed sources are used only if the species does not occur on Mana Island. Most seed is germinated off the island and the seedlings returned to the island, where they are pricked out and raised for a further 1–2 years before being planted out. Herbicides are no longer used to remove grasses before planting. Initial plantings are of seral species (Table 5.2) to overtop the rank grass, attract birds and provide suitable microhabitats for eventual canopy species to become established. Some interplanting of canopy species (e.g., wharangi, kahikatea and tawa) under earlier plantings has also occurred to provide a seed source so that natural processes (e.g., seed dispersal by fruit-eating birds) will dictate the eventual forest composition (see Wright & Cameron 1990). Effort has been put into creating a corridor between Forest Valley and the longest established plantings near the houses. Over 200,000 plants of 50 species were planted in about 30 ha between 1987 and 1996 (Table 5.2).

TABLE 5.2 SUMMARY OF REVEGETATION EFFORT ON MANA ISLAND, 1987 TO 1996.

YEAR	NUMBER OF PLANTS	SPECIES
1987	11,500	Titoki, rengarenga, rangiora, tauhinu, *Coprosma lucida*, taupata, karamu, cabbage tree, pigeonwood, kanuka, manuka, ngaio, kohuhu, five finger
1988	27,000	Rangiora, taupata, karamu, kanuka, manuka, kawakawa, wharangi, mahoe, ngaio, akiraho, kaikomako, wharariki, harakeke, five finger
1989	15,000	?
1990	20,000	Titoki, *Coprosma lucida*, taupata, karamu, karaka, kahikatea, kanuka, manuka, wharangi, mahoe, ngaio, mapou, five finger, kowhai
1991	22,000	*Coprosma propinqua*, kohekohe, wharangi, ngaio, five finger, lancewood
1992	23,900	Tawa, tree lucerne, *C. propinqua*, taupata, karamu, cabbage tree, toetoe, karaka, kahikatea, kohekohe, puka, kanuka, kawakawa, wharangi, mahoe, ngaio, mapou, kaikomako, kohuhu, five finger, kowhai
1993	17,000	Tawa, rangiora, putaputaweta, *Coprosma lucida*, *C. propinqua*, taupata, karamu, cabbage tree, karaka, kahikatea, koromiko, pigeonwood, kanuka, kawakawa, wharangi, mahoe, ngaio, mapou, wharariki, kohuhu, totara, five finger, kowhai

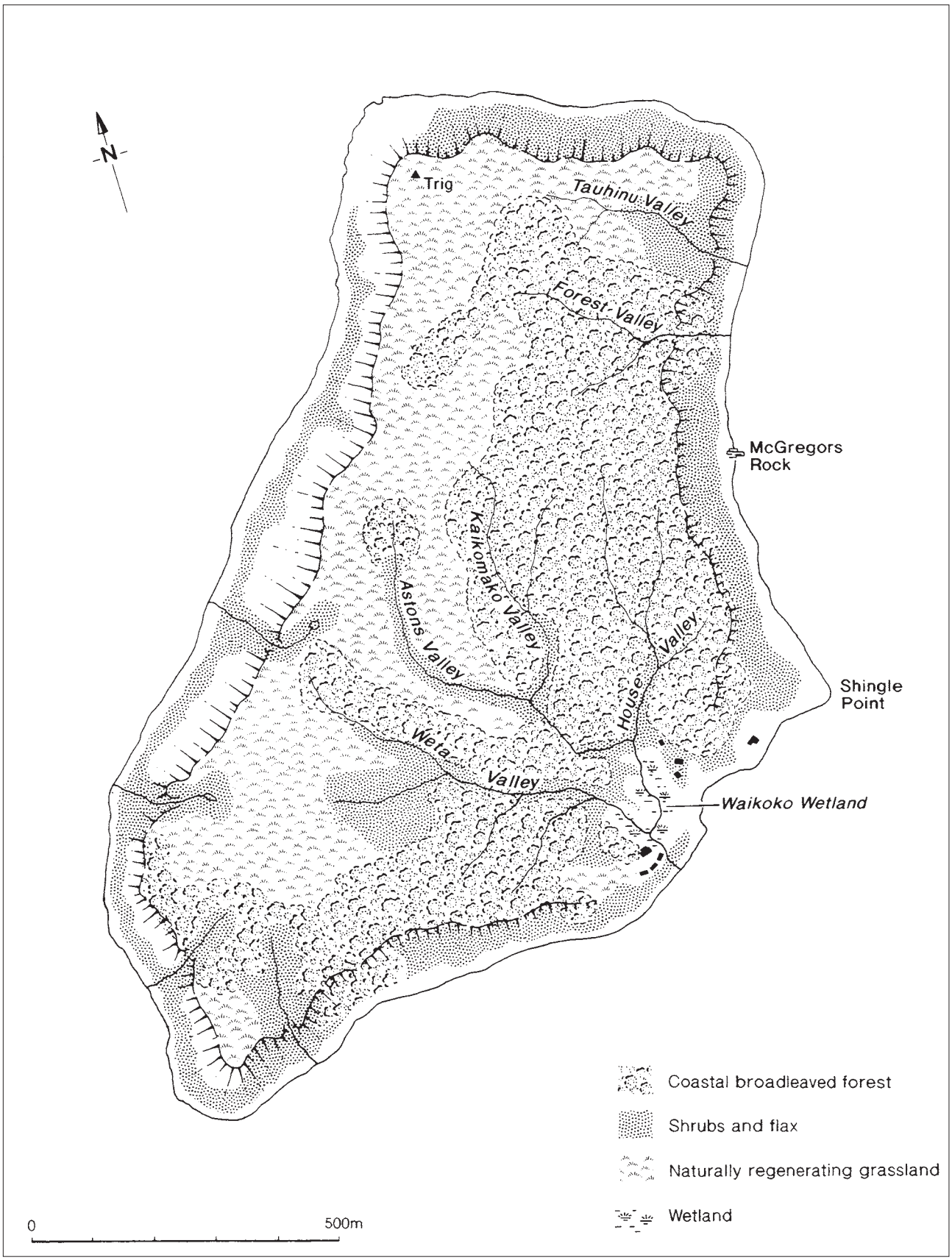

Figure 5.2 Projected forest and scrub cover on Mana Island in 2030 A.D. if ecological restoration is completed as planned.

TABLE 5.2 cont. SUMMARY OF REVEGETATION EFFORT ON MANA ISLAND, 1987 TO 1996.

YEAR	NUMBER OF PLANTS	SPECIES
1994	13,500	Tawa, *Coprosma lucida*, *C. propinqua*, taupata, karamu, karaka, kahikatea, kohekohe, puka, koromiko, kanuka, Cook's scurvy grass, manuka, wharangi, *Melicytus crassifolius*, mahoe, ngaio, akiraho, kaikomako, lemonwood, kohuhu, totara, five finger, lancewood
1995	27,800	Rengarenga, tawa, *Carex* sp., *Carmichaelia arborea*, *Coprosma lucida*, *C. propinqua*, taupata, karamu, cabbage tree, toetoe, karaka, kahikatea, kohekohe, puka, koromiko, pigeonwood, kanuka, Cook's scurvy grass, manuka, mahoe, ngaio, akiraho, *Olearia solandri*, wharariki, lemonwood, kohuhu, totara, five finger, lancewood, nikau, kowhai
1996	29,800	Rengarenga, tawa, *Carex* sp., *Carmichaelia arborea*, tauhinu, *Clematis forsteri*, *Coprosma lucida*, *C. propinqua*, *C. rhamnoides*, taupata, karamu, cabbage tree, toetoe, karaka, kahikatea, turutu, kohekohe, hangehange, puka, koromiko, pigeonwood, kanuka, Cook's scurvy grass, manuka, kawakawa, wharangi, harakeke, *Melicytus obovatus*, mahoe, ngaio, akiraho, *Olearia solandri*, wharariki, kohuhu, miro, five finger, poroporo, large-leaved milk tree
Total	207,500	

5.5 SELECTING APPROPRIATE FOREST COMMUNITIES FOR MANA ISLAND

Plant communities within a region are often determined by physical parameters such as soil type, slope, aspect, drainage and exposure to wind (references in Meurk & Blaschke 1990), and restoration programmes should be stratified according to the landforms, soils, microclimate and drainage patterns within the island. Experience from the first ten years of the planting programme provides a more realistic basis for planning a reviewable revegetation strategy based on site factors and anticipated landscape character.

There are four soil types present on Mana Island (Figure 5.3; based on Heine 1975): Paremata silt loam, Porirua fine sandy loam, Terawhiti steep-land soils and Titahi hill soils. To aid restoration of forest communities on Mana Island, Gabites (1994) surveyed vegetation communities at 12 sites on the adjacent mainland in relation to soil type, gradient, aspect, drainage and exposure. Gabites' results have been combined with Ogle's (1985) surveys of forest remnants in the Plimmerton area to produce the species lists in Table 5.3. On all four soil types kohekohe was a dominant canopy species along with tawa, karaka or ngaio. Other canopy species included wharangi, kaikomako, titoki, miro and kohuhu. The most abundant subcanopy species were kawakawa, hangehange, mahoe, rangiora, pigeonwood and *Coprosma* species. Important seral species during forest establishment included mahoe, manuka, kanuka, koromiko, five finger and small-leaved *Coprosma* species. Lianes present at all sites included *Metrosideros fulgens*, aka, kaiwhiria and supplejack. Of the 69 native woody species recorded by Ogle (1985) and Gabites (1994)

36 occur naturally on Mana Island (Timmins et al. 1987a); the remaining 33 species, which may be candidates for the revegetation programme on Mana Island, are listed in Table 5.4. Two tree species already used in the revegetation programme (lemonwood and kowhai) were not recorded by Gabites (1994) from the 12 sites she surveyed and do not occur naturally on Mana Island, but are present elsewhere in the Cook Strait Ecological District (e.g., on Kapiti Island); these two species should be used sparingly in the Mana Island revegetation programme.

Within each soil type Gabites (1994) found that other physical factors influenced community structure. Kohekohe was prevalent on sites that were very exposed to wind, but was less common on steep slopes with thin soils, where akiraho, kohuhu and titoki were co-dominant. Ngaio mainly occurred on those steep slopes with thin soils that had a northerly aspect. Karaka and rangiora showed strong preferences for sheltered sites or those with southerly aspects, though karaka and mahoe can thrive on quite mobile screes. Loess soils (Paremata hill soil and Porirua fine sandy loam) had tawa and miro in the canopy and previously had totara. Five finger was only evident on these richer soils in sheltered sites. Titoki was found mainly on well drained soils and was not common on slow draining loess loams, whereas kohekohe appeared tolerant of a wide range of drainage conditions. On quick draining soils (Terawhiti steep-land soils and Titahi hill soils) manuka and kanuka dominated recolonisation, followed by mahoe, tree ferns and kaikomako. In shady, sheltered sites rangiora, five finger, kawakawa and hangehange followed, with the latter two species persisting under a closed canopy at all sites. In exposed sites on well drained soils small-leaved *Coprosma* species and New Zealand broom established first. On less well drained soils regeneration was dominated by broadleaved species, with pigeonwood present.

Timmins et al. (1987b) listed 36 species of trees and shrubs suitable for propagation and planting on Mana Island; of these, 22 have been recorded naturally from Mana Island, and 12 were recorded at sites surveyed by Ogle (1985) and Gabites (1994). The two remaining species (akeake and *Pseudopanax anomalus*) are rare or absent from forest remnants on the coastline near Mana Island. There may be no natural akeake present on the Wellington coast of Cook Strait Ecological District, but *P. anomalus* is common in shrublands on Kapiti Island.

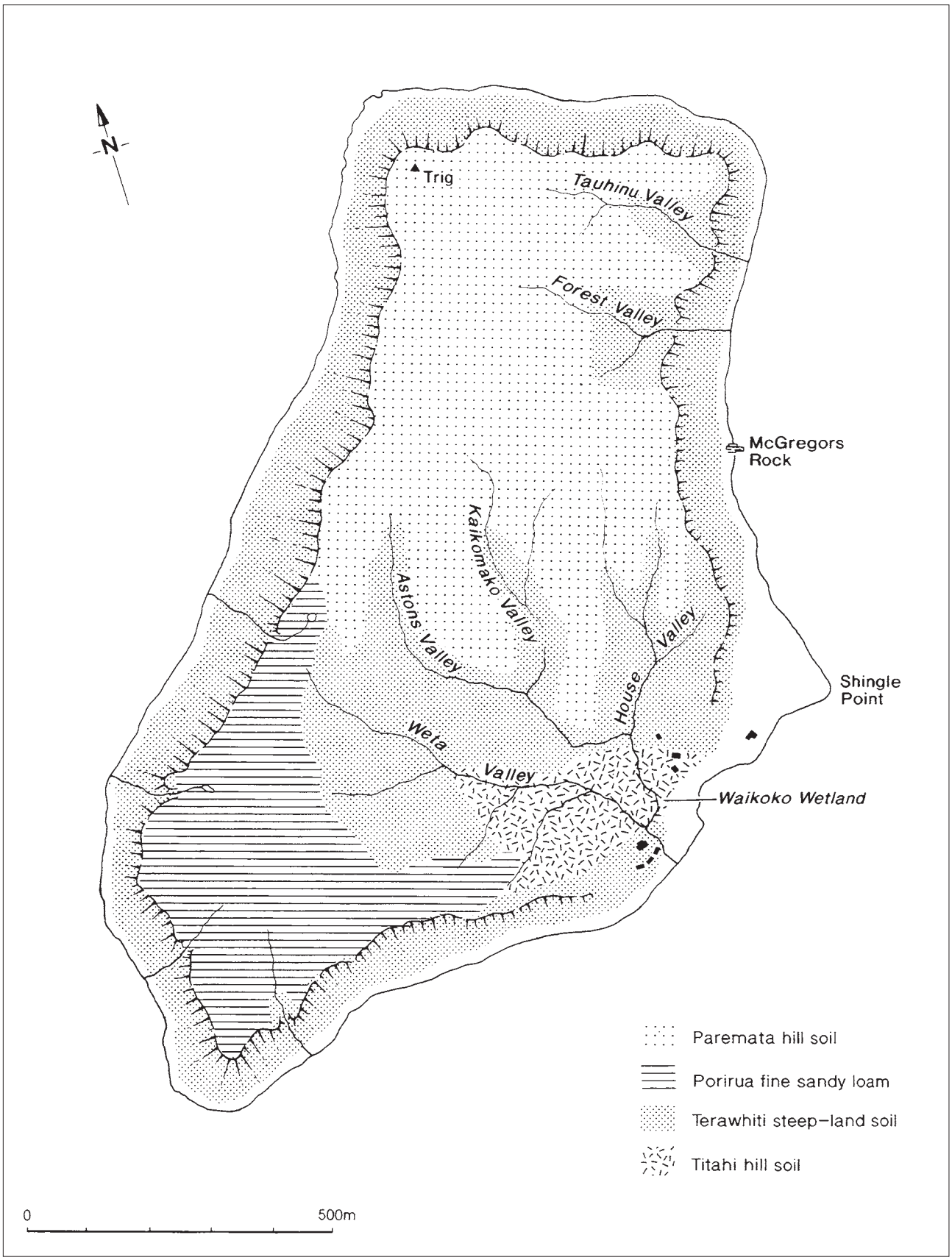

Figure 5.3 Distribution of soil types of Mana Island (after Heine 1975).

TABLE 5.3 VEGETATION COMMUNITIES TYPICAL OF THE SOIL TYPES PRESENT ON MANA ISLAND AS DETERMINED BY SURVEYS OF FOREST REMNANTS ON THE ADJACENT COAST (OGLE 1985; GABITES 1994).

SOIL TYPE	PAREMATA HILL SOIL*	PORIRUA FINE SANDY LOAM	TERAWHITI STEEP-LAND SOILS	TITAHI HILL SOILS
Soil description	Loess and weathered greywacke on greywacke. Moderately well drained	Loess on rolling country, slow drainage	Greywacke and greywacke scree on steep slopes. Rapid drainage	Deep, soft consolidated sand. Prone to erosion. Excessive drainage
Sites surveyed	Karehana Bay Steps (deep gully); Track Bush, Plimmerton (spur crest)	Rangi's Bush; Pikarere Homestead (upper slopes)	Raroa Reserve (true right); West Wairaka Point; Paekakariki Hill Rd; Clarke Reserve; Pikarere Homestead; North Pikarere Homestead (lower slopes); SH1 escarpment	Raroa Reserve (true left); Brews Bush; Airlie Road
Dominant canopy species	Kohekohe, tawa	Kohekohe, tawa	Kohekohe, karaka	Kohekohe, ngaio
Other canopy species	Karaka, titoki, miro, wharangi, heketara, ngaio, totara, large-leaved milk tree, matai, cabbage tree	Mahoe, hinau, wharangi, kohuhu, kaikomako	Akiraho, kohuhu, titoki, wharangi, kaikomako, ngaio (northerly aspects)	Tawa, kahikatea, kaikomako, totara, miro, rata vines
Dominant understorey	Mahoe, kawakawa, hangehange	Kawakawa	Kawakawa	Kawakawa, hangehange
Other understorey species	Rangiora, *Coprosma areolata*, pigeonwood, ramarama, rohutu, kiekie	Rangiora, mapou, hangehange, pigeonwood, raurekau, *Coprosma rotundifolia*	Rangiora, mahoe, hangehange, pigeonwood, five finger, mapou, karamu	Mahoe, *Coprosma rhamnoides*, lancewood
Seral species	Manuka, mahoe and other broadleaved species with early appearance of canopy species, coastal tree daisy	Mahoe, pigeonwood	Tauhinu, kanuka, *Coprosma areolata*, *C. propinqua*, *C. rhamnoides*, *C. rotundifolia*, NZ broom, koromiko	Manuka, kanuka, mahoe, tree ferns, rangiora, five finger
Lianes	*Metrosideros diffusa*, *M. fulgens*, aka, kiekie, kaiwhiria, supplejack, kohia, puawananga	Aka, *Metrosideros fulgens*, kaiwhiria, supplejack	Aka, aka kiore, kaiwhiria, kohia, pohuehue, *Muehlenbeckia australis*, supplejack	*Metrosideros fulgens*, aka, *Muehlenbeckia australis*, kaiwhiria, kohia, supplejack
Other tree and shrub species recorded from this soil type	Wineberry, karamu, *Coprosma rotundifolia*, puka, rewarewa, kanuka, northern rata, mapou, kaikomako, kohuhu, five finger, lancewood, nikau, pukatea, white maire, kahikatea, rimu	*Coprosma rhamnoides*, *C. areolata*, kapuka	Wineberry, puka, lancewood, pate, milk tree	Titoki, hinau, putaputaweta, *Coprosma areolata*, *C. rotundifolia*, *C. propinqua*, *C. lucida*, raurekau, karamu, mingimingi, mapou, koromiko, ramarama, northern rata, kohuhu, nikau, swamp maire

** (nearest mainland equivalent to Paremata silt loam)*

TABLE 5.4 NATIVE TREES, SHRUBS AND LIANES NOT NATURALLY OCCURRING ON MANA ISLAND BUT PRESENT ON SIMILAR SOIL TYPES AND SITES ON THE ADJACENT MAINLAND. THOSE SPECIES ASTERISKED HAVE ALREADY BEEN USED DURING THE MANA ISLAND PLANTING PROGRAMME.

DICOT TREES AND SHRUBS			
wineberry	raurekau	rimu	kapuka
pukatea	white maire	totara*	lancewood*
tawa*	*Coprosma rotundifolia*	hinau	pigeonwood*
ramarama	heketara	miro*	pate
putaputaweta*	kahikatea*	hangehange*	rewarewa*
rohutu	kohuhu*	matai	swamp maire
DICOT LIANES			
puawananga	kohia	*R. schmidelioides*	*Metrosideros diffusa*
Rubus australis	*M. fulgens*	*R. cissoides*	
MONOCOT LIANES AND TREES			
nikau*	supplejack		

5.6 A REVEGETATION STRATEGY FOR MANA ISLAND

The following revegetation strategy is based on:

(a) Gabites' (1994) and Ogle's (1985) surveys (see Table 5.3)

(b) the distribution of different soil types on Mana Island (Figure 5.3)

(c) the areas identified for revegetation (Figure 5.1)

(d) past experience with survival of plantings in different sites

(e) specific habitat requirements of species such as kahikatea, pukatea and swamp maire

Predominant species for planting on each soil type are asterisked.

Paremata silt loam (plateau north of both Kaikomako Valley and House Valley)

Loess, moderate drainage.

Initial plantings

mahoe*, karamu*, pigeonwood, ngaio* (thin out later), tree lucerne* (remove later), karaka (south-facing gullies), kohuhu, coastal tree daisy, five finger, cabbage tree.

Subsequent interplanting

kohekohe*, tawa*, wharangi, titoki, miro, totara, large-leaved milk tree, rewarewa, white maire, matai, rimu, kawakawa*, hangehange*, rangiora, kiekie (in gullies), ramarama, rohutu.

Porirua fine sandy loam (south east plateau, south of Weta Valley)

Loess, poor drainage.

Initial plantings
mahoe*, ngaio*(thin out later), pigeonwood, kohuhu, *Coprosma* spp., mapou.

Subsequent interplanting
kohekohe*, tawa*, hinau, wharangi, kaikomako, kawakawa*, hangehange, rangiora.

Terawhiti steep-land soils (north side of Weta Valley, Kaikomako Valley, House Valley)

Steep slopes with rapid drainage.

Initial plantings
Coprosma spp.*, mahoe*, kanuka*, koromiko*, ngaio*(north facing slopes), akiraho, kohuhu, mapou, five finger.

Subsequent interplanting
kohekohe*, karaka* (south facing slopes), wharangi, titoki, kaikomako, large-leaved milk tree, kawakawa*, rangiora, hangehange, pigeonwood, wineberry, puka, pate.

Titahi hill soils (low-lying areas west of houses, lower sections of Weta Valley and slopes to south)

Sandy soils, well drained.

Initial plantings
ngaio*, mahoe*, kanuka*, five finger*, *Coprosma* spp.*, manuka, kaikomako, kohuhu.

Subsequent interplanting
kohekohe*, tawa, kahikatea, totara, miro, titoki, hinau, northern, rata, swamp maire, pukatea, kawakawa*, hangehange*, rangiora, lancewood, putaputaweta, mapou, nikau.

Assuming an initial planting density of 6000 plants/ha, a further 260,000 plants will be required before initial planting of 72 ha is complete. A further 70,000 trees of canopy species (1000/ha) and 70,000 plants of subcanopy species (also 1000/ha) will be required during interplanting, which is in its initial stages on Mana Island. This suggests that a total of about 400,000 trees and shrubs will be required from 1997 onwards to complete the planned restoration of forest communities on Mana Island (Table 5.5). If annual plantings of 35,000 trees and shrubs can be achieved, the planting programme will take a further 11 years to complete, i.e., through to the year 2007 A.D.

When the forest structure is established, work can begin on restoring groundcovers and lianes to each forest type (see species lists in Ogle 1985; Timmins et al. 1987a; Gabites 1994). As most lianes, ferns, herbs, sedges and grasses mature

quickly, large scale planting should not be necessary. Once a seed source is established within appropriate habitats, natural processes should ensure the rapid spread of each species if conditions are suitable.

TABLE 5.5 ESTIMATED PLANT REQUIREMENTS FOR RESTORATION OF FOREST COMMUNITIES ON MANA ISLAND 1997-2007.

INITIAL PLANTINGS (263,000)					
ngaio	59,000	koromiko	14,100	karaka	4,000
karamu	48,000	pigeonwood	10,000	akiraho	3,500
mahoe	37,500	tree lucerne	10,000	kohuhu	3,000
Coprosma lucida	19,000	kaikomako	5,000	manuka	3,000
kanuka	18,400	mapou	5,000	coastal tree daisy	1,000
fivefinger	17,500	cabbage tree	4,800		
INTERPLANTINGS OF CANOPY SPECIES (67,000)					
kohekohe	28,200	wharangi	4,500	pukatea	400
tawa	9,800	miro	800	swamp maire	300
karaka	5,000	totara	800	kahikatea	300
large-leaved milk tree	5,000	northern rata	500	matai	300
titoki	5,000	hinau	500	white maire	300
kaikomako	5,000	rewarewa	400	rimu	300
INTERPLANTINGS OF SUBCANOPY SPECIES (69,500)					
kawakawa	25,000	puka	3,700	putaputaweta	2,000
rangiora	10,000	pigeonwood	4,900	mapou	2,000
hangehange	9,900	pate	4,000	nikau	800
wineberry	5,000	lancewood	2,000	kiekie	200

This revegetation programme will produce forest types that will provide suitable habitat for all the forest bird species proposed for translocation to Mana Island. Kohekohe-tawa-karaka forests are found over large areas of Kapiti Island, which supports abundant populations of little spotted kiwi, New Zealand pigeon, kaka, whitehead, robin, tui and bellbird—seven of the nine forest and shrubland bird species proposed for release on Mana Island. Yellow-crowned parakeets on the Chetwode Islands are abundant in kohekohe forest, flax shrublands and regenerating grasslands, all habitats that are or will be present on Mana Island. Habitat requirements of rock wren in the absence of mammalian predators are not known, but are likely to include open shrublands and rock falls such as occur on the cliffs and shore platform of Mana Island.

Most planting effort to date on Mana Island has focused on initial plantings, and so there is little experience as yet of the success of interplantings of canopy and subcanopy species. An iterative approach is therefore required to check whether the recommended species mix presented here will thrive at each planting site, and to modify the planting strategy accordingly.

6. Restoration of non-forest communities

While restoring forest cover to Mana Island is one of the key steps in the restoration programme, restoring forest to most or all of the island would jeopardise the survival of several resident threatened animal and plant species, and reduce the habitat available for some of the threatened animal and plant species proposed for translocation. Cook Strait giant weta are widely regarded as preferring low-growing shrubs and forest margins to the forest interior (Meads 1990), and since removal of stock and mice from Mana Island, giant weta have become abundant throughout the rank pasture. Giant weta are not found in the interior of the forest remnant on Mana Island, and it is likely that their numbers will decline on the island as the forest cover returns. Both of the threatened lizard species resident on Mana Island (McGregor's skink and goldstripe gecko) occur in non-forest habitats on the island. It is expected that both will spread into forest habitats, but possibly at lower densities to where they currently occur in coastal shrublands and flax respectively.

Many animal species proposed in this Restoration Plan for translocation to Mana Island prefer or require non-forest habitats: grassland (takahe, snipe, spotted skink), wetlands (brown teal, banded rail, fernbird), flax (flax weevil), shrublands (rock wren) or herbfields (speargrass weevil).

Four of the five threatened plant species that survived on Mana Island occur in non-forest communities (Cook's scurvy grass, *Melicytus obovatus*, rengarenga, Jersey fern), and most of the threatened plants identified as suitable for planting on the island occur in coastal shrublands and herbfields rather than forest.

The retention and development of a variety of non-forested plant communities is an essential part of the Restoration Plan, with the aim of creating a mosaic of habitats all appropriate to the landforms on Mana Island and supporting a diverse range of plants and animals representative of the eastern Cook Strait Ecological District.

6.1 CURRENT SITUATION

Less than one percent of Mana Island can be regarded as forest, although about 30 ha has recently been planted with forest-forming species. Mana Island is predominantly covered in rank grassland comprised almost entirely of naturalised species. More natural communities are found on the cliffs and shoreline (61 ha), where shrublands, grasslands and herbfields comprise a mix of native and alien species. The few small wetlands on the island are either highly modified or artificial, having been created to enhance habitat for takahe, provide irrigation water and/or to provide a water supply for fire fighting. Timmins et al. (1987a) recorded 17 species of native shrubs that are more typical of shrubland than forest, 10 species of native lianes, 10 species of native grasses, 19 species of native sedges and rushes, and 53 species of native herbs. These 100+ species provide the basis for restoring non-forest plant communities, though plantings of threatened plants (Section 7) may dominate some communities at selected sites.

6.2 FORMER DISTRIBUTION OF NON-FOREST PLANT COMMUNITIES

There is no historical record of the distribution of non-forest plant communities on Mana Island before forest clearance occurred. Chester & Raine (1990) concluded that a small wetland dominated by sedges existed continuously near the houses "until very recent times when it was drained". Shrublands and native grasses and herbs were likely to have dominated the thin soils on exposed coastal cliffs and on the shore platform, similar to their current distribution.

6.3 PROJECTED EXTENT AND DISTRIBUTION OF NON-FOREST PLANT COMMUNITIES

Completion of the current revegetation programme will recreate about 76 ha of coastal broadleaved forest, leaving about 57 ha of grassland on the plateau and in the valleys (Figure 5.2). The balance (84 ha) will be a mixture of flax/sedge dominated wetlands, and structurally complex shrub/grass/herbfields on the cliffs and shore platform.

6.4 RESTORING WETLANDS

The major non-forest community requiring active restoration on Mana Island is Waikoko wetland just inland from the buildings. This low-lying area is partially flooded in winter, but dries out in summer. A system of farm drains criss-cross the former swamp. A detailed contour map prepared by the Ministry of Works in 1973 reveals that the ground surface around the MAF research buildings was built up considerably before the buildings were erected, but there is still space to recreate several hectares of wetland. Restoring Waikoko wetland is likely to involve a combination of disrupting the drain system, recontouring to create a system of ponds and channels, installing control structures to hold water levels higher in summer months, and revegetation with sedges, flax, herbs and shrubs (Waugh et al. 1996).

Species likely to benefit from restoration of Waikoko wetland on Mana Island include regionally threatened wetland herbs and sedges (e.g., *Ranunculus macropus*, *Epilobium pallidiflorum*, *Galium trilobum*, swamp nettle, *Carex diandra*, *Sparganium subglobosum*), fernbird and brown teal. There are few comparable wetlands in the eastern Cook Strait Ecological District to guide restoration; perhaps the best examples are Taupo swamp and adjoining wetlands, Plimmerton (Ogle 1978; Bagnall & Ogle 1981; Clelland 1984) and Okupe Lagoon, Kapiti Island (Cockayne 1907; Bell & Atkinson 1975).

The species mix of wetlands is very dependent on physical parameters such as substrate type, water chemistry (salinity, pH, fertility), water depth, and timing and periodicity of submersion and exposure. While some parameters can be manipulated easily during construction (e.g., water depth and methods to control water levels), it will not be possible to predict which species

are appropriate for planting in a restored wetland on Mana Island until the wetland has been formed and water chemistry parameters can be measured. Wetland plants that may be suitable for planting on Mana Island are listed in Table 6.1 (from a list provided by Colin Ogle, June 1992).

TABLE 6.1 WETLAND PLANT SPECIES THAT MAY BE SUITABLE FOR A RESTORED WETLAND ON MANA ISLAND (FROM COLIN OGLE IN LIT. JUNE 1992). NOTE THAT WATER CHEMISTRY WILL DICTATE THE MIX OF SPECIES THAT COULD BE PLANTED. FOR EXAMPLE, RAUPO AND *CAREX MAORICA* REQUIRE HIGH Ph AND HIGH FERTILITY, WHILE *DROSERA*, *UTRICULARIA* AND *LYCOPODIUM* REQUIRE LOW Ph AND LOW FERTILITY. SOME SPECIES GROW READILY IN MORE THAN ONE HABITAT, SO THE DIVISIONS BELOW ARE NOT CLEAR-CUT. ALL ARE SPECIES APPROPRIATE FOR THE ECOLOGICAL DISTRICT.

	BASIC SPECIES (TO GIVE COMMUNITY STRUCTURE)	THREATENED SPECIES
Brackish water	*Juncus maritimus*	*Leptinella dioica* ssp. *monoica*
	Leptocarpus similis	*Mimulus repens*
	Bolboschoenus caldwellii	*Schoenus nitens*
	Schoenoplectus pungens	*Carex litorosa*
	shore ribbonwood	*Baumea juncea*
Freshwater, constant water level	raupo	*Ranunculus macropus*
	harakeke	*Epilobium pallidiflorum*
	Carex secta	*Epilobium chionanthum*
	Coprosma tenuicaulis	*Drosera binata*
	Coprosma propinqua	*Polygonum salicifolium*
	Manuka (wetland ecotype)	*Hypolepis distans*
	Gahnia xanthocarpa	*Myriophyllum robustum*
	toetoe	*Carex diandra*
	Carex maorica	*Galium trilobum*
		Hydrocotyle pterocarpa
Freshwater, fluctuating water level	*Lilaeopsis novae-zelandiae/*	*Ranunculus limosella*
	L. ruthiana	*Glossostigma dimorphum*
	Limosella lineata	*Potamogeton pectinatus*
	Myriophyllum propinquum	*Mazus novae-zelandiae*
		Lepilaena bilocularis
		Elatine gratioloides
		Myriophyllum votschii
		Sebaea ovata
Wet edge	coastal tree daisy	*Leptinella tenella*
	Coprosma rigida	*Rorippa palustris*
		Rumex flexuosa
		Callitriche muelleri
		swamp nettle
		Gleichenia microphylla
		Gahnia rigida
		Carex dipsacea
		Gratiola sexdentata
		Mentha cunninghamii
		Carex sinclairii
		Deparia petersenii
		Ophioglossum coriaceum
		swamp maire
		Gunnera prorepens

Biotic factors such as interspecific competition, presence of herbivores and presence/absence of shade will also influence the final plant community structure.

Initial planning for the restoration of Waikoko wetland on Mana Island has been undertaken (Waugh et al. 1996), and advice has been sought from Ducks Unlimited.

Other small wetlands on Mana Island maintained for takahe should also provide habitat for fernbird, brown teal and some threatened plants. Further small wetlands should be developed on the plateau to improve habitat for takahe there as lower altitude territories become increasingly covered with woody vegetation. Plantings of toetoe and sedges around wetlands provide nesting cover for takahe, while corridors of flax linking wetlands along the valley floors will allow goldstripe geckos to colonise new areas of plantings.

6.5 RESTORING SHRUBLAND AND HERBFIELD COMMUNITIES

Sufficient elements of the coastal cliff and shoreline shrub and herbfield communities remain to allow natural succession to proceed without planting. One exception to this is an area to the east of Hole-in-the-Rock on the south coast where an historical map (Wilkinson 1873) shows a karaka grove that should be recreated. Ongoing weed control will be necessary, particularly of boxthorn. In areas that are heavily infested with boxthorn (e.g., the northern cliffs) some planting of *Coprosma propinqua*, tauhinu and prostrate taupata may be necessary following boxthorn control to prevent other weed species dominating shrub communities. Small scale plantings of speargrass will be made to prepare sites for liberations of Wellington speargrass weevils. Speargrass is already present at likely release sites, but the current density of plants does not match areas of preferred habitat on the Wellington south coast (Hunt 1996).

Most of the threatened plant species planned for establishment on Mana Island are coastal species. Specific habitat requirements will determine localities where plantings occur, but there are unlikely to be conflicts between small scale plantings of threatened plants and existing conservation values. Where conflicts over preferred planting sites do occur, establishment of further colonies of locally sourced Cook's scurvy grass and *Melicytus obovatus* should have priority over non-local species.

6.6 MAINTAINING GRASSLANDS

Attempts to replace alien grass species with native grasses are considered futile, and so grasslands on the plateau and in the valleys will be dominated by alien grasses until eventually succeeded by bracken and shrubs. Natural succession outside areas to be planted is likely to be slow, but eventually (100 years plus) almost all of the island interior will be forested. Natural succession will not be hindered apart from on archaeological sites with surface and subsurface features that could be obscured or damaged by woody vegetation. There will be an inevitable decline in the area of grassland on the

island, but the only threatened species likely to be adversely affected by this is the takahe. Mana Island is too small to maintain a takahe population other than by intensive management; this should occur only if other conservation values are not unduly compromised. Given the long time frame involved (many decades), it is anticipated that there will be other large, predator-free sites available for self-sustaining takahe populations long before Mana Island grasslands have diminished to the extent that the island no longer has a role in takahe recovery.

7. Threatened plants

Nearly 160 species of indigenous terrestrial plants in the Wellington region are considered nationally or regionally threatened (Empson & Sawyer 1995; Department of Conservation 1996); of these, about 39% typically occur in coastal habitats, 47% occur in lowland areas, and 43% are classified as wetland species. The threatened plant database maintained by Wellington Conservancy lists 27 critical, endangered and vulnerable plant species from the eastern Cook Strait Ecological District, with a further 21 species from Wellington Ecological District (Table 7.1). Atkinson (1992) has argued that threatened plants from both eastern Cook Strait and Wellington Ecological Districts should be considered for introduction to Mana Island. As there are many other opportunities for threatened plant conservation, there is no need to compromise ecological restoration goals on Mana Island by introducing threatened plant species that were never known to occur in either eastern Cook Strait or Wellington Ecological Districts.

Habitat disturbance and browsing or seed predation by introduced mammals are major causes of local plant extinctions, and sites free of introduced mammals are likely to gain increasing importance as refugia for threatened plants. However, as plants do not need the large areas of land required by many threatened animal species, it is often possible to manage the threats posed by browsers in situ by techniques such as fencing, banding, shooting, trapping and poisoning. It is more difficult to improve the conservation status of threatened plants when their habitat has been destroyed and is no longer available for restoration. Over 90% of the wetlands in Wellington have been totally destroyed (Fuller 1993) and coastal habitats and flood-plain forests have been extensively modified (Ogle 1989b; Gabites 1993). Mana Island has enormous potential for establishing populations of regionally threatened coastal, forest and wetland plants in habitats free of browsing mammals and development threats.

Compared to animals, plants require only a very small area for establishment, and so there should be little conflict between threatened plant management and the main revegetation programme on Mana Island. The small number of plants required (perhaps less than a hundred per species for initial establishment) make propagation and introduction of threatened plants to Mana Island particularly suitable for community participation. Guidance on seed sources and propagation techniques can be provided by the Wellington Conservancy Plant Conservation Strategy (Empson & Sawyer 1995) and Department of Conservation staff. However, if threatened plants are being propagated by private individuals particular care must be taken against introduction of inappropriate organisms (including invertebrate pests, pathogens and weeds).

The main criterion for assessing the success of threatened plant introductions to Mana Island must be the establishment of self-sustaining populations, so that any further human intervention needed is minimal.

TABLE 7.1 CRITICAL, ENDANGERED AND VULNERABLE PLANT SPECIES OF THE EASTERN COOK STRAIT ECOLOGICAL DISTRICT AND WELLINGTON ECOLOGICAL DISTRICT LISTED IN THE THREATENED PLANT DATABASE MAINTAINED BY WELLINGTON CONSERVANCY. SPECIES MARKED WITH AN ASTERISK ARE ALREADY PRESENT ON MANA ISLAND.

SPECIES	NATIONAL STATUS	CONSERVANCY STATUS	ECOLOGICAL DISTRICT
Adiantum hispidulum (rosy maidenhair)		Vulnerable	Wellington
Anogramma leptophylla (Jersey fern)*	Endangered	Susceptible	Both
Arthropodium cirratum (rengarenga)*		Vulnerable	Both
Atriplex billardierei	Endangered	Extinct	Cook Strait
Atriplex buchananii		Endangered	Cook Strait
Atriplex cinerea (grey salt bush)	Endangered	Extinct	Wellington
Botrychium australe (parsley fern)		Vulnerable	Cook Strait
Brachyglottis kirkii s.s. (Kirk's tree daisy)		Endangered	Cook Strait
Carex diandra		Vulnerable	Wellington
Coprosma acerosa (sand coprosma)		Endangered	Wellington
Coprosma virescens		Endangered	Cook Strait
Crassula peduncularis	Vulnerable	?Extinct	Cook Strait
Crassula ruamahunga		Endangered	Wellington
Dactylanthus taylorii (wood rose)	Endangered	?Extinct	Wellington
Deschampsia caespitosa var. *macrantha*	Vulnerable	Extinct	Cook Strait
Desmochoenus spiralis (pingao)		Vulnerable	Cook Strait
Discaria toumatou (matagouri)		Vulnerable	Cook Strait
Doodia squarrosa		Critical	Both
Entelea arborescens (whau)		Vulnerable	Cook Strait
Euphorbia glauca (shore spurge)		Vulnerable	Cook Strait
Gahnia rigida		Critical	Wellington
Ileostylus micranthus (pirita)		Endangered	Cook Strait
Juncus prismatocarpus	Vulnerable	Indeterminate	Wellington
Lepidium flexicaule	Endangered	Extinct	Wellington
Lepidium oleraceum (Cook's survy grass)*	Endangered	Endangered	Cook Strait

TABLE 7.1 cont. CRITICAL, ENDANGERED AND VULNERABLE PLANT SPECIES OF THE EASTERN COOK STRAIT ECOLOGICAL DISTRICT AND WELLINGTON ECOLOGICAL DISTRICT LISTED IN THE THREATENED PLANT DATABASE MAINTAINED BY WELLINGTON CONSERVANCY. SPECIES MARKED WITH AN ASTERISK ARE ALREADY PRESENT ON MANA ISLAND.

SPECIES	NATIONAL STATUS	CONSERVANCY STATUS	ECOLOGICAL DISTRICT
Lepidium tenuicaule	Vulnerable	Indeterminate	Cook Strait
Leptinella dioica ssp. *monoica*	Vulnerable	Endangered	Cook Strait
Leptinella nana	Endangered	Vulnerable	Wellington
Leptinella pusilla		Endangered	Wellington
Libertia peregrinans		Endangered	Wellington
Lycopodium laterale		Endangered	Wellington
Mazus novaezeelandiae	Vulnerable	Vulnerable	Cook Strait
Melicytus obovatus ssp. "coast"*		Susceptible	Cook Strait
Muehlenbeckia astonii (shrubby tororaro)	Endangered	Endangered	Cook Strait
Peraxilla tetrapetala (red-flowered mistletoe)	Vulnerable	Endangered	Wellington
Pimelea aridula var. "Cook Strait"		Critical	Cook Strait
Pittosporum obcordatum (heart-leaved kohuhu)		Endangered	Wellington
Pleurosorus rutifolius (blanket fern)		Vulnerable	Cook Strait
Pseudopanax ferox (fierce lancewood)		Vulnerable	Wellington
Pterostylis micromega	Critical	Endangered	Wellington
Pterostylis puberula	Critical	Critical	Wellington
Rumex flexuosus		Endangered	Cook Strait
Scandia geniculata		Vulnerable	Cook Strait
Senecio sterquilinus		Endangered	Wellington
Streblus banksii (large-leaved milk tree)*		Endangered	Cook Strait
Suaeda novae-zelandiae		Critical	Cook Strait
Teucridium parvifolium	Vulnerable	Endangered	Wellington
Urtica linearifolia (swamp nettle)	Vulnerable	Susceptible	Wellington

7.1 CURRENT SITUATION

Six threatened species of plants are recognised as occurring naturally on Mana Island: Cook's scurvy grass (nationally endangered), Jersey fern (nationally endangered), large-leaved milk tree (regionally endangered), rengarenga (regionally vulnerable), *Melicytus obovatus* (regionally vulnerable) and *Hypolepis dicksonioides* (indeterminate). Cook's scurvy grass was reduced to fewer than ten plants on a single rock stack, although two plants have now established naturally on the shoreline at the base of the stack. Jersey fern is probably extinct on Mana Island following removal of stock, as rank grass is now covering the one site where it was known to occur (Colin Ogle pers. comm.). There are only four adult large-leaved milk trees on Mana Island (two male and two female). Two trees are isolated and are not producing viable seed, but the two trees in Forest Valley are reproducing, with abundant seedlings and a few saplings present. Rengarenga is abundant at a few sites around the coast of Mana, and in the lower sections of Tauhinu Valley. *M. obovatus* is represented by fewer than 30 shrubs on the cliffs. *H. dicksonioides* was first discovered on the island in 1994 and is spreading rapidly along the margins of the stream flowing out of Aston's Valley.

It is likely that many other threatened plant species were originally present on Mana Island, but were eliminated by over 150 years of grazing, seed and seedling destruction by mice, and periodic fires.

7.2 PROGRESS WITH THREATENED PLANT MANAGEMENT ON MANA ISLAND

Initial attempts at establishing some threatened plant species on Mana Island were made by Colin Ogle in November 1987: four plants of rohutu, three plants of *Pimelea aridula* and about 50 plants of the semi-prostrate Kapiti Island form of kowhai were planted. The rohutu were grown from seed from Pipinui Point, south of Titahi Bay, and were planted on the stream bank near the mouth of Forest Valley; two were alive in July 1988, but none was present in May 1994. The *Pimelea* were cutting-grown from Pipinui Point and were planted on a steep rock face at the lower end of Tauhinu Valley; two were alive in July 1988, but none was present in May 1994. The kowhai were planted on the hill slope above Hole-in-the-Rock on the south coast; at least ten were alive and flowering in May 1994, when ripe seed from the previous year was placed in suitable sites nearby.

Five potted plants of Cook's scurvy grass were planted on a rock stack near the island's only natural population in November 1987; they failed to survive. Plants have been maintained in the manager's garden on Mana Island since at least 1987; cuttings from these were grown on and 36 were planted out in 1994, mainly on the clifftop near the main sooty shearwater colony. Most of these plants were thriving and flowering in December 1994, but there is no evidence of new seedlings establishing to date. Seed collected from the wild plants on Hole-in-the-Rock in January 1995 produced over 900 seedlings, of which about 600 were planted out around Mana Island in September 1995

(Jason Christensen pers. comm.). Four hundred were planted in three mass plantings along the south coast to compare three different treatments: (a) direct planting among grass, (b) planting among grass with fertiliser added, and (c) grass physically removed, fertiliser added. The remaining plants were planted near the main sooty shearwater colony, on the clifftop below the trig (70-80 plants; Cook's scurvy grass was present there in the 1970s), and on McGregor's Rock and two other stacks to the north of there.

About 150 locally sourced rengarenga were planted out on Mana Island in 1995, mainly around ponds and wetlands on the plateau. Abundant *Melicytus obovatus* seed has been collected for the same purpose, and about 40 seedlings were planted in 1996. A large quantity of seed was collected from the two adult large-leaved milk trees in Forest Valley in 1996, and about 100 wild seedlings were brought into cultivation in 1995 for growing on and planting out.

7.3 ESTABLISHING POPULATIONS OF THREATENED PLANTS ON MANA ISLAND

The following lists of potential threatened plant introductions to Mana Island (Tables 7.2, 7.3 & 7.4) are an amalgam of suggestions by Timmins et al. 1987b; Ogle 1989b and in lit. July 1992; Atkinson 1992; and Peter de Lange in lit. July 1992. All proposed introductions are consistent with recommendations in the Wellington Conservancy Conservation Management Strategy (Department of Conservation 1996) and the Wellington Conservancy Plant Conservation Strategy (Empson & Sawyer 1995).

The main criteria used in assessing whether a threatened plant species was appropriate for introduction to Mana Island were:

(a) taxon recognised as a regionally or nationally threatened by Empson & Sawyer (1995)

(b) evidence of past or present occurrence within either or both of eastern Cook Strait Ecological District and Wellington Ecological District

(c) suitable habitat likely to be present on Mana Island

None of the species proposed for introduction was considered likely to compromise other conservation values on Mana Island through, e.g., hybridisation, parasitism, or competition. Inclusion in the lists does not in itself mean that a given plant species can be successfully established on Mana Island. Each introduction must be based on sound understanding of the ecological requirements of that species, and may require some site preparation and follow-up management until a self-sustaining population is established.

TABLE 7.2 THREATENED FOREST AND FOREST-EDGE PLANTS SUITABLE FOR INTRODUCTION TO MANA ISLAND, WITH POSSIBLE SOURCE LOCATIONS. SPECIES MARKED WITH AN ASTERISK ARE CONSIDERED HIGH PRIORITIES.

SPECIES	POSSIBLE SOURCE
Trees, shrubs and lianes	
Dodonaea viscosa (akeake)*	Paekakariki
Entelea arborescens (whau)	Paekakariki
Ileostylus micranthus (pirita)*	Benge Park
Korthalsella lindsayi	Kapiti Lookout (Paraparaumu)
Korthalsella salicornioides	Kapiti Island
Lophomyrtus obcordata (rohutu)*	Pipinui Point, Pukerua Bay
Rhabdothamnus solandri (waiuatua)*	Smith's Creek (Makara - southern limit)
Sophora microphylla (kowhai)	Papakowhai
Streblus banksii (large-leaved milk tree)*	Mana Island
Tupeia antarctica (tupia)*	Kapiti Island
Herbs	
*Acaena juvenca**	Pukerua Bay
Ferns	
Anogramma leptophylla (Jersey fern)*	Carter Scenic Reserve
Blechnum "Green Bay"	Pukerua Bay
Doodia media	Pukerua Bay
Doodia squarrosa	Porirua East
Hymenophyllum minimum	South Wellington
Pellaea calidirupium	Pukerua Bay
Pteris saxatilis	?

TABLE 7.3 THREATENED PLANT SPECIES SUITABLE FOR INTRODUCTION TO CLIFF AND SHORELINE HABITATS ON MANA ISLAND, WITH POSSIBLE SOURCE LOCATIONS. SPECIES MARKED WITH AN ASTERISK ARE CONSIDERED HIGH PRIORITIES.

SPECIES	POSSIBLE SOURCE
Trees, shrubs and lianes	
Clematis afoliata (leafless clematis)*	Spooky Gully, Waipapa Stream
*Convolvulus verecundus**	?Cape Palliser
Coprosma acerosa (sand coprosma)*	Paekakariki, Otari (ex Red Rocks)
Coriaria sarmentosa (coastal tutu)	Pukerua Bay
Discaria toumatou (matagouri)*	Kapiti Island
Fuchsia perscandens	Spooky Creek, Sinclair Head
Hebe elliptica var. *crassifolia**	Titahi Bay
*Melicytus obovatus**	Mana Island
Muehlenbeckia astonii (shrubby tororaro)*	Sinclair Head
*Muehlenbeckia ephedroides**	Fitzroy Bay
*Pimelea aridula**	Pipinui Point
Rubus squarrosus (leafless lawyer)	Sinclair Head, Waipapa Stream
*Scandia geniculata**	Kapiti Island
Sophora microphylla (kowhai – prostrate form)*	Kapiti Island (western cliffs)
*Tetragonia tetragonioides**	Petone Beach
Herbs	
Acaena pallida (giant bidibidi)*	Porirua Harbour, mouth of Long Gully
*Atriplex buchananii**	Miramar
Atriplex cinerea (grey salt bush)*	Waimea Estuary
Crassula peduncularis	Turakirae Head
Daucus glochidiatus (New Zealand carrot)	Pipinui Point
Euphorbia glauca (shore spurge)*	Stack off Kapiti Island
Lepidium oleraceum (Cook's scurvy grass)*	Mana Island
*Lepidium tenuicaule**	?Kapiti Island
*Leptinella nana**	Whitireia Park
*Leptinella pusilla**	Baring Head
Mentha cunninghamii (New Zealand mint)	Mount Misery
Rumex flexuosus	Te Ikaamaru Bay
Rumex neglectus (shore dock)	Cape Terawhiti
Grasses and sedges	
Carex spinirostris	
*Rytidosperma petrosum**	Kapiti Island (western cliffs)
Zoysia minima	Titahi Bay
Ferns	
Asplenium obtusatum	Titahi Bay
Pleurosorus rutifolius	Palliser Bay

TABLE 7.4 THREATENED PLANT SPECIES THAT MAY BE SUITABLE FOR ESTABLISHING IN WETLAND HABITATS ON MANA ISLAND. SEE ALSO TABLE 6.1.

SPECIES	POSSIBLE SOURCE
Brackish wetland	
Baumea juncea	Taupo Swamp
Carex litorosa	Waikanae River
Leptinella dioica ssp. *monoica*	Makara Estuary
Ruppia polycarpa	Lake Kohangatera
Schoenus nitens	Pauatahanui
Freshwater wetland	
Carex diandra	Taupo Swamp
Centipeda minima	Kapiti Island
Epilobium pallidiflorum	Taupo Swamp, Kapiti Island
Gahnia rigida	Mangaroa
Galium trilobum	Taupo Swamp, Kapiti Island
Gunnera prorepens	Mount Kaukau, Otaihanga
Lepilaena bilocularis	Lake Kohangapiripiri
Leptinella dispersa	Whitireia Park
Leptinella tenella	Kakaho Stream (Pukerua Bay)
Mazus novaezeelandiae	?
Myriophyllum robustum	?
Myriophyllum votschii	Lake Wairarapa
Potamogeton pectinatus	Lower Hutt
Pratia perpusilla	Kapiti Island
Ranunculus macropus	Taupo Swamp
Rumex flexuosus	Kapiti Island
Sebaea ovata	?
Urtica linearifolia (swamp nettle)	Taupo Swamp

8. Birds

Designing a future avifaunal community on Mana Island required information on:

- what indigenous species are currently present or are likely to colonise naturally (not including species already introduced for conservation reasons)
- what species are likely to have been present historically
- what nationally threatened species require habitats free of introduced mammals to ensure their continued survival, and whether there are other more appropriate sites for their introduction
- potential conflicts between proposed introductions and resident species and/or other proposed introductions (including plants, invertebrates and reptiles), e.g., predation, competition, disease risk, hybridization.

The list of landbirds recorded from the entire Cook Strait Ecological District is not an appropriate model for guiding restoration of Mana Island's avifauna, as at least 18 landbird species were found on only one side of Cook Strait, and a further 14 pairs of subspecies were separated by Cook Strait (data from Turbott 1990). For example, both members of the following species or subspecies pairs could be considered for introduction to Mana on the basis of historic records from Cook Strait Ecological District: North Island kaka/ South Island kaka, whitehead/yellowhead, and N.I. robin/S.I. robin. Ogle (1989) argued that faunistic differences either side of Cook Strait warrant an Ecological Region or District boundary dividing Cook Strait.

As a starting point, landbirds recorded from the southern North Island (south of Manawatu gorge) were considered as potential candidates for restoring the Mana Island avifauna. Some species were excluded if their known habitat or home range requirements indicated that it was unlikely that Mana Island would ever have supported a resident population (brown kiwi, blue duck, takahe, kakapo, North Island rifleman). However, Mana Island's predator-free status, accessibility and history of extreme modification make it one of the most suitable islands around the New Zealand coast for intensive management of critically endangered bird species as part of a national metapopulation (discussed below for brown kiwi, takahe and kakapo). Any such intensive management programmes to maintain species artificially on Mana must not compromise longer term conservation objectives on the island.

Landbird species were identified as being candidates for introduction if they met one of the following sets of criteria:

(a) species recorded in middens on Mana Island that were likely to have had a resident population, and that are unlikely to have significant impacts on threatened plant or animal species that survived on Mana (9 species).

(b) species known to have been present in the southern North Island (or their nearest living relative), that are unlikely to survive in the presence of mammalian predators, are likely to be able to establish a self-sustaining

population on the island, and are not expected to compromise other conservation values on the island (5 species).

(c) species that may require translocation to a predator-free island in the event of a catastrophe threatening the only remaining population, and that would not conflict with other conservation values during the short time present on Mana (i.e., until able to be restored to the original habitat) (1 species).

(d) species known to have been present in the southern North Island (or a close relative), that are unlikely to survive longterm on Mana without human intervention, but for which small predator-free islands have a role in a national recovery programme, and which would not unduly compromise other conservation values or objectives on the island (3 species).

8.1 CURRENT SITUATION

The following indigenous bird species have been recorded from Mana Island recently. The list does not include species deliberately introduced to the island, species known only as beach wrecks, or seabirds seen more than 100 metres offshore. Species known to breed are in bold lettering.

Sooty shearwater	about 100 pairs
Fluttering shearwater	common offshore
Common diving petrel	two caught ashore
Blue penguin	100s of pairs
Fiordland crested penguin	two records (K. Oates pers.comm.)
Australasian gannet	common offshore, 2 roosting Dec 1997
Black shag	always present around coast
Pied shag	vagrant
Little shag	large roost on dam, always present around coast
Spotted shag	vagrant
White-faced heron	usually present
Reef heron	1–4 birds usually present, 1 nest found
Royal spoonbill	vagrant
Paradise shelduck	about 10 pairs
Grey duck	occasionally with mallards on dams
Australasian harrier	always present, may breed
New Zealand falcon	one record
Pukeko	abundant breeder
Variable oystercatcher	10–15 pairs breed
Spur-winged plover	frequent visitor
Pied stilt	vagrant
Southern black-backed gull	c. 2500 pairs
Red-billed gull	about 150 pairs
Black-fronted tern	regular winter visitor in low numbers
Caspian tern	1–2 often feed along eastern shore
White-fronted tern	about 20 pairs
New Zealand pigeon	vagrant
Long-tailed cuckoo	one record (G. Timlin pers. comm.)
Shining cuckoo	occasional visitor

Morepork	occasional reports
New Zealand kingfisher	usually present, may breed
Welcome swallow	breeds around buildings and in sea cave
New Zealand pipit	often present, may breed
Grey warbler	present in Bush Valley and plantings
North Island fantail	abundant around coast, scrub and plantings
Silvereye	abundant in scrub and plantings
Tui	occasional reports (P. Todd pers.comm.)

8.2 WHAT WAS MANA ISLAND'S ORIGINAL AVIFAUNA?

There is no historical record of what bird species were present on Mana before the island was cleared. If we accept that Mana Island's original vegetation was predominantly mixed broadleaved forest (Timmins et al. 1987a), then it is likely that most forest birds of the southern North Island would have been present. This was partially confirmed following archaeological excavations on Mana Island in January 1990 (see Horwood 1991) that produced bones of at least 35 bird species (Table 8.1). This list is an invaluable resource to guide restoration of Mana Island's avifauna. However, the list must be used with caution, as it is likely that some species were captured away from the island; this is obviously the case for many of the seabirds, and may apply to some of the landbirds. For example, it is unlikely that moa would have survived on an island of 217 ha. It is hoped that further analysis of the bones collected (minimum number of individuals present; presence of different skeletal elements in relation to known preserving techniques) will shed light on which species were likely to have been caught locally. This is particularly important for weka, which is the only extant indigenous landbird listed that is not currently being considered for reintroduction (see below).

8.3 NATIONALLY THREATENED LANDBIRD SPECIES THAT MAY REQUIRE ISLANDS FREE OF MAMMALIAN PREDATORS

Two different groups of birds must be considered—those that evolved in isolation on the islands to which they are confined (Table 8.2), and mainland species that were formerly more widespread (Table 8.3). Where possible, forms that evolved in isolation should be conserved entirely within their natural range. Fortunately most of the taxa involved occur on more than one island within their respective island groups, and are unlikely to become extinct following a single predator colonization. Exceptions are landbirds endemic to the Poor Knights (1 subsp.), Codfish I. (1 subsp.), the Mangere Islands (1 subsp.), the Snares Islands (3 subsp.) and islands off Campbell I (1 species and 1 subspecies). Suggested recovery options for these taxa are given in Table 8.2. Two of these eight taxa can be used to replace extinct taxa (Snares Island snipe/Stewart Island snipe, Snares Island fernbird/Chatham Island fernbird), as can three further taxa confined to single island groups (Three Kings bellbird/Chatham Island bellbird, Chatham Island snipe/Little Barrier snipe, Reischek's parakeet/Macquarie Island parakeet).

TABLE 8.1 BIRD SPECIES IDENTIFIED FROM MIDDENS ON MANA ISLAND (PHIL MILLENER IN LIT.). PRESENCE IN MIDDENS DOES NOT NECESSARILY MEAN THAT A BREEDING POPULATION WAS PRESENT ON MANA ISLAND. SPECIES IN BOLD ARE THOSE CONSIDERED APPROPRIATE FOR REINTRODUCTION TO MANA ISLAND AS DISCUSSED IN TEXT.

	BREEDING LOCALITY NEAREST TO MANA ISLAND
SEABIRDS	
Royal/wandering albatross[1]	Otago Peninsula (royal albatross)
Shy mollymawk	Snares Islands
Fluttering/Hutton's **shearwater**[1]	Brothers Is (Cook Strait E.D. – fluttering shearwater)
Northern/southern giant petrel[1]	Chatham Islands (northern giant petrel)
?**Fairy prion**[2]	Brothers Islands (Cook Strait Ecological District)
?Fulmar prion[2]	Snares Islands
?Salvin's prion[2]	Crozet Islands, Indian Ocean
?Broad-billed prion[2]	Fiordland islands
?Cook's petrel[2]	Little Barrier Island
Common diving petrel	Brothers Islands (Cook Strait Ecological District)
Blue penguin	Mana Island
?Erect-crested penguin[2]	Bounty Islands
Black shag	Kapiti Island (Cook Strait Ecological District)
Pied shag	Makara (Cook Strait Ecological District)
Southern black-backed gull	Mana Island
LANDBIRDS, WATERBIRDS AND WADERS	
Stout-legged moa	Extinct
Coastal moa	Extinct
Paradise shelduck	Mana Island
Grey duck	Cook Strait Ecological District
Australasian harrier	?Mana Island
New Zealand quail	Extinct
Domestic fowl	Introduced poultry
Banded rail	Marlborough Sounds (Sounds-Wellington Ecological Region)
Weka	Gisborne
?Variable oystercatcher[2]	Mana Island
?Lesser knot/New Zealand dotterel[1]	Kawhia (New Zealand dotterel)
New Zealand pigeon	Cook Strait E.D. (especially Kapiti Island)
Kaka	Kapiti Island (Cook Strait Ecological District)
Red-crowned/**yellow-crowned parakeet**[1]	Chetwode Is (Cook Strait E.D. – yellow-crowned parakeet)
New Zealand pipit	?Mana Island
Fernbird	Manawatu Estuary
Whitehead	Kapiti Island (Cook Strait Ecological District)
New Zealand robin	Kapiti Island (Cook Strait Ecological District)
Bellbird	Kapiti Island (Cook Strait Ecological District)
Tui	Cook Strait Ecological District (especially Kapiti Island)

[1]*Species paired in this way cannot be reliably differentiated on the material available. The first species listed is the most likely option.*

[2]*Species listed in this way are difficult to distinguish from closely related species on the material available. The species listed are those that provide the "best fit" for the specimens compared with a wide range in the Museum of New Zealand collections.*

TABLE 8.2 NEW ZEALAND LANDBIRDS, WADERS AND WATERFOWL ENDEMIC TO SINGLE ISLANDS OR ISLAND GROUPS, WITH SUGGESTED OPTIONS FOR CONSERVATION MANAGEMENT. NOTE THAT THE SHORE PLOVER IS INCLUDED IN TABLE 8.3, AS IT FORMERLY OCCURRED ON THE MAINLAND, THOUGH NOW CONFINED TO THE CHATHAM ISLANDS. SPECIES IN BOLD ARE DISCUSSED FURTHER IN TEXT.

SPECIES	RESTORATION OPTIONS AND COMMENTS
Kermadec parakeet	Conserve solely within Kermadecs. High risk of hybridization elsewhere.
Three Kings bellbird	Conserve within Three Kings. Introduce to Mangere Island to replace extinct Chatham Island bellbird. High risk of hybridization elsewhere.
Poor Knights bellbird	Conserve solely within Poor Knights. High risk of hybridization elsewhere.
Stewart Island fernbird	Conserve solely on Stewart Island and adjacent islands.
Stewart Island robin	Conserve solely on Stewart Island and adjacent islands.
Codfish Island fernbird	Conserve on Codfish Island, introduce to Solander Island if weka eradicated.
Chatham Island oystercatcher	Conserve solely within Chathams. Risk of hybridization on offshore islands.
Chatham Island snipe	**Snipe formerly occurred throughout New Zealand. Conserve within Chathams and introduce to predator-free offshore islands around North Island.**
Chatham Island pigeon	Conserve solely within Chathams. Risk of hybridization on offshore islands.
Chatham Island red-crowned parakeet	Conserve solely within Chathams. High risk of hybridization elsewhere.
Forbe's parakeet	Conserve solely within Chathams. High risk of hybridization elsewhere.
Chatham Island fantail	Conserve solely within Chathams. High risk of hybridization on offshore islands.
Chatham Island tomtit	Conserve solely within Chathams. Some risk of hybridization elsewhere.
Black robin	Conserve solely within Chathams.
Chatham Island warbler	Conserve solely within Chathams.
Chatham Island pipit	Conserve solely within Chathams. High risk of hybridization elsewhere.
Chatham Island tui	Conserve solely within Chathams. High risk of hybridization on offshore islands.
Snares Island snipe	Conserve within Snares. Introduce to predator-free islands off Stewart Island, especially those that formerly had extinct Stewart Island snipe.
Snares Island fernbird	Conserve within Snares. Introduce to Mangere Island (?and other islands) in Chathams group to replace extinct Chatham Island fernbird.
Snares Island tomtit	**Conserve within Snares. Introduce to predator-free offshore islands only if Snares population under immediate threat of extinction. Risk of hybridization elsewhere, especially if resident tomtit population nearby.**
Antipodes Island snipe	Conserve solely within Antipodes Is.
Antipodes I. parakeet	Conserve solely within Antipodes Is.
Reischek's parakeet	Conserve within Antipodes Is. Could be introduced to Macquarie Island to replace extinct subspecies if cats and rats eradicated. High risk of hybridization elsewhere.
Antipodes Island pipit	Conserve solely within Antipodes Is. High risk of hybridization elsewhere.
Auckland Island teal	Conserve solely within Auckland Is. Risk of hybridization on most offshore islands, including Mana I.
Auckland Island rail	Conserve solely within Auckland Is.
Auckland Island banded dotterel	Conserve solely within Auckland Is. High risk of hybridization on offshore islands and Chathams Is.

TABLE 8.2 cont.

SPECIES	RESTORATION OPTIONS AND COMMENTS
Auckland Island snipe	Conserve solely within Auckland Is.
Auckland Island tomtit	Conserve solely within Auckland Is. Risk of hybridization elsewhere.
Campbell Island teal	Conserve within Campbell Is. Introduce to an island in Foveaux Strait until Campbell Island cleared of cats and rats as per Recovery Plan. Risk of hybridization on most offshore islands, including Mana.
Campbell Island snipe	Conserve solely within Campbell Is.

TABLE 8.3 THREATENED BIRDS OF THE NORTH AND SOUTH ISLANDS FOR WHICH TRANSFER TO (FURTHER) PREDATOR-FREE ISLANDS COULD ENHANCE THEIR CHANCES OF SURVIVAL. TAXA LISTED ARE THOSE IN CATEGORIES A, B, C AND X OF MOLLOY & DAVIS (1994). NOTE THAT SOME SPECIES ARE NO LONGER PRESENT ON THE MAINLAND. TAXA IN BOLD SHOULD BE INTRODUCED TO MANA; TAXA IN ITALICS COULD BE MANAGED ON THE ISLAND, BUT ARE UNLIKELY TO FORM SELF-SUSTAINING POPULATIONS.

	SUITABILITY OF MANA ISLAND
Little spotted kiwi	**Could hold 50–100 pairs. Two birds present.**
Other kiwi spp	?Too small for self-sustaining population. May be suitable as "nursery" during intensive management of mainland populations in short/medium term.
Brown teal	**Habitat available, but would improve following restoration of wetland.**
Weka (4 subspecies)	Introduction could endanger resident threatened species.
Takahe	Insufficient habitat for self-sustaining population. Suitable for intensive management.
Shore plover	**Habitat should be suitable, but requires gull numbers to be reduced.**
New Zealand pigeon	**Habitat may be suitable in 5-10 years.**
Kakapo	Too small for self-sustaining population. Suitable for intensive management.
Kaka (2 subspecies)	**Reintroduce North Island kaka when forest cover established.**
Yellow-crowned parakeet	**Suitable habitat present.**
Orange-fronted parakeet	[May be colour morph of yellow-crowned parakeet]. Currently known only from beech forests. Southern islands more appropriate.
Rock wren	**Habitat may be suitable now.**
Yellowhead	Habitat not suitable. Southern islands more appropriate.
Stitchbird	Suitable habitat unlikely to be present for many years (review following trial introductions to other small islands).
Kokako (2 subspecies)	Suitable habitat unlikely to be present for many years (review following trial introductions to other small islands).
Saddleback (2 subspecies)	Introduction could threaten resident and introduced threatened invertebrates. Sufficient other predator-free islands available for both subspecies.

There are three taxa for which ex situ management on islands not previously inhabited by closely related extinct taxa may be necessary (without risking hybridization with related taxa): Codfish Island fernbird, Snares Island tomtit and Campbell Island teal. None of these taxa is recommended for release on Mana Island, although the tomtit niche on Mana could be left vacant so that there is a site available to move Snares Island tomtit to in an emergency. Recovery options for the two other taxa are given in Table 8.2.

The accessibility of Mana Island and its extensively modifed habitats make it more suitable for intensive species management than most rodent-free islands (see Table 2.1). Most other rodent-free islands have largely intact forest cover, and so are not suitable for species that require grassland or wetland habitat (e.g., takahe, brown teal and fernbird). Islands with highly modified ecosystems (e.g., most of Mana, Maud and Tiritiri Matangi Islands) have more potential for experimental manipulation of habitats than do islands that have retained largely intact ecosystems, and so these few modified, permanently staffed islands are more likely to be used for intensive management of small populations of species such as takahe and kakapo. However, experimental habitat manipulation and intensive species management must not jeopardise the long-term survival of resident threatened animal and plant species.

8.4 A COMPARISON WITH KAPITI ISLAND

Mana Island is situated only 22 km south of Kapiti Island, one of New Zealand's three most important island sanctuaries for forest bird communities. Kapiti Island is nine times the size of Mana Island and has extensive forest cover with breeding populations of 21 species of native forest birds (cf. currently four on Mana Island). However, Kapiti Island may still have two species of rats (eradication attempted in 1996) and has an abundant weka population. The presence of weka makes Kapiti Island less suitable than Mana Island for restoring populations of small burrowing seabirds and some other species of ground-nesting birds (e.g., snipe, shore plover and banded rail). While many species of forest birds will be restored to Mana Island, Mana Island will eventually complement rather than replicate the forest bird community on Kapiti Island. Differences between the bird communities likely to be restored to the two islands are emphasised in Table 8.4

TABLE 8.4 BIRD SPECIES LIKELY TO BE CONFINED TO ONE OF EITHER MANA OR KAPITI ISLANDS FOLLOWING ECOLOGICAL RESTORATION OF BOTH ISLANDS. ABOUT THIRTY OTHER NATIVE BIRD SPECIES ARE LIKELY TO OCCUR ON BOTH ISLANDS.

MANA ISLAND ONLY	KAPITI ISLAND ONLY
Fluttering shearwater	Tokoeka
Common diving petrel	Weka
Fairy prion	Red-crowned parakeet
Australasian gannet	North Island rifleman
Banded rail	North Island tomtit
Shore plover	Stitchbird
Chatham Island snipe	North Island kokako
Yellow-crowned parakeet	North Island saddleback
Rock wren	

8.5 RECREATING AN AVIFAUNAL COMMUNITY FOR MANA ISLAND

The following annotated list includes 20 species that currently breed (or occur regularly) on Mana, 17 species that should be introduced or attracted to the island, six species that may colonise the island naturally, three species that could only be maintained on the island by intensive management (considered necessary as part of national recovery programmes), one species that should be introduced only as a "last ditch" conservation measure, and five species that are not considered appropriate for introduction within the next 20 years even though formerly present in the southern North Island. The species recommended for establishment on Mana Island are based on the assumptions that (a) forest will be restored to at least a third of the island; (b) the island will be kept free of introduced mammals; (c) the wetland area near the houses will be restored; and (d) significant areas of grassland and shrubland will be retained. Beyond these broad habitat manipulations, it is assumed that the bird species to be introduced are ecological generalists that do not require plantings of specific plant species to ensure their survival. None of the species recommended for introduction in the next 20 years is likely to jeopardise the continued survival of resident threatened animal and plant species on Mana Island.

Species that should not be introduced in the next 20 years (unless new information is obtained on habitat requirements and/or impacts on other species) are listed in square brackets. Species to be introduced or deliberately attracted to the island are listed in **bold** lettering. Species that either require intensive management on the island <u>or</u> should only be introduced as a last ditch conservation measure are listed in italic lettering. Records of bones in middens at Paremata are from Davidson (1978), those from Mana are from Phil Millener (in lit.)

1. Little spotted kiwi (kiwi-pukupuku)

Criterion (b). Recorded from Cook Strait Ecological District (D'Urville & Kapiti Islands, bones at Paremata). Little spotted kiwi are apparently the kiwi most vulnerable to predation by introduced mammals, and may now be extinct on the mainland. Fortunately, little spotted kiwi can live at higher densities (about 0.5 pairs/ha) than other kiwi, and can tolerate the presence of rodents, and so there are several islands apparently suitable for little spotted kiwi. Little spotted kiwi from Kapiti Island have already been liberated on Long Island (Queen Charlotte Sound), Hen, Red Mercury and Tiritiri Matangi Islands.

The Kiwi Recovery Plan (Butler & McLennan 1991) identifies the need to establish further island populations of most kiwi taxa. As little spotted kiwi were found naturally within the Cook Strait Ecological District, Mana Island is an appropriate location to establish a population.

Mana Island is currently being used to attempt preservation of South Westland little spotted kiwi genes (one bird from Franz Josef paired with a bird from Kapiti Island). If this attempt fails, liberations of little spotted kiwi from Long Island (=D'Urville population) and/or Kapiti should be made to establish a self-maintaining population on Mana.

Conflicts between little spotted kiwi and other conservation values on Mana Island are likely to be minimal, especially while the kiwi are at a low population density. The presence of little spotted kiwi is unlikely to affect the establishment of those threatened invertebrates proposed for release on Mana Island, but kiwi should be fenced out of release sites for litter-dwelling species such as the giant pill millipede. Kiwi could potentially take giant weta nymphs, however giant weta are scarce or absent in forest habitats on Mana Island. Little spotted kiwi are not known to consume lizards.

Management action

Introduce further little spotted kiwi from mainland South Island, Kapiti Island and/or Long Island as determined by the Kiwi Recovery Group. Monitor populations of threatened invertebrates and reptiles as the little spotted kiwi population increases, to ensure that populations of all species of conservation interest are stable or increasing.

2. Okarito brown kiwi

Criterion (d). Bones of brown kiwi found in middens at Paremata. Mana Island is probably too small to maintain a breeding population (typically require 5+ ha per pair). However, environments free of mammalian predators may be required in future to raise captive-hatched mainland kiwi until they are large enough to return to mainland forests, as part of an intensive management programme. Such a programme is already underway for the endangered Okarito brown kiwi. Mana Island may be suitable as a"nursery" for other kiwi taxa, as long as there is no conflict with the main aim of establishing a little spotted kiwi population on the island.

Management action

Kiwi Recovery Group to determine whether Mana Island is suitable as a nursery for mainland kiwi taxa given the presence of one or more pairs of little spotted kiwi.

3. Sooty shearwater (titi)

Although widely distributed around New Zealand as a breeding species, most colonies north of Foveaux Strait number fewer than 100 pairs. If the small size of northern colonies is due to marine conditions, it may be unrealistic to expect the current population of about 100 pairs on Mana to increase greatly.

Management action

Continue monitoring burrow occupancy and breeding success of sooty shearwaters on Mana Island.

4–6. Fluttering shearwater (pakaha), common diving petrel (kuaka) & fairy prion (titi wainui)

All three species recorded from middens on Mana Island, and breed elsewhere in Cook Strait Ecological District. "Keystone species" with the potential to form large breeding colonies, importing large quantities of nutrients and thus supporting abundant invertebrate communities that, in turn, support abundant lizards. The top predator in a typical Cook Strait seabird/invertebrate/lizard ecosystem is the tuatara.

Trials are underway to attract all three species to an artificial colony, using a solar-powered tape deck that broadcasts their calls from dusk till dawn throughout the year. If successful, the same technique could be used to attract other petrels breeding in the Cook Strait region (flesh-footed shearwater and white-faced storm petrel).

There are few apparent conflicts between establishing further petrel colonies and other conservation objectives on Mana Island. However, any attempts to attract petrels to Mana Island should not occur close to archaeological sites (particularly the lighthouse and associated earthworks) as their burrowing activity may compromise the integrity of surface and subsurface features.

Management action
Continue trials to attract small petrels using acoustic stimuli. If unsuccessful within three breeding seasons, continue trial along with transfers of prebreeders from Cook Strait breeding islands. If necessary, transfer chicks before fledging as trialled with fluttering shearwaters on Maud Island (Bell 1994).

7. Blue penguin (korora)

Mana Island, along with other islands in the region, is an important breeding location for blue penguins, which are becoming increasingly scarce on the mainland.

Management action
None required.

8. Australasian gannet (takapu)

Gannets have increased markedly throughout New Zealand in the last fifty years (Wodzicki et al. 1984). However, the only colonies in the Cook Strait region are at Waimaru Bay, Pelorus Sound (29 nests in 1980/81; Wodzicki et al. 1984) and Farewell Spit (c.600 pairs in 1987/88; Hawkins 1988). It may be possible to attract gannets to a suitable site on Mana Island by the simple measure of putting out models of adult gannets to attract birds foraging offshore.

A gannet colony would result in total removal of plant cover within the area covered by the colony, but it would be a major nutrient source to support plant, invertebrate and reptile communities downslope. A gannet colony established by such a method would also be a important focus for interpretation, away from the more fragile petrel colonies.

Management action
Select suitable clifftop site and install 50-100 model gannets (recommend painted concrete casts to withstand elements). Monitor by regular checks for presence of gannets and signs of visits (e.g., feathers, nests). If visual cues alone are unsuccessful in attracting gannets, investigate the use of acoustic stimuli as well.

9. Black shag (kawau)

Unlike most cormorants, black shags can nest on both trees and cliff ledges. However, they are very susceptible to human disturbance. The nearest known breeding colony is on Kapiti Island. Black shags are nearly always present around the coast of Mana, and may attempt to breed in future, particularly if little shags start breeding.

Management action
Keep human disturbance of areas where shags attempt to nest to a minimum.

10. Little shag (kawaupaka)

There is a little shag roost on trees around the dam at the base of House Valley. As little shags typically nest on trees overhanging water, it is possible that they will attempt to breed at this site. As for black shag, little shags are wary of humans, and most fly away when they see people on the vehicle track above the dam. This track is closed to the public, and will eventually be screened by plantings.

Management action
Keep human disturbance of areas where shags attempt to nest to a minimum.

11. White-faced heron

One or two white-faced herons are often present around the coast of Mana. Typical nest sites are in the tops of tall trees, though they occasionally nest on the ground. The most likely nest sites on Mana are the big old macrocarpas and pine trees, all of which will eventually be windthrown or cut down. As the white-faced heron is a recent immigrant to New Zealand, and is very abundant throughout the country, it is not considered necessary to retain potential nest sites on Mana.

Management action
None required.

12. Reef heron (matuku-moana)

One to four reef herons are often present around the coast of Mana, and breeding was first confirmed in December 1994. Typical breeding sites are in sea caves (there are few on Mana), on cliff ledges and in low vegetation.

Management action
Discourage people from walking along any sections of coasts where reef herons attempt to breed.

13. Paradise shelduck (putangitangi)

Several pairs are present on Mana, and broods of ducklings have been seen on some of the dams. With increasing tall vegetation around these dams they are likely to become less attractive to shelducks, which require all round vision from brood-rearing areas. However, restoring the Waikoko wetland should provide sufficient habitat to retain shelducks on Mana. The presence of paradise shelduck bones in middens on Mana suggests that they were part of the original avifauna.

Management action
Restore Waikoko wetland, keeping at least two hectares clear of tall woody vegetation.

14. Grey duck (parera)

Recorded from middens on Mana, but now all but replaced by the introduced mallard, with which grey ducks hybridize. Restoring the main wetland on Mana should improve habitat for dabbling ducks, but it would be difficult to develop habitat for grey ducks that would not attract mallards. Control of mallards is not feasible due to their abundance and mobility.

Management action
Restore Waikoko wetland.

15. Brown teal (pateke)

Criterion (b). Teal bones were found in middens at Paremata, and brown teal were recorded historically from Cook Strait Ecological District. The nearest population is on Kapiti Island (descended from captive-bred birds release in 1968). Mana Island has been suggested as a possible site for releasing captive-bred Campbell Island teal, however this has been rejected by the Subantarctic Teal Recovery Group because of the risk of hybridization with brown teal dispersing from Kapiti Island. The brown teal is also nationally threatened, and may require habitats free of mammalian predators for its own survival. The draft Brown Teal Recovery Plan has a goal of establishing breeding populations of brown teal on at least five further small islands by 1999 (Dumbell & Williams 1994). Potential habitat already exists on Mana Island, but would be increased by the restoration of Waikoko wetland. Ducks Unlimited run a captive-breeding programme for brown teal (Operation Pateke) and should be able to provide advice on wetland restoration, as well as providing birds for release.

There is increasing evidence that, in the absence of mammalian predators, the brown teal was a terrestrial species, occurring under forest a long way from standing water (Worthy & Holdaway 1994). It is anticipated that once

established on Mana Island, brown teal will occupy grassland and forest habitats as well as the wetlands.

There are no apparent conflicts between the release of brown teal and other conservation values on Mana Island.

Management action
Restore Waikoko wetland, liberate captive-bred brown teal (or wild-caught birds if recommended by the Brown Teal Recovery Group).

16. Australasian harrier (kahu)

Common on Mana, though not known to breed there. Also recorded in middens from Mana. Harriers are extremely mobile, and are often seen flying between Mana and the mainland. Although natural members of the Mana avifauna, harriers have the potential to disrupt conservation programmes by preying upon recently released "predator-naive" animals such as captive-reared teal and plover and translocated petrel chicks. Long term control of harriers on Mana is neither desirable nor practical, however short term control through trapping or shooting of problem individuals may be required during and after releases of vulnerable species.

Management action
Monitor harrier presence and behaviour during releases of species that may be vulnerable to harrier predation; remove or destroy any harriers that are considered to be jeopardising the success of releases.

17. New Zealand falcon (karearea)

A rare straggler to Mana Island. It is unlikely that falcons will become resident on Mana given the small size of the island, and the absence of resident falcons on the much larger, forested Kapiti Island nearby. Even more than harriers, falcons have the potential to jeopardise releases of other bird species on Mana.

Management action
Check for presence of falcons immediately before any planned release of any bird species on Mana. If considered necessary, live-trap falcons for release elsewhere.

18. [Banded rail (moho-pereru, mioweka)]

Criterion (a). Found in middens on Mana Island, not known elsewhere in Cook Strait Ecological District at present. Nearest populations are at the heads of Pelorus and Queen Charlotte Sounds where banded rails are confined to saltmarshes (Elliott 1989). Elsewhere in New Zealand banded rails also occur in freshwater wetlands; on a few islands free of mammalian predators (Three Kings Islands, Poor Knights Islands and at least five islands near Stewart Island) banded rails occur among forest, scrub and tussock grasslands. On mammal-free Mana Island, banded rails could be expected to colonise most habitats.

Banded rails are secretive and rarely seen, yet are efficient colonists that have reached isolated islands throughout the Philippines, Indonesia, Melanesia, western Polynesia, Australia and New Zealand, including (formerly) Chatham Island and Macquarie Island. The New Zealand subspecies is endemic; whilst local in distribution, it is not considered threatened nationally. Banded rails are absent from the Wellington region, but there are two recent records from the Wairarapa. Restoring banded rails to Mana Island would achieve the dual goals of re-establishing a population in the region, and restoring a species presumed to have been part of the original Mana Island avifauna.

Although banded rails should eventually be returned to Mana Island, they are predators and could affect the establishment and expansion of reptiles, invertebrates and ground-nesting birds. Banded rails may recolonise the island naturally, but if they do not, their re-introduction should occur only once all planned releases of potential prey are complete and the new species are well established (i.e., in 20+ years).

Management action

Check for the presence of banded rails at five-yearly intervals by playing taped calls. Assuming that banded rails do not recolonise naturally in the interim, re-introduce them to Mana Island once all other restoration programmes involving reptiles, invertebrates and ground-nesting birds are complete and the target species well established.

19. Spotless crake (puweto)

Spotless crakes are rarely seen but widespread inhabitants of raupo dominated wetlands, including those in the Sounds-Wellington Ecological Region. On a few islands free of mammalian predators (e.g., Meyer Islets in Kermadec group, Three Kings and Poor Knights Islands) spotless crakes also inhabit forest and scrub. Spotless crakes are thought to have good powers of dispersal and may colonise Mana Island naturally, especially once Waikoko wetland is restored.

Management action

Restore Waikoko wetland. Check for the presence of spotless crakes at five-yearly intervals by playing taped calls.

20. [Weka]

Weka bones have been found in middens on Mana Island, and weka are present within the Marlborough Sounds (western weka) and on Kapiti Island (probably hybrid stock). North Island weka are now extinct in the Wellington region, but there are plans to reintroduce them to Karori Wildlife Sanctuary.

Weka have been introduced to many islands around the New Zealand coast, and at several sites are considered to have had severe impacts on indigenous fauna including reptiles, invertebrates, small petrels, shorebirds and some landbirds. Introduction of weka to Mana Island could endanger giant weta and McGregor's skink, as well as many of the species proposed for introduction. For this reason, weka should not be introduced to Mana Island unless (a) there is clear evidence that weka were part of the original avifauna on Mana, (b)

there is new evidence indicating that past claims of the impacts of weka on other biota have been overstated, and (c) introduction of North Island weka to Mana is considered necessary to ensure their survival. Even if all these criteria are met, weka should not be introduced until all other species are well established. This stance is more moderate than that of Towns (1992b), Whitaker (1993) and Newman (1994) and who did not think weka should be considered at all for introduction to Mana.

Management action

Investigate weka bones from Mana Island middens to establish whether they were likely to have been obtained locally. Support research into the impacts of weka on other biota. Do not introduce weka to Mana Island unless criteria (a) to (c) above are met.

21. Pukeko

Pukeko are very abundant on Mana Island, and have caused problems by pulling out plantings and interfering with supplementary feeding stations for kakapo and takahe. Most of these problems can be overcome by modifying management practices, however, in some situations localised control of pukeko may be the only practical option to limit damage. There is also an unknown risk of disease or parasite transfer from the dense pukeko population to threatened bird species, especially the closely related takahe. Weighed against this is the potential to use pukeko to enhance takahe breeding success by cross-fostering takahe eggs to pukeko. It is possible that pukeko could hinder the establishment of, e.g., brown teal by predation of eggs and chicks.

Pukeko are likely to decline on Mana as the forest cover increases, but are expected to remain abundant in more open habitats.

Management action

Support research into the disease risk posed by the dense pukeko population on Mana. Monitor impacts of pukeko on plantings and on other animal species that are introduced to Mana, and undertake localised control if necessary.

22. Takahe

Criterion (d). The North Island takahe is extinct, though bones of it have been found in middens at Paremata. The South Island takahe population is reduced to a small wild population in the Murchison Mountains west of Lake Te Anau; birds from this source have been introduced to Kapiti, Mana, Maud and Tiritiri Matangi Islands and to the Stuart Mountains. There is also a small captive population. Although takahe survive well at low altitudes, there is currently a shortage of mammal-free non-forested lowland sites suitable for takahe. Of the 17 islands greater than 100 ha that are free of introduced mammals around the New Zealand mainland (Table 2.1) there are only four (Mana, Kapiti, Maud and Tiritiri Matangi) that have suitable habitat for takahe and where the presence of takahe is compatible with other management objectives. This situation is likely to change as further islands are cleared of introduced mammals, and as methods to keep mainland areas clear of predators improve. For the foreseeable future, however, Mana Island is expected to play a key role in the takahe recovery programme.

South Island takahe were first introduced to Mana Island in 1988; there are currently six pairs on the island. Intensive management is guided by the Takahe Recovery Group; this has included supplementary feeding, moving birds between the islands to minimise inbreeding, use of enclosures to aid pair-bonding and territory spacing, and egg transfers to ensure that as many pairs as possible have a fertile egg. Recent trials on Mana Island to determine whether takahe eggs/chicks can be reared by pukeko were inconclusive (Bunin & Jamieson 1996), and these trials are unlikely to resume in the near future.

Concerns have been raised over the potential impact of takahe on other threatened fauna on Mana Island, particularly McGregor's skink, goldstripe gecko and giant weta. Takahe are almost entirely herbivorous, rarely consuming large-bodied animal prey. In contrast, the closely related pukeko takes a larger proportion of animal prey in its diet. Pukeko have naturally colonised Mana Island, and currently outnumber takahe there by over 40 to one. However, in the presence of both takahe and a dense pukeko population, McGregor's skinks and goldstripe gecko have apparently increased markedly in the last four years (Whitaker 1993; Newman 1994) and giant weta remain abundant. It is very unlikely that takahe are having any impact on other threatened fauna on Mana Island.

Mana Island could potentially hold up to 53 pairs of takahe if suitable ponds and plantings are provided on the plateau (Ryan & Jamieson 1998). However, if plantings and regeneration reduce the total area of grassland and shrubland on the plateau and valleys to 70 ha by the year 2030 as recommended in this plan, there would be sufficient habitat for about 25 pairs of takahe on Mana Island.

Takahe on Mana Island mainly have territories centred on the valley floors, usually around small artificial wetlands. Most territories include extensive areas of young plantings, but observations on Kapiti Island indicate that takahe are unlikely to live in mature forest. As the revegetation programme and natural regeneration will eventually produce tall forest on most valley floors and sides, it is likely that most current territories will not be suitable for takahe in 20 years time unless windows of open grass and shrubland are maintained within forest catchments. The Takahe Recovery Plan (Crouchley 1994) recommended that maintenance of grassland habitat be emphasised in the management plan for Mana Island. This will be achieved by leaving unplanted windows of grassland on valley floors and lower slopes, and by leaving most of the plateau unplanted, apart from small areas of cover for nesting and roosting adjacent to ponds and depressions. In the short term, the Department does not intend preventing natural regeneration of forest and shrubland in order to maintain habitat for takahe, but this may become necessary if Mana Island remains a key site for takahe in 10 to 20 years time.

Takahe are unlikely to ever have a self-sustaining population on Mana Island (and may all eventually be moved to another island or mainland site), and so we must ensure that any habitat modifications made to provide for takahe do not unduly compromise other conservation values on the island. Maintaining small ponds on the island will provide habitat for other planned introductions (e.g., brown teal, fernbird) as well as takahe, but keeping large areas of the valley floors and sides clear of woody vegetation would conflict with the restoration of forest communities on Mana. If small windows of grassland

are retained (or even maintained) within forest catchments, these will rapidly regenerate if takahe are ever removed from Mana Island.

In summary, Mana Island could support up to 25 pairs of takahe in the short to medium term if required by the Takahe Recovery Group. Takahe are not considered part of the long term restoration goal for Mana Island as it is unlikely that there will be sufficient habitat on the island to support a self-sustaining population.

Management action

Continue intensive management of takahe on Mana Island as long as required by the Takahe Recovery Group. Prepare habitat on the plateau by planting flax, toetoe, sedges and shrubs around ponds, and creating further small ponds if required. Retain windows of unplanted grassland on the valley floors and lower slopes of catchments that are otherwise forested. Ensure that any management actions taken to support the takahe recovery programme do not unduly compromise other conservation values and restoration goals on the island.

23. Variable oystercatcher (toreapango)

About 15 pairs of variable oystercatcher breed on Mana Island. Although variable oystercatchers are widely distributed around the Wellington coastline, there are very few sites where they are able to breed successfully. Fledging success in the presence of the large black-backed gull population on Mana has not been determined, but the island has the potential to be the main breeding site for variable oystercatchers in the entire Wellington region.

Management action

Monitor breeding success annually in relation to gull density. Colour-band adults and chicks to determine the importance of Mana Island in maintaining the variable oystercatcher population in the Wellington region.

24. Shore plover (tuturuatu)

Criterion (b). The shore plover is confined to a single wild population of about 130 birds on Rangatira (South East) Island in the Chatham Islands, but formerly occurred around the South Island and possibly the North Island (Dowding & Kennedy 1993). There are also about 30 captive-reared and captive-bred shore plover held at the National Wildlife Centre (Mt Bruce) and Peacock Springs (Christchurch). The main purpose of the captive flock is to produce sufficient birds for release onto one or more predator-free islands, as described in the draft Shore Plover Recovery Plan (Kennedy 1993). Mana Island is within the presumed original distribution of shore plover, and is one of the top priority islands identified by the Shore Plover Recovery Group for a trial release.

Habitat suitability for shore plover on Mana Island has been assessed in preparation for release of shore plover there (Miskelly & Aikman 1993). While the intertidal zone of Mana is not as extensive as the wave platforms and saltmarshes of Rangatira Island, there appears to be sufficient habitat and

intertidal invertebrates to attempt a release of shore plover. The major barrier to establishing a breeding population of shore plover on Mana Island is the presence of a large colony of black-backed gulls. The very large number of gulls on Mana is thought to be the result of poor waste management in the Wellington region (see below). Gulls are known predators of shore plover chicks, and their numbers on Mana Island will have to be greatly reduced before a release of shore plover is attempted.

Apart from the need to control black-backed gulls, there are no apparent conflicts between releasing shore plover and other conservation values on Mana Island. The grass area behind the landing beach and the margins of any dams that shore plover frequent should be kept mown as bad-weather roost sites and feeding areas, but there is no justification for large-scale habitat manipulation for shore plover on Mana Island.

Management action

Reduce the black-backed gull population by at least 90% and maintain at that level. Introduce captive-reared and captive-bred shore plover to Mana Island. Following release, provide supplementary food as required, and control predatory birds (harriers, black-backed gulls) if necessary. Keep all areas currently mown as a low turf, and mow the margins of any dams the shore plover use.

25. Chatham Island snipe (tutukiwi)

Criterion (b). Snipe formerly occurred throughout New Zealand; the nearest known subfossil records to Mana Island are in the Wairarapa and at Marfell's Beach, Marlborough (Miskelly 1987), but this is probably due to the paucity of suitable sites for the preservation of small bird bones in the Wellington region. Snipe survived on offshore islands in the Hauraki Gulf and off Stewart Island until 1870 and 1964 respectively (Miskelly 1987 & 1988) but both these subspecies are now extinct due to introductions of cats, rats and weka. Snipe still occur on the Chatham Islands, Snares Islands, Antipodes Islands, Auckland Islands and Campbell Islands, with a distinct species or subspecies on each group.

Snipe should be reintroduced to offshore islands that are free of introduced mammals as part of their ecological restoration and to reduce the risk of snipe becoming extinct. The forms of snipe currently at greatest risk from extinction are the Campbell Island snipe, Snares Island snipe and Chatham Island snipe, due to their small total population size, small area of habitat available, low number of islands inhabited, and accessibility to fishing craft capable of mooring close offshore (Chatham Island snipe has the added risk of frequent expeditions to Mangere and Rangatira Islands, with increased opportunity for rodent invasion). In contrast, it is unlikely that a single predator invasion would endanger Auckland Island and Antipodes Island snipes, each of which occurs on several widely spaced and infrequently visited islands within their respective archipelagos.

On biogeographical and morphological grounds, the most appropriate snipe to introduce to islands off the North Island is the Chatham Island snipe, while the Snares Island snipe should be introduced to islands off Stewart Island.

Unfortunately all offshore islands known to have had snipe historically still have introduced mammals and/or weka. However, as snipe occurred on many offshore islands as well as the mainland, it is appropriate to attempt liberations on modified islands that are now free of introduced mammals, such as Mana, Moutohora, Cuvier and Tiritiri Matangi Islands.

Snipe occur throughout any habitat with dense ground cover, including grassland; there is abundant habitat and suitable prey for snipe on Mana Island. The liberation of snipe is unlikely to conflict with other conservation values on Mana Island.

Management action

Seek support from the Chatham Island community for transfer of Chatham Island snipe from Rangatira to Mana, either direct or via a captive breeding programme..

26. Southern black-backed gull (karoro)

Black-backed gulls are over abundant on Mana Island, with 2500-2600 pairs breeding around the coastal platform, cliffs and on the plateau adjacent to Tauhinu Valley (Empson 1994). Scavenging on anthropogenic wastes has led to such a huge increase in black-backed gulls in the Wellington region that the breeding population on Mana is at least two orders of magnitude greater than it would be if gulls were feeding solely on natural food sources. While black-backed gulls are a natural part of the Mana Island avian community, at current densities the gulls have the potential to severely compromise restoration programmes on Mana Island. Species that could be affected by black-backed gull predation include petrels, gannets, oystercatchers, shore plover, red-billed gulls and terns. Black-backed gulls are also a potential disease risk to threatened species on Mana; gulls are notorious as disease carriers, presumably because of their scavenging habits.

While a reduction in black-backed gull numbers should benefit many other bird species on Mana Island, gull control will reduce nutrient inputs to the coastal platform and cliff communities, which may impact on plant, invertebrate and reptile communities. Such effects, if they occur, should be temporary, i.e., until populations of other seabirds increase.

Management action

Reduce the breeding population of black-backed gulls on Mana Island to about 100 pairs centred on the north-western cliffs, and maintain at this level. Monitor gull predation on vulnerable species, and adjust control programme accordingly. Advocate better management of landfills and other gull feeding sites in the Wellington region.

27. Red-billed gull (tarapunga)

Red-billed gulls breed in at least two discrete colonies on the northern cliffs and adjacent stacks of Mana Island, with a 1993/94 population of about 155 pairs (C. Miskelly pers. obs.). Red-billed gulls take a greater proportion of natural prey than black-backed gulls, feeding mainly on marine crustacea during the breeding season. Their current breeding distribution on Mana Island is

away from areas where most species vulnerable to gull predation do or may breed; however, white-fronted terns nest among the red-billed gulls and are vulnerable to egg or chick loss to gulls if disturbed by people. Red-billed gulls may increase in numbers and breeding distribution on Mana following black-backed gull control. Any increase should be monitored to ensure that other species (especially shore plover) are not unduly threatened.

Management action

Discourage people from approaching mixed red-billed gull/white-fronted tern colonies. Monitor distribution and size of breeding colonies.

28. Caspian tern (taranui)

Caspian terns are frequent visitors to the eastern shoreline of Mana Island. The only breeding colony in Wellington Conservancy is on Onoke Spit, Wairarapa. Caspian terns are extremely vulnerable to human disturbance when nesting. It is possible that Caspian terns may attempt to breed on Shingle Point, particularly after black-backed gull numbers are decreased.

Management action

Monitor the presence of Caspian terns on Mana Island. Discourage people from walking around Shingle Point if Caspian terns begin roosting or nesting there.

29. White-fronted tern (tara)

White-fronted terns bred on two stacks (20 pairs) off the northern coast of Mana in 1993/94 (C. Miskelly pers.obs). Both colonies were among breeding red-billed gulls. White-fronted terns are more wary of humans than gulls, leaving their nests when approached and exposing their eggs and chicks to the less timid gulls. The size and distribution of tern breeding colonies on Mana Island may increase following black-backed gull control.

Management action

Identify roosting and nesting sites of white-fronted terns on Mana, and discourage people from approaching closer than 50 metres.

30. New Zealand pigeon (kereru)

Criterion (a). New Zealand pigeon bones have been found in middens on Mana Island and individuals occasionally occur there as vagrants; it remains a conspicuous member of coastal forest ecosystems in Cook Strait Ecological District. The kereru is considered a keystone species of New Zealand forest ecosystems, as it is the most widely distributed New Zealand bird species capable of dispersing large seeds. Restoration of kereru to Mana Island would be a major step in the shift from an artificially created forest to a forest with a structure that is modified and maintained by natural processes.

Kereru are strong fliers, and will probably colonise Mana Island naturally from Kapiti Island when the forest on Mana is well established. Conversely, if kereru are reintroduced to Mana too soon, they are likely to fly away. It

is possible that kereru will become seasonal visitors to Mana initially until the forest is sufficiently diverse and mature to maintain them year round. If kereru do not begin visiting Mana when there appears to be abundant fruiting of favoured species, then a transfer of kereru to the island should be attempted.

There are no likely conflicts between the reintroduction of kereru and other conservation values on Mana, although kereru may damage some plantings when feeding on leaf and flowerbuds.

Management action

Continue revegetation programme. Record timing and duration of visits by kereru, and note diet. If kereru are not regular visitors when habitat appears suitable, conduct a trial release of kereru from Kapiti Island.

31. Kakapo

Criterion (d). The kakapo is the most critically endangered New Zealand bird. Bones have been found at Paremata, and it is recordedly historically from the Tararua Ranges and Marlborough Sounds, but it is unlikely that an island as small as Mana would have held a kakapo population. However, as an accessible, modified, mammal-free island, Mana Island has potential for intensive management of kakapo as long as this does not unduly compromise other conservation values and objectives on the island.

Two male kakapo were introduced to Mana Island in May 1992, and one of these survived in good condition for 15 months. This trial provided sufficient encouragement to support further use of Mana Island as a site for close order management of kakapo in a semi-captive environment.

If further kakapo are to be brought to Mana Island, it may be necessary to provide favoured food plants. These should be locally sourced plants appropriate to the Ecological District wherever possible. If it is considered essential that exotic plants be used (e.g., garden vegetables) then care must be taken to ensure that they do not become established in the wild on the island. As there is never likely to be a self-sustaining kakapo population on Mana Island, any habitat modification undertaken for kakapo should not compromise the main restoration programme, and should be reversible.

Although there are unlikely to be any direct ecological conflicts between kakapo and other conservation values on the island, the high priority given to kakapo may create indirect conflicts through reallocation of resources from other tasks. Sufficient staff resources must be available on the island to ensure the continuation of the overall restoration programme, regardless of the presence of kakapo.

Management action

Recommence intensive management of kakapo on Mana Island as and when required by the National Kakapo Team. Ensure that any management actions taken do not unduly compromise other conservation values and restoration goals on the island.

32. North Island kaka

Criterion (a). Kaka bones have been found on Mana Island, and kaka are still present in Cook Strait Ecological District (most notably on Kapiti Island). Kaka are thought to require forest that contains large amounts of dead wood, as wood-boring insect larvae are an important protein source during the breeding season. Natural thinning of plantings may provide a source of dead wood once plantings are well established, but this is expected to take at least ten years. Kaka may colonise or visit Mana Island naturally from Kapiti Island. If this does not occur, juvenile kaka from Kapiti should be released on Mana when forest cover is well established.

There are few apparent conflicts between the reintroduction of kaka and other conservation objectives on Mana Island. Kaka may carry diseases that kakapo are susceptible to, but note that kakapo occur alongside dense kaka populations on Codfish and Little Barrier Islands.

Management action

Continue revegetation programme. Record sightings of kaka that reach Mana naturally. Reintroduce kaka from Kapiti Island if kaka have not colonised naturally by the time forest is well established on Mana. Erect suitable nest boxes.

33. Yellow-crowned parakeet (kakariki)

Criterion (a). Parakeet bones have been found on Mana; these are most likely of red-crowned parakeet, but may be of yellow-crowned parakeet or both species. Red-crowned parakeets are abundant on Kapiti Island, and yellow-crowned parakeets are abundant on the Chetwode Islands and Titi Island in outer Pelorus Sound (all within Cook Strait Ecological District). Yellow-crowned parakeets formerly occurred on Kapiti Island, and are still present in the Tararua Ranges.

All eight taxa of *Cyanoramphus* parakeets in New Zealand are rare and/or have restricted ranges. Five taxa (Kermadec parakeet, Chatham Island red-crowned parakeet, Forbe's parakeet, Antipodes parakeet and Reischek's parakeet) have evolved on isolated islands; all five of these taxa should be conserved within the island group where they occur naturally, as it is unlikely that any would become extinct following a single predator colonisation, and there is a high risk of hybridisation with local forms if they were introduced to offshore islands (Table 8.2).

Of the three "mainland" parakeets, the most threatened form is the orange-fronted parakeet. There is still debate over whether the orange-fronted parakeet is a distinct species or a colour morph of the yellow-crowned parakeet (Taylor et al. 1986; Daugherty & Triggs 1991). Regardless of this debate, all recent sightings of orange-fronted parakeets have been in South Island beech forests, and it is more appropriate for any releases to occur on predator-free islands in Fiordland or South Island lakes.

Of the two remaining New Zealand parakeets, the yellow-crowned parakeet is currently considered the most threatened species (Molloy & Davis 1994). Red-crowned parakeets occur on at least 18 island groups around the mainland and Auckland Islands, and yellow-crowned parakeets occur on at least nine

(Taylor 1985; Miskelly pers. obs). Both species were sympatric on at least 11 island groups, but on islands where both occur red-crowned parakeets are usually much more abundant. Indeed, yellow-crowned parakeets have apparently recently become extinct on Kapiti, Solander and Three Kings Islands, while red-crowned parakeets remain abundant. The only islands which have yellow-crowned parakeets but not red-crowned parakeets are the two Chetwode Islands and Titi Island.

It is possible that red-crowned parakeets will eventually colonise Mana Island naturally from Kapiti. While both species can coexist in some circumstances, it is important that a stable population of the (apparently) less competitive yellow-crowned parakeet be established on Mana Island as soon as possible. This could be achieved by direct transfer of birds from the Chetwode Islands, as yellow-crowned parakeets from the northern South Island are apparently genetically identical to those from the North Island (Triggs & Daugherty 1988; Daugherty & Triggs 1991). Habitats on Mana Island are more similar to those on the Chetwode Islands (especially Te Kakaho) than they are to montane forest in the Tararua Ranges.

Parakeets should exploit the super abundance of exotic grass seed on Mana Island. It is unlikely that parakeets would have any major impact on threatened plants on Mana, as all plants in the Cook Strait Ecological District would have evolved in the presence of parakeets. There are no other apparent conflicts between the reintroduction of parakeets and other conservation objectives on Mana Island.

Management action

Discuss transfer of yellow-crowned parakeets from Chetwode Islands with Nelson/Marlborough Conservancy and relevant iwi. Seek support for transfer of 20–30 yellow-crowned parakeets from Te Kakaho to Mana Island. Erect nest boxes in the most established plantings and monitor their use. Monitor parakeet flocks for the presence of red-crowned parakeets.

34. Shining cuckoo (pipiwharauroa)

The shining cuckoo is a brood-parasite of the grey warbler. Both species are widespread on the mainland. Shining cuckoos are migratory, and well able to colonise Mana Island naturally. More shining cuckoos are likely to occur on Mana as the forest cover increases, and grey warblers become more abundant.

Management action

Continue revegetation programme. Record sightings of shining cuckoo adults and fledglings.

35. Long-tailed cuckoo (koekoea)

The long-tailed cuckoo is a brood parasite of the whitehead. Both species are widespread in forests of central and southern North Island. Long-tailed cuckoos are migratory, and well able to colonise Mana Island naturally; one was recorded there in March 1998 (G. Timlin pers. comm.) However, they will not breed successfully until whitehead are established.

Management action
Continue revegetation programme. Reintroduce whitehead. Record sightings of long-tailed cuckoo adults and fledglings.

36. Morepork (ruru)

Moreporks were regularly reported on Mana before mice were eradicated. Reports since the mouse eradication have been irregular, and morepork are not considered resident on the island. Moreporks are expected to recolonise Mana Island naturally; as they are the top nocturnal predator in New Zealand forest ecosystems, deliberate reintroduction of moreporks is not considered appropriate, at least until all nocturnal invertebrates and reptiles introduced as part of this restoration plan are well established. Note that moreporks are also potential predators of petrels, snipe, and roosting bushbirds, but are unlikely to limit established populations.

Management action
Check for presence of moreporks before any liberations of nocturnal reptiles and large bodied invertebrates. If necessary, construct exclosures to keep morepork out of liberation sites.

37. New Zealand kingfisher (kotare)

Kingfishers are present on Mana Island in low numbers, although there is no evidence of breeding. This may be due to a paucity of nest sites. In forest ecosystems kingfishers typically nest in holes in trees, but they also use holes in banks. Road cuttings may provide potential nest sites on Mana Island, but potential nest sites will increase with maturing forest cover.

Management action
Record evidence of breeding by kingfishers.

38. Rock wren

Criterion (b). New Zealand wrens form an endemic family that was formerly one of the most diverse groups of landbirds in New Zealand. Six species and three subspecies are recognised in Turbott (1991), and a seventh species has since been described (Millener & Worthy 1991). Three of these species are known only from subfossil remains, and a further two have become extinct in the last 100 years. It is likely that at least four species occurred in the Wellington region, but the only confirmed species are rifleman (still present in Tararua, Rimutaka and Aorangi Ranges), North Island bush wren (two specimens from Rimutaka Range, 1850) and North Island stout-legged wren (subfossil bones from Wairarapa).

The bush wren is considered to have become extinct following the invasion of Big South Cape Island by ship rats in the 1960s (Bell 1978), leaving the rock wren as the only surviving species in the genus *Xenicus*. Atkinson (1990) developed an argument for attempting to re-establish a lowland population of *Xenicus* by introducing rock wren to Matiu/Somes and Mana Islands. The hope is that this introduced population would become adapted to living in

forest, thus restoring some of the ecological and evolutionary processes lost with the extinction of the bush wren. This proposed experiment is given even greater poignancy following the suggestion by Worthy & Holdaway (1993) that the rock wren and bush wren may be forms of the same species. If this is the case, then liberating rock wren on Matiu/Somes and Mana Islands would be restoring a species to the Wellington region that has been absent for over 140 years.

Potential conflicts between rock wren and other conservation values on Matiu/Somes and Mana Islands are discussed by Atkinson (1990). The only apparent conflict is potential predation of giant weta nymphs by rock wren. This could be checked by introducing both giant weta and rock wren to Matiu/Somes Island initially, and only transferring rock wren to Mana if both species become established successfully.

Management action
Support introduction of Cook Strait giant weta and rock wren to Matiu/Somes Island. If giant weta become established in the presence of rock wren, and rock wren establish successfully, then transfer rock wren from Matiu to Mana Island.

39. Welcome swallow

Welcome swallows are common on Mana Island, breeding around the buildings and in sea caves.

Management action
None required.

40. New Zealand pipit (pihoihoi)

Pipits occur on Mana Island in low numbers. Breeding has not been recorded. Pipits are birds of open country, and remain widespread throughout New Zealand.

Management action
None required.

41. North Island fernbird (matata)

Criterion (a). Fernbird bones have been found on Mana Island. The nearest surviving population of North Island fernbird is at the Manawatu Estuary.

Five taxa of fernbird are recognised. The Chatham Island fernbird is extinct. The Snares Island fernbird is naturally confined to a small archipelago, and could become extinct following a single predator introduction. The Codfish Island fernbird is naturally confined to a single island, and could also become extinct following a single predator introduction. The Stewart Island fernbird is scarce on Stewart Island, but occurs abundantly on at least nine islands around Stewart Island; it has recently been exterminated by ship rats, cats and/or weka on a further six islands. The South Island fernbird is widespread

in Nelson, the West Coast (including Open Bay Islands), Otago and Southland. The North Island fernbird is widespread in Northland, but patchy in central North Island and scarce as far south as Manawatu and southern Hawkes Bay. It was found at Lake Wairarapa as recently as 1948 (Watt et al. 1949). The North Island fernbird is also found on Great Barrier Island, and formerly occurred on Great Island (Three Kings Is) and the Alderman Islands.

Of the extant fernbird taxa, Snares Island fernbird and Codfish Island fernbird are the forms that most urgently require transfer to further predator-free islands (Table 8.2). However, it is not necessary to move either taxa 840–1000 km north to Mana Island, which would have formerly held North Island fernbird. Snares Island fernbirds could be translocated to Mangere (and other) Islands in the Chatham Islands to replace the extinct Chatham Island fernbird; Codfish Island fernbirds could be translocated to nearby Solander Island if weka are eradicated. Reintroducing North Island fernbird to Mana Island would restore the fernbird taxon most likely to have been present, as well as restoring a species no longer present in Wellington Conservancy.

Fernbirds are usually thought of as inhabitants of densely vegetated wetlands or pakihi scrublands, as these are the habitats most often occupied on the three main islands, Great Barrier Island and Codfish Island. However, fernbirds inhabit tall scrub and tussock grasslands on the Snares Islands, islands off Stewart Island and on the Open Bay Islands; all these islands are free of introduced mammals. The implication is that fernbird have broad habitat requirements, but are confined to densely vegetated wetlands in the presence of rats and other predators.

Habitat preferences by North Island fernbirds on predator-free islands are poorly known. They became extinct on Great Island between 1887 and 1934, apparently due to vegetational changes caused by goats (Turbott 1948; Turbott & Buddle 1948). Fernbirds disappeared from the Alderman Islands between 1927 and 1950 (Sladden & Falla 1927 & 1928; Falla 1953). Fogarty & Douglas (1973) suggested that regeneration had destroyed fernbird habitat on the Alderman Islands. As any North Island fernbirds released on Mana Island are likely to have come from wetland habitats, it would be prudent to restore the wetland on the island beforehand, even if fernbirds subsequently utilise grass and shrubland habitats on the island.

There are no apparent conflicts between reintroducing North Island fernbirds and other conservation objectives on Mana Island.

Management action

Restore Waikoko wetland. Translocate North Island fernbirds from the nearest viable population (?Manawatu Estuary).

42. Whitehead (popokatea)

Criterion (a). Whitehead bones have been found on Mana Island, and whiteheads remain abundant on Kapiti Island in both seral and mature forest. A successful transfer of whiteheads to Tiritiri Matangi Island from Little Barrier Island occurred five years after the revegetation programme on Tiritiri Matangi was initiated (Allen 1990), however, Tiritiri Matangi had a larger area of existing

forest than Mana Island does. Mana Island could probably support a small whitehead population now, but translocation should wait 5-10 years until the existing plantings have formed a closed canopy.

There are no apparent conflicts between the reintroduction of whiteheads and other conservation objectives on Mana Island.

Management action
Transfer whiteheads from Kapiti to Mana Island when there is at least 10 ha of closed canopy scrub.

43. Grey warbler (riroriro)

Grey warblers are common in scrub and the more established plantings on Mana Island.

Management action
None required.

44. North Island fantail (piwakawaka)

Fantails are abundant on Mana Island.

Management action
None required.

45. Snares Island tomtit

Criterion (c). There is no evidence that tomtits occurred on Mana, although this is possible given their presence on Kapiti Island. North Island tomtits are widespread in forested areas of the North Island, as well as on Hen and Chickens, Little and Great Barrier and Kapiti Islands; further island introductions are not required to ensure its survival. There is a slight chance that North Island tomtits will colonise Mana Island naturally.

Although it would be biogeographically and ecologically more appropriate to introduce North Island tomtits to Mana Island, it may be prudent to leave the tomtit niche vacant in case a transfer site for Snares Island tomtits is required in an emergency.

The Snares Islands are a small archipelago of about 350 ha. The two islands large enough to hold resident populations of the three endemic landbird species are separated by a channel of only 100 metres. If ship rats or some other terrestrial predator colonised either North East or Broughton Islands, there is a high probability that Snares Island snipe, Snares Island fernbird and Snares Island tomtit would all become extinct within a couple of years. There is potential to use the snipe and fernbird to replace extinct taxa (Stewart Island snipe and Chatham Island fernbird) as part other island restoration programmes (Table 8.2); this should occur before Snares Island landbirds are placed under immediate threat of extinction. However, there is no apparent site where it would be appropriate to establish a new "permanent" population of the Snares Island tomtit. As a sufficiently large, highly modified, predator-free island that is accessible but reasonably remote from other tomtit

populations, Mana fits many of the criteria for a "lifeboat" island that could be used to maintain Snares Island tomtits in an emergency, until the predator introduced to the Snares is eradicated, and tomtits (along with snipe and fernbird) can be reintroduced.

Management action

Do not introduce North Island tomtits to Mana Island. If rats or other mammalian predators colonise the Snares Islands, transfer Snares Island tomtits to Mana Island until they can be returned to the Snares Islands (i.e., following predator eradication). The fate of any Snares Islands tomtits remaining on Mana Island should be determined following reintroduction to Snares Islands, and assessment of risk of reinvasion by predators.

46. North Island robin (toutouwai)

Criterion (a). Robin bones have been found on Mana, and robins remain abundant on Kapiti Island. Robins are no longer present elsewhere in Wellington Conservancy.

All three subspecies of New Zealand robin have patchy distributions on the three main islands, but each also occurs on two or more offshore islands. Successful translocations of North and South Island robins to predator-free islands have been carried out, and there are further opportunities to introduce all three subspecies to other islands within appropriate ecological districts. The closely related black robin of the Chatham Islands is now confined to two islands, with no prospect of range expansion until cats and weka are eradicated from large areas of Pitt Island. However, as two separate predator invasions would have to occur to seriously endanger the black robin, there is no pressing need to introduce black robins to an island outside the Chatham Islands.

Bait trials on Kapiti Island indicated that robins could be vulnerable to nontarget poisoning during a toxic airdrop to eradicate rats. As a precaution, two transfers of robins to Mana Island were made in 1995 and 1996, and robins are now well established there.

Robins are diurnal insectivores that mainly forage on or near the forest floor. While it is possible that robins could consume giant weta nymphs, there is unlikely to be much overlap in robin and giant weta distribution on Mana. The Cook Strait giant weta is active at night and is mainly found in grassland and at the shrubland/grassland interface, whereas robins prefer a closed canopy with little ground vegetation. None of the threatened invertebrates being considered for release on Mana are likely to be threatened by the presence of robins.

Management action

Monitor robin diet and distribution on Mana to ensure that giant weta or other threatened invertebrate populations are not being adversely affected.

47. Silvereye (tauhou)

Silvereyes are abundant on Mana Island.

Management action
None required.

48. [Stitchbird (hihi)]

Stitchbirds formerly occurred in the southern North Island and on Kapiti Island, but from about 1885 became confined to Little Barrier Island. Attempts to translocate stitchbird to other islands (including Kapiti Island) have not been particularly successful to date, although the reasons for this are unclear. Stitchbirds on Little Barrier Island are sympatric with New Zealand's two other honeyeater species (bellbird and tui). Of the three species, stitchbirds take the highest proportion of fruit (Table 8.5), but there is no obvious feature of their feeding ecology that predisposes them to local extinctions (Angehr 1986).

The forest on Kapiti Island has been regenerating for 100 years, but may still not be sufficiently diverse to support stitchbird. It may be unrealistic to expect Mana Island to provide suitable habitat for stitchbird in the short or medium term, but this should be reviewed if new information on the factors limiting stitchbird populations comes to light following further translocation attempts and pest eradications.

TABLE 8.5 DIET OF THREE HONEYEATER SPECIES ON LITTLE BARRIER ISLAND APRIL 1982 TO MARCH 1983 EXPRESSED AS PERCENTAGE OF FEEDING OBSERVATIONS (FROM ANGEHR 1986).

	NECTAR	INSECTS	FRUIT
Stitchbird	40	33	27
Bellbird (male)	32	66	2
Bellbird (female)	71	27	2
Tui	81	10	9

Management action
Do not introduce stitchbirds to Mana Island unless evidence from other island liberations and pest eradications suggest that suitable habitat is present on Mana.

49. Bellbird (korimako)

Criterion (a). Bellbird bones have been found on Mana, and bellbirds remain abundant on Kapiti Island. Bellbirds are the most insectivorous of the honeyeaters (Table 8.5) and it is expected that sufficient habitat will be created on Mana when the existing plantings form a closed canopy (5-10 years). While bellbirds may be able to fly to Mana Island naturally, evidence from Auckland and Northland shows that male bellbirds disperse much more than females (Craig & Douglas 1984), and so new breeding populations take many years to establish.

As pollinators, bellbirds play an important role in maintaining a natural forest ecosystem. For this reason, bellbirds should be reintroduced to Mana as soon as habitat there appears suitable. There are no apparent conflicts with other conservation objectives on the island, although the presence of bellbirds may reduce the suitability of Mana Island for stitchbirds if/when the forest is

sufficiently diverse to support stitchbirds. However, as bellbirds are known to have occurred on Mana Island in the past, their reintroduction should remain a priority.

Management action
Reintroduce bellbirds to Mana Island from Kapiti Island as soon as there is sufficient forest/shrub cover on Mana Island.

50. Tui

Criterion (a). Tui bones were the most abundant bird bones in middens on Mana Island (Horwood 1991). Occasional birds visit Mana when flax is in flower (Phil Todd pers.comm.). It is not known whether both sexes visit the island, but there is a chance that tui will colonise Mana naturally when a sufficient diversity and abundance of nectar and berry producing plants is established. Tui take a greater proportion of nectar and fruit than do bellbirds (Table 8.5), and so it may take a few more years for the habitat on Mana to be sufficient to support a resident tui population.

Tui are important pollinators and seed dispersers of native trees and shrubs. The re-establishment of tui would be an significant step in restoring natural processes in the forest ecosystem on Mana. There are no apparent conflicts with other conservation objectives on the island.

Management action
Record the timing and duration of visits by tui on Mana Island, and note diet. If tui are no longer visiting Mana when habitat appears to be suitable for them, conduct a trial liberation of adults and juveniles from Kapiti Island.

51. [North Island kokako]

Kokako apparently were not numerous in the southern North Island during European colonisation. There is no direct evidence that they occurred on Mana Island, but South Island kokako were present on Stephens Island (Cook Strait Ecological District). Translocations of kokako have been attempted to two large islands with extensive forest cover: the initial liberations on Little Barrier were very successful, but it is too early to determine the success of liberations on Kapiti Island. Kokako are thought to require tall, multi-layered podocarp/broadleaved forest, as they are confined to such habitats on the North Island mainland and on the islands to which they have been introduced. It is doubtful that Mana Island would ever support sufficient podocarp forest to hold a resident kokako population. However, the former presence of kokako on Stephens Island (150 ha) suggests that in the absence of mammalian predators and competitors, South Island kokako (at least) could survive in low, windswept forest with few podocarps. Whether North Island kokako could survive in seral forest on a small island could be determined by a trial release on, e.g., Tiritiri Matangi Island, where the revegetation programme is more advanced than on Mana. The suitability (and necessity) of Mana Island for kokako should be assessed following such a trial.

Management action
Do not introduce kokako to Mana Island unless evidence from other island liberations suggests that suitable habitat is present on Mana.

52. [North Island saddleback (tieke)]

Saddlebacks formerly occurred throughout the North Island and on at least five offshore islands including (apparently) Kapiti Island. There is no evidence that saddleback occurred on Mana Island, and the absence of their bones from middens there seems surprising given the assemblage of other bushbirds present. Predation by introduced mammals eventually confined the North Island saddleback to Hen Island only. From this one population, North Island saddlebacks have been successfully introduced (or reintroduced) to eight islands that have (or had) kiore (Lovegrove 1996). On Kapiti Island reintroduced saddlebacks maintained a precarious toehold due to predation by Norway rats, but should become well established if rat eradication has been successful.

The South Island saddleback would be extinct but for a successful rescue operation following the invasion of Big South Cape Island by ship rats. South Island saddlebacks now occur on nine small islands around Stewart Island, and have recently been released on Breaksea Island (Fiordland) and Motuara Island (Queen Charlotte Sound; Lovegrove 1996). With the increasing success of rat eradications on islands, the survival prospects for both subspecies of saddleback becomes more secure each year.

Saddlebacks are vigorous foragers that are capable of taking large-bodied invertebrates. Of all the New Zealand passerines, the saddleback is the species most likely to consume species such as giant weta and large weevils. Recent evidence from Breaksea Island indicates that two species of large weevil have successfully established in the presence of an expanding population of saddlebacks (Thomas et al. 1992; Bruce Thomas pers.comm.), but there is no need to expose threatened invertebrates on Mana Island to saddleback predation given the number of islands where saddlebacks are now found, and the absence of evidence for the former occurrence of saddlebacks on Mana. The long-term presence of saddlebacks on Mana (and the Wellington region) should be reassessed following the success or otherwise of rat eradication on Kapiti Island.

Management action
Do not introduce saddlebacks to Mana Island. Reassess the potential impacts of saddlebacks on Mana Island invertebrates if rat eradication on Kapiti Island is unsuccessful.

8.6 NON-INDIGENOUS BIRDS ON MANA ISLAND

Eighteen species of introduced birds have been recorded from Mana Island (Table 8.6). As the restoration goal for Mana Island is to restore the island to a state similar to what existed before human contact, the continued existence of populations of any introduced bird species conflicts with the overall restoration programme. Introduced birds could potentially compromise other conservation values on Mana Island by competing for food and nest sites, direct predation (especially magpie), seed destruction, and dispersal of weed seeds. Potential

benefits of the presence of introduced bird species include seed dispersal of native plants, high nutrient inputs below starling roosts (possibly analogous to the high nutrient input occurring around petrel colonies), and control of introduced invertebrates. The mosaic of habitats that will be created on Mana Island by the restoration programme will undoubtedly provide suitable habitats for all the species in Table 8.6 (with the possible exceptions of black swan and sulphur-crested cockatoo). Most of these bird species are extremely mobile and will undoubtedly continue to recolonise Mana Island even if the local population dies out or is eradicated. The high costs of attempting to control most species of introduced birds on Mana Island are not justified by the conservation gains that would be achieved. Management of those species for which control (or eradication) is feasible is discussed under "Control of animal pests".

8.7 HABITAT CREATION FOR BIRDS

Suitable habitat is already present on Mana Island for nine of the bird species proposed for introduction or attraction (fluttering shearwater, fairy prion, diving petrel, gannet, banded rail, shore plover, Chatham Island snipe, yellow-crowned parakeet and, possibly, rock wren). Completion of the planting programme will create sufficient forest habitat to support resident populations of little spotted kiwi, New Zealand pigeon, kaka, whitehead, robin, bellbird and tui within the next twenty years. Restoration of Waikoko wetland is regarded as necessary before brown teal and fernbird are reintroduced, and creation and maintenance of a network of small wetlands will provide habitat for takahe, brown teal and fernbird.

TABLE 8.6 INTRODUCED BIRD SPECIES RECORDED FROM MANA ISLAND. MAGPIES HAVE BEEN ERADICATED BY SHOOTING, AND BLACK SWAN, SULPHUR-CRESTED COCKATOO AND CIRL BUNTING ARE INFREQUENT VISITORS. THE SINGLE RED-RUMPED PARROT FOUND ON THE ISLAND IN MARCH 1996 WAS PROBABLY A CAGE ESCAPE, BUT ITS ORIGIN REMAINS A MYSTERY.

Black swan	Mallard	Rock pigeon
Sulphur-crested cockatoo	Red-rumped parrot	Skylark
Hedge sparrow	Blackbird	Song thrush
Yellowhammer	Cirl bunting	Chaffinch
Greenfinch	Goldfinch	Redpoll
House sparrow	Starling	Australian magpie

There is already suitable habitat on Mana Island for Snares Island tomtit if required, but further reafforestation will enhance the suitability of Mana Island as a "nursery" for young brown kiwi. Many of the plant species used in the planting programme are eaten by kakapo, but it is anticipated that provision of supplementary food will be necessary as part of any future intensive management of kakapo on Mana Island.

Smaller scale habitat manipulation for birds on Mana Island will include: excavation of artificial burrows to aid attraction of burrowing seabirds, planting toetoe and sedges around ponds to provide takahe nest sites, keeping existing

tracks and the beach ridge mown to provide some areas of low turf for shore plover, and providing nest boxes for parakeets and kaka.

8.8 ACTION PLAN

Assuming that the revegetation programme is completed in the next 15 years, and that the main wetland on Mana Island is restored, it should be possible to introduce one or two species of bird per year for the next ten years, while experiments to attract four species of seabird continue concurrently (Table 8.7). The sequence of introductions should be:

1999–2003 little spotted kiwi, shore plover, Chatham Island snipe, yellow-crowned parakeet

2000–2005 (assuming that Waikoko wetland is restored) brown teal, fernbird

2001–2005 New Zealand pigeon, whitehead, bellbird, tui

2006–2010 kaka

2006–2010 (assuming that initial introduction to Matiu/Somes Island has been successful) rock wren

TABLE 8.7 SUMMARY OF BIRD SPECIES RECOMMENDED FOR TRANSLOCATION OR ATTRACTION TO MANA ISLAND. TIMING IS BASED ON HOW SOON SUITABLE HABITAT IS EXPECTED TO BE AVAILABLE, AND THUS REPRESENTS HOW SOON A SPECIES COULD BE RELEASED RATHER THAN A WINDOW OF OPPORTUNITY THAT WOULD OTHERWISE BE MISSED. NOTE HOWEVER THAT THE TIMING OF INTRODUCTION OF BANDED RAIL (ESTIMATED AT 20+ YEARS) IS DEPENDENT ON THE SUCCESSFUL ESTABLISHMENT OF ALL OTHER SPECIES PROPOSED FOR INTRODUCTION (INCLUDING REPTILES AND INVERTEBRATES).

ESTABLISH SELF-SUSTAINING POPULATIONS	TIMING	SOURCE/COMMENT
Little spotted kiwi	Continuing	Franz Josef/Kapiti, 2 birds present
Fluttering shearwater	1–5 years	Cook Strait islands, trial underway
Fairy prion	1–5 years	Cook Strait islands, trial underway
Diving petrel	1–5 years	Cook Strait islands, trial underway
Australasian gannet	1–5 years	Attract birds foraging offshore, trial underway
Brown teal	1–5 years	Ducks Unlimited/Great Barrier I. Restore wetland first
Banded rail	20+ years	Marlborough Sounds/Tasman Bay/Golden Bay
Shore plover	1–5 years	Rangatira Island via National Wildlife Centre
Chatham Island snipe	1–5 years	Rangatira Island. Restore evolutionary potential
New Zealand pigeon	5–10 years	Kapiti Island. Important seed disperser

TABLE 8.7 cont. SUMMARY OF BIRD SPECIES RECOMMENDED FOR TRANSLOCATION OR ATTRACTION TO MANA ISLAND. TIMING IS BASED ON HOW SOON SUITABLE HABITAT IS EXPECTED TO BE AVAILABLE, AND THUS REPRESENTS HOW SOON A SPECIES COULD BE RELEASED RATHER THAN A WINDOW OF OPPORTUNITY THAT WOULD OTHERWISE BE MISSED. NOTE HOWEVER THAT THE TIMING OF INTRODUCTION OF BANDED RAIL (ESTIMATED AT 20+ YEARS) IS DEPENDENT ON THE SUCCESSFUL ESTABLISHMENT OF ALL OTHER SPECIES PROPOSED FOR INTRODUCTION (INCLUDING REPTILES AND INVERTEBRATES).

North Island kaka	10+ years	Kapiti Island. Needs extensive forest
Yellow-crowned parakeet	1–5 years	Chetwode Islands
Rock wren	1–5 years	?Fox Glacier. Restore evolutionary potential
North Island fernbird	1–5 years	?Manawatu Estuary. Restore wetland first
Whitehead	5–10 years	Kapiti Island. Await further revegetation
North Island robin	1995–96	Kapiti Island. Apparently established
Bellbird	5–10 years	Kapiti Island. Important pollinator
Tui	5–10 years	Kapiti Island. Important pollinator
INTENSIVE MANAGEMENT IN SHORT/MEDIUM TERM	COMMENT	
Other kiwi sp.	?Nursery for captive-hatched Haast tokoeka until large enough to cope with suite of predators present on mainland.	
Takahe	Supplementary feeding, ?cross-fostering to pukeko, and translocation of young between islands to reduce inbreeding.	
Kakapo	Supplementary feeding, intensive management (if required by Kakapo Recovery Programme)	
INTRODUCE ONLY IF UNDER IMMEDIATE THREAT OF EXTINCTION	COMMENT	
Snares Island tomtit	Introduce only if rats or other predators colonise Snares, and if North Island tomtit has not colonised naturally in the interim.	

9. Reptiles

Designing a future reptile community on Mana Island required information on:

- what indigenous species are currently present
- what species are likely to have been present historically
- what nationally or regionally threatened species require habitats free of introduced mammals to ensure their continued survival, and whether there are other more appropriate sites for their introduction
- potential conflicts between proposed introductions and resident species and/or other proposed introductions (including invertebrates and other reptiles), e.g., predation, competition, disease risk, hybridisation.

Mana Island already has nationally important populations of two threatened lizard species (McGregor's skink and goldstripe gecko) and it is essential that future introductions and habitat management do not jeopardise their survival.

The list of reptiles recorded from the entire Cook Strait Ecological District is not an appropriate model for guiding restoration of Mana Island's reptile fauna, as many lizard taxa do not occur on both sides of Cook Strait. Of 17 lizard species recorded from Cook Strait Ecological District, only eight (47%) occur on both sides of Cook Strait (Table 9.1). Most notably, Cook Strait is the southern limit of the skink genus *Cyclodina*, five species of which occur (or occurred) in the Wellington region.

TABLE 9.1 REPTILE SPECIES RECORDED FROM COOK STRAIT ECOLOGICAL DISTRICT, WITH A SUMMARY OF PAST AND PRESENT DISTRIBUTION ON BOTH SIDES OF COOK STRAIT. NOTE THAT PACIFIC GECKOS OCCUR NEARBY IN THE WELLINGTON ECOLOGICAL DISTRICT, AND WERE PROBABLY PART OF THE ORIGINAL COOK STRAIT REPTILE FAUNA. OGLE (1989a) RECOMMENDED THAT THE TWO SIDES OF COOK STRAIT BE INCLUDED IN DIFFERENT ECOLOGICAL REGIONS OR DISTRICTS BASED ON DIFFERENCES IN FAUNA EITHER SIDE OF THE STRAIT.

SPECIES	SOUTHERN NORTH ISLAND	MARLBOROUGH SOUNDS
Brothers Island tuatara	Tuatara bones from middens on Mana Island (species not determined)	North Brother Island
Cook Strait tuatara		Stephens & Trio Islands
Copper skink	Widespread (including Mana Island)	absent
Robust skink	Middens on Mana Island	absent
McGregor's skink	Mana Island	absent
Ornate skink	Kapiti Island and mainland	absent
Whitaker's skink	Pukerua Bay	absent
Speckled skink	Wairarapa	Stephens Island

TABLE 9.1 cont.

SPECIES	SOUTHERN NORTH ISLAND	MARLBOROUGH SOUNDS
Spotted skink	Matiu & Makaro Islands, rare elsewhere	On many islands and mainland
Common skink	Widespread (including Mana Island)	Widespread
Brown skink	Kapiti & Mana Islands and west coast	On many islands and mainland
Goldstripe gecko	Mana Island	absent
Duvaucel's gecko	Middens on Mana Island	Several islands (incl. Brothers & Trios)
Forest gecko	Kapiti Island and mainland	Maud, Motuara and Long islands and mainland
Common gecko	Widespread (including Mana Island)	Widespread
"Marlborough mini" gecko	Wellington south coast	Widespread
Striped gecko	absent	Stephens and Maud Islands
Wellington green gecko	Kapiti Island and mainland	absent
Marlborough green gecko	absent	Stephens, Arapawa & D'Urville Islands and mainland

As the reptile fauna of Cook Strait Ecological District is not an appropriate model for restoring the Mana Island reptile community, reptiles recorded from the Cook Strait coast of the southern North Island were used as a starting point for restoration. Reptile species were identified as being candidates for introduction if they met one of the following sets of criteria:

(a) species recorded in middens on Mana Island that were likely to have had a resident population, and that are unlikely to have significant impacts on threatened plant or animal species that survived on Mana (3 species).

(b) species present in the southern North Island that are declining in the presence of mammalian predators, are likely to be able to establish a self-sustaining population on the island, and are not expected to compromise other conservation values on the island (4 species).

Restoration of Mana Island's reptile fauna was considered in relation to potential ecological restoration on Kapiti and Matiu/Somes Islands, to ensure that at least one island population is established for each reptile species that is extinct or declining on the southern North Island mainland.

9.1 CURRENT SITUATION

Six reptile species are present on Mana Island: copper skink, McGregor's skink, common skink, brown skink, goldstripe gecko and common gecko. Copper skink, common skink and common gecko are abundant and widespread on Mana Island and elsewhere. Brown skinks were only discovered on Mana Island in 1996, but they are probably common in the island interior; their

distribution in the Wellington region is disjunct, but they are locally abundant. The Mana Island populations of McGregor's skink and goldstripe gecko are restricted and of national significance.

McGregor's skink occurs on only four islands: Motuharakeke (5.8 ha) in the Cavalli Group, Mauitaha (4.5 ha) in the Outer Bream Group, Sail Rock (3.4 ha) near Hen Island and Mana Island (217 ha), and is currently listed as a Category B species for conservation priority (Molloy & Davis 1994). McGregor's skink occur on less than 5 ha of Mana Island, but the population is increasing steadily since mice were eradicated (Newman 1994). The Mana Island population is of considerable significance as the southernmost population (by over 560 km) and the population with the greatest potential for natural expansion. It is also the most accessible population for research and management purposes. Changes in density and distribution have been monitored annually since 1985 on Mana Island (Newman 1994), and there is a coordinated programme to search other parts of the island for further surviving populations.

Goldstripe geckos are found in coastal Taranaki between Urenui and Patea, and on Mana Island; the species is currently listed as a Category C for conservation priority (Molloy & Davis 1994). Only four goldstripe geckos were found on Mana Island between their discovery in 1972 and 1992. A targetted survey in February 1993 (three years after mouse eradication) located a minimum of 112 goldstripe geckos at 11 sites scattered over a distance of 1.7 km (Whitaker 1993). Goldstripe geckos were found predominantly in areas of flax (9 of 11 sites), a rare vegetation type on the island. The Mana Island goldstripe gecko population is of national significance as the only island population, the only population free of predation by introduced mammals, and it is possibly the single largest surviving population (Whitaker 1993). Mana Island is also the largest protected land area where goldstripe gecko occur.

Future introductions of birds and reptiles to Mana Island as part of an ecological restoration programme must not compromise the continued survival and expansion of these two resident threatened reptile species.

9.2 WHAT WAS MANA ISLAND'S ORIGINAL REPTILE FAUNA?

Seven reptile species were identified following archaeological excavation on Mana Island (Horwood 1991 and in lit.; Table 9.2). Four of these species are still present on Mana Island, but the three others are no longer present in the southern North Island. These three species (tuatara, robust skink and Duvaucel's gecko) are all likely to have been resident on Mana Island, and should be high priorities for reintroduction.

The list of reptile species recorded from midden deposits on Mana Island is unlikely to be complete, as evident by the apparent absence of goldstripe gecko and brown skink remains from the midden (they may be impossible to distinguish from common gecko and common skink respectively). It is possible that any or all of the 17 reptile species recorded from the southern North Island may have been present on Mana, as all but three (speckled skink, Pacific gecko and "Marlborough mini" gecko) are known to have occurred on Kapiti Island, Mana Island and the coast in between.

TABLE 9.2 REPTILE SPECIES RECORDED FROM MIDDEN DEPOSITS ON MANA ISLAND (MICHELLE HORWOOD IN LIT.). MNI = MINIMUM NUMBER OF INDIVIDUALS REPRESENTED BY BONES RECOVERED. BONES IDENTIFIED BY TREVOR WORTHY.

SPECIES	MNI	NEAREST EXTANT POPULATION
Tuatara sp.	4	North Brother Island
Robust skink	7	Castle Island
McGregor's skink	4	Mana Island
Ornate/copper skink	3	Mana Island (copper skink)
Common skink	2	Mana Island
?Duvaucel's gecko	1	Brothers Islands
Common gecko	4	Mana Island

9.3 REPTILE SPECIES OF THE SOUTHERN NORTH ISLAND THAT MAY REQUIRE ISLANDS FREE OF MAMMALIAN PREDATORS

Of the 17 reptile species recorded from the southern North Island, only four (copper skink, common skink, common gecko and "Marlborough mini" gecko) remain widespread and abundant on the mainland (Miskelly 1995; Rod Hitchmough pers. comm.). The brown skink is locally abundant at a few sites, while ornate skink, spotted skink, forest gecko and Wellington green gecko are widely distributed, nowhere abundant and probably declining. Whitaker's skink, speckled skink and Pacific gecko are each known from only one or two sites in Wellington Conservancy, and are rare at these sites. The remaining five species are known only from islands within Wellington Conservancy (McGregor's skink, goldstripe gecko) or elsewhere (tuatara, robust skink, Duvaucel's gecko).

Islands free of mammalian predators may be required to ensure the long term survival of up to twelve species of reptiles from the southern North Island. Six of these species are already present on Kapiti Island (ornate skink, forest gecko, green gecko), Mana Island (McGregor's skink, goldstripe gecko) or Matiu/Somes Island (spotted skink), although the three species on Kapiti Island are all very rare there, possibly due to predation by Norway rats, kiore and a variety of predatory birds (morepork, kingfisher, long-tailed cuckoo and weka). The remaining six species (tuatara, robust skink, Whitaker's skink, speckled skink, Duvaucel's gecko and Pacific gecko) will have to be introduced, or reintroduced, to one or more of these islands to ensure their survival in the southern North Island. This will not be possible on Kapiti Island until rat eradication is confirmed.

9.4 RESTORING MANA ISLAND'S REPTILE FAUNA

Possible future reptile faunas for Mana, Kapiti and Matiu/Somes Islands are given in Table 9.3, with more detailed discussion for each species below. If all translocations recommended are completed successfully, there will eventually be 13 reptile species on Mana Island (217 ha), 15 species on Kapiti Island (1970 ha) and 11 species on Matiu/Somes Island (26 ha); are these islands able to support such diverse reptile faunas?

TABLE 9.3 REPTILES OF THE LOWER NORTH ISLAND, WITH SUGGESTIONS FOR RESTORING THE REPTILE FAUNAS OF MANA, KAPITI AND MATIU/SOMES ISLANDS. POSSIBLE SOURCE POPULATIONS FOR TRANSLOCATIONS ARE GIVEN IN BRACKETS. NOTE THAT SOME MAINLAND LIZARD POPULATIONS ARE NOW AT VERY LOW DENSITIES AND CONSIDERABLE CATCH EFFORT WILL BE REQUIRED TO OBTAIN SUFFICIENT ANIMALS FOR TRANSFER: ORNATE SKINK, WHITAKER'S SKINK, SPECKLED SKINK (WAIRARAPA), FOREST GECKO, PACIFIC GECKO AND WELLINGTON GREEN GECKO.

SPECIES	STATUS ON MANA ISLAND	STATUS ON KAPITI ISLAND	STATUS ON MATIU/SOMES ISLAND
Tuatara	Reintroduce (Stephens I)	?Introduce (Stephens I)	Reintroduce (Brothers Is)
Copper skink	Present	Present	Present
Robust skink	Reintroduce	Introduce	—
McGregor's skink	Present	Introduce (Mana I.)	—
Ornate skink	—	Present (rare)	Introduce (Wellington)
Whitaker's skink	Introduce (Pukerua Bay)	Introduce (Pukerua Bay)	—
Speckled skink	Introduce (Stephens I.)	Introduce (Stephens I.)	Introduce (Wairarapa)
Spotted skink	Introduce (Matiu)	Introduce (Matiu)	Present
Common skink	Present	Present	Present
Brown skink	Present	Present	Introduce (Makaro)
Goldstripe gecko	Present	Introduce (Mana I.)	—
Duvaucel's gecko	Reintroduce (Brothers Is)	?Present	—
Forest gecko	—	Present (rare)	Introduce (Wellington)
Common gecko	Present	Present	Present
"Marlborough mini" gecko	—	—	—
Pacific gecko	—	—	Introduce (Upper Hutt)
Wellington green gecko	Introduce (Wellington)	Present (rare)	Introduce (Wellington)
Number of species	6 → 13	7 → 15	4 → 11

There are three main factors that are likely to lead to reptiles failing to establish a new population, assuming that sufficient animals are released: lack of suitable habitat, excessive predation, and competition from ecologically similar species. All 17 species are likely to have been present in coastal habitats in the southwest North Island historically, and suitable habitat for all these species is likely to exist on Kapiti Island with its diverse vegetation and extensive rock talus slopes and boulder beaches. Kapiti Island is also

sufficiently large for closely related species to be spatially segregated during establishment. However, two species of rats were/are present on Kapiti (eradication attempted in 1996) along with a guild of predatory birds. Even if rats were successfully eradicated, it will be at least the turn of the century before eradication is confirmed and further checks are made for rare lizard species that may have survived rat predation in numbers too low to detect at present. It is too early to assume that it will be possible to restore a diverse reptile fauna to Kapiti Island.

Both Mana and Matiu/Somes Islands are free of rodents, have few resident predatory birds, and are predominantly covered in rank grass and seral shrubland. However, Mana Island is considerably larger than Matiu, and has larger areas of talus slopes and boulder beaches to provide suitable microhabitats for reptiles while the forest cover on the island becomes established. Of the reptile species listed in Table 9.3, almost all can occur and thrive in coastal shrublands, grassland and/or seral forest (Table 9.4). Within the Wellington region, possibly only the forest gecko requires established forest. All the larger *Cyclodina* skinks are primarily forest dwellers, but can survive in more open habitats provided there are sufficient retreats such as rock crevices, talus slopes, seabird burrows and dense ground cover.

Both Mana Island and Matiu/Somes Island are undoubtedly large enough to hold the diverse reptile faunas suggested for them. Middle Island in the Mercury Island group is half the size of Matiu and supports a reptile fauna composed of 11 species (tuatara, four *Cyclodina* skinks, three *Oligosoma* skinks and three *Hoplodactylus* geckos; Towns et al. 1990).

TABLE 9.4 SIZE, HABIT AND HABITAT OF THE SEVENTEEN REPTILE SPECIES RECORDED FROM THE SOUTHERN NORTH ISLAND. SVL IS MAXIMUM SNOUT-TO-VENT LENGTH (IN MM) RECORDED FOR COOK STRAIT SPECIMENS WHERE POSSIBLE (NOT KNOWN FOR ROBUST SKINK, PACIFIC GECKO AND FOREST GECKO). "COVER" REFERS TO ROCKS, LOGS ETC. LYING ON THE GROUND. NOTE THAT ALL LARGER *CYCLODINA* SKINKS REQUIRE HABITATS WITH DEEP RETREATS SUCH AS BURROWS, BOULDER BANKS, SCREES, LOGS OR DEEP LITTER. DATA FROM ROBB 1980, TOWNS 1992a, WHITAKER 1993 AND PERS. COMM., CREE 1994, NEWMAN 1994, ROD HITCHMOUGH PERS. COMM. AND MISKELLY PERS. OBS.).

SPECIES	SVL	HABIT	HABITAT
Tuatara	213	Nocturnal, ground-dwelling	Forest, scrub/seabird burrows
Copper skink	57	Diurnal/crepuscular, ground-dwelling	Open sites with cover/scrub
Ornate skink	72	Crepuscular, ground-dwelling	Forest/scree/scrub with cover
Whitaker's skink	100	Nocturnal, ground-dwelling	Forest/scrub/scree/seabird burrows
McGregor's skink	114	Nocturnal/crepuscular, ground-dwelling	Boulder beach/scrub/seabird burrows
Robust skink	120	Nocturnal, ground-dwelling	Forest/scree/seabird burrows
Common skink	63	Diurnal, ground-dwelling	Dry open sites with/without cover
Brown skink	66	Diurnal, ground-dwelling	Moist sites with cover/scrub/forest
Spotted skink	95	Diurnal, ground-dwelling	Open sites with cover/scrub/burrows
Speckled skink	115	Diurnal, ground-dwelling	Forest/scrub with cover/burrows
Common gecko	65	Nocturnal, ground-dwelling/arboreal	All habitats
"Marlborough mini" gecko	50	Nocturnal, ground-dwelling/arboreal	Coastal screes, cliffs and boulder beaches
Goldstripe gecko	75	Nocturnal/diurnal, arboreal	Flax/scrub
Pacific gecko	85	Nocturnal, arboreal/ground-dwelling	All habitats
Forest gecko	87	Nocturnal/diurnal, arboreal	Forest/scrub
Duvaucel's gecko	116	Nocturnal, ground-dwelling/arboreal	Cliffs/scrub/forest
Wellington green gecko	95	Diurnal, arboreal	Scrub/forest

While all the reptile species under discussion have been broadly sympatric in the past, not all species pairings have been recorded from the same site (Figure 9.1). This raises the issue that some species may be ecologically incompatable with each other, and that inappropriate introductions may lead to one or more species becoming locally extinct through competitive interactions. However, there are few data to support this possibility, as most species pairs that are known to have similar ecological requirements (Table 9.4) are currently sympatric at some sites, e.g., copper/ornate skinks, ornate/McGregor's skinks, Whitaker's/robust skinks, common/brown skinks, spotted/speckled skinks, common/goldstripe geckos, goldstripe/Pacific geckos, common/Pacific geckos, Pacific/forest geckos. It is possible that ecological interactions may be more complex than revealed by species-pair comparisons, for example there are no known sites in Taranaki where goldstripe, Pacific and common geckos occur together (Tony Whitaker pers. comm.).

	Green gecko	Pacific Gecko	Common gecko	Forest gecko	Duvaucel's gecko	Goldstripte gecko	Brown skink	Common skink	Spotted skink	Speckled skink	Whitaker's skink	Ornate skink	McGregor's skink	Robust skink	Copper skink
Tuatara sp.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Copper skink	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Robust skink	●	●	●	●	●	●	●	●	●	●	●	●	●		
McGregor's skink	❍	●	●	❍	●	●	●	●	❍	❍	●	●			
Ornate skink	●	●	●	●	●	●	●	●	❍	●	❍				
Whitaker's skink	●	●	●	❍	●	❍	●	●	❍	❍					
Speckled skink	●	❍	●	❍	●	❍	●	●	●						
Spotted skink	●	❍	●	●	●	❍	●	●							
Common skink	●	●	●	●	●	●	●								
Brown skink	●	●	●	●	●	●									
Goldstripe gecko	●	●	●	●	●										
Duvaucel's gecko	●	●	●	●											
Forest gecko	●	●	●												
Common gecko	●	●													
Pacific gecko	●														

Figure 9.1 Recorded sympatry in reptiles of the southern North Island, based on records at specific sites for islands, or records from the same 10,000 metre grid square on the mainland. Data mainly from Amphibian and Reptile Distribution Scheme database administered by Department of Conservation. Note that all 120 potential species pair combinations have been recorded within one Ecological District. ● = reported sympatry for respective species pair, ❍ = no reported sympatry. Some records are from subfossil remains (Worthy 1987 & 1991) therefore temporal sympatry is unproven in these cases. Species not intended for introduction to Mana Island are shaded to highlight that only eight new sympatry pairings will be created during restoration of the Mana Island reptile fauna (see text for discussion).

The seven reptile reintroductions/introductions proposed for Mana Island will create eight species pairings that have not previously been recorded at a single site (Figure 9.1). In all eight cases the two species involved have very

different ecological requirements; in seven cases one species is diurnal and the other is nocturnal, and in the remaining case (Whitaker's skink/goldstripe gecko) one species is ground-dwelling and the other arboreal. There is a possibility that the diurnal speckled skink could occupy the same habitats and retreats as the large, nocturnal or crepuscular *Cyclodina* species, and so liberation sites for these species should be widely separated. A pen trial to assess competition for retreats between McGregor's skink and speckled skink should also be attempted.

Perhaps the most contentious reptile introduction issue for Mana Island is whether Whitaker's skink should be introduced, given the presence of the larger, aggressive McGregor's skink, and plans to reintroduce robust skinks. All three species are large (maximum weights 20 g for Whitaker's skink, 40 g for McGregor's skink and 70 g for robust skink), all are nocturnal and have similar physiological requirements (Cree & Daugherty 1991). Whitaker's and robust skinks are naturally sympatric on two islands (Middle Island and Castle Island; Table 9.5), but McGregor's skink no longer occurs at any site where either of the two other species occurs. Historically all three species occurred throughout the North Island, and their bones have been found together in one cave deposit (Tapuwae Weka Cave, Waitomo; Worthy 1987). McGregor's skink and robust skink were sympatric at several sites including Mana Island.

Large *Cyclodina* skinks are extremely vulnerable to mammalian predators, and the current distribution of robust, McGregor's and Whitaker's skinks probably reflects sites at which they were able to escape predation either through the absence of mammals (eight islands), or unusual features of their habitat that provided protection from predators (Pukerua Bay and Mana Island). The eight northern islands with these large *Cyclodina* skinks are all tiny, ranging in size from 1 ha to 13 ha, and so it is hardly surprising that these three large *Cyclodina*s have failed to survive at any one site due to the effects of chance, stochastic events and/or competitive interactions. Perhaps what is most surprising is that on the largest island (Middle Island, 13 ha) an additional large *Cyclodina* (marbled skink, c. 15 g; D.R. Towns pers. comm.) has survived, this is the only location where three large species of *Cyclodina* are currently sympatric, although the same three species have recently been introduced to nearby Korapuki, Red Mercury and Stanley Islands.

Mana Island is sufficiently large that all three large *Cyclodina* species could be widely separated during establishment of robust and Whitaker's skinks, and it is unlikely that all three would occur at any one site for many decades. By the time any of the three populations expands sufficiently for their ranges to overlap all three species should be sufficiently abundant and widespread for each species to have a competitive advantage in its preferred habitats.

TABLE 9.5 SYMPATRY IN THE THREE LARGE *CYCLODINA* SKINKS KNOWN FROM THE SOUTHERN NORTH ISLAND. ALL SUBFOSSIL LOCATIONS ARE FROM WORTHY (1987 & 1991), EXCEPT ROBUST SKINK FROM MANA ISLAND (SEE TOWNS 1992B).

McGregor's skink only	Motuharakeke (5.8 ha; Cavalli group) Mauitaha (4.5 ha; Outer Bream group) Sail Rock (3.4 ha; near Hen Island)
Robust skink only	Matapia Island (2 ha; Northland) 2 sites, Northland (subfossil) Moturoa Island (9.5 ha; Northland) Green Island (4 ha; Mercury group) 12 sites, Waitomo (subfossil) Coonoor region, southern Hawkes Bay (subfossil) 6 sites, Martinborough (subfossil)
Whitaker's skink only	2 sites, Waitomo (subfossil) Pukerua Bay
McGregor's skink Robust skink	Tokerau Beach, Northland (subfossil) Otangaroa Station Cave, Northland (subfossil) 3 sites, Waitomo (subfossil) Mana Island (robust skink only from midden deposits)
McGregor's skink Whitaker's skink	—
Robust skink Whitaker's skink	Motutapu Island (subfossil) Middle Island (13 ha; Mercury group) Both introduced to Korapuki Island (18 ha), Red Mercury Island (225 ha) and Stanley Island (100 ha) in the Mercury Island group Castle Island (3 ha; off Hot Water Beach) Opening Day Cave, Waitomo (subfossil)
McGregor's skink Robust skink Whitaker's skink	Tapuae Weka Cave, Waitomo (subfossil)

9.5 RECREATING A REPTILE COMMUNITY FOR MANA ISLAND

The following annotated list includes six species that are currently present on Mana, seven species that should be introduced (or reintroduced) to the island, and four species that are not considered appropriate for introduction within the next 20 years even though present (or formerly present) in the southern North Island.

Species that should not be introduced in the next 20 years (unless new information is obtained on habitat requirements and/or impacts on other species) are listed in square brackets. Species to be introduced (or reintroduced) to the island are listed in bold lettering. Possible release sites are shown in Figure 9.2.

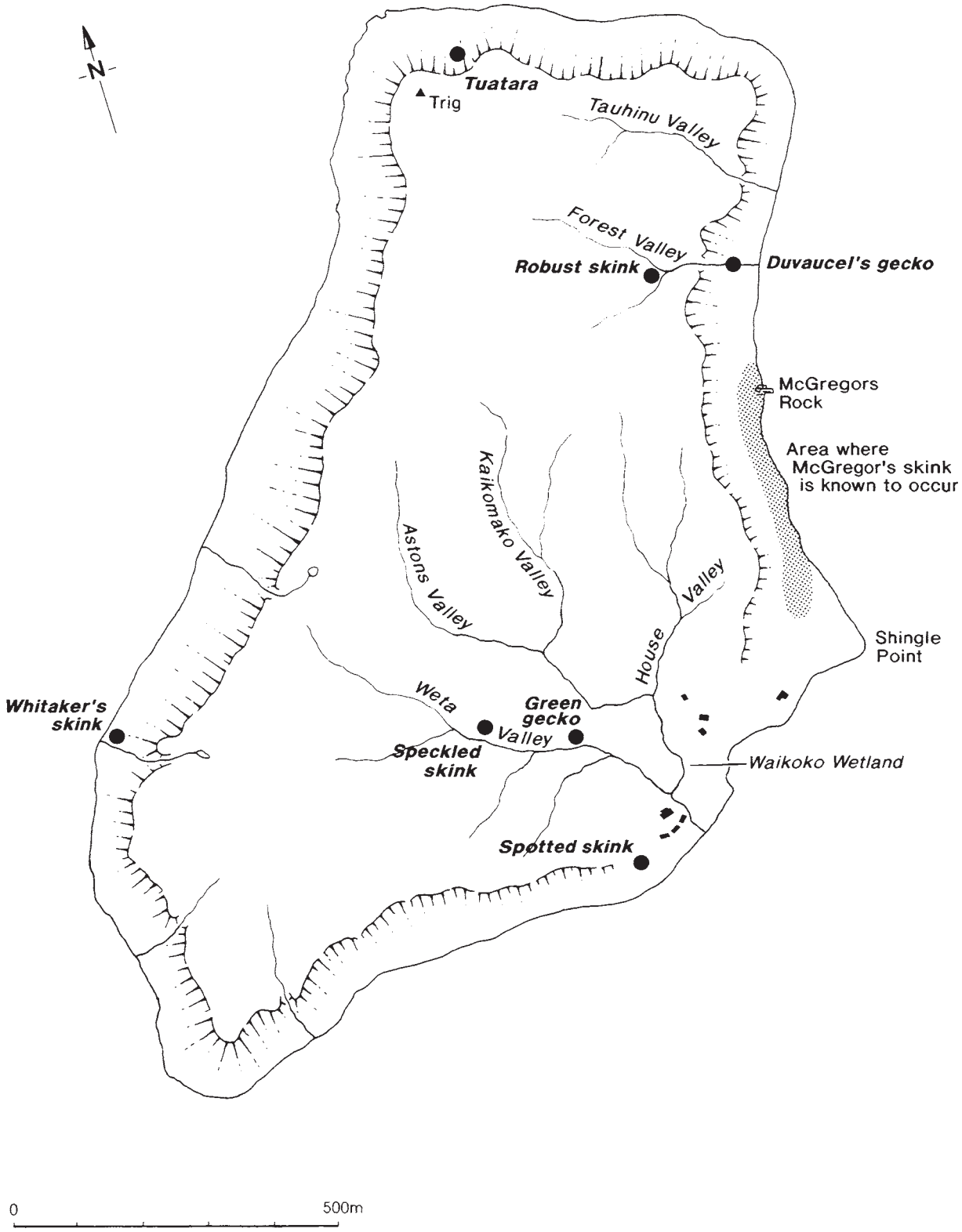

Figure 9.2 Map of Mana Island showing possible liberation sites for reptiles, and the current distribution of McGregor's skink.

Cook Strait tuatara [Brothers Island tuatara]

Brothers Island tuatara has a category A national conservation priority (Davis & Molloy 1994) and medium conservancy priority (Department of Conservation 1996); Cook Strait tuatara has a category B national conservation priority and medium conservancy priority. Both species of tuatara are present in the Cook Strait region. Tuatara bones (species not determined) have been recovered from middens on Mana Island. The Tuatara Recovery Group has recommended that Cook Strait tuatara be released on Mana Island.

There are many current proposals to introduce or reintroduce tuatara to islands (e.g., Cuvier, Red Mercury, Stanley, Moutohora, Titi and Matiu/Somes Islands). These programmes are likely to provide information on release and monitoring methods that will be used to guide establishment on Mana Island.

Tuatara are predators on other reptiles and large invertebrates, and so care should be taken to ensure that liberations of tuatara on Mana Island do not jeopardise liberations of other threatened species or populations of resident threatened species on the island. For this reason, release sites for tuatara should not be on the shore platform (habitat for McGregor's skink on northeast coast and possible release site for Whitaker's skink on southwest coast) or near Forest Valley (proposed release site for robust skink and Duvaucel's gecko). The intrinsically low reproductive rate of tuatara (Cree 1994) and the low number of animals likely to be released should ensure that there is ample time for all other reptile species to become established on Mana Island before tuatara are sufficiently numerous to limit population expansion of other species (see Towns 1994).

One issue that has not yet been resolved is whether tuatara are dependent on the presence of burrowing seabirds. All of the islands where tuatara currently occur support populations of burrowing petrels. However, there is increasing evidence that tuatara were abundant at some mainland sites in the absence of petrels (Worthy & Holdaway 1994) and that the current distribution of tuatara and petrels has been determined by the absence of mammalian predators rather than an obligate dependence of tuatara on petrels. Liberation of tuatara on Matiu/Somes and Mana Islands will be opportunities to test the relationship between tuatara and burrowing petrels.

Management action

Select a release site that meets the ecological and physiological requirements of tuatara, is distant from proposed released sites for other threatened reptiles, and away from public tracks (in consultation with Tuatara Recovery Group). The most likely release site is a north-facing amphitheatre part way down the cliff east of the trig (Figure 9.2), where there is a small colony of sooty shearwaters. Another possible release site is near the main sooty shearwater colony on a clifftop at the southwest of the island. Prepare the release site by digging artificial burrows, and any other measures recommended by the Tuatara Recovery Group. Plan for release in 1999 or soon after. Continue with attempts to attract burrowing seabirds to Mana Island.

Copper skink

Low conservancy priority (Department of Conservation 1996). Common throughout Mana Island. May increase with increasing scrub cover and more extensive forest margins, but unlikely to remain abundant in dark forest interior.

Management action

None required. Some monitoring occurs as by-catch during McGregor's skink monitoring.

Robust skink

Category B (Davis & Molloy 1994); medium-high conservancy priority (Department of Conservation 1996). Known from midden deposits on Mana Island. Robust skinks are thought to be primarily forest-dwelling, but their current distribution is confined to scrub and low forest with dense seabird colonies on small rodent-free islands. The release site chosen has high invertebrate prey densities and could easily be modified to provide humid microclimates required by robust skinks (Cree & Daugherty 1991), however Forest Valley is unlikely to have high densities of burrowing seabirds for many decades.

The current distribution and habitat use by large *Cyclodina* skinks has been dictated by the presence or absence of rodent predators. Release of robust skinks into Forest Valley on Mana Island would provide information on habitat use, including whether robust skinks are dependent on the presence of burrowing seabirds.

Management action

Prepare Forest Valley as a release site by digging artificial burrows, placing logs and slabs of untreated wood on the forest floor, and erecting leaf litter traps. Liaise with *Cyclodina* Recovery Group to identify source population and timing for release (preferably 1999 or soon after). Conduct pitfall trapping at proposed release site for at least one summer season prior to release to determine whether McGregor's skinks are present. Continue revegetation programme and attempts to attract burrowing seabirds to Mana Island.

McGregor's skink

Category B (Davis & Molloy 1994); high conservancy priority (Department of Conservation 1996). Confined to less than 5 ha of the north-eastern shore platform. Although the population is increasing and expanding in range since mice were eradicated, the intrinsically low reproductive rate of large *Cyclodina* skinks (Cree 1994) and the sedentary behaviour of McGregor's skinks on Mana Island (Newman 1994) indicate that it will be many decades, if not centuries, before all suitable habitats on the island are colonised. While currently confined to a shore platform of cobbles and boulders, it is expected that McGregor's skinks will spread through forested areas as revegetation progresses, especially if burrowing seabirds are present.

An existing survey and monitoring programme seeks to ascertain whether other pockets of McGregor's skinks still survive on Mana Island. Although there is one old record (1972) from the southwest coast, there is no intention to

reintroduce McGregor's skinks to this site, as it is close to a possible release site for Whitaker's skink. A pittrapping survey was conducted at this site during 1995-96 and 1996-97, and no McGregor's skinks were found.

Management action

Continue monitoring population dynamics of the known population, and southward expansion onto Shingle Point. Conduct pitfall trapping from McGregor's Rock north to the mouth of Tauhinu Valley. Continue revegetation programme and attempts to establish populations of burrowing petrels on Mana Island.

[Ornate skink]

Low conservancy priority (Department of Conservation 1996). Although widely distributed in the Wellington region, ornate skinks are rare and difficult to locate on the mainland. They are present on Kapiti Island, but are currently very rare there presumably due to predation by rats and weka. Ornate skinks occur on several northern offshore islands, but are not sympatric with Whitaker's skink at any site. As ornate skinks are only slightly smaller than Whitaker's skink and are likely to inhabit similar habitats, ornate skinks are not recommended for introduction to Mana Island at this stage. Future observations on Kapiti Island (assuming that rats are eradicated and Whitaker's skinks introduced) may establish whether ornate and Whitaker's skinks can coexist, and indicate whether it is feasible to create a lizard community with five species of *Cyclodina* on Kapiti and/or Mana Islands.

Management action

Do not introduce ornate skinks to Mana Island unless there is new evidence that five species of *Cyclodina* (copper, robust, McGregor's, ornate and Whitaker's skinks) can coexist.

Whitaker's skink

Category B (Davis & Molloy 1994); high conservancy priority (Department of Conservation 1996). The only remaining population of Whitaker's skink in the Wellington region occurs in less than one hectare of habitat at Pukerua Bay (Towns 1992a). The *Cyclodina* Skink Recovery Group has identified the establishment of an island population of Whitaker's skink sourced from Pukerua Bay as a high priority (Towns 1992b). Neither of the two other islands in the Wellington region are suitable for the introduction of Whitaker's skink in the near future, as there may still be two species of rat plus weka on Kapiti Island, and Matiu/Somes Island does not have extensive areas of rock scree, boulder beach or petrel colonies. The issue of whether to introduce Whitaker's skinks to Mana Island given the presence of McGregor's skinks is discussed above; this section is written assuming that introduction of Whitaker's skinks to Mana Island is appropriate.

At Pukerua Bay, Whitaker's skinks occur at a north-facing site at the toe of a scree slope covered with *Muehlenbeckia* and *Coprosma* (Towns 1992a). There are many similar sites on Mana Island, although those with a north-east or north aspect are within or close to the known range of McGregor's skinks on the island. The most promising site for liberating Whitaker's skinks on

Mana Island is at the southern end of the western bay (Figure 9.2) where they would be separated from known populations of McGregor's skink by 3 km of shore platform. This site has a north-west aspect, is densely vegetated, has reasonable densities of nesting penguins and gulls, and receives sunshine from at least 1030 hrs even in mid-winter.

Whitaker's skinks have a very low intrinsic reproductive rate and appear to be more ecologically specialised than their congeners (Towns 1994). In reviewing translocation methodology for Whitaker's skinks, Towns (1994) recommended that they be released as early as possible in the restoration programme, or at sites well away from species that are better colonisers or predators. On islands larger than 100 ha, Towns recommended simultaneous release of all reptile species at widely separated sites.

Management action

Survey the southern end of the western bay on Mana Island to identify a site with similar microhabitats to the Pukerua Bay Whitaker's skink colony, but with a variety of different habitats in close proximity (Towns 1994). Liaise with *Cyclodina* Skink Recovery Group to determine capture and transfer methodology and timing.

Speckled skink

Medium-high conservancy priority (Department of Conservation 1996). Speckled skinks have an enigmatic distribution, occurring on Moutohora Island (Bay of Plenty), Stephens Island and at a few sites in central and southern North Island and north-west South Island. There are two records from the Wairarapa (Miskelly 1995). The animals on Stephens Island are considerably larger than those recorded from other sites (Hardy 1977, Robb 1980) but no genetic differences are apparent (Daugherty et al. 1994). Introduction to Mana Island would establish an island population in the southern North Island and provide a second population of the large animals from Stephens Island. If a Wairarapa population is located, establishment on Matiu/Somes Island should be investigated (Table 9.3).

Speckled skinks are diurnal, and favour damper sites with dappled sunlight compared to the similarly sized spotted skink. Both species occur together on Stephens Island and near Nelson Lakes.

On Stephens Island speckled skinks are often found in seabird burrows under forest, i.e., in similar habitats and sites to those where large *Cyclodina* skinks occur on northern islands. There are no known sites where speckled skinks are currently sympatric with robust, McGregor's or Whitaker's skinks (although there is one subfossil site where robust and speckled skinks occur together; Worthy 1991). Large *Cyclodina* skinks are all nocturnal or crepuscular, and so would be active at different times of day than speckled skinks. However, it is not known how speckled skinks and these other species would interact if there were few retreats available, and pen trials should be undertaken to determine this. The release site chosen for speckled skinks is far from those chosen for robust and Whitaker's skinks to reduce the risk of competition for retreats. The spread of both speckled skink and McGregor's skink should be monitored so that any competitive interactions can be assessed when they eventually come into contact.

The release site chosen (Figure 9.2) is on the edge of established plantings and old macrocarpa trees at the mouth of Weta Valley, distant from other skink release sites.

Management action

Conduct cage trials to assess competition for refuges between speckled and McGregor's skinks. Prepare release site by ensuring that ample loose cover is present (e.g., rocks and logs). Continue monitoring of the southward spread of McGregor's skink, and study interactions with speckled skinks if/when they come into contact.

Spotted skink

Medium-high conservancy priority (Department of Conservation 1996). Spotted skinks are abundant on Matiu/Somes, Mokopuna and Makaro Islands in Wellington Harbour. Although not recorded from Mana Island, there are old records from Titahi Bay and Plimmerton (Miskelly 1995). Spotted skinks are now rare or absent from mainland sites west of the axial ranges in the southern North Island.

Spotted skinks are diurnal and prefer sunny sites with abundant cover. It is anticipated that spotted skinks will eventually spread throughout the rank grasslands and around the shore platform on Mana Island. The area of habitat suitable for spotted skinks will decline as revegetation progresses, but extensive areas of habitat will remain around the shore, on the cliffs and on the plateau.

The other diurnal skinks present/proposed for release on Mana Island are common skink, brown skink and speckled skink, all of which are sympatric with spotted skinks on 150 ha Stephens Island (East et al. 1995).

The release site chosen (Figure 9.2) is distant from other reptile release sites and the resident McGregor's skink population, and is similar to sites where spotted skinks are abundant on Matiu/Somes Island.

Management action

Fifty adult spotted skinks from Matiu/Somes Island were released at a site on the south-eastern shore platform in February 1998. Monitor population expansion by pitfall trapping and hand-searching.

Common skink

Low conservancy priority (Department of Conservation 1996). Extremely abundant throughout grassland, open shrubland and around the shoreline on Mana Island. Absent from the forest remnant and the most established plantings. Likely to decline as forest cover becomes more prevalent, but large areas of suitable habitat will remain around the shore platform, clifftops and around forest margins.

Management action

None required. Some monitoring occurs as by-catch during McGregor's skink monitoring.

Brown skink

Low conservancy priority (Department of Conservation 1996). Brown skinks were only recognised as being present on Mana Island in 1996, but there have since been at least ten records spread over a large area of the island's interior. It is presumed that a combination of habitat modification (grazing) and mouse predation reduced brown skinks to such low levels that they were not detected during lizard survey work before 1996. Brown skinks are likely to increase in numbers and range now that there are large areas of suitable habitat and no mammalian predators.

Management action

None required. Some monitoring may occur as by-catch during other skink monitoring programmes.

Goldstripe gecko

Category C (Davis & Molloy 1994); medium conservancy priority (Department of Conservation 1996). Although widespread and locally abundant on Mana Island, there are still areas of apparently suitable habitat, including recent plantings, that have not yet been colonised by goldstripe geckos. On Mana Island goldstripe geckos are most numerous in flax, and so corridors of flax could be used to ensure that goldstripe geckos can colonise all areas of shrubland and forest, and some areas of flax should be retained permanently. The national importance of the Mana Island goldstripe gecko population is such that monitoring by encounter rates during spotlighting should be conducted at five-yearly intervals (Whitaker 1993). This monitoring could be designed to assess the spread of goldstripe geckos into new habitats.

Management action

Plant flax around wetlands and water storage ponds, and along all valley floors where active revegetation is planned. Ensure that corridors of flax link all areas of suitable habitat for goldstripe geckos. Monitor distribution and abundance of goldstripe geckos on Mana Island at five-yearly intervals.

Duvaucel's gecko

Not mentioned in Wellington Conservancy CMS (Department of Conservation 1996). Recorded from midden deposits on Mana Island. Duvaucel's gecko is New Zealand's largest extant lizard, and is now confined to islands off the north-east coast of the North Island and in Cook Strait. In the Cook Strait region, Duvaucel's geckos are present on the Brothers Islands, Trio Islands and Sentinel Rock, and possibly Stephens and Kapiti Islands (unconfirmed records).

Duvaucel's geckos are nocturnal and use a wide range of habitats, including foraging on flax nectar. It is anticipated that Duvaucel's geckos will eventually spread through forest, scrub and cliff habitats on Mana Island from the preferred release site in Forest Valley. There are no sites where Duvaucel's and goldstripe geckos are currently sympatric, and so it is difficult to predict how the two species will interact [this is the subject of a current MSc study by Halema Flannagan, Massey University]. However, both species must have

coexisted on Mana Island in the past, and so it is unlikely that reintroduction of Duvaucels's gecko will have a major impact on the expanding goldstripe gecko population. Goldstripe geckos are present in low numbers in Forest Valley (Whitaker 1993), but this is over 500 m from the largest goldstripe gecko population near the houses.

Management action

Assess potential for competition between Duvaucel's geckos and goldstripe geckos. Plan for release in 1998 or soon after. Monitor spread of Duvaucel's gecko and study habitat use compared to goldstripe and common geckos.

[Forest gecko]

Medium conservancy priority (Department of Conservation 1996). Forest geckos are widely distributed on the New Zealand mainland and a few offshore islands, but are very difficult to locate on the mainland. Within the Cook Strait region, forest geckos have been recorded from Kapiti, Long, Motuara and Maud Islands, but were very rare on Kapiti, Motuara and Long Islands in the presence of rats. Forest geckos occur only on islands with established forest, although the very similar "Westland" gecko and *Hoplodactylus nebulosus* (both included with forest gecko in *H. granulatus* until recently; Daugherty et al. 1994) both occur on very small islands with low scrub cover.

Forest geckos may require mature trees to ensure sufficient cavities and loose bark to hide in. The seral forest being established on Mana Island may not provide sufficient retreats for forest geckos in the presence of goldstripe, common and Duvaucel's geckos. Coexistence of these four species should be examined on Kapiti Island if rats are eradicated and goldstripe geckos introduced. Forest geckos could be considered for introduction to Mana Island in the long term if mature forest is established and if there is little risk of competition with goldstripe geckos.

Management action

Do not introduce forest geckos to Mana Island. Reassess when mature forest is established and if goldstripe geckos are proven to be able to establish on Kapiti Island in the presence of forest and common geckos.

Common gecko

Low conservancy priority (Department of Conservation 1996). Extremely abundant in most habitats on island. May increase further as grassland converted to forest.

Management action

None required. Some monitoring occurs as by-catch during McGregor's skink monitoring.

[Pacific gecko]

Currently low conservancy priority (Department of Conservation 1996), however, this may need revision (Raewyn Empson pers. comm.). Pacific geckos are widely distributed in the North Island and occur on many of the northern offshore islands (Pickard & Towns 1988). However, Pacific geckos

are very rare in the southern North Island, with only three records south of Palmerston North, all in the vicinity of Upper Hutt (Miskelly 1995). Pacific geckos are not nationally threatened, but attempts should be made to establish an island population in the Wellington region using local stock. As there is uncertainty over whether Pacific gecko, goldstripe gecko and common gecko can all coexist at one site (see above), Matiu/Somes Island (where goldstripe geckos are absent) is recommended as a release site for Pacific geckos from the Wellington region, with the potential to eventually establish a second population on Kapiti Island.

Management action

Pacific geckos should not be introduced to Mana Island unless there is clear evidence that they can coexist sympatrically with both common and goldstripe geckos.

Wellington green gecko

Medium-high conservancy priority (Department of Conservation 1996). Green geckos are mainly found in seral forest and scrub habitats, and have been found on only ten offshore islands to date: Great Barrier (27761 ha), Little Barrier (3083 ha), Waiheke (9333 ha), Kapiti (1970 ha), Stephens (150 ha), D'Urville (16782 ha), Arapawa (7785 ha), Adele (88 ha), Green (81 ha) and Codfish (1396 ha). This preference for large islands may be because large land areas are necessary to ensure that there are always some areas of seral forest present (D.R. Towns pers. comm.). However, the apparent preference of green geckos for seral habitats may be an artefact of search effort, as the canopy of mature forest is very difficult to search; green geckos do occur in mature forest as well (A.H. Whitaker pers. comm.).

Green geckos are widespread in the Wellington region, but there were few reports in the ten years to 1995 (Miskelly 1995). The decline in green geckos on the New Zealand mainland is thought to be due to predation by introduced mammals, but there is little direct evidence for this. On Stephens Island (where green geckos occur in the absence of rodents), green geckos are exceptionally abundant.

The revegetation programme on Mana Island is creating extensive areas of seral forest that will provide large areas of suitable habitat for green geckos. As the forest matures there will be an opportunity to determine habitat preferences of green geckos in the absence of mammalian predators. A healthy and expanding Wellington green gecko population on Mana Island could be used as a source population for other restoration programmes in the Wellington region, e.g., Karori Reservoir.

It will be very difficult to obtain sufficient Wellington green geckos from a single site to establish a population on Mana Island. It is envisaged that animals will have to be sourced from a wide area (following a public request for recent sightings).

Management action

Seek recent reports of green geckos from Wellington region through local media. Trickle release Wellington green geckos into established plantings as animals become available, beginning in 1998.

9.6 SUMMARY OF ACTIONS REQUIRED TO RESTORE A DIVERSE REPTILE COMMUNITY REPRESENTATIVE OF THE SOUTHERN NORTH ISLAND ON MANA ISLAND

1. Select/confirm release sites
   - Tuatara
   - Robust skink
   - McGregor's skink
   - Whitaker's skink
   - Speckled skink
   - Spotted skink
   - Duvaucel's gecko
   - Wellington green gecko

2. Survey for presence of McGregor's skink
   - Robust skink release site
   - Mouth of Tauhinu Valley

3. Prepare habitat
   - Tuatara (dig burrows)
   - Robust skink (dig burrows, provide decaying wood, create litter traps)
   - Speckled skink (provide cover)
   - Spotted skink (provide cover)
   - Goldstripe gecko (plant flax corridors)
   - Continue revegetation (provide habitat for geckos and *Cyclodina* skinks)
   - Attract burrowing seabirds (keystone species to support diverse and abundant reptile fauna)

4. Monitor
   - McGregor's skink (annual monitoring of population growth and spread)
   - Goldstripe gecko (5-yearly monitoring of distribution)
   - Establishment and expansion of all reptile species introduced to Mana Island

5. Liaise with recovery groups
   - Tuatara
   - *Cyclodina* skinks

6. Liaise with Nelson/Marlborough Conservancy to confirm availability of animals for translocation to Mana Island, and to co-ordinate transfers with island restoration programmes in the Marlborough Sounds
   - Cook Strait tuatara
   - Speckled skink
   - Duvaucel's gecko

7. Liaise with iwi
   - All translocations

8. Liaise with captive breeders of reptiles
   - Robust skink
   - Whitaker's skink (to hold Pukerua Bay animals until sufficient caught for transfer)

- Wellington green gecko

9. Identify source populations
   - Robust skink
   - Wellington green gecko

10. Translocations
    a. As soon as possible between 1998 & 2005
    - Cook Strait tuatara
    - Robust skink
    - Spotted skink
    - Wellington green gecko
    - Whitaker's skink

    b. Following further research on interactions with resident species
    - Speckled skink
    - Duvaucel's gecko

11. Research required to finalise reptile community structure on Mana Island
    - Sympatry and niche overlap in *Cyclodina* skinks (*C. aenea*, *C. alani*, *C. macgregori*, *C. ornata*, *C. whitakeri*)
    - Interactions between speckled skink and *Cyclodina* skinks
    - Sympatry and niche overlap in *Hoplodactylus* geckos (*H. chrysosireticus*, *H. duvaucelii*, *H. granulatus*, *H. maculatus*, *H. pacificus*)

10. Other vertebrates

The Wellington region would have originally supported at least three species of bats (Daniels 1990), four species of leiopelmid frog (Worthy 1987b) and about 19 species of freshwater fish (McDowall 1990). Of these, four species (greater short-tailed bat, the frogs *Leiopelma markhami* and *L. waitomoensis*, and the grayling) are now extinct, and two further frogs ("Hamilton's" type frog and Hochstetter's frog) are locally extinct. Two species of bat are thought to be still present, with long-tailed bats on Kapiti Island and in the Tararua and Rimutaka Ranges, and occasional reports of lesser short-tailed bats from the Tararua Ranges. Both species of bats are high priorities for recovery programmes (Molloy 1995).

Five species of freshwater fish that survive in the southern North Island are considered threatened (Molloy & Davis 1994): short-jawed kokopu (Category A), giant kokopu and brown mudfish (Category B), and koaro and banded kokopu (Category C).

10.1 CURRENT SITUATION

No bats or amphibians have been recorded from Mana Island (though note reference to a mythical giant frog "*moka-mokai a Maru-te-whare-aitu*" on Mana Island in Best 1923). The only freshwater fish recorded are shortfinned eels.

10.2 POTENTIAL OF MANA ISLAND AS HABITAT FOR NATIVE BATS, FROGS AND FRESHWATER FISH

Suitable habitat for bats will not be present on Mana Island for many decades, as bats require many old hollow trees or trees with loose bark as roost sites. In the long term long-tailed bats, and possibly short-tailed bats, should be introduced to Mana Island, but it would be unrealistic to attempt introductions of bats to Mana Island within the time frame of other restorative actions outlined in this restoration plan.

Two species of native frogs have survived in the Sounds-Wellington Ecological Region: Hamilton's frog on Stephen's Island, and Maud Island frog (Bell et al. 1998). The two species cannot be distinguished osteologically (Trevor Worthy pers. comm.) and either species may be represented by bones from the Wairarapa (Worthy 1987b). Both frogs are terrestrial, occurring in rock piles and under logs or deep, damp litter on the forest floor. Mana Island has only one tiny area of rock tumble in the island interior (in Kaikomako Valley) and the forest interior is likely to be too dry to support leiopelmid frogs. While it may be possible to engineer small areas of rock piles to provide habitat for frogs on Mana Island, the effort could not be justified given the extensive areas of apparently suitable habitat on nearby Kapiti Island. If

leiopelmid frogs are to be restored to the Wellington region, the top priority must be Kapiti Island following rat eradication.

Mana Island has very limited potential as habitat for freshwater fish, as the streams stop flowing in summer, and all three stream outlets reach the sea by flowing through (rather than over) beach gravels. Restoration of the main wetland may provide suitable habitat for the threatened brown mudfish, which does not require access to the sea (McDowall 1990). However, the recent discovery of eels on Mana Island may prevent the establishment of mudfish. The brown mudfish is a high priority for conservation action in Wellington Conservancy (Department of Conservation 1996); the nearest population to Mana Island is in Paraparaumu Scenic Reserve.

10.3 RECOMMENDED MANAGEMENT ACTION

Restore the Waikoko wetland. When vegetation is established, introduce brown mudfish fry obtained from the wild (or via aquaria from adults obtained from the wild).

11. Invertebrates

Conservation management of invertebrates is severely constrained by both the enormous number of species involved, and the lack of taxonomic, distributional and ecological information compared to vertebrates and vascular flora. While a select few species of large, flightless invertebrates are the focus of recovery programmes analagous to those for vertebrates (Parrish et al. 1995; Sherley 1995), most invertebrate conservation effort has been at a community level, focussing on preserving habitat and reducing the impacts of introduced mammals (Duncan & Johns 1989; Barratt 1994). Management of invertebrate communities is obviously preferable to a single-species approach, as a suite of species with similar needs can be conserved. Resources spent on habitat protection will conserve far more genotypes than we could ever hope to monitor (Hutcheson 1994).

With respect to conservation management of invertebrates, the ecological restoration of Mana Island is a huge field experiment. A major predator (mouse) has been removed, and extensive areas of diverse habitats are being recreated where previously the island was covered in a sward of exotic pasture grasses. The new forest and shrub communities are comprised of a few plant species that had remained locally abundant on the island plus many species that had survived in very low numbers or were absent from the island. It is likely that many of the invertebrate species that would have been present in forest communities on Mana Island are no longer present, and are unlikely to be introduced incidentally during the revegetation programme. This is certainly so for those invertebrate species that are host-specific on the many plant species proposed for planting on Mana Island that did not survive the farming era.

Simply restoring appropriate habitat on Mana Island will not be sufficient to restore a diverse native invertebrate fauna appropriate to those habitats. Kuschel (1990) has documented how inefficient flighted native beetles are at colonising appropriate host plants very close to a source population, and so colonisation across a 2.5 km water gap is highly unlikely for most species. [N.B. beetles are the most appropriate group for assessing biodiversity as they are by far the most species-rich group of animals on earth, and more than half of all New Zealand insect species are beetles].

In contrast to native beetles, introduced beetles are highly efficient colonists, and are likely to dominate habitats where native beetles are scarce (Kuschel 1990). Without active intervention to introduce appropriate native invertebrates to Mana Island, forest habitats there are likely to support a fauna of predominantly alien invertebrates, which may not produce the same intricate network of trophic relationships and interdependence found in natural ecosystems. However, it is simply not feasible to introduce species one at a time due to the vast number of species involved. For this reason, a new technique will be trialled on Mana Island to attempt to restore diverse native invertebrate communities in the recreated forest habitats. Mass collection techniques (litter samples, rotting timber, and malaise trapping) will be used to collect invertebrates from kohekohe, karaka and tawa forests growing on appropriate soil types on Kapiti Island. Samples will be thoroughly screened by a competent entomologist to identify as many of the species as possible, and to check for

the presence of injurious alien species. The samples will then be introduced to appropriate habitats on Mana Island.

This proposal is the opposite of recommendations by Duncan & Johns (1989) and Gibbs (1990) who specifically argued against transferring leaf mould, litter or soil to (a) avoid biogeographically inappropriate introductions that would obscure original relationships, and (b) avoid introducing weeds, pathogens and exotic soil organisms. However, Mana Island is a special case where the native invertebrate fauna is so depleted and opportunities for natural recolonisation so minimal that the benefits of restoring a diversity of native invertebrates greatly outweighs the risk of obscuring natural species distributions. By limiting collection sites to appropriate vegetation and soil types on Kapiti Island, the risk of introducing weeds, pathogens and exotic soil organisms not already present on Mana Island will be minimised. The partial species lists generated during transfers will (when compared to the known Mana Island invertebrate fauna) provide a benchmark for future assessments of the effectiveness of the transfers.

In addition to attempts to restore diverse native invertebrate faunas to appropriate habitats on Mana Island, a select few single species transfers of biogeographically and ecologically appropriate species with high conservation values will be attempted.

11.1 CURRENT SITUATION

Our knowledge of the invertebrate fauna of Mana Island is based on surveys conducted in June 1972 & April 1975 (M.J. Meads in Department of Lands & Survey 1981), November 1993 & February 1994 (Townsend 1994; Gibbs 1994), March 1994 (Gibbs 1994) and May 1994 (Patrick 1994). The total number of species of invertebrates recorded from the island is about 340, although many groups (e.g., flies) have not been investigated. The two large orders that have been most thoroughly investigated are coleoptera (beetles; 145 species) and lepidoptera (moths and butterflies; 76 species). Biogeographic analysis of those coleoptera and lepidoptera for which distributions are known reveals that Mana Island has strong links with both the North Island and the northern South Island (Table 11.1). Of 37 species with restricted distributions, 18 species are found only in the North Island and 19 species are found in both the southern North Island and northern South Island (including the Marlborough Sounds).

TABLE 11.1 SUMMARY OF BIOGEOGRAPHIC RELATIONSHIPS OF MANA ISLAND COLEOPTERA AND LEPIDOPTERA.

DISTRIBUTION	NUMBER OF SPECIES	
	COLEOPTERA	LEPIDOPTERA
Widespread	15	64
North Island only	16	2
Southern NI and northern SI	9	6
Cook Strait	4	—

Adventive	8	4

The beetle fauna of the forest remnant appears typical of forests in the Wellington area (Ian Townsend and John Nunn pers. comm.); at least 69 of the species recorded from Mana Island were also found on Tinakori Hill, and at least 42 of the species have been recorded from other localities around the Wellington south coast.

Mana Island has a depauperate invertebrate fauna compared to other rodent-free islands in the Sounds-Wellington Ecological Region. Notable absences include large flightless weevils, large stag beetles and the Cook Strait amychus, species thought to be extremely vulnerable to rodent predation (Meads 1990). The majority of large beetle species present on Mana Island belong to the families Carabidae and Tenebrionidae (Table 11.2), both of which have powerful chemical defences that may have deterred mouse predation. These observations indicate that the Mana Island invertebrate fauna has been decimated by the combined effects of habitat destruction and mouse predation.

TABLE 11.2 SUMMARY OF SIZE CLASSES OF BEETLE SPECIES COLLECTED ON MANA ISLAND. NOTE THAT LARGER SIZE CLASSES ARE DOMINATED BY SPECIES OF CARABIDAE AND TENEBRIONIDAE.

	<5 mm	5-10 mm	11-15 mm	16 + mm
Carabidae	1	11	4	2
Tenebrionidae	—	4	3	—
Other	85	24	5	3

The only nationally threatened invertebrate species recorded from Mana Island is the Cook Strait giant weta, which has increased dramatically in numbers since mice were eradicated (Todd & Miskelly in press). Mana Island is the national stronghold for Cook Strait giant weta, which also occurs on Stephens Island and the Trio Islands, and has been introduced to Maud Island and Matiu/Somes Island from Mana Island.

11.2 THREATENED INVERTEBRATES

Mana Island has considerable potential as a refuge for threatened macroinvertebrates that are vulnerable to predation by mammals. However, as there are no habitats in the Wellington region that have do not have a history of rodent presence, we do not know what invertebrate species have become locally or nationally extinct. Although the Mana Island invertebrate fauna has strong biogeographical links with islands in the Marlborough Sounds, caution is urged over introducing threatened Marlborough Sounds invertebrates to Mana Island unless there is evidence that the taxon formerly occurred in the Wellington region. As there is an increasing number of islands in the Marlborough Sounds that are being cleared of mammalian predators (Millar & Gaze 1997), it is unlikely that Mana Island would be required to ensure the continued survival of any Marlborough Sounds invertebrate taxon, therefore any introductions should be based on biogeographic rather than purely conservation grounds.

The following list of ten species of threatened Cook Strait macroinvertebrates is based on information in Notman (1984) and Meads (1990). Previous workers have not given much thought to threatened invertebrate introductions to Mana Island, but Timmins et al. (1987b) suggested that the speargrass weevil be considered. Species recommended for introduction to Mana Island are listed in bold lettering. These single species introductions are recommended primarily to ensure survival of threatened taxa, although all of the species may have formerly been present on Mana Island. Restoration of invertebrate communities on Mana Island will require introductions of hundreds or thousands of species that are not considered threatened, and it is not feasible to do this using a single species approach (see 11.3 below)

Cook Strait giant weta

Giant weta on Mana Island are most abundant in rank grass and in shrub communities, and are rare or absent in forest habitat. The revegetation programme will reduce the area of habitat available for giant weta, but suitable habitat should remain on about two thirds of the island. Several potential predators of giant weta are proposed for reintroduction (e.g., tuatara, robin) and others are present or may recolonise naturally (pukeko, harrier, morepork). Although it is unlikely that any of these species will threaten the giant weta population on Mana Island, the national significance of the population requires that any impacts of the restoration programme (including species introductions) on the weta should be monitored.

Management action

Develop and implement a monitoring programme for giant weta based on the transects established by Mary McIntyre.

Flax weevil

Flax weevils have a relict distribution on rodent-free islands between the Poor Knights Islands and Fiordland (Meads 1990). The only mainland locality where they are still known to be present is above the bushline in the Tararua Ranges. Within the Marlborough Sounds, flax weevils are abundant on Maud and Stephens Islands, and have been recorded from Te Kakaho and D'Urville Islands (Notman 1984).

There is little doubt that flax weevils formerly occurred in suitable habitats throughout New Zealand, however no coastal populations remain in the southern North Island. There is ample suitable habitat on Mana Island, and continued plantings of both flax species will ensure that flax weevils can spread throughout the island. Introductions from Maud Island are recommended because the island is accessible, flax weevils are very abundant there, and the climatic conditions are similar to Mana Island (cf. high altitude populations in the Tararua Ranges). Flax weevils are one of a very few invertebrate species that have previously been translocated to a rodent free island for conservation purposes (Thomas et al. 1992).

Management action

Obtain up to 50 adult flax weevils from Maud Island and release into flax behind the beach ridge near the houses on Mana Island.

Speargrass weevil

The Wellington speargrass weevil is host specific on *Aciphylla squarrosa* growing on the Wellington south coast. The relationship between the Wellington population and speargrass weevils in the South Island has not been resolved (George Gibbs pers. comm.), but the Wellington population is considered to be vulnerable to extinction (Molloy & Davis 1994; Department of Conservation 1995; Hunt 1996). Likely causes of population decline include predation by rodents and habitat modification by goats, fire and natural succession (Bull 1967). Habitat requirements of Wellington speargrass weevils were assessed by Hunt (1996).

While it is desirable to maintain a population of speargrass weevils on the Wellington south coast, it would be prudent to establish a population at at least one site free of mammalian predators and browsers. The most promising initial site is Matiu/Somes Island, which is closer to existing populations than Mana Island, and has similar aspect and climate to sites where speargrass weevils have survived (Hunt 1996). While speargrass is common around the cliffs and shoreline of Mana Island, patches may not be sufficiently dense to support weevils currently. At least one site on Mana Island should be prepared for speargrass weevil liberation concurrent with initial releases on Matiu/Somes Island.

Management action

Plant locally sourced speargrass among existing plants on Mana Island to create denser patches of speargrass. If transfers of speargrass weevils to Matiu/Somes Island are successful, use Matiu as a source population for transfer to Mana Island.

Stephens Island weevil

This large weevil is known only from Stephens Island, where it is apparently host-specific on ngaio. It is likely that the larvae require dead and dying ngaio wood, and so suitable habitat may not be present on Mana Island until current plantings become senescent.

Unless subfossil remains of Stephens Island weevil are found north of Cook Strait, introduction of this species to Mana Island cannot be justified on biogeographic grounds. There are several other islands in the Marlborough Sounds that may be more suitable for introductions of Stephens Island weevil.

Management action

Do not introduce Stephens Island weevil to Mana Island. Review suitability of Mana Island if remains of Stephens Island weevil are identified from subfossil deposits in the North Island.

Cook Strait amychus

The three species of *Amychus* beetles show a classic relict distribution on rodent-free islands in the Three Kings, Cook Strait and the Chatham Islands (Meads 1990). The Cook Strait species has been recorded from Stephens Island, Maud Island, the Brothers Islands, the Trio Islands and Sentinel Rock (Ian Millar pers. comm.), and is likely to be introduced to other islands in the Marlborough Sounds that have been cleared of rodents (Millar & Gaze 1997).

While restoration of kohekohe forest to Mana Island may eventually provide suitable habitat for the Cook Strait amychus, introduction to Mana Island should only occur if *Amychus* remains are identified from subfossil deposits in the North Island.

Management action

Do not introduce Cook Strait amychus to Mana Island. Review suitability of Mana Island if remains of Cook Strait amychus are identified from subfossil deposits in the North Island.

Lissotes reticulatus

Large flightless stag beetles of the genera *Dorcus* and *Lissotes* are considered vulnerable to rodent predation, and several species are nationally threatened (Notman 1984; Meads 1990; Molloy & Davis 1994). Large stag beetles are notably absent from Mana Island, which would be expected to have a population of *Lissotes reticulatus*, a species with a wide distribution between Auckland and Christchurch (Holloway 1961). Notman (1984) only found *L. reticulatus* on islands that lacked rodents, and so it is likely that they were eradicated by mice on Mana Island.

L. reticulatus are common in the forest remnant on Maud Island (Notman 1984). The only suitable habitat currently on Mana Island is within Forest Valley, but stag beetles should spread over the island as the forest cover matures and provides a supply of dead wood.

Management action

Create litter traps and provide dead wood as cover in Forest Valley. Introduce adult *Lissotes reticulatus* from Maud Island.

Giant pill millipede

Although widespread in the North Island and northern South Island (Holloway 1956), giant pill millipedes reach their largest size on mammal-free islands (Meads 1990). They are abundant on Maud Island, where they feed on decaying leaves and fruit (Notman 1984; Meads 1990). Other localities in the region where giant pill millipedes have been recorded include Stephens Island, Blumine Island, Tararua and Rimutaka Ranges, Kaitoke, Akatarawa and Orongorongo. Giant pill millipedes should spread over Mana Island as the forest cover becomes established and leaf litter accumulates.

Management action
Create litter traps and provide dead wood as cover in Forest Valley. Introduce giant pill millipedes from Maud Island.

Large land snails

No large species of land snails have survived on Mana Island, although the island is within the range of the genera *Powelliphanta*, *Rhytida* and *Wainuia*, all of which are found on islands in the Marlborough Sounds as well as in the southern North Island. All species of large land snails in the Wellington region have declined through the combined effects of habitat destruction and increased predation, and two taxa (*Powelliphanta traversi traversi* and *P. t. otakia*) are endangered (Molloy & Davis 1994; Department of Conservation 1996). Species that should be considered for introduction to Mana Island if suitable habitats are present include *P. t. otakia*, *Rhytida greenwoodi* and *Wainuia urnula*, all of which survive in the greater Wellington region. Suitable habitat is probably present now for *Rhytida* which occur in forest, shrubland and grassland. *Wainuia* will benefit from the restoration of forest cover with deep leaf litter, while *P. t. otakia* is most likely to prefer taller broadleaved forest in the moist valley floors. All three species will benefit from the provision of dead wood to provide moist retreats at release sites

Management action
Continue revegetation programme. Trial releases of *Rhytida greenwoodi* from Paremata into established plantings, and *Wainuia urnula* from Belmont into litter traps in Forest Valley. Do not introduce *Powelliphanta traversi otakia* until the mainland population is large enough to be cropped, and closed canopy forest with deep leaf litter has formed around the restored wetland on Mana Island. Provide rotting logs as cover at release sites for all three species.

11.3 RESTORING INVERTEBRATE COMMUNITIES

Restoring diverse invertebrate communities into restored forest communities on Mana Island will require mass transfers of many species from similar forests from biogeographically and ecologically appropriate sites (see discussion above). The most suitable sites are kohekohe, karaka and tawa forests on nearby Kapiti Island, which is also within the eastern Cook Strait Ecological District, has similar soils to Mana Island (Heine 1975) and has extensive native forest cover that is unlikely to have been colonised by as many adventive invertebrate species as forest remnants on the adjacent mainland. Care should be taken to avoid introductions of potentially injurious adventive species (most notably vespulid wasps), and so litter and malaise trap samples should be screened by experienced entomologists. Decaying wood should not be moved in autumn or winter, when it may harbour hibernating vespulid wasp queens. Species lists of moths and large beetles (>4 mm body length) transferred should be kept to aid future interpretation of species distributions on Mana Island.

The apparent inability of most native beetles to colonise new habitats that are not in direct contact with the source population (Kuschel 1990) highlights the importance of creating forest corridors linking all areas of plantings to

the existing forest remnant on Mana Island. The forest remnant in Forest Valley is an extremely important reservoir of invertebrate biodiversity on the island, with at least 56 species (16%) recorded from only this site (Townsend 1994).

Management action

Continue revegetation programme, ensuring that forested corridors link all areas planted to the existing forest remnant. Following canopy closure of the three main canopy species (kohekohe, tawa, karaka), collect leaf litter, malaise trap samples and decaying wood from similar forest types on Kapiti Island. Decaying wood to be collected only between November and February, when it is unlikely to contain hibernating vespulid wasp queens. Screen samples to remove most potentially injurious species, and to create species lists of lepidoptera and larger coleoptera. Transfer samples to appropriate habitat on Mana Island.

12. Control of animal pests

An animal pest could be defined as an animal occurring where it isn't wanted, or an animal that it is having unacceptable impacts on other values at a site. The two definitions are overlapping, but are not equivalent. In terms of the restoration goals for Mana Island, the first definition is unambiguous – any animal species that would not have been present on Mana Island when human contact first occurred would be considered a pest. However, there are three problems with this definition:

(a) by defining all introduced animals as pests, the task of controlling animal pests is both immense and unachievable. Introduced birds and insects are so widely distributed and are such efficient colonisers that the presence of some species must be accepted in even the most "pristine" ecosystems. Mana Island lies only 2.5 km offshore from abundant source populations of many species, and so continuing influx of alien species is inevitable.

(b) by focussing on the organism rather than its effects we risk turning a blind eye to indigenous species that are causing unacceptable damage to other conservation values.

(c) a select few animal species may be introduced to Mana Island as part of national recovery programmes *even though it is unlikely or impossible that they occurred there in the past* (e.g., takahe, kakapo, brown kiwi, Snares Island tit); by defining these animals as pests we compromise the value of Mana Island to global biodiversity.

The second definition is more workable, but is subjective in that there are no all-encompassing guidelines as to what is an unacceptable impact. For example, predation by a harrier on several giant weta or one McGregor's skink might be acceptable, but predation of a single shore plover soon after release might not. Impacts might be accepted in situations where it would be difficult to prevent them occurring (e.g., weed dispersal by roosting starlings), while in other situations control might be undertaken because a quick, cheap solution can be achieved (e.g., preventing re-establishment of magpies).

It is apparent that the best model for determining whether to proceed with animal pest control on Mana Island is a cost-benefit approach: in situations where the conservation benefits of pest control justify the costs, then control should be initiated. The cost-benefit equation may be complex (Table 12.1), particularly where the agent that is perceived to be having an unacceptable impact has its own intrinsic values. In situations where there is likely to be some public opposition to the proposed control programme, the department should consult with the Wellington Conservation Board and Ngati Toa.

This model allows both introduced pests and native pests to be assessed. As the perceived value of a native species is likely to be higher in most peoples' eyes, any impacts by a native species on other conservation values would have to be higher before control is initiated than would be the case if an introduced species was having the same impact. In all cases, control must be achievable (even if only over a critical small area) for the costs of control to be low enough to justify action.

TABLE 12.1 POTENTIAL COSTS AND BENEFITS OF AN ANIMAL PEST CONTROL PROGRAMME.

COSTS	BENEFITS
Financial cost of the control programme	Alleviation of impacts
Impacts on other work programmes caused by diversion of resources	Financial savings where immediate action can prevent an extended control programme being necessary
Public opposition where the "pest" species is valued	Public goodwill where the "pest" is widely perceived as being injurious
Harm to other biota if non-selective control techniques used	

Potential impacts on other conservation values that may lead to an animal being considered a pest include:

- limiting predation of valued animal species
- competition for food
- disruption of energy flow
- competition for nest sites
- physical disturbance during breeding
- destructive herbivory of valued plant species
- dispersal of weed seeds
- disease/parasite transmission

12.1 CURRENT SITUATION

The only animal control programme currently occurring on Mana Island is an attempt to lower the breeding population of black-backed gulls by about 90%, primarily to reduce potential predation on shore plover (shore plover will not be released on Mana Island until the gull population on Mana Island is effectively confined to the western cliffs). Gull control was initiated during the 1994/95 breeding season using alphachloralose poisoning of breeding adults and pricking of eggs. Intensive control will continue until the target density is achieved, then the population will be maintained at low levels by annual egg-pricking.

12.2 PREVIOUS ANIMAL PEST CONTROL PROGRAMMES

The most notable pest control programme on Mana Island was the eradication of house mice by a combination of aerial and bait station based poisoning in 1989/90 (Todd & Miskelly in press). Apart from the removal of farm stock in 1986, the only other control programme of note was the eradication of magpies by shooting in 1987 (Phil Todd pers. comm.).

12.3 POTENTIAL ANIMAL PESTS ON MANA ISLAND

1. Introduced mammals

The most serious threat to ecological restoration on Mana Island is colonisation by introduced mammals. Predatory and browsing mammals have such profound effects on New Zealand ecosystems that prevention of their establishment on Mana Island is critical for this restoration programme to proceed. A mammal contingency plan has been prepared for all islands in Wellington Conservancy (including Mana) outlining precautions to prevent colonisation, and measures to contain and eradicate introduced mammals once they get ashore (Empson 1995).

2. Raptors

Harriers, falcons and moreporks are all considered part of the natural avifauna of Mana Island, although falcons and moreporks are not currently resident there. All three species are capable of recolonising the island repeatedly.

There is no intention to undertake sustained control of harriers, falcons and moreporks on Mana Island, but some measures may be required to limit their impact on newly released threatened species. Trial releases of captive-reared shore plover on Motuora Island have shown them to be vulnerable to predation by harriers and moreporks, and many of the species proposed for release on Mana Island are likely to be vulnerable to predation by raptors.

The need to implement raptor control measures will have to be assessed prior to each proposed release, based on factors such as whether falcon and morepork are known to be present at that time, habitat preferences and behaviour of the species to be released, and whether the animals for release are sourced from predator-naive populations (including captive populations). Preferred measures to limit raptor predation are live-capture, banding and release elsewhere. While recolonisation is inevitable, it is hoped that there will be a sufficiently long window of low predation pressure to allow the target species to become established. If the same (banded) individuals return rapidly, more draconian measures may be required as appropriate to each raptor species' national and regional conservation status.

3. Pukeko

Increasing levels of pukeko damage to plants used in the revegetation programme mean that localised control of pukeko may be necessary during the planting season (May-September). While appropriate planting techniques such as using larger plants in areas prone to pukeko damage, heeling plants in firmly and concealing the plant among rank grass may reduce damage, it is anticipated that pukeko damage will continue to increase as pukeko become more abundant on Mana Island. Bird scaring devices can not be used, as they will disturb takahe (all areas identified for planting occur within takahe territories).

Where damage exceeds 10% of plantings and can be clearly attributed to pukeko damage, control should be initiated by either shooting with a silencer, or live-trapping followed by humane dispatch. This will reduce disturbance to takahe, which would be vulnerable to other less selective control methods.

Those pukeko killed should be made available for scientific (e.g., disease assessment) or cultural purposes.

As control will occur only at planting sites (usually less than 5% of the island in any year), mortality due to localised control is unlikely to exceed pukeko productivity on the island – i.e., the pukeko population on Mana Island will not be limited by control measures.

4. Gulls

Intensive black-backed gull control will be continued on Mana Island until the breeding population is confined to the western cliffs (see above). Disturbance and predation of other seabirds and shorebirds by gulls should be monitored, and the control programme adjusted accordingly.

5. Magpies

A small breeding population of magpies on Mana Island was eradicated in 1987, when 15 were shot (Phil Todd pers. comm.). Magpies continue to turn up on Mana Island occasionally, and about ten further birds have been shot between 1988 and 1996. Although specific impacts of magpies on other Mana Island biota have not been documented, continued shooting of vagrants will ensure that a species that is widely perceived as injurious to native biota does not re-establish.

6. Small introduced birds

About a dozen species of introduced birds are resident on Mana, and some species (especially blackbird, song thrush and starling) are thought to be the predominant seed dispersers for plant species with fleshy fruits on Mana Island. Until native fruit-eating birds are established on Mana Island, these three species will play the major role in dispersing seeds of both native shrubs and weed species. The species which poses the greatest threat for introducing (or reintroducing) weed species to the island is the starling, of which many thousands regularly feed on the mainland and return to the island in the evening to roost. Estimates of the number of starlings roosting on Mana Island range as high as over a million (M.J. Meads in Brockie 1983). Many hundreds of starlings also forage and breed on Mana Island, and so are likely to spread weed species away from roost sites.

Starlings may also impact more directly on some of the threatened bird species restored to Mana Island. Starlings are aggressive competitors for nest holes and cavities, and caused many problems during the black robin recovery programme (Butler & Merton 1992); species potentially at risk on Mana Island include North Island robin and yellow-crowned parakeets. Starlings on South East Island were also considered the main source of ectoparasite infestations in black robin nest (Butler & Merton 1992), and the mites involved were presumed vectors of avian pox which killed at least five black robins.

There are currently no effective methods for discouraging roosting and nesting by starlings over a large area, although individual nest sites of vulnerable species can be protected (Butler & Merton 1992). Starling control on Mana

Island would be futile using existing methods, but trials could be undertaken there if new methods are developed.

7. Vespulid wasps

It is remarkable that neither German wasps nor common wasps have established on Mana Island. There is a single record of German wasp from Mana Island in 1972 or 1975 (M.J. Meads in Department of Lands & Survey 1981), but it is not known whether a nest was present then. Both species are very widely distributed throughout New Zealand, including most offshore islands; their impacts on native biota have been well documented (e.g., Beggs & Wilson 1991; Harris 1993). If either species colonises Mana Island they are likely to have severe impacts on invertebrates through predation and competition for nectar, and on birds through competition for food and nest sites.

Worker wasps are sterile – only a queen can establish a new colony. Queens hibernate during the winter, and seek new nest sites in the spring. Thus the most critical times of the year for wasp colonisation are spring/early summer, when queens are actively seeking nest sites, and autumn, when young queens seek suitable crevices for hibernating. Jacqueline Beggs (pers. comm. October 1995) considered that the most likely means for vespulid wasps to colonise Mana Island would be for a hibernating queen to be carried to the island among equipment or supplies. Island staff should remain alert to the possibility of hibernating queen wasps being carried to the island in autumn and winter, and ensure that all possible hibernation sites are inspected and/or fumigated.

Once established on the island, it is unlikely that vespulid wasps could be eradicated. However, if the first nest is located before new queens are produced, it may be possible to prevent colonisation. Therefore as soon as wasps are detected on the island every effort must be made to locate the nest and destroy it immediately. Stocks of wasp poison should be held on the island for this purpose.

13. Control of pest plants

The spread of weed species is a major threat to the restoration programme on Mana Island. While about half of the vascular plant species on Mana are adventive, most do not compromise conservation values on the island, and many are likely to die out as natural succession proceeds. Species of greatest concern are those that are aggressive colonists that could dominate shrub communities (e.g., brush wattle, bone-seed, broom, boxthorn, karo, elderberry and gorse). Boxthorn is the most widely distributed and abundant of the aggressive adventive shrubs on the island, and it already dominates shrub communities on the eastern and northern cliffs and shore platform.

Weed control will be a major and ongoing component of the Mana Island restoration programme. Priority must be given to control of species that could potentially dominate forest and shrub communities, and eradication of establishing weeds before they have an opportunity to spread. Localised control of less aggressive species may be a necessary component of attempts to establish or enhance populations of threatened plants on the island.

13.1 CURRENT SITUATION

The greatest weed control effort to date on Mana Island has been control of boxthorn. Control has involved cutting stems near ground level and immediately painting stumps with a mixture of Grazon and diesel. The branches are mulched, and the mulchings composted to kill seeds. Any regrowth is sprayed with Grazon and diesel. This programme is extremely labour intensive, but has shown that removal of adult boxthorn and control of regeneration is feasible.

Other weed control on the island has included removal of karo, trial spraying of kikuyu, pampas grass and angelica, and *ad hoc* removal or spraying of brush wattle, broom, blackberry, gorse, bone-seed, holly-leaved senecio, pohutukawa, tree mallow and Tasmanian ngaio.

13.2 PRIORITIES FOR WEED CONTROL

Plant species known to be present on Mana Island that should be eradicated or controlled as part of the restoration programme are listed in Table 13.1. The top priority for weed control should be eradication of those weed species that have not yet become widely distributed on the island where rapid action could prevent a major infestation occurring. The second priority is ongoing control of the most serious invading shrub species (boxthorn and karo). The third priority is control or eradication of species that are well established but are not spreading rapidly. Macrocarpa and pine seedlings should be destroyed, but removal of adult trees is not a priority until forest cover has become well established. However, macrocarpas and pines on Mana Island are a valuable source of slabs of wood to create retreats for threatened reptiles and invertebrates, and so some mature trees should be felled if windthrows do not provide sufficient timber for this purpose.

TABLE 13.1 PLANT SPECIES RECOMMENDED FOR ERADICATION OR CONTROL ON MANA ISLAND.

TOP PRIORITY FOR ERADICATION (SMALL INFESTATIONS)	DISTRIBUTION ON MANA ISLAND
Brush wattle *Paraserianthes lophantha*	Forest Valley
Bone-seed *Chrysanthemoides monilifera*	Isolated shrubs on plateau
Broom *Cytisus scoparium*	Isolated shrubs
Blackberry *Rubus fruticosus*	Two patches on shore
Holly-leaved senecio *Senecio glastifolius*	Isolated shrubs
Wandering willie *Tradescantia fluminensis*	Near buildings
Gorse *Ulex europaeus*	Mainly top of northern cliff
TOP PRIORITY FOR CONTROL (WIDESPREAD, AGGRESSIVE SHRUBS)	
Boxthorn *Lycium ferocissimum*	
Karo *Pittosporum crassifolium*	
SECOND PRIORITY FOR CONTROL/ ERADICATION	DISTRIBUTION ON MANA ISLAND
Pampas grass *Cortaderia jubata* & *C. selloana*	Windbreaks
Everlasting pea *Lathyrus latifolius*	Northern and western cliffs below trig
Pohutukawa *Metrosideros excelsa*	Near buildings
Tasmanian ngaio *Myoporum insulare* (& hybrids)	Early plantings
Kikuyu *Pennisetum clandestinum*	Isolated patches
Elderberry *Sambucus nigra*	Mainly Shingle Spit
LOW PRIORITY FOR ERADICATION	DISTRIBUTION ON MANA ISLAND
Macrocarpa *Cupressus macrocarpa*	Isolated mature trees
Pine *Pinus radiata*	Isolated mature trees

Localised control of large adventive herbs (e.g., angelica, fennel, tree mallow) may be necessary along the shore platform to reduce competition as part of threatened plant conservation programmes.

14. Archaeological and waahi tapu sites

14.1 THE ISLAND'S HUMAN HISTORY

Mana Island has a long and fascinating history of human occupation (Day 1987; Horwood 1991). The island's name is a contraction of Te Mana o Kupe ki Aotearoa, which refers to the ability of the explorer Kupe to cross the ocean to Aotearoa. The island was inhabited around 1400 A.D. (Chester & Raine 1990; Horwood 1991), but little is known of the Maori history prior to its occupation by Ngati Toa in the 1820s. During the 1840s Te Rangihaeata (a nephew of Te Rauparaha) lived in an elaboratedly carved wharepuni near the site of the current boatshed (Day 1987; Horwood 1991). Archaeological excavation of the beach ridge revealed evidence of two periods of occupation: the fifteenth century and the early nineteenth century through to the present (Horwood 1991).

In 1832 the island was sold by Te Rauparaha, Te Rangihaeata and Nohoroa (Te Rauparaha's brother) to Alexander Davidson, George Bell and Archibald Mossman for goods to a collective value of £24. Soon after this Davidson sold his share to Bell, and Mossman sold his share to Frederick Peterson (Day 1987). Bell was the first European settler on the island, where he resided from 1832 until his death there in 1838. The first wool clip from the island was exported to Sydney in June 1835, and is believed to be among the earliest wool exported from New Zealand. Bell also established a small whaling station which was taken over in 1837 by Alec and Thomas Fraser, who leased the station from Peterson. Whaling continued at the island until at least 1845 (Day 1987).

Following Bell's death his two third share in the island passed to his father, Thomas Bell, who then sold it to Henry Moreing for £750. Moreing acquired the remainder of the island from Peterson for £250 in 1841. The purchase of Mana Island was investigated by Commissioner Spain in 1843, who awarded title to Moreing despite Ngati Toa and the Fraser brothers disputing Moreing's claim. This dispute continued until 1865 when the Crown purchased Mana Island and paid £300 compensation to Ngati Toa (Day 1987). Following Crown purchase the island was leased as a sheep farm for 100 years from 1873. Leaseholders were J.F Wright (1873-1893), the Vella family (1893-1953, although Mariano Vella had earlier sub-leased the island from Wright) and John Gault (1953-1973). The woolshed that still stands at the base of Shingle Point was apparently built by Mariano Vella in 1887 (Day 1987).

A lighthouse was erected on the summit of Mana Island in 1864 and was operational from 1865 until 1877, following which it was dismantled and moved to Cape Egmont. Several ditch and bank structures near the lighthouse site are thought to have been constructed to protect the lighthouse keepers' gardens from wandering stock (Jones 1987), and a similar structure near the landing may represent the site of Bell's garden from the 1830s.

In 1973 the island was taken over by the Ministry of Agriculture and Fisheries as an exotic sheep quarantine and breeding research station. However, a suspected scrapie outbreak in 1978 led to all the sheep being slaughtered and control of the island passed to the Department of Lands and Survey. Following removal of the last cattle in 1986 the island has been managed purely for conservation purposes.

14.2 CURRENT SITUATION

Our knowledge of archaeological sites on Mana Island is based on historical maps (particularly Mantell 1865), and archaeological surveys carried out since 1963 (particularly Jones 1987 and Horwood 1991). Documented sites on the island include:

- early Maori occupation sites (15th century) on the beach ridge near the landing
- evidence of Maori gardens and pits, particularly on the low hill north of the houses
- Ngati Toa occupation sites (1820-1850) on the beach ridge, particularly Te Rangihaeata's house site
- Bell's settlement (1830s) including the earliest evidence of European gardening in New Zealand
- the whaling station (1830-1850) to the north of Shingle Point
- the lighthouse site (1865-1880) including the lighthouse base, house site, and ditch and bank exclosures
- the woolshed (c.1887)

Management of three sites (the woolshed, the lighthouse site and the beach ridge habitation site) is discussed in the Wellington Conservancy Historic Resources Strategy (Department of Conservation 1992; note that the beach ridge site includes early Maori, Ngati Toa and European habitation). While most archaeological effort to date on Mana Island has been put into investigation and interpretation, the woolshed was restored in 1986 and is now used as a visitor centre.

14.3 CONFLICTS BETWEEN ECOLOGICAL RESTORATION AND MANAGEMENT OF HISTORIC SITES

Restoration of historic sites is beyond the scope of this ecological restoration plan, but it is important to ensure that the ecological restoration of the island is, as far as possible, compatible with management of historic sites, and conversely that management of historic sites does not unduly compromise other conservation values on the island. There are several areas where ecological restoration and management of historic sites are not fully compatible, and some compromises will be necessary.

1. Impact of revegetation on historic sites

Revegetation and regeneration can obscure and/or disturb archaeological sites. Tall vegetation can hide surface features, while root damage can disturb subsurface features. Digging holes to plant trees also has direct impacts on soil stratification. As recognised sites with surface features are quite localised on Mana Island (mainly near the trig and near the houses) excluding these areas from planting will have little effect on the overall restoration programme. The most important sites to exclude from planting are an area surrounding the lighthouse and associated ditch and bank exclosures, horticultural soils on the low spur just north of the houses, the site of Bell's garden near the mouth of Aston's Valley, the habitation site from the base of the wharf along the beach ridge to just north of the houses, and the early Maori occupation site at the old stream mouth south of the worksheds (Fig. 5.1). Island staff need to be aware of where these sites are, and should periodically handpull or spray any woody vegetation that colonise them.

The only archaeological site that will be mown regularly is the beach ridge, which is a major assembly and transition area for people arriving on the island. Maintaining a low sward here makes the area available for shore plover during spring tides and storms, reduces the fire risk from people picnicking on the beach, and improves visibility from the houses out to the landing bay. Other archaeological sites will be covered by rank grass, but could be mowed occasionally to reveal surface features (e.g., for photographic documentation or prior to archaeological excavation) at the discretion of the Area Manager in discussion with the island manager.

2. Disturbance to the beach ridge

The beach ridge behind the landing bay and about the former stream exit contains extremely important archaeological sites. Although few surface features remain, stratified deposits reveal a chronological sequence from early Maori occupation through to Maori occupation at the time of European colonisation, and early European settlement. Over the years these deposits have been disturbed by other management activities on the island, including construction of a road along the beach ridge, cutting of drainage ditches, and construction of the boatshed. Root damage and wind-throw of the large macrocarpas growing on the beach ridge also disturb stratification. Future management should ensure that disturbance of subsurface deposits is minimised, including removal of large trees growing on the site. Stems should be cut near ground level and roots left to rot *in situ* to reduce disturbance caused by uprooting.

3. Wetland restoration

Wetland restoration could potentially disturb or destroy archaeological sites during recontouring to creating pools and channels. Raising the water table in itself is unlikely to disturb subsurface features, and may even preserve some sites.

Known archaeological sites will not be affected by the proposed wetland restoration, which is situated between the beach ridge and the presumed

site of Bell's garden. However, care should be taken during any excavations in case any archaeological deposits are revealed. The Historic Places Act (1993) requires that any site disturbed during development be assessed by the Historic Places Trust before work proceeds.

4. Woolshed interpretation

The historic woolshed would have originally stood in a pastoral setting. This restoration plan recommends natural regeneration of shrub communities on Shingle Point, and planting of forest species on the adjacent scarp. It is foreseeable that in the future shrubs and trees will surround the woolshed, analogous to the situation around the whare on Kapiti Island. While having a woolshed sited among tall vegetation may appear contextually inappropriate, this situation mirrors changing land use and public perception of the values of Mana Island. The historical significance and setting of the woolshed could be enhanced by ensuring that historical photographs of the woolshed in a pastoral setting are included in interpretative displays within the building.

5. Whaling site interpretation

The presumed site of the whaling station on Mana Island is at the northern base of Shingle Point (Day 1987), and fragments of whale bone are still present at this site. This area is currently off limits to the public, as it contains the core of the remnant McGregor's skink population, including permanently installed pitfall traps for monitoring purposes that are extremely vulnerable to disturbance. Public access to this site is inappropriate while monitoring of the McGregor's skinks at the site is considered necessary.

As the landforms and vegetation at the southern side of Shingle Point (near the woolshed) are similar to the northern side, interpretation of whaling, including display of relicts, would be contextually appropriate in or near the woolshed.

14.4 WAAHI TAPU

Although Ngati Toa apparently inhabited Mana Island for a period of only about 30 years from 1820, the island was obviously extremely important to them during this period (Day 1987). The painter George French Angus visited the island in 1844 and painted both "Kai Tangata" (Te Rangihaeata's house) and a mausoleum for Waitohi, who was both Te Rangihaeata's mother and Te Rauparaha's elder sister. Te Rauparaha also had a house nearby, though usually residing on Kapiti Island.

Ngati Toa are the tangata whenua and are consulted on all major management initiatives there, both through their representation on the Wellington Conservation Board, and direct contact between departmental staff and the Kaumatua Council at Takapuwahia Marae.

Specific waahi tapu sites on Mana Island have not been brought to the department's attention to date, but there are two mechanisms by which

appropriate management of sites of significance could be incorporated in development proposals on the island. Under the current management regime, management proposals are discussed with both the Wellington Conservation Board and directly with Ngati Toa, and so inappropriate actions at particular sites can be avoided. The department has commissioned Ngati Toa researchers to prepare a waahi tapu file on Kapiti Island, and the possibility of conducting a similar exercise on Mana Island should be discussed with Ngati Toa.

14.5 MANAGEMENT ACTIONS

Management of important historic sites on Mana Island is outlined in the Wellington Conservancy Historic Resources Strategy and Conservation Management Strategy (Department of Conservation 1992 & 1996). The following summary highlights management actions for historic sites that impact on ecological restoration of the island (or vice versa):

- remove macrocarpas from the beach ridge, and maintain a mown sward there
- avoid subsurface disturbance of the beach ridge
- exclude archaeological sites (particularly the lighthouse complex, Bell's garden and the beach ridge) from the planting programme, and maintain these areas free of woody vegetation
- check for archaeological sites during wetland restoration, and liaise with Historic Places Trust if any sites are found
- discuss compilation of a Mana Island waahi tapu file with Ngati Toa
- limit any on site interpretation of whaling on Mana Island to the area around the woolshed

15. Fire

Fire is the second highest risk to the ecological restoration of Mana Island (the highest risk being colonisation by mammalian predators), and it is the highest risk to human safety and infrastructure on the island. A fire could spread rapidly through the rank grass at any time of year, but the risk is highest during drought conditions in late summer. The potential damage that a fire is likely to cause should reduce over time as revegetation with less flammable plant species progresses, but fire risk will remain high in the 57 ha of grassland on the plateau and in the upper valleys.

A fire plan for Mana Island is maintained by Wellington Conservancy, identifying the resources available for fire suppression and key personnel.

15.1 REDUCING THE RISK OF A FIRE OCCURRING OR SPREADING

Potential fire sources on Mana Island include cigarette butts, machinery, the diesel generator, fire places in the houses, barbecues, rubbish fires, illegal bonfires/ cooking fires and rescue flares. The risk of any of these potential fire sources causing a wild fire can be reduced by a combination of the following management actions:

- maintain a mown sward at the sole public landing point
- restrict cigarette smoking to the landing beach and houses
- meet and inform visiting public of restrictions on smoking and fire lighting (including use of barbecues)
- limit use of fires (heating and rubbish disposal) to times of low fire risk
- set up fire-fighting equipment next to any planned controlled fire (e.g., rubbish fire)
- regular maintenance of machinery (including the generator) to reduce the risk of spark discharge
- regular maintenance of woodburners and chimneys in the houses, including maintenance of spark catchers on the chimneys
- ban use of machinery away from the buildings during times of high fire risk
- keep boat owners aware of landing and fire restrictions on the island, including maintenance of signs at possible landing sites
- restrict public access to part/all of the island during periods of extreme fire risk

15.2 FIRE SUPPRESSION

A fire store is maintained on the island and all resident staff are trained in the use of fire-fighting equipment. However, a major fire would require additional personnel and equipment (particular helicopters with monsoon buckets) to be brought from off site. Maintaining a network of small ponds on the plateau and in the valleys will provide a water supply for fighting small fires as well as providing drinking/bathing water for birds and habitat for wetland animals and plants.

16. Research

The ecological restoration programme outlined in this document provides many opportunities for research programmes designed to assess the effectiveness or success of management actions. However, the following list summarises specific research projects needed to develop new restoration techniques, to support identified management actions, or to reduce the risk of ecological restoration not succeeding:

- a study of water chemistry following physical restoration of the wetland to guide selection of plant species suitable for restoration plantings
- assessment of Minimum Number of Individuals of different bird and reptile species represented in archaeological material excavated on Mana Island
- development of techniques to re-establish species of burrowing petrels on Mana Island
- assessment of weka bones from archaeological deposits on Mana Island to determine whether they are likely to have been obtained locally
- determine the impacts of weka on reptiles and invertebrates (at other sites)
- assess the disease risk posed by the dense pukeko population on takahe
- monitor the impacts of pukeko on recent plantings
- monitor breeding success of variable oystercatchers in relation to black-backed gull population density
- determine diet of yellow-crowned parakeets post-release to identify any impacts on plantings and threatened plants
- determine whether rock wren can be established in low altitude forest habitats
- monitor robin distribution and diet to identify any potential impact on giant weta
- determine whether Mana Island could provide suitable habitat for stitchbird and kokako
- investigate lizard communities present at release sites proposed for terrestrial reptile species
- monitor southward expansion of the remnant McGregor's skink population
- investigate competition between species of *Cyclodina* skinks
- investigate competition for refuges between speckled skinks and McGregor's skinks
- investigate competition between all *Hoplodactylus* geckos known from the Wellington region
- develop methods to control starlings

17. Community use and involvement

Guidelines for recreation management and advocacy on Mana Island are given in the Wellington Conservancy Conservation Management Strategy (Department of Conservation 1996). The following discussion focusses only on issues where community use and involvement on Mana Island may impact on ecological restoration, and the implications of ecological restoration on public access.

17.1 ACCESS

Mana Island is administered as a Scientific Reserve, and visitors to the island do not require a permit. However, public use of the island is controlled to some extent by by-laws, which currently restrict access to the island to the hours 10:00 a.m. to 5:00 p.m. Wednesday to Sunday and on public holidays. The island is closed on Mondays and Tuesdays as current staffing levels do not allow a seven day per week operation. Visitors can land only near the boat shed, and must report to the island manager on landing. Some small areas of the island (e.g., Forest Valley) are off limits to reduce disturbance to threatened species and communities.

Visitors to the island arrive either by private boat or charter, but there is currently no regular ferry service to the island. Current visitation levels are about 1,500 people per year, mainly as participants in the planting programme.

Continued public access to Mana Island (subject to protection of natural and historic resources) is identified as an objective in the Wellington Conservancy CMS. It is anticipated that public interest in and visitation rates to Mana Island will increase as restoration progresses.

Implementation of this ecological restoration plan is considered compatible with high levels of public use, with the following provisos:

- some coastal bird species are vulnerable to disturbance at nesting and roosting sites (e.g., oystercatchers, terns, shags, reef heron, shore plover) and so access to most of the coast may have to be restricted to outside the breeding season
- seabird colonies are vulnerable to trampling of burrows (petrels) or disturbance (gannets); if colonies are successfully established, access to them will have to be restricted to nearby tracks and viewing points
- some reptile species (especially tuatara) are a high security risk, and so release sites should not be made public, and release sites should not be adjacent to public tracks
- as revegetation progresses, visitors should be requested to remain on public tracks to reduce trampling of vegetation and soils, and disturbance to wildlife

- the department will retain the right to close off sections of the island temporarily or permanently if high levels of public use would compromise conservation values at that site
- the department will retain the right to close the island at times of extreme fire risk

17.2 PUBLIC USE AND RECREATION

As a special wildlife habitat, Mana Island is one of the key destinations in Wellington Conservancy for ecotourism and conservation based education and recreation (Department of Conservation 1996). The recreation management approach advocated in the CMS is to develop Mana Island as an opportunity for public involvement in conservation restoration, and as a site for the interpretation of species held on the island. Recreational use of Mana Island is restricted to passive activies such as walking, picnicking and nature appreciation. Dogs and other pets are prohibited on the island apart from their use for management purposes.

Visitors walking the loop track on the island gain access to the historic woolshed (containing some interpretative material), they obtain views over Shingle Point, the building complex, the adjacent mainland, Kapiti Island, Cook Strait and the Marlborough Sounds, they pass through plantings of various ages, and they visit the trig and historic lighthouse site. Most visitors to the island see takahe and will notice basking common skinks on warm days, but they are unlikely to see giant weta and geckos unless shown them by island staff.

The existing loop track will provide adequate public access to most communities and species being restored to the island, while leaving sufficient "off-limits" areas for management and research purposes.

Management action

- maintain tracks at a standard suitable for management needs and for walkers
- develop interpretation signs and material on the special features of the island

17.3 COMMUNITY INVOLVEMENT IN ECOLOGICAL RESTORATION

Volunteers have made an enormous contribution to ecological restoration on Mana Island through their participation in the mouse eradication programme, bird counts, species transfers, nursery work and the planting programme. Continued involvement of community groups and private individuals is essential for this restoration plan to be implemented fully. Groups that have had a close involvement with ecological restoration on Mana Island include the Royal Forest & Bird Protection Society, Ngati Toa, Conservation Corps, Ornithological Society, Wellington Botanical Society, Tararua Tramping Club,

Wellington Conservation Board, Victoria University, Mana College, and many other schools, businesses and community groups that have participated in the planting programme.

Table 17.1 highlights future ecological restoration activities where community groups, students and interested individuals could contribute.

TABLE 17.1 OPPORTUNITIES FOR VOLUNTEER PARTICIPATION IN ECOLOGICAL RESTORATION ON MANA ISLAND. SRARNZ = SOCIETY FOR RESEARCH ON AMPHIBIANS & REPTILES IN NEW ZEALAND.

ACTIVITY	RECOMMENDED INTEREST GROUP OR SKILL
Nursery work	Forest & Bird, Botanical Society, interested individuals
Planting	Any interested groups and individuals
Threatened plant propagation, introduction and monitoring	Botanical Society, Forest & Bird
Monitoring revegetation/succession	Victoria University, Botanical Society
Wetland restoration	Ducks Unlimited, Botanical Society
Bird introductions	Ngati Toa, Ornithological Society, Forest & Bird
Attracting seabirds	Ornithological Society, Forest & Bird
Bird monitoring	Ornithological Society, Victoria University, Forest & Bird
Reptile introductions	Ngati Toa, captive breeders, SRARNZ
Reptile monitoring	SRARNZ, Victoria University
Invertebrate monitoring	Victoria University, interested individuals
Weed control	Forest & Bird, interested individuals and groups

18. Summary and action plan

18.1 CRUCIAL TASKS

There are six key restorative actions required to provide the basis for recreating viable ecosystems on Mana Island that will be representative of what may have existed on the island prior to human disturbance. While introductions of other plants and animals will provide detail, and increase the island's potential for maintaining indigenous biodiversity, these six actions are fundamental to restoring ecosystem viability because of the species and processes that are dependent on their successful implementation.

1. Restore forest

It is presumed that most of Mana Island was forested originally. Restoration of forest to at least a third of the island will provide habitat for many plants, invertebrates, birds and reptiles, most of which are no longer present on the island and will have to be reintroduced.

2. Attract nesting seabirds

Terrestrial ecosystems on New Zealand islands that have never had introduced predators are dominated by the presence of dense nesting colonies of seabirds, especially burrowing petrels. These birds have an enormous impact on other components of the ecosystem through their burrowing, trampling, gathering of nest material and, especially, through the input of nutrients. The droppings, regurgitations and corpses generated by dense seabird colonies support dense and diverse communities of invertebrate scavengers and predators, which are in turn preyed on by lizards and birds. The top predator in these seabird-dominated ecosystems is the tuatara, which preys directly on the seabirds, as well as taking large invertebrates and lizards. Seabird burrows also provide sheltered microhabitats of relatively constant temperature and high humidity that provide homes for a diversity of obligate and facultative burrow-dwellers including cave and ground weta, skinks and tuatara.

3. Restore Waikoko wetland

Wetlands on islands are a rare habitat, and so there are few wetland habitats in New Zealand that are free of the effects of introduced mammals. Restoring the wetland on Mana Island will provide habitat for a variety of threatened wetland plants, two locally extinct birds (brown teal and fernbird) and possibly the threatened brown mudfish.

4. Reintroduce avian pollinators and seed dispersers

The composition and distribution of tree and shrub species within the forest on Mana Island will reflect the minds and methods of the people who created it for many decades. Over time the natural processes of pollination, seed dispersal, germination and seedling survival will gradually create a more

natural forest, with local community structure suited to the microclimate at each site. While there are many potential invertebrate pollinators on the island, the only bird pollinators present are recently arrived generalists such as silvereyes and starlings, rather than species like bellbird, tui and kaka that co-evolved with New Zealand forest plants. Similarly with seed dispersal, introduced passerines and silvereyes can only cope with small fruits, while the reintroduction of kereru will ensure a seed dispersal agent is present for the large-fruited dominant canopy species tawa, karaka and kohekohe.

5. Introduce a diversity of forest-dwelling invertebrates

Invertebrates have crucial roles in nutrient cycling and pollination as well as providing a prey source for most vertebrates proposed for introduction. Diverse invertebrate communities are essential for the functioning of terrestrial ecosystems, providing (along with fungi) the means by which organic material is broken down and made available to plants or higher trophic levels. The sheer number of invertebrate species present in a healthy ecosystem is far too vast to consider a species-by-species approach to restoration, but the community approach advocated here should ensure that the dominant invertebrate species characteristic of the three main forest types (kohekohe, tawa and karaka) are restored to Mana Island.

6. Weed control

There is a real risk that plant communities on Mana Island will become dominated by inappropriate species before restoration has proceeded sufficiently far for natural processes to ensure the spread of plant species typical of the eastern Cook Strait Ecological District. While there will be a long term need for maintenance control of aggressive weed species, intensive weed control is crucial during the early stages of ecological restoration on Mana Island. Continual vigilance will be required to ensure that colonising (and recolonising) weed species are destroyed before they become established.

18.2 TIME FRAME

The rate at which ecological restoration proceeds on Mana Island is dependent on funding levels (both governmental and sponsorship) and the extent of community involvement. Specialist interest groups such the Wellington Botanical Society, Forest & Bird, the Ornithological Society, Ducks Unlimited and the Society for Research on Amphibians and Reptiles have the skills, knowledge and, in some cases, financial resources to implement components of the restoration plan with little financial input from the Departmental of Conservation. Because of the difficulties of forecasting funding levels and the level of specialist interest group involvement in the restoration of Mana Island, the following time frame (Table 18.1) is based on five-year time blocks rather than a detailed annual work plan. Crucial steps that must be completed before dependent actions can proceed are forest restoration, wetland restoration,

gull control and speargrass planting, as failure to complete these tasks will prevent dependent animal and plant introductions occurring.

TABLE 18.1 ACTION PLAN FOR MAIN TASKS REQUIRED TO IMPLEMENT ECOLOGICAL RESTORATION ON MANA ISLAND.

		1996-2000	2001-2005	2006-2010	2011-2015	2016-2020
Forest restoration	Planting[1]	Intensive (175,000)	Intensive (175,000)	70,000 + ground covers and lianes	Ground covers and lianes	
	Pukeko control	Localised	Localised			
	Weed control	Intensive	Maintenance	Maintenance	Maintenance	Maintenance
	Animal introductions	Little spotted kiwi, yellow-crowned parakeet, robin, robust skink, Duvaucel's gecko, green gecko, *Rhytida*	Kereru, bellbird, tui, whitehead, giant pill millipede, *Wainuia*	Kaka, stag beetle, forest invertebrates from Kapiti Island	Forest invertebrates from Kapiti Island	*Powelliphanta*
Grassland/ shrubland/ coastal restoration	Planting[1]	Speargrass, flax	Speargrass, flax			
	Gull control	Intensive	Maintenance	Maintenance	Maintenance	Maintenance
	Weed control	Intensive	Intensive	Maintenance	Maintenance	Maintenance
	Animal introductions	Shore plover[2], snipe, tuatara, spotted skink, flax weevil; attract seabirds	Whitaker's skink, speckled skink; attract seabirds	Rock wren[3], speargrass weevil[3]; attract seabirds	Attract seabirds	Attract seabirds
Wetland restoration	Create wetland	Plan and implement	Maintain	Maintain	Maintain	Maintain
	Planting[1]	Intensive	Intensive	Threatened plants	Threatened plants	Threatened plants
	Animal introductions		Brown teal, fernbird, mudfish			
Threatened plants	Planting[1]	Constant effort throughout				

[1]Most planting requires at least two years lead in time to allow for seed collection, propagation and growing-on
[2]Dependent on successful gull control
[3]Dependent on success of trials on Matiu/Somes Island

18.3 RESPONSIBILITIES

The Kapiti Area Manager (Wellington Conservancy, Department of Conservation) is responsible for securing the resources to implement the ecological restoration plan. The actual work will be carried out or supervised by Mana Island Field Centre staff accountable to the Kapiti Area Manager. Technical Support staff (Wellington Conservancy) will provide specialist technical advice, including planning and permitting, to assist with delivery of conservation outputs in the field.

The Mana Island Field Centre Supervisor will be responsible for supervision of volunteer groups on the island and liaison with organisations involved in implementation of this plan.

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References

Allen, D.G. 1990: Assessment and transfer of the whitehead to Tiritiri Matangi Island (abstract). p.305 in Towns, D. R.; Daugherty, C. H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Angehr, G.R. 1986: Ecology of honeyeaters on Little Barrier Island: a preliminary survey. Pp 1–11 in Wright, A. E.; Beever, R. E. (eds) The offshore islands of northern New Zealand. Department of Lands and Survey, Wellington.

Atkinson, I.A.E. 1988: Presidential address: opportunities for ecological restoration. *NZ J. Ecology 11*: 1–12.

Atkinson, I. A. E. 1990: Ecological restoration on islands: prerequisites for success. Pp 73–90 in Towns, D. R., Daugherty, C. H.; Atkinson, I. A. E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Atkinson, I. A. E. 1992: Ecological restoration of Mana Island: threatened plants. *Conservation Advisory Science Notes No. 5*, Department of Conservation, Wellington. 6p.

Atkinson, I. 1995: Principles of ecological restoration. Pp 12–17 in Bell, V.; James, G; Sawyer, J. (eds) Ecological restoration in the Wellington area. Unpublished workshop proceedings, Wellington Branch, Royal Forest and Bird Protection Society.

Atkinson, I.A.E.; Towns, D.R. 1990: Functional categories for managing islands of conservation significance. Pp 83–84 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Bagnall, R.G.; Ogle, C.C. 1981: The changing vegetation structure and composition of a lowland mire at Plimmerton, North Island, New Zealand. *NZ J. Botany 19*: 371–387.

Barratt, B. 1994: Research and monitoring in the Cromwell Chafer Beetle Nature Reserve. Pp. 7–8 in Cresswell, M.; Veitch [C.R.] (eds) Threatened terrestrial insects: a workshop to advance conservation. *Threatened Species Occasional Publication No. 6*. Department of Conservation, Wellington.

Beggs, J.R.; Wilson, P.R. 1991: The kaka (Nestor meridionalis), a New Zealand parrot endangered by introduced wasps and mammals. *Biological Conservation 56*: 23–28.

Bell, B.D. 1978: The Big South Cape rat irruption. Pp 33–40 in Dingwall, P.R.; Atkinson, I.A.E.; Hay, C. (eds) The ecology and control of rodents in New Zealand nature reserves. *NZ Department of Lands and Survey Information Series 4*.

Bell, B.D. 1994: Translocation of fluttering shearwaters: developing a method to re-establish seabird populations. Pp 143–148 in Serena, M. (ed.) Reintroduction biology of Australian and New Zealand fauna. Surrey Beatty & Sons, Chipping Norton.

Bell, B.D.; Atkinson, I.A.E. 1975: Proposals for increasing the diversity of wetland habitats on Kapiti Island. Unpublished report to Wellington District Office, Department of Lands and Survey (file 8/5/359/9 vol. 2).

Bell, B.D.; Daugherty, C.H.; Hay, J.M. 1998. *Leiopelma pakeka* n. sp. (Anura: Leiopelmatidae), a cryptic species of frog from Maud Island, New Zealand, and a reassessment of the conservation status of *Leiopelma hamiltoni* from Stephens Island. *J. Royal Society NZ 28*: 39–54.

Best, E. 1923. Notes on the occurrence of the lizard in Maori carvings. *NZ J. Science & Technology 5*: 321–335.

Brockie, R.E. 1983: Starling (*Sturnus vulgaris*) roosts and flightlines near Wellington. *Notornis 30*: 217–226.

Bull, R.M. 1967: A study of a large New Zealand weevil *Lyperobius huttoni* Pascoe 1876, (Coleoptera: Curculionidae, Molytinae). Unpubl. MSc thesis, Victoria University of Wellington.

Bunin, J.S.; Jamieson, I.G. 1996: A cross-fostering experiment between the endangered takahe (Porphyrio mantelli) and its closest relative, the pukeko (*P. porphyrio*). *NZ J. Ecology 20*: 207–213.

Butler, D.; McLennan, J. 1991: Kiwi recovery plan. *Threatened Species Recovery Plan No. 2*. Department of Conservation, Wellington.

Butler, D.J.; Merton, D.V. 1992: The black robin: saving the world's most endangered bird. Oxford University Press, Auckland.

Chester, P.I. 1991: Recent vegetation history of Mana Island: palynological investigations. *Science & Research Series No. 28*. Department of Conservation, Wellington.

Chester, P.I.; Raine, J.I. 1990: Mana Island revegetation: data from late Holocene pollen analysis. Pp 113–122 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Clelland, D. 1984: Unprotected natural areas of the Wellington Region: a survey of eleven areas of biological significance. Unpublished report prepared for the Wellington District Office, Department of Lands and Survey.

Cockayne, L. 1907: Report on a botanical survey of Kapiti Island. Appendix to the Journal of the House of Representatives (NZ) C8.

Craig, J.L.; Douglas, M.E. 1984: Bellbirds in Auckland and Northland. *Notornis 31*: 82–86.

Cree, A. 1994: Low annual reproductive output in female reptiles from New Zealand. *NZ J. Zoology 21*: 351–372.

Cree, A.; Daugherty, C.H. 1991: High rates of cutaneous water loss in nocturnal New Zealand reptiles. Unpublished report to Director, Science & Research, Department of Conservation.

Crouchley, D. 1994: Takahe recovery plan. *Threatened Species Recovery Plan No. 12*. Department of Conservation, Wellington.

Daniel, M.J. 1990: Bats: order Chiroptera. Pp. 114–137 in King, C.M. (ed.) The handbook of New Zealand mammals. Oxford University Press, Auckland.

Daugherty, C.H., Patterson, G.B.; Hitchmough, R.A. 1994: Taxonomic and conservation review of the New Zealand herpetofauna. *NZ J. Zoology 21*: 317–323.

Daugherty, C.H.; Triggs, S.J. 1991: Population differentiation in New Zealand birds. Acta XX Congressus Internationalis Ornithologici 1: 525–533.

Davidson, J. 1978: Archaeological salvage excavations at Paremata, Wellington, New Zealand. *National Museum of NZ Records 1*: 203–236.

Day, K. 1987: Mana Island. *Porirua Museum History Series No. 2*.

Department of Conservation 1992: Historic resources strategy; Wellington Conservancy.

Department of Conservation 1996: Conservation management stategy for Wellington. 1996-2005 Vol. 1. *Wellington Conservancy Conservation Management Planning Series No. 2*. Department of Conservation, Wellington.

Department of Lands & Survey 1981: Mana Island: a concept plan for its management and future use. *Department of Lands & Survey Land Use Series No. 13*, Wellington.

Department of Lands & Survey 1986: Mana Island management plan. Department of Lands & Survey, *Management Plan Series CL 63*, Wellington.

Dowding, J.E.; Kennedy, E.S. 1993. Size, age structure and morphometrics of the shore plover population on South East Island. *Notornis* 40: 213–222.

Dumbell, G.; Williams, M. 1994: Brown teal recovery plan (draft).

Duncan, K.W.; Johns, P.M. 1989: Reserves for invertebrates. Pp. 78–82 in Norton, D. A. (ed.) Management of New Zealand's natural estate. *Occasional Publication No. 1*, New Zealand Ecological Society, Christchurch.

East, K.T.; East, M.R.; Daugherty, C.H. 1995: Ecological restoration and habitat relationships of reptiles on Stephens Island, New Zealand. *NZ J. Zoology* 22: 249–261.

Efford, M.G.; Karl, B.J.; Moller, H. 1988: Population ecology of Mus musculus on Mana Island, New Zealand. *J. Zoology (London) 216*: 539–563.

Elliott, G. 1989: The distribution of banded rails and marsh crakes in coastal Nelson and the Marlborough Sounds. *Notornis 36*: 117–123.

Empson, R. 1994: Black-backed gull management, Mana Island. Unpublished report to Wellington Conservation Board.

Empson, R. 1995: Wellington Conservancy mammal contingency plan for Kapiti, Mana, Mokopuna, Motungarara, Somes, Tahoramaurea, Tokomapuna & Ward Islands. Unpublished report, Department of Conservation, Wellington.

Empson, R.A.; Sawyer, J.W.D. 1995: Wellington Conservancy plant conservation strategy. Unpublished report, Wellington Conservancy, Department of Conservation.

Falla, R.A. 1953: Change and adjustment in plant and animal communities. NZ Ecol.Soc. Report of 2nd Annual Meeting: 3–4.

Fogarty, S.M.; Douglas, M.E. 1973: The birds of the Aldermen Islands. *Tane 19*: 31–39.

Fuller, S. 1993: Wetlands in the Wellington Region. Unpublished report, Wellington Regional Council.

Gabites, I. 1993: Wellington's living cloak: a guide to the natural plant communities. Wellington Botanical Society and Victoria University Press, Wellington.

Gabites, I. 1994: Mana Island/mainland sites: generalised site descriptions. Unpublished report to Wellington Conservancy, Department of Conservation.

Gibbs, G.W. 1990: The silent majority: a plea for the consideration of invertebrates in New Zealand island management. Pp 123–127 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Gibbs, G.W. 1994: Mana Island insect samples. Unpublished report to Wellington Conservancy, Department of Conservation.

Godley, E.J. 1972: Does planting achieve its purpose? *Forest & Bird 185*: 25–26.

Hardy, G.S. 1977: The New Zealand Scincidae (Reptilia: Lacertilia); a taxonomic and zoogeographic study. *NZ J. Zoology 4*: 221–325.

Harris, R.J.; Oliver, E.H. 1993: Prey diets and population densities of the wasps Vespula vulgaris and V. germanica in scrubland-pasture. *NZ J. Ecology 17*:5–12.

Hawkins, J.M. 1988: The Farewell Spit gannetry – a new sea level colony. *Notornis 35*: 249–260.

Heine, J.C. 1975: Interim report on soils of Wellington Region, New Zealand. *NZ Soil Bureau Record 39*.

Holloway, B.A. 1956: Revision of the New Zealand pill millipedes (Oniscomorpha, Sphaerotheridae). *Trans. Roy. Soc. NZ 84*: 431–446.

Holloway, B.A. 1961: A systematic revision of the New Zealand Lucanidae (Insecta: Coleoptera). *Dominion Museum Bulletin No. 20*.

Horwood, M. 1991: Prehistoric and nineteenth century Maori settlement on Mana Island, Cook Strait: excavations at site R26/141. *NZ J. Archaeology 13*: 5–40.

Hunt, M.R. 1996: The distribution and habitat requirements of the large speargrass weevil (*Lyperobius huttoni*) and charcteristics of host speargrass plants (*Aciphylla squarrosa*) and their vegetation associations. Unpubl. MSc thesis, Victoria University of Wellington.

Hutcheson, J. 1994: Standards of monitoring. Pp. 13–15 in Cresswell, M.; Veitch [C.R.] (eds) Threatened terrestrial insects: a workshop to advance conservation. *Threatened Species Occasional Publication No. 6*. Department of Conservation, Wellington.

Jones, K.L. 1987: Early gardening on Mana Island, Cook Strait, New Zealand. *NZ Geographer 43*: 18–22.

Kennedy, E. 1993: New Zealand shore plover recovery plan (draft).

Kuschel, G. 1990: Beetles in a suburban environment: a New Zealand case study. *DSIR Plant Protection Report No. 3*.

Lovegrove, T.G. 1996: Island releases of saddlebacks *Philesturnus carunculatus* in New Zealand. *Biological Conservation 77*: 151–157.

Mantell, W.B.D. 1865: Island of Mana (survey plan). National Archives, Group WP 7/7 1865.

McDowall, R.M. 1990: New Zealand freshwater fishes: a natural history and guide. Heinemann Reed, Auckland.

McEwen, W.M. (Ed.) 1987: Ecological regions and districts of New Zealand (3rd edn). *New Zealand Biological Resources Publication No. 5*. Department of Conservation, Wellington.

McGlynn, M. 1990: Revegetation of Motuhora (Whale Island) Whakatane. p. 310 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Meads, M. 1990: Forgotten fauna: the rare, endangered, and protected invertebrates of New Zealand. DSIR Publishing, Wellington.

Meurk, C.D.; Blaschke, P.M. 1990: How representative can New Zealand islands really be? An analysis of climo-edaphic environments in New Zealand. Pp 52–72 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Millar, I.; Gaze, P. 1997: Island management; a strategy for island management in Nelson/Marlborough Conservancy. *Occasional Publication No. 31*, Nelson/Marlborough Conservancy, Department of Conservation.

Millener, P.R.; Worthy, T.H. 1991: Contributions to New Zealand's Late Quaternary avifauna II, *Dendroscansor decurvirostris*, a new genus and species of wren (Aves: Acanthisittidae). *J. Roy. Soc. NZ 21*: 179–200.

Miskelly, C.M. 1987: The identity of the hakawai. *Notornis 34*: 95–116.

Miskelly, C.M. 1988: The Little Barrier Island snipe. *Notornis 35*: 273–281.

Miskelly, C.M. 1995: Distribution of reptiles in Wellington Conservancy, with a key to lizard species. Unpublished report, Wellington Conservancy, Department of Conservation.

Miskelly, C.; Aikman, H. 1993: Assessment of Mana Island as habitat for shore plover: a preliminary report. Unpublished report, Wellington Conservancy, Department of Conservation.

Molloy, J. (compiler) 1995: Bat (pekapeka) recovery plan (*Mystacina*, *Chalinolobus*). *Threatened Species Recovery Plan No. 15*. Department of Conservation, Wellington.

Molloy, J.; Davis, A. 1994: Setting priorities for the conservation of New Zealand's threatened plants and animals. 2nd edn, collated by C. Tisdall. Department of Conservation, Wellington.

Newman, D.G. 1994: Effects of a mouse, *Mus musculus*, eradication programme and habitat change on lizard populations of Mana Island, New Zealand, with special reference to McGregor's skink, *Cyclodina macgregori*. *NZ J.Zool 21*: 443–456.

Nicholls, M. 1989: Mana Island revegetation programme: draft implementation plan. Department of Conservation, Wanganui.

Notman, P.R. 1984: An invertebrate survey of some Pelorus Sound islands with reference to their predator status. Unpublished Msc thesis, Victoria University of Wellington.

Ogle, C. 1978: Vegetation of swamp pockets near Plimmerton. *Wellington Botanical Society Bulletin 40*: 24–29.

Ogle, C. 1985: Forest remnants in Plimmerton area: species lists of indigenous plants. Unpublished report.

Ogle, C.C. 1989a: An overview of reserve design and location in New Zealand. Pp 11–18 in Norton, D.A. (ed.) Management of New Zealand's natural estate. *NZ Ecological Society Occasional Publication No. 1*, Christchurch.

Ogle, C. 1989b: Wellington's threatened plants for Mana Island. (revised October 1989). Unpublished report, Department of Conservation, Wanganui. 8p.

Parrish, R.; Sherley, G.; Aviss, M. 1995: Giant land snail recovery plan: *Placostylus* sp., *Paryphanta* sp. *Threatened Species Recovery Plan No. 13*. Department of Conservation, Wellington.

Patrick, B. 1994: Mana Island lepidoptera. Unpublished report to Wellington Conservancy, Department of Conservation.

Pickard, C.R.; Towns, D.R. 1988: Atlas of the amphibians and reptiles of New Zealand. *Conservation Sciences Publication No. 1*. Department of Conservation, Wellington.

Robb, J. 1980: New Zealand amphibians and reptiles in colour. Collins, Auckland.

Ryan, C.J.; Jamieson, I.G. 1998: Estimating the home range and carrying capacity for takahe (*Porphyrio mantelli*) on predator-free offshore islands: implications for future management. *NZ J. Ecology 22*: 17–24.

Sherley, G. 1995: Recovery plan for threatened weta. Draft report, Department of Conservation, Wellington.

Simberloff, D. 1990: Reconstructing the ambiguous: can island ecosystems be restored? Pp 37–51 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Sladden, B.; Falla, R.A. 1927 & 1928: Aldermen Islands: a general description, with notes on the flora and fauna. *NZ J.Sci.Tech. 9*: 193–205, 282–290.

Smale, S.; Owen, K. 1990: Motuhora: a whale of an island. Pp 109–112 51 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Taylor, R.H. 1985: Status, habits and conservation of *Cyanoramphus* parakeets in the New Zealand region. Pp 195–211 in Moors, P.J. (ed.) Conservation of island birds. *ICBP Tech.Publ. No.3*, Cambridge.

Taylor, R.H.; Heatherbell, E.G.; Heatherbell, E.M. 1986: The orange-fronted parakeet (*Cyanoramphus malherbi*) is a colour morph of the yellow-crowned parakeet (*C. auriceps*). *Notornis 33*: 17–22.

Thomas, B.W.; Meads, M.J.; Notman, P.R. 1992: A report on the restoration of knobbled weevils (Hadramphus stilbocarpae) and flax weevils (Anagotus fairburni) to Breaksea Island, Breaksea Sound, Fiordland. *DSIR Land Resources Technical Record 79*.

Timmins, S.; Ogle, C.; Atkinson, I.A.E. 1987a: Vegetation and vascular flora of Mana Island. *Wellington Botanical Society Bulletin 43*: 41–74.

Timmins, S.M.; Atkinson, I.A.E.; Ogle, C.C. 1987b: Conservation opportunities on a highly modified island: Mana Island, Wellington, New Zealand. *NZ J. Ecology 10*: 57–65.

Timmins, S.M.; Atkinson, I.A.E.; Ogle, C. 1988: Planting trials for the revegetation of Mana Island. Science & Research Internal Report 3. Department of Conservation, Wellington.

Timmins, S.; Wassilieff, M. 1984: The effects of planting programmes on natural distribution and genetics of native plant species. *The Landscape 21*: 18–20.

Todd, P.; Miskelly, C. In press: Eradication of mice from Mana Island, New Zealand. Department of Conservation, Wellington.

Towns, D.R. 1992a: Distribution and abundance of lizards at Pukerua Bay, Wellington: implications for reserve management. Science & Research Internal Report No. 125. Department of Conservation, Wellington.

Towns, D.R. 1992b: Recovery plan for Whitaker's skink and robust skink. *Threatened Species Recovery Plan No. 3.* Department of Conservation, Wellington.

Towns, D.R. 1994: The role of ecological restoration in the conservation of Whitaker's skink (*Cyclodina whitakeri*), a rare New Zealand lizard (Lacertilia: Scincidae). *NZ Journal of Zoology 21*: 457–471.

Towns, D.R.; Atkinson, I.A.E.; Daugherty, C.H. 1990: The potential for ecological restoration in the Mercury Islands. Pp 91–108 in Towns, D.R., Daugherty, C.H. & Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Townsend, J.I. 1994: Mana Island fauna survey. Unpublished report to Wellington Conservancy, Department of Conservation.

Triggs, S.J.; Daugherty, C.H. 1988: Preliminary genetic analysis of New Zealand parakeets. Science & Research Internal Report No. 14. Unpublished report, Department of Conservation, Wellington.

Turbott, E.G., 1948: Effects of goats on Great Island, Three Kings, with descriptions of vegetation quadrats. *Rec. Auck. Inst. Mus. 3*: 253–272.

Turbott, E.G., (Convener) 1990: Checklist of the birds of New Zealand and the Ross Dependency, Antarctica (3rd edn). Ornithological Society of New Zealand and Random Century, Auckland.

Turbott, E.G.; Buddle, G.A. 1948: Birds of the Three Kings Islands. *Rec. Auck. Inst. Mus. 3*: 319–336.

Watt, A.H.; Cunningham, J.M.; Hunt, W.F.I.; Stidolph, R.H.D.; Sansom, O. 1949: Notes of the fern bird. *New Zealand Bird Notes 3*: 131–132.

Waugh, J.R.; Keane, A.J.; Palmer, L. 1996: Mana Island wetland restoration initial field investigation. Unpublished report, Wellington Conservancy. Department of Conservation, Wellington.

Whitaker, A.H. 1993: Research on the goldstripe gecko (*Hoplodactylus* chrysosireticus Robb 1980) on Mana Island, Cook Strait, 18–24 February 1993. Unpublished report, Wellington Conservancy. Department of Conservation, Wellington.

Wilkinson, J.S. 1873: Survey of the Island of Mana for J.F.E. Wright. Manuscript map, Alexander Turnbull Library.

Wodzicki, K.; Robertson, C.J.R.; Thompson, H.R.; Alderton, C.J.T. 1984: The distribution and numbers of gannets (*Sula serrator*) in New Zealand. *Notornis 31*: 232–261.

Worthy, T.H. 1987a: Osteological observations on the larger species of the skink *Cyclodina* and the subfossil occurrence of these and the gecko *Hoplodactylus* duvaucelii in the North Island, New Zealand. *NZ J.Zoology 14*: 219–229.

Worthy, T.H. 1987b: Palaeoecological information concerning members of the frog genus Leiopelma: Leiopelmatidae in New Zealand. *J. Royal Society NZ 17*: 409–420.

Worthy, T.H. 1991: Fossil skink bones from Northland, New Zealand, and description of a new species of *Cyclodina*, Scincidae. *J. Royal Society NZ 21*: 329–348.

Worthy, T.H.; Holdaway, R.N. 1993: Quaternary fossil faunas from caves in the Punakaiki area, West Coast, South Island, New Zealand. *J.Royal Society NZ 23*: 147–254.

Worthy, T.H.; Holdaway, R.N. 1994: Quaternary fossil faunas from caves in Takaka Valley and on Takaka Hill, northwest Nelson, South Island, New Zealand. *J. Royal Society NZ 24*: 297–391.

Wright, A.E.; Cameron, E.K. 1990: Vegetation management on northern offshore islands. Pp 221–239 in Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. (eds) Ecological restoration of New Zealand islands. *Conservation Sciences Publication No. 2*. Department of Conservation, Wellington.

Appendix 1

SCIENTIFIC NAMES OF ANIMALS MENTIONED IN TEXT

Antipodes Island parakeet	*Cyanoramphus unicolor*
Antipodes Island pipit	*Anthus novaeseelandiae steindachneri*
Antipodes Island snipe	*Coenocorypha aucklandica meinertzhagenae*
Auckland Island banded dotterel	*Charadrius bicinctus exilis*
Auckland Island rail	*Rallus pectoralis muelleri*
Auckland Island snipe	*Coenocorypha aucklandica aucklandica*
Auckland Island teal	*Anas aucklandica*
Auckland Island tomtit	*Petroica macrocephala marrineri*
Australasian gannet	*Morus serrator*
Australasian harrier	*Circus approximans*
Australian magpie	*Gymnorhina tibicen*
Axis deer	*Axis axis*
Banded kokopu	*Galaxias fasciatus*
Banded rail	*Rallus philippensis*
Bellbird	*Anthornis melanura*
Black robin	*Petroica traversi*
Black shag	*Phalacrocorax carbo*
Black swan	*Cygnus atratus*
Black-backed gull	*Larus dominicanus*
Blackbird	*Turdus merula*
Black-fronted tern	*Sterna albostriata*
Blue duck	*Hymenolaimus malacorhynchos*
Blue penguin	*Eudyptula minor*
Broad-billed prion	*Pachyptila vittata*
Brothers Island tuatara	*Sphenodon guntheri*
Brown kiwi	*Apteryx mantelli*
Brown mudfish	*Neochanna apoda*
Brown skink	*Oligosoma zelandicum*
Brown teal	*Anas chlorotis*
Bush wren	*Xenicus longipes*
Campbell Island snipe	*Coenocorypha aucklandica* n. subsp.
Campbell Island teal	*Anas nesiotis*
Caspian tern	*Sterna striata*
Cat	*Felis catus*
Cattle	*Bos taurus*
Chaffinch	*Fringilla coelebs*

Chatham Island bellbird	*Anthornis melanura melanocephala*
Chatham Island fantail	*Rhipidura fuliginosa penita*
Chatham Island fernbird	*Bowdleria rufescens*
Chatham Island oystercatcher	*Haematopus chathamensis*
Chatham Island pigeon	*Hemiphaga novaeseelandiae chathamensis*
Chatham Island pipit	*Anthus novaeseelandiae chathamensis*
Chatham Island red-crowned parakeet	*Cyanoramphus novaezelandiae chathamensis*
Chatham Island snipe	*Coenocorypha pusilla*
Chatham Island tomtit	*Petroica macrocephala chathamensis*
Chatham Island tui	*Prosthemadera novaeseelandiae chathamensis*
Chatham Island warbler	*Gerygone albofrontata*
Cirl bunting	*Emberiza cirlus*
Coastal moa	*Euryapteryx curtus*
Codfish Island fernbird	*Bowdleria punctata wilsoni*
Common diving petrel	*Pelecanoides urinatrix*
Common gecko	*Hoplodactylus maculatus*
Common skink	*Oligosoma nigriplantare polychroma*
Common wasp	*Vespula vulgaris*
Cook Strait amychus	*Amychus granulatus*
Cook Strait giant weta	*Deinacrida rugosa*
Cook Strait tuatara	*Sphenodon punctatus* subsp.
Cook's petrel	*Pterodroma cookii*
Copper skink	*Cyclodina aenea*
Diving petrel	*Pelecanoides* sp.
Domestic fowl	*Gallus gallus*
Duvaucel's gecko	*Hoplodactylus duvaucelii*
Erect-crested penguin	*Eudyptes sclateri*
Fairy prion	*Pachyptila turtur*
Falcon	*Falco novaeseelandiae*
Fernbird	*Bowdleria punctata*
Fiordland crested penguin	*Eudyptes pachyrhynchus*
Flax weevil	*Anagotus fairburni*
Flesh-footed shearwater	*Puffinus carneipes*
Fluttering shearwater	*Puffinus gavia*
Forbe's parakeet	*Cyanoramphus auriceps forbesi*
Forest gecko	*Hoplodactylus granulatus*
Fulmar prion	*Pachyptila crassirostris*
Gannet	*Morus serrator*
German wasp	*Vespula germanica*
Giant kokopu	*Galaxias argenteus*
Giant pill millipede	*Procyliosoma tuberculata tuberculata*

Giant weta	*Deinacrida rugosa*
Goat	*Capra hircus*
Goldfinch	*Carduelis carduelis*
Goldstripe gecko	*Hoplodactylus chrysosireticus*
Grayling	*Prototroctes oxyrhynchus*
Greater short-tailed bat	*Mystacina robusta*
Green gecko	*Naultinus* sp.
Greenfinch	*Carduelis chloris*
Grey duck	*Anas superciliosa*
Grey warbler	*Gerygone igata*
Haast tokoeka	*Apteryx australis* subsp.
Hamilton's frog	*Leiopelma hamiltoni*
Harrier	*Circus approximans*
Hedge sparrow	*Prunella modularis*
Hochstetter's frog	*Leiopelma hochstetteri*
House sparrow	*Passer domesticus*
Hutton's shearwater	*Puffinus huttoni*
Kaka	*Nestor meridionalis*
Kakapo	*Strigops habroptilus*
Kermadec parakeet	*Cyanoramphus novaezelandiae cyanurus*
Kingfisher	*Halcyon sancta*
Kiore	*Rattus exulans*
Kiwi sp.	*Apteryx* sp.
Koaro	*Galaxias brevipinnis*
Kokako	*Callaeas cinerea*
Lesser knot	*Calidris canutus*
Lesser short-tailed bat	*Mystacina tuberculata*
Little Barrier snipe	*Coenocorypha aucklandica barrierensis*
Little shag	*Phalacrocorax melanoleucos*
Little spotted kiwi	*Apteryx owenii*
Long-tailed bat	*Chalinolobus tuberculatus*
Long-tailed cuckoo	*Eudynamys taitensis*
Macquarie Island parakeet	*Cyanoramphus novaezelandiae erythrotis*
Magpie	*Gymnorhina tibicen*
Mallard	*Anas platyrhynchos*
Marbled skink	*Cyclodina oliveri*
Marlborough green gecko	*Naultinus manukanus*
"Marlborough mini" gecko	*Hoplodactylus* n. sp.
Maud Island frog	*Leiopelma pakeka*
McGregor's skink	*Cyclodina macgregori*
Morepork	*Ninox novaeseelandiae*

Mouse	*Mus musculus*
New Zealand dotterel	*Charadrius obscurus*
New Zealand falcon	*Falco novaeseelandiae*
New Zealand kingfisher	*Halcyon sancta vagans*
New Zealand pigeon (kereru)	*Hemiphaga novaeseelandiae novaeseelandiae*
New Zealand pipit	*Anthus novaeseelandiae novaeseelandiae*
New Zealand quail	*Coturnix novaezelandiae novaezelandiae*
New Zealand robin	*Petroica australis*
North Island bush wren	*Xenicus longipes stokesii*
North Island fantail	*Rhipidura fuliginosa placabilis*
North Island fernbird	*Bowdleria punctata vealeae*
North Island kaka	*Nestor meridionalis septentrionalis*
North Island kokako	*Callaeas cinerea wilsoni*
North Island rifleman	*Acanthisitta chloris granti*
North Island robin	*Petroica australis longipes*
North Island saddleback	*Philesturnus carunculatus rufusater*
North Island stout-legged wren	*Pachyplichas jagmi*
North Island takahe	*Porphyrio mantelli mantelli*
North Island tomtit	*Petroica macrocephala toitoi*
North Island weka	*Gallirallus australis greyi*
Northern giant petrel	*Macronectes halli*
Norway rat	*Rattus norvegicus*
Okarito brown kiwi	*Apteryx mantelli* subsp.
Orange-fronted parakeet	*Cyanoramphus* [*auriceps*] *malherbi*
Ornate skink	*Cyclodina ornata*
Pacific gecko	*Hoplodactylus pacificus*
Paradise shelduck	*Tadorna variegata*
Pied shag	*Phalacrocorax varius*
Pied stilt	*Himantopus himantopus*
Pig	*Sus scrofa*
Poor Knights bellbird	*Anthornis melanura oneho*
Possum	*Trichosurus vulpecula*
Pukeko	*Porphyrio porphyrio melanotus*
Rabbit	*Oryctolagus cuniculus*
Rat	*Rattus* sp.
Red-billed gull	*Larus novaehollandiae scopulinus*
Red-crowned parakeet	*Cyanoramphus novaezelandiae*
Redpoll	*Carduelis flammea*
Red-rumped parrot	*Psephotus haematonotus*
Reef heron	*Egretta sacra*

Reischek's parakeet	*Cyanoramphus novaezelandiae hochstetteri*
Rifleman	*Acanthisitta chloris*
Robin	*Petroica australis*
Robust skink	*Cyclodina alani*
Rock pigeon	*Columba livia*
Rock wren	*Xenicus gilviventris*
Royal albatross	*Diomedea epomophora*
Royal spoonbill	*Platalea regia*
Saddleback	*Philesturnus carunculatus*
Salvin's prion	*Pachyptila salvini*
Sheep	*Ovis aries*
Shining cuckoo	*Chrysococcyx lucida*
Ship rat	*Rattus rattus*
Shore plover	*Thinornis novaeseelandiae*
Shortfinned eel	*Anguilla australis*
Short-jawed kokopu	*Galaxias postvectis*
Short-tailed bat	*Mystacina tuberculata*
Shy mollymawk	*Diomedea cauta*
Silvereye	*Zosterops lateralis*
Skylark	*Alauda arvensis*
Snares Island fernbird	*Bowdleria punctata caudata*
Snares Island snipe	*Coenocorypha aucklandica huegeli*
Snares Island tomtit	*Petroica macrocephala dannefaerdi*
Snipe	*Coenocorypha* sp.
Song thrush	*Turdus philomelos*
Sooty shearwater	*Puffinus griseus*
Southern black-backed gull	*Larus dominicanus*
Southern giant petrel	*Macronectes giganteus*
South Island kaka	*Nestor meridionalis meridionalis*
South Island kokako	*Callaeas cinerea cinerea*
South Island robin	*Petroica australis australis*
South Island saddleback	*Philesturnus carunculatus carunculatus*
South Island takahe	*Porphyrio mantelli hochstetteri*
Speargrass weevil	*Lyperobius huttoni*
Speckled skink	*Oligosoma infrapunctatum*
Spotted shag	*Stictocarbo punctatus*
Spotless crake	*Porzana tabuensis*
Spotted skink	*Oligosoma lineoocellatum*
Spur-winged plover	*Vanellus miles novaehollandiae*
Starling	*Sturnus vulgaris*
Stephens Island weevil	*Anagotus stephenensis*
Stewart Island fernbird	*Bowdleria punctata stewartiana*

Stewart Island robin	*Petroica australis rakiura*
Stewart Island snipe	*Coenocorypha aucklandica iredalei*
Stitchbird	*Notiomystis cincta*
Stoat	*Mustela erminea*
Stout-legged moa	*Euryapteryx geranoides*
Striped gecko	*Hoplodactylus stephensi*
Sulphur-crested cockatoo	*Cacatoe galerita*
Takahe	*Porphyrio mantelli*
Three Kings bellbird	*Anthornis melanura obscura*
Tokoeka	*Apteryx australis*
Tomtit	*Petroica macrocephala*
Tuatara	*Sphenodon* sp.
Tui	*Prosthemadera novaeseelandiae*
Variable oystercatcher	*Haematopus unicolor*
Vespulid wasps	*Vespula* sp.
Wandering albatross	*Diomedea exulans*
Weka	*Gallirallus australis*
Welcome swallow	*Hirundo tahitica*
Wellington green gecko	*Naultinus elegans punctatus*
Western weka	*Gallirallus australis australis*
Whitaker's skink	*Cyclodina whitakeri*
White-faced heron	*Ardea novaehollandiae*
White-faced storm petrel	*Pelagodroma marina*
White-fronted tern	*Sterna striata*
Whitehead	*Mohoua albicilla*
Yellow-crowned parakeet	*Cyanoramphus auriceps*
Yellowhammer	*Emberiza citrinella*
Yellowhead	*Mohoua ochrocephala*

Appendix 2

SCIENTIFIC NAMES OF PLANTS MENTIONED IN TEXT

Aka	*Metrosideros perforata*
Aka kiore	*Parsonsia capsularis*
Akeake	*Dodonaea viscosa*
Akiraho	*Olearia paniculata*
Angelica	*Angelica pachycarpa*
Blackberry	*Rubus fruticosus*
Bone-seed	*Chrysanthemoides monilifera*
Boxthorn	*Lycium ferocissimum*
Broom	*Cytisus scoparium*
Brush wattle	*Paraserianthes lophantha*
Cabbage tree	*Cordyline australis*
Coastal tree daisy	*Olearia solandri*
Cocksfoot	*Dactylis glomerata*
Cook's scurvy grass	*Lepidium oleraceum*
Elderberry	*Sambucus nigra*
Everlasting pea	*Lathyrus latifolius*
Fennel	*Foeniculum vulgare*
Five finger	*Pseudopanax arboreus*
Flax	*Phormium* sp.
Gorse	*Ulex europaeus*
Hangehange	*Geniostoma rupestre*
Harakeke	*Phormium tenax*
Heketara	*Olearia rani*
Hinau	*Elaeocarpus dentatus*
Holly-leaved senecio	*Senecio glastifolius*
Jersey fern	*Anogramma leptophylla*
Kahikatea	*Dacrycarpus dacrydioides*
Kaikomako	*Pennantia corymbosa*
Kaiwhiria	*Parsonsia heterophylla*
Kanuka	*Kunzea ericoides*
Kapuka	*Griselinia littoralis*
Karaka	*Corynocarpus laevigatus*
Karamu	*Coprosma robusta*
Karo	*Pittosporum crassifolium*
Kawakawa	*Macropiper excelsum*
Kiekie	*Freycinetia baueriana*
Kikuyu	*Pennisetum clandestinum*

Kohekohe	*Dysoxylum spectabile*
Kohia	*Passiflora tetrandra*
Kohuhu	*Pittosporum tenuifolium*
Koromiko	*Hebe stricta* var. *macroura*
Kowhai	*Sophora microphylla*
Lacebark	*Hoheria populnea*
Lancewood	*Pseudopanax crassifolius*
Large-leaved milk tree	*Streblus banksii*
Lemonwood	*Pittosporum eugenioides*
Macrocarpa	*Cupressus macrocarpa*
Mahoe	*Melicytus ramiflorus*
Manuka	*Leptospermum scoparium*
Mapou	*Myrsine australis*
Matagouri	*Discaria toumatou*
Matai	*Prumnopitys taxifolia*
Mingimingi	*Cyathodes juniperina*
Miro	*Prumnopitys ferruginea*
New Zealand broom	*Carmichaelia arborea*
Ngaio	*Myoporum laetum*
Nikau	*Rhopalostylis sapida*
Northern rata	*Metrosideros robusta*
Ongaonga	*Urtica ferox*
Pampas grass	*Cortaderia jubata* and *C. selloana*
Pate	*Schefflera digitata*
Patotara	*Leucopogon fraseri*
Pigeonwood	*Hedycarya arborea*
Pinatoro	*Pimelea prostrata*
Pine	*Pinus radiata*
Pohuehue	*Muehlenbeckia complexa*
Pohutukawa	*Metrosideros excelsa*
Poroporo	*Solanum aviculare* and *S. laciniatum*
Prairie grass	*Bromus willdenowii*
Prickly mingimingi	*Cyathodes juniperina*
Puawananga	*Clematis paniculata*
Puka	*Griselinia lucida*
Pukatea	*Laurelia novae-zelandiae*
Putaputaweta	*Carpodetus serratus*
Ramarama	*Lophomyrtus bullata*
Rangiora	*Brachyglottis repanda*
Rata vines	*Metrosideros* sp.
Raupo	*Typha orientalis*
Raurekau	*Coprosma grandifolia*

Rengarenga	*Arthropodium cirratum*
Rewarewa	*Knightia excelsa*
Rimu	*Dacrydium cupressinum*
Rohutu	*Lophomyrtus obcordata*
Rye grass	*Lolium perenne*
Shore ribbonwood	*Plagianthus divaricatus*
Shore spurge	*Euphorbia glauca*
Speargrass	*Aciphylla squarrosa*
Supplejack	*Ripogonum scandens*
Swamp maire	*Syzygium maire*
Swamp nettle	*Urtica linearifolia*
Tasmanian ngaio	*Myoporum insulare*
Tauhinu	*Cassinia leptophylla*
Taupata	*Coprosma repens*
Tawa	*Beilschmiedia tawa*
Titoki	*Alectryon excelsus*
Toetoe	*Cortaderia toetoe*
Totara	*Podocarpus totara*
Tree lucerne	*Chamaecytisus palmensis*
Tree mallow	*Lavatera arborea*
Tree tutu	*Coriaria arborea*
Turutu	*Dianella nigra*
Wandering Jew	*Tradescantia fluminensis*
Wharangi	*Melicope ternata*
Wharariki	*Phormium cookianum*
White clover	*Trifolium repens*
White maire	*Nestegis lanceolata*
Wineberry	*Aristotelia serrata*
Yorkshire fog	*Holcus lanatus*