



# ECOLOGICAL MANAGEMENT

Chris Ward  
East Coast Conservancy  
Department of Conservation  
GISBORNE

NUMBER 5, JUNE 1997

1



Department of Conservation  
*Te Papa Atawhai*

# ECOLOGICAL MANAGEMENT

NUMBER 5, JUNE 1997

Published by  
Department of Conservation  
P.O. Box 10-420  
Wellington, New Zealand

© June 1996, Department of Conservation

ISSN 1172 - 7802

ISBN -0 - 478 - 01872 - X

ECOLOGICAL MANAGEMENT is produced by the Biodiversity Recovery Unit of the Science, Technology and Information Services Division, Department of Conservation. Articles published in Ecological Management do not necessarily reflect current Department of Conservation policy on materials or methods. Views expressed in this publication are not necessarily those of the Department of Conservation.

The editor for this issue was Craig Mundy. The map of Motuaro Island was prepared by Chris Edkins. To submit material for publication in ECOLOGICAL MANAGEMENT, please send two copies to The Editor, Ecological Management.

Please address comments and contributions to;

The Editor,  
Ecological Management,  
Biodiversity Recovery Unit,  
Department of Conservation,  
P.O. Box 10-420, Wellington.

Cover design by Erika Mackay, based on the original by Cathy Jones.

Additional copies may be obtained from the Science Publications Unit, at a cost of \$10.00 per copy. To receive ECOLOGICAL MANAGEMENT on a regular basis, you can request to be placed on our standing orders list. You will be sent each copy as it is published and invoiced on receipt. We are currently producing one to two issues of Ecological Management per year.

Send your order to;  
Science Publications Unit,  
Conservation Sciences Centre  
Po Box 10-420  
Wellington,  
New Zealand

# Contents

ERADICATION OF KIORE FROM MIDDLE CHAIN ISLAND, ALDERMAN ISLANDS. Rick Thorpe	1
ERADICATION OF NORWAY RATS FROM MOTU-O-KURA John Adams	5
CHETWODE ISLAND KIORE AND WEKA ERADICATION PROJECT Derek Brown	11
EFFECT OF THE POISON BRODIFACOUM ON NON-TARGET BIRDS ON THE CHETWODE ISLANDS Kath Walker and Graham Elliott	21
EFFECT OF AERIAL DISTRIBUTION OF 1080 FOR POSSUM CONTROL ON WEKA, GREAT SPOTTED KIWI, MOREPORK AND FERNBIRD Kath Walker	29
HAND-REARING OF NEW ZEALAND FALCON ( <i>FALCO NOVAESEELANDIAE</i> ) CHICKS Debbie Stewart-Badger	39
TECHNIQUES FOR MONITORING POPULATIONS OF POWELLIPHANTA LAND SNAILS Kath Walker	53
A COMPARISON OF IUCN RED LIST CATEGORIES AND DOC PRIORITY RANKINGS FOR NEW ZEALAND HERPETOFAUNA Ben D. Bell	65
SHORT NOTES	
RODENT ERADICATION - BLACK ROCKS Tim Shaw	73
POST-ERADICATION RECOVERY AT CHETWODE ISLAND: AN UPDATE Mike Avis	75
GUIDELINES FOR SUBMISSION OF MANUSCRIPTS TO ECOLOGICAL MANAGEMENT	79

# Eradication of kiore from Middle Chain Island - Aldermen Islands

**Rick Thorpe**<sup>1</sup>

Waikato Conservancy, Department of Conservation, Private Bag 3072, Hamilton.

<sup>1</sup> Current address. WWF - Fiji

## ABSTRACT

Kiore (the Polynesian rat) were eradicated from Middle Chain Island in the Aldermen Island group off the eastern Coromandel Coast using aerially spread anticoagulant poison "Talon 20p" (brodifacoum).

## INTRODUCTION

Middle Chain Island is situated in the Aldermen Island group off the eastern Coromandel Coast. The 23 hectare island is very steep and covered in predominantly coastal pohutukawa forest.

The Aldermen Islands were gifted to the Crown by Ngati Haku, Ngati Hei and Ngati Maru in the 1970s. This gift was subject to Tangata Whenua keeping the right to harvest titi and kaimoana, and representatives of the Tangata Whenua also became Trustees for the Aldermen Islands. Three of the original Trustees (Ngati Hei, Haku and Maru) remain on the Committee, and more people are currently being sought for representation on the Committee.

The Alderman Islands were first declared Wildlife Sanctuaries under the Wildlife Act, 1953 and later, as Nature Reserves under the Reserves Act, 1977. The Alderman Islands were also included in the Hauraki Maritime Park. Currently, the Islands are managed by the Department of Conservation in conjunction with the Aldermen Island Trustees. It is envisaged the Trustees will be more involved in future management of these islands.

Middle Chain Island had previously been identified as a high priority for restoration (Taylor 1989). The restoration required was the eradication of kiore. Middle Chain Island was the only island in the Aldermen group with a rodent population, and there was a high risk of kiore either swimming, or being transported to other islands in the group. The other islands support important assemblages of rare plants such as *Carmichaelia williamsii*, and animals including tuatara, small petrels, and lizards, which are vulnerable to kiore impact. Eradication of kiore would enable recovery of the petrel and lizard fauna on Middle Chain Island, and reduce the threat to surrounding islands.

On a trip to Middle Chain Island in June 1992, kiore were in such high numbers that they were raiding the camp stores at night and were often seen in the forested areas during the day. The effects of kiore on the native fauna of the Island is largely unknown due to the lack of previous monitoring data. However, the paucity of skinks, geckos, and invertebrates on Middle Chain was in contrast with the other rat free islands in the Aldermen Island group. Tuatara have not been located on Middle Chain Island, despite numerous searches.

In 1992/93 the Department of Conservation budgeted for eradication of kiore from the Island. Funds were also provided by the Waikato Branch of the Royal Forest and Bird Protection Society.

## METHODS

The Middle Chain kiore eradication was carried out in conjunction with the Red Mercury Island (Mercury Islands) kiore operation (September 1992) in order to make best use of staff and equipment. A Jet Ranger helicopter fitted with a monsoon bucket was used to spread Talon 20P baits over the island. Although there were a few initial problems with the modified monsoon bucket these were ironed out and the Middle Chain drop was straight forward.

Four runs were made along the length of the island to make sure of good coverage. Due to the steep razor back terrain (Plates 1, 2), many of the baits collected at the base of cliffs and banks. These baits were picked up later and redistributed on the faces and areas where baits were a bit thin.

Apart from the build up of baits at the base of cliffs, the spread of baits over the island was comparatively even with an approximate spread of two baits per m<sup>2</sup>. The helicopter pilot was very accurate and few baits were dropped into the sea or on the intertidal wave platform. There was however, a build up of baits around the base of the coastal cliffs, although coincidentally, this was the area where most kiore sign was found on this and previous trips to the island.

At the same time as the aerial drop, additional baits were distributed by hand on the many rock stacks around the coast of Middle Chain Island. We attempted to distribute the baits by using a shanghai loaded with Talon 20P, although the shanghai was not as accurate as hand throwing. Access to these rock stacks was provided by Minow canoe, which gave us a stable platform to throw from, a dry place to store baits (under the spray skirt or in a day pack), and the ability to sneak into small rock guts and to land on rocky beaches in moderate surf.

A team of two people stayed on the island for three nights after the Talon drop to check on bait distribution and monitor rainfall.

### **Kiore sampling**

As requested by Anthropology Department of the University of Auckland, kiore were collected, prior to the poison drop, for genetic comparisons. All samples were stored in liquid nitrogen. Only seven kiore were caught out of 150 trap nights (September 18, 19, 20). All kiore were caught just above the high tide line where they appeared to be scavenging amongst the flotsam for crab carcasses and insects.

On the September eradication trip kiore were in low numbers and although much time was spent at night searching, very few were seen. There was also an abundance of Tawapou seed on the ground, uneaten by kiore. This was in contrast to the June trip when all seed had been chewed.

## RESULTS AND DISCUSSION

Due to poor weather and logistical problems, post-drop monitoring was not carried out until October and November 1993.

Chew sticks (hardwood dipped in fish oil), candles and Talon 50 WB baits were placed just above the high tide mark around fruiting trees and active petrel colonies where rat sign had previously been found. The baits were left on the island for approximately three weeks before being picked up and brought back. All baits were individually inspected for kiore sign. None of the baits had been chewed indicating the eradication attempt had been successful. Kiore have not been seen on the island in the three years following the aerial drop, confirming a successful eradication programme (C. Smuts-Kennedy, pers. comm.).

Talon 50WB baits in waterproof tunnels have been left on the island in areas favored in the past by kiore and around easily accessible beaches, and will act as protection in case of future landings of rats. Baits left on Middle Chain Island, and other islands in the Aldermen group will be checked periodically by field staff to ensure their continuing status as rat free. Refer to the *'Pest Contingency Plan for the DoC Managed Offshore Islands in the Waikato Conservancy'* (Thorpe, et al. 1993).

This eradication project was carried out using solely Talon 20P baits, and demonstrates that eradication of kiore using an aerial distribution of baits is effective for this purpose. The modified monsoon buckets proved to be a practical method for spreading the baits. The Minow canoes were particularly useful for distributing baits on rocky shorelines, and on small adjacent rock stacks.

Special thanks are due to the Royal Forest and Bird Protection Society for supporting this project.

## REFERENCES

- Taylor G.A.S. 1989. A Register of Northern Offshore Islands and a Management Strategy for Island Resources. Northern Region, Department of Conservation Technical Report Series No. 13, Auckland.
- Thorpe, R.J., Stanway, L.A. and P. Thompson 1993. Pest Contingency Plan for the Offshore Islands within the Waikato Conservancy. Waikato Conservancy Publication.
- Veitch, CR and Bell, BD. (1990) Eradication of introduced animals from the islands of New Zealand. in Towns, D.R., Daugherty, C. and I.A.E. Atkinson Eds., Ecological Restoration of New Zealand Islands. Conservation Sciences Publication No. 2, Wellington.



FIGURE 1 ALDERMAN ISLAND GROUP. MIDDLE CHAIN IS THE FORWARD MOST OF THE ISLANDS IN THE CENTRE OF THE PHOTO.



FIGURE 2. A VIEW OF THE WESTERN END OF MIDDLE CHAIN ISLAND, SHOWING RUGGED NATURE OF THE TERRAIN

# Eradication of norway rats from Motu-o-kura

**John Adams**

Hawkes Bay Conservancy, Department of Conservation, PO Box 644, Napier

## ABSTRACT

Norwegian rats were accidentally introduced to Motu-o-kura Island approximately 50 years ago. Since then, a burgeoning rat population has apparently resulted in the decline of many species of birds, lizards, invertebrates and plants. A successful attempt to eradicate Norwegian rats from Motu-o-kura Island was made in August-September 1990, using manually distributed Talon 50WB (Brodifacoum) baits. Dramatic increases in abundance of some lizard and invertebrate populations were apparent in the first few years following the eradication programme.

## INTRODUCTION

Motu-O-Kura (also known as Bare Island), lies 1.5 km from the coast approximately 15 km south of Cape Kidnappers in southern Hawke's Bay (Figure 1). It is the only island of any significance found along the south-east coast of the North Island between Wairoa and Wellington. Motu-O-Kura is approximately 800 m long, 300 m wide and 13.5 ha in area. The island is owned by members of hapu from the Waimarama area and has a long history of pre-European Maori occupation.

Viewed from the Waimarama coast the island's north-west facing slopes consist almost entirely of steep bare and crumbling papa mudstone. It's more gently sloping south-western faces are mainly covered in flax but also contain small patches of coastal shrubs such as taupata, rangiora, karo<sup>1</sup> and karamu and the occasional cabbage tree. There are also areas of grasses, herbs and eroding bare slump faces. The island's largely soft mudstone coastline and exposed cliffs are being actively eroded by the combined affects of wind, rain and sea.

Today the island is visited by the owners and unauthorized members of the public mainly over the summer period, usually for the purpose of collecting various forms of kaimoana. Because of the complex nature of the reefs and submerged rocks that surround the island, and the absence of sheltered beaches, landing is extremely difficult in all but the best of sea conditions. The sea bed surrounding the island is an extremely popular recreation crayfishing area and attracts pot-fishers, scuba and snorkel divers.

---

<sup>1</sup>Not karo in the strict sense, but *Pittosporum ralphii* which looks similar.

## History of human colonisation

Prior to the modification of Motu-O-Kura by humans, the islands southeastern slopes were thought to be densely covered with woody coastal tree species, and would have supported a far greater variety of endemic animals than at present. It is likely that a number of burrow-nesting petrel species used the island for breeding and that a plentiful lizard and invertebrate fauna thrived in the guano-enriched environment.

Centuries of Maori occupation led to the near total removal of woody vegetation, leaving bare surfaces as recorded by Cook in 1769. During these times accelerated slumping and wave-lap erosion would have resulted, and the composition of the island's flora and fauna would have been depleted or altered considerably. Several species of seabird were probably extirpated as a result of these changes. During the early years of European colonisation of Hawke's Bay Maori occupation of Motu-O-Kura gradually declined. It is not recorded when the last inhabitants left the island.

## Rat presence and impacts

Norwegian rats (*Rattus norvegicus*) are thought to have been accidentally introduced to Motu-O-Kura in about 1936, when a launch was wrecked on its western coast<sup>2</sup>. There is no evidence to date that any other species of rodent, including the Polynesian rat (*Rattus exulans*) has ever been present on the island.

In November 1960 a New Zealand Wildlife Service survey team recorded about 100 occupied sooty shearwater (*Puffinus griseus*) burrows at the southern end of the island and large numbers of little blue penguins (*Eudyptula minor*) and black-backed gulls (*Larus dominicanus*) on the eastern flanks. The island was considered "over-run" by rats.<sup>2</sup>

No other survey took place until February 1988<sup>3</sup>, when a D.S.I.R. party (contracted to the Department of Conservation to undertake a natural history survey of the island) reported that rats and penguins were dominant features of the island's fauna and that sooty shearwaters had declined in number to about 20 active burrows. They concluded that: "... Norway rats are abundant on the island, and are by far the greatest biological problem. Not only do they browse plants and seeds, impairing regeneration, but they also prey on invertebrates, lizards and the eggs of both seabirds and land birds. We consider eradication of rats quite feasible, and the sooner the better... if rats were eliminated from Motu-O-Kura it could become a site for the conservation of rare or endangered plants, birds, reptiles and/or invertebrates".

<sup>2</sup> Merton, D.V. 1961: Notes on some offshore islands. *Notornis* 9(5): 167-169.

<sup>3</sup> Walls, G., McLennan, J. and J. Watt 1988: Natural History of Motu-O-Kura (Bare Island) Hawke's Bay. DSIR Havelock North, report for Department of Conservation, Napier.

Following publication of the above report a meeting with the owners and trustees of the island was convened at the Taupunga Marae, Waimarama on 10 September 1988. A motion was passed at this meeting that "*a rat eradication programme be implemented by the Department of Conservation and the D.S.I.R.*".

### **Wildlife values**

Little blue penguins are the most numerous seabird species found on the island. In 1988 the population was estimated to be in the vicinity of 750 to 1000 nesting pairs. This is by far the largest breeding colony in the Hawke's Bay Conservancy, and in view of an apparent decline of this species generally, is of national significance. A small but diminishing nesting population of sooty shearwaters (between 10 and 20 pairs) has survived the rat invasion. Black-backed gulls currently nest on open and exposed ridges and grassy outcrops, and black shags (*Phalacrocorax carbo*), red-billed gulls (*Larus novaehollandiae*), white-fronted terns (*Sterna striata*), pied shags (*Phalacrocorax varius*), reef herons (*Egretta sacra*), white-faced herons (*Ardea novaehollandiae*) and welcome swallows (*Hirundo tabitica*) also occur in small numbers.

Common skinks (*Leiopisma nigriplantare maccanni*) are known to be present. It is possible that geckos have also survived (a cast skin and a single specimen were observed by the D.S.I.R. party in 1988, but were not identified).

### **Rodent eradication and restoration proposal**

Following consideration of the D.S.I.R. report it was determined by departmental staff that provided rats could be eradicated, Motu-O-Kura had significant potential as a safe haven for species of native plants and animals threatened by introduced predators elsewhere. While its relatively small size meant that the island would have little value for species requiring large areas, it was felt that significant opportunities would be created to re-establish populations of selected plants, invertebrates and reptiles, as well as restoring breeding seabird colonies.

A detailed proposal for rodent eradication and possible re-introductions was then prepared which was subsequently supported by the Trustees.

### **The eradication operation**

Planning for a poison application operation began in May 1990 with the preparation of a written proposal. This was undertaken in consultation with various departmental specialists and subsequently taken to the Maori owners and discussed with them in July 1990. Their support for the proposal was granted and they also offered to assist with the laying of toxic baits.

It was proposed to manually lay anticoagulant rodenticide "Talon 50WB" (active ingredient - Brodifacoum) baits at a rate of 6 kg/ha over the parts of the island inhabited by rats in two applications approximately 2 weeks apart. The timing of the poison application was set for late winter. Studies elsewhere have shown that food sources for rats are in low supply at this time and the baits

would be keenly sought after. Once this phase was complete 30 bait stations were to be installed around the island and monitored until there was no further bait take and it was established beyond doubt that the last rat had been eliminated.

Talon baits were laid on 15 August, and again on 3 September 1990 by Napier Field Centre and Conservancy Office staff, and landowner representatives. The baits were put on the ground in piles of 5 baits every 10 meters along parallel lines spaced some 20 meters apart (see Map 2). To ensure even distribution long bamboo poles were used as markers and six two-man teams moved down slope in as close to "line abreast" as could be managed. The dense, largely flax-dominant cover (up to 3 m high in places) made navigation, forward progress, and keeping in contact with adjacent "teams" a somewhat slow and difficult task at times. Despite these difficulties we were confident a good coverage was obtained.

Approximately 2500 individual baits (45 kg in total) were laid in each application. Large sections of near vertical papa cliffs along the north-western side of the island were not covered, but the amount of bait laid along the shorelines was doubled (10 baits/site) as it was anticipated that rats would be present in higher densities in those areas.

On 11 November 1990 a further trip to the island was made to install 30 permanent bait stations. These were located at the points marked on Map 2. Each station consisted of a numbered stake, a "Novacoil" bait station containing two Talon 50WB baits, two "Storm" (active ingredient - Bromadiolone) baits, a gnaw stick (20 mm square rimu stake which had been boiled in cooking oil), and an apple. Even at this early stage (8 weeks after the initial poison application) none of the six people involved in the establishment of the bait stations were able to find any recent evidence of rat survival.

The bait stations were checked and replenished on six occasions between December 1990 and April 1992. No rat feeding sign or droppings were ever noted on any of these occasions and we are confident that all the rats on the island succumbed to the initial poison applications.

### **Subsequent monitoring and the future**

A number of actions have been taken to monitor the island's recovery following the eradication operation, and to minimize the risk of rodent re-infestation:

1. vegetation monitoring plots and photo points have been established to document future changes;
2. pitfall traps have been installed to sample and monitor invertebrate and lizard populations;
3. a draft Rat Contingency Plan has been prepared and is now nearing completion following consultation with the Maori owners. They have agreed to the implementation of a number of preventative measures including the active discouragement of non-authorized landings, the erection of suitable signs, and the maintenance of a number of permanent stations loaded with toxic bait.

Already populations of skinks and invertebrates (spiders, beetles, cave weta, moths and butterflies) have shown dramatic increases. In time, it is hoped the population of sooty shearwaters will expand and other seabird species will re-establish.

Once the Rat Contingency Plan is operational, Motu-O-Kura has potential to be a suitable site for the establishment of other rare or threatened species of plants and animals.

## ACKNOWLEDGMENTS

Getting on and off the island in most sea conditions, was quite challenging, and distributing poison baits to some parts of the island also proved something of an adventure at times. The success of this eradication operation was in no small part due to the dedicated efforts of the owners and departmental staff involved. In particular I would like to acknowledge the cooperation and sterling efforts of Walter Broadman, our primary owner contact. Graeme Taylor, Ian McFadden and Paul Jansen also provided valuable advice as the eradication proposal was developed.

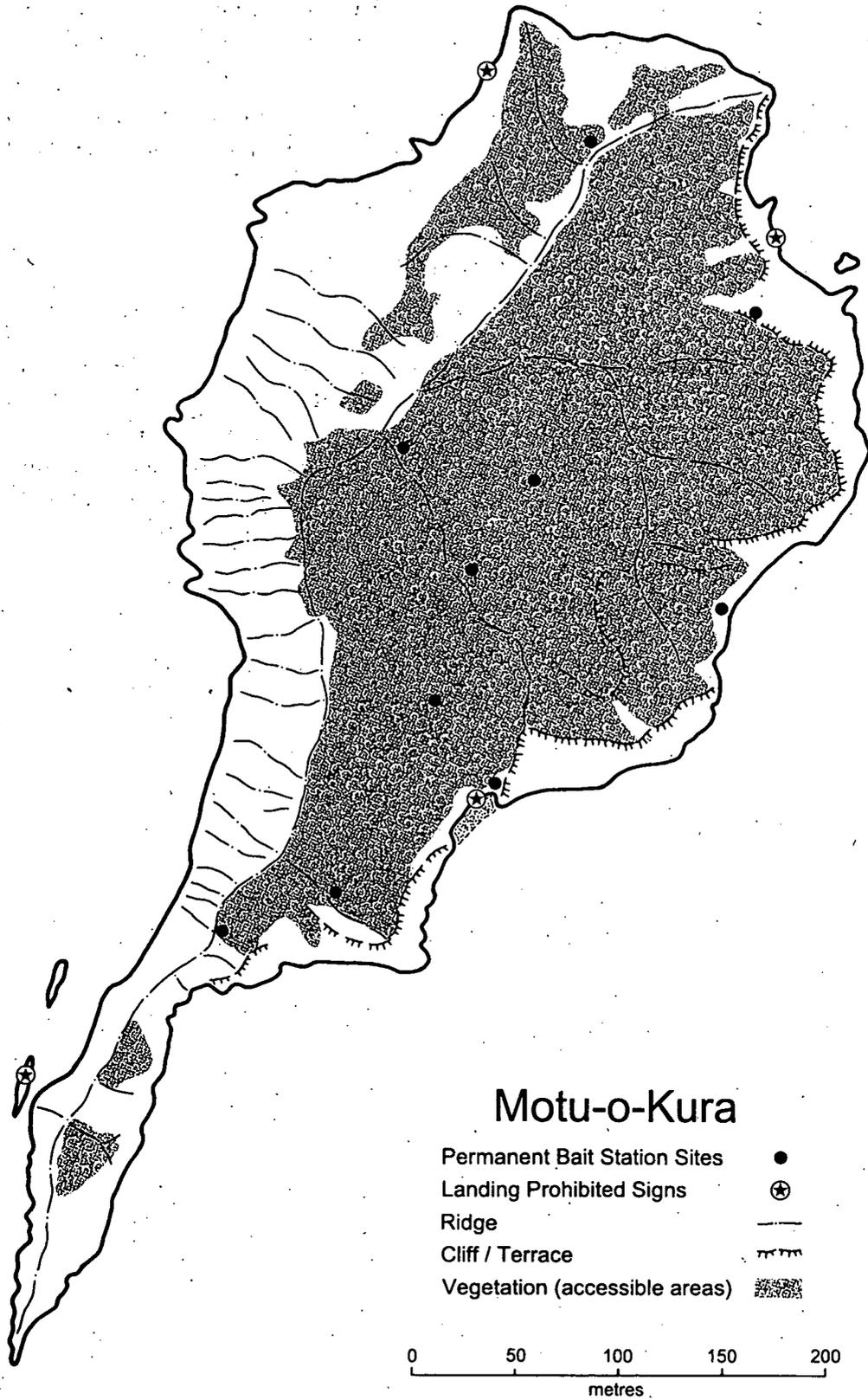


FIGURE 1. MAP OF MOTU-O-KURA

# Chetwode Island kiore and weka eradication project

**Derek Brown**

c/- Nelson/Marlborough Conservancy, Department of Conservation, Private Bag 5, Nelson

## ABSTRACT

A programme to eradicate kiore and weka from the Chetwode Islands initiated in August of 1993, using a variety of methods. Kiore and weka were removed from Nukuwaiata (Inner Chetwode Island) using aerially spread Wanganui No. 7 pellets (Brodifacoum), while a range of live-capture techniques were used to remove weka from Te Kakaho (Outer Chetwode Island). The eradication attempt was successful, and initial monitoring results indicate populations of several species of invertebrates, lizards and native trees have benefited from the removal of kiore and weka. These large islands are now free of introduced predators, and will play an important role in the conservation of New Zealand's threatened species.

## INTRODUCTION

The Chetwode Islands are situated in Cook Strait, just outside the entrance to Pelorus Sound. They consist of two large islands, Nukuwaiata (Inner Chetwode) and Te Kakaho (Outer Chetwode) plus several small rocky islets. Nukuwaiata, the largest island in the group is c. 195 ha in area and Te Kakaho is 83 hectares. The Chetwode Islands were purchased by the Crown in 1856, and subsequently leased for farming. Nukuwaiata was made a Scenic Reserve in 1904, and Te Kakaho the same in 1934. The Chetwodes now have Nature Reserve status, and landing on the islands is prohibited without a permit. The islands are administered by the Department of Conservation through its Havelock Field Centre.

Past usage of the islands includes clearance of bush for farmland and the introduction of pigs and rabbits. Historical records suggest weka were deliberately introduced to the islands in the 1920's, and kiore may have been present for considerably longer. By 1990, the only remaining introduced predators on the Chetwodes were the western weka *Gallirallus australis australis* (Nukuwaiata and Te Kakaho) and the Polynesian rat, or kiore *Rattus exulans* (Nukuwaiata only).

A biological survey of the Chetwodes by Geoff Walls in 1983 concluded that the Chetwode islands were particularly important biologically within the Marlborough Sounds region, in terms of the existing fauna and flora, and their potential for supporting populations of other animals and plants. However, this

was dependent on the removal of wekas and kiore. The Chetwodes are also a sufficient distance (3 km) from the nearest point of the mainland to ensure that once predators are removed, they will be unable to re-establish without human assistance.

The Chetwode islands have escaped serious lasting damage, have a high cover of natural vegetation remains, and thus have considerable potential for conservation purposes. There are few predator free islands of this size remaining in New Zealand, and the removal of weka and kiore from the Chetwodes will provide an important resource for the conservation of endangered plants wildlife.

## METHODS

### **Background**

An initial grant of \$19,000 was provided in 1992/1993 to undertake preliminary investigations for removal of kiore and weka, and a further \$46,000 in 1993/94 for the eradication operation itself. Two small huts were flown by helicopter to Nukuwaiata to establish a base camp. Over 15 kilometers of track were then cut to provide access to all portions of both islands. The intention of the tracking system was to ensure every portion of both islands was within 100m of a track or the coastline, for monitoring and trapping purposes. Nova coil bait stations (110) were distributed at 100m intervals along tracks on Nukuwaiata by volunteers as a back-up option and for later use as weatherproof monitoring or bait stations.

### **Iwi consultations**

Consultations with the Ngati Kuia iwi who have mana whenua over the islands was considered vital to the success of the project. Three separate hui were held with Ngati Kuia representatives and a visit to the island by the senior kaumatua and Kuia arranged. Liaison with the iwi was maintained throughout the project, culminating in a hui to present a koha of weka feathers (from birds shot on the island) to members of the iwi. Iwi members also participated in a transfer of weka off the islands, and offered a karakia for the birds. Regular progress reports of the eradication project were provided to the iwi by the conservancy Kaupapa Atawhai manager. Iwi will be involved in any subsequent transfer of wildlife to (or from) the islands if they so desire.

### **Weka genetics**

Colin Miskelly (DoC Advisory Scientist, Wellington, Conservancy) visited the islands on 19-23 April 1993 to obtain blood samples for his study on genetic variability in weka. Preliminary results from morphometric data suggested weka on the Chetwodes (particularly on Nukuwaiata) may be genetically distinct. The 12 adult birds, captured and measured on Nukuwaiata were all very small (between .485 and .85 kg) and 10 of 17 seen or handled had partial albinism (white head and wing feathers)(Miskelly, 1993). An alternative explanation to 'genetic distinctness' of the birds is that such features arise from

a very limited gene pool. Few birds were released in the original transfer, and many birds were removed in the 1970's (in an attempt to protect saddleback).

However, to ensure the survival of the potentially unique gene pool, 24 Nukuwaiata birds were captured in August 1993 and taken into captivity. Aviaries at six different institutions or private individuals residences were constructed (or a donation made in lieu of) to hold these birds until clear results are obtained in the genetic analysis. Currently 15 birds survive, (4 died, 5 escaped) and genetic work has not progressed sufficiently to determine their genetic relationship to other weka.

### **Kiore**

Eradication of kiore from Nukuwaiata was planned through a single aerial broadcast drop of anticoagulant poison. The poison bait used was the small sized Wanganui No. 7 pellets (c.2g each) containing 20 ppm brodifacoum. Approximately 2.5 tonne of bait were used in the eradication project, nearly two tonne of which was surplus from the Enderby Island rabbit eradication project. The target period for application of poison baits was between mid-August and late September 1993, and when the long-range forecast predicted no rain for 4 - 5 days. A few spots of rain fell the night after the drop, but no significant rain fell during the following 11 days. Baits remained in recognisable form (and presumably toxic) for at least six weeks.

On 23 August 1993, 2.2 tonne of poison bait were distributed over Nukuwaiata and offshore rock stacks (Ninepins and Te Kiore) using a Bell Jet-Ranger helicopter and a purpose built bait dispensing bucket. Trials using non-toxic baits were conducted at Omaka Aerodrome (Blenheim) with the helicopter and bait-spinner to be used in the operation, to test and calibrate swath width and sowing rate. The bucket was loaded from the back of a small truck above Waihinu Bay on the mainland, 10 km from Nukuwaiata. Each load contained between 200 and 300 kg of bait, with a total of nine loads flown.

Bait distribution was visually determined, using the sectioned nature of the island as a guide. GPS navigation was not used. The dispersal of baits on Nukuwaiata was monitored on the day of the drop by a ground team of three. Each track was walked after all bait was dropped, to check for any gaps in coverage. Distribution of 100 kg of baits by hand was carried out in localised areas where ground inspection found coverage of aerially-sewn baits to be (apparently) light. Fifteen grids of 4m x 4m were established over the length of the island before the drop and the number of baits falling into each was noted. The average density was seven pellets per grid, which was close to the predicted eight pellets per grid calculated from average weight of individual pellets, amount dispersed and total area of the island.

A total of six pellets were taken from the grids after the first night, along with many pellets along the tracks that were eaten or partially eaten. A further nine pellets from grids were eaten or partially eaten on each of the second and third nights, with only one on the fourth night and two on the fifth before monitoring ceased.

No surveys of kiore were carried out prior to the poison drop, although Auckland University staff carried out trapping to obtain kiore samples three

months prior to the eradication operation. During 21 - 23 May 1993, 20 traps were set over two nights at Nukuwaiata. A total of 21 kiore were captured, with 10 kiore caught one hour after the traps were set on the first night (Simone Holmes, pers comm.).

Post-poisoning monitoring was conducted by DoC staff, using standard snap-traps, nova-coil tunnels (with either chocolate, soap or poison wax blocks - Talon 50WB or Storm), segments of wax candles. Fresh seedfalls and known kiore husking stations were also investigated for fresh activity. One hundred and ten permanent bait stations have been maintained since the poison drop, using both poison baits and passive detectors. To date, no evidence of a continued presence of kiore on Nukuwaiata has been found.

## **Weka**

It was suspected that aerially broadcast baits on Nukuwaiata would be eaten by weka, affecting a significant proportion of the population. Initial efforts were therefore focused on the Te Kakaho weka population. The initial decision to destroy all birds (i.e. using 'kill' techniques) on this island was revised in response to adverse public reaction. Consequently, the primary technique used to remove weka from Te Kakaho was live-capture using hand-nets and standard cage-traps (up to 10) baited with mutton-fat. Mark Four Fenn traps were trialed under special permit, to kill-trap wekas. They were fastened to tree trunks c. 300 mm off the ground and baited with fish or fat held on to the plate by string or rubber bands. These were employed late in the programme and were successful in catching a small number of weka, but were immediately withdrawn when it became apparent the birds were not always humanely killed (instantly).

The hand-nets proved very effective for naive wekas. Wekas were drawn into catching range using a piece of mutton-fat or fish attached to a long string which was cast in front of the bird. The birds would invariably show interest in the bait and follow (or be dragged!) behind the bait as it was pulled to within range of the catcher. These birds were held in temporary holding pens, constructed of chicken mesh and waratah standards, for up to two weeks on Nukuwaiata before transfer to a liberation site near Nelson. A total of 113 birds were captured and subsequently transferred. A further two died while in the holding pens, one probably because of starvation (refusal/inability to eat) and one due to persecution from other wekas due to an open wound around one eye. Two dogs were also used for tracking weka, being 'refreshed' in training during the early stages of the operation, and used again intensively in the latter stages, when wekas were less numerous and more difficult to locate.

Cage trapping, hand-netting and shooting (without use of tapes) removed the bulk of the weka, but it became obvious the last 20 or so weka had become shy of cage traps, and human presence. An application for experimental use of hens eggs injected with 1080 was approved in March 1994. Te Kakaho was pre-baited twice with non-toxic eggs at intervals of approximately 100 m along tracks. These were replaced by 1080-injected eggs (15 ml per egg, quoted LD50 being 8 ml), two at each station (74 stations) based on the assumption that wekas may travel in pairs.

Wekas broke into and ate contents of more than half the eggs laid out. Although a small number of weka were suspected to have died as a result of consuming these eggs, there was no confirmation of this. The remaining wekas became poison-shy through non-toxic doses and showed an aversion to taking further eggs. We presume that the suggested LD50 for wekas was too low, having been based on a small sample of wild-caught birds held in captivity. After the use of 1080 eggs, taped calls of weka were used to locate and attract remaining birds. A total of nine further birds were shot or trapped, the last one being detected by dogs on 6 August 1994, and subsequently shot the next day. It had not responded to any taped calls played in or near its territory over several days prior to this.

A known total of 177 weka were removed from Te Kakaho (113 transferred, 64 shot/trapped), with possibly a few more killed by 1080 poison eggs. Virtually all of the birds handled were adults, indicating there was probably a minimum of 90 territories on the 83 ha island.

On Nukuwaiata our predictions that the wekas would be greatly affected by the poison bait proved correct. After the transfer of 24 to the mainland aviaries, only two wekas (<2% of the remaining population) appeared to survive more than two weeks past the drop. One was shot on September 20, 1993 (28 days after the drop), and one other was located by dogs and shot on April 25, 1994 (sign of this bird had been seen for several months). None of the fifteen weka banded on Nukuwaiata (by Colin Miskelly in April and DoC staff in August) survived the poison drop.

Trained dogs have traveled all tracks on both islands subsequently and have not detected any further sign of weka presence. Ordinary hens eggs were used on Nukuwaiata as a further detection method, and all parts of the island have been searched repeatedly.

## RESULTS: RESPONSE OF FAUNA AND FLORA TO KIORE AND WEKA ERADICATION

### Seabirds

Between 26 and 29 November 1993, Simon Walls (DoC) undertook a survey of existing colonies. This involved mapping areas where burrows occurred, counting the number of burrows (active and disused), and where possible, identifying the species present by burrow size, extracting chicks or examining feathers in burrow areas.

Over 350 burrows were found on Nukuwaiata, the majority of which were used by fluttering shearwaters, with a few small colonies of sooty shearwater. Most of the burrows occurred on the northern (approx. 302) and southern (approx. 47) extremities of the island. On Te Kioire (a small semi-detached stack), 20 active sooty shearwater burrows were found. Approximately 50 fluttering and sooty shearwater burrows were located on Te Kakaho, all of which were on the semi-detached headland closest to Nukuwaiata. Penguin burrows were not intentionally counted on this survey.

Diving petrels have been regularly heard flying over the islands and have been heard calling from the ground. No sign of nesting has been detected, although nests may be located in areas inaccessible to weka or kiore (e.g. cliff-faces).

On two occasions during this operation there was clear evidence of weka preying upon penguin chicks. Weka were seen attacking penguin chicks in or near penguin burrows.

The mapping and counting of burrows will provide good baseline information on the response of these colonies to weka and kiore removal. However, a significant increase in population numbers are not expected for several years given the slow recruitment rate, and time delay before newly fledged young birds mature and return to breed.

### **Kaka**

A small number of kaka were known to be present on the Chetwodes prior to this programme although it was unclear whether they were resident or just seasonally present, traveling from nearby populations on d'Urville Island or the mainland. Consequently, one male kaka was caught in a mist-netting trip by Landcare Research staff, and was fitted with a transmitter.

Subsequent monitoring by both Landcare and DoC staff of this bird and the other kaka it associated with, indicated that a small population of approximately six birds was present on the islands all year round. No obvious change in numbers or behavior of kaka has been observed since the eradication programme.

### **Invertebrates**

Landcare Nelson were contracted to undertake invertebrate and reptile monitoring as part of the eradication project. The bulk of the field work was undertaken by two students, Cathy Rufaut and Simon Clearwater, in association with more detailed work carried out by Cathy on rodent - tree weta relationship for her MSc. General invertebrate pit-fall trapping lines were established as were study areas for tree wetas and flax weevils.

Some interesting preliminary results include a 50% increase in tree weta numbers within the study area on Nukuwaiata in the first year since the drop, and an 80% increase by the second year. Results so far also suggest population densities of larger invertebrates such as ground weta, carabid beetles and flax weevils are higher on Te Kakaho compared with Nukuwaiata.

Four species of *Coleoptera* present on Te Kakaho were not found at all on Nukuwaiata (Clearwater et al 1996), and in 1995, pit-fall trapping on Te Kakaho revealed 291 carabid beetles, whereas only five individuals were caught in Nukuwaiata traps with a similar trapping effort in similar habitats (S Clearwater pers obs). The lower diversity and numbers of invertebrates on Nukuwaiata are assumed to be related to kiore predation prior to the eradication project.

Invertebrate feeding sign was monitored by counting leaf-notching on flax plants within specified plots. Numbers of notchings were not significantly

different between years, however casual observations suggest flax weevil populations are in low densities on Te Kakaho and absent from Nukuwaiata

### Lizards

Populations of geckos and skinks were monitored using spotlighting and pit fall traps respectively, on both Nukuwaiata and Te Kakaho. A noticeable change in population densities has occurred with *Oligosoma lineoocellatum* increasing by 67% on Nukuwaiata and 43% on Te Kakaho over the two years post-poisoning. *O. zelandicum* increased by 73% on Te Kakaho, but did not show any appreciable increase on Nukuwaiata (Clearwater *et al.* 1996). The mean weight and length of *O. lineoocellatum* has also significantly increased (Clearwater *et al.* 1996) perhaps indicating a greater survival of juvenile or sub-adult animals through to larger size classes. No significant change in age-size structure has occurred in *O. zelandicum* as yet. The unintentional capture of seven *H. maculatus* in day pitfall traps in 1995 as opposed to none in 1993/94 may indicate an expanding population or change in behavior since the removal of kiore and weka. More sightings of geckoes occurred on Te Kakaho than on Nukuwaiata, which was also assumed to be a consequence of earlier kiore predation on the latter. Anecdotal evidence suggests a slow increase in numbers on both islands.

### Vegetation

To obtain a rough estimate of vegetation response, a count of seedlings was made within a 2m radius of some large seed-producing trees for seedlings of species thought to be vulnerable to kiore. Two to four trees each of nikau, kohekohe, hinau and matai were monitored, along with one miro. For monoecious species the selected trees were known to be female. Due to a lack of time, these counts were not done prior to the drop. Counts however, were made after the poison drop but before the next seasons seedfall. The counts were repeated during the following two years. Seedling counts beneath each tree focused specifically on seedlings of the parent tree species, but general notes were kept on all seedlings establishing (see appendix 1 for a summary of seedling counts).

Clear results will take some time to emerge, in part due to the prolonged dormancy period of seeds from some of the target species. However, casual observations to date support the theory that kiore were inhibiting establishment of many seedlings through consuming the bulk of each seasons seedfall. A noticeable increase in young (<1 yr) seedlings of nikau has been seen beneath monitored trees, as well as titoki and kohekohe (Appendix 1). Since the eradication programme, large numbers of seeds lie uneaten on the ground (a feature not evident prior to the kiore eradication) and many, including miro, kohekohe and tawa, were showing the first signs of germination during the field check in May 1995. Few matai seedlings less than 1m tall had been seen on Nukuwaiata prior to the operation, but during the last check, an appreciable number of first-year seedlings (<10 cm height) were located, often amongst very dense accumulations of uneaten seed.

## SUMMARY

The Chetwode Islands are now predator free, and the tremendous potential of these large islands can now be realised, with benefits of the project for native species already apparent in results of non-target species monitoring. Working within the parameters of the Island Classification System (Atkinson 1990) and the Nelson/Marlborough Island Management Strategy (Millar, 1996) consideration can be given to the establishment or re-establishment of species to the Chetwodes, particularly those previously present or now severely restricted in distribution in the Marlborough Sounds.

Several species have already been suggested as candidates for transfer to the Chetwodes; South Island saddleback (Roberts, 1994), Hamiltons frog (Brown, 1994), kakapo (Imboden, Jones and Atkinson, 1995) and tuatara (Cree and Butler, 1993). Other species such as Stephens Island (striped) gecko, Stephen Island (ngaio) weevil, Duvaucels gecko, yellowhead, little spotted kiwi and short-tailed bat have also been considered (Millar, 1996).

Perhaps most importantly however is the fact that the Chetwodes existing flora and fauna can recover towards a pre-human condition. As an example of Marlborough Sounds coastal forest, as a seabird island habitat, and a predator-free environment the Chetwodes Islands are already one of the most important sites in the region, and with careful management their conservation value can be further enhanced.

## RECOMMENDATIONS

The monitoring programmes for invertebrates, reptiles, vegetation and birds should continue, or resume later, for several more years if at all possible, to yield more accurate and conclusive data to support or rebuff the current trends.

## ACKNOWLEDGMENTS

Sincere thanks to a dedicated field crew who were instrumental in the success of the operation, particularly Dave Rees, James Fraser, Gus McAlister, Ken Smith and Gary Aburn. Many others too numerous to mention helped as wildlife-counters, track-cutters, boat drivers, general hands or provided logistic support. Thanks to Cathy Rufaut and Simon Clearwater for the lizard and invertebrate monitoring and general field assistance, and also to Landcare staff of Nelson for their support of this aspect of the project, and the kaka monitoring.

Thanks are also due to Ngati Kuia iwi for their support and assistance, and to Ben Hippolite (Kaupapa Atawhai) for continued liaison. DoC staff from Nelson Conservancy also contributed greatly, in particular Peter Lawless, Ian Millar and Kath Walker who willingly provided support and advice. Ian McFadden and other staff within TSU also provided helpful advice and assistance.

## REFERENCES

- Atkinson, I.A.E. 1978. Evidence for effects of rodents on the vertebrate wildlife of New Zealand islands. *in* The ecology and control of rodents in New Zealand nature reserves (Ed. P R Dingwall, I.A.E. Atkinson and C. Hay) Department of Lands and Survey information series No.4, Wellington.
- Atkinson, I.A.E. 1986. Rodents on New Zealand's northern offshore islands: distribution, effects and precautions against further spread. The offshore islands of northern New Zealand. Department of Lands and Survey Information Service 1986, No. 16: 13-40
- Atkinson, I.A.E. 1990. *in* Towns, D.R., Daugherty, C.H., Atkinson, I.A.E. (Eds) 1990. Ecological restoration of New Zealand islands. Conservation Sciences Publication No.2, Department of Conservation, Wellington
- Brown, D.A. 1995. Transfer of Hamiltons Frog, *Leiopelma hamiltoni*, to a newly created habitat on Stephens Island, New Zealand. NZ Jour. Zool. 21: 425-439
- Clearwater, S.; Rufaut, C.; Thomas, B. 1996. Monitoring of key invertebrate and lizard species following the eradication of kiore (*Rattus exulans*) and weka (*Gallinallus australis australis*) from Nukuwaiata and Te Kakaho, Chetwode Islands, Pelorus Sound. Landcare Research Manaaki Whenua, Nelson.
- Cree, A; Butler, D. 1993. Tuatara recovery plan. Threatened species recovery plan series No.9. Department of Conservation, Wellington.
- Imboden, C. Jones, P. Atkinson, I. 1995. Review of the kakapo recovery programme. Report for the New Zealand Department of Conservation.
- Mcintosh, I.G. Bell, J. Poole, W.S.H.; Staples, E.L.J. 1996. The toxicity of sodium monofluoracetate (1080) to the North Island weka (*Gallinallus australis greyi*). NZ Jour. Sci. 9: 125-128.
- Meads, M.J. 1976 Visit to Chetwode Island, Middle Trio Islands, Cook Strait; Marlborough Sounds, from 23 September to 7 October 1976: A Report. Unpublished report Ecology Division, DSIR, Taita.
- Millar, I. 1996. A strategy for island management in Nelson/Marlborough Conservancy. Second draft. Unpublished report, Department of Conservation, Nelson.
- Miskelly, C. 1993. Report on blood samples collected from Nelson/Marlborough Conservancy, April and May 1993. Unpublished report to Department of Conservation, Wellington
- Roberts, A. 1994. South Island saddleback recovery plan. Department of Conservation, Wellington.
- Rafaut, C. 1995. A comparative study of the Wellington tree weta *Hemideira crassidens* (Blanchard, 1851), in the presence and absense of rodents. Unpublished M.Sc thesis, Victoria University of Wellington.
- Thomas, B.W., Wilson, P.R.: Investigation for potential studies of kaka, kiore and lizards in conjunction with removal of weka and kiore from the Chetwode Islands, Marlborough Sounds. Draft proposal to Department of Conservation, Nelson. Manaaki Whenua Landcare Research, Nelson.
- Walls, G. 1984 Scenic and allied reserves of the Marlborough Sounds. Department of Lands and Survey, Wellington.

APPENDIX 1: SEEDLING ESTABLISHMENT  
UNDER SELECTED MONITORED TREES

MONITORED TREE	SEEDLING SPP	SEEDLING NUMBERS		
		1994	1995	1996
Matai 1	karaka	few (<10)	3	21
	kohekohe	0	8	60
	matai	0	0	0
	nikau	0	2	29
	titoki	0	16	21
Matai 2	kohekohe	0	10	20
	matai	0	0	0
	nikau	0	5	10
	tawa	0	5	4
Kohekohe 1	karaka	few	0	2
	kohekohe	0	0	1
	nikau	few	several	36
	pigeonwood	few	0	6
	titoki	0	0	2
Kohekohe 2	kohekohe	0	0	0
	nikau	0	4	79
	pigeonwood	0	0	2
Nikau 1	five-finger	0	20	25
	karaka	few	few	15
	kohekohe	0	5	7
	nikau	25	45	69
	titoki	0	0	9
Nikau 2	five-finger	0	(no count)	5
	karaka	few	(no count)	9
	nikau	56	(no count)	151
Hinaiu 1	hinaiu	0	0	fresh seed fall
	karaka	few	0	11
	kohekohe	0	15	87
	nikau	0	10	152
	pigeonwood	few	1	16
	titoki	0	4	14
Hinaiu 2	hinaiu	0	0	few fruit
	karaka	few	0	3
	kohekohe	few	4	24
	nikau	0	0	9
	tawa	0	0	1
Matai 3	kohekohe	0	many	41
	matai	0	seeds germinating	-
	nikau	0	few	3
	pigeonwood	0	many	47
	titoki	0	many	27
Miro 1	kohekohe	(no count)	few	14
	miro	old seeds eaten	fresh seedfall	fresh seedfall
	nikau	(no count)	few	7
	tawa	(no count)	few	4
	titoki	(no count)	0	5

# Effect of the poison brodifacoum on non-target birds on the Chetwode Islands

Kath Walker<sup>1</sup> and Graeme Elliott<sup>2</sup>

<sup>1</sup> Nelson/Marlborough Conservancy, Department of Conservation, Private Bag 5, Nelson

<sup>2</sup> 549 Rocks Road, Nelson

## ABSTRACT

Numbers of forest birds were monitored before and after an aerial drop of brodifacoum poison in pollard pellets on Chetwode Island (Nukuwaiata) to eradicate kiore. For most species no significant change was detected. However, there was a possible loss of up to 30% of robins, and indications that morepork were affected.

## INTRODUCTION

Aerial broadcast of anticoagulant poisons in pollard baits is being increasingly used to rid islands of rats. Concern has been expressed about the likelihood of non-target bird deaths either through directly eating baits, or from eating rodents and insects that have eaten baits. An attempt to eradicate kiore (*Rattus exulans*) from Nukuwaiata Island in the Chetwodes group in the Marlborough Sounds (Figure 1), provided the opportunity to investigate the effect of aerial broadcast of brodifacoum on the bird species that were present on the island. As well as the usual assemblage of common native and introduced birds, Nukuwaiata supports populations of rarer kaka (*Nestor meridionalis*), yellow crowned parakeet (*Cyanoramphus auriceps*), kereru (*Hemiphaga novaeseelandiae*) and South Island robin (*Petroica australis*), and it was the effect on these species that we were particularly interested in.

## METHODS

### Poison Drop

Full details of the aerial poison operation are given in Brown (this volume). In brief, 2.2 tonnes of Wanganui No. 7 pollard pellets with 20 ppm brodifacoum were spread from a helicopter onto Nukuwaiata Island on 23 August 1993 at a rate of 11 kg per hectare.

### **Five Minute Bird Counts**

Diurnal bird numbers were assessed in both the southern and northern ends of Nukuwaiata Island before and after the poison drop using five minute bird counts (Dawson and Bull, 1985). Counts were carried out by two observers on three days before the poison drop (10-12 August 1993) and three days after (7-9 September 1993), with the two observers alternating between the two areas each day. Bird counts were carried out at permanently marked stations at 250 meter intervals along transect lines through the forest. There were fifteen bird count stations in each transect, and during the counting days they were counted once in the morning and once in the afternoon.

Bird counts were also carried out on neighboring Te Kakaho Island which was not poisoned. The counting regime was similar to that on Nukuwaiata except the counts were made on only one day before the poison drop by two people, and on three days after the poison drop by only one of the original observers. The distance between count stations was also smaller.

Changes in numbers of birds counted before and after the poison drop are not necessarily attributable to poison, but may reflect normal seasonal changes in bird conspicuousness. The counts on Te Kakaho were carried out to control for the effect of seasonal changes. Analysis of bird counts were undertaken using analysis of deviance (Baker and Nalder, 1978), a technique similar to analysis of variance except that it assumes a Poisson rather than a normal distribution. We attempted to determine whether differences in bird counts could be attributed to:

- I. differences between the three places we counted; two places on Nukuwaiata and one on Te Kakaho;
- II. seasonal changes between August and September;
- III. the effect of the poison drop.

### **Robin Banding**

A total of 20 robins were caught and colour banded on 10-12 August 1993. Robins were attracted by the use of taped calls, then caught in box traps lured with cheese or meal worms. We estimated 11 of the birds banded were male and five were female, and the sex of the remaining three was not noted. Both partners of three pairs were banded.

After the poison drop, banded robins were searched for on 7-9 September 1993, and then on two separate occasions during the following year. Each time, in addition to general observation in and near the robins previous territory, tapes were played to try and attract them.

### **Morepork Call Counts**

From 2125 hours until 2155 hours on three nights prior to the drop (10-12 August 1993), and on two nights following the drop (7 and 8 September 1993), five observers listened from fixed stations 0.25 to 0.35 kilometers apart for morepork calls. The distance, direction and time of each call was noted.

## RESULTS

For many species on Nukuwaiata the number of birds counted before and after the poison drop differed (Table 1), but for most species the difference was not significant or was apparently related to a seasonal change, rather than attributable to the poison.

Five species showed changes in counts that were nearly significantly (probabilities between 0.05 and 0.10) related to the poison drop (Table 1)).

Bellbird counts declined on both islands, but declined more on poisoned Nukuwaiata than on unpoisoned Te Kakaho. Grey warbler and silvereye increased on both islands, but the size of the increase was less on poisoned Nukuwaiata than unpoisoned Te Kakaho.

However, tui numbers declined more on unpoisoned Te Kakaho than on poisoned Nukuwaiata (though not significantly) and kotare numbers increased significantly more on Nukuwaiata than on Te Kakaho. Neither of these results are likely to have been caused by the poison. The only conceivable way kotare could benefit from the poisoning is through an increase in food supply, but this is unlikely to have occurred so quickly after the poison drop.

Kaka call counts declined on Nukuwaiata after the poison drop, but unfortunately kaka were not present on Te Kakaho, so we have no test of the seasonal changes in kaka conspicuousness. The low numbers of kaka on Nukuwaiata, the wide distance over which they traveled, and the known seasonal fluctuations in call rates, makes five minute counts of limited use in detecting change in this situation.

Kereru declined on poisoned Nukuwaiata, but the change in numbers associated with the poison drop was small and insignificant compared with other sources of variation in their numbers.

Differences in call counts on poisoned Nukuwaiata and unpoisoned Te Kakaho for both yellow-crowned parakeet and robin were not significant. However, only 14 of the 20 banded robin could be relocated after the poison drop.

Results for morepork were inconclusive, as there was large variation in calls between nights within both the pre and post period, apparently due to the weather (Table 2). Furthermore, as with kaka, we did not have a control, as simultaneous counts at night on Te Kakaho proved logistically too difficult. Morepork call rates are also known to vary greatly with season (O'Donnell, 1980).

One freshly dead morepork was found beside a waterhole on 7 September 1993, 15 days after the drop. Subsequent analysis showed it had ingested a lethal dose of brodifacoum, probably via secondary poisoning after eating poisoned rats.

TABLE 1: RESULTS OF BIRD COUNTS CARRIED OUT ON NUKUWAIATA AND TE KAKAHO ISLANDS IN AUGUST AND SEPTEMBER, AND RESULTS OF ANALYSIS OF DEVIANCE TESTING THE EFFECTS OF DIFFERENCES BETWEEN PLACES, MONTHS AND THE POISON DROP ON THE MEAN NUMBER OF BIRDS COUNTED.

SPECIES		MEAN NUMBER OF BIRDS PER 5 MIN COUNT			Probabilities of Tests of Effects		
		NUKUWAIATA NORTH	NUKUWAIATA SOUTH	TE KAKAHO	PLACES	AUGUST- SEPT	POISON
Bellbird	Before	4.256	4.067	4.683	0.046*	0.000***	0.093
	After	2.557	2.688	3.311			
	% change	-40	-34	-29			
Robin	Before	0.578	0.778	0.833	0.325	0.567	0.302
	After	0.955	0.909	0.922			
	% change	+65	+17	+11			
Parakeet	Before	1.722	1.744	1.583	0.691	0.031*	0.975
	After	1.136	1.286	1.100			
	% change	-34	-26	-30			
Tui	Before	1.833	1.533	0.383	0.000***	0.003**	0.061
	After	0.761	1.571	0.122			
	% change	-58	+2	-68			
Warbler	Before	1.178	1.189	0.183	0.000***	0.006**	0.070
	After	1.500	1.481	0.400			
	% change	+27	+25	+119			
Fantail	Before	0.333	0.467	0.217	0.007**	0.109	0.786
	After	0.216	0.286	0.122			
	% change	-35	-39	-43			
Silvereye	Before	1.267	0.678	0.383	0.003**	0.022*	0.100
	After	1.034	1.260	0.822			
	% change	-18	+85	+115			
Kaka	Before	0.000	0.089	0.000	0.000***	0.087	0.000***
	After	0.068	0.247	0.000			
	% change	+8	+177	+0			
Kotare	Before	0.011	0.000	0.033	0.000***	0.103	0.000***
	After	0.307	0.169	0.011			
	% change	+2690	+8	-67			
Kereru	Before	0.222	0.356	0.000	0.000***	0.206	0.160
	After	0.125	0.312	0.011			
	% change	-44	-12	+8			

\* Significant at the 5% level.

\*\* Significant at the 1% level.

\*\*\* Significant at the .1% level.

TABLE 2: RESULTS OF NOCTURNAL MOREPORK CALL COUNTS CARRIED OUT ON NUKUWAIATA ISLAND IN AUGUST AND SEPTEMBER 1993, AND RESULTS OF MANN-WHITNEY TESTS OF THE DIFFERENCE.

	MEAN NUMBER OF MOREPORK PER STATION PER 30 MIN COUNT	N	U	P
Before	3.53	15	93.5	0.292
After	2.80	10		

## DISCUSSION

In common with many smaller pest eradications in New Zealand, where the emphasis has of necessity fallen on the eradication campaign itself, on the Chetwodes Island minimal time was spent assessing the impact of the campaign on non-target species.

It was desirable to carry out more rigorous bird counts over a longer period both before and after the poison drop, and to spend a longer period immediately after the drop searching for banded robin, and to include morepork counts on Te Kakaho. This would have allowed us to be more confident of immediate impacts and to assess longer-term changes as food supplies for birds altered in the absence of rats and wekas.

However, even with this brief investigation, some conclusions on the immediate impact on non-target species can be drawn. Three species - bellbird, grey warbler and silvereve - showed possible small (not significant) deleterious effects of poisoning. Though call counts detected no difference in robin numbers, monitoring of individual birds found a possible loss of 30% of birds. However, losses are unlikely to be this high: breeding began soon after the poison operation and females in particular became difficult to attract. Two banded birds escaped attention until the third census, a year after the operation. The results for robin reiterate the value of detailed monitoring of individuals in preference to the coarser technique of call counts, whenever possible.

Of the other species of conservation concern on which we had hoped to assess the impact of brodifacoum, yellow-crowned parakeet were almost certainly unaffected, while the impact on kereru and kaka was unclear. While there was a drop in the number of morepork calling after the poison drop, the results were not significant. Although we did no specific searching, one morepork which had died of brodifacoum poisoning was found, and this species must remain of concern in anti-coagulant poison operations.

Robin and morepork, and perhaps also bellbird, silvereve and grey warbler may be detrimentally affected through secondary poisoning if there were to be long-term continuous broadcast of brodifacoum poison. However, no such operations exist or are planned in New Zealand, and for one-off, single-season, pest eradication programmes such as the recent Chetwode project, the overall long-term benefit to each of these species may rapidly outweigh the initial costs.

## ACKNOWLEDGMENTS

Thanks to Ian Millar, Derek Brown, Peter Gaze, Dave Rees and Kirsty Gerard who helped with the field work for this study.

## REFERENCES

- Baker, R.J. & Nalder, J.A. (1978): *The GLIM System. Release 3*. Numerical Algorithms Group, Oxford.
- Brown, D. (this volume): Chetwode Island kiore and weka eradication project. *Ecological Management* (5), Department of Conservation, Wellington.
- Dawson, D.G. & Bull, P.C. 1975: Counting birds in New Zealand forests. *Notornis* 22: 101-109.
- O'Donnell, C.F.J. (1980): Morepork calling frequency in Nelson. *Notornis* 27.

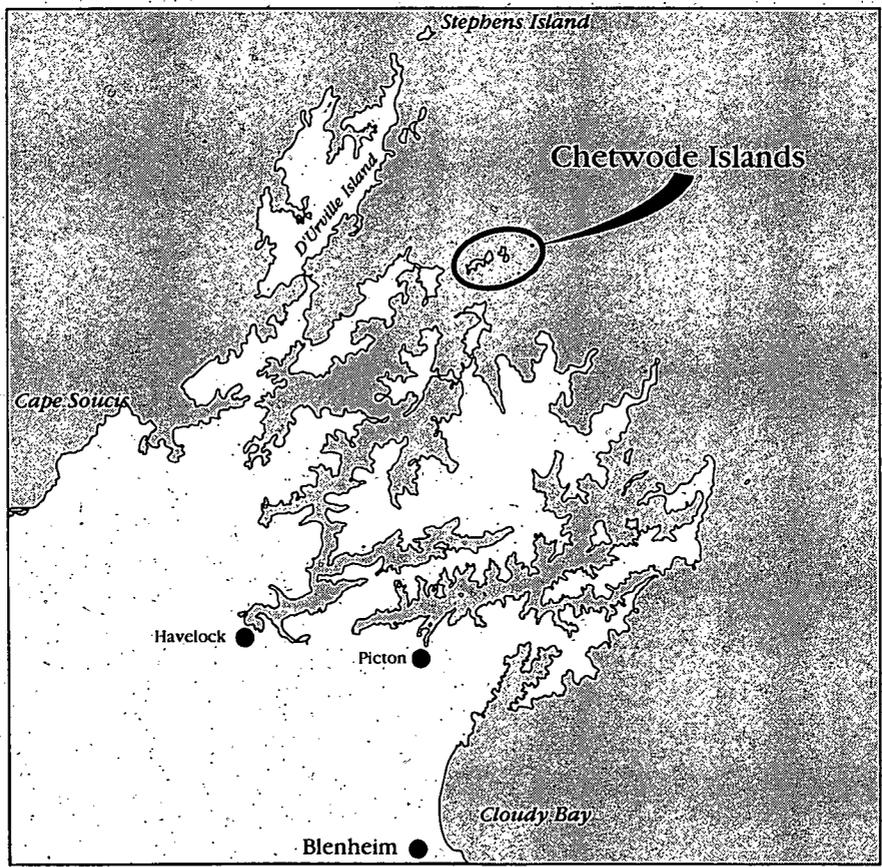
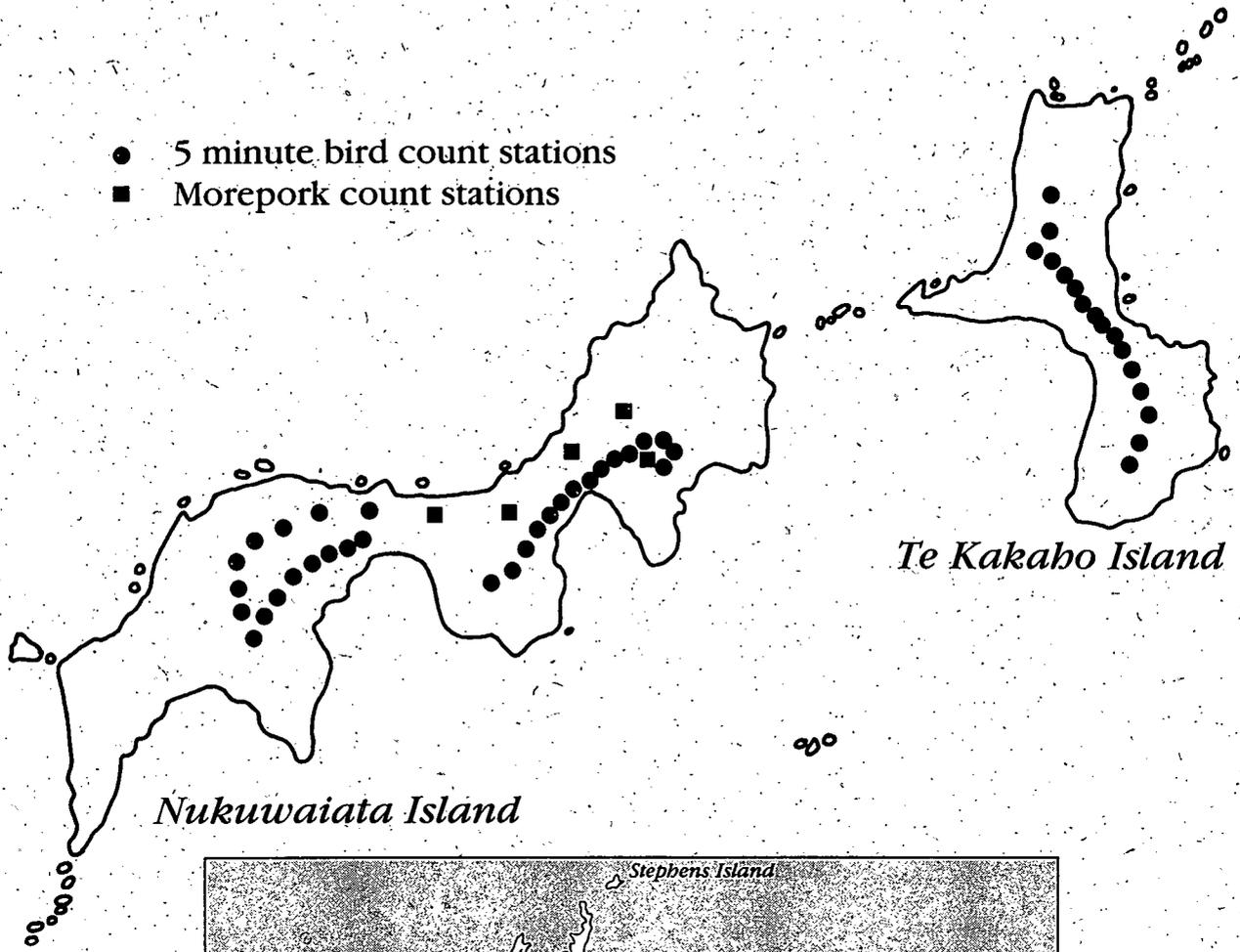


FIGURE 1: LOCATION OF BIRD COUNT STATIONS ON CHETWODE ISLANDS

# Effect of aerial distribution of 1080 for possum control on weka, great spotted kiwi, morepork and fernbird

**Kath Walker**

Nelson/Marlborough Conservancy, Department of Conservation, Private Bag 5, Nelson

## ABSTRACT

The effect on non-target birds of aerial distribution of 1080 poison in pollard pellets for possum control was assessed in 1994 in North-west Nelson and the Marlborough Sounds.

Radio transmitters were attached to nine great spotted kiwi, seven morepork and 24 western weka, and nine fernbird and two robin were colour banded before the poison operation. The survival of these birds was monitored for three months after the drop.

- One weka died of 1080 poison, but all other radio-tagged weka, kiwi and morepork survived. Both robins survived. Four of the nine fernbird could not be relocated, but they may have moved or died in the seven weeks between banding and the weather-delayed poison drop.

## INTRODUCTION

The Department of Conservation's 10 year possum (*Trichosurus vulpecula*) control plan (Department of Conservation, 1994) identified 75,800 hectares of forest in Nelson, Marlborough and North Westland as high priority for long-term possum control, mainly because of the presence of small populations of endemic *Powelliphanta* land snails, which are directly threatened by possum predation. Most of the possum control areas are large, rugged and remote, so aerial distribution of the poison 1080 (sodium monofluoroacetate) is the most cost effective method of control.

However, many of these areas are also strongholds of two vulnerable ground birds, great spotted kiwi (*Apteryx haasti*) and western weka (*Gallirallus australis*). On both Kapiti and Chetwode Islands in 1993, weka were found to eat large quantities of non-toxic Wanganui No. 7 pollard pellets (C. Miskelly and D. Brown, pers. comm.), a very similar bait to that which will be used for the northern South Island possum control operations (Waimate R55). The susceptibility of weka to 1080 meant that theoretically, 50% of average sized (1000 g) western weka could die from eating only one standard size 1080

pollard pellet (McIntosh et al. 1966; E. Spurr pers. comm.). Thus, it was possible that weka populations would be adversely affected by 1080 operations.

There was also cause for concern for great spotted kiwi. Trials in the early 1990's showed little spotted kiwi (*Apteryx owenii*) and North Island brown kiwi (*Apteryx australis*) sometimes consume pollard baits, though usually only in small quantities, and no kiwi deaths had been attributed to 1080 (Pierce and Montgomery 1992; Robertson et al. 1993). According to McLennan, Porter and Cowan (1993): "*Great spotted kiwi probably eat both carrot and pollard baits. They are the most vegetarian of the three kiwi species, and often eat seeds and leaves when invertebrate foods are scarce.*" Unlike the other kiwi species which feed largely by probing, great spotted kiwi also feed on the surface, regularly taking food such as koura (McLennan and McCann 1991).

Other species possibly vulnerable to 1080 poison drops and present in areas identified for long-term possum control include morepork (*Ninox novaeseelandiae*), South Island robin (*Petroica australis australis*), South Island fernbird (*Bowdleria punctata punctata*) and kea (*Nestor notabilis*).

In this study, we attached radio transmitters to great spotted kiwi, western weka and morepork in North-west Nelson, and weka and morepork in the Marlborough Sounds. We also banded fernbirds and robins in North-west Nelson. We then monitored the survival of these birds following 1080 drops that occurred in each area in August 1994. We had also intended to monitor kea survival in North-west Nelson, but were unable to catch any prior to the drop.

The North-west Nelson drop zone comprised 5,000 hectares in the headwaters of the Saxon River on the Goulard Downs (Fig. 1). The vegetation is a mosaic of red tussock grasslands and silver and mountain beech forest with some southern rata, quintinia, kamahi, toro, *Dracophyllum traversi* and *D. townsoni*. It lies between 600 and 900 meters above sea level and the climate is predominantly cold and wet.

The Marlborough Sounds drop zone comprised 10,000 hectares at Tennyson Inlet (Fig. 1) and stretched from sea level to 970 metres. A dense coastal podocarp/beech/broadleaf forest covered much of the area, with rimu, miro and occasional pukatea emergent from a red, hard, and black beech, kamahi, tawa, nikau, toro, mahoe and putaputaweka canopy. At higher altitudes silver and mountain beech was dominant with southern rata on rocky sites. The climate is mild with considerably less rain than the North-West Nelson study area.

## METHODS

### Great Spotted Kiwi

In April 1994 five male and four female great spotted kiwi were caught in the Saxon area using taped calls, whistles, and dogs trained to detect kiwi.

Compared to other species of kiwi, great spotted kiwi are difficult to catch as their burrows have multiple entrances and the birds tend to run, rather than hole-up. Radio transmitters were attached to one leg and a metal band with

reflective tape to the other. The transmitters had a slow pulse rate (30 ppm) and a battery life of 18 months. They were also fitted with a mortality switch in which the pulse rate doubled to 60 ppm if the bird (or transmitter) was inactive for longer than 27 hours.

### **Morepork**

In February and April 1994 when morepork were reasonably vocal, tape recordings were made of the local morepork dialect, and the position of all birds heard were mapped. In June, mist net rigs were erected in forest clearings near where birds had been heard. Each rig comprised 3 x 4" gauge nets, mounted on portable aluminium poles. Birds were lured into the nets by taped calls played just after dusk.

At Tennyson Inlet the forest was too tall and the birds consistently flew over the rigs. Subsequently, only two morepork were caught there and unfortunately, the first transmitter fitted failed immediately. At Saxon River the forest was much lower and frequently dissected by tussock corridors, making it much easier to find suitable mist net sites.

Eight morepork were caught at Saxon River, and fitted with transmitters. A single-stage transmitter with a battery life of 6.5 months was attached using a back harness. The morepork on average weighed 186 g so the transmitters at 5 g comprised less than 3% of the bird's body weight. Though we weighed and measured each bird, we did not band them as their legs seemed too short and down-covered for bands to be comfortable. In hindsight this was a mistake as we could not confirm that birds who had lost their transmitters, but were apparently still occupying the same territory, had indeed survived the 1080 drop.

In December 1994 on completion of the study, mist nets were re-erected at the original capture sites, and although birds were not calling, they still reacted to the taped calls and were fairly easily re-caught and their transmitters removed.

### **Weka**

Once located with taped calls, weka were lured into a landing net using a piece of mutton fat tied to the end of a long string. Birds were banded, measured and a radio transmitter attached under the back feathers using a harness which looped under both wings. The tightness of harness-fit was a problem: too tight and it cut into the skin at the junction of the wing and back; too loose and the birds shrugged the whole package off. A "flying-bird" style harness (loops round the neck and body) would be more appropriate for any future weka studies.

In total, 10 birds were caught at Saxon River and 30 at Tennyson Inlet. However, before the 1080 drop one bird wandered out of the study area, three birds died, and transmitters fell off a further eight birds. Originally the harness contained a single strand of cotton as a "weak link", but as the weka were strong enough to break these easily, they were subsequently replaced with a four strand weak link. Even the stronger versions usually only lasted a couple of months, and all transmitters had fallen off after six months.

Most of the weka transmitters were similar to the kiwi transmitters and contained a mortality switch, although battery life was only 11.6 months.

### **Kea**

A small number of kea live in the Saxon area and it was intended to fit radio transmitters on up to eight birds. Unfortunately, no kea were seen during the period of the study, so the transmitters were used on weka instead.

### **Fernbird**

Fernbird are common in the red tussock of the Saxon area, and we intended to colour band up to 25 birds. However, for the five months prior to the 1080 operation, fernbirds were very quiet and unresponsive to tapes. Consequently only nine birds were caught, measured and banded. Between three and 10 days after the 1080 drop, 13 fernbirds (including five of the previously banded sample) were caught and examined for signs of fluorescence at the mouth and anus, and in faeces.

Catching the birds was more successful with a large, rather than small team. Once a bird was detected, two people held two tent poles with a short fine mist net stretched between them, in front of the bird. A third person played a tape on the far side of the net, while another three people quietly herded the bird up to the net, taking care not to alarm it into flight until the last minute, when it could not fly high enough to go over the net.

### **South Island Robin**

We aimed to catch and colour band 25 robins, but like kea, too few were present to form a useful sample. We caught eight robins over the summer, but by the time of the drop in August, all but two had disappeared from the study area.

The birds were all caught in a collapsing box trap, baited with live meal worms and cheese.

## **THE POISON OPERATION**

The poison baits used in both study areas were 6 g RS 5 cereal pellets loaded with 0.15% ww 1080 and lured with cinnamon. A fluorescent dye, Pyranine, was added to the Saxon River pellets to allow easy identification of animals which had eaten baits, even a sub lethal dose. Pyranine 120% is a pale green biotracer which fluoresces strongly when irradiated with UV light, even when present at very low concentrations. It gradually fades over a period of several weeks exposure to bright sunlight.

The poison pellets were distributed by helicopter at a rate of 5 kg per hectare. Bait was dropped on 10 August 1994 at Tennyson Inlet and on 19 August 1994 at Saxon River. In both study areas toxic bait was available to birds for four days before heavy rain on the fifth day probably reduced the pellets toxicity.

## POST-OPERATION MONITORING

At Tennyson Inlet weka and morepork survival was monitored daily for the first week after the drop, then at weekly intervals for the next month, and thereafter at fortnightly intervals for the subsequent two months. Three and a half months after the 1080 drop all transmitters had either fallen off or been retrieved.

At Saxon River a similar regime was followed. For the first two weeks after the drop, kiwi, weka and morepork survival was monitored daily, and as many fernbird as possible were caught and re-caught and checked each time for signs of fluorescence. For the following fortnight weka, kiwi and morepork were checked weekly, and then fortnightly for the next month. All remaining transmitters were removed in mid-December.

Monitoring of radio-tagged birds involved approaching the general vicinity of each bird and determining whether the radio signal was fluctuating (i.e. whether the bird was moving).

## RESULTS

### **Weka**

Combining both study areas, 24 weka wearing radio transmitters were exposed to sufficient poison for a realistic assessment of survival. Unfortunately three other radio-tagged weka near the Tennyson Inlet road could not in the end be included in the sample because a wide strip of forest beside the road was left unpoisoned. Although these birds may have come in contact with the bait, a decision was made to exclude them from the sample.

All 24 weka survived the first week after the 1080 drop. However, for the next three months, transmitters gradually fell off, slowly reducing the size of the sample. About a month after the 1080 drop, 18 weka were still wearing transmitters or being regularly seen. About two months after the drop, 13 weka still had transmitters on.

A radio tagged weka died 17 days after the poison drop at Tennyson Inlet. As the toxicity of many pellets was much less than, this weka was initially presumed to have died of natural causes. However, autopsy showed lethal quantities of 1080 were present in muscle tissue.

An untagged weka was found distressed and shaky on its feet 48 hours after 1080 was dropped at Tennyson Inlet. It was held in captivity overnight and was much better the next day, so after a transmitter was attached it was released. The bird survived the next week, after which unfortunately, the transmitter fell off. A faecal sample collected from this bird was found to contain 1080.

### **Kiwi**

All nine radio tagged kiwi were alive at least 15 days after the drop. One transmitter then fell off, but the remaining eight transmittered birds were still alive six and a half weeks after the 1080 operation. Three more transmitters then fell off, but five birds with transmitters continued to be monitored for five

months after the drop. These birds were re-caught at the end of the breeding season in late January 1995 and their transmitters removed.

Between three and 11 days after the 1080 operation, seven faecal pellets were collected from six individual kiwi and tested for fluorescence, with no evidence of fluorescence found.

### **Morepork**

All seven radio-tagged morepork were alive five days after the 1080 operations, although one transmitter fell off soon after. A month after the drop all six radio-tagged birds were alive, although a second transmitter fell off after this, reducing the sample to five birds. The five morepork were re-caught and their transmitters removed more than three and a half months after the poison operation, and all appeared to be healthy.

Between one and nine faecal pellets were collected from the roosts of five of the radio-tagged morepork five to 10 days after the 1080 drop. None of the pellets tested showed signs of fluorescence.

### **Fernbird**

Despite extensive searches, only five of the nine banded fernbirds were seen after the 1080 operation. Though the fernbirds were banded in late July, bad weather meant the 1080 was not dropped until seven weeks later in mid-August, and unfortunately a census of banded fernbirds was not possible immediately before the operation began. Because of this long time delay, it seems more likely these four missing fernbirds had moved out of the study area or died of natural causes before the poison drop. None of the 13 fernbirds or their faeces examined after the 1080 operation showed signs of fluorescence.

### **Robin**

Both of the banded robins remaining in the study area when the poison was dropped, were alive a month later. Faecal pellets collected daily from one of these robins in the week following the drop showed no sign of fluorescence.

## **DISCUSSION**

Despite earlier fears, it appears that great spotted kiwi, morepork and western weka are not at great risk from possum control operations using aurally distributed 1080 pollard pellets.

There were indications, that South Island fernbirds may be detrimentally affected, but shortcomings in the study design mean these results cannot be relied upon. Additionally, too few South island robins were monitored to allow useful conclusions to be drawn.

All nine radio-tagged kiwi and seven morepork survived the initial drop. Though the sample size decreased as transmitters fell off, there was no evidence of 1080 related deaths in the following five months.

The most surprising result was that only one (four percent) of the 24 radio-tagged weka died of 1080 poisoning. Western weka on the Chetwode Islands and on Kāpiti Island readily ate non-toxic pollard pellets, and at the 1080 loadings used in this study it should have taken only one toxic pellet to kill an average-sized weka. However, several radio-tagged weka in the Saxon area were resident around huts, and despite plenty of pellets lying around the staff hut site, and a well-developed interest in potential food stuffs, none of these birds were seen touching bait.

There seem three potential explanations:

1. weka can detect 1080, dislike the smell and ignore the pellets;
2. weka only peck at pellets, receive a sub-lethal dose, and subsequently avoid pellets;
3. the LD50 for weka is higher than existing information suggests, so that it takes more than one pellet to kill a weka.

The second alternative seems the most likely as weka on Kāpiti Island were seen to peck fragments off pellets, rather than swallowing them whole. Furthermore, during a weka eradication programme on the Chetwode Islands, domestic hens' eggs injected with the same dose of 1080 as the R55 cereal pellets, were left around the island. Although weka readily ate non-toxic eggs in captivity, on the Chetwodes they holed many poisoned eggs, but left most of the contents untouched and few, if any, weka died.

Whether aerial 1080 operations are a safe way to control possums when weka are present depends on the density of the weka population, and the scale and frequency of the poison operations. In Marlborough, where weka numbers are high, the benefits to weka of possum control (increased invertebrate supply) probably outweigh the risks, but this may not be true in Gishorne, where North Island weka are in very low numbers, and the loss of even a few birds could have a significant impact on the population.

At present, aerial 1080 operations are the safest known way to reduce possum numbers in areas that have large numbers of ground birds. Only one of the 24 radio-tagged weka in this study died of 1080 poisoning, while four were killed on the relatively few leg-hold traps set to control possums beside the road and monitor possum numbers after the poison operation.

In other parts of the Tennyson Inlet block, ground control methods alone were used in over 9500 hectares to control possum numbers, and 42 weka were caught in 2193 trap nights.

As a result of these alarmingly high weka catch rates and the long recognised problem of leg-hold traps catching kiwi, Nelson/Marlborough Conservancy contracted Landcare Research to design and test possum trap sets which excluded ground birds, and to compare their efficacy at catching possums with those of standard ground set traps. The results of this work form the basis of new guidelines currently being prepared by DOC on possum trapping in areas inhabited by ground birds.

In Nelson/Marlborough, most areas requiring possum control are too remote and rugged for ground-based methods, particularly those with sets which exclude ground birds, to be cost effective. This study shows that aerial

distribution of 1080 for possum control has less impact on several key species than do more expensive ground control methods.

## ACKNOWLEDGMENTS

Many people helped with the field work for this study, particularly Les Moran, Rhys Buckingham, Graeme Elliott, Ian McFadden, Kaye Stark, Peter Dilks, Rogan Colbourne, Hugh Robertson, John Lyall, Mike North, Guyon & Sally Warren, Phil Clerke and Derek Brown. Others who helped were Ralph Powlesland, Julie McLintock, Claire Sykes, Hannah Edmonds, Josh Kemp, Greg Napp, Simon Walls and Jo Joice.

Thanks to Guyon & Sally Warren for the use of their bach at Tennyson Inlet, and their cheerful assistance throughout.

## REFERENCE

- Department of Conservation (1994): *National Plan for Managing Possums in New Zealand: A ten year Plan 1993-2003*. Estate Protection Policy Division, Department of Conservation, Wellington.
- McIntosh, I. G.; Bell, J.; Poole, W. S. H.; Staples, E. L. J. (1966): The toxicity of sodium monofluoroacetate (1080) to the North Island weka (*Gallirallus australis greyi*). NZJ. Sci. 9: 125-28.
- McLennan, J. A. & McCann, A. J. (1991): Ecology of great spotted kiwi, *Apteryx haasti*. DSIR Land Resources unpublished contract report No. 91/48 for Science & Research, Department of Conservation, Wellington.
- McLennan, J.; Porter, D.; Cowan, P. (1992): Compounds to prevent non-target animals from eating poisonous baits laid for possums. DSIR Land Resources Contract Report No. 92/55 for Science & Research, Department of Conservation, Wellington.
- Pierce, R. J. & Montgomery, P. J. (1992): The fate of birds and selected invertebrates during a 1080 operation. Science & Research Internal Report No. 121. Department of Conservation, Wellington.
- Robertson, H.; Colbourne, R. M.; Nieuwland, F. (1993): Survival of little spotted kiwi and other forest birds exposed to brodifacoum rat poison on Red Mercury Island. *Notornis* 40(4) 253-262.

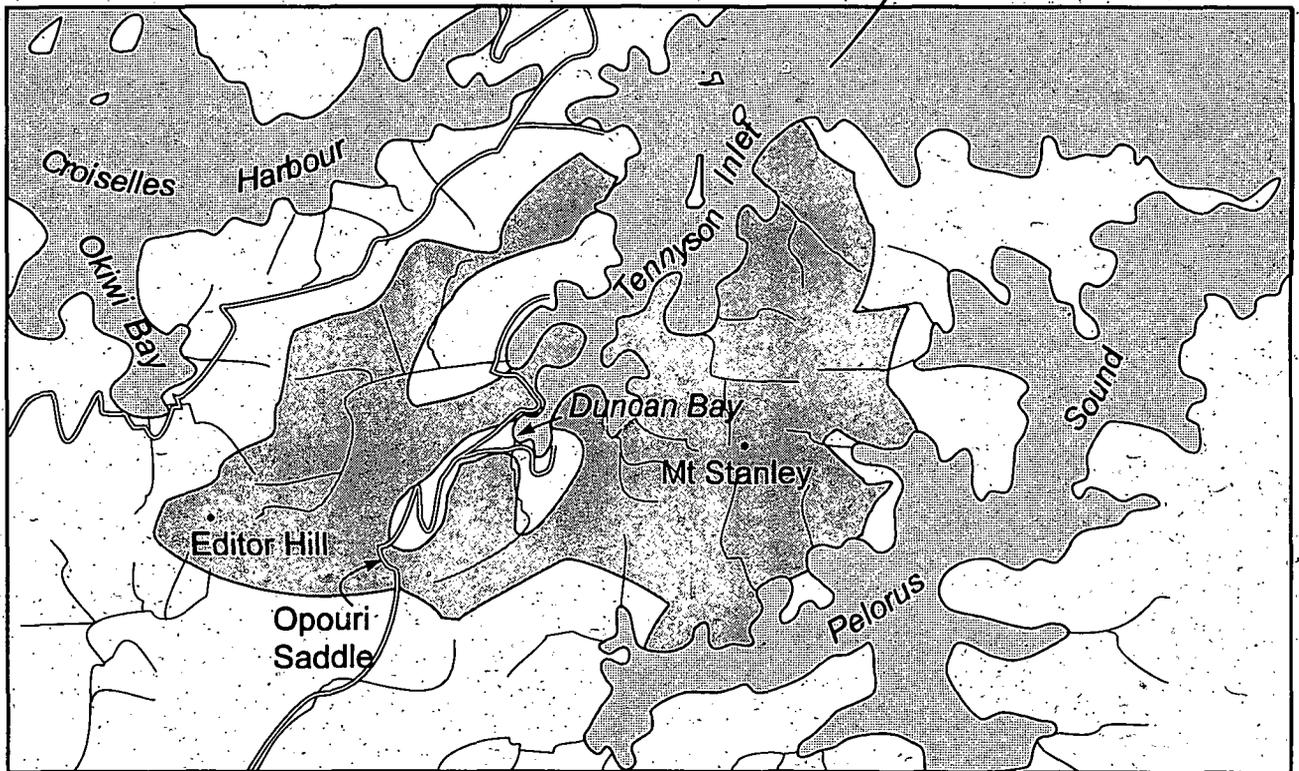
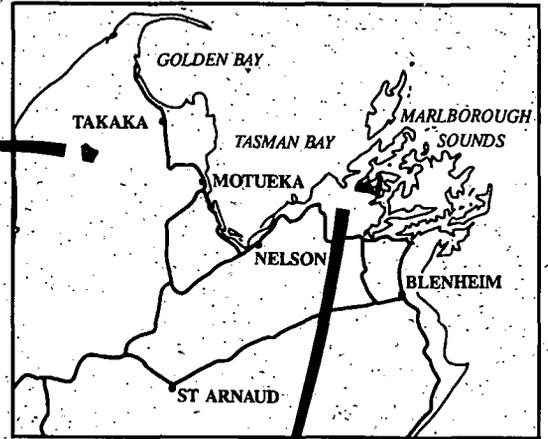
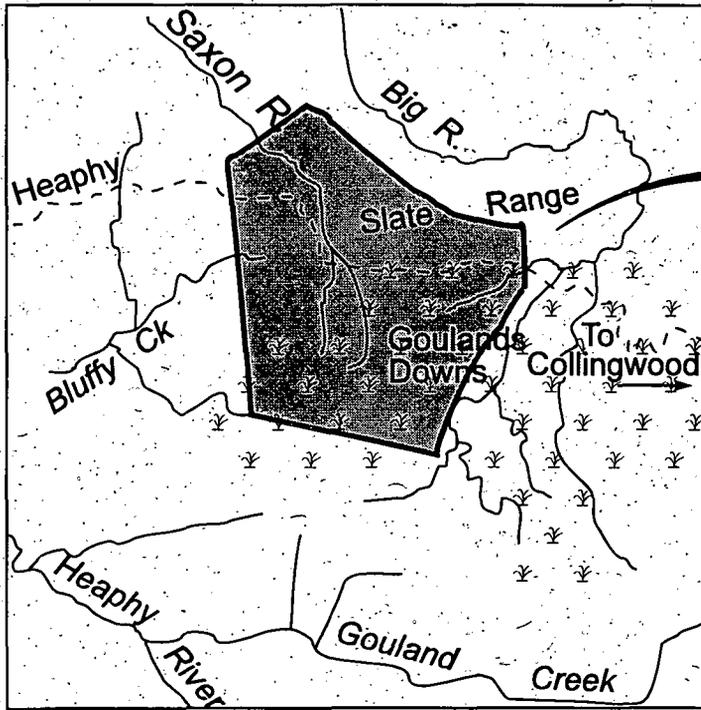


FIGURE 1. LOCATION OF GOULAND DOWNS (TOP LEFT) AND TENNYSON INLET. 1080 POISON DROPS FOR POSSUM CONTROL IN 1994. EFFECTS ON NON-TARGET BIRDS ASSESSED WITHIN PART OF THESE BLOCKS.

# Hand-rearing of New Zealand falcon (*Falco novaeseelandiae*) chicks

Debbie Stewart-Badger

Wingspan, Birds of Prey Trust, P O Box 993, Rotorua

## ABSTRACT

Two day-old New Zealand falcon chicks (*Falco novaeseelandiae*) were rescued from a scrape in an active logging site within the Kaingaroa Forest. The chicks were hand-reared in captivity through to fledging. One of these chicks has been successfully re-introduced to the wild, while the other had difficulty adapting to the natural environment, and has been retained in captivity to supplement the Wingspan Captive Breeding Program

## INTRODUCTION

On 8 November 1994 the Department of Conservation was called by a logging crew contracted to the Forestry Corporation, about a wild falcon nest located at their logging site in the Kaingaroa Forest (Figure 1). The vegetation at the nest site was 100% modified exotic forest of mature *Pinus radiata*. Trees had been felled around the nest but none had been removed from the vicinity of the nesting site. Six weeks earlier the logging crew had reported the presence of a falcon pair in the area, observing dive-bombing, kekking (a rapid succession of the falcon vocalisation *kek-kek-kek*, generally associated with territorial and courtship displays), and mock attacks characteristic of falcons defending their territory. The crew subsequently discovered a small scrape, or nest, approximately 70 centimeters in diameter, on the forest floor. The nest was located in a hollow, and lined with grasses, twigs, lichens, and dead fern. Small live ferns bordered the nest but offered no immediate protection or significant shelter; the nest was situated in an essentially open and exposed site. The logging operation was considered to pose an immediate threat to both the chicks and the adults. It was considered likely that the adult birds would either be killed by the tree felling operation or abandon the nestlings. It was therefore necessary to remove the chicks from the area to ensure their survival, and it was anticipated that the adults would then naturally disperse.

Research by Fox (1985) indicates New Zealand falcons are a threatened species, and are classified as a Category B species by Molloy and Davis (1994). Fox (1978, 1985) suggests the Bush falcon is the most vulnerable and may be declining in numbers (the New Zealand falcon is polytypic with three geographically separate forms; a 'Bush' form in the North Island & north-west of the South Island; a large paler 'Eastern' form in the east of the South Island; and

an intermediate 'Southern' form in the south-west of the South Island). There is also some concern of the New Zealand falcon's ability to adapt and survive in modified forest ecosystems (Fox, 1985). Records of New Zealand falcon breeding sites have not previously been recorded within 100% modified or exotic forests (Notornis, Ornithological Society of New Zealand, and records of the Raptor Association of New Zealand). Although, two observations have been reported of New Zealand falcon's nesting on the side of forest fire-breaks (Geoff Moon *pers comm.*). In these particular instances it is not known if the birds were displaced from alternative nesting habitat or had chosen to nest within the pine forests. This paper is particularly significant as it documents one of the few known incidents of falcons siting their nest in an exposed area within an exotic forest of *Pinus radiata*.

This report provides the only recorded documentation of captive rearing of wild falcon nestlings in New Zealand. New Zealand falcon chicks have been hand-reared to day 12 in the United Kingdom, and then returned to parents or foster parents (Fox 1993). The success of this rescue is of great interest given that the chicks were small and very young, and therefore particularly at risk, and that the chicks were to be captive-reared through to fledging rather than returned to the parents. The rearing of the two juvenile falcon extends our knowledge on the Bush falcons growth and development, and offers some guidelines for future management of rescued or captive bred chicks.

## RESCUE

When the officers from the Department of Conservation (DoC) first arrived at the nesting site, they observed a female Bush falcon sitting on the nest. When they approached the nest, the falcon flew into neighbouring trees from where she proceeded to dive-bomb. There were two newly hatched white nestlings and an addled egg within the scrape. The chicks were placed into a polystyrene box, with a warm water bottle to provide warmth, and soft toweling to provide support. The initial rescue day is hereafter referred to as Day 1.

On arrival at the Wingspan aviary, the chicks appeared cold; they were hunched over with their feathers fluffed out, and were slightly shivering. No long term effects of being chilled were subsequently noted. During the first two days in captivity neither chick was handled or weighed. The chicks were moved only when necessary and always using the toweling as support.

By the chicks' coloration (white), and noting their size and behavior over the first two days of captivity they were estimated to be about one or two days old. Fox (1985) reports that each egg of a clutch of falcon eggs tends, generally, to hatch at approximately the same time. One chick was slightly larger than the other (in body, beak, and talons), and they were identified as female (chick 1), and the smaller, as male (chick 2). The initial assumption about the sex of the birds was made without considering the possibility that a difference in size could occur as a result of a one or two day timing difference in hatching. Observations made during the growth and development of the chicks over the next 20 days suggests that the chicks may have hatched one day apart. The

correct sex of the birds was confirmed when the birds were fully grown, at 21 days of age.

Following the removal of the chicks from the nest site, both the adult male and female falcon moved from the immediate area. Within three weeks of the initial nest discovery, at the end of November 1994, another nest site was located in essentially the same forest compartment less than one kilometer away from the original nest site (refer Table 1). In this instance the Forestry Corporation was able to work around the site leaving it undisturbed. Despite the Forestry Corporation's rescheduling of logging work in the vicinity of the nest to avoid disturbing falcons during the breeding period, the falcons none-the-less deserted the scrape. When this second nest site was inspected by Department of Conservation officers in mid-December, it was found abandoned. Remaining in the deserted scrape was one cold, intact egg and the remains of another. The adult birds were not sighted.

## REARING

Three management options for rearing the chicks were considered; fostering the chicks to unrelated birds; leaving the chicks *in situ*; or hand-rearing the chicks in captivity. Although fostering of juvenile birds to unrelated paired adults is frequently used overseas, this option was rejected because there were no known wild nesting sites or breeding pairs of falcon in the vicinity at the time. Although an adult female bush falcon held at the Wingspan aviaries was incubating a clutch of infertile eggs, the bird had no previous history of successfully rearing young (Steve Lawrence *pers. comm.*). It had also killed a male falcon sharing its enclosure in August 1993. Given the age, size, and developmental stage of the chicks, they were not considered capable of fending for themselves.

The chicks were kept together to reduce potential imprinting problems (especially in the form of human bonding) by enhancing sibling interaction. Stewart (1985) suggested that interaction among siblings, from juvenile age through to dispersal from the nest, ensures proper imprinting in the absence of natural parents. Alternative management techniques for rearing the chicks, such as the use of feeding puppets, and secure hack platforms were precluded due to limited resources, time and training of personnel.

## BROODING

It was essential to keep the chicks' surrounding air temperature constant and between 37-39° C. In the absence of an appropriate brooder to maintain a constant air temperature, the falcon chicks were placed together on a small electric blanket designed for domestic pets. Synthetic tetron fibrefill (as insulation) and toweling was layered over the heat pad to form a "nest". For the first four days a section of toweling was arranged directly over the top of the chicks to form a brood pocket.

A maximum/minimum thermometer was placed with the chicks to ensure that the temperature of the brood pocket was checked and maintained at 39° C for

the first day. This is the standard initial brooding and hatching temperature for most birds (Anderson Brown 1985). Temperature was checked regularly at two-hourly intervals (day and night). To compensate for slightly cooler evenings, and as back-up in the event of power failure, a warm water bottle was positioned next to the birds. From Day 2, the brood pocket temperature was recorded between 31-37° C.

When chicks 1 and 2 were at an estimated age of 6 and 7 days old respectively (Day 5) they were able to thermoregulate and moved about the nest more easily. They were less likely to remain dependent within the artificial brooding pocket. To provide a temperature gradient the "nest" was positioned so that only 50% of the toweling was positioned on the heat pad. The chicks could then choose to move either towards or away from the heat source. On Day 7 the heat pad was turned off during the day, and turned on only at night. By Day 14 the chicks required no further artificial heating, day or night.

Before the chicks were permanently transferred to an outdoor aviary (Day 25), they were placed (with their nest in a box) outside in sunlight for short periods of time. This was considered important for the synthesis of Vitamin D3, which could not otherwise be metabolised through diet (Weaver and Cade, 1983). This method also familiarised the chicks with their intended enclosure, and enhanced their interactions with falcons in adjacent aviaries.

## FEEDING

Consideration was given to the diet, quantity and method of feeding, frequency, and the expected behavior of the chicks, as well as the possibility of shock brought on by the transfer, dehydration caused by stress, and handling injuries. In an effort to stabilise the chicks' physical condition the birds were fed once they had settled, about two hours after their arrival.

### Diet

The chicks' diet was composed mainly (approximately 30%) of dead day old cockerels, with the remaining 70% made up of a mixture of adult quail, mice, and small amounts of venison. The day old cockerels and quail were initially prepared by removing feathers, beaks, legs and feet and cut into small, bite sized morsels. Whole food (partially plucked) was first introduced on Day 12, with little interest shown by either chick for feeding. By Day 17 the chicks would attempt to feed from whole unplucked quail but would imbalance and fall over each time they tried to tear meat from the carcass. By Day 19 the chicks could easily feed from the whole foods presented. Once the chicks were partially fledged (Day 32) they were offered live huhu beetles and large moths but were not observed to eat these.

Food was prepared fresh at each feeding time, and never re-refrigerated. It was placed in a metal bowl and left to stand over a jug of warm water to reduce chill, until slightly warmer than room temperature. Household scissors were used to cut the food into bite sized pieces. From Day 6 to Day 10 trimmings of bone and organs were included in the prepared food. On several occasions liquidised chick was fed to the chicks. This method tended to be messy to

deliver and resulted in a build up of waste food around the cere and nares, and especially in the cavity of the lower mandible. Acting on a suggestion by Paul Barrett (Wellington Zoo) cotton buds were used to wipe the beak and cere of the falcons after each feed. As the chicks grew larger (from Day 8), damp toweling was used in place of cotton buds. On one occasion, yolk got into the right eye of Chick 2. An eyedropper was used to gently flush the eye clean with warm water, to prevent infection and blindness that could occur from food being left in the eye (Weaver and Cade 1983).

Dietary supplements administered included a broad spectrum vitamin/mineral supplement given every second day for the first 14 days, a calcium supplement given for the first 7 days, and SA37 a vitamin mineral supplement recommended by Cooper (1978), administered twice per week after 21 days.

### **Quantity/method**

The first feed consisted of 3-4 match-head sized pieces of day old chick leg muscle which had been dipped in luke warm water (Ford, 1982). Blunt nosed tweezers were initially used to place the meat into the chicks' beaks. They adapted readily to this feeding approach, and were both alert, sitting upright, and begging for food at the second feeding time. Care was taken to avoid feeding the chicks too much. Only small amounts of food were offered at any one time, and feeding was undertaken over a period of 20-30 minutes. The chicks' were never force-fed.

Feeding the chicks by hand was stopped once both chicks could focus on food (Day 8). After this time they were partially fed by hand, and left to finish the remaining food themselves. Hand feeding stopped completely by Day 12. By minimising the hand feeding in this manner, it was hoped to avoid problems associated with human bonding.

Initially, the chicks were fed during daylight hours at two hour intervals (i.e. six times daily). They were never fed at night, and were given fewer feeds as they grew larger. By Day 10, they received four feeds daily, and by Day 20 just two feeds daily. The quantity of food prepared for feeding the chicks increased steadily each day. They each consumed the equivalent of approximately eight grams (1 teaspoonful) of food at Day 3, 23 grams (1 tablespoon) each of food per feed by Day 12, and by Day 20 up to 40 grams each.

### **Behavior during feeding**

There were observed differences in the feeding behavior of the birds. Chick 1 would focus and "bob" at small pieces of meat, could pick up dropped food by Day 7, and was self feeding at Day 11. The behavior of Chick 2 lagged behind Chick 1 by approximately one day.

The chicks would continue begging for food even when their crops were obviously quite full. Their begging and chipping for food was however less vigorous than before they had eaten.

Consequently the chicks crop appearance, behavior, and vocalisation (especially voice tone) was assessed to determine when the chicks had eaten sufficiently. A visual check of the stomach can also be used to ascertain

whether chicks have eaten sufficiently (Weaver and Cade 1983). If the stomach appears dark in colour, a large amount of food remains undigested, and feeding should be delayed until the stomach is soft and flaccid returning to a normal pink colour.

## Hygiene

To prevent the chicks from introducing diseases from the wild into the aviary (affecting resident captive raptors), and to prevent the chicks cross-infecting one another, the following strict hygiene precautions were taken;

- All feeding utensils were washed after use with a commercial disinfectant cleanser (Avi-care).
- Old food was removed from the nest after each feed. This practice made it easier to monitor the amount of food consumed by the birds, and acted as a precaution against fly-borne disease and maggot infestation.
- Toweling was changed after each feeding and mutes were carefully inspected for condition, coloration, worms and/or diarrhoea.
- Diarrhoea was observed from Chick 2 on two occasions at about Day 3. The introduction of small amounts of venison into the chick's diet was the suspected cause of the problem. As diarrhoea may also be an early symptom of bacterial or parasitic infection, or enteritis (Cooper, 1978), Kaolin (about 15 ml/kg of weight) was added to the chicks' food, to act as a mild anti-diarrhoeal and binding agent. Kaolin was added to the chicks' food on five occasions over four days, and no further problems were noted.

## Pellets

Roughage in food has been identified as an important component of raptors' diets by providing casting material which aids digestion (Cooper, 1978; Graham and Halliwell, 1978). Lack of appropriate bone, skin and visceral organs in the diet may also lead to bone disease (due to inadequate calcium content), poor calcium to phosphorous ratio (Cooper, 1978) or to vitamin deficiencies (Graham and Halliwell, 1978). Ford (1982) reports that regurgitated or "cast" pellets are expected when chicks are approximately 9 or 10 days old. Accordingly, material in the form of small bones and feathers was slowly introduced to the diet from Day 8 forward.

Unexpectedly, the chicks produced pellets before significant amounts of casting material were introduced into their diet. A small regurgitated pellet was first produced by Chick 1 on Day 6. A second pellet, twice the size of the first was cast two days later (Day 8). Fresh pellets were again found in the nest two days later but it was unclear if these were from the same bird or alternated between the two. From Day 11 both chicks produced pellets on a daily basis. The pellets were found freshly regurgitated each morning, prior to the first feed, and were often tinged with a green coloration which indicates a complete emptying of their crops.

## GROWTH AND DEVELOPMENT

On the morning of Day 2, the chicks were weighed for the first time, at 54 and 46 grams respectively. The chicks were subsequently weighed each morning, prior to feeding (Figure 1, Table 1). Over the first 10 days the chicks were noticeably bigger each day (Plate 1, 2). The maximum weight gain of both chicks occurred on day 5 (Chick 1 - 24.5%; Chick 2 - 27.3%). After Day 18, the chicks gained little weight. The pattern of growth over the first 22 days was similar for both chicks (Table 1). Growth of Chick 2 lagged behind Chick 1 by about one day. If the assumption that the chicks were one and two days old when discovered is correct, then Fox's (1985) suggestion that falcons reach their full adult weight at 18 days of age, may be questioned. The weights recorded for these chicks suggest adult weights are attained at ages 20-22 days of age, at least in captivity.

### **Mobility and flight**

On arrival at the Wingspan facilities both chicks were able to sit upright, albeit unsteadily, beg for food, and move slightly forwards on haunches. Observations of unsteady attempts at walking (but not on heels and feet) were noted on Day 2. After three days they were able to move and shuffle slightly forwards. At rest, they tended to sit back on their haunches or prop themselves against the nest surrounds. On Day 11, the chicks were observed to stand on several occasions. Both chicks could stand for relatively longer periods of time (up to one hour) from Day 14.

Attempted flying behavior was first observed on Day 5. Initial attempts were characterised by vigorous wing flapping, with no forward movement. Attempts at wing flapping occurred at frequent intervals throughout the day, in short bursts lasting 2-3 minutes. By Day 17 both chicks would run with their wings outstretched and would jump to levels similar to their own height. This would occur in short bursts of up to five minutes before the chicks would tire and sit back on their haunches.

On Day 25 both chicks flew to the top of a one meter tree stump, and by Day 28 had flown to all perches within the aviary, the highest of which was 1.9 metres above the ground. The chicks also undertook and maintained short, level flights across the aviary. Flying down from a height to land on the aviary floor appeared to pose some difficulties for the chicks and there was hesitation by the birds before attempting this manoeuvre. Both birds were able to fly and land competently (with no apparent hesitation) within the aviary by Day 34. Both birds had fully fledged by 54 days.

TABLE 1. COMPARATIVE WEIGHTS AND PERCENTAGE GAINS OF FALCON CHICKS

DAY #	DATE	CHICK #1				CHICK #2			
		AGE (DAYS)	WGT (GRAMS)	WGT. INC.	% GAIN	AGE (DAYS)	WGT (GRAMS)	WGT. INC.	% GAIN
2	10-11	4	54	-	-	3	46	-	-
3	11-11	5	62	8	12.90	4	53	11	20.70
4	12-11	6	74	12	16.20	5	64	11	17.10
5	13-11	7	98	24	24.49	6	88	24	27.27
6	14-11	8	112	14	12.50	7	97	9	9.28
7	15-11	9	134	22	16.42	8	116.5	19.5	16.74
8	16-11	10	147	13	8.84	9	130	13.5	10.38
9	17-11	11	166	19	11.45	10	146	16	10.96
10	18-11	12	167	1	0.60	11	151	5	3.31
11	19-11	13	180	13	7.22	12	162.5	11.5	7.08
12	20-11	14	200.5	20.5	10.22	13	184.5	22	11.92
13	21-11	15	230.5	30	13.02	14	219	34.5	15.75
14	22-11	16	236.5	6	2.54	15	225	6	2.67
15	23-11	17	252	15.5	6.15	16	240	15	6.25
16	24-11	18	260	8	3.08	17	254	14	5.51
17	25-11	19	284	24	8.45	18	281	27	9.61
18	26-11	20	286	2	0.70	19	279	-2	-0.72
19	27-11	21	293	7	2.39	20	284	5	1.76
20	28-11	22	300	7	2.33	21	294	10	3.40
21	29-11	23	-	-	-	22	-	-	-
22	30-11	24	300	0	0	23	298	(2)	(0.67)

### Splayed legs

On Day 3 the smaller chick (chick 2) appeared to have a splayed left leg. Apparently, this is not uncommon in captive reared chicks (Weaver and Cade, 1983) and occurred here despite careful handling and a coarse toweling nest base. The following day, small anklets of soft leather were fitted loosely about the chick's ankles with a leather tie (approximately 3 cm between anklets). The chick appeared to rest more comfortably immediately after the anklets were fitted and could tuck its legs under its body when resting. The chick was also less restless and no longer attempted to pull its leg into the correct position. The anklets were removed after seven days and the condition appeared to be improved. There was no further observation of the splayed condition, although a slight weakness in the left leg was noticed at a later date during flight training.

### Preening

Preening by both chicks was first observed on Day 4, and on Day 5, the larger chick was observed preening and wiping its beak, sometimes with its feet, and sometimes under its wing. Chick 2 was observed to conduct the same type of preening on the following day. From Day 12 onward, both chicks also utilised the toweling and small branches provided as nest material, to clean their beaks. Mutual preening was observed from Day 6, and continued until the birds had fledged after Day 54. No further mutual preening was observed after this time. The first observation of either bird rousing was recorded on Day 14.

## **Vocalisation**

Small "chups" were heard during the first feeding (Day 1), and continued throughout the feeding period. The chicks whined regularly to one another at night while sleeping. This behavior was recorded until Day 7, when its frequency declined. After Day 8 the chicks were observed less frequently at night as it became apparent they were unlikely to rest while being observed. Chick 1 was first heard to "kek" loudly seven times on Day 9. This may have been in response to a falcon call from an adult bird in an adjoining aviary. Subsequently, this chick was heard kekking regularly, while the second chick was never heard to do so.

## **Aggression**

Aggressive behavior was first observed on Day 2. The behaviors displayed may have been a form of sibling rivalry or competition. Initially the chicks would bite each other slightly with no apparent injury. These bites were infrequent at first, but occurred with greater frequency as the chicks grew older, or when there was food on the other's beak. By Day 5 the biting was noticeably severe and included beak grappling and loud vocalisation. The most severe incident of aggression occurred on Day 8, when the chicks attacked each other's heads and the loose skin of the crop.

Initially the larger chick seemed to be the most dominant, initiating aggression more often. After Day 3, the initiator of aggressive behavior alternated at each feed. The chicks would continue their aggressive behavior even after they had fed and had full crops. During these aggressive periods, the chicks were quite vocal and would screech at one another. The chicks' aggression to one another was reduced once they were mobile and able to move away from each other.

## **Play**

Branches, twigs, leaves and stones were introduced to the "nest" on Day 8. By this time the chicks could walk and the leather ties had been removed from the legs of Chick 2. The chicks were interested in the additions to their enclosure, and attempted to get atop the twigs, balance on their haunches, and grasp the twigs with both talons and beaks. On Day 12 Chick 1 was observed snapping twigs with its beak and tossing them. On Day 13 both chicks were observed rustling and stirring through dried leaves.

The birds were permanently transferred to the flight aviary on Day 25, where there was an increase in available space and stimuli. Interactions observed in the flight aviary was interpreted as a form of "play". This "play" was characterised by a variety of behaviors, including the pursuit of one another (either running on the ground or in flight), pulling small branches with beak and talons and also between one another (tug-o-war), hiding from one another under tree stumps or foliage, and sudden pouncing onto one another. Mock attacks were also frequent throughout the day.

## RELEASE

The birds could not be returned to the site of the wild nest, as the habitat had been destroyed and neighbouring forests were also due for further logging. Additionally, there was a lack of trained personnel in the area to offer assistance with post-release monitoring, and an adult female falcon was shot in this area.

It was considered more appropriate to release both juveniles in the vicinity of the Wingspan facilities in Paradise Valley, Rotorua as both birds had imprinted on this area, and, post-release monitoring was available, and an existing hack (feeding) post is operational. The area was unoccupied by other wild falcon, there was an adequate availability of prey, and had supportive landowners.

Spring/Summer was considered the most appropriate time for release. Winter months are considered unsuitable for release of predatory birds as food is often scarce (Glasier 1978). Llewellyn (1987) suggested autumn may be appropriate, but only if the birds released have had hunting experience.

The birds were trained using falconry techniques, in order to provide them with the opportunity to develop muscular conditioning, and hunting and flying skills, which would enhance the probability of post release survival. Several factors may contribute to losses of hacked birds, such as young birds not orienting to the hack site, dispersal prior to developing hunting skills, and to direct losses through predation (Oliphant and Thompson 1988)

Chick 2 was released on 30th May 1995 and monitored using radio telemetry, after training for a 12 week period (February-May) using falconry techniques as described by Fox (unpub. notes). Chick 2 exhibited normal flight behavior for falcons, and showed some interest in hunting and chasing small birds. This falcon was trained to the feeding area (hack post) and initially, returned for feeding on a daily basis. Over the first 12 weeks, Chick 2 was recorded and seen within a 5km radius from the initial release site. At 15 weeks post-release, Chick 2 was tracked 14 km north of the release site. This also coincided with a reduced number of visits to the hack site, with visits for supplementary feeding recorded on average, twice per week.

In November 1995, the attached transmitter became dislodged, however the falcon was seen regularly in the area with occasional visits to the feeding table every 5 - 8 days. A confirmed sighting of this bird was last reported in mid-January 1996. While it would be inappropriate to surmise the birds outcome, it should be considered that given the age of the bird, the patterns of sightings would fit with normal expectations of wild juvenile dispersal, and it is possible this falcon has moved to another territory. In addition, incidental falcon sightings have been reported from the Mamaku and Hamurana areas (8 km north and north-east of the release site), however none were close enough to confirm as a banded bird.

Chick 1 underwent training and was scheduled for release in September 1995. This falcon did not respond as positively as Chick 2 and despite attempts to introduce the bird to hunt usual prey species, was not successful. In addition, the bird was particularly threatened by other territorial birds in the area (especially magpies and spur-winged plover) which questioned this birds ability in defense. Given that this falcon was considered unlikely to hunt or survive

independently, and being essentially 'domestic', this falcon was retained in captivity for the Wingspan falcon breeding programme.

The release of both birds was supported by radio-telemetry monitoring. The training, release and post release monitoring are important to quantify the success or failure of this type of release. It may also provide sufficient information upon which to offer recommendations for future releases of either rescued or captive bred New Zealand falcon.

## DISCUSSION AND CONCLUSIONS

The discovery of the pair of New Zealand falcon nesting in *Pinus radiata* shows that falcons are capable of adapting to a new habitat, although this has not previously been recorded. This contrasts with suggestions by Fox (1978) that the even forest canopy in stands of single generation forests is an unsatisfactory habitat for falcon, and that the resulting hunting conditions are difficult. *Pinus* was also considered to support only a poor range of prey. This report suggests that falcon are more adaptable than previously thought, and that stands of exotic forest, with neighbouring pastoral/farming land, may provide suitable habitat for these birds, and requires further research.

This report demonstrates that it is possible to successfully hand-rear New Zealand falcon chicks. The approach adopted here has had no noticeable negative effect on the birds' development, and the birds' behavior is similar to that of recently fledged wild juveniles (Laurence Barea *pers comm.*).

Both birds have progressed well, with neither bird exhibiting any of the recognisable signs of human bonding or imprinting. (Imprinting in falcon is often illustrated by food begging, screaming, mantling over food, aggression to humans, and/or preening of the handler). The detailed records maintained during the rearing of these birds provides data not previously recorded on the growth and development of falcon in New Zealand and extends our understanding of these birds. The opportunity to study the chicks in captivity facilitated the collection of many details about the falcon development which could not be easily observed in the wild.

## ACKNOWLEDGMENTS

Paul Meroiti and Gang 90, Logging Crew, New Zealand Forestry Corporation for reporting the discovery of the falcon to the Department of Conservation. Dave Paine and Fiona Hennessey (Department of Conservation) for the safe delivery of the young chicks to the Wingspan facilities. Raptor Association of New Zealand and the New Zealand Lotteries Commission for providing the transmitters for post-release monitoring. Paul Jansen, Department of Conservation, Protected Species Division, Rotorua, for the loan of radio-telemetry equipment. Finally, Winnie O'Grady for her patience, perseverance, and editing skills in the drafting and preparation of this report.

## REFERENCES

- Anderson-Brown, A.F. (1985). *The Incubation Book*. World Pheasant Association. A. Wheaton and Co. Ltd., Exeter, Great Britain.
- Belovsky, G.E. *et al.* (1994). Management of Small Populations: Concepts Affecting the Recovery of Endangered Species. *Wildlife Society Bulletin No. 22*: pp. 307-316.
- Brown, D. (1986). Artificial Incubation and Rearing of Morepork Owls. *RANZ Bulletin*. Vol. 10. pp. 21-22.
- Brown, D. (1987). First Aid. *RANZ Bulletin*. Vol. 11. #4. pp. 41-45.
- Brown, D. (1988). First Aid - A Discussion. RANZ AGM Presentation 1988.
- Cooper, J.E. (1978). *Veterinary Aspects of Captive Birds of Prey*. Standfast Press, Saul, Gloucestershire.
- Craig, G.R. Reintroduction and Augmentation of Peregrine Falcon Production, pp. 165-169.
- Ford, E. (1982). *Falconry in Mews and Field*. Butler and Tanner Ltd. Batsford, London.
- Fox, N. Dr. (1978). Falcon Distribution. *Notornis* Vol. 25, pp. 317-331.
- Fox, N. (1985). Complete Book of New Zealand Birds. Readers Digest Serv. Pty. Ltd., pp. 154-155.
- Fox, N. Unpublished Notes on the Training of New Zealand Falcon.
- Fox B,M (1993). The problems in establishing a domestic, self sustaining international population of New Zealand Falcons (*Falco novaeseelandiae*). In *Biology and Conservation of small falcons*. Proceedings of the 1991 Hawk and Owl Trust Conference. Eds. M.K. Nicholls and R. Clarke.
- Glasier, P. (1978). *Falconry and Hawking*. Batsford, London.
- Graham, D.L. and Halliwell, W.G. (1978). Malnutrition in Birds of Prey. In *Zoo and Wild Animal Medicine*. Ed Fowler, M.E. W.B. Saunders Col., Philadelphia.
- Llewellyn, P. (1987). Assessing Conditions Prior to Raptor Release. *Breeding and Management in Birds of Prey*. Proceedings of the Conference at the University of Bristol, Jan 24-26, 1987. Edited by D.J. Hill. Published by University of Bristol. pp. 103-119.
- Oliphant, L.W., Thompson, W.J.P. (1988). The Use of Falconry Techniques in the Reintroduction of Peregrine. *Peregrine Falcon Populations, Their Management and Recovery*. Edited by Cade, T., Enderson, J., Thelander, C., White, C. pp. 611-617.
- Stewart, G. Rearing and Release Techniques for Orphaned Raptors. *Wildlife Journal*. Volume 10, No. 22, pp. 3-6.
- Weaver, J.D, Cade, T.J. (1983). Falcon Propagation. A Manual on Captive Breeding. The Peregrine Fund Inc., pp. 68-76.



FIGURE 1 CHICK 1(LEFT) AND CHICK 2 (RIGHT), FIVE DAYS AFTER HATCHING (ESTIMATED). BIRDS COMPLETELY COVERED WITH WHITE DOWN. FEET, BEAK, AND CERE ARE PINK, EYES ARE BLACK. WEIGHTS ARE 74 AND 64 GRAMS (CHICK 1 AND 2 RESPECTIVELY)

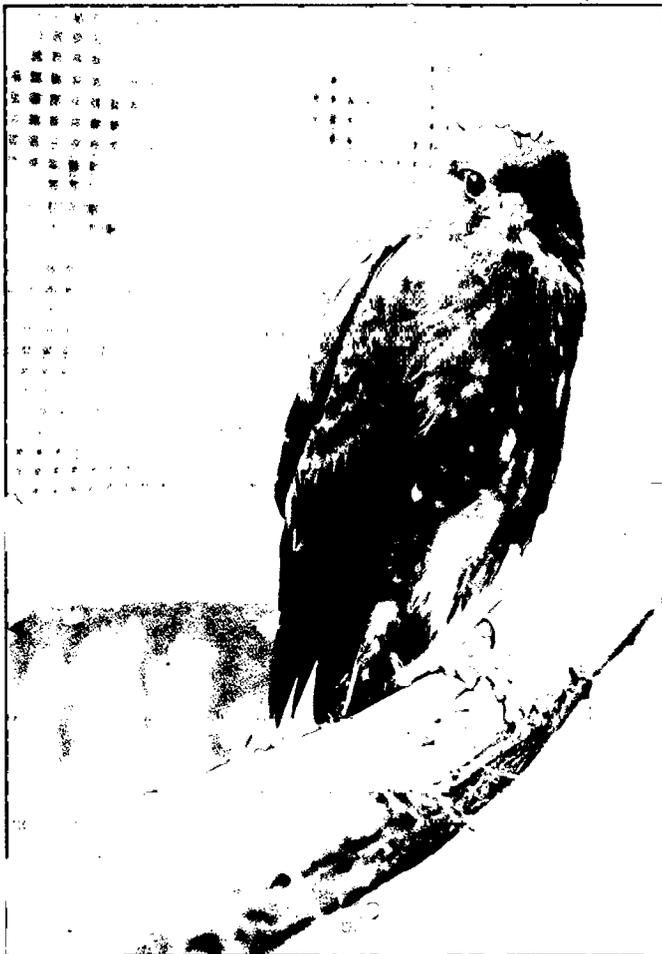


FIGURE 2. CHICK 1(LEFT) AND CHICK 2 (RIGHT), 30 DAYS AFTER HATCHING (ESTIMATED AGE). BOTH BIRDS ARE ABLE TO FLY TO ALL PERCHES WITHIN THE AVIARY.

# Techniques for monitoring populations of *Powelliphanta* land snails

**Kath Walker**

Nelson/Marlborough Conservancy, Department of Conservation, Private Bag 5, Nelson

## ABSTRACT

Two techniques for monitoring *Powelliphanta* land snails are described. The first technique, the collection of shells lying on the surface, provides a quick and simple method for assessing the presence of snails, determining distribution patterns and detecting predation levels. The second technique involves detailed searching of permanent plots for live snails, and is used to assess trends in population size and structure.

## INTRODUCTION

The endemic genus of large, brightly coloured land snails, *Powelliphanta*, is an important component of New Zealand forests and tussock grasslands from Urewera to Fiordland. Comprising at least 10 species and 22 subspecies, they have radiated into a variety of habitats.

The genus includes the largest and most conspicuous examples of New Zealand's diverse land snail fauna. However, preserving this diversity is a difficult task as all New Zealand's medium to large land snails (the vegetarian *Placostylus* and the carnivorous *Rhytida*, *Wainuia*, *Paryphanta* and *Powelliphanta*) fall easy prey to introduced rats, pigs, possums, hedgehogs, and blackbirds and thrushes. With most populations of *Powelliphanta* apparently in decline, the need for good information on the range, size and health of each subspecies has become urgent.

To ensure that Department of Conservation staff monitor *Powelliphanta* in a standard, comparable manner, two common monitoring techniques are described here. The first technique involves collection of shells lying on the ground surface. This simple method is useful for assessing the presence of snails, determining distribution patterns and detecting predation levels. The second technique involves detailed searching of permanent plots for live snails, and is used to assess trends in population size and structure.

Nocturnal counts of live snails have also been tried, but were found to be too variable and too uncomfortable to be useful as a long-term monitoring technique, so are not considered further here.

## 1. SURFACE COLLECTION OF SHELLS

Select this technique when you want a quick, low input assessment of the snails in an area.

### **This method can:**

- Provide a very rough assessment of numbers of snails in an area.
- Indicate the proportions of empty shells damaged by particular predators.
- Indicate the diversity of snail morphologies within the population.
- Provide a picture of their distribution in an area.
- Provide a quick guide as to the likelihood of finding live snails.

### **Disadvantages**

- The number of empty shells is not a reliable way of assessing the status of the live population. At best, it can only indicate what the live population used to be (empty shells last several years, and populations can undergo rapid declines).
- The removal of empty shells may deplete the available calcium supplies for live snails: after a decade of removing *Placostylus* shells from a plot in the Far North (a particularly calcium-deficient area), many live snails developed shell deformities (Andrew Penniket pers. comm.). Calcium deficiency should not be a problem in most areas sampled very rarely, but this potential problem should be kept in mind when choosing areas to sample.

### **Method**

Find out whether snails are known from the area you plan to survey (I can help with locality records).

### **Site selection**

#### **If there are earlier records:**

- Mark the grid references where shells have been collected from on a detailed topographical map.
- Write down and take with you any habitat descriptions attached to earlier records: there is nothing more frustrating when fruitlessly searching an area than wondering if you are overlooking the snails or simply not in the right place.

#### **If there are no earlier records:**

- In the North Island, focus survey on forests above 900 metres and in tussock and shrubland around the bushline for most of the forms of *Powelliphanta marchanti* (the only species likely to be found in previously unknown localities).

- In the South Island, new records for the smaller *P. rossiana* and *P. spedeni* are very likely just above or below the bushline in any of the mountain ranges on the western edge of the main divide, in all Nelson and Fiordland Ranges, and in the taller tussock grasslands of the ranges from Te Anau to the Clutha. Forests near the coasts in Fiordland and North-west Nelson are other likely sites.
- Select a traverse which enables you to sample a good number of likely spots over a wide area, but without making it a logistical nightmare (i.e. it will be pretty demoralizing scrub-bashing along a sidle at the bushline if no snails are present). It is probably more useful to cover a large area than to search in detail, until you have good reason to think snails may be present.

### **Survey**

(a) When you have found the first snail shell, have a good look at it and memorize the shape, size and colour of the shell. Then walk slowly around the area, carefully scanning it by eye. In forest there is generally no need to physically sweep aside the litter, but in tall tussock you may need to lift back the skirts of the tussock.

(b) Put all shells found (including broken fragments) in a plastic bag, along with a piece of paper giving the topographic map number and grid reference and the date - vital information if your shell collection is to have any value. If possible, a label detailing; the name of the general locality; the name of the searcher(s); a brief description of the habitat and snail predator sign seen; and the time spent searching.

(c) Start a new plastic bag about every 1-2 kilometers; sooner if there is an observable change in shell characteristics, or a big break in the habitat. While it is easy to combine bags later if necessary, it is impossible to divide one, so a gradually varying snail population may only be interpretable as a single, polymorphic one.

## **2. MONITORING LIVE SNAIL POPULATIONS**

The most simple technique for obtaining a reliable estimate of live snail density is by establishment of a permanent plot which is thoroughly searched for live snails every year or so.

### **This method can:**

- Provide a quantitative result which can be directly compared with *Powelliphanta* densities recorded elsewhere in the country, or with earlier counts in the same location.

### **Disadvantages**

- If recounted too frequently, or during a long dry period, or in a destructive manner, may degrade the snail habitat in the square or even directly kill

snails through trampling or causing desiccation of eggs, and consequently influence the results.

- May be very difficult to lay out and search adequately if all the habitat is steep and densely vegetated.

## Method

### (a) Selection of a site:

- Usually the aim of the monitoring is to try and detect changes in snail densities, and this is easiest achieved if the plots are placed in an area where the subspecies to be sampled is at its highest densities. If densities are too low, changes from year to year are likely to be difficult to detect. If there is no alternative to a low density site, the plot size may have to be increased, involving more search time.

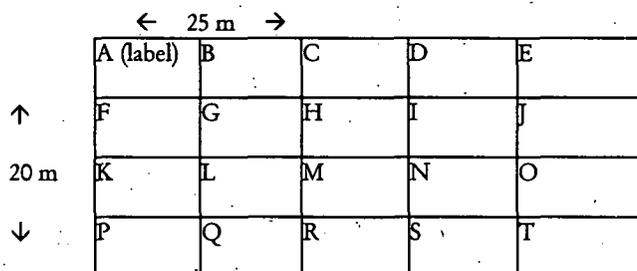
Exceptions include:

- when you are trying to measure the effect on snail densities of management actions at a particular site;
- when total numbers of a subspecies need to be estimated, involving sampling across its entire range.
- In general, the sites with the highest numbers of empty shells usually have the highest number of live snails. However, there are several important exceptions to this:
  - in tussock grasslands, empty shells are usually well hidden in the dense vegetation, yet there may be a relatively dense live population;
  - in some forest areas where there has been a recent dramatic decline in snail numbers (e.g. in North-west Nelson because of possum predation) large numbers of empty shells do not reflect an existing large live population;
  - where flooded streams or predators such as rats have gathered snails from a wide area and deposited the shells in one site.
- Once you have found an area with a reasonable number of empty shells, or have done a bit of deeper searching and found a few live snails, look for a homogenous area within it. A 500 square meter plot in which 200 square metres is occupied by a large dead tree trunk, or a pile of rocks, is obviously not equivalent to a 500 square meter plot where all the area is prime snail habitat.
  - Good snail habitat comprises a deep, moist litter layer, and alkaline and fertile soil with abundant earthworms. However, *Powelliphanta* can live in many less favoured sites and some (e.g. *P. rossiana patrickensis* on the Denniston coal plateau) live in very acidic (though still moist) conditions.
  - Micro habitats to seek include patches of bush rice-grass *Microlaena* spp.) in forests, and tall unburnt red tussock (*Chionocloa rubra*) in grasslands.

- Ensure that your selected site is logistically easy:
  - not so hard to reach that enthusiasm for re-measuring the snails is hard to maintain; let alone the cost of getting there. Unfortunately for some subspecies a remote location will be inevitable;
  - the site should have long-term security from habitat destruction, and be hidden from general view so that pegs are unlikely to be interfered with;
  - the site should be uniformly flat or evenly sloping in one direction so that it is easy to peg out a square plot and easy to systematically search.

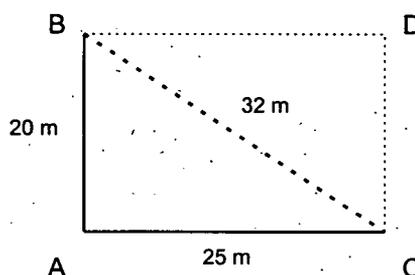
**(b) Laying out the plot:**

- The optimum size of a plot is about 500 square metres: much smaller and too few snails are likely to be present; much larger and it will take an unsustainable effort to re-measure it.
  - A 500 m<sup>2</sup> plot in a dense, healthy population of *P. lignaria johnstoni* on the West Coast, contained on average 84 live snails (four years of counts).
  - However, the same plot contained only four live snails after five years of possum predation, and density levels of this sort appear standard in many subspecies in North-west Nelson similarly affected by possums (e.g. two live snails/300 on the Goulard Downs, eight live snails/400 m<sup>2</sup> and two live snails/400 m<sup>2</sup> in two plots in the Flora Stream area of the Arthur Range).
- To make it easier to search systematically for snails within the plot, divide the 25 x 20 meter plot into four rows of five, 5 x 5 meter quadrats.

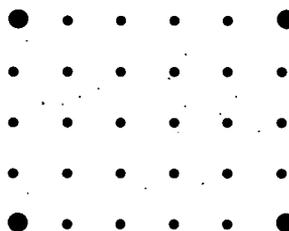


- If it is too difficult to find a piece of suitable habitat this big, the 25 x 5 meter quadrats need not be contiguous, but can be scattered over a short distance, as long as you are sure you can relocate them all.
- Equipment required for laying out and counting snails in one 25 x 20 meter plot:
  - compass (preferably a good sighting one);
  - two x 50 meter tapes;
  - several long rolls of string (or even better if you have them, more 50 meter tapes);
  - a five meter aluminium tape;

- thirty aluminium pegs, 80 cm long, made of 11 mm x 11 mm angle iron, with one end spray-painted a bright fluorescent colour;
  - twenty additional aluminium pegs to use as temporary markers of live snails;
  - Dymo labeler to label each quadrat;
  - notebook, pencil, rubber;
  - Vernier calipers;
  - plastic bags and labels.
- Using a compass and the tapes, mark out three corners of the whole 25 x 20 meter plot, taking care to get a good right angle by running a tape 32 metres long between points 'B' and 'C', and altering the position of pegs 'B' and 'C' (without changing their total distance from 'A') until the 32 meter tape between them is stretched tight.



- Put the last corner peg 'D' in at the point which causes a tape 25 metres from 'B' and 20-metres from 'C' to become taut.
- Run other tapes across the square, putting pegs in at five meter intervals:



- Take care not to trample the plot as you lay it out.
- Label each 5 x 5 meter quadrat ('A', 'B', 'C' ... 'T'), with a permanent mark (Dymo labelers are good) on the top left-hand peg of the plot.

**(c) Time and personnel requirements:**

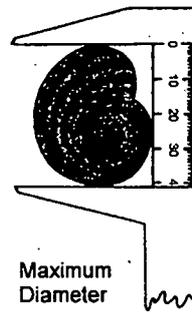
- The optimum number of searchers is four people.
  - Two people can quite adequately search the plot, but it can get a bit tiresome if snail numbers are too low to keep interest up.
  - It seems false economy to use more than four people: there is too much trampling of the area; the chances of areas being missed are increased through people searching at different speeds; and if there are lots of live snails, there can be confusion as to which have been measured and where each snail has come from and should be returned to.
  - It will take 4½ - 5 hours for four people to search a 500 square meter (20 5x5 quadrats) plot. An additional 1½ hours or so will be needed to establish the plot the first time the snails are counted.

**(d) Searching the plots:**

- Spread all four searchers out along the base (bottom edge if it is on a slope) of the first 5 x 5 meter quadrat.
- Lay a stick (or something similar) to mark the edge of the zone each person is searching across to, and either move it up as you work up the quadrat, or verbally check with your neighbours about which bits they have checked and which they have left unsearched for you.
- Working systematically, brush aside all the leaf litter in a small patch, sifting the leaf litter through your hands as you drop it to check there are no snails in it.
  - You do not need to dig down into compacted soil, but do jam your hand into cracks where fallen logs (anything bigger than about 15 cm diameter) meet the ground, and into any small holes in tree roots.
  - If you are searching in tussock, heave aside the grass skirt and hold it back with your body while you feel with your hand right up around the base of the tussock, especially into any nooks or crannies.
  - It is slow-going if the ground is moss-covered: do not pull out the moss, but try and feel all the ground beneath it, checking for hard, snail-shaped lumps.
- Ensure all the litter and vegetation you have pushed aside is carefully returned to where it came from, before moving on to the next small patch in your zone.
- Use bare hands for preference: much of the finding is in feeling appropriately sized, round hard lumps. If the ground is frozen, you may have to resort to rubber gloves or a small stick for brushing aside the wet litter, but it is very easy to overlook snails that way.
- Though *Powelliphanta's* small (usually less than 12 mm) white, hard-shelled eggs are fairly easy to spot, only slightly bigger juvenile snails are easily overlooked because of their dark colour, and this monitoring technique consistently under-estimates the number of juveniles.

**(e) Measuring live snails:**

- Collect all empty shells found in the quadrat.
- When you find a live snail, mark the spot with a spare, brightly painted aluminium peg, ensure the snail is well covered with damp material, then finish searching the quadrat before coming back and recording all snails found.
- Record the date searched and the number of live snails and empty shells found in each quadrat of the plot.
- Using Vernier calipers, measure the maximum diameter of the live snails found, as this will give some idea of the age structure of the population.



- Similarly, measure the maximum diameter of any empty shells found, and record whether the shell was broken and, if by a predator, which sort.
  - Place all shells found in a plastic bag and label with date and plot name. If you are unsure of the identity of predators, send the shells to me or keep the bags for future analysis. Otherwise, scatter the shells found in the vicinity of the plot, but in a position which ensures the shells cannot roll back into the plot.

**(f) Frequency of monitoring:**

- The number of plots needed to adequately monitor a single taxa depends on the diversity of conditions affecting it.
  - If there is an even spread of both snails, and any disturbing factors and management effort across the range of a *Powelliphanta* subspecies, then a single 500 m<sup>2</sup> plot is probably adequate.
  - If any of the variables have an uneven distribution, then extra plots will be required to ensure the full range of situations is sampled.
- Plots should not be surveyed more than once a year, as inevitably some damage occurs to the snails habitat each time.
- The best time to survey the plots from the snail's point of view is winter, when rainfall is high and the litter layer can quickly recover moisture after being turned over. However, as cold wet weather slows down the survey process, the best compromise is probably to survey on a fine day in spring or

autumn. Do not search plots in prolonged hot, dry periods when small snails can easily die of desiccation.

- It is usually not necessary to re-survey a plot every year, as *Powelliphanta's* low reproductive ability and slow growth rate (relative to other invertebrates) means population changes are slow. However, when a finer level of population monitoring is required, an annual recount is useful.

### 3. Information Storage

To ensure a national database on *Powelliphanta* is maintained, please send a copy of any new distribution records to:

Kath Walker  
Department of Conservation  
Private Bag 5, Nelson

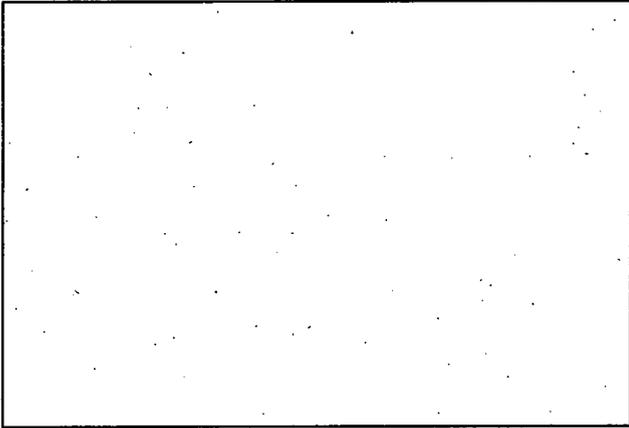
I would also be most grateful to receive copies of any density data you gather each year from permanent snail plots, to allow national comparisons of conservation status of *Powelliphanta* subspecies.

COVER SHEET FOR SNAIL MONITORING  
PLOTS

Plot Name: ..... Date of Survey: .....

Location ..... Grid reference .....

Topographical map extract with plot location marked Description of how to reach the plot:



Line drawing of plot showing quadrat names, and position of plot relative to route there.

**Summary of Results**

Total number of live snails ..... Total number of empty shells .....

**Cause of Death::** .....

Natural (intact shell) .....

Rat predation: .....

Pig Predation: .....

Possum predation: .....

Balckbird/thrush predation: .....

Hedgehog predation: .....

Unknown: .....

## DATA RECORDING SHEET FOR LIVE SNAIL MONITORING

PLOT NAME: GRID REFERENCE:	DATE: OBSERVERS:
-------------------------------	---------------------

Quadrat letter:				Quadrat letter:			
Live snails:				Live snails:			
	Max diam		Max diam		Max diam		Max diam
1		9		1		9	
2		10		2		10	
3		11		3		11	
4		12		4		12	
5		13		5		13	
6		14		6		14	
7		15		7		15	
8		16		8		16	

Empty Shells			Empty Shells		
	Max diam	cause of death		Max diam	Cause of death
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		

COMMENTS	COMMENTS
----------	----------

SUMMARY	SUMMARY
Total live snails	Total live snails
Total empty shells	Total empty shells

Send copy to: **Kath Walker**  
Department of Conservation, Private Bag 5, Nelson



# A comparison of 1996 IUCN Red List categories and Department of Conservation priority rankings for the New Zealand herpetofauna

**Ben D. Bell**

School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington

## ABSTRACT

For the New Zealand herpetofauna, categories in the *1996 IUCN Red List of Threatened Animals* are compared with the Department of Conservation's 1994 priority rankings for the conservation of New Zealand's threatened plants and animals. Differences in the ranking of species are discussed in relation to the different approaches adopted by the two systems.

## INTRODUCTION

Following an approach in 1966 from Dr. Hal Cogger, convenor of the Australasian Amphibian and Reptile Specialist Group of the IUCN Species Survival Commission, I initiated, with Don Newman, a revision of the New Zealand herpetofauna entries published in the *1994 IUCN Red List of Threatened Animals* (Groombridge 1993). This revision is included in the *1996 IUCN Red List of Threatened Animals* (IUCN 1996) that utilizes the latest IUCN Red List categories (IUCN 1994, 1996; Baillie, *et al.*, 1995).

For this task, a specialist committee of New Zealand herpetologists was established comprising: Ben Bell (convenor), Charles Daugherty, Rod Hitchmough, Don Newman, Dave Towns and Tony Whitaker. The committee reached agreement on most New Zealand species. Where there was divergence of opinion, the majority view was adopted. In May 1996, the committee's list (see below) was sent to the Species Unit, World Conservation Monitoring Centre, Cambridge, UK

## THE NEW IUCN CATEGORIES

The need to revise the earlier IUCN Red List categories had been recognised for some time (IUCN 1994). The new IUCN criteria have several specific aims: to provide a system that can be applied consistently by different people; to

improve the objectivity by providing those using the criteria with clear guidance on how to evaluate different factors which affect risk of extinction; to provide a system which will facilitate comparisons across widely different taxa; and to give people involved with threatened species a better understanding of how individual species are classified (IUCN 1994).

The main IUCN categories are: *Extinct* (EX), *Extinct in the Wild* (EW), *Critically Endangered* (CR), *Endangered* (EN), *Vulnerable* (VU), *Lower Risk* (LR), *Data Deficient* (DD) and *Not Evaluated* (NE). *Lower Risk* categories are subdivided into three sub-categories: *conservation dependent* (cd), *near threatened* (nt) and *least concern* (lc). The various quantitative criteria by which a taxon is given one of the threatened categories (CR, EN, VU) are indicated with appropriate notations for the criteria (A to E) and sub-criteria (a, b etc., i, ii etc.). These quantitative criteria and sub-criteria need to be evaluated so that risk factors across a broad range of organisms can be determined. The five main quantitative criteria are: (A) extent of population reduction; (B) extent of occurrence or area of occupancy; (C) population size (mature individuals) and extent of decline; (D) absolute population size (mature individuals); (E) probability of extinction in the wild (determined from quantitative analysis). Full explanations of these categories and criteria are given in the booklet *IUCN Red List Categories* (IUCN 1994) and are further discussed in the *1996 IUCN Red List* (IUCN 1996).

## DEPARTMENT OF CONSERVATION PRIORITIES

Molloy & Davis (1994) use different scoring criteria than IUCN to determine priorities for the conservation of threatened New Zealand species (animals and plants). The main Department of Conservation (DoC) alphabetic rankings are: 'A' (highest priority), 'B' (second priority), 'C' (third priority) and 'T' (little information but considered threatened).

Seventeen criteria are set out and used to determine these threatened species priorities and in so doing Molloy & Davis (1994) assess five main factors: *taxonomic distinctiveness*, *status of the species*, *threats facing the species*, *vulnerability of the species*, and *human values*. An expert panel of herpetologists applied appropriate scores for endemic New Zealand amphibians and reptiles (Charles Daugherty, Rod Hitchmough, Don Newman, Geoff Patterson and Dave Towns).

A ranking score of 1-5 is used for each of the seventeen criteria, except for the two *human values* criteria where the score range is 1-4. The higher the score the higher the conservation value. The maximum possible total score is 83 ((15x5)+(2x4)). In practice, a species is eligible for category A if its score is greater than 47; for category B if the score is 39-47 inclusive; and category C if 30-38 inclusive (Molloy & Davis 1994).

For the single *taxonomic distinctiveness* criterion, the conservation of species which do not have any close relatives is given higher priority than species with close relatives. When assessing a species against this criterion, the highest scoring category which applied was selected, and only relationships with other living taxa were considered.

Scoring the six *status of the species* criteria embraces: the number of populations, the mean population size; the largest population; the geographic distribution; the condition of the largest population; and the wild population decline rate. The six *status of the species* criteria cover similar aspects to the criteria used by IUCN for threatened species.

For mean population size and largest population, different criteria were used for three different groups of organisms: (i) vertebrates, except reptiles, amphibians and fish; (ii) invertebrates, reptiles, amphibians and fish; and (iii) plants. For invertebrates, reptiles, amphibians and fish, the top scoring mean population criterion (5) was "less than 50, or area <0.25 ha", while the lowest score (1) was for "more than 1000, or area >100 ha, or unknown but suspected to be large"; similarly the largest population scores ranged from "less than 50" (5) to "More than 1000, or unknown-but suspected to be large" (1).

*Threats facing the species* criteria cover five categories: legal protection of the habitat, habitat loss rate, predator/harvest impact, competition, and other factors affecting survival (a "catch bag" for such factors as disease, pollution and pesticides).

The three *vulnerability of the species* criteria relate to habitat and/or diet specificity, reproductive and/or behavioral specialisations, and cultivation and captive breeding.

Finally, but significantly, the DoC rankings include two *human values* criteria that embrace Maori and Pakeha (non-Maori) cultural values. Many of New Zealand's plants and animals have symbolic value to Maori, and consequently their conservation is important. Similarly, particular plants and animals are valued to Pakeha for aesthetic, symbolic, economic or historic reasons. The possible monetary value of a species was not assessed by this criterion.

## RED LIST OF NEW ZEALAND HERPETOFAUNA

Items in the list below are given in the following order: abbreviated IUCN classification, DoC letter code, vernacular name, scientific name. Vernacular names follow Gill & Whitaker (1996).

These categories are summarised in Appendix 1, which shows the overall relationship between the IUCN and DoC systems of classifying New Zealand herpetofauna at risk.

### CLASS AMPHIBIA<sup>1</sup> ORDER ANURA FAMILY LEOPELMATIDAE

LR (nt)	B	Archey's Frog	<i>Leiopelma archeyi</i>
VU (D2)	A/B*	Hamilton's frog	<i>Leiopelma hamiltoni</i>
LR (lc)	B	Hochstetter's frog	<i>Leiopelma hochstetteri</i>

<sup>1</sup> Stephens Island frog ranked 'A', Maud Island frog ranked 'B' ;

CLASS REPTILIA  
 ORDER SPHENODONTIDA  
 FAMILY SPHENODONTIDAE

VU (D1,2)	A	Günther's Tuatara	<i>Sphenodon guntheri</i>
LR (lc)	B	Tuatara	<i>Sphenodon punctatus</i>

ORDER SAURIA  
 FAMILY GEKKONIDAE

LR (lc)	C	Goldstripe Gecko	<i>Hoplodactylus chrysosireticus</i>
EX (presumed NZ)	-	Kawekaweau	<i>Hoplodactylus delcourti</i>
LR (lc)	-	Duvaucel's Gecko	<i>Hoplodactylus duvaucelii</i>
LR (nt)	B	Black-eyed Gecko	<i>Hoplodactylus kabutarae</i>
LR (lc)	B	Cloudy Gecko	<i>Hoplodactylus nebulosus</i>
LR (nt)	B	Harlequin Gecko	<i>Hoplodactylus rakturae</i>
VU (D2)	B	Striped Gecko	<i>Hoplodactylus stephensi</i>
LR (lc)	-	Rough Gecko	<i>Naultinus rudis</i>
LR (lc)	-	West Coast Green Gecko	<i>Naultinus tuberculatus</i>

FAMILY SCINCIDAE

VU (D1/2)	B	Robust Skink	<i>Cyclodina alani</i>
VU (D2)	B	MacGregor's Skink	<i>Cyclodina macgregori</i>
LR (lc)	-	Marbled Skink	<i>Cyclodina oliveri</i>
VU (D1/2)	B	Whitaker's Skink	<i>Cyclodina whitakeri</i>
LR (nt)	C	Falla's Skink	<i>Oligosoma fallai</i>
DD	-	Narrow-bodied Skink	<i>Oligosoma gracilicarpus</i>
VU (C2a)	A	Grand Skink	<i>Oligosoma grande</i>
VU (D2)	A	Chevron Skink	<i>Oligosoma homolonotum</i>
LR (nt)	-	Speckled Skink	<i>Oligosoma infrapunctatum</i>
VU (B1/B2b,c,d)	A	Small-scaled Skink	<i>Oligosoma microlepis</i>
LR (lc)	I	Southern Skink	<i>Oligosoma notosaurus</i>
VU (C2a)	A	Otago Skink	<i>Oligosoma otagense</i>
LR (lc)	C	Small-eared Skink	<i>Oligosoma stenotis</i>
VU (B1, B2b, c, d)	A	Striped Skink	<i>Oligosoma striatum</i>
VU (B1/B2b, d)	B <sup>2</sup>	Scree Skink	<i>Oligosoma waimatense</i>

\**Oligosoma waimatense* is named as a result of its appearance in field guides as a distinct species from *O. otagense* (Gill 1986, Gill & Whitaker 1996) although it has not been more fully described.

## DISCUSSION

Essentially, categorising threatened species using the IUCN criteria involves "keying-out" a given species against a series of quantitative criteria and sub-criteria options. On the other hand, the DoC system uses an additive system - an accumulated score based on selection of the most appropriate individual score for each of the seventeen contributing criteria that combine subjective and quantitative approaches: that total score then determines the conservation priority category. Despite common conservation goals, there are differences in outcome of the two reports: the *1996 IUCN Red List* provides *categories of risk*, while Molly & Davis (1994) provide *priorities for conservation*.

In the *1996 IUCN Red List* the revised species ratings are grouped into seven lists. Of these, Lists 1 and 7 are of particular significance. List 1 includes *Critically Endangered* (CR), *Endangered* (EN), and *Vulnerable* (VU), and it is noted that only taxa in these three categories should be termed threatened. List 7 includes those species categorised as being of *Lower Risk least concern* (LR:lc) and are interpreted as taxa to be removed from the *1996 IUCN Red List*.

As only critically endangered, endangered, or vulnerable species are considered threatened under IUCN criteria, it follows that New Zealand now has only 12 threatened species of herpetofauna: one frog (Hamilton's frog), one tuatara (Gunther's tuatara), one gecko (striped gecko), and nine skinks (robust skink, MacGregor's skink, Whitaker's skink, grand skink, chevron skink, small-scaled skink, Otago skink, striped skink, and scree skink).

Ten New Zealand species have now been removed as taxa ranked *Lower Risk least concern*: one frog (Hochstetter's frog), one tuatara (northern/Cook Strait tuatara), five geckos (goldstripe gecko, Duvaucel's gecko, cloudy gecko, rough gecko, and West Coast green gecko), and three skinks (marbled skink, southern skink, and small-eared skink).

IUCN has an international perspective, attempting to embrace all the world's threatened animals. Although many of the species are of international interest, the focus of Molloy & Davis (1994) is primarily one of national conservation priority, and their list embraces both animals and plants. Such differences in approach and methodology have resulted in differences and similarities in ranking. While both agree that the grand and Otago skinks, for instance, are of high priority (DoC A; IUCN *Vulnerable*), the cloudy gecko rates DoC B but has only been assigned IUCN *Lower Risk least concern* i.e. it is removed from the Red List. Conversely, the speckled skink does not feature in Molloy and Davis (1994) but receives an IUCN rating of *Lower Risk near threatened*.

A marked distinction between the IUCN and DoC criteria is the inclusion in the latter of taxonomic distinctiveness and human value. A species that is taxonomically very distinct and of high human value has an enhanced score in the DoC system. Amongst the herpetofauna, the tuatara - for example - ranks highly as it is both taxonomically distinct and culturally valued (by both Maori and Pakeha). Gunther's tuatara is classified as threatened by both systems: DoC category A and IUCN *Vulnerable*. On the other hand, DoC recognises the northern/Cook Strait tuatara as category B, but the species has the more lowly

ranking of *Lower Risk least concern* under IUCN criteria, so is removed from the IUCN list of threatened animals.

Undescribed species are not included in the 1996 IUCN Red List but some are in the DoC list: Maud Island frog (B), Dansey's Pass gecko (B), Matapia Island gecko (B), Mount Arthur gecko (B), Mokohinau skink (A), Poor Knights *Cyclodina* (C), Garston skink (A), Long-toed skink (B), Open Bay Island skink (A) and West Coast skink (B).

No New Zealand amphibian or reptile in the 1996 IUCN Red List ranks as Endangered (EN), although the Stephens Island frog *Leiopelma hamiltoni* will assume the category EN(D) once the Maud Island frog (status VU(D2)) is formally described as a separate species (Bell 1994). The Stephens Island frog is already classified as A by Molloy & Davis (1994). The New Zealand committee applied the following IUCN categories to undescribed lizards which did not get into the 1996 IUCN Red List: Mount Arthur Gecko VU(D2); Matapia Island Goldstripe Gecko VU(D2); and Long-toed Skink VU(B1/B2b,d).

While some New Zealand amphibians and reptiles classed *Lower Risk least concern* have been removed from the IUCN list, they may still be at greater risk than other species that are still included despite their having wider geographic ranges and numbers. For instance, the fire-bellied toad *Bombina bombina* and great crested newt *Triturus cristatus* are both *Lower Risk conservation dependent*, yet they are listed for 23 and 22 European countries respectively (IUCN 1996). They remain on the 1996 IUCN Red List, but the more localised Hochstetter's frog, confined now to northern New Zealand, drops off as a *Lower Risk least concern* species. Such inconsistencies indicate further review and revision of the relative status of species in the 1996 IUCN Red List is desirable, at both national and international level.

Of further interest is the 1996 IUCN Red List classification of two Australian bell frogs introduced in New Zealand: in Australia the southern bell frog *Litoria raniformis* is *Endangered* (EN(A1ac)) and the green and golden bell frog *Litoria aurea* is *Lower Risk near threatened* (LR(nt)). *L. raniformis* is widespread in New Zealand and *L. aurea* occurs in the northern part of the North Island (Bell 1981, 1994). Given global declines of amphibians (Pechmann et al. 1991; Tyler 1991), we need to resurvey and monitor both species in New Zealand, while re-introduction of stocks back to Australia may be a possible conservation option for the future.

## ACKNOWLEDGMENTS

I am indebted to fellow members of the committee set up to review the New Zealand amphibian and reptile entries for the 1996 IUCN Red List: Charles Daugherty, Rod Hitchmough, Don Newman, Dave Towns and Tony Whitaker. I also wish to thank an anonymous referee for constructive comments on an earlier version of this paper.

## REFERENCES

- Baillie, J., Callahan, D. & Gärdenfors, U. (1995). A closer look at the IUCN Red List categories. *Species* 25: 30-36.
- Bell, B.D. 1982. The amphibian fauna of New Zealand. In D.C. Newman, (Ed): *New Zealand Herpetology. New Zealand Wildlife Service Occasional Publications 2*: 27-89.
- Bell, B.D. (1994). A review of the status of New Zealand *Leiopelma* species (Anura: Leiopelmatidae), including a summary of demographic studies in Coromandel and on Maud Island. *New Zealand Journal of Zoology* 21: 341-349.
- Gill, B.J., 1986. *Collins handguide to the frogs and reptiles of New Zealand*. Collins, Auckland.
- Gill, B.J., Whitaker, A.H. 1996. *New Zealand Frogs and Reptiles*. Bateman, Auckland.
- Groombridge, M. ed. (1993). *1994 IUCN Red List of threatened animals*. Cambridge, U.K. IUCN Species Survival Commission. 285 p.
- IUCN. (1994). *IUCN Red List Categories*. IUCN, Gland, Switzerland.
- IUCN. (1996). *1996 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland.
- Molloy, J., Davis, A.. 1994. Setting priorities for the conservation of New Zealand's threatened plants and animals. (2nd edition collated by C. Tisdall). Department of Conservation, Wellington. 44p.
- Pechmann, J.H.K., Scott, D.E., Semlitsch, R.D., Caldwell, J.P., Vitt, L.J., Gibbons, J.W. 1991. Declining amphibian populations: the problem of separating human impacts from natural fluctuations. *Science* 253: 892-895.
- Tyler, M.J. 1991. Where have all the frogs gone? *Australian Natural History* 23: 618-620.

## APPENDIX 1

Summary comparison of 1996 IUCN Red List categories and Department of Conservation priority rankings for New Zealand herpetofauna at risk

IUCN RED LIST CATEGORY <sup>3</sup>	DEPARTMENT OF CONSERVATION PRIORITY RANKINGS					
	A	B	C	I	NONE	TOTAL
Endangered (D)	1	-	-	-	-	1
Vulnerable (B)	2	1	-	-	-	3
Vulnerable (C)	2	-	-	-	-	2
Vulnerable (D)	2	5	-	-	-	7
Lower Risk (nt)	-	3	1	-	1	5
Lower Risk (lc)	-	3	2	1	4	10
Extinct (EX)	-	-	-	-	1	1
Data Deficient (DD)	-	-	-	-	1	1
<b>Total</b>	<b>7</b>	<b>12</b>	<b>3</b>	<b>1</b>	<b>7</b>	<b>30</b>

<sup>3</sup> Maud Island and Stephens Island frogs treated as separate species, as in Molloy & Davis (1994).

# Short Note

## Rodent eradication - Black Rocks

**Tim Shaw<sup>1</sup>**

Kerikeri Field Centre, Northland Conservancy, Department of Conservation, PO Box, 128 Kerikeri.

<sup>1</sup> Current address: Motueka Field Centre, Nelson/Marlborough Conservancy, Department of Conservation, PO Box 97 Motueka.

In early 1992 the 17 islands that make up the Black Rocks in the Bay of Islands (refer map one) were treated with talon 50WB rat poison. The object of this treatment was to eradicate ship and Norway rats. This eradication was recommended in 1990 by the Offshore Island Research Group (OIRG).

Most of the Black Rocks are less than a hectare in size. The method used to eradicate the rats followed that suggested by Don McKenzie (DoC 028, WAM 207, 21 Feb. 1992). This involved treating each of the 17 islets with 20 to 40 individual talon 50WB baits. These were placed in groups of three under available cover, approximately every 40 sq metres. In addition 1-3 permanent bait stations (100 mm nova pipe) loaded with two baits each were set up to act as a monitor of the presence of rats and as a first line of defence against possible reinvasion of rats.

The eradication attempt took place as a trial on two of the islands (East and West Atolls) on 3 February 1992 and on the remaining 14 island on 22 April, 1992. Eradication was deemed successful on all 17 islands in the month after poisoning when no further baits were eaten and no further rat sign noted. Subsequently the baits on half the islands (1 to 7, map one) have been checked at least twice a year and on the remaining half of the islands (8 to 17, map one), have been checked a total of three times. No sign of rats has been noted, nor have any of the baits in bait stations been taken. It was therefore assumed that the eradication attempt has been successful and that reinvasion had not occurred.

In early 1995 it was decided to test the assumption of successful rodent eradication. On each of the 17 islands, different combinations of four proven methods of rodent monitoring were employed. One to three apples, chew sticks (soft wood soaked in peanut oil) and blocks of fragrant hand soap were placed on all the islands. Snap traps baited with peanut butter and soft sweets were set on 14 of the 17 islands. These monitoring methods were set up and checked for two concurrent periods from 13 January to 20 March, 1995. The exact number of baits and traps employed on each island is presented in table one. On none of the 17 islands was any sign detected to suggest the continued presence of rats. It has therefore been concluded the 17 Black Rocks listed in table one, are at present rodent-free.

Monitoring of the permanent bait stations on 14 of the 17 islands has been continued by Kerikeri Field Centre staff. This project has been complemented by an operation on neighbouring Matoroa Island by private landowners.

TABLE 1: RAT MONITORING BAITS (RAT MONITORS) PLACED ON THE BLACK ROCKS DURING JANUARY-MARCH 1995

ISLAND NAME	#	# OF RAT MONITORS				DATE SET	DATE CHECK	RAT SIGN
		CHEW STICK	SOAP	APPLE	TRAP			
West Atoll	1	3	3	3	2	13/1, 15/3	15/1, 20/3	Nil
East Atoll	2	2	1	2	2	13/1, 15/3	15/1, 20/3	Nil
Outer Little Rat	3	2	2	2	1	13/1, 15/3	15/1, 20/3	Nil
Rat Island	4	3	2	3	1	13/1, 15/3	15/1, 20/3	Nil
Little Rat Island	5	1	1	1	1	13/1, 15/3	15/1, 20/3	Nil
Mouse Island	6	2	1	2	1	13/1, 15/3	15/1, 20/3	Nil
Phils Hat	7	1	1	1	1	13/1, 15/3	15/1, 20/3	Nil
West Tern Rock	8	1	1	1	1	13/1, 15/3	15/1, 20/3	Nil
Tern Rock	9	1	1	1	1	13/1, 15/3	15/1, 20/3	Nil
Flat Top Rock	10	1	1	1	1	13/1, 15/3	15/1, 20/3	Nil
NW Crater Rim	11	1	2	1	1	13/1, 15/3	15/1, 20/3	Nil
NE Crater Rim	12	1	1	1	0	13/1, 15/3	15/1, 20/3	Nil
SW Crater Rim	13	2	2	2	2	13/1, 15/3	15/1, 20/3	Nil
SE Crater Rim	14	1	1	1	0	13/1, 15/3	15/1, 20/3	Nil
Battleship Rock	15	2	3	2	2	13/1, 15/3	15/1, 20/3	Nil
Stuck Anchor Rock	16	1	1	1	1	13/1, 15/3	15/1, 20/3	Nil
Outer Stuck Anchor Rock	17	1	1	1	0	13/1, 15/3	15/1, 20/3	Nil

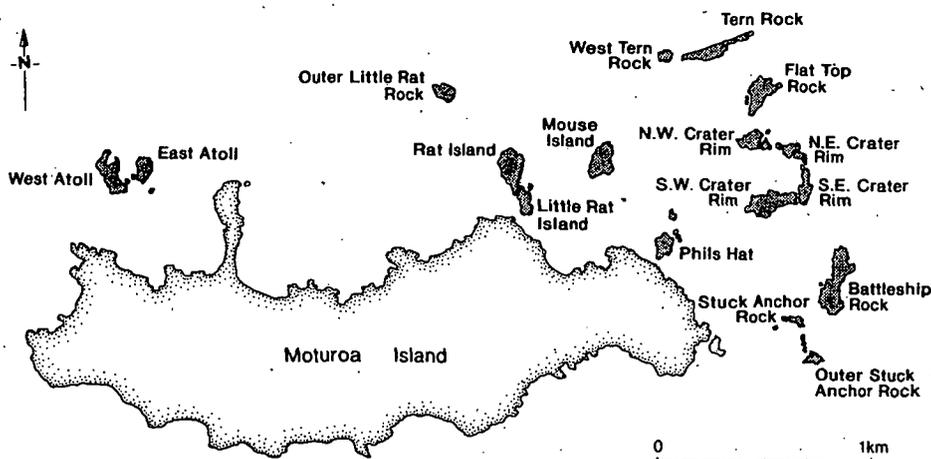


FIGURE 1. MAP OF BLACK ROCKS AREA, MOTUROA ISLAND.

# Short note:

## Post-eradication recovery at Chetwode Island: an update

**Mike Avis**

Havelock Field Center, Department of Conservation, 13 Mahakipawa Rd, Havelock.

Following eradication of kiore and weka from the Chetwode Islands (see Brown this issue), monitoring of the recovery of the biota of the main islands in the group was initiated.

Part of the annual monitoring programme involves measuring the production and survival of seedlings beneath 10 mature forest trees (namely three matai, two kohekohe, two nikau, two hinau and one miro) in order to show assess the impact of had on the health of the forest. Brown's results from the first three year's monitoring show a dramatic increase in seedling production. The 1997 resurvey showed some similar patterns but also a few interesting observations. For the purposes of this report I have disregarded Nikau 2 study site as no counts were undertaken in 1995.

Using totals recorded for the three most commonly encountered species nikau, kohekohe and karaka, I found that there was a huge increase in seedlings between year 2 and 3, and a slightly lower increase between years 3 and 4 (Table 1).

TABLE 1. INREASE IN SEEDLING ABUNDANCE UNDER NIKAU, KOHEKOHE, AND KARAKA

SPECIES	1995	1996		1997	
	TOTAL SEEDLINGS	TOTAL	% INCREASE	TOTAL	% INCREASE
Nikau	c.105	394	375%	660	168%
Kohekohe	c.65	254	391%	239	94%
Karaka	6	52	867%	106	204%

Even in this pristine environment seedling survival is not 100% in all species, however the total number of seedlings from all species increased under each tree each year.

It took four years for some species to show up at all in the seedling counts. Kawakawa, hinau, *Coprosma grandifolia*, mapou and kaikamako all took four years to produce seedlings, even though with hinau the seedlings came from seed dropped only the previous season (Table 2).

There seems to be little correlation for most species between the adult tree and the seedlings produced beneath it. The major exception to this is nikau, which had large numbers of nikau seedlings beneath them. Kohekohe were the second most abundant seedlings but were virtually absent below the adult

kohekohe trees monitored. Elsewhere on the Island, it was common to see carpets of hundreds of karaka seedlings in areas containing no karaka. - This most likely illustrates the importance of pigeons in seed dispersal.

TABLE 2. NUMBER OF SEEDLINGS FOUND IN EACH STUDY SITE OVER THREE CONSECUTIVE YEARS AFTER KIORE AND WEKA ERADICATION.

MONITORED TREE	SEEDLING SPECIES	SEEDLING NUMBERS			
		1994	1995	1996	1997
MATAI 1	titoki	0	16	21	16
	kohekohe	0	8	60	16
	nikau	0	2	29	90
	karaka	few(<10)	3	21	39
	matai	0	0	0	0
	mapou				2
	five-finger				2
	pigeon wood				2
MATAI 2	kohekohe	0	10	20	20
	tawa	0	5	4	7
	nikau	0	5	10	12
	matai	0	0	0	0
	<i>Cop. grandifolia</i>				5
	hinau				3
	karaka				4
MATAI 3	titoki	0	many	27	32
	kohekohe	0	many	41	39
	pigeon wood	0	many	47	18
	nikau	0	few	3	13
	matai	0	seeds germinating	0	0
	mapou				7
	kaikomako				7
	karaka				9
KOHEKOHE 1	nikau	few	quite a few	36	124
	kohekohe	0	0	1	0
	pigeon wood	few	0	6	2
	karaka	few	0	2	1
	titoki	0	0	2	0
	<i>Cop. grandifolia</i>				4
	kawakawa				3
KOHEKOHE 2	nikau	0	4	79	53
	pigeon wood	0	0	2	5
	kohekohe	0	0	0	1
	kawakawa				9
	karaka				7

TABLE 2. CONTINUED

MONITORED TREE	SEEDLING SPECIES	SEEDLING NUMBERS			
		1994	1995	1996	1997
NIKAU 1	nikau	25	45	69	140
	kohekohe	0	5	7	12
	karaka	few	few	15	21
	titoki	0	0	9	10
	five-finger	0	20	25	42
	kawakawa				6
NIKAU 2	nikau	56	no count	151	189
	karaka	few	no count	9	8
	five-finger	0	no count	5	8
	kawakawa				8
	pigeon wood				2
HINAU 1	kohekohe	0	15	87	93
	nikau	0	10	152	203
	titoki	0	4	14	6
	karaka	few	0	11	15
	pigeon wood	few	1	16	12
	hinau	0	0	0 fresh seed fall	15
	<i>Cop. grandifolia</i>				3
	five-finger				2
HINAU 2	kohekohe	few	4	24	33
	nikau	0	0	9	14
	karaka	few	0	3	2
	tawa	0	0	1	0
	hinau	0	0	0 few fruit	2
	five finger				1
MIRO 1	nikau	no count	few	7	11
	titoki	no count	0	5	5
	kohekohe	no count	few	14	25
	tawa	no count	few	4	17
	miro	old seeds eaten	fresh seedfall	fresh seedfall	
	five-finger				18
	<i>Cop. grandifolia</i>				11
karaka				8	

# Guidelines for submission of manuscripts to Ecological Management

## INSTRUCTIONS FOR AUTHORS

### **Content:**

Ecological Management is a journal for conservation workers to present topical information applicable to the management of New Zealand species, habitats, and ecosystems. Appropriate articles include those describing results of management (including field trials and experimental management) and evaluations of existing or potential management approaches. Research results will generally not be published in Ecological Management unless there is a specific management focus.

### **Article length:**

Standard article (1500 to 5000 words); review paper (up to 7500 words); short note (up to 1500 words)

### **Manuscript structure:**

The structure of manuscripts submitted to Ecological Management varies widely, and may not necessarily fit into a standard format (i.e. Introduction, Methods, Results, Discussion). Most articles however, should at least have Abstract, Introduction and Discussion sections. For those new to the writing process, some brief notes on writing Abstracts, Introductions and Discussions are given below.

The abstract should state the purpose of the study or investigation, outline the procedures or methods used, present the main findings and principle conclusions (no more than 150 words). The introduction should present the nature and scope of the problem investigated; review the pertinent literature to orient the reader; and state the method of investigation. The discussion should present the principles, relationships, or generalisations shown by results. The results should be discussed, rather than merely repeat the results section. Exceptions and lack of correlations should be pointed out, and unsettled points defined. The discussion should consider the implications of the work, as well as any practical applications. The evidence for each conclusion should be summarised clearly, don't assume.

### **Submission of manuscripts:**

A hardcopy (two copies) of the manuscript should be forwarded to the Editor, Ecological Management, Department of Conservation, PO Box 10-420,

Wellington. Line spacing should be at least 1.5, with 3cm left/right margins, and text should be left justified. Tables and figures should be located at the end of the text (not inserted in the text), with captions clearly describing the material presented in the figure/table. Send clear copies of figures and tables (not originals).

### **Additional manuscript information:**

Authors may provide the names and addresses of up to three persons (resident within New Zealand) who would be qualified to review their manuscript. The identity of the reviewers will be kept confidential, and the editor reserves the right to select reviewers other than those named by the author.

## **INSTRUCTIONS FOR REFEREES**

A referee is asked to consider what contribution a paper makes to knowledge. Even though a referee may disagree with the author's opinions, the referee should allow them to stand, provided they are consistent with available evidence. When assessing a paper's suitability for publication in *Ecological Management*, criteria listed below are considered by the editor to be important. An answer/evaluation of each question is not required. All criticisms however, must be substantiated.

A recommendation on the manuscript's suitability for publication should be made in a covering letter to the editor, along with an assessment of the manuscript in relation to the criteria set out below. An additional page containing comments or recommendations for the author may be attached. Please do not make specific statements concerning the acceptability of the manuscript in comments for transmission to the author. You may write on the manuscript supplied. The anonymity of a referee will be preserved unless the referee wishes otherwise.

Referees are cautioned about being unduly negative in their comments. Where warranted a referee should identify particularly good aspects, in addition to constructive criticism.

### **Criteria for consideration**

#### ***Article content:***

Articles published in *Ecological Management* should present topical information applicable to the management of New Zealand species, habitats and ecosystems. Articles presenting results from pure research should not be accepted, unless written with a management focus.

#### ***Presentation***

Is the information presented in a logical sequence? Does the manuscript contain irrelevant material? Is it too brief for clarity, or could it be shortened? Does the Introduction provide a clear indication of the project aims and relevant background?

### ***Interpretation/Conclusions***

Are the conclusions justified? Consider whether the interpretation is adequate, not warranted by the data, or suffers from important omissions or loose generalisations.

Please note that *Ecological Management* is a technical bulletin. As such, we can be a little less rigorous in our demands for comprehensive justifications and bibliographies. This does not imply however, that errors of fact, or unjustified assertions should be accepted. Referees are asked to consider the value of the manuscript on this basis.