ECOLOGICAL MANAGEMENT

Number 1

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CONSERVATION
TE PAPA ATAWHAI

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DEPARTMENT OF CONSERVATION
THREATENED SPECIES UNIT

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Views expressed in this publication are not necessarily those of the Department of Conservation.

Address all comments to the Editor, Threatened Species Unit, Department of Conservation, P.O. Box 10-420, Wellington. Please follow the format in the following articles when submitting material for ECOLOGICAL MANAGEMENT, or otherwise contact the Editors. Send material either as an attachment on the DoC internal communication system or on a floppy disk (WordPerfect 5.1).

Cover designed by Cathy Jones

FOREWORD

The conservation management scene in New Zealand is characterised by resourceful and committed field managers addressing themselves to a selected range of conservation problems. While working towards the recovery of key species, these field managers have made important achievements and developed new techniques, innovations which will help a growing range of conservation programmes.

Some of the papers published here in ECOLOGICAL MANAGEMENT describe field techniques and findings useful for managers now and in the future. Other papers describe failures ... bright ideas that didn't work ... techniques and approaches no longer used or considered suitable by the Department for one reason or another. We think it's important that this knowledge be available for conservation managers to use and learn from.

As the array of conservation challenges and management techniques grows, it is increasingly important that effective dialogue amongst conservation managers is developed and maintained. Written dialogue - like spoken dialogue - reflects a wide range of voices and accents; we intend that ECOLOGICAL MANAGEMENT will be a forum for these voices of field operators and others working in differing circumstances and often under difficult conditions. The Threatened Species Unit has compiled this first issue to provide one place for field managers to share their experiences.

If support for this publication is demonstrated - through the submission of articles for further issues - it is proposed that two issues of ECOLOGICAL MANAGEMENT will be published annually. We welcome your suggestions and comments on ECOLOGICAL MANAGEMENT - on its contents and its scope. Its continued survival past this first issue will be totally dependent on your support. I am hopeful that ECOLOGICAL MANAGEMENT will constitute a significant contribution to conservation biology in New Zealand and elsewhere.

Alan Saunders
Manager, Threatened Species Unit

PROTECTION MEASURES FOR MISTLETOES IN TONGARIRO-TAUPO CONSERVANCY

Cathy Jones
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ABSTRACT: Mistletoes – *Peraxilla* and *Tupeia* species – are gradually disappearing from the Tongariro/Taupo Conservancy. About 250 specimens, noted in 1990, were checked out; where possible, inexpensive possum protection has been put in place to protect the surviving plants.

In 1990 it was realised that red mistletoes were no longer a visible component of the forests of the Tongariro/ Taupo Conservancy in the way that they used to be. One magnificent specimen near the Chairman's lodge at Whakapapa still flowered every year because Department staff kept a possum trap under its host tree, but all the rest seemed to have disappeared over the preceding five years or so. It was decided to try to find previously known specimens in an attempt to discover what had happened to them.

Survey

Past records of *Peraxilla colensoi* (in the Kaimanawa Forest Park and near Ohakune), *P. tetrapetala* (in Tongariro National Park at Whakapapa and near Ohakune) and the green-flowered *Tupeia antarctica* (along the shore of Lake Taupo at Pukawa and Omori) were followed up and in most cases the plants were found to be still present. All three species were suffering from heavy possum browse, some individuals more than others.

Surveys were conducted close to tracks for three reasons: siting of the majority of past records, ease of access, and maximising public appreciation of the problem and (we hoped) of the positive results of management. University students were employed to survey more widely in the areas where plants still occurred. Surveys were intensive with every tree being inspected in detail. Binoculars were necessary for finding *Peraxilla colensoi* as it grows well up on silver beech trees. The other two species could generally be seen with the naked eye from the ground. Staff very quickly developed their spotting skills.

More plants were found than was originally expected but many of these were browsed right back to the bark of the host tree. Very few were flowering and even fewer (mainly *Tupeia*) were producing mature fruit. The plants were tagged and documented to provide a baseline for monitoring the effects of proposed management. Less accessible areas will be covered at some time in the future.

Management

Three forms of management have been used:

(i) **Planting host tree species.** This is being done for *Tupeia antarctica* because several of the hosts (*Pittosporum tenuifolium*, a relatively shortlived species) have reached or are approaching the end of their lives. There is a high chance that these new trees will be "infected" with mistletoe by natural means as some of the plants still fruit prolifically. It was assumed that the seeds are moved to new hosts by birds, but a new hypothesis suggests that geckos are also a possible agent of dispersal.

(ii) **Setting traps at the base of host trees.** This is possible only where staff have easy, frequent access or where local residents have volunteered to help. Timms traps have been used.

(iii) **Collaring host trees.** This seems at present to be the most useful form of protection as it does not require constant surveillance. For isolated hosts a single collar is sufficient. In many instances it is difficult to isolate the host and it may be necessary to collar neighbouring trees or to do some judicious pruning. Collaring the host trunk above and below the mistletoe may remove the need for isolation, provided that possums can not jump down onto branches from above. A description follows of the collaring method used.

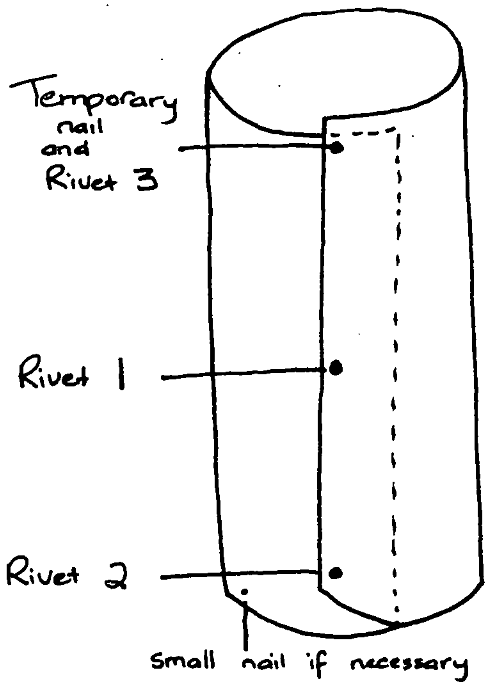
Materials and Tools

Foil, 0.55 mm thick, bought by the roll from local power authority. It is also possible to use offset sheets from the local printer – that is, the thin metal plates used in small rotary presses. These have some disadvantages – set size which is too small for many hosts, too malleable – and some advantages – they may be available at no cost.

Hammer, tin snips, rivet gun, rivets, 100 mm or 150 mm nails, ladder, secateurs, pruning saw, chainsaw, measuring tape. Rivets have strong advantages because they do not provide footholds for possums and they can be pulled apart and replaced as the tree expands. They also minimise damage to the host trunk.

Method

Measure trunk, allowing for bumps, slight curves etc. Cut foil. You should have at least 7 cm overlap (allowing for re-riveting as tree expands) and the collar should not be too tight. Place foil around trunk. Hammer temporary 100 mm or 150 mm nail a little way in at



top to hold foil and create hole for last rivet. Use another nail to make rivet hole in middle position, insert rivet. Make hole at base and insert second rivet. Remove top nail and insert last rivet. If necessary insert one smaller nail at base of foil away from join to hold collar in place. This should sit flush with the foil but allow room for the tree to expand inside the collar.

AVOID CREATING FOOTHOLDS FOR POSSUMS!

The works supervisor of our local power authority warns that collars must be curved and not bent through sharp angles. They have experienced possums climbing over collars which have been bent to fit around square powerpoles. He suggests using four rivets rather than three but says any more than that can be used by the possums as a ladder. They are working on a cone-shaped guard which protects powerpoles well but would not allow for variations in tree size and shape. Another disadvantage of this design is that the cone is filled with Indurathane (a two-pot resin mix) to hold its shape and stop it moving in the wind.

It is a real challenge for us to come up with a less clumsy, more efficient collar which is sufficiently adaptable to fit any size of tree and to cope with lumpy trunks.

Note: Hawkes Bay Conservancy have been protecting some of their mistletoes with wire netting. Contact Phil Mohi at DoC's Puketitiri Field Centre (R.D. 4, Napier) for details.

Pinus contorta CONTROL IN THE CENTRAL NORTH ISLAND

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ABSTRACT: Efforts to control *Pinus contorta* in the central North Island need to continue another ten years to ensure that only isolated seedlings remain. Existing cooperation between government agencies and volunteer groups needs to be maintained.

Central government agencies, acting with the best intentions, were responsible for the introduction of *Pinus contorta.*

Plantings took place in Karioi State Forest on the southern slopes of Mount Ruapehu between 1925 and 1935. By the early 1930s, as a result of extensive failings of early *Pinus radiata* plantings, *P. contorta* was established as a better species for the local climate.

Other plantings took place within the Waiouru Military Reserve (1939-1940), within the Erua State Forest and shelter belts between National Park township and Erua, and within the Karioi, Ruanui and Erewhon Ridings. During the 1960s the Department of Lands and Survey established *Pinus contorta* as wind breaks on land development projects throughout the Waimarino and Rangitikei districts. As late as 1967 the Justice Department were actively planting *Pinus contorta.*

These plantings took place without the realisation of the economic and ecological damage that would occur.

The problem

Pinus contorta is a plant that has adapted rapidly in the region as a vigorously growing tree sourced from wind thrown seed produced by the historical plantations. It grows comfortably to an altitude of 2,000 metres and also has the following characteristics:

* Trees cone and seed within five years;

* Seeds can stay viable for up to eight years;

* Seedlings are prolific. During a full botanical survey of the Tongariro National Park undertaken in 1962 by Dr I Atkinson, sightings of up to 121,000 stems per hectare were recorded.

He concluded that unless control measures were taken, most of the upper slopes of Mount Ruapehu between 1,350 and 2,000 metres would be covered by pine forest or pine scrub by the end of the century.

The above features mean that the plant has the potential to establish readily and spread rapidly; it is imperative that any control programme recognises the importance of wind thrown seed sources.

Pinus contorta will have a major impact on the ecological, economic and management values of:

1 **The Tongariro National Park:** The present alpine ecology will be completely modified. Multi-aged exotic plantations will blanket the existing alpine environment;

2 **The Department of Defence Training Ground at Waiouru:** It will render

the Waiouru Army Training Ground inoperative for defence training;

3 The Kaimanawa, Kaweka and Tongariro Conservation Parks: As in the Tongariro National Park it will compromise the ecological and economic values of the Kaimanawa, Kaweka Forest and Tongariro Conservation Parks, including the wilderness areas between the Waiouru Army Training Ground and the Kaweka Forest Park.

It will make the establishment of productive forests in the area difficult and very expensive.

Realisation of the problem

First recorded concerns were noted by various agencies in the late 1950s. In 1962, Atkinson's quantification of the spread of *Pinus contorta* was the key factor in the Park Board initiating a total commitment to the removal of *Pinus contorta*. Early caution for contorta eradication came from a number of professional foresters who could not accept that the spread was as serious as claimed. Some saw the natural spread and development of a *Pinus contorta* forest as being of considerable potential economic value to the country. This strong opposition from foresters was a problem as many people accepted their professional opinion as a valid argument against the removal of *Pinus contorta*.

Opposition to the removal of pines also came from senior Army officers who saw the trees within the Waiouru Army Ground as an advantage for training, as they would provide ground cover, shelter and shade for exercise.

However, it became rapidly apparent that if not controlled, Army lands would be so thick with *Pinus contorta* that they would be useless for training, as well as becoming a major fire hazard. Professional foresters came to accept that *Pinus contorta* was causing a problem through uncontrolled spread throughout the central North Island.

By the mid 1970s the New Zealand Forest Service and Defence Department had joined Tongariro National Park staff in carrying out control work, but authorities who were controlling *Pinus contorta* were frustrated by the lack of action by other authorities.

Establishment of *P. contorta* co-ordinating committee

The Waimarino County Council called a meeting of District Noxious Plants Authorities and other interested parties on 21 April 1982. The following agencies attended the meeting:

- Waimarino District Noxious Plants Authority
- Taumarunui District Noxious Plants Authority
- Rangitikei District Noxious Plants Authority
- Taupo District Noxious Plants Authority
- Lands and Survey Department
- Rangitikei/Wanganui Catchment Board
- Ministry of Defence
- New Zealand Forest Service

The meeting had occurred at the request of the Department of Lands and Survey who were concerned at the effect of *Pinus contorta* on the ecology of Tongariro National Park.

Major concern was expressed at the spread of *Pinus contorta* in the Maori blocks above Karioi Forest. Central government funding was requested.

Pinus contorta was declared a Class B Noxious Plant as a result of this co-ordinated approach and the subsequent central government funding of control measures did much to reduce the amount of *P. contorta*.

Figure 1. Removing Pinus contorta in the National Park, 1982. Photo: Department of Conservation.

Control methods

The control strategy in Tongariro National Park that was developed in 1962 and which has been followed ever since was to divide the park into zones and to ensure that each zone was reworked on a four year cycle. The success of the strategy is evident from the low level of cost required in 1993 to ensure that *P. contorta* is controlled in Tongariro National Park. In the adjacent Army land the control cycle has been longer than four years and there are strong indications that the success of long term removal is less likely and that the annual cost per hectare is higher. Unfortunately, there is insufficient data available to prove this claim. Scientific research indicates that trees can flower and produce cones at 2-3 years old but that most plants do not until they are older. Peak cone production of fertile seed is not produced until trees are 6-8 years old. There have been many methods used over the years including a variety of chemical trials, roller crushing, roller crushing and burning, and burning.

Chemical application has not proved particularly successful, has been costly and ecologically damaging. As a result of these factors, there has been no extensive application of chemicals for *Pinus contorta* control. Roller crushing and burning have also not proved successful. Other alpine plants have been destroyed and the viability of seeding increased by the roller crushing and, in particular, by burning.

The Manawatu/Wanganui Regional Council have recently chemically sprayed a herbicide (Hyvar) and burnt a live firing zone (Zone 12) on Defence land. The results appear more satisfactory than previous trials. The *Pinus contorta* was very dry when fired and the fire was especially hot. However, the cost of the operation was high and the ecological impact is still to be determined. It is possible that other weeds such as hieracium and heather will thrive in the regeneration.

The most successful method has been to remove the *P. contorta* by hand. Large trees are cut by chainsaw, trees less than 75 mm diameter are cut by heavy pruners or axes, and small trees are pulled by hand. Unless all the 'leaders' are cut as low as possible and the stump debarked with an axe, trees will regrow. Quality control is an essential element.

Tendered contracts have proved most successful for cutting dense or mature pines. The contracts must have good quality control with a maximum allowance of stems per hectare left to ensure a re-work is not required by the contractor. In more remote areas where the trees are less dense, volunteers have been particularly valuable. Volunteers have been used since 1962.

Most effort by DoC has been applied to the southeast of the Tongariro National Park above the Waiouru Military Reserve and the Karioi Forest (adjacent to the Rangipo Maori land). It is this effort that has enabled the introduction of a buffer zone to prevent heavy infestation in the remainder of the park. In the beginning a contract rate was paid to volunteers - mainly tramping clubs but this has now evolved to a transport subsidy payment for each member attending. To give an indication of the impact from volunteer groups in the period 1 April 1982 to 31 March 1986, 22,464 volunteer hours were recorded.

The prime value of volunteers however is their enthusiasm. This enthusiasm, by people who are committed to the removal of *P. contorta* and protection of the park, has been of immense value to park staff and other groups involved in the removal of *P. contorta.* They have never lost optimism.

As volunteers become successful in removing most trees from within the national park boundary they have been utilised further in the adjacent Defence Department land and in particular the upper reaches of the Rangipo Maori blocks.

Helicopter control commenced in Tongariro National Park in 1971. The helicopter is used to sight trees and to transport staff armed with pruners, axes and slashers to individual trees. It is the most successful and economical method in areas of low infestation and at higher altitudes (up to 2,000 m). This method has prevented the establishment of seed trees throughout the park and minimised areas of dense infestation. Each area of the park (zone) is flown on a four year cycle with the objective of preventing the establishment of seed trees. It has been an annual operation for the last 15 years with a slowly decreasing amount of helicopter use. At this stage about 20 hours per year is required. At various times employment projects have been utilised in order to supplement the work. The biggest thrust occurred in 1981 to 1983 when large groups were used on *P. contorta* control. For example in 1982/83, much of the PEP (Public Sector Employment Programme) funds available for weed control were spent on *Pinus contorta* control. In addition to these methods staff have spent countless hours removing trees in the course of other duties.

Costs

In recent years costs within the national park have been reduced as *P. contorta* has been brought under control, so the emphasis has been shifted to adjacent conservation land at Erua and Tongariro forests and more recently to the Rangitaiki area. Expenditure in the Kaimanawa Forest Park has always been modest because managers were able to benefit from experience in Tongariro National Park and on Defence land at Waiouru. Early removal of seedlings has presented no major problems. The situation is not as promising in the Kaweka Conservation Park where control programmes have been slow to gain momentum.

Present situation

The programme to date has made major progress towards *Pinus contorta* eradication but it is vital at this stage that the removal of remaining seed source plants is recognised as holding the key to success. Due to the nature of *Pinus contorta* as a vigorous self-seeding plant with a short regeneration interval, control resources will be continually taxed if sources of wind thrown seeds are not eradicated. The major areas of seed source are:

1 Karioi Forest: The purchasers of Karioi Forest are committed to the removal of mature stands by 1994/95. Regeneration is still a concern to the Department of Conservation.

2 The Army Training Ground: Two years ago the Defence Department removed existing stands in Zone 11 (a live firing zone). The major concern in the Army Training Group is that the *P. contorta* control programme cycle appears to be one or two years slower than desirable - many young trees are bearing seed before they are destroyed.

3 The Comet Range within the Kaweka Forest Park: Work has been slow to get underway in the Kaweka Forest Park to remove trees that were grown to slow erosion.

4 Shelter belts in the Ohakune, Waiouru area: Local authorities appear reluctant to take hard attitudes with land owners who are reluctant to move trees until they are mature.

5 Maori land: Maori land is a special problem. The Maori owners of land at Karioi, Rangipo and Rangitaiki do not wish to dispose of this land and have no plans at present for its use. The altitude here may prevent forestry or farming development. The spread of *Pinus contorta* is not currently perceived as having a noticeable effect on the cultural value or 'mana' of the land. In the past, work has taken place on these lands with the assistance of central government funding and in the case of Karioi and Rangipo, volunteer labour.

Conclusion

A continual effort for a further ten years will ensure that only isolated seedlings remain. It will then be simple to ensure that a new spread is prevented. After ten years, limited plants will remain and each land owner should easily be able to control their own re-seeding. In Tongariro National Park and Kaimanawa Forest Park the plant is well under control. Periodic helicopter support and volunteer ground parties will be required for many years but on a decreasing scale.

A major programme for removal is required in the Kaweka Conservation Park. In the last two years seed trees have been removed in Erua and Tongariro forest. The situation has been improving in Karioi Forest each year and all seed trees can be removed within the next two or three years. Throughout the central North Island in areas such as Karioi and the Defence Department land, a major effort will be required to remove seedlings for the next ten years. If this can be achieved, further control for all land owners should become a minor task.

Local authorities need to continue to press land owners to remove shelter belts and assistance from the Crown and local authorities on Maori land is required to ensure that progress or removal is continued.

Respective local authorities need continuous encouragement to ensure that private land owners remove the last of the *Pinus contorta* in the region.

The consequences of a breakdown in control measures will be the rapid re-establishment of *Pinus contorta* and a loss of the conservation and other values the programme seeks to protect.

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ERADICATION OF NORWAY RATS AND RABBITS FROM MOUTOHORA (WHALE) ISLAND, BAY OF PLENTY

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ABSTRACT: Norway rats (*Rattus norvegicus*) and rabbits (*Oryctolagus cuniculus cuniculus*) were eradicated from the grass, forest and shrubland covered Moutohora (Whale) Island (143 ha) in the Bay of Plenty using sodium monofluoroacetate (compound 1080) coated carrot and the anticoagulant poison "Talon 20p" (Brodifacoum).

Until the Moutohora eradication programme started in August 1985, indications from other island eradication programmes were that total removal of rats and rabbits was difficult if not impossible to achieve on large islands (Yaldwyn 1978; Wildlife Service 1981; Veitch and Bell 1990). Rats had previously been removed from New Zealand islands up to 22 ha in size but these operations had been costly and protracted. Rabbit eradications were much the same with few successes being achieved in New Zealand, except on islands of small size or with minimal rabbit habitat.

Moutohora was purchased by the Crown in 1985 in recognition of its potential as a site for marooning threatened species (New Zealand Wildlife Service file 1985). The island was also significant for the large colony of grey-faced petrels (*Pterodroma macroptera gouldi*) estimated to be of around 40,000 pairs (Imber 1969). Therefore removal of introduced animals was highly desirable.

The New Zealand Wildlife Service had a significant association with the island prior to purchase. The island was declared a Wildlife Refuge in 1965 to protect the dwindling grey-faced petrel stocks from harvest (Imber 1971). At the same time a goat control programme was initiated which resulted in eradication in 1977 (Veitch and Bell 1990). Grey-faced petrel monitoring was begun in 1968 (Imber 1969, 1971) and has continued on a yearly basis. This work has shown that significant improvement to habitat quality and petrel survivorship could be achieved through the removal of mammals from the island (Imber 1971, Ogle 1989). In 1991 an overlying status of Government Purpose Wildlife Management Reserve was placed on the island, to control public access and thus reduce the risk of fire.

Rabbit control had been conducted by various agencies on Moutohora since 1973 (Pedersen *et al.* 1973) but it was not until the purchase of the island in 1985 that a serious attempt at eradication was undertaken.

Site description

Moutohora Island lies approximately 10 km northeast of the Whakatane Harbour entrance and rises steeply from the sea (Figs 1, 2). It is a fragment of the rim of an extinct volcano (Ramsey and Hayward 1971). The northern side of the island is predominantly cliff face falling nearly 300 m from the summit directly into the sea. Vegetation on the cliffs is sparse, being mainly large pohutukawa (*Metrosideros excelsa*). The southern slopes of the island are reverting exotic grasslands containing manuka (*Leptospermum scoparium*), pohutukawa

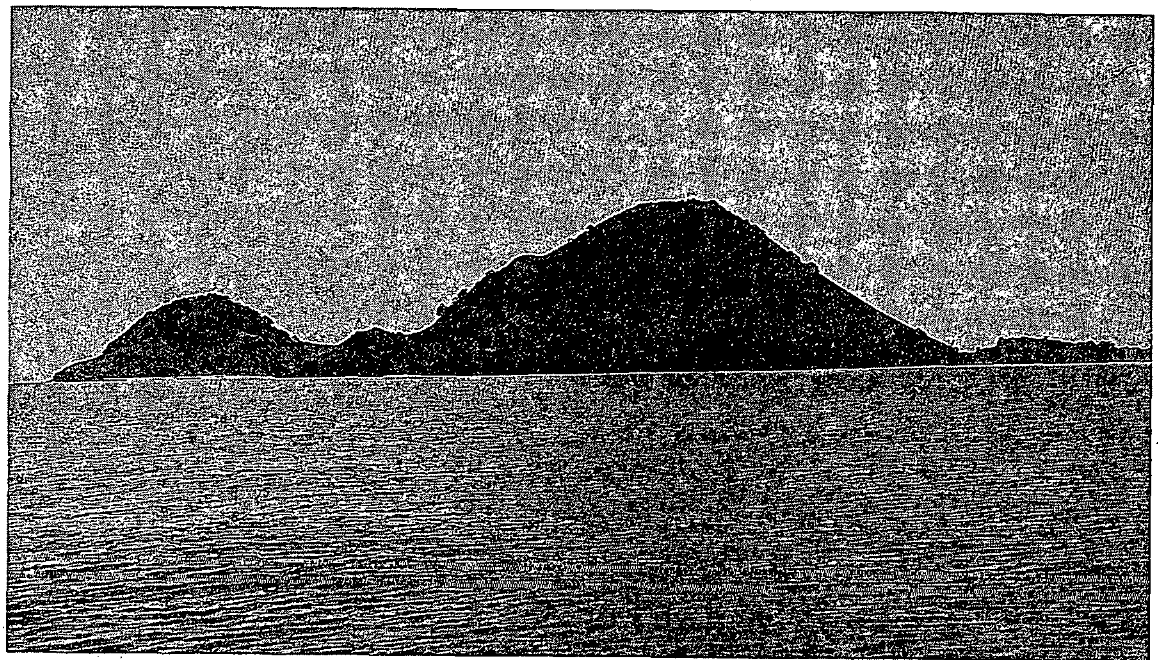


Figure 1 - Moutohora (Whale) Island from the south. Photo: Mike Imber.

and bracken (*Pteridium esculentum*). Small areas around the summit and on the western side of the island have more advanced forest containing mahoe (*Melicytus ramiflorus*), whau (*Entelea arborescens*), puriri (*Vitex lucens*) and five-finger (*Pseudopanax arboreus*).

The island's area is gazetted as 143 ha, though a recent estimate using a planimeter suggests the island is some 20 ha bigger (Taylor 1989).

Methods

Two methods were used in the eradication:

1: Broadcast of toxin by hand and aircraft.

2: Trapping with the Lane's Ace Gin steel jawed leg-hold trap (Fig. 3).

Several applications of poison were used during the operation, beginning in 1985 and ceasing in 1987. All baits were dyed green to avoid non-target species mortality.

Traps were used successfully to capture two rabbits in the sand dune area behind Boulder Bay near the completion of the programme on 15 July 1987. The table presents the methods and dates of operations of the programme.

Monitoring

Monitoring of the success of each phase of the eradication was predominantly by observation. For example, after the 12 August 1985 1080 toxic carrot drop, the Bay of Plenty Pest Destruction Board and Wildlife Service staff stated "A good kill - very low numbers of rabbits remain - reduction in rat numbers noted" (NZWLS files 1985). There is no mention of the techniques used to formulate these conclusions.

On 2 September 1986, during ground and aerial sowing of poison, rat sign was noted in the rock jumbles adjacent to the summit track (P Jansen, G Murman, pers. obs.). This was the last record of rat sign on the island (see Fig. 4).

On the December 1986 expedition rabbit sign was noted at seven sites around the island (Fig. 2). On the same expedition, despite intensive searching around the hut sites, rubbish pit and amongst the rock jumbles along the summit track, no rat sign was encountered.

Until this point searches for rabbit and rat sign were subjective, favouring sites perceived to be preferred habitat of these species. To put more rigour into confirming whether eradication had been achieved, a formal grid search was undertaken on 5 May 1987. The island was divided into 12 manageable sectors of approximately the same size and then searched along transect lines. Stations were spaced at 25 m intervals. Each station was carefully searched for faecal pellets, scratching, rodent burrows or feeding sign. An approximate area of 6 m^2 was searched at each station. A total of 1331 stations were searched in this manner. The only area which was not searched was the precipitous northern cliffs. Fresh rabbit sign was found in three locations during this search. A common theme to all three areas of sign was the arid nature of the sites. All these sites had been liberally treated with Talon 20p on the 4 December expedition. One hundred and ninety rodent trap nights (corrected figure per Moors and Cunningham 1983) and 96 vegetable oil impregnated indicator sticks showed no sign of rodents during this four day exercise.

Results

Both rabbits and rats were eradicated. Only two rabbits were removed by methods other than poison (trapping). These may well have been the last rabbits;

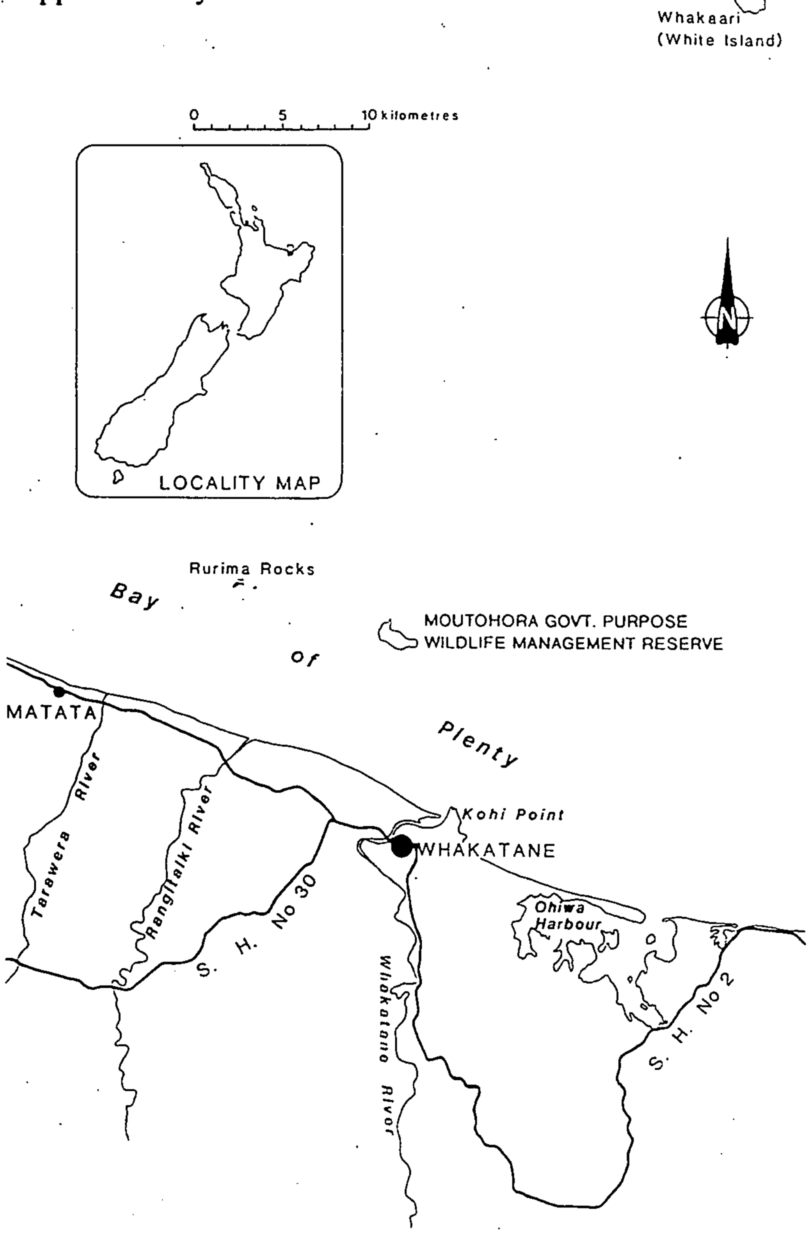


Figure 2 - Locality map of Moutohora Government Purpose Wildlife Management Reserve.

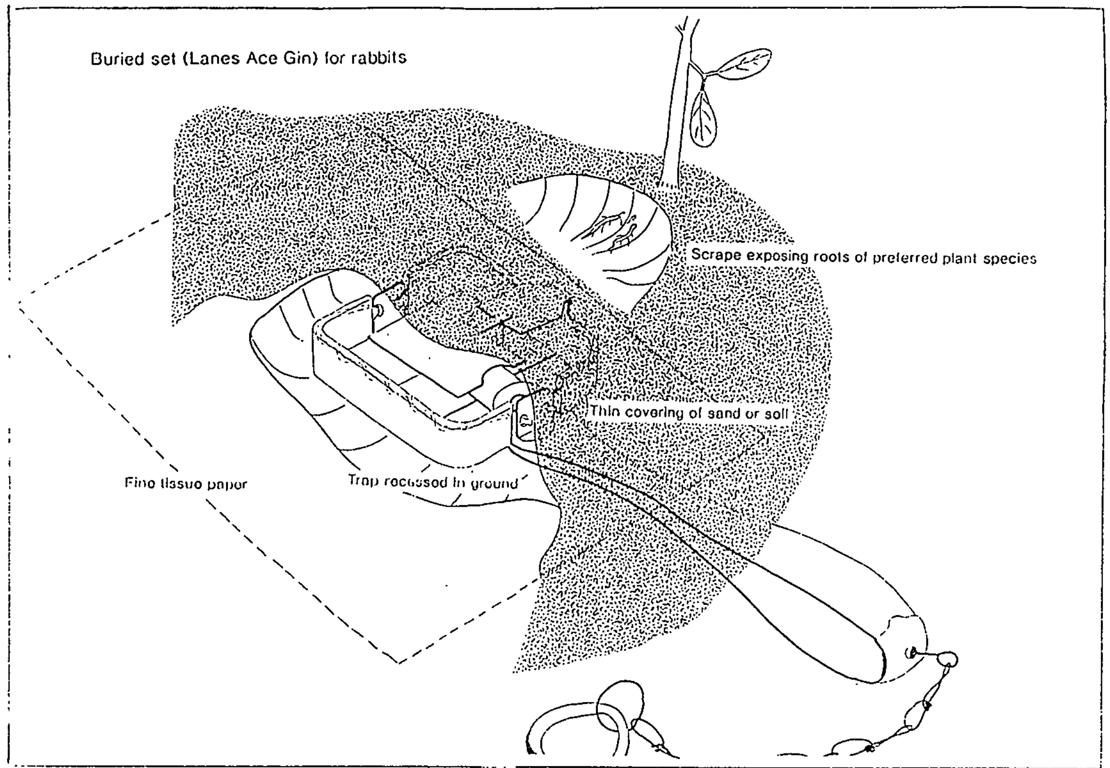
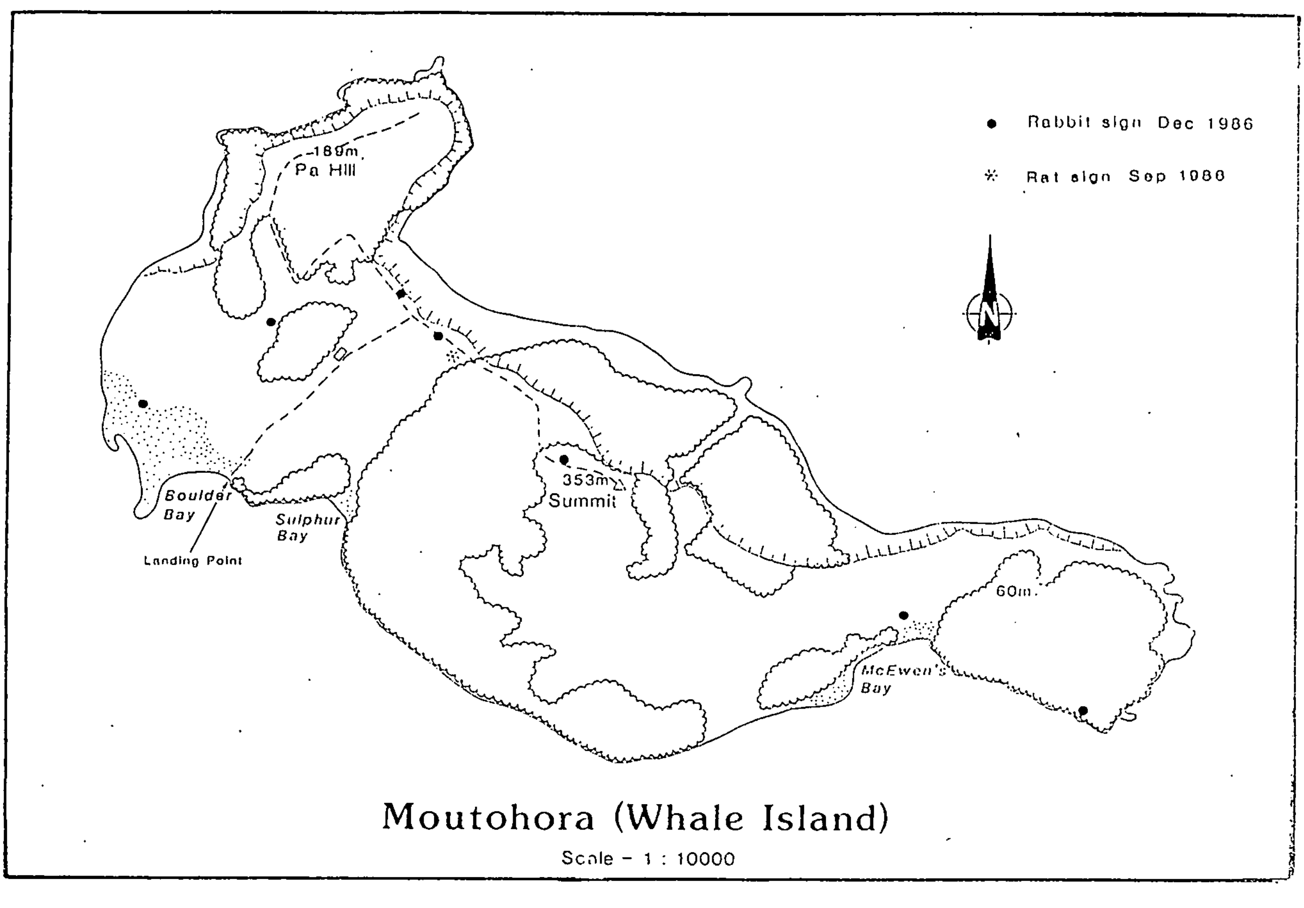


Figure 3 (above) - Lane's gin trap. Figure 4 (below) - Rat and rabbit sign, Moutohora.



Date	Toxin	Bait	Application rate	Application method
05-08-85	-	carrot	17.5 kg/ha whole island	Fixed wing aircraft
12-08-85	1080	carrot	22 kg/ha whole island	Fixed wing aircraft
30-09-85	Brodifacoum 20ppm	Talon 20p	50 kg in areas of rabbit sign	Broadcast by hand
18-05-86	1080	pollard	425 kg	Broadcast by hand
02-09-86	Brodifacoum 20ppm	Talon 20p	2.4 kg/ha whole island	Helicopter with under slung bucket
02-09-86	Bromodia-lone	Rentokil Rid Rat wax block bait	100 kg over whole island	Placed by hand to control rats during Grey-faced petrel fledgling period
02-09-86	Bromodia-lone	Strawberry jam	20 litres	Placed in "spits" in areas of persistent rabbit sign
04-12-86	Brodifacoum 20ppm	Talon 20p rabbit bait	50 kg in areas of rabbit sign	Broadcast by hand along summit track sand dunes and McEwens Bay
15-07-87			6 traps in sand dune and sulphur gully area (see Fig. 3)	Gin traps disguised and buried placed near "scratchings"
16-07-87		carrot	2 kg/ha whole island	Fixed wing aircraft
21-07-87	1080	carrot	12 kg/ha whole island	Fixed wing aircraft
01-09-87	Brodifacoum 20ppm	Talon 20p with fish lure	6 kg/ha whole island	Helicopter with under-slung bucket

however, this is difficult to confirm as a toxic carrot operation over all the island was conducted six days later.

Rats were not initially targeted, and their eradication was certainly not contemplated, as it was thought that eradication of rodents from islands of this size was impossible. It was not until rat numbers were only incidentally observed to be very low in the May 1986 search that efforts were made to complete their eradication.

Discussion

The rat and rabbit numbers were significantly reduced as a result of Compound 1080 coated carrots being applied to Moutohora. Rat sign did not disappear until after an application of Talon anticoagulant poison was applied to the island.

Rabbit sign still persisted in three areas in May 1987 despite heavy applications of Talon poison at these sites. It appears that the rabbits at these locations did not eat the toxin (as opposed to their becoming immune), as the faecal pellets did not contain the characteristic green dye from the bait formulation. The rabbits at these three locations were exposed to fresh cut carrot in May 1987 which was taken readily. Rabbit "take" as opposed to other disturbance was gauged by the presence of supportive sign such as foot prints, droppings etc.

The acceptance of carrot would discount a neophobic reaction to the toxic baits (Barnett 1975). Bait shyness was not an issue, and death occurred four to eleven days after consumption of a lethal dose.

The arid nature of these three sites was perhaps why the dry Talon bait was rejected and the fresh carrot consumed. Merton (1987) noted during the Round Island eradication programme (on an extremely arid site in the Indian Ocean) that a small number of rabbits did not consume the Talon 20p rabbit bait. This phenomenon should be investigated further.

From the intensive sign search in May 1987, only three very confined areas of sign (which were considered to represent only three animals) were discovered. Only two traps were set at each of these sites. Within two days a rabbit had been caught at two of the three sites. Trapping was stopped at the third site two days later.

Searches for rabbit sign stopped about one year after the last toxic drop. Rodent monitoring is an ongoing process (as a contingency against re-introduction). Over 3000 rodent trap nights, plus apple lures, have been conducted on a 64 site trap line at the time of writing.

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ERADICATION OF KIORE FROM MOTUOPAO ISLAND

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ABSTRACT: To protect an endangered flax snail from predation, a successful kiore eradication programme was begun in 1990. This was a ground-based operation using 'Rentokil' bromadiolone baits.

Motuopao Island lies 500 m northwest of Cape Maria van Dieman at the northwestern tip of the North Island. Abandoned as a lighthouse station in 1951 it now forms part of the Te Paki reserve complex, presently managed by the Department of Conservation in Northland.

The island covers 30 ha, and the hills at either end are separated by a low sandy saddle which divides the island roughly in half. Access across this saddle to the western shore is straightforward; however, steep cliff faces around much of the rest of the island restrict access from the hills to the shore and around the shoreline.

An open, often rough channel of water flows between the island and the mainland, and access by boat can be treacherous at times. A steep, open sand beach, which faces east towards the mainland is the only suitable landing site and fair weather is required.

Large areas of buffalo grass and dense pockets of flax dominate the island's vegetation with occasional patches of taupata growing around the coastal faces of the southern and northern ends of the island. Other components of the vegetation include *Coprosma acerosa*, *Muehlenbeckia complexa*, other grasses, rushes and spinifex (see map).

On a visit to the island in 1982, staff of the former Wildlife Service had observed rats gnawing on seabird carcasses, and the presence of kiore was suspected. A return visit to the island in 1989 by DoC staff established that kiore were preying on flax snails, as the radula of a flax snail was found in the stomach contents of a trapped kiore. This was of concern as flax snails were known to be very few in numbers on the island (estimated at less than 10 individuals) and in addition, small nesting seabirds – in particular white-faced storm petrels and diving petrels – which are vulnerable to kiore predation had been found.

In August 1989 a work plan for the removal of kiore was written, with the eradication planned for October 1990. The first visit to the island for the eradication was made by boat; however, because of the unpredictable nature of the sea conditions, a helicopter was used to transport field staff and equipment once the operation began.

Methods

The island was divided into six roughly equal sections and labelled A-F. Staff were assigned to each section to be responsible for the laying out, loading and monitoring of poison stations over the course of the operation.

Stations comprised 'Novacoil' 110 mm drainage pipe, cut into 400 mm lengths and laid out at approximately 50 m intervals over all accessible places on the island. These were each given a unique number, and their location was

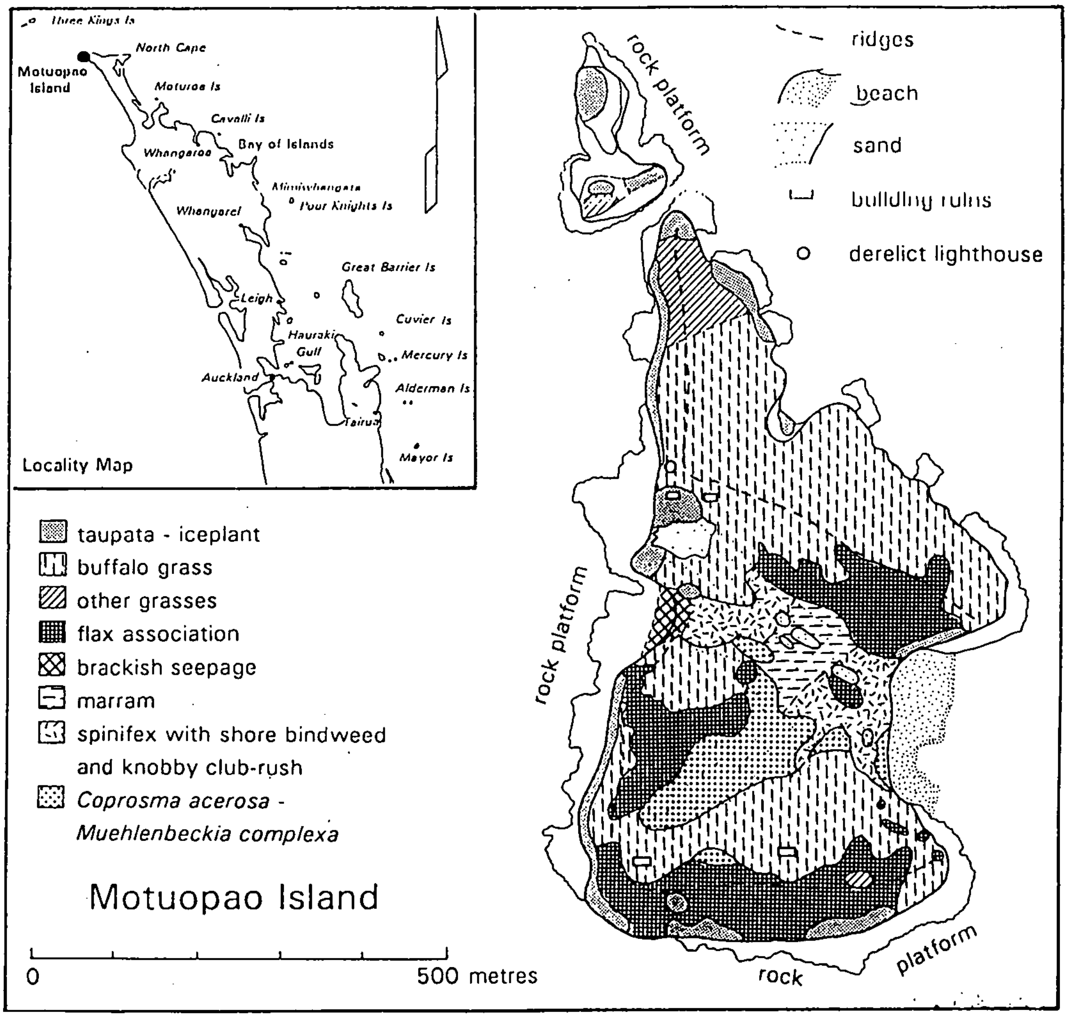

Figure 1 - Vegetation types of Motuopao.

marked on the ground with coloured flagging tape.

To encourage kiore to visit the stations before laying toxic bait, pre-feeding was carried out using 35 gm of non-toxic kibbled wheat placed in a small aluminium pie dish in each station. Stations were checked and restocked with kibbled wheat over the next three nights. On the fourth day, pie dishes were filled with 'Rentokil' kibbled wheat laced with bromadiolone (0.005% w/w). In addition, two 'Rentokil' wax baits containing the same concentration of toxin were placed one at either end of the station. Stations were checked again on the fifth day and restocked with poison. Each day poison was laid, wax blocks were thrown over the steep, inaccessible bluffs. A return visit was made to the island ten days later, and all stations were rechecked. From this time on non-toxic lures – e.g. chocolate and cheese – along with snap traps were used to check for the presence of kiore. The last visit to the island was in January 1992. Kiore were not known to be on the rock stack just north of the island: nevertheless, some poison was laid in stations here while the first few days of poisoning was completed. It remained untouched and was removed by staff after a few days.

Results

Following the first two nights of pre-feeding in October, 45% of stations were being visited by kiore. Kiore pellets inside the stations were common and wheat had been consumed from the pie dishes. By the fourth night, 77% of stations were being visited with some kiore in the buffalo grass nesting close to the stations and feeding at regular intervals on the kibbled wheat. On the first return visit ten days after the initial poisoning, rodent sign was observed in 98% of stations. All stations were thoroughly cleaned out and refilled with toxic kibbled wheat, and the following day kiore sign was seen in 14% of stations. All stations were cleaned again and restocked with toxic kibbled wheat and two wax baits.

A visit the following February noted old droppings in some of the stations; however, snap trapping and the use of non-toxic lures gave no indication that kiore were still present on the island. No fresh kiore droppings could be found and stations were restocked with poison wax blocks. During the next visit in November, a single old dropping was found in one station and was confirmed as being kiore by Ian McFadden (DoC Science & Research Division). Again the use of snap traps and non-toxic lures did not indicate any presence. At this stage, re-stocking of poison stations ceased.

The last visit, made in January 1992, also used snap traps and a variety of lures – including soap, candle wax and bacon rind; no kiore were detected. Given the time span between the 1990 and 1992 visits, any surviving kiore capable of breeding should have done so, and young kiore should have been relatively easy to catch or detect using snap traps and non-toxic lures. However, no kiore can be found and we are now confident that they have been eradicated from Motuopao. Although reinvasion by rodents is an unlikely scenario, a small number of stations have been set up permanently along the dunes behind the eastern shore of the island and stocked with wax baits.

ERADICATION OF MICE FROM ALLPORTS AND MOTUTAPU ISLANDS

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ABSTRACT: The presence of mice (*Mus musculus*) is a bar to restoration of natural ecosystems on islands. The paper describes the 1989 eradication programme using 'Storm' poison baits, which was one of the first attempts to eliminate mice from a New Zealand island.

Allports and Motutapu islands (Fig. 1, Map 1) are both scenic reserves, situated within the Marlborough Sounds Maritime Park. The islands are approximately 7 km northeast of Picton in Queen Charlotte Sound, and are 16 ha and 2 ha in size respectively. At the nearest point Allports Island is 1.3 km from the mainland. Motutapu is an equal distance from the mainland and separated from Allports by an 80 m wide channel. Both islands are moderately steep, Allports Island rising to 79 m a.s.l. and Motutapu to 40 m.

The islands were extensively cleared of their original vegetative cover either during Maori occupation of the islands (numerous pits and terraces remain as evidence of habitation) or during the subsequent use of the islands for farming. By the turn of the century the islands were virtually denuded as can be judged by part of a letter dated 28 October 1901 from the then Commissioner of Crown Lands to the Surveyor General - "there is a little scrub on it [Allports] but the greater portion is open grass with a little fern ...."

The islands were used for sheep and goats until 1913 when the grazing lease stopped and the islands were reserved. They were officially gazetted as Scenic Reserves in 1927. Since grazing ceased the vegetation has regenerated well and is now at a mid-to-late seral stage.

On Allports Island (Map 2) there are small pockets of kohekohe (*Dysoxylum spectabile*) and mahoe (*Melicytus ramiflorus*) forest occurring in gullies and sheltered faces but in most areas manuka (*Leptospermum scoparium*) is still the dominant species, especially on northern faces and on ridges. A multitude of broadleaved species including five-finger (*Pseudopanax arboreus*), mahoe and kohuhu (*Pittosporum tenuifolium*) are rapidly overtaking and replacing the manuka.

As regeneration continues, it is expected hinau (*Eleocarpus dentatus*), kamahi (*Weinmannia racemosa*) and rewarewa (*Knightia excelsa*) will become dominant in drier sites with mahoe, kohekohe and large-leaved milk tree (*Streblus banksii*) prevalent in gullies and some faces.

Motutapu generally has a low secondary forest cover of akiraho (*Olearia paniculata*), mahoe, kohuhu, ngaio (*Myoporum laetum*) and large-leaved milk tree. Several large pohutukawas (*Metrosideros excelsa*), planted in 1913 by reserves rangers, are easily the largest trees on the island.

The more exposed situation of Motutapu and its relatively dry soils means its vegetation will remain generally more "coastal" and "windswept" in composition and appearance than that of Allports Island.

The now rare large-leaved milk tree is

Figure 1 - Allports Island and Motutapu. Photo: Alan Tennyson, 1993.

abundant on the islands, as is the rengarenga lily (*Arthropodium cirrhatum*); also of botanical interest is rewarewa, which reaches its southern limit on Allports.

The variety of wildlife currently inhabiting the islands appears somewhat limited, no doubt due to the previous modifications of habitat and subsequent introduction of exotic competitors and predators. Little blue penguins nest on the island in low numbers as do a few pairs of fluttering shearwaters, but breeding success for both species appears to be very low due to predation by weka. Reef herons and variable oystercatchers frequent the rocky coastline, along with gulls, terns and shags. The occasional fur seal is seen hauled out on the rocks.

Terrestrial bird species are quite abundant, but limited in variety. During 50x 5-minute bird counts conducted on Allports Island as a precursor to the eradication project, only seven species were recorded. These were, in order of abundance, silvereye, South Island robin, grey warbler, fantail, weka, blackbird and chaffinch. However, several other species were recorded outside of these counts. Some bird species common elsewhere in the Marlborough Sounds such as the tui and morepork are only occasional visitors, and the bellbird appears to have never been able to recolonise the island.

The South Island robins have established from a liberation of five birds from Kowhai Bush near Kaikoura in 1974, which was carried out as a transfer experiment linked to a management programme for the endangered Chatham Island black robin. The original release has expanded to a probable "saturation" population of 55 to 70 birds.

Weka were first recorded on Allports Island in 1974 to 1975, probably originating from an illegal release. They have established a small population which undoubtedly has had a significant impact on indigenous fauna. Both wekas and robins have crossed the narrow gap to Motutapu to establish small populations there. Possums were illegally liberated on the island some time in the late 1970s or early 1980s and established a dense population (see paper in this volume).

The history of house mice (*Mus musculus*) on Allports Island is not well documented but it is assumed they became established around the turn of the century through farming activities (a dwelling and other buildings were present for some time). Whether they became established the same way on Motutapu or managed to colonise the island by swimming the gap, is open to conjecture.

Eradication

Rodent eradication on islands is a relatively new field, but numerous campaigns have been tried on a number of islands around the coast of New Zealand in recent years, with a great deal of success.

Successful projects have included Hawea, Breaksea and Titi Islands (Norway rat), Tawhitinui Island (ship rat) and Korapuki Island (kiore), but despite this rapid expansion of eradication skills and an increased confidence in ability to eradicate rodents from larger islands, only one attempt had been made on the smallest of New Zealand's four species of rodent, the house mouse, prior to 1989.

The impact of mice on island ecosystems is not as well understood as that of the various rat species.

While the mouse, because of its smaller size, is not such an obvious predator as a rat, it undoubtedly has a detrimental effect on indigenous flora and fauna, though this effect is perhaps more subtle or insidious than that of rats. Certain plant species (especially their seeds) and some invertebrates may be preyed upon to such an extent that they could become very rare or extinct on the island, thereby also causing changes in community composition.

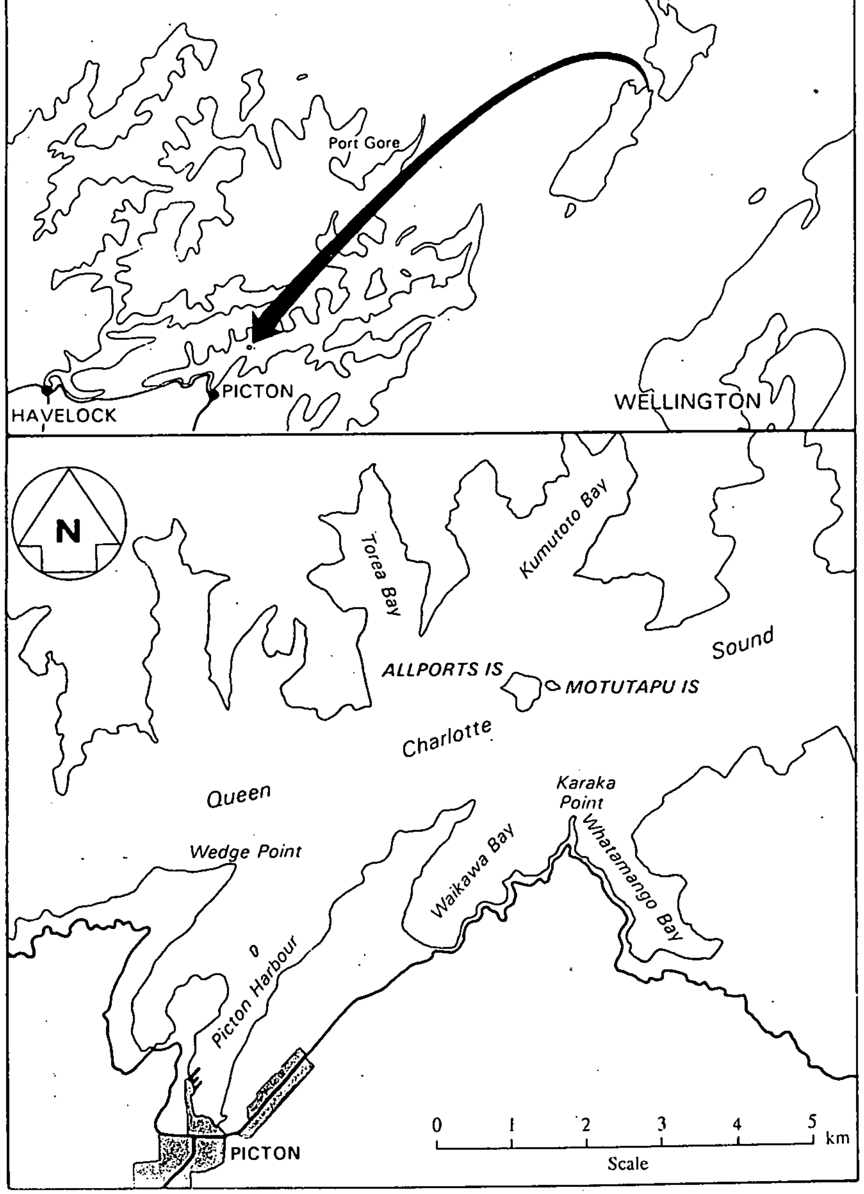
No extinctions (local or total) have been directly attributed to mice, but they are known to prey upon eggs of small seabirds and it is assumed they would do the same to eggs of small land birds if the opportunity arose (Moors, Atkinson and Sherley 1989).

Mice have been known to kill reptiles up to the size of adult tuatara (Whitaker 1978). An interesting point is the Maori name for Allports Island - "Motu-ngararara" - which can be interpreted as meaning "island of lizards". Presumably Allports Island had a reptilian fauna that was either dense or diverse. However, its current lizard biota is best described as depauperate. Only the occasional common gecko (*Hoplodactylus maculatus*) has been seen over recent years. As weka arrived on Allports relatively recently, the apparently drastic reduction of lizards is probably attributable to the removal of forest cover and the colonisation of the island by mice.

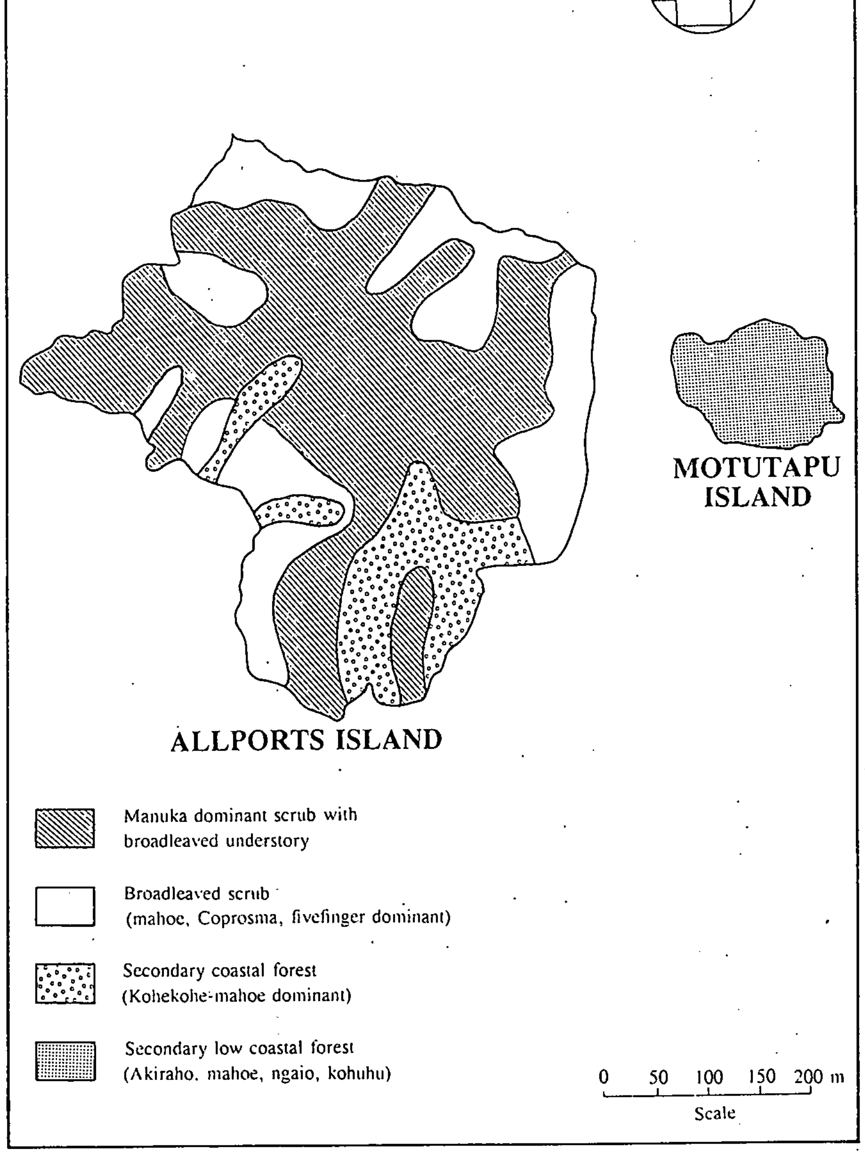
Monitoring the effect of removal of mice is therefore of considerable interest, as are any lessons learnt from the eradication project in relation to the reaction of mice to poison (for future contingency and control work).

Eradication of mice will also aid in the restoration of the natural ecosystems on the islands, with both islands having the potential to become completely free of introduced mammals. As such, the islands can then be made available for endangered species programmes as and when appropriate. They have a range of habitats suitable for various endangered species (including for example, invertebrate species and/or the South Island saddleback) but use of the islands for

MAP 1 LOCATION OF ALLPORTS AND MOTUTAPU ISLANDS



MAP 2 VEGETATION OF ALLPORTS AND MOTUTAPU ISLANDS



this purpose will depend on future management plans and classifications of the islands in the Marlborough Sounds.

Eradication method

It was decided that the proven technique of rat eradication using anticoagulent poisons in plastic Nova-coil tunnels should be used for this operation on mice. On Allports Island the Nova-coil bait stations (with removable lids for ease of inspection) were placed at 50 m intervals along prominent ridges, and along parallel compass lines at right angles again placed at intervals of 50 m.

Stations on Motutapu were spaced far more randomly, as access and slope permitted. (See Map 3 for both islands.)

Seventy-five stations were initially established on Allports Island, but this was later increased to 81 to fill some obvious gaps in coverage.

Poisoning began on Allports Island on 28 July and on Motutapu five days later on 1 August 1989.

Motutapu initially only had four stations but this was increased to 12 by 10 August and to a maximum of 16 by 13 August then slightly reduced to 11 to cater for the unexpectedly high numbers of mice found there and the initial lack of bait-takes which led to the fear that the four stations were not providing adequate coverage.

In practice, the spacing of 50 m between stations meant that for the bulk of the operation, each station on Allports covered a map area of 45 m x 45 m, and each on Motutapu covered 43 m x 43 m, though the surface area of land covered would have been significantly more due to the considerable slope of most of the land area on both islands.

The anticoagulant rodenticide 'Storm'(containing 0.005% flocoumafen), manufactured by Shell Chemicals was chosen as the bait to be used, in its 16 g block form. It was chosen because it was advertised as containing insect and bird deterrent and was resistant to fungi. 'Storm' was relatively new on the New Zealand market and we were keen to test its effectiveness on mice and its field qualities such as longevity and palatability to non-target species.

Once the bait stations had been set out, they were all baited with two to three 16 g 'Storm' blocks. The stations were then inspected daily for mouse feeding signs. Stations were cleaned of partly eaten baits and mouse droppings when necessary, so that any further mouse activity inside the tunnel on the subsequent night would be easily detectable and not confused with old sign. Baits which were partly eaten were removed each day and replaced with fresh baits. In terms of eradication, this was probably not necessary, but it gave us an important opportunity to gather data on nightly feeding activity from which we could extrapolate or surmise the total mouse population, time taken for individual mice to die, feeding behaviour in relation to weather and other unknowns.

Initially an experiment was carried out on Allports Island, dividing the stations into three "groups" into which were placed either plain unwrapped baits, or ones wrapped in aluminium foil, or enclosed in small sealable plastic bags. This was done to see if there was any preference for any type of bait presentation as there are indications some rodent species are positively attracted by shiny objects such as foil (R. Buckingham, pers. comm.).

By protecting the baits from insects and rain, foil and plastic wrappings may greatly extend the viability and palatability in permanently maintained bait stations on supposedly rodent-free islands.

However, all baits were left unwrapped after approximately two weeks when it became apparent that although mice would readily take all types of bait, when all three types were presented together they generally preferred the unwrapped baits.

Later in the operation, when stations were no longer being checked daily, a foil-wrapped bait was re-introduced to all stations in association with the normal two to three unwrapped baits to ensure at least one palatable bait was available at each station should the unwrapped baits be affected by moisture or other factors.

Results

On Allports Island, mouse feeding sign was evident from day one of the poisoning campaign. Takes of poison rose steadily to a peak of 37.5 percent (28 of 75 stations) on days 15 and 16, then dropped to a low of 6.7 percent on days 21 and 22 before resurging to peak again on day 30. From day 31 onwards, takes tapered away to disappear completely by day 50.

Feeding sign on baits was initially concentrated in the south-western corner of the island but gradually spread to cover all of the island.

On Motutapu, mice were at first very slow to show any interest in the baits. It took seven nights before any baits were even touched, despite the subsequent observation that the density of mice on Motutapu was considerably higher than that on Allports.

Motutapu mice may have had an alternative food source readily available, which could explain their initial disinterest in poison baits. However, once mice on Motutapu took baits, the number of stations with bait takes rose quickly and in similar fashion to Allports, with a double peak of feeding activity.

Unfortunately detailed (daily) records were not available from poison day 29 on Motutapu and poison day 32 on Allports because limited resources meant staff were no longer able to remain on the island. Instead, baits were checked every few days on day trips from Picton.

The last feeding sign was detected on Allports Island on 27 September 1989 and for Motutapu on 18 October 1989. Bait stations were kept stocked and regularly checked for feeding sign till 23 July 1991 (i.e. over two summer periods when numbers formerly built to a peak).

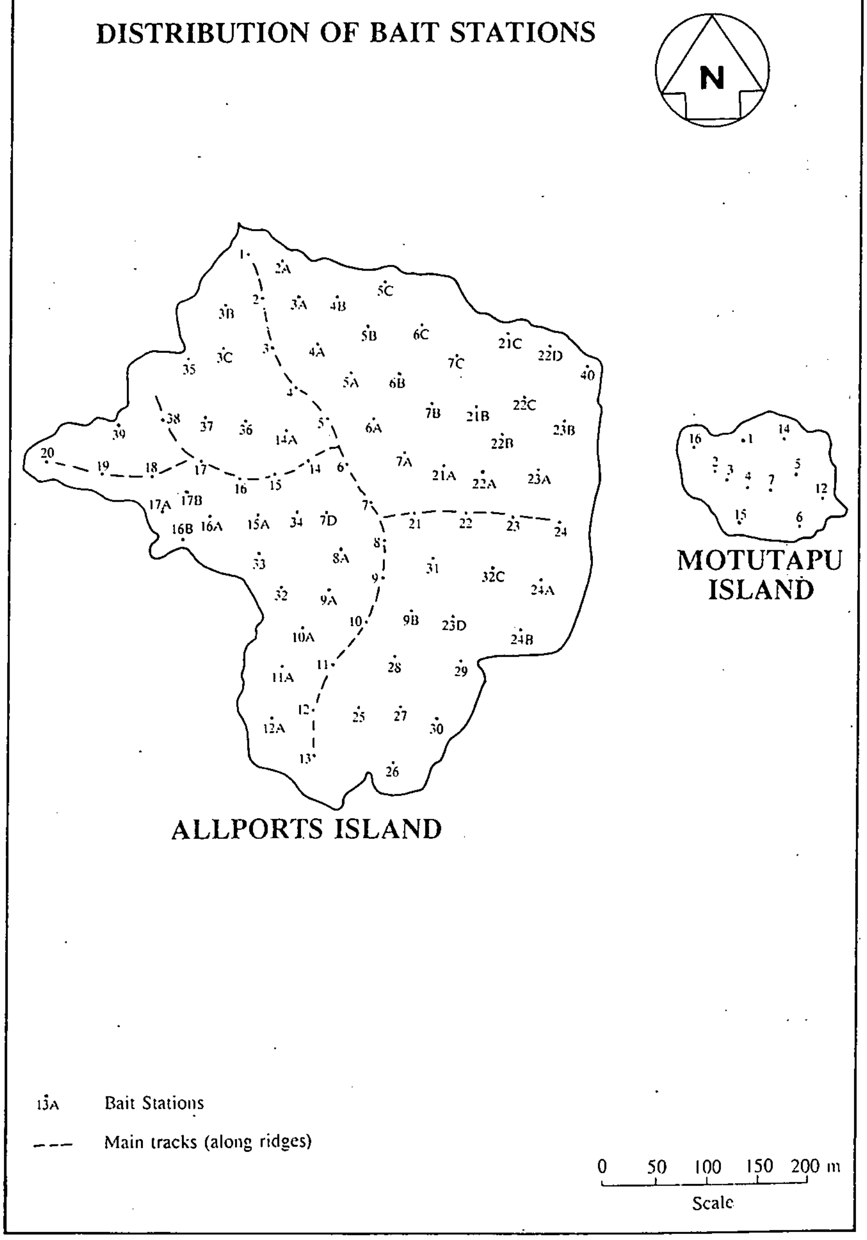
Since then, fallen fruit, especially those of species considered to be highly palatable to mice, have been closely inspected for rodent feeding. Large quantities of ripe fallen apples from a wild apple tree on Motutapu have been left untouched with no evidence of mouse feeding sign. Heavy seedfalls from a number of trees have no sign of being eaten by mice (no "husking" of hard seeds, and accumulation of new falls on older ones). Seeds of species such as kohuhu, *Coprosma robusta*, kawakawa (*Macropiper excelsum*), wharangi and *Hymenanthera obovata* lie uneaten on the ground.

Population and distribution

For a variety of reasons it is very difficult to estimate the pre-poison size of mice populations on Allports and Motutapu Islands. Unfortunately we have no way of determining how many mice were feeding at any particular

MAP 3

DISTRIBUTION OF BAIT STATIONS



unclear whether mice would regularly move between stations in a single night.

But interference by possum or weka also affected estimates of how much bait was actually consumed by mice.

Laboratory trials on mice have shown an individual mouse will eat approximately three grams of 'Storm' in a 24 hour period, which corresponds to about 20% of an average block of poison used in this operation.

At some stations, whole blocks of bait were consumed in a single night, and even if mice in wild populations eat considerably more than laboratory mice, because they use more energy, it can be assumed that at least three to four mice were involved in such feeding efforts. Up to four baits were eaten at a single station over one night (several stations on Motutapu had their stockpile of ten baits reduced to a few crumbs over the three nights between checks, indicating large numbers of mice were visiting the stations over these nights).

I estimated that mice took on average, six to seven days to die after ingestion of the initial toxic dose (the 'Storm' information booklet states up to ten days). Based on this and the feeding data outlined above, I estimated the total population size by extrapolating from individual bait station records. Allports Island appeared to have a late winter population of approximately 120 mice (about eight per hectare). Motutapu had a much higher density of mice, estimated at a staggering 45 mice per hectare, or close to 100 mice on a two hectare island. These figures are only guesstimates and could be way out, but there were certainly very high densities of mice on Motutapu Island, and much denser than that on Allports.

According to Murphy (1986), the population of mice reaches an annual low-point in late winter or early spring so these populations would be close to the annual minimum. My density estimate of mice on Allports is comparable to those calculated by Murphy for a similar time of year during the years 1984 to 1986.

The density of mice on Motutapu may have been the result of a "plague" year where numbers were temporarily high due to unusually abundant food supplies and/or the expected "crash" in the population during winter had not occurred to the same extent as in "normal" years. However, it seems unlikely that this was the cause as such plagues are climate-induced, so should have been obvious on Allports too.

Two other possible explanations for the comparatively dense population on Motutapu are that the vegetation is significantly different from that of Allports, and that Motutapu is used as a roost for literally thousands of starlings.

The starlings provide abundant quantities of fertiliser via their droppings and this creates in places a rich deep humus which presumably benefits a variety of invertebrate species. These in turn would provide an abundance of food for mice.

The vegetation of Motutapu contains elements absent from or very rare on Allports such as pohutukawa, mature *Streblus banksii*, and dense *Muehlenbeckia australis*, along with a variety of weed species including inkweed, elderberry, crabapple and barberry which may provide important seasonal food sources.

Unfortunately no data are available to compare peak (autumn) densities on the two islands.

Highest takes of poison and presumably therefore the highest concentrations of mice on Allports occurred in the broad-leaved scrub areas, as opposed to manuka-dominated scrub or secondary forest. This is probably due to the greater floral diversity and associated diversity of food sources. However, the aspects of the various vegetation types may also have had some bearing - the manuka is generally on drier north faces and ridges, and the secondary forest in cool damp south facing gullies and slopes, with the broadleaved scrub occupying the "middle ground".

Bait stations clearly within the broad-leaved scrub areas (n = 14) had bait-takes on average of 12 nights, those in manuka areas (n = 31) on an average of six nights and those in the taller kohekohe /mahoe forest (n = 7) had less than three nights of visitation on average. Stations close to boundaries of vegetation zones were not included in this calculation; these 29 stations had a mean of six nights of bait takes.

Motutapu's vegetation is most similar to the broadleaved scrub zones of Allports. The 11 long-term stations on Motutapu had a mean of over 29 nights of bait takes.

Behaviour

It appears from the results obtained that the mice were quite cautious about taking baits. Almost invariably a bait would be "tested" with a very small portion (less than five per cent) of the bait eaten for at least one night (and in one instance ten consecutive nights) before lethal doses were consumed over subsequent nights.

Generally, after the usual slow start, feeding would peak and then taper off slowly to zero, presumably as the mice weakened from effects of the poison for a period before dying.

Bait takes were initially concentrated on the south-west corner of Allports Island but gradually spread to cover all of the island. It appears that the "peer pressure" in Norway rats (noted by many observers - Taylor & Thomas 1989) in which rats prefer to eat the same foods as their peers may apply to mice as well (Bean, Goief & Mason, 1988) as it appears the "takes" spread out quite uniformly from the primary takes, as if information was passed on "by smell of breath".

No carcasses of dead mice or moribund individuals were found at any stage, a not unexpected result on Allports where mouse numbers were low. On Motutapu, where density was high, it is surprising however, and suggests mice weaken and die from the poison while in their burrows or nests.

On two occasions mice were disturbed while feeding at bait stations in the middle of the day, but it is not known whether this was a sign of abnormal behaviour induced by the poison, or simply an indication of the attractiveness of the bait.

Mice on both islands had a tendency to move baits outside the Nova-coil tunnels, although most were eaten inside. The size of the baits would have made them difficult for mice to move, but many were dragged out of the stations (for a distance of a few centimetres to c.2 m or more) to be consumed in the open. This may have been an individual's attempt to move baits to a safe eating place away from the attentions of other mice, or through nervousness about eating baits inside tunnels with restricted escape routes. This behaviour caused problems with non-target species, as "leftovers" were available to poison bird species.

It is not clear whether mice attempted to carry baits (or portions of baits) back to their burrows as Norway rats are inclined to do (Taylor and Thomas 1989). However, one mouse under visual observation over two nights made no attempt to carry off any baits, preferring to eat all bait (even easily carried portions) on site.

Bait

The 50-m spacings between bait stations appeared to be quite sufficient to enable all mice to find at least one station without any difficulty. There is some evidence to suggest individual mice were aware of at least two different poison stations. In one instance one bait station was regularly being visited by mice but on two nights this station was disrupted and the baits eaten by a possum. On both of these nights an adjacent bait station (previously unvisited) recorded bait takes by mice. Once the first station had been "possum-proofed", feeding resumed at this station and ceased at the second, indicating a single mouse was responsible for bait takes from two adjacent stations.

The bait stations, which were 500 to 600 mm long, proved very efficient in preventing access to baits by many non-target species, but wekas could easily reach baits inside the stations. Wekas only provided a minor disruption, with baits generally only dragged out of the tunnel but not eaten.

Possums created a more significant problem in the latter stages of the poisoning campaign, when several individuals learnt to extract baits from the stations, either by pulling out the wire restraining hoops and tipping out the baits, or by pulling off the detachable inspection covers. Addition of extra wire hoop hold-downs satisfactorily solved the problem.

Mice showed a clear preference for "unwrapped" baits when presented with a choice between these, foil-wrapped and plastic-enclosed baits at the one site. Foil-wrapped baits were an equally clear second preference above plastic-enclosed baits.

However, the initial trial conducted on Allports Island where the three types of baits were presented separately (i.e., in separate stations), bait takes were spread relatively equally over the three different types. This indicated that when no other choice was available at a particular station, mice still found foil-wrapped or plastic-enclosed baits to be readily acceptable.

Foil appears to have some "stand-alone" attraction to mice similar to that noted on Stewart island with ship rats (*Rattus rattus*). Rhys Buckingham repeated his Stewart Island trials on Allports Island prior to the poisoning campaign by setting out foil wrapped pebbles. The attractiveness of foil was shown by mice frequently nibbling holes in the foil and occasionally shredding it to pieces, despite the obvious lack of food held within.

Wrapping baits in foil can significantly increase the longevity of baits in the field (by five fold or more), especially in damp or humid conditions (pers. obs.).

'Storm'

Flocoumafen, the poison contained in 'Storm', is obviously a very effective rodenticide achieving a 100% kill in a relatively short time with no bait shyness or avoidance noted. It appeared to be very palatable to mice.

Mice need to eat approximately ten times more than a Norway rat in proportion to body weight (Shell pamphlet on 'Storm') and therefore the LD50 for a large mouse is similar to that for an average Norway rat, i.e. 1 to 1.5 g of bait. Laboratory trials show that mice can eat about 3 g of bait per day so a lethal dose is easily obtainable from a single night's feeding.

Ministry of Agriculture, Fisheries and Food trials in the United Kingdom showed mice took a mean of 7.2 days to die after ingestion of block bait flocoumafen and Shell states in its information booklet on 'Storm' that it takes from 2 to 10 days for mice to die from the poison. Interpretation of individual bait station records from Allports and Motutapu suggests the results on these islands are in line with these calculations, although often it proved difficult for any firm conclusions to be drawn because of the recurring problem of determining just how many mice were feeding at any one station at any one time. For example, one station had approximately 30 consecutive nights of bait takes. It is impossible to say how many mice were involved and how long each took to die in this situation.

Fresh whole baits were, as the manufacturers claim, generally unattractive to birds and did not seem to attract insects. Wekas and robins showed initial interest in whole blocks to the extent of picking them up and carrying them off, and pecking at them. However, the baits were unbreakable and both species quickly lost interest. As baits weathered, it appeared that they became more susceptible to insect attack and birds were seen to glean "crumbs" of baits left out in the open by mice.

Longevity of baits varied considerably, depending on the location of the bait station and on weather conditions. Most baits easily last for two months or more before requiring replacement (and then often only as a precautionary measure). However, baits in stations situated in cool south-facing gullies, or baits subjected to prolonged humid conditions, quickly developed surface mould and had to be replaced much more frequently.

Non-target effects

While 'Storm' may have some deterrent qualities, these are obviously not 100% effective, as during the project there were numerous observations of non-target species taking bait.

Placing baits inside Nova-coil plastic tunnels is generally very effective in preventing accidental poisoning of birds but as described, on several occasions, weka and robins were seen gleaning crumbs. Although birds have a far higher tolerance of the poison than rodents, evidence suggests some bird deaths occurred as a result of such feeding.

Over the latter stages of the poisoning programme, five wekas, two robins and one blackbird were found dead on Allports and Motutapu. Although evidence is only circumstantial (as dead birds were also found prior to any use of poison on the islands), it is presumed most of these birds died through ingestion of poison bait.

Predators of mice are not common on either island with the only two species likely to prey on mice being weka and morepork. Morepork are only irregular visitors to the islands and weka were not considered a major predator of mice on Allports (Murphy 1984). Secondary poisoning of these species (through eating poisoned mice) is considered to have been very unlikely.

Numerous instances of insects feeding on baits were recorded, with the tree weta *Hemideina crassidens* appearing to be the main culprit. Weta sign was usually able to be differentiated from mouse feeding sign by the generally smaller amount of bait taken and the way wetas "grazed" the top of the bait while mice tended to eat away at the edges and corners first. However, on several occasions, characteristic weta droppings were found in association with what we considered "typical" weta feeding sign.

Other insect droppings were found in tunnels where minute portions of baits had been eaten. It is presumed some other larger terrestrial insects such as carabid beetles or cockroaches were responsible.

Anticoagulant poisons such as flocoumafen are supposedly non-toxic to insects but presumably can be the cause of secondary poisoning to insectivorous birds. However, given that insect "takes" of baits were only occasional and not localised, and that amounts of poison consumed were generally very small, secondary poisoning of birds by eating such insects is expected to have been negligible.

The main threat to non-target species appears to have been from direct ingestion of baits rather than through a secondary source.

Monitoring

In order to obtain some indication of the effect mice have on indigenous flora and fauna, several basic monitoring programmes were initiated, with the aim of repeating these surveys and assessments over successive years.

Ideally, monitoring should have been carried out for several years prior to commencement of the eradication project; nevertheless, it was considered that a single year's monitoring database would provide a useful baseline to detect any major changes.

Several basic, easily-repeated assessments of flora and fauna diversity and abundance were carried out on Allports Island prior to the campaign. These were:

- 50x 5 minute bird counts, spread proportionately over the three major vegetation types of the island;
- 40 standard invertebrate pit-fall traps (20 in each of the two most common vegetation types), maintained for a period of 24 nights;
- Establishment of three, 2 x 2 m vegetation plots (one in each of the vegetation types);
- Counts of first year seedlings within a c.2 m radius of the parent tree, using eight species of tree or shrub which were considered most likely to be affected by mice eating their seeds. One or two mature specimens of each of the following species where used for these seedling counts: large-leaved milk tree, kohekohe, rewarewa, kohuhu, wharangi (*Melicope ternata*), kaikomako (*Pennantia corymbosa*), poroporo (*Solanum laciniatum*) and *Hymenanthera obovata*.

It is intended to repeat these assessments annually (at a similar time of the year) for at least three years.

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ERADICATION OF POSSUMS FROM ALLPORTS ISLAND

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ABSTRACT: A programme to eradicate mice from Allports Island also affected the possums, which had been illegally introduced in the late 1970s or early 1980s. Possums were subsequently eradicated using Talon brodifacoum baits.

Allports Island (16 ha) in the inner Queen Charlotte Sound of the Marlborough Sounds was extensively modified last century through forest clearance, human occupation and agricultural use. (See Brown's other article in this volume for mapping of Allports Island and its vegetation patterns.) However, the island's vegetation has recovered remarkably since its reservation early this century, undoubtedly aided by the fact that since 1913, no large grazing or browsing animals have been present.

For many years the only introduced mammal present was the mouse *Mus musculus*. The regeneration of coastal broadleaved forest was therefore occurring relatively unaffected by introduced animals until the illegal introduction of possums (*Trichosurus vulpecula*) sometime in the late 1970s or early 1980s. This introduction was probably made to create a new accessible population for the then-lucrative possum fur trade.

Sign of possum presence was first notified to the Department of Lands and Survey by scientists (Ralph Powlesland and Tony Connor) in 1981. However, the island was visited infrequently by knowledgeable staff, and it is difficult to detect sign when the density is very low, so possums may already have been present for several years.

Lands and Survey staff undertook limited control action in 1983 on the basis of this report and removed a number of possums by poisoning (cyanide) and cage-trapping, but no focused efforts were made toward eradication. At this stage the possum population was described as "relatively healthy" (Lands and Survey file report). Control measures lapsed shortly after.

In 1989 the Department of Conservation began a programme to eradicate mice from Allports and nearby Motutapu Islands, with the intention of eradicating possums at a later date (if and when funds came available).

Methods

Eradication of mice was attempted using anticoagulant poisons in the form of waxy bait blocks (see Brown, this volume). While staff were camped on the island during the initial stages of the mouse programme, a dense population of possums was noted. Up to ten possums were observed at night within 30 m of the campsite. These possums were readily observed and it was apparent they had a strong attraction to Talon 50WB baits being trialled for the mouse bait stations, although possums were not being targeted. The opportunity was taken to determine the poison bait's palatability and effect on possums and to try several different methods of bait presentation.

Results showed possums could very easily detect the presence of baits.

Detection was primarily by smell; on several occasions possums were seen trying to prise or chew the lid off the opaque buckets containing poison baits. They readily accepted baits, and consumed them rapidly.

Staff from Ecology Division of DSIR and animal toxicologists from Forest Research Institute confirmed the toxicity of Talon to possums. It became obvious that we could greatly reduce the possum numbers in conjunction with the mouse eradication project for very little extra effort and no extra staffing requirements. As bait-stations for mice had to be checked and replenished daily, bait-stations for possums could be established along the same routes.

To protect baits from non-target species (e.g. birds such as blackbirds, weka and robins) and to prevent deterioration of baits through absorption of moisture, the baits were either wrapped in ordinary kitchen-grade aluminium foil, or placed in small seal-top plastic bags.

Foil-wrapped baits were not recognised as food by bird species but could easily be detected from smell by possums. Possums showed no aversion to the foil, and easily bit through and removed the covering. Similarly, the plastic bags could not be pierced by bird beaks, but were easily ripped open by possums.

Both types of baits could therefore be placed wherever convenient, with very little risk of direct non-target poisoning. However, as a further safeguard, the baits were usually placed above "weka-height" in forks of trees or on large, near-horizontal branches. Some were initially presented in a tray (made from a cut-down plastic milk bottle) tied to a tree-trunk, but such trays proved to be unnecessary. The baits were quite waterproof in the wrappings used and lasted for several weeks or more in often damp conditions before requiring replacement.

A small number of stations were initially installed on 26 July 1989 as a trial, and the obvious success of these led to the installation of 58 stations, at 50 - 100 m intervals (a density of 3.6 per hectare) over the whole island. Each station had either two foil-wrapped baits or two baits within a plastic bag. Information received from experts suggested two 50WB baits would provide a toxic dose for most possums.

Stations were checked daily (and replenished if necessary) for the first 32 days, in conjunction with mouse bait station checks, but as takes reduced over time, periods between checks increased as staff began making only occasional visits to the island.

In order to accelerate the decline of possum numbers and to test theories on density of the possum population, a small number of possums were trapped using gin traps on the northern side of the island, mid-way through the poisoning campaign.

Results

It took 223 days from commencement of the project until all takes of poison by possums ceased, and within this period checks and replenishment of baits took place on 43 days.

Most individual stations had a slow start to "takes" as the possums had to first encounter the station and then "tested" the baits over one or two nights (eating small portions of the amount available). However, once a station became "active" the amount of bait taken was (over 80% of all observations) close to 100% of all the bait that was available. The percentage of stations that were "active" was c.50% in the first two weeks (early August), increasing steadily over the next two weeks until over

90% of all stations were being visited throughout the period September 1989 - December 1989. A definite "crash" occurred between the 26 January 1990 check (74%) and the 7 March check (3.5% take). No further bait takes were recorded after 7 March.

Three moribund possums were found and humanely destroyed, and the bodies of seven other possums were discovered after they had presumably succumbed to the poison. One distinctively marked individual, resident around the campsite, was seen nightly around the camp for 18 nights after ingestion of the initial toxic dose, before being found close to death. Over the last few days before its death, it was noticeably slower than normal and somewhat clumsy, but otherwise showed no outward signs of distress from the poison. When found in a moribund state it appeared to be sleeping and had watery eyes but otherwise had no obvious sign of pain or stress.

A total of six possums were caught in gin traps over 20 trap/nights on the northern and eastern sides of the island.

The removal of six possums by trapping, although some had bait in their stomachs, had no effect on numbers of baits being taken in the area from which they were trapped, indicating a number of possums were competing for baits at the same stations. It appeared that individual possums would if possible, take baits from several different stations per night. As the programme wore on, and numbers dropped, it became even more obvious that individual possums would take numerous baits per night, if competition did not prevent it. Consequently bait takes in most areas remained constantly high until a very abrupt cessation of takes as the last one or two possums in that area succumbed.

From the number of possums trapped, killed or discovered dead, the number of baits taken, and observations of time to death after taking baits, a population estimate was derived. Prior to poisoning, a population of at least 50 and possibly up to 70 possums were present on the island, equating to a minimum of just over three per hectare.

As bait checks were done in conjunction with the mouse eradication project (which was the primary objective) the additional time involved to prepare and lay out possum baits was estimated to be one and half hours per day. On this basis, eradication was achieved with only 65 hours (approx. one and a half person-weeks) additional effort above that required to eradicate mice.

The last sign of possum presence was seen on the island on 7 March 1990. This was bait take at two adjacent stations which obviously occurred between 26 January (the previous check) and 7 March. Since then the island has been visited several times with no fresh sign of any description having been seen. Night searches and trapping have failed to show any further sign of possums.

Bait stations remained in place until 23 July 1991.

To June 1993, no evidence of continued possum presence has been found.

Summary and discussion

The use of Talon 50WB anticoagulant poison in waterproof wrappers proved to be an extremely effective method of eradicating possums from Allports Island, when done in conjunction with the mouse eradication.

The costs over and above those for the mouse programme were low, both in money and in hours, whereas if it had been done as a stand-alone project, costs would have been considerably higher;

other options such as use of dogs, other poisons, or traps may have been as, or more, cost effective.

Though effective in this situation and a useful experiment, the applications for this technique may be limited, perhaps being most useful when several pest species are being targeted at the same time.

Some perceived advantages of anticoagulant poisons such as Talon 50WB using methods adopted for the Allports project include:

- the bait's high attractability;
- the relative ease of use and safety in handling (cf. other poisons);
- apparently very little poison shyness develops;
- longevity and waterproofness of baits (cf. cyanide or 1080);
- little effect on, or attractiveness to non-target species.

Some obvious disadvantages include:

- the length of time between poisoning and death (up to four weeks, and possibly longer);
- repeated application of poison may be necessary for dense or large populations, or significantly higher densities of poison initially applied;
- relatively high cost and length of project if done as a stand-alone project
- can't be used in conjunction or prior to use of possum dogs because of the acute vulnerability of dogs to this poison.

Anticoagulant poisons have now been specifically developed for possums with the production of a specific Talon Possum Bait, but to our knowledge this project was the first in which anticoagulant poison was used as the primary eradication tool. While a small proportion of the population was trapped, we are confident that all possums could have been removed by use of poison alone.

Circumstantial evidence gained while on Allports suggests possums may display some degree of learned behaviour in taking food items, similar to the behaviour displayed by rodent species. An alternative hypothesis is that all possums found the baits highly palatable and sought them out actively of their own accord.

Removal of possums has effectively made Allports Island free of all introduced mammals, which should benefit many indigenous species.

Allports has many plant species which are vulnerable to possum browse, including a significant proportion of the "climax" canopy species (kohekohe (*Dysoxylum spectabile*), wharangi (*Melicope ternata*), large-leaved milk tree (*Streblus banksi*), five-finger (*Pseudopanax arborea*), tree fuchsia (*Fuchsia excorticata*)).

Some wildlife species may also benefit from reduced levels of predation, particularly on nest contents, and these include pigeon (*Hemiphaga novaeseelandiae*), South Island robin (*Petroica australis australis*) and fluttering shearwater (*Puffinus gavia*).

Acknowledgements

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SPECIES AS INDICATORS: THE FALL AND RISE OF McGREGOR'S SKINK, MANA ISLAND

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ABSTRACT: Monitoring a threatened species – in this case, McGregor's skink, *Cyclodina macgregori*, from Mana Island near Wellington – reveals changes not only in the animal's status but also in its habitat, its community and its ecosystem.

It is little wonder that conservation attention is swinging away from individual species towards groups of species, their habitats and their ecosystems; we simply do not have the time, or the resources, to investigate individually each of the species at risk. Over 500 NZ plants and animals are regarded as threatened; however, there are probably many more, since our invertebrates and lower plant forms are generally poorly known. It does not follow, however, that past, or future work on individual species has, or will be misdirected, but rather that we will need to take special care when singling out species for attention.

When selecting a species, we will need to take into account not only its status (risk of extinction), but also its perception by the public and iwi (for example, 'flagship' species such as kakapo, kiwi, black robin have a high public profile); its ecological role ('keystone' species such as burrowing seabirds on islands, for instance, have a dominant influence on ecosystems); other species which will benefit from any conservation actions taken (the removal of rodents from islands has improved the prospects of not only the tuatara, but also many birds and lizards); and its value as a biological indicator. (Globally, frogs are held to be excellent biological indicators of environmental stresses – they may very well be an environmental early warning system, just as last century's canary in a mine shaft was affected by toxic gases before miners were.)

Biological indicators can be used to judge the consequences of management actions. In February 1990, the last mouse ever (we hope!) was removed from Mana Island – it is instructive to follow what has happened since to the island's lizard community, in particular to the population of the threatened McGregor's skink. Apart from Mana, this species is confined to three small (each <5 ha) rodent-free islands off Northland.

Biological attributes contributing to the vulnerability of a species may enhance its value as an indicator: McGregor's skinks appear particularly sensitive to habitat disturbance and to introduced mammalian predators. They belong to an endemic genus *Cyclodina*, a group of six species, four of which are threatened. Current genetic research suggests two further species exist, at least one of which is at risk. Those at risk are the largest members in the group. Unlike the more commonly encountered skinks which are abroad by day, *Cyclodina* skinks are generally intolerant of hot, dry conditions even though they are most active during the warmest months. They emerge from sheltered retreats (rock piles, seabird burrows) at night, dusk, or dawn and, as a consequence, are especially vulnerable to night-hunting predators. Further, in comparison to their diurnal relatives, they are rather sluggish movers. Having access to sheltered retreats is essential for the skinks' survival, as they can quickly die if exposed for too long to direct summer sun.

It was the prospect of major change to the habitat of McGregor's skink that first led me to Mana Island in the summer of 1985/86. The island (Fig. 1) was then being used by the Department of Lands and Survey to raise dairy bulls, a temporary operation intended to lower fire risk after MAF had closed down an exotic sheep quarantine and breeding research station in 1978 because of a suspected scrapie outbreak. As part of the cattle operation, an unsanctioned farm road had been constructed along the narrow coastal platform below the northeast cliffs – an area of the island where all but one sighting of McGregor's skink had been made. The Wellington Commissioner of Crown Lands wanted to know if this construction had had any negative impact on the skink.

A line of pit traps was established along the northeast coastal platform and, subsequently, traps were installed at other parts of the island where habitat appeared suitable. However, McGregor's skinks were only caught along part of the northeast coast, generally in areas not affected by the road. When the cattle were removed from Mana in April 1986, the road was left to revert (vegetation was allowed to encroach), and over the next two seasons capture rates of McGregor's skinks increased. Then, during April 1988 something went wrong. Dead, partially eaten lizards started to appear in traps (including two McGregor's skinks) and, eventually, mice were actually disturbed in traps attacking common geckos and skinks. The following season (1988/89) the capture rate of McGregor's skinks dropped dramatically and stayed low through 1989/90. I attributed this decline to increased predation by mice

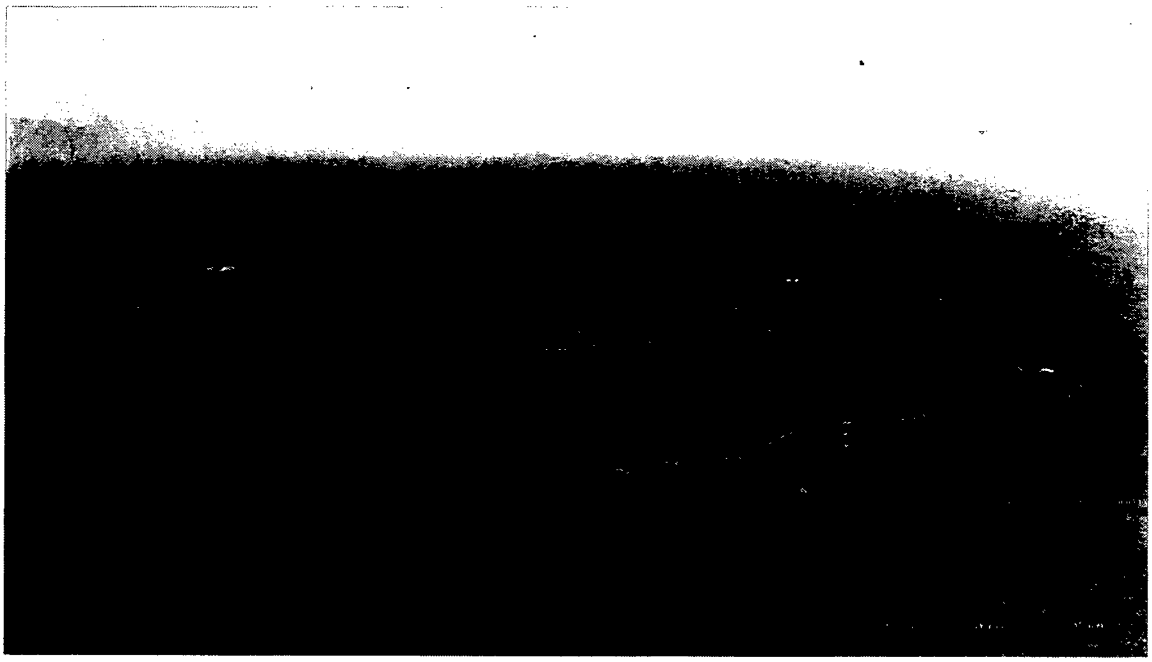


Figure 1 - Mana Island from the air, 1986. Photo: Bob Maysmor.

after a build-up in their numbers following the removal of cattle from the island. The bulls' removal resulted in pasture grasses becoming rank and going to seed. The grass seed sustained intensive breeding by mice, allowing them to build up to unprecedented numbers.

At the completion of seeding, hungry mice turned to lizards for food. The few captures recorded during 1988/89 and 1989/90 – mostly of small (young) animals – indicate that large adult McGregor's skinks were particularly vulnerable. Periodic mouse plagues on Mana were not new, but Ross Pickard found in the early 1980s that rodent numbers were largely concentrated in coastal and cliff habitats, few being trapped in the extensive areas of grazed pasture.

When making the decision to proceed with the mouse eradication campaign, the plight of McGregor's skink was recognised; also recognised was the potential Mana Island held for many species vulnerable to rodents and other introduced predators. If mice could be removed, I predicted that the McGregor's skink population, although depleted, had the capacity to recover since throughout the decline, small (young) skinks were still being caught. Mice were successfully eradicated in the 1989/90 summer, and, indeed, continued monitoring has revealed statistically significant increases in both total captures and individuals of McGregor's skinks caught each trapping season since then (Fig. 2). The skink population now seems well on the way to recovery; the timely intervention of the mouse eradication campaign has converted a "rise and fall' situation to one of "fall and rise".

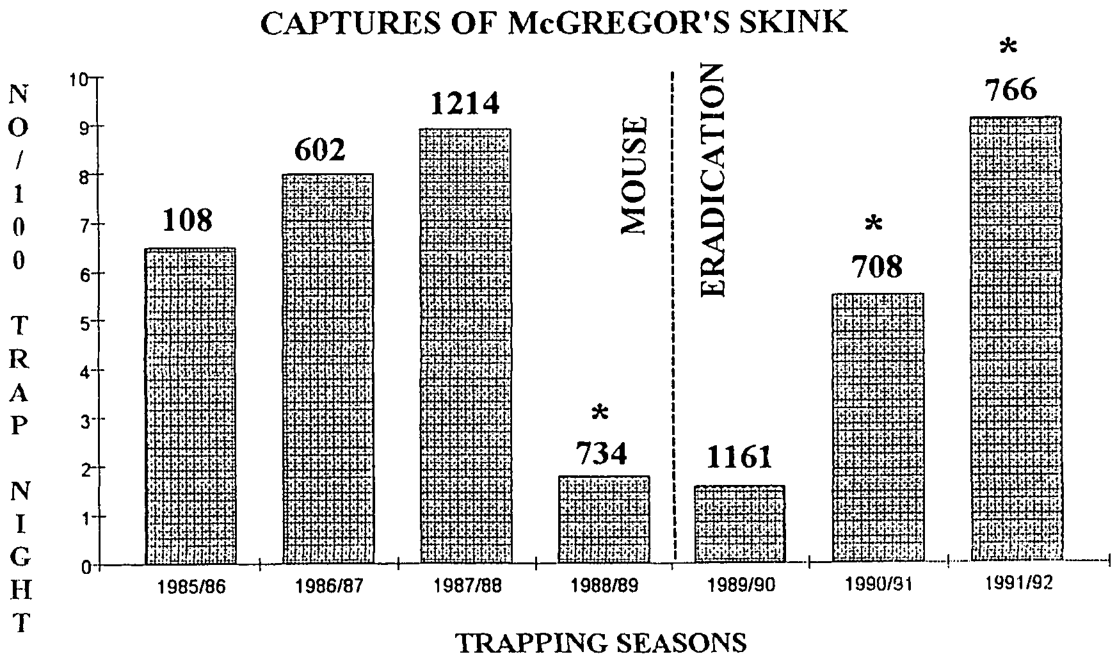
Further evidence that the "fall" of McGregor's skink was real and not a consequence of disturbed lizards moving to new sites comes from an evaluation of individual capture records. These suggest that the species is long-lived (taking six years or more to reach adult size) and that individuals display strong site fidelity (most lizards recaptured are caught in the same trap, or in one no more than 4 m away). In spite of this, of the 64 individuals caught to April 1988, only two have been recaptured since the last mouse was caught.

Three other species of lizards were also caught in the traps: copper and common skinks, and common gecko. Of these, no major change was detected in capture rates of copper skinks, the smallest of the *Cyclodina* species which, although widely dispersed over Mana, was never caught in large numbers. Captures of common skinks (a diurnal species) have declined slightly, possibly a consequence of coastal vegetation recovery – this species appearing to prefer more open habitats – while an **enormous** increase in the numbers of common gecko has been recorded since the removal of mice. The extent of this increase came somewhat as a surprise because it cannot be explained solely by improved survival and reproductive success (female geckos can produce only two young per season). Perhaps reduced interference by mice at trap sites was a factor – geckos are adept climbers and can readily escape from traps; the regular inspection of traps by hungry mice may well have provided all the stimulus geckos needed to make hurried exits!

Finally, it is also apparent that since the removal of mice, greater numbers and a wider variety of invertebrates are being caught than previously. More giant wetas (*Deinacrida rugosa*) were caught in traps last season (1991/92) than in all six earlier seasons combined! On a less positive note, introduced snails (*Helix aspersa*) have started to appear in traps: none were recorded during the first five seasons, but over the last two, 37 and 58 were caught respectively. These pests, which presumably had been kept in check by mice, could pose a nuisance to the revegetation programme for the island.

Thus the monitoring programme for a threatened species (McGregor's skink) revealed changes not only in its status, but also in its habitat, its community and its ecosystem - primarily as a consequence of human activities (albeit largely benign).

Figure 2 - Captures of McGregor's skinks on Mana Island over the past seven seasons. Although up to 247 pit traps have been run on the island, only 59 have caught McGregor's skinks – these results come from those 59 traps. The figures above each bar represent the total number of trap nights for any particular season; note that capture effort (number of trap nights) varies among seasons being particularly low for 1985/86. Capture rate is expressed as numbers of McGregor's skink caught per 100 trap nights to enable comparisons to be made. An asterisk above a bar indicates that the capture rate recorded that season is significantly different statistically from that recorded the previous season (either higher or lower). Cattle were removed from the island during April 1986, while the mouse eradication campaign which commenced in August 1989, concluded with the capture of the final mouse in February 1990.



INTRODUCTION OF NORTH ISLAND ROBINS TO MOKOIA ISLAND, LAKE ROTORUA, AND PUBLIC INVOLVEMENT

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ABSTRACT: Seventeen North Island robins (*Petroica australis longipes*) were released in June 1991 onto Mokoia Island, Lake Rotorua. Of these, 13 birds were caught from the wild and four came from captivity. All birds originated from the Mamaku Plateau. A minimum of 13 robins survived the release and produced at least 16 juveniles in 1991/92.

The Department of Conservation and Rotorua Girls' High School (RGHS) released 17 North Island robins in June 1991 onto Mokoia Island (Lake Rotorua) with the objectives of student education, conservation advocacy and community restoration. The students were involved from an early planning stage and were the major contributors to the Departmental policy requirement of a "Transfer Proposal". Observations of North Island robins on Mokoia were collected on 25 October 1991, 23 January and 14-15 March 1992 with the aim of assessing adult survivorship and breeding success.

Background

The requirement for the public to become involved and see at close quarters the activities of the Department is crucial in maintaining political support for conservation. Community ownership of conservation is a growing resource. Evidence of this can be found in the growing number of "conservation volunteers" and support programmes such as the supporters of the restoration of Tiritiri Matangi Island in the Hauraki Gulf. Conservation based activities on Mokoia Island achieve a focus for public involvement in conservation from active management to more passive pastimes. The broadest possible spectrum of the community has already become involved with the restoration of Mokoia Island. These range from conservation interest groups to marae run "job creation" schemes.

Mokoia Island has not always been suitable for the introduction of wildlife. Its past history of occupation, grazing, fires and introduced mammals resulted in a habitat with very limited diversity of fauna or potential for native colonisers.

Permanent occupation of the island ceased in 1950 and since that time predominantly native vegetation has recolonised the island (Beadle 1990). However the presence of high numbers of Norway rats (*Rattus norvegicus*) (Daniels and Beveridge 1965) and the subsequent introduction of goats (*Capra hircus*) to the island have meant that the natural fauna of the island has remained impoverished. In 1989 a campaign to remove exotic mammals was undertaken by the Department. This programme was highly successful; however, one mammal, the house mouse (*Mus musculus*), still remains.

The 135 ha island (Fig. 1) is designated a Wildlife Refuge under the Wildlife Act 1953. It is Maori owned and administered by the Mokoia Island Trust Board as a public asset. Access to the island is unrestricted, and a small landing fee is payable to the trust.

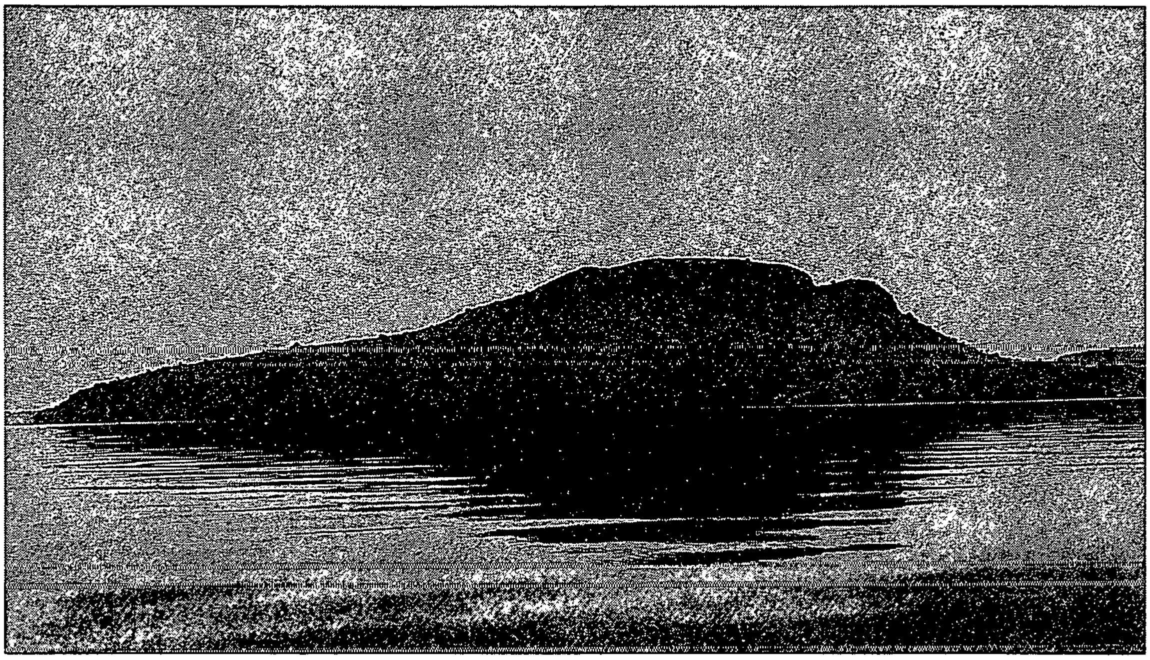

Figure 1 - Mokoia Island. Photo: Department of Conservation.

Objectives

- To establish a self-perpetuating population of North Island robins on Mokoia Island.

- To establish Mokoia Island as a focus for public involvement in conservation.

Source of release stock

Robins were caught from the Otanewainuku and Tokoroa ecological districts. The habitat type was predominantly 15-year-old exotic pine forest and adjacent indigenous remnants. Most of the birds (14) came from a very discrete area of the Tokoroa Ecological District within pine forest. The total area from which these birds were taken was <120 ha. Four individuals were caught from indigenous bush margins in the Otanewainuku ecological district from widely separate sites.

Robins were attracted using tape recorded robin song played in short bursts. When a robin appeared, the tape was turned off and the bird was attracted to the ground by raking aside leaf litter over an area of one square metre, to expose the naturally occurring invertebrates. The natural food was supplemented with commercially cultured meal worms to extend the birds' interest, while an electronically triggered clap trap was set nearby. Ground litter was removed from the effective area of the trap to encourage inspection by the bird and the trap was baited with more meal worms. Once caught, birds were transported to holding boxes in cloth bags.

Four robins for the release came from captivity at the National Wildlife Centre at Mount Bruce. An adult male which had been taken into captivity three years ago (from the Otanewainuku Ecological District) had been paired with a female of unknown source. Their three offspring were included in the release, along with the male parent.

Marking

All birds released onto the island were

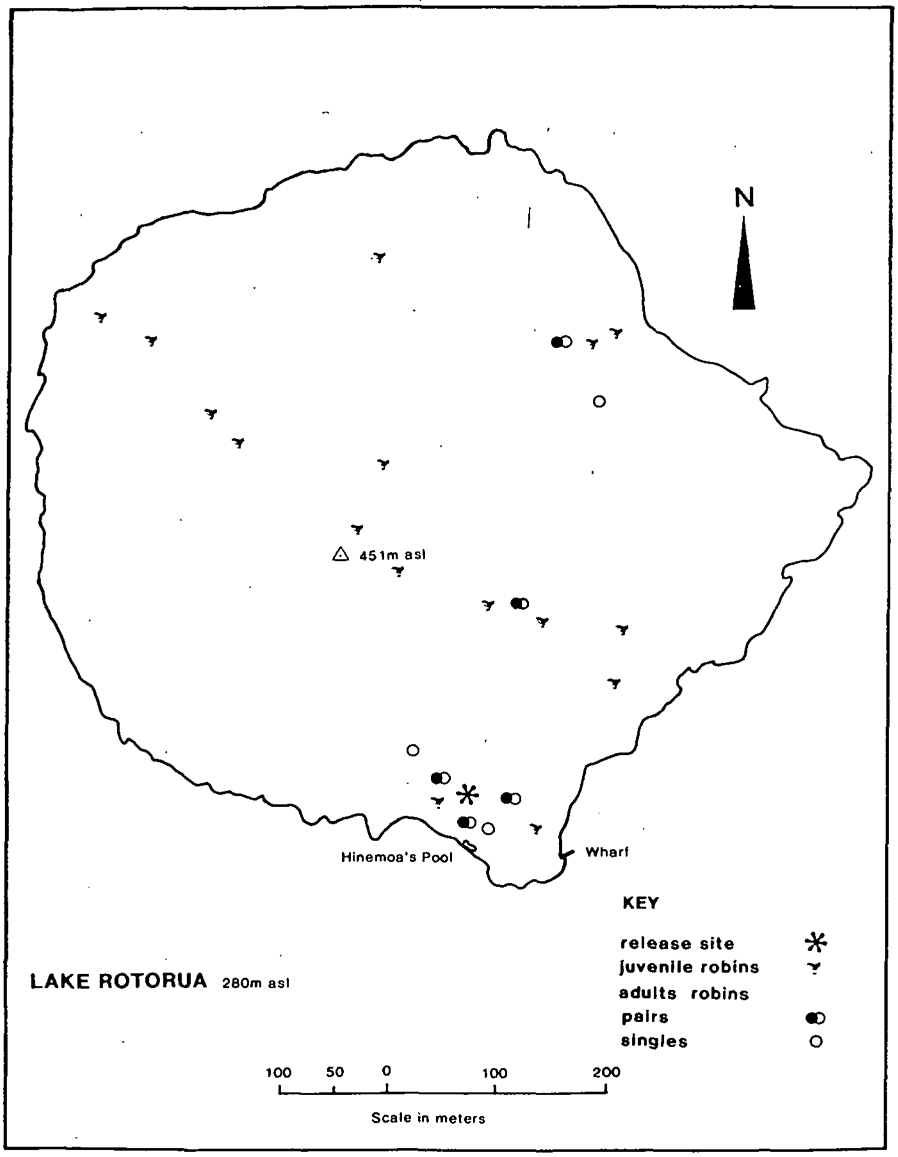

Figure 2 - Robin observations, Mokoia Island.

leg banded with a metal band and a unique colour combination to aid identification. Sexing of the birds was also attempted at this stage, though differentiation between the sexes is difficult.

Housing before release

All birds were housed individually and were held for a period ranging from 1-21 days. The majority of birds were released within three days of being caught. This decision was reached when seven individuals died after their third night in captivity. The reasons for this mortality are unclear: one female which survived for 21 days was housed in an aviary with a layer of earth over the concrete floor, while all other birds held were housed on bare concrete. This may point to a dietary deficiency which this bird may have been able to overcome by supplementing the supplied diet of commercially cultured meal worms, wax moth larvae, and cheese, with naturally occurring foods in the substrate.

Thirteen wild-caught robins and the four from Mount Bruce were released 24-30 June 1991 on Mokoia Island at the junction of the walking tracks above Hinemoa's Pool.

Monitoring

Post-release monitoring has been done on short visits to the island. A survey of birds using response to tape-recorded song was conducted on 25 October 1991 when ten robins were observed. This survey only covered the area in the immediate vicinity of the tracks and the 7 ha grass flat on the eastern side of the island.

Another visit to the island on 23 January 1992 revealed 11 banded birds. The area covered by this survey was similar to that of the first; however, access to the northern end of the grass flat was barred due to a heavy infestation of blackberry (*Rubus fruticosus*).

A third survey was conducted on 14-15 March 1992 to assess adult survivorship and juvenile production. Methods differed slightly from the first two surveys. The primary difference was that playing of taped song was kept to a minimum in an effort to observe adults with dependent juveniles. It is believed that while adults respond strongly to song, juveniles may have an aversion to these calls. Observers stopped every 100 m, raked the leaf litter aside and then waited for a period of 5 minutes. If a robin did not turn up in this time a short burst of song was played of approximately 10 seconds followed by a further 5 minutes of observation. The observer then moved on to the next site. The presence of leg bands and colour combinations were noted for all robins which were seen and the location noted.

Adult survival

At least 13 adults survived the release and were available to contribute to the 1991/92 breeding season. Because of the profuse regeneration of the vegetation, access to all areas is difficult, and it is quite possible that some robins have survived in areas which have not been fully searched.

The survival of the captive-bred birds appeared good. Two of the three juveniles released survived, and one established a territory with its parent, which originally came from the wild. This pairing had successfully produced two offspring. The other captive-reared bird, thought to be an adult female, does not appear to have a partner.

The released stock have not dispersed widely over the island. All are within easy hearing range of their neighbours and occupy the lower slopes and gullies of the island's southeastern side (Fig. 1).

Juvenile production

Juveniles produced on the island had dispersed widely by March 1992 and were observed in a number of habitat types all over the island. At least 16 juveniles were produced in the 1991-92 breeding season, and there could well have been more.

Discussion

The release of North Island robins on Mokoia Island has been successful in achieving its objectives. Survival of the transfer stock has been high, with juveniles recorded post fledging. The results indicate that a self-sustaining population of robins is already established. The public's attention has also been captured by the introduction of robins. The release stimulated numerous articles in the press and has also prompted further attention from schools wishing to participate in the restoration of Mokoia Island.

Initially it was thought that the high level of planned involvement by secondary school students might have proved unwieldy. This was not the case, however. Good organisation is the key to any successful bird transfer programme and is vitally important when co-ordinating activities which involve more than one agency, as happened in this case.

Acknowledgements

I wish to thank the Rotorua Girls' High School pupils and faculty for their participation in the programme. In particular I would like to thank Gary Dender, the principal teacher involved in the programme. Also special thanks to the Mokoia Island Trust Board, who graciously provided their permission and support for the transfer of birds to Mokoia island. Thank you also to Dave Hunt for editorial comment on this report

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ECOLOGY OF THE KUKUPA IN TAITOKERAU: PROBLEMS AND SOME SOLUTIONS

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ABSTRACT: Kukupa (New Zealand pigeon) populations are in decline, with some populations having declined 50% since 1979. If kukupa are to be saved on the mainland, immediate action is necessary to stop predation by mustelids, rats and possums, and human hunting.

The kukupa

The kukupa or kereru (*Hemiphaga novaeseelandiae*) is the only native pigeon in New Zealand. It has no close relatives except for subspecies; one that formerly inhabited Norfolk Island was exterminated in the nineteenth century through habitat destruction and by predators. Another form on Raoul Island was also exterminated last century. A larger bird, the parea, inhabits the Chatham Islands, where it is very rare.

The kukupa is probably derived from an ancestral fruit pigeon from the rainforests of Australia or New Caledonia. Whatever the source, it has been in New Zealand a very long time (possibly millions of years) and has several unique features: it is the only fruit pigeon that has 12 tail feathers (the others have more) and an elaborate territorial display flight.

Foods

In Taitokerau - the top of the North Island - the kukupa is a true frugivore, helping itself to a range of berries year round. The staple fruits are puriri in summer and autumn, miro in autumn-winter and taraire in winter-spring. Many other species figure highly in their fruit salad, including karaka, nikau, and kahikatea. In spring they sometimes also feed temporarily on high-protein legume leaves like kowhai and houhere and their flowers. During the year a kukupa may shift several kilometres following the cycle of fruiting trees. Normally the annual range is in the order of 25 km^2.

The kukupa depends on fruiting trees for its livelihood. But it is not a one-way relationship; the trees also benefit by having their seeds spread around the forest. If the seeds of most species simply fell to the ground beneath the parent tree, most would rot away. Tree species generally require their seeds to be transported away to new places where they have a better chance of establishing e.g. a clearing or other thinly wooded area. The kukupa performs this function of shifting seeds around, especially seeds of the larger fruit. This has the added benefit of increasing genetic diversity for the trees as the new seedlings might establish several kilometres from their parents.

Before the arrival of people in New Zealand, the kukupa shared this seed dispersing role in the forest with a number of other birds. Some of the moa species and perhaps the giant rails foraged on fallen berries and deposited the seeds at new localities. But now that these larger species have been exterminated the kukupa is the sole remaining seed disperser for many tree species. It is the only bird that can wrap its bill around and swallow the large berries of

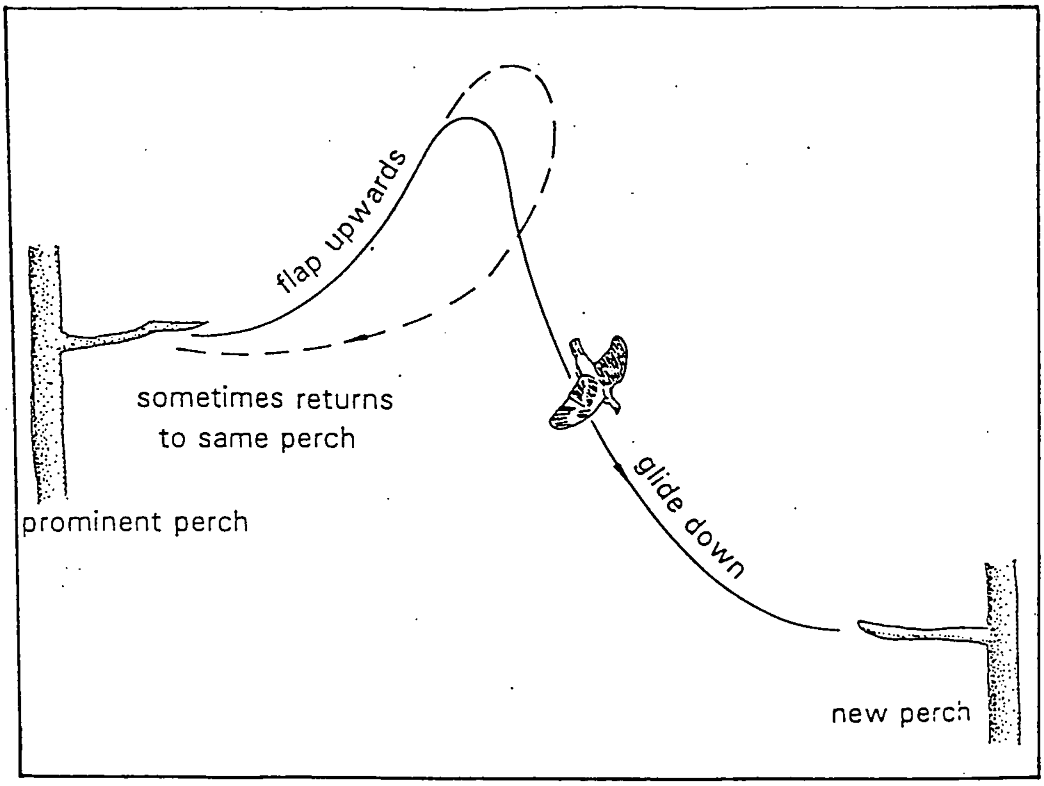

Figure 1 - Kukupa display dive.

karaka, taraire, tawa, puriri, miro and several others. Its role has thus become vital, a truly pivotal species for the continued health of the forest.

Nesting behaviour

Kukupa are seasonal nesters, most nesting taking place in spring or early summer. The first indication that the birds are preparing to breed is the spectacular display dive performed mainly by the territorial males. "He has been sitting conspicuously on a dead branch, white breast shining in the sunlight, and suddenly launches himself upwards in a steep climb, wings flapping heavily, and then stalling to glide down steeply and levelling out to alight on the same or a new perch" (Fig. 1).

At the same time of year there is an increase in the numbers of paired flights seen. Instead of birds flying individually or in loose flocks, they are increasingly seen flying in pairs.

The nest

It could take two weeks or as long as two months after the onset of display diving before the pair eventually begin to build a nest. Nesting trees can be of any sort, but totara, puriri, taraire and mamangi (*Coprosma arborea*) are frequently selected. In those trees the nests are generally in the canopy or subcanopy at 10-20 m height, and often where supplejack or other climbers weave through the branches. On other occasions nests are placed in saplings or small trees down to about 1.5 m in height, and are often quite conspicuous. Another preferred site is in nikau or ponga, on one or more fronds near the base. On the Marotere (Chickens) Islands, nests may be as low as 0.5 m.

The birds build with twigs obtained from manuka, kanuka, totara or any other podocarp. The twigs can be gathered some hundreds of metres from a nest and the birds fly to and fro repeatedly until they have enough material for the nest (usually 30-60 individual twigs). Nest building is sometimes temporarily abandoned while the birds embark on courtship flights and elaborate head bobbing. The courtship flights comprise a series of short chases (walking and flying) from branch to branch.

Egg and chick

Only one egg is laid and incubation, which is shared by both male and female birds, takes 28-29 days. The female incubates throughout the night and up until about midday when the male comes on for the afternoon bout. His bout lasts until early evening when the female returns. During the incubation period a pile of seeds accumulates on the ground directly below the nest.

After hatching the chick is continuously brooded in the nest for about a week. During this time it is fed on "pigeon milk", a protein-rich milky secretion derived from the wall of the crop and mixed with fruit pulp. After a week or so the chick is weaned off the milk and onto a diet of berries regurgitated by its parents. Chick feeding occurs infrequently, possibly only two or three times daily, and the chick is left unattended the rest of the time.

All going well, the chick will leave the nest (fledge) at the age of 4-5 weeks (compared to 6-7 weeks in the South Island). Usually it will spend the next week or so with its parents in the general area of the nest before it becomes fully independent.

We do not know if successful pairs will attempt to renest the same season, but there is one record of this having taken place in Marlborough. On the Marotere Islands some individually marked adults may provide us with that answer in 1993.

Nest predators - A fine balance

In Taitokerau, kukupa do very badly at nesting with only about 15% of nests producing a fledgling. The very flimsy looking kukupa nest tempts one to speculate that most eggs simply fall out of the nests. But it is not because of any poor housekeeping that these nests fail. It's mainly because of predators like stoats, weasels, ship rats and possums, all excellent tree climbers who have a taste for both birds' eggs and their nestlings.

The low success of kukupa nests is mirrored throughout New Zealand. At Wenderholm, near Warkworth, out of 20 nests not one succeeded, and in 18 months of study there was only one juvenile seen in what otherwise seemed like a healthy-looking population. Low productivity also occurs in Hawkes Bay and Marlborough, the latter site (at Pelorus) having been researched since the mid 1980s.

All this wouldn't be so bad if the birds lived for a long time and therefore had the opportunity for many nesting attempts in which to raise progeny and replace themselves. Being such a large bird one might expect that they would be long-lived, like so many of our other endemic birds. Unfortunately, this just isn't the case with kukupa. The most authoritative study carried out on them was in Marlborough where they survived for an average of 5-6 years only, mainly a result of predation on the adult birds by ground predators. When the birds feed on shrubs close to the ground they are susceptible to stoats and cats.

With a breeding success of only 15-20% and 2-3 breeding attempts a year, it takes a pair of Marlborough birds almost exactly 5-6 years to replace themselves. Not much margin for error!

The crunch - human predators

In Taitokerau, radiotelemetry studies suggest that in some areas at least, the birds are not averaging the 5-6 years of the Marlborough birds but only about three years, the lower survival rate being the result of illegal hunting. This means that on average a kukupa will die before it can replace itself, clearly a recipe for disaster.

Birds in general can sustain significant hunting pressure only if they have high productivity. Examples of ideal "game" birds include pheasants, quails, and some duck species, all of which have clutches of 8-16 eggs and each autumn-winter there are high proportions of juveniles around, many of which would die anyway before the following season. The kukupa has only a one-egg clutch, and most clutches fail. Over 90% of individuals seen in the autumn-winter are likely to be older birds, not juveniles. Removing adults from a threatened population is not a sound management practice.

The possum - a dual problem

Because the possum competes for food with kukupa it also has the potential to reduce the productivity of this bird. In southern New Zealand, kereru are known to abandon nesting in poor fruiting seasons and the impact that possums have on fruiting species like taraire in Taitokerau could mean that they will influence kukupa here, e.g. delaying birds attaining their physiological peak for breeding.

But it is direct predation by possums that has recently gained attention. Over the last few years increasing evidence has revealed the predatory impacts of possums, accounting for destruction of at least two of nearly 30 kukupa nests studied in Taitokerau.

The result - kukupa are declining in Taitokerau

A survey of six forests in 1979 was repeated in 1993 and revealed that the numbers of kukupa had fallen on average by a staggering 50%. Greatest declines were in Russell, Raetea and Omahuta forests, all of which have sustained three- to five-fold reductions in kukupa numbers over the last 14 years. These three forests also have the highest hunting pressure. An unhunted reserve near one of these forests, however, supported the highest densities of birds recorded anywhere in Taitokerau in 1993, despite a moderate density of possums. The increasing rarity of kukupa in our forests means that its role as a seed disperser is being increasingly impaired, to the extent that it may be "functionally extinct" in some areas and the health of the forest is jeopardised as a result.

Options for helping the kukupa

1. Stop hunting

A complete cessation of hunting is required to solve the kukupa problem in Taitokerau. Birds would then live to an acceptable longevity and be able to replace themselves during their lifetime.

Can a rahui be achieved? The Department's approach has been a combination of law enforcement, general advocacy and working the issues through with iwi authorities. Despite an increased DoC commitment to all three approaches, the birds continue to be slaughtered e.g. one hunter's patch in Puketi as at June 1993 is dotted with caches of feathers from this year's and last year's hunting. Law enforcement is time-consuming and often difficult and dangerous for those involved in the apprehensions or in providing information. General advocacy can reach a lot of people, but it may not change the ways of the hunters.

2. Stop nest predation

In the absence of ship rats, stoats, weasels and possums, kukupa do well at breeding e.g. about 50% of nests succeed on the Marotere Islands, about three times better than mainland nests. If we could control the mainland predators mentioned above, kukupa would become productive breeders in Taitokerau and the population should increase (provided hunting was not a problem).

Technology for animal pest control is improving each year. Possums can be temporarily controlled over extensive areas by 1080 poison operations. By timing operations to early spring, ship rats too will be depleted for several months, possibly taking more pressure off the nesting kukupa and other birds. We still do not know the roles of the stoat and weasel in this equation.

In smaller areas possums and rats can be controlled possibly indefinitely by combinations of poison bait stations and/or traps. Similarly stoats and weasels can be effectively controlled in small areas by Fenn trapping (break--back traps), already used effectively in some areas to protect kokako research.

Where a nest tree has been found in a residential area or small grove of trees, it may be more appropriate to band the tree. By wrapping a 1 m high sheet of tin round the trunk (and trunks of any interconnected trees), predators will be prevented from reaching the nest.

3. Improve food supply

In some parts of Taitokerau, the birds are under feeding pressure in different seasons, because of local food shortages. This can be a result of either past logging/firing of that area, dieback of some species, or competition with possums for berries. In some springs the failure or poor fruiting of taraire and nikau could cause the birds to starve or place them under physiological stress that might reduce breeding performance in that year.

Trees which are important to kukupa and which may be locally depleted and/or under pressure from possums and other browsers include:

taraire - browsed by possums, which also take unripe and ripe fruit.

puriri - the most important food tree throughout the breeding season.

miro - preferred autumn berry, but local scarcity may force birds to exotics or foliage feeding.

nikau - often the trigger for spring breeding.

Stands of these trees merit protection from possums, stock and people to enable regeneration. For example ageing taraire stands on the volcanic soils of Maungatapere/ Bay of Islands need to be allowed to regenerate or should be replanted. Planting of these and other faster growing fruiting species e.g. pate and pigeonwood should be encouraged.

The three areas discussed - stopping hunting and nest predation and improving food supply - are broad divisions of the options for helping kukupa. The pigeon deserve a concerted effort from all of the people of Taitokerau to prevent their disappearance from our forests in the immediate future.

AN IMPROVED KOKAKO SURVEY METHOD

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ABSTRACT: The standard walk-through kokako call survey methodology was adapted during the survey of the northern Te Urewera to increase response rates by using local dialectical variations in song pattern. Using neighbouring birds' song lets surveyors find kokako throughout the year, over a large area, with a high level of response.

Standard kokako survey methodology as outlined as Appendix One of the NI Kokako Recovery Plan (Rasch 1991) dictates that playback of taped kokako song and calls be used to encourage the birds to respond and thereby enhance their findability. It has been accepted (although not scientifically tested) that due to local variations in kokako song, tapes using "local" song produced the best results and the "mew" (a close contact call comprising a single note often repeated) was not specific to any area and could be used widely.

During the 1080/kokako monitoring of the 1980s (Speed 1988a), "local" calls were accepted as being anything from the general area - e.g. Puketi forest, Pureora north block.

This appeared to work satisfactorily for surveys. It was estimated that 60% of birds in an area were found in the initial walk-through survey (Speed 1988b.) For mistnetting, it was found that the kokako's own song or neighbour's song worked best at drawing the bird(s) into the net.

However, surveyors continued to use a single song to cover a wide area, perhaps influenced by the standard call tape's formal structure of three "mew" calls, five minute wait, three "mew" calls, five minute wait, thirty seconds of song. This formal structure did not encourage changing the song tape part way through the survey.

While surveying kokako in the northern Urewera, we considerably modified the use of taped song, and believe this to be a key to improved survey efficiency.

Developing the technique

In November 1991 Grant Jones and Jeff Hudson were employed under contract to the East Coast Conservancy to survey and monitor kokako on the Tawai and Onepu ridge systems (Waimana catchment of northern Te Urewera National Park). They were to territory map 15 pairs of kokako and any single birds on each side of the Waimana. At the completion of territory mapping a chick survey was to be undertaken to determine the productivity of both sides of the Waimana. Broad scale survey work was not undertaken at this time, but began at the completion of chick monitoring (April 1992). Katheryn Tallentire, formerly a volunteer, was taken on as part of the paid field crew at that time. Staff input comprised Pete Shaw and other Opotiki Field Centre personnel with supervision and direction from Chris Ward and Dave King of the conservancy office.

When we undertook the survey of the

Tawai and Onepu areas prior to territory mapping, only two recordings of calls were available for us to use. One had been recorded by Paul Jansen in December 1990 on the Ngutuoha track, 2 km south of the Tawai study area. The other tape was a variety of mews from the Rotorua area.

We played these tapes on National Slimline tape recorders which have a low-moderate volume output.

At first we were reasonably satisfied with the response from these tapes, but it did become apparent that the ridge lines we were surveying had to be gone over several times to find all the birds. Generally the birds turned up but quickly lost interest in the taped calls, so it was difficult to follow birds. At the time we felt that the birds might have been becoming tape shy. However we did notice the tape we were using did not seem to accurately reflect the song pattern of the birds we were following. Combined with experience of kokako song elsewhere in the northern Urewera, we began to think the differences in kokako dialects on a very local scale may be important.

The tape Paul Jansen had recorded on the Ngutuoha track came from an area to the south of our survey area and mews as well as song appeared different to the tape used. The Onepu bird song was different again, and some features of the song were used only by a small percentage of the birds. We concluded that there were two dialects on the Tawai side of the valley and at least two on the Onepu side.

To overcome this problem, in February 1992, we obtained a directional microphone and used this on the slimline tape recorder to record local mews and song. The response of the birds to the new tapes was quite amazing. Birds that previously had been evasive or impossible to locate with any regularity would now turn up very quickly and if we lost contact while we were following them they could be recalled and located easily.

The technique for recording was simple and quick. If we arrived while the birds were singing, song and mews were recorded straight away without too much regard to optimum quality. If singing had ceased, a few mews were played and any response was recorded. This was usually a couple of mews and/or other contact calls.

These were then played back to the bird which would usually repeat its calls and start singing, the birds usually came in quite close and that often allowed good quality recordings to be made.

This process of recording and playback led to a comprehensive range of taped mews, contact calls and song, which were carefully edited on labelled tapes.

The operation could be done in a very short time, but this depended a lot on the bird's shyness, with singles tending to be the hardest to record. The quality of tapes varied according to how close the birds were and if there was any wind blowing. Strong wind meant that the tapes became cluttered with surface noise. However even the tapes that were of poor quality still seemed to work well and the birds did not seem put off by the extraneous noise.

With the use of directional microphones we approached broad scale survey work with more confidence.

The broad scale survey

In May 1992 we started on a survey of the northern Urewera. Each team (of two usually) was equipped with a slimline tape deck enhanced with a walkman type speaker (self amplifying). For recording either a Nakamichi shotgun type or small video zoom microphone was used.

Territory monitoring had established that kokako territories were centred primarily on main ridges and upper slopes, so the survey was concentrated on those ridges and major side spurs. Emphasis was placed on determining the distribution and density of kokako and not finding every last one (cf. territory mapping).

The technique we had developed was expected to enable us to cover the maximum area at an intensity likely to encounter most birds present. Suitable habitat was targeted but survey routes continued some way into less suitable habitat (e.g. beech forest), when encountered.

On arriving at a new area, with an unknown dialect, only mews were played. When the bird approached it was recorded by the method previously explained.

Once a bird or pair had been called in it was sometimes possible to keep them with us as we progressed through the territory. By playing the tape at regular intervals the bird(s) could be kept in view, and a lot of the time they kept singing. When/if they became silent it often meant they were entering a neighbouring bird's territory.

Often with all the noise of tape playing and resident bird singing and moving, bird(s) in the next territory were attracted to the territorial boundary where they could be observed while the other birds were still in sight. When this happened, it ensured we did not miss out or double count birds and it was possible to move through the territories very quickly. After four territories or so had been covered, another recording was made to ensure local dialect was being used.

If however there was no response in an area which appeared suitable habitat, special care was taken and the whole process slowed down. Keen observation was necessary because there may have been a gap between territories or a territory may have been occupied by a single which may have approached silently.

Kokako density varied from territories every 250-400 m along a ridge, predominantly held by pairs, to having isolated and predominantly single birds several kilometres from neighbours. Shyness was also noted particularly in areas of low kokako density.

It was observed in the Urewera that birds were most likely found:

- Where ridges converged;
- Where the altitude allowed a tawa /tawari mix - i.e., about the transition to lower mountain forest at about 600 m;
- Where there were plenty of berry trees and thick understorey - i.e., tawa, miro, rata, hinau, rimu, totara, with mahoe and supplejack.

Conditions for good response were:

- Clear and still early mornings;
- Light warm drizzle;
- Light winds;

Conditions for poor response were:

- Rain;
- Strong winds;
- Fog, with damp, cold mist;
- Sudden drop in temperature;
- Lateness in time of day (after 10 am summer and 1 pm winter).

Up until this survey, we believed that winter would be a poor time for survey work, because of the lack of spontaneous singing. This did not turn out to be the case at all, as the birds remained very responsive throughout winter and in fact were able to be found much later in the day. So in summer usually four and a half hours could be worked effectively, and in winter six hours.

Data recording

Kokako survey record forms were drawn up to gather data from every encounter with a bird. The forms required data on the nature of the kokako observed, the manner in which it was encountered (including the song tape used, if any, to call it up), weather, and other physical details.

All survey routes were marked on NZMS 260 maps enlarged to 1:25000 scale, with each route colour-coded as to the weather conditions. Another map depicted the locations and number of kokako found. A third map recorded vegetation types encountered during the survey.

Conclusion

To January 1993 we surveyed 68000 ha of the northern Urewera forest tract, covering about 70% of ridge length considered suitable within that area, and found 604 birds. Using the technique described in this article we consider a further 36000 ha of the northern Urewera warrants additional survey. We believe that by using this record and playback survey method, we have improved on the 60% kokako detection rate thought to have been achieved in walk-through surveys in the past.

We believe the record/playback method utilising local dialect is an effective method of maximising the response of kokako to taped song and one which might have application to other species such as kiwi where often one song tape is used to cover a wide area or a number of semi-isolated populations.

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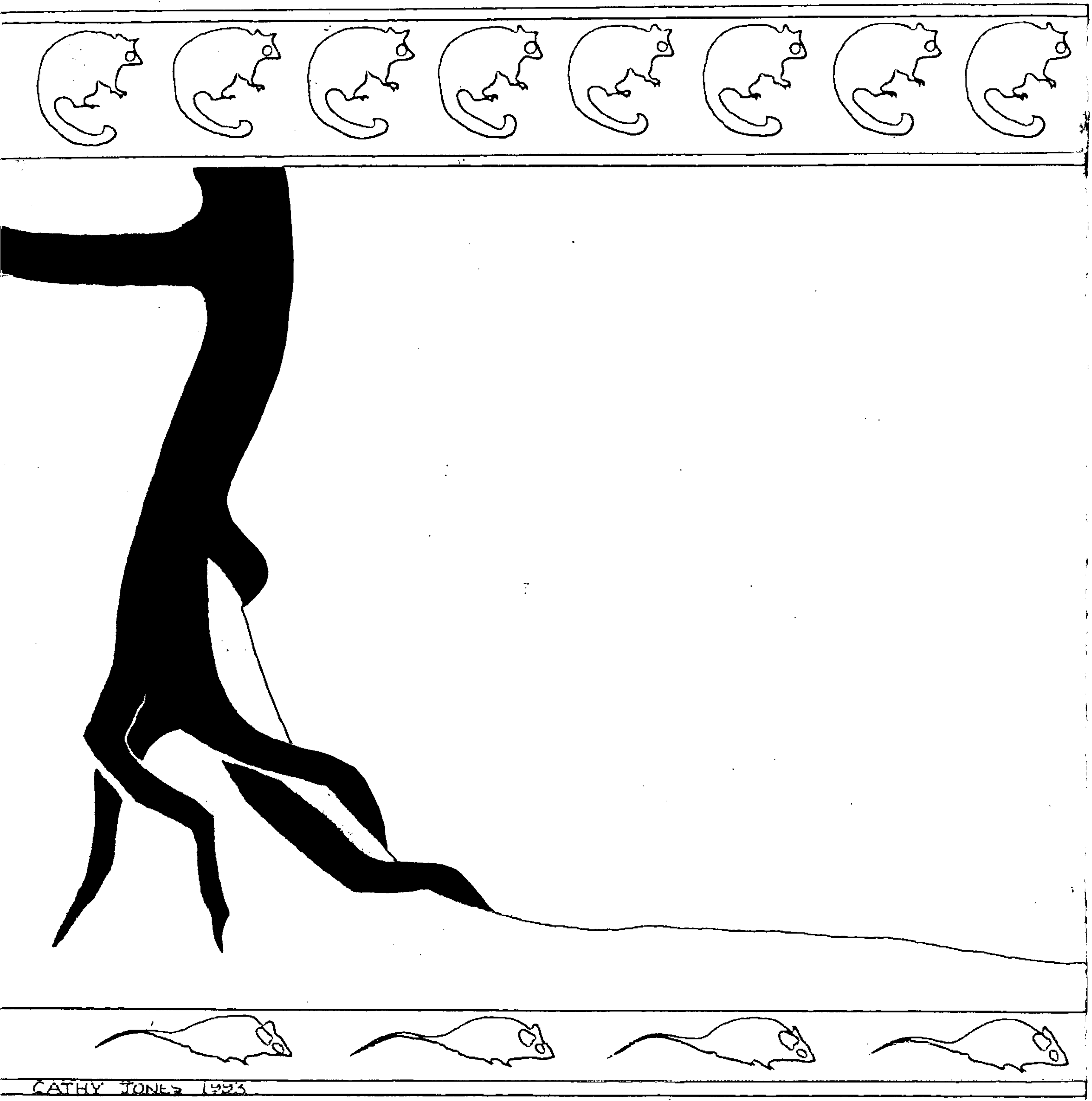

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