Native Frog (*Leiopelma* spp.) Recovery Plan

Threatened Species Recovery Plan No. 18

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1.0 Introduction

The native frogs of New Zealand, *Leiopelma* spp., are regarded as amongst the most primitive living in the world today. Primitive features, some of which are shared with South American fossil frogs of Jurassic age (195 to 136 million years ago), are the presence of nine presacral vertebrae (most living frogs have eight or fewer), amphicoelous vertebrae, free ribs (not fused to the vertebrae) and the retention in the adult of a "tail-wagging" muscle. These features are present in the North American tailed frog, *Ascaphus truei*, which of living species is considered to be most closely related to *Leiopelma*. Recent studies, however, support separation of the two genera into separate families (Ascaphidae and Leiopelmatidae (e.g., Green & Cannatella 1993) - both genera included in the suborder of "archaic frogs", the Archaeobatrachia (Duellman 1975).

New Zealand's native frog fauna consists of three living described species: Hochstetter's frog, *Leiopelma hochstetteri*, which occurs in forested patches of the North Island from Northland to Pureora and East Cape, and on Great Barrier Island; Archey's frog, *Leiopelma archeyi*, found on the Coromandel Range; and Hamilton's frog, *Leiopelma hamiltoni*, restricted to Maud and Stephens Islands in the Cook Strait-Marlborough Sounds region. Electrophoretic evidence recently acquired, indicates that the Stephens Island and Maud Island populations of *L. hamiltoni* are distinct species (B.D. Bell, C.H. Daugherty & J.M. Hay, pers. comm.). Consequently, only the Stephens Island form corresponds to *L. hamiltoni (sensu stricto)* while the Maud Island form is as yet unnamed. This recovery plan covers each form separately. The status of the Stephens Island species (*L. hamiltoni)* is of particular concern as it is confined to a 600m2 boulder tumble near the island's summit and the population consists of only a few hundred individuals (Newman 1990, Brown 1994). In 1991 native frogs resembling *L. archeyi* were discovered with *L. hochstetteri* in Whareorino Forest, western King Country; the taxonomic status of these `Archey-type' frogs awaits confirmation, but allozyme electrophoresis indicates that this population is indeed *L. archeyi* (B.D. Bell & R.A. Hitchmough, pers. comm.).

A clear separation exists between *L. hochstetteri* and the other living native frogs. Differences occur in their ecology and habitat requirements, water metabolism, morphology and development, karyotype (chromosome number and type) and liver and serum proteins (e.g. Bell 1982, Bell et al. 1985, Cree 1985, 1988, Daugherty et al. 1981, 1982). Archey's, Hamilton's and Maud Island frogs can be considered terrestrial while Hochstetter's frogs are semiaquatic, inhabiting stream verges and seepage areas. The extent of the separation has prompted suggestions (e.g., Green et al. 1989; Bell 1994) that generic differentiation of the two groups seems warranted.

Individual Hochstetter's frogs may have widely different chromosome numbers, resulting from additional, or supernumerary, chromosomes (e.g., Green 1988, 1994). Different populations may be cytogenetically distinctive with specimens from Mt. Moehau, Coromandel, having among the highest numbers of supernumerary chromosomes found in any type of animal. Further, North Island Hochstetter's frogs uniquely possess a univalent, female-specific chromosome; other animals, including *L. hochstetteri* from Great Barrier Island have sex chromosomes in pairs

(Green et al. 1993). Such findings suggest that at least some conservation measures for *L. hochstetteri* might be best framed population by population rather than at the species level (Green 1994), even though much cytogenetic variation may occur within populations (B. Waldman, pers. comm.).

Subfossil remains indicate that native frogs were once widely distributed throughout New Zealand and that formerly, several more species existed (Worthy 1987a, b). The distributions of all living species have been reduced during human occupation of the country and although the frogs have benefited from legal protection since 1922, their mainland habitats are still being lost (Bell 1985). According to the Department's species ranking system (Molloy & Davis 1994), Hamilton's frog is in category `A' (`requiring urgent recovery work'), and Maud Island, Archey's and Hochstetter's frogs are in category `B' (`requiring work in the short term'). Using the most recent IUCN (International Union for the Conservation of Nature) Red Data Book categories, Bell (1994) has suggested that the appropriate classification for each would probably be *L. hamiltoni (*= endangered), *L.* Maud Island (= vulnerable), *L. archeyi (*= at risk), and *L. hochstetteri (*= at risk, but of less concern than *L. archeyi).*

This recovery plan has been produced as a response to halt, as far as is practicable, any further declines in four species of considerable evolutionary importance: four frogs which make a special contribution to New Zealand's biodiversity. The plan establishes a long-term (50-year) goal of maintaining and enhancing existing genetic stocks of native frogs, and a series of aims over the next five years to work towards that goal. The key aims include maintaining all known populations as far as possible, establishing new populations of Hamilton's and Maud Island frogs, setting up long-term monitoring sites for all species of native frogs, identifying areas of potential habitat worth searching to try and locate further, as yet unknown, frog populations, and improving captive husbandry techniques - especially those involved in raising juveniles through to adulthood.

Where frogs co-exist with other threatened species, especially those highly sensitive to habitat degradation, conservation measures will be linked. Management of Hochstetter's and Archey's frogs, in particular, will rely on effective advocacy and habitat management and will therefore have strong links with land management strategies (e.g., DoC Conservation Management Strategies, local government plans).

The plan will serve to guide the Department in its management of native frogs. Implementation of the recovery strategy will be overseen by the Frog Recovery Group and will be dependent on and vary with the resources and information available at any time. The Frog Recovery Group members are representatives of. Northland, Auckland, Waikato, Bay of Plenty, East Coast and Nelson/Marlborough Conservancies, Threatened Species Unit and Science & Research Division of the Department of Conservation; Victoria University of Wellington.

NOTES TO SECTION 1

vertebral centra are slightly biconcave or flat terminally and separated by intervertebral cartilage.

2.0 Past Distribution

Subfossil distributions of Hochstetter's and Hamilton's frogs show that until the late Holocene (within the last 2000 years) these species ranged from Punakaiki, on the west coast of the South Island, to Waitomo in the North Island; *L. hamiltoni* was still present in the Waitomo area till at least 1680 years ago (Worthy 1987b, but see section 2.1, pg 3). As yet, no subfossil material positively referrable to Archey's frog has been recovered, the skeleton of this species being identical to that of *L. hamiltoni* in all aspects except size (Worthy 1987a). Also, it has yet to be determined if Hamilton's and Maud Island frogs can be distinguished from their skeletons alone.

Three further native frogs have been described solely from subfossil material: *Leiopelma waitomoensis,* an offshoot of the *L. archeyi/L. hamiltoni* lineage, and *Leiopelma markhami* and *Leiopelma auroraensis,* which are more closely related to *L. hochstetteri* (Worthy 1987a). Worthy (1987b) has mapped the distribution of native frog subfossil sites; nearly all the remains examined have been found in cave deposits in the karst regions of New Zealand.

2.1 *LEIOPELMA HAMILTONI*

L. hamiltoni subfossil remains were recorded from caves around Punakaiki; the Heaphy River; Patarau; Takaka; and Mt Owen in the South Island. Also from the Puketoi Range south of Dannevirke; Patoka in Hawkes Bay; and Waitomo in the North Island (Fig. 1). However, the discovery of Archey-type frogs at Whareorino Forest led Bell (1994) to suggest that these could be the Waitomo subfossil species described by Worthy as *L. hamiltoni.* Bell (1994) further speculated that perhaps *L. hamiltoni* was not in the northern North Island as Worthy (1987b) suggested, but that northern subfossils represent *Larcheyi,* though these are a little larger in body size than individuals from Coromandel populations (Thurley & Bell 1994).

2.2 *LEIOPELMA HOCHSTETTERI*

L. hochstetteri subfossil remains have been found in caves near Punakaiki; Karamea; Paturau; and Takaka Hill in the South Island. Also from Hawkes Bay; and near Waitomo in the North Island (Fig. 1).

2.3 *LEIOPELMA WAITOMOENSIS* (EXTINCT)

L. waitomoensis had a distribution wholly confined to the North Island. Its remains were found in caves at Mangamuka near Kaitaia; Waipu; Waitomo; Hawkes Bay; Puketoi Range; and Martinborough (Fig. 1).

2.4 *LEIOPELMA MARKHAMI* (EXTINCT)

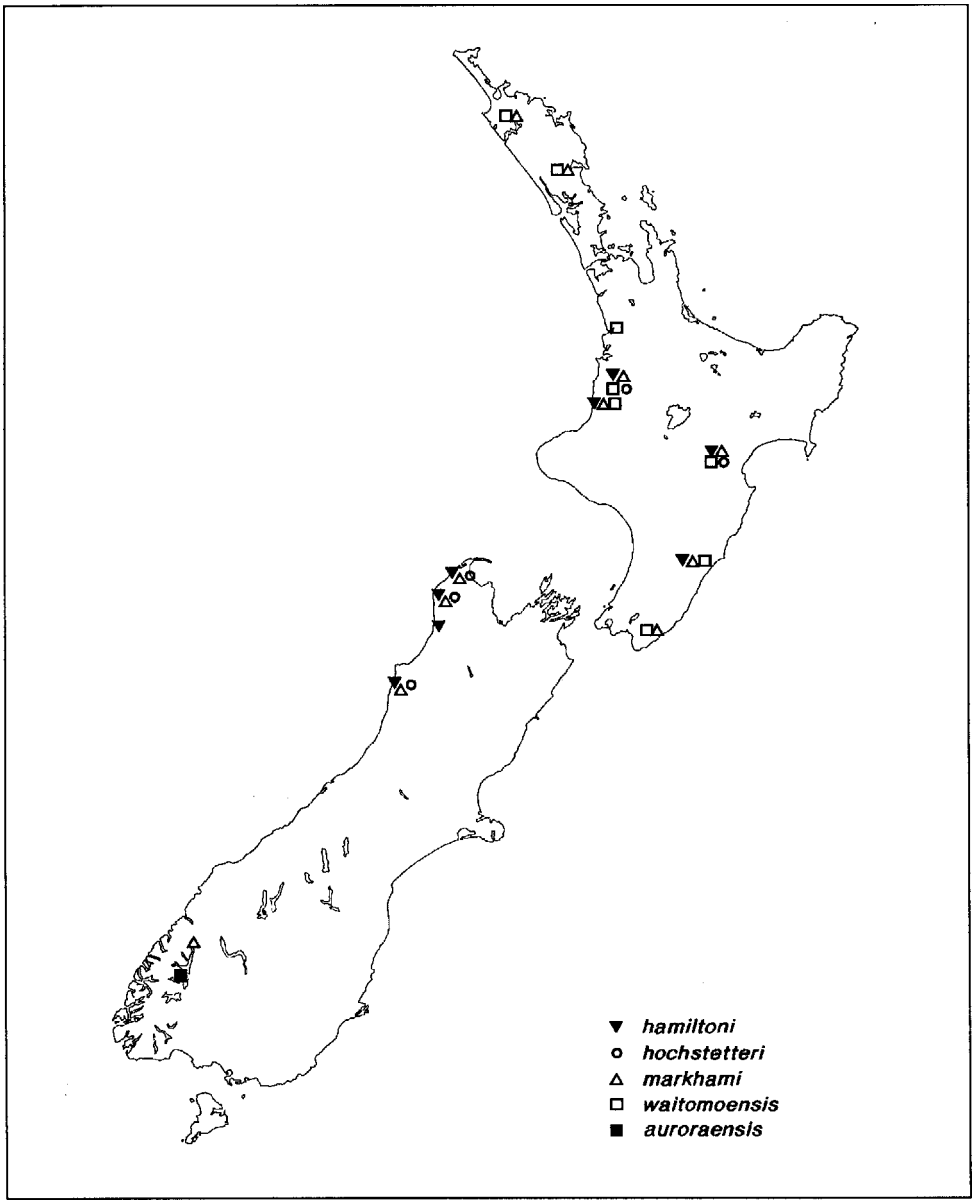
L. markhami lived in both main islands, and its remains have been recovered from Mangamuka in Northland to Te Anau in Fiordland (Fig. 1).

2.5 *LEIOPELMA AURORAENSIS* (EXTINCT)

L. auroraensis is so far known only from Aurora Cave on the western side of Lake Te Anau in Fiordland (Fig. 1).

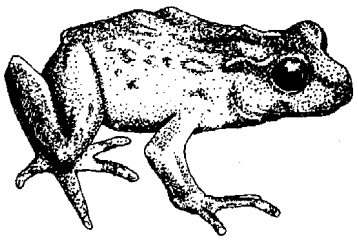
The disappearance of the presumed extinct species, and the commencement of the decline in range of the surviving species, happened between 1000 and 2000 years ago and are probably correlated with the arrival of kiore, *Rattus exulans,* in New Zealand (Worthy 1987b).

FIGURE 1. FORMER DISTRIBUTION OF *LEIOPELMA* TAXA IDENTIFIED FROM SUBFOSSILS (BELL 1994, AFTER WORTHY 1986, 1987B).



3.0 Present Distribution

3.1 HAMILTON'S FROG

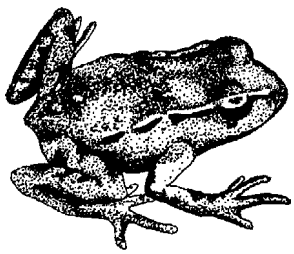


Known only from a 600m2 rock bank (`frog bank') at 275m on Stephens Island in Cook Strait. In May 1992, 12 frogs were transferred to the `frog pit', a newly created habitat of approximately 72m2 within the nearest remaining forest patch to the frog bank (Brown 1994).

3.2 MAUD ISLAND FROG

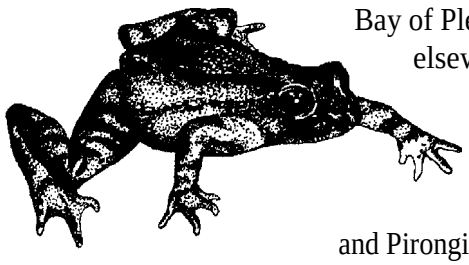
Present in a 15ha remnant of coastal forest on Maud Island, Pelorus Sound, Marlborough Sounds. Another population has been established in a second forest remnant above Boat Bay on the island following liberations made in 1984 and 1985 (Bell 1985, 1994). The species is expanding its range naturally on the island as revegetation progresses. Some low-density populations now probably exist outside the main forest remnant, generally below and to the north of it. For instance, early in 1994 a frog was found some 400m from the main forest (D. Brown, pers. comm.).

3.3 ARCHEY'S FROG



Found in three main areas of the Coromandel region of the North Island: Mount Moehau; the central Coromandel Range from north of Tokatea to south of the Tapu-Coroglen saddle; and east of Paeroa in the southern Coromandel Ranges. Archey-type frogs (referred to subsequently in this plan as *'L. archeyi')* have been located in Whareorino Forest, western King Country (Thurley & Bell 1994).

3.4 HOCHSTETTER'S FROG



Most widespread of *Leiopelma* species. Found in an extensive area in the eastern Bay of Plenty and Raukumara Ranges to East Cape; and in scattered populations elsewhere in the northern North Island, from Whareorino Forest, Pureora Forest in the south, northwards to Otawa Forest (near Te Puke), and the northern Kaimai Ranges, through the Coromandel, Hunua, Waitakere and Warkworth ranges to Great Barrier Island and the Whangarei district. Further unconfirmed reports are from near Lake Waikaremoana and Pirongia Forest (the Pirongia record may have been of an introduced frog - P. de Lange, pers. comm.).

Illustrations by Sonia Frimmel

3.5 CAPTIVE STOCKS

The following animals are currently held in captivity by Dr Ben Bell (Victoria University of Wellington):

Maud Island frog: 13

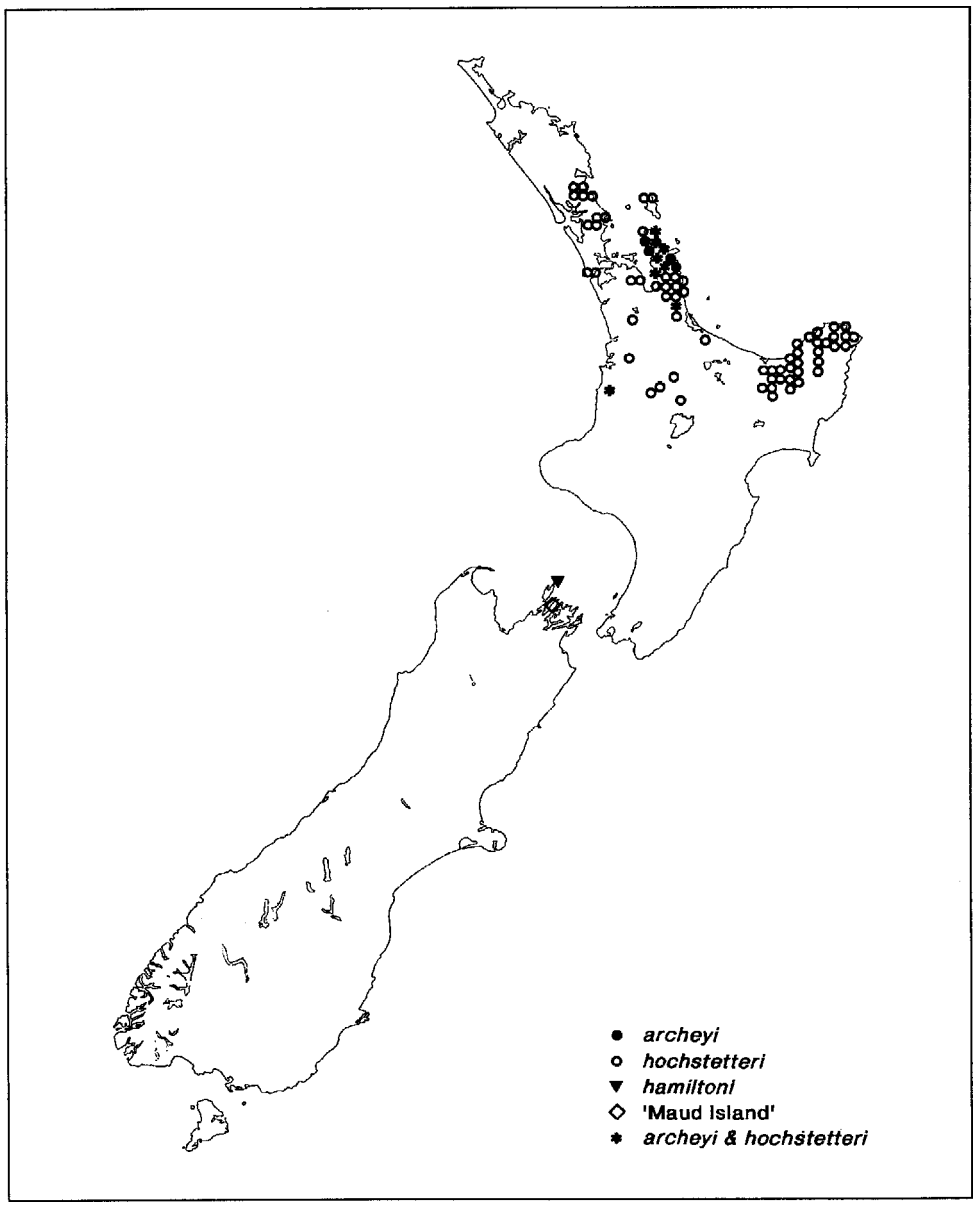
Hamilton's frog: 1

Hochstetter's frog: 12

Archey's frog: 12

Although breeding has occurred over the last 10 - 15 years (in all but Hochstetter's), only one froglet has reached adulthood (B.D. Bell pers. comm.).

FIGURE 2. KNOWN DISTRIBUTION OF EXTANT *LEIOPELMA* TAXA (BELL 1994).



4.0 Threats to Native Frogs

A complex of factors has affected New Zealand's frogs over recent geological time, with different species varying in their vulnerability. Climatic factors, habitat availability and interactions with introduced animals have all been implicated in confining surviving species to the limited areas where they now occur and in bringing about the extinction of species known only from subfossil records (Bell 1985). Principal continuing common threats are habitat destruction, impact of introduced fauna, and possibly reduced genetic variation because of small population size in at least some remnant populations. Particular threats faced by the different frogs are:

4.1 HAMILTON'S FROG

Small population size: the Stephens Island frog bank probably supports only 150-200 individuals (Newman 1990, Brown 1994) making this species one of the rarest frogs in the world. Circumstantial evidence suggests that Hamilton's frog may not be able to co-exist with certain introduced mammalian predators, such as rodents, since Stephens Island is free of such predators. However, a feral cat population became established in the island after 1894, but was exterminated early this century. Studies of captive frogs indicate that Hamilton's frogs have lower fertility and productivity compared to Maud Island frogs - possibly a consequence of small population size following a genetic "bottleneck" (Daugherty et al. 1981).

4.2 MAUD ISLAND FROG

Although an estimate of their total numbers is 19,000 individuals (Bell & Bell 1994), the species is restricted to just one island so is vulnerable to habitat destruction by fire, or to the arrival of mammalian predators, which could be brought in with island supplies, visiting boats, shipwrecks, or by swimming from the mainland (about 1km). Over the last 10 years stoats have invaded the island at least twice (D. Brown, pers. comm.).

4.3 ARCHEY'S FROG

Probably many thousands occur in total although precise information is lacking. Very locally in the central Coromandel, densities as high as 8 frog/m2 have been recorded (Bell 1994) cf. Hamilton's frog: up to 0.6 frogs/m2, and Maud Island frog: up to 1.3 frogs/ml (Newman 1990). The main threat is continued depletion and modification of habitats from exotic afforestation, farming, quarrying and mining activities. The impact of introduced mammals on *L. archeyi* is not fully understood, though goats, cattle and pigs have a detrimental impact at some Coromandel sites (Bell 1985). At Whareorino predation has been recorded on *"L. archeyi"* by the introduced golden bell frog *Litoria aurea,* and by mammals, possibly rodents (Thurley & Bell 1994).

4.4 HOCHSTETTER'S FROG

Most widespread and numerous of *Leiopelma* species, although destruction or modification of its habitat is still occurring, either directly through human activity e.g. exotic afforestation, quarrying, roadworks, mining and stormwater discharge or indirectly, e.g. impacts of feral goats (can cause accelerated erosion leading to the silting up of frog streams - see Newman & Towns 1985). The extensive East Cape populations are threatened with fragmentation due to goat impacts, especially on the true left of the Motu River. Impacts occur through siltation and destabilisation of watercourses, drying of moist scree habitats from loss of forest understorey and failed regeneration after slips (C. Ward pers. comm.). The effect of introduced mammalian predators is uncertain, but *L. hochstetteri* co-exists with them throughout its range. However, research on the impacts of introduced predators, including introduced frogs, on Hochstetter's frog, should be undertaken (see Section 9, topics 5 d & e).

Locally the species reaches densities as high as 4 - 5 frogs/m2 alongside suitable watercourses, though availability of retreat sites markedly affects distribution (Bell 1985, D. Slaven, pers. comm.). For *L. hochstetteri,* numbers/100 m of watercourse searched may be a better descriptor of relative density: up to 65 frogs/100 m of stream (minimum number alive) have been observed, but such densities are very localised (D. Slaven, pers. comm.). Daugherty et al. (1981) found less genetic variability in Hochstetter's frog than in the other species and suggested the concentration of *L. bocbstetteri* along watercourses may result in the size of individual populations of this species being smaller than those of the native frogs which occupy less linear habitats. Further, the localisation of these small populations may make *L. h ochstetteri* more susceptible to environmental fluctuations such as floods or siltation following rains or ground disturbance.

4.5 GLOBAL DECLINES OF AMPHIBIAN POPULATIONS

Worldwide, the populations of many amphibian species, in widely scattered habitats, appear to be in severe decline (e.g., Pechmann et al. 1991, Tyler 1991); other amphibians show no such declines. There is no known single cause for the declines, but their widespread distribution suggests involvement of global agents, for instance some atmospheric source. Industrial chemicals, increased UV-B radiation, and infectious disease, especially viral diseases, are all being investigated as possible causes.

In response to international concern, in 1992 the IUCN Species Survival Commission (SSC) established a Declining Amphibian Populations Task Force (DAPTF). DAPTF's mission is to determine the nature, extent and causes of declines of amphibians throughout the world, and promote means by which the declines can be halted or reversed. DAPTF produces a quarterly newsletter, "Froglog" which reports latest knowledge on the extent of declines, and research findings on possible causes. Of particular concern is the speed of many declines, some occurring over periods of as little as three months. No evidence exists that the status of NZ frogs has changed significantly over the past 10 years, but given the paucity of long-term monitoring, there is no room for complacency.

5.0 Ability to Recover

Clearly, the status of Hamilton's and Maud Island frogs gives rise to greater concern than that for Archey's and Hochstetter's frogs. Unlike the latter two, Hamilton's and Maud Island frogs are known to occur on just one island each. Both islands are, however, predator-free and the Maud Is frog at least, has demonstrated an ability to respond to habitat improvement (revegetation).

There are a number of other predator-free islands which have potential as transfer sites for both species. Establishment of further populations on new islands will significantly improve the conservation prospects for these two species. In fact a new population of Maud Island frogs has already been established - in a forest remnant on Maud Island, separate from its main habitat (Bell 1994), and 12 Hamiltons frogs have been transferred to a purpose built "frog pit" on Stephens Island (Brown 1994).

It may simply be a coincidence that Maud Island and Hamilton's frogs are restricted to islands free of introduced predators. This could be tested by trying to establish populations of Maud Island frog on islands where some introduced predators occur, or at mainland sites. Success at such sites would greatly increase the conservation prospects for these species.

The status of Archey's and Hochstetter's frogs should remain stable if not improve, as long as there is a halt to habitat destruction. They both have an apparent ability to survive in association with introduced frogs and mammals, despite a certain degree of predation. A more accurate indication of the level of predation, as well as long term monitoring of native frog populations, will be necessary however before it can be determined whether or not this level is sustainable. Both demography and habitat factors need to be monitored. The results of such work will improve our ability to select transfer sites, determine numbers for release and areas for further survey. The possibility of finding new populations, in light of the recent discovery at Whareorino, gives some cause for optimism.

Terrestrial species of *Leiopelma* have laid eggs in captivity, although captive-held *L. hochstetteri* have done so only occasionally, probably due to difficulties in recreating suitable breeding sites for this species in terraria (Bell 1985, Sharbel and Green 1992). Only one native frog has been raised to adulthood. Self-sustaining captive populations would ultimately assist recovery by providing an alternative source of frogs for research and advocacy purposes.

6.0 Options for Recovery

All options for recovery assume some level of monitoring. Monitoring approaches, along with suggestions for further survey and taxonomic revision, are included in sections 7.0 and 8.0.

6.1 HAMILTON'S FROG

Option 1

Do nothing more. That is, maintain rodent/stoat free status of Stephens Island and maintain current revegetation, fencing and weed control programmes, as required by the draft island management agreement (I. Millar pers. comm.) as well as the tuatara recovery plan (Cree & Butler 1993). The population size may remain stable or even expand as a consequence however, since Stephens Island is the sole known location for the species, extinction, owing to unpredictable events such as rat invasion, is always a possibility.

Option 2

Maintain current island management. Select and prepare a site on another island free of introduced mammalian predators for the establishment of a new population and attempt a transfer of frogs.

Option 3

As for option 2 but, in addition, establish one long-term self sustaining captive population.

Preferred option

The option chosen for the duration of this recovery plan is Option 1. Within the next 5 - 10 years, however, Option 2 must be considered. The population of the frog bank and the frog pit combined is as yet too small to sustain the removal of more than 15 individuals within the five year period covered by this plan. It would be prudent, though, to select, as soon as possible, a site on another island, free of introduced mammalian predators, for the establishment of a new population.

6.2 MAUD ISLAND FROG

Option 1

Do nothing more. The population size may remain stable or even expand as a result of current island management (maintenance of current rodent/stoat-free status and

"controlled" natural regeneration). Maud Island remains the sole known location for the species and extinction is always a possibility, owing to unpredictable events such as rat or stoat invasion.

Option 2

Maintain current island management. Investigate potential transfer sites and establish a new population on at least one further predator-free island; establish one long-term self sustaining captive population.

Option 3

As for option 2 but consider establishment of new populations of Maud Island frogs on islands where some introduced predators occur, or at mainland sites.

Preferred option

The option chosen for the duration of this recovery plan (1-5 years) is Option 2. Within the next 5-10 years, however, Option 3 should be considered.

6.3 ARCHEY'S FROG

Option 1

Do nothing more. Current management (e.g., control of introduced mammals) will be maintained. The total frog population might remain much the same as at present, but it could also decline as a result of habitat degradation and/or loss through unpredictable events either on or off Conservation land.

Option 2

Advocate for protection of all habitat containing populations ofArchey's frog.

Option 3

As for option 2 but, in addition, establish one long-term self sustaining captive population for supply of frogs for research and advocacy purposes.

Preferred option

The option chosen for the duration of this recovery plan is Option 2. Captive breeding is currently a low priority for this species, although if long-term monitoring indicates a significant decline then establishment of a captive population should be considered, as an alternative supply of frogs.

6.4 HOCHSTETTER'S FROG

Option 1

Do nothing more. Current management in some areas will include control of introduced mammals. The total frog population might remain much the same as at present, but it is more likely to decline as a result of habitat degradation and/or loss through unpredictable events, either on or off Conservation land. Where no conservation management is taking place, the likelihood of decline is even greater.

Option 2

Advocate for the protection of Hochstetter's frog habitat to avoid fragmentation or destruction of existing populations, particularly in Northland

Option 3

As for Option 2, but in addition transfer frogs from degraded Northland sites, e.g., Brynderwyn Range, to protected areas north of Waipu Caves which are to be identified in the Draft Northland Conservation Management Strategy (1995) as being priority areas for the management of threatened species.

Option 4

As for Option 3 but, in addition, establish one long-term self-sustaining captive population for supply of frogs for research and advocacy purposes.

Preferred option

The option chosen for the duration of this recovery plan is Option 2, however assessments of degraded Northland sites should be made and, if practicable, recommendations made for their restoration. Conservation measures proposed for other species co-existing with Hochstetter's frog, such as Chevron skink at Te Paparahi, Great Barrier Island, will also benefit this species (Towns & McFadden 1993). The need for a captive population is considered a low priority in the short-term.

7.0 Recovery Strategy: Goal and Objectives

LONG TERM GOAL

The long-term (50-year) goal of this recovery programme is to maintain and enhance, in the wild, existing genetic stocks of native frogs (*Leiopelma* spp.).

SUMMARY OF OBJECTIVES FOR THE DURATION OF THIS PLAN

1. Maintain as far as is practicable, all known populations of native frog and protect them from adverse human impacts.
2. Work towards establishing two new wild populations of Hamilton's frog (one on Stephens Island and a second on another predator-free island).
   (associated research requirement: translocation methods/strategies).
3. Establish a population of the Maud Island frog on a second predator-free island.
   (associated researcb requirement, taxonomic status, translocation methods/ strategies, monitoring techniques).
4. Establish long-term monitoring at selected sites for all species of native frog to determine population trends.
   (associated research requirements: development of standardised monitoring methods; effects of 1080; impact from introduced mammals/frogs/birds).
5. Survey areas of potential habitat seeking to locate further as yet unknown, populations of native frogs and integrate all existing native frog distribution data.
   (associated research requirement., genetic population studies)
6. Raise public awareness and public advocacy for protection of native frogs and their habitat.
7. Maintain at least one long-term, self-sustaining captive population of each species of native frog. (Low Priority)

8.0 Recovery Strategy: Work Plan

Actions required are listed in priority order.

OBJECTIVE 1

Maintain, as far as is practicable, all known populations of native frog, and protect them from adverse human impacts.

Explanation

Except in Northland, the majority of frog populations occur in protected areas. Where habitat is not legally protected, formal protection of this land should be sought (e.g., establishment of scenic reserves, wildlife management reserves, etc.). Whether habitat has legal protection or not, existing human activities, especially forestry, farming practices on adjoining land and quarrying operations will continue to place certain mainland populations at risk. These activities and increasing animal pest impacts may lead to further loss of native vegetation cover, accelerated erosion and the silting-up of streams destroying frog habitat. DoC staff need to be aware of the location of frogs in their Conservancy, activities (both on and off Conservation land) which may impact upon frog habitat, and make efforts to mitigate these factors where possible. Control of introduced mammals, especially goats and pigs, in areas of frog habitat is of particular importance.

Action

- Advocate, through local government, for the protection of all native frog populations from adverse human impacts (earthworks or catchment vegetation disturbance) .
- Ensure that surveys of potential frog habitat are undertaken prior to any development proceeding (either on site or upstream) and that, where frogs are found, disturbance is minimised or prohibited.
- Where habitat containing native frog populations is not legally protected, formal protection of the land should be sought (e.g., acquisition covenant) where adequate protection cannot be achieved elsewhere (e.g., Resource Management Act controls).

Key Personnel

DoC Northland,Auckland, Waikato, Bay of Plenty, East Coast, Nelson/Marlborough.

OBJECTIVE 2

Work towards establishing two new wild populations of Hamilton's frog.

Explanation

The security of this species should be increased by extending its range on Stephens Island by creating new habitat, and by having it represented on at least one further island. The second island should be within the Cook Strait-Marlborough Sounds region and be free of introduced mammalian predators. Should these transfers be successful, islands outside of this area could be considered for further transfers. In addition, the extensive boulder banks at the western end of Stephens Island should be thoroughly searched for frogs. If no frogs are found, these sites could be developed (revegetation, etc.) as new habitats for the species.

Progress

During 1991, a new habitat, the `frog pit', was created on Stephens Island 40m from the frog bank. In May 1992 12 adult frogs were transferred to the frog pit and seven have since been recaptured there (Brown 1994).

Nukuwaiata (Inner Chetwode) Island, 25 km from Stephens Island, is being investigated for consideration as the second island for Hamilton's frog. It is heavily forested and climatically and floristically very similar to Stephens Island (Brown 1994). An attempt to rid Nukuwaiata of kiore seems to have been successful and habitat suitable for the frogs appears to be present. If necessary, it can be enhanced or new habitat created.

Action

- Transfer further frogs to the frog pit once breeding at this site has been confirmed.
- Link the frog pit and frog bank by a corridor of rock-filled pits and trenches.
- Plant forest species on either side of the corridor (eventually, it is hoped that the frog pit and frog bank populations will merge).
- Investigate and decide, in consultation with Recovery Group, Kaupapa Atawhai Manager and local iwi, the suitability of Nukuwaiata Island for frog transfers. If necessary, enhance potential frog habitat on Nukuwaiata Island, or create new habitat.

Key Personnel

DoC Nelson/Marlborough.

OBJECTIVE 3

Establish a population of the Maud Island frog on a second predator-free island.

Explanation

The security of this species should be increased within the next five years by having it represented on at least one further predator-free island. It may simply be a co-incidence that Maud Island and Hamilton's frogs are restricted to islands free of introduced predators, not withstanding the occasional invasion of Maud Island by stoats. To test this, an attempt should be made, within the next 5-10 years, to establish a population of Maud Island frogs on an island where some introduced predators occur (e.g., island in Tennyson Inlet), or at a mainland site (Tennyson Inlet mainland, or Mt Shewell Scenic Reserve).

Action

- Identify a predator-free island suitable for establishing a new population of the Maud Island frog. Ensure that the Maud Island frog is not transferred to an island identified as a transfer site for Hamilton's frog.
- Transfer Maud Island frogs to the new site and monitor success
- Investigate and decide, in consultation with Recovery Group, Kaupapa Atawhai Manager and local iwi, on the suitability of islands where some introduced predators occur, or mainland sites, for further frog transfers.

Key Personnel

DoC Nelson/Marlborough to select transfer site in consultation with Recovery Group.

OBJECTIVE 4

Establish long-term monitoring sites for all species of native frog to determine population trends.

Explanation

Although no evidence exists that the status of NZ frogs has changed to any significant extent over the last 10 years (some local populations of Hochstetter's frog may have been lost), monitoring sites should be established to ensure that there is no cause for concern (see section 4.5). The semiaquatic Hochstetter's frog is very sensitive to catchment modification (e.g., McLennan 1985, Newman &Towns 1985) so is likely to prove a valuable biological indicator of catchment stability and, by extension, of the effectiveness of catchment management. Generally, frogs are held to be excellent biological indicators of the health of the environment because of such attributes as their permeable skins and, in many species, their life cycles which include both aquatic and terrestrial phases (Heyer et al 1994).

Progress

Populations of Hamilton's and Maud Island frogs are already being monitored (Bell & Bell 1994, Brown 1994), as is the central Coromandel (Tapu Ridge) population of Archey's frog (Bell 1994). At sites 13 and 14 (below), land tenure belongs to Auckland Regional Council, staff of whom have expressed interest in frog surveying (S. Boyd, pers. comm.). Some work has already been done at Hunua in relation to a 1080 operation (McNaughton & Greene 1994).

While Archey's and Hochstetter's frog rank as species at less risk than *L. hamiltoni* or *L.* Maud Island, both, especially *L. hochstetteri,* occur in isolated populations of variable size and extent. Some of these isolates may be threatened or vulnerable. In genetically and geographically discontinuous species, every population may be an important component in biogeographic diversity since each isolate may represent "an emergent historical entity" (Green 1994). Geographic subdivisions in Hochstetter's frog can be identified from variation in supernumerary chromosome number and, particularly, the morphology of the sex chromosome, in conjunction with isozyme evidence (Green 1994). Such findings suggest that at least some conservation measures for frogs might be best framed population by population rather than at the species level. Monitoring is best done at the population level. A listing of populations in priority order for monitoring would be:

1.	Stephens Island:	Hamilton's frog: frog bank and frog pit.
2.	Maud Island:	Maud Is frog: main forest remnant and Boat Bay.
3.	Whareorino:	Archey-type and Hochstetter's frogs.
4.	Great Barrier Is:	Hochstetter's frog (cytogenetically distinct from North Island populations).
5.	Waipu:	Hochstetter's frog populations of Northland appear to be the most threatened of North Island populations.
6.	Rangitoto Range:	Hochstetter's frogs from Mt Ranginui are the most chromosomally and biochemically distinctive of the North Island populations.
7.	South Coromandel:	Archey's and Hochstetter's frogs - particular threats from mining in this area.
8.	Otawa Forest:	Hochstetter's frog - threats from quarrying in this area.
9.	East Cape:	Hochstetter's frog (Motu River catchment, includes Toatoa and Whanarua; Pukeamaru Range; Waioeka).
10.	Warkworth:	Hochstetter's frog.
11.	Central Coromandel:	Archey's and Hochstetter's frogs (the former are already being monitored at Tapu Ridge).
12.	North Coromandel:	Archey's and Hochstetter's frogs (Moehau Range).
13.	Hunua Mountains:	Hochstetter's frog.
14.	Waitakere:	Hochstetter's frog.

Action

- Conservancy representatives of the recovery group are to recommend final sites for monitoring. When doing so, priority should be given to populations put at risk from 1080 programmes or other resource consents, as well as to populations within areas assigned to be managed as "mainland islands".

- Not all populations need to be monitored at the same intensity, greatest effort should be devoted to those of highest priority. Low priority populations may only require checking at 3-5 year intervals. Monitoring techniques could range from rigorous assessments of population density (involving the permanent marking of individuals, e.g., Stephens Island frog pit, Maud Island Boat Bay) to simple indexing (timed searches along permanent transects - measuring snout-vent length (SVL) being a handy adjunct to abundance). Techniques most appropriate to specific circumstances should be decided upon by the recovery group in consultation with the DoC Conservancies concerned. As part of the monitoring, habitat features must also be assessed. There is an urgent need to standardise monitoring procedures for each species. For a summary of interim monitoring procedures refer to Appendix 2.

Key Personnel

Hamilton's frog:	DoC Nelson/Marlborough;
Maud Island frog:	Dr B. D. Bell (VUW) in association with DoC Nelson/Marlborough;
Archey's frog:	DoC Waikato, Dr B. D. Bell (VUW);
Hochstetter's frog:	DoC Northland, Auckland, Waikato, Bay of Plenty, East Coast; Auckland Regional Council

OBJECTIVE 5

Survey potential habitat to locate further poulations of native frog and integrate all existing native frog distribution data.

Explanation

Native frogs are small, nocturnal and cryptically coloured; they are easily overlooked. Many populations may exist which we are unaware of - it was not until 1991 that Archey-type and Hochstetter's frogs were found at Whareorino. There is a need to firstly identify priority areas for survey and secondly to ensure that all existing information on frog distribution is readily available.

Priority areas for searching (ordered by species) are:

Hamilton's frog

1. Stephens Island

Hamilton's & Maud Island frogs

1. D'Urville Island
2. Chetwode Islands
3. Marlborough Sounds mainland
4. Arapawa Island
5. North West Nelson (especially Paturau coast)

Archey's & Hochstetter's frogs

1. Western King Country
2. Pirongia

Hochstetter's frog

1. South of East Cape
2. Southern Urewera
3. Kaimai-Mamaku
4. Central and northern Northland

Distribution data on native frogs must be made more easily available to DoC officers and *bona fide* research workers. Dr B. D. Bell (VUW) has extensive distribution records of native frogs and further records are held as part of DoC's Amphibian and Reptile Distribution Scheme. These records must be combined, ideally as part of DoC's Amphibian and Reptile Distribution Scheme.

Action

- Conservancies will determine survey sites and conduct surveys annually in consultation with the Recovery Group.
- DoC Science & Research and Dr B. D. Bell (VUW) to advise if data are in a form that can be readily exchanged between DoC and VUW Due recognition should be given to Dr Ben Bell for gathering and providing records.

Key Personnel

DoC Nelson/Marlborough, East Coast, Bay of Plenty, Waikato, Northland.

DoC Science & Research, Dr B. D. Bell (Victoria University).

OBJECTIVE 6

To raise public awareness of native frogs to advocate protection of their habitat.

Explanation

Native frogs are cryptic creatures which are easily overlooked. Scientifically, however, quite a lot is known about them. There is a need to inform the public, local bodies, regional councils and private landowners about native frogs, and to encourage their concern for, and involvement in, the protection of native frog habitat.

Progress

A "fact sheet" about native frogs has been produced (by DoC), giving descriptions of both native and introduced frogs and their likely habitats (see Appendix 3).

Action

- Distribute the fact sheet to organisations involved with land management, and those involved in outdoor pursuits (tramping, hunting, etc.). Copies of the fact sheet could be left in appropriate back-country huts.
- Prepare a popular article on native frogs and their conservation for contribution to publications such as *Forest & Bird* magazine, *Straight Furrow* etc.
- Produce a video on frog conservation to be used at captive institutions in lieu of a live captive display. Existing material should be checked first.
- Seek the support of non-government organizations to assist with frog advocacy.

Key Personnel

DoC Science & Research, Threatened Species Unit, & Public Awareness Unit in consultation with Recovery Group.

OBJECTIVE 7

Maintain at least one long-term, self-sustaining population of each species of native frog (low priority).

Explanation

Terrestrial species of *Leiopelma* have been bred in captivity, but captive-held colonies of *L. hochstetteri* breed only occasionally. Further, for all species, survival of captive-bred young to adulthood has been poor. Improved captive husbandry techniques leading to the establishment of self-sustaining colonies would allow supply of frogs for research (e.g., toxic bait trials, predator response trials), advocacy/education and even, perhaps, establishment of new wild populations.

Ultimately, the aim should be to maintain at least one long-term, self-sustaining captive population of each species of native frog. Such an aim is unlikely to be achieved within the next five years (duration of this plan), especially for Hamilton's frog. Priority for *L. hamiltoni* must be the establishment of at least two new wild populations (Objective 2) and only when this has happened will some individuals be available to be taken into captivity.

Action

- Refine techniques for maintaining and breeding Hochstetter's frog in captivity.
- For Hochstetter's, Archey's and Maud Island frogs - improve survival of captive bred young to adulthood.

Key Personnel

Dr Ben D. Bell (Victoria University) in consultation with Recovery Group and DoC Species Protection Division.

NOTES TO SECTION S

a discrete area on the mainland intensively managed as an entire ecosystem i.e., as if it were an offshore island.

9.0 Research Priorities

Topics are listed in order of priority.

a) Review and test techniques for monitoring frog populations in order to recommend most suitable protocols for NZ species.

Explanation

Develop standard techniques for monitoring; also tagging/monitoring techniques for individual frogs. When developing techniques, reference should be made to Heyer et al (1994) "Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians".

b) Effect on frog populations, of aerially broadcast poisons used to control possums.

Explanation

Determine proportion of individuals in frog populations which would be at risk of consuming poison baits, or of secondary poisoning during a control operation. Conduct non-toxic marker trials. Observe impact of toxic baits on captive individuals. Document impact on local populations of Archey's and Hochstetter's frogs before, during and after control operations. A research contract has been negotiated between DoC Science & Research and Dr B.D. Bell (VUW) to investigate the effects of 1080 on native frog populations. Some basic work has already been done by Auckland Regional Council in the Hunua Ranges (McNaughton & Greene 1994).

c) Refinement of frog translocation methodologies.

Explanation

Research should aim at providing protocols for evaluating potential habitats, safe transportation of frogs, and schemes for monitoring the survivorship of translocated populations (latter may involve revaluation of marking and/or tagging procedures).

d) Impact of introduced mammalian and avian predators on surviving mainland populations.

Explanation

What mammals and/or introduced birds are predators of native frogs, and which of these are of greatest threat to the frogs? *Leiopelma* are known to possess a suite of anti-predator mechanisms (Bell 1985b, Green 1988b). Any study should assess the significance of frog paratoid secretions as a deterrent to predators.

e) Impact of introduced frogs on surviving mainland populations.

Explanation

Document the extent and the consequence of predation and competition from introduced frogs. At Whareorino, predation was recorded on *"L. archeyi"* by the golden bell frog *Litoria aurea* (Thurley & Bell 1994). Although native frogs were once distributed along the west coast of the South Island (Worthy 1987b), this area is now extensively occupied by the whistling frog *Litoria ewingi* - was competitive exclusion involved?

f) Genetic population studies.

Explanation

Establish the taxonomic status of the Maud Island frog, and the Archey-type frog at Whareorino. Refine understanding of what constitutes a discrete population (has implications for possible translocations). Note that research being conducted by Bruce Waldman (University of Canterbury) is basically concerned with developing non-destructive tools to characterise genetic variation within frogs.

9) Demography, behaviour and habitat requirements of Archey's and Hochstetter's frogs.

Explanation

Further information is required on habitat requirements (limits of tolerance), recruitment of juveniles into populations, and behaviour in relation to daily activity patterns (emergence). This information will be of importance in any assessment of potentially adverse impacts on native frogs (see topics b, d and e, page 19).

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Acknowledgements

The compilation of this plan was undertaken intermittently over a period of three years (1993-1995) largely because of the intervention of higher priority work. While this period may seem excessive, it has allowed for extensive consultaiton and it is with gratitude that I acknowledge the many people who generously provided advice and comment on various drafts, in particular Peter Anderson, Ben Bell, Shaarina Boyd, Derek Brown, Alison Cree, David Green, David King, Ian Millar, Keith Owen, Richard Parrish, David Slaven, Rick Thorpe, David Towns, Dick Veitch, Bruce Waldman, Chris Ward, Tony Whitaker and Thelma Wilson. My very special thanks, though, go to Suzanne Clegg who, as DoC's Threatened Species Unit contact for native frogs, gave me much appreciated support and encouragement to see this project through to its completion.

Appendix l:
Estimate of Funding Required

An estimate of funds required to carry out projects outlined in this recovery plan for the next five years are given below. Estimates exclude salaries of DoC staff, but include provision for contracts where these may be involved (e.g., for research projects). The table outlines ongoing costs over 5 years. One-off projects and research objectives are outlined below.

	5 YEARS	5 YEARS	5 YEARS	5 YEARS		
	Monitoring	Establish new popns	Attend recovery group	Survey	Total funds required *over five years*	Funds required *per year*
Northland	$ 7,500	-	$ 2,500	$ 3,000	$10,500	$ 1,500
Auckland	$ 7,500	-	$ 2,000	-	$7,000	$ 1,400
Waikato	$12,500	-	$ 2,000	$ 5,000	$17,000	$ 3,400
Bay of Plenty	$ 5,000	-	$ 2,000	-	$8,000	$ 1,000
East Coast	$7,500	-	$ 2,000	$ 3,000	$12,000	$ 2,400
Nelson/Marl.	$ 7,500	$15,000'	$ 2,500	$ 5,000	$27,500	$ 5,400
Science & Research	-	-	$ 2,000	-	$ 2,000	$ 400
TOTAL	$47,500	$15,000	$15,000	$16,000	$84,000	$15,500

* *Continued development of the frog pit, monitoring survival of transferred frogs to the pit, linking the pit to the frog bank, assessing suitability of Nukuwaiata Is. for Hamilton's frog.*

One-off tasks

Nelson/Marlborough Conservancy:

- Select and transfer Maud Island frogs to a new site: $ 5,000

Research objectives

- Effects of 1080 on frog populations $ 10,000
- Review and testing of monitoring techniques $ 9,500
- Refinement of translocation techniques $10,000
- Impact of predators (introduced mammals/birds/frogs) on native frog populations $15,000
- Refinement of captive breeding techniques 5,000

Total research funds required over five years $49,500

TOTAL FUNDS REQUIRED *OVER FIVE YEARS* $ 138,500

Appendix 2: Monitoring Techniques for Native Frogs

This recovery plan identifies that there is an urgent need for the standardisation of monitoring procedures for each species of native frog. Techniques that have been used in New Zealand were reviewed by the recovery group during the course of the development of this plan. As a result of these discussions, interim monitoring procedures forArchey's and Hochstetter's frogs were agreed upon and are presented below. There is however a need for research aimed at reviewing and testing monitoring techniques for New Zealand species, in order to recommend those most suitable. Determining the most suitable monitoring protocols is noted as being the highest priority for research in the plan.

It is recognised in the plan that not all populations need to be monitored at the same intensity. Greatest efforts should be devoted to those of highest priority. Lower priority populations may only require checking at 3-5 year intervals. Some populations are already being closely monitored, e.g., Stephens and Maud Island populations, and central Coromandel populations (Tapu ridge), the latter involving the marking of individuals within permanent quadrats.

Monitoring techniques could range from rigorous assessments of population density (involving the permanent marking of individuals) to simple indexing (timed searches along permanent transects). Techniques most appropriate to specific circumstances should be decided upon by the recovery group in consultation with the DoC Conservancies concerned.

Typically, on any sampling occasion, at least the following should be recorded:

- time spent observing (start/finish times)
- weather conditons 24 hours prior to search
- rain during search
- air temperature and relative humidity at the start and finish of search
- physical description of habitat and of where each frog was found: on ground (substrate: rock, soil, leaf litter, logs), under cover (rock, logs, etc), in foliage, on tree trunk, height from ground.
- sketch map of area searched, with approximate location of frogs
- snout-vent length of frogs, weight (useful but not essential)

PROPOSED MONITORING TECHNIQUE FOR ARCHEY'S FROG

- monitor at least 2 to 5 transects (100m x 2m) side by side
- monitor in late January-February
- monitor during the day
- lift rocks/logs, search in vegetation up to head height
- record a physical description of habitat, including photopoints
- record climatic information

PROPOSED MONITORING TECHNIQUE FOR HOCHSTETTER'S FROG

- monitor 2 x 100m transects, upstream verge (i.e., splash zone)
- monitor in late January-February
- monitor during the day
- search in all suitable habitat along the transect (under rocks, vegetation, in crevices), all non-destructive
- record a physical description of habitat, including photopoints.
- record climatic information

Appendix 3:
Advocacy Pamphlet

DOC Fact Sheet
*** 1995

New Zealand Native Frogs

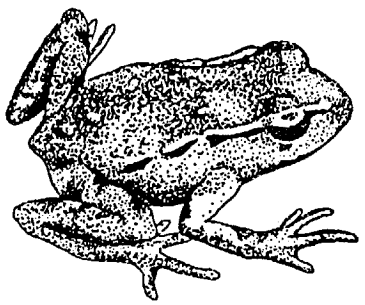
Have you seen a native frog? The Department of Conservation needs help in finding out where our native frogs are. Populations of frogs may exist that we don't know about. If you see one please report it.

New Zealand has four native frogs. All are threatened. The Maud Island and Hamilton frogs are found only on off-shore islands, the Hochstetter and Archey's frogs live in forests in the northern half of the North Island.

All native frogs are protected

New Zealand frogs are the most primitive of all living frogs

- They do not have external eardrums and have an extra vertebra in their backbone
- Native frogs hatch from the egg as tailed froglets - they don't have a tadpole stage.
- Native frogs are active at night
- They are smaller than most introduced frogs, average size is 10 -50 mm.



Archey's Frog

Threats

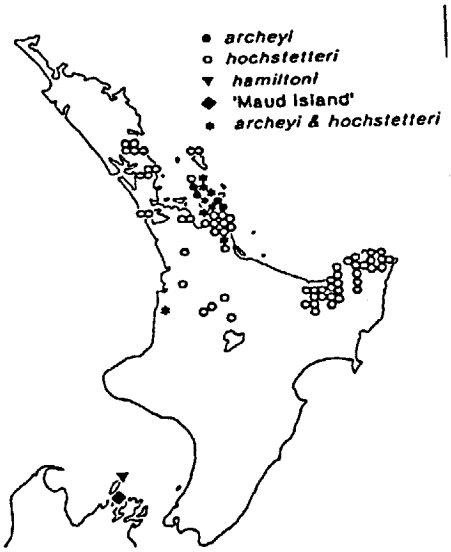
New Zealand originally had seven species of native frog, three are now extinct. Habitat destruction has been the single biggest threat to native frogs.

Where are they found?

The Hochstetter frog is found close to small forest streams.

All other native frogs live in forest areas where they can find good shelter from rocks, logs etc. Frogs must keep their skin moist to survive so they only come out on moist evenings to feed. The best time to find them is on warm, moist, autumn nights.

Once out frogs usually sit on the ground, occasionally they climb trees and shrubs.



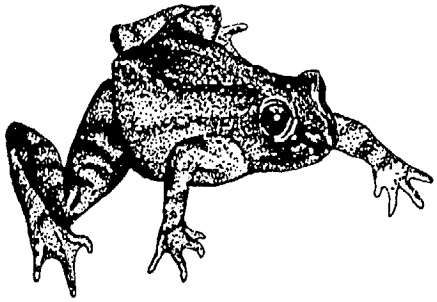
Department of Conservation
Te Papa Atawhai

Please don't not move rocks or logs when looking for frogs, doing so will destroy the habitat they need to survive

How to recognise a native frog

Most frogs seen in New Zealand have been introduced from Australia.
Native frogs are distinguishable from Australian frogs because:

- Native frogs don't have external eardrums
- Eye pupils are round (Australian frogs pupils are horizontal)
- Native frogs don't make loud breeding calls
- Native frogs are generally smaller than introduced frogs

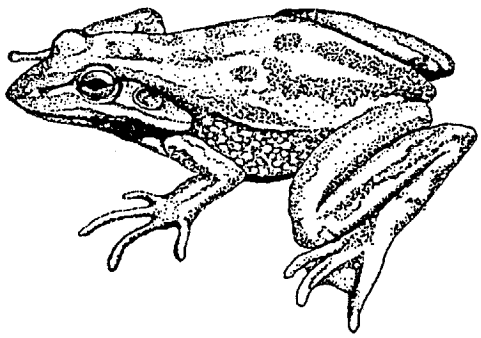


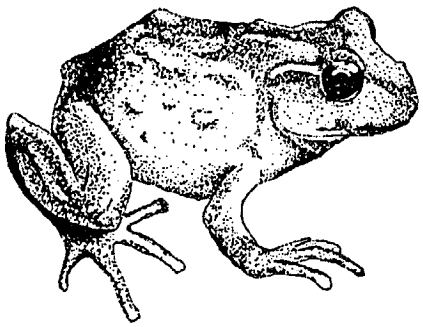
Hochstetter Frog

What to do if you see a native frog

Check to make sure it isn't an Australian frog. (large, green and horizontal eye pupils)
If you can, try photographing the frog.
Try not to handle the frog. If you do touch the frog make sure your hands are wet.
Report your sighting to a Department of Conservation office:
Note the location, number of frogs seen and the type of habitat they were seen in.

Golden Bell Frog - Australian (Introduced)





Maud Island Frog (Native)

Produced by Department of Conservation, 59 Boulcott Street, P O Box 10-420, Wellington, New Zealand. Telephone (04) 471-0726

Appendix 4:
Published Recovery Plans

Stitchbird	($15)	Approved 1996
Brown teal	($15)	Approved 1996
Native frogs	($15)	Approved 1996
Dactylanthus taylorii	($15)	Approved 1995
Bat (Peka peka)	($15)	Approved 1995
Otago and grand skinks	($15)	Approved 1995
Giant land snail	($15)	Approved 1995
South Island saddleback	($15)	Approved 1994
Takahe	($15)	Approved 1994
New Zealand Dotterel	($15)	Approved 1993
Tuatara	($15)	Approved 1993
Mohua (yellowhead)	($15)	Approved 1993
Subantarctic teal	($15)	Approved 1993
Kowhai ngutukaka	($15)	Approved 1993
Chevron skink	($15)	Approved 1993
Black stilt	($15)	Approved 1993
Whitaker's and robust skinks	($15)	Approved 1992
North Island kokako	($15)	Approved 1991
Kiwi	($15)	Approved 1991
Yellow-eyed penguin*	-	Approved 1991
Blue duck **	($10)	Approved 1991
Kakapo	Out of print	Approved 1989

* *Available: from Otago Conservancy, Department of Conservation, Dunedin*

** *Available:* Science & Research Internal Report *No.30, Science & Research Division, Department of Conservation, Wellington*

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