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, hybridization.

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	North Brother Island
Cook Strait tuatara	Island (species not determined)	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 CONTINUED

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	I	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 I.	STATUS ON KAPITI I.	STATUS ON MATIU/SOMES 1.
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 1.)	–
Ornate skink	–	Present (rare)	Introduce (Wellington)
Whitaker's skink	introduce (Pukerua Bay)	Introduce (Pukerua Bay)	–
Speckled skink	introduce (Stephens 1.)	Introduce (Stephens 1.)	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 1.)	–
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 comprised of 11 species (tuatara, 4 *Cyclodina* skinks, 3 *Oligosoma* skinks and 3 *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

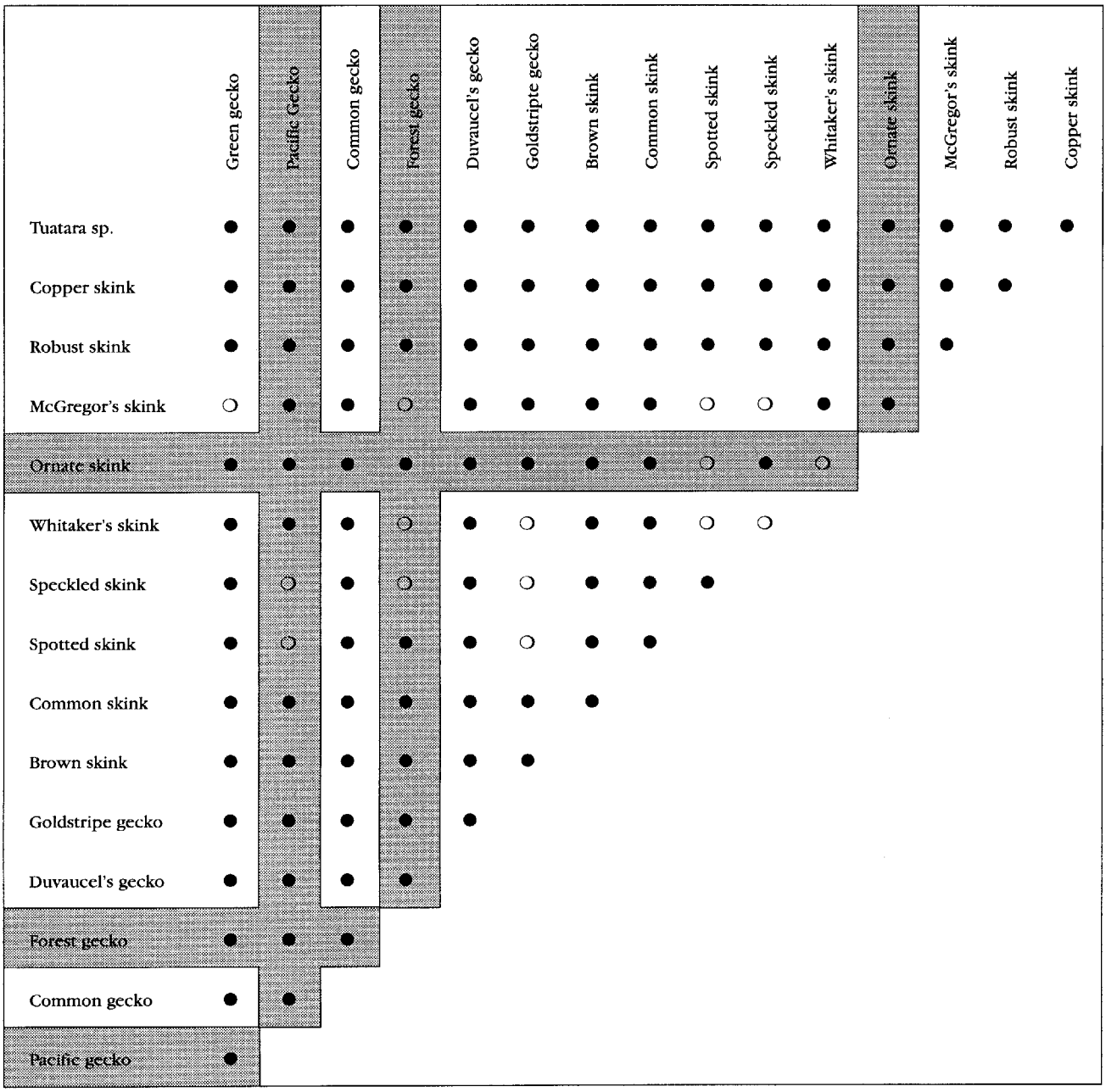

Figure 9.1 Recorded sympatry in reptiles of the southern North Island, based on records at specific sites for islands, or records from the same 10,000 metre grid square on the mainland. Data mainly from Amphibian and Reptile Distribution Scheme database administered by Department of Conservation. Note that all 120 potential species pair combinations have been recorded within one Ecological District. • = reported sympatry for respective species pair, O = 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).

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.).

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 *Cyclodinas* 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.

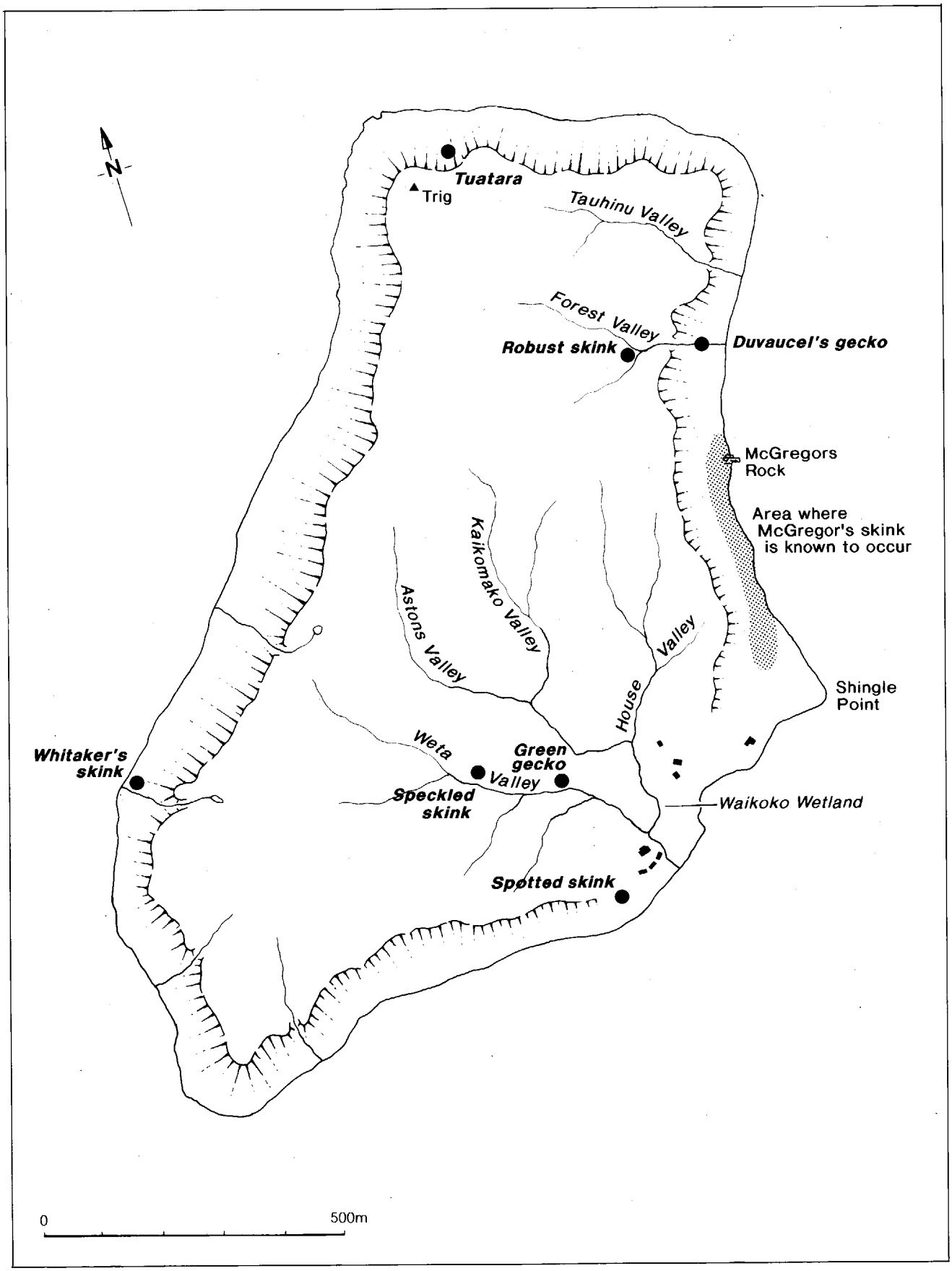

Figure 9.2 Map of Mana Island showing possible liberation sites for reptiles, and the current distribution of McGregor's skink.

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 Maria 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. wbitakeri)*
    - 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 leiopehnid 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 (MJ 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 spcargrass 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 reticulates,* 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 *Pt. 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 *Pt. 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 *Pt. 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 montlifera*	isolated shrubs on plateau
broom	*Cytisus scoparium*	isolated shrubs
blackberry	*Rubus fruticosus*	two patches on shore
holly-leaved senecio	*Senecio glastifoUus*	isolated shrubs
wandering Jew	*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*	n. & w cliffs below trig
pohutukawa	*Metrosideros excelsa*	near buildings
Tasmanian ngaio (& hybrids)	*Myoporum insulare*	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.

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