Eradication of introduced Australian marsupials (brushtail possum and brushtailed rock wallaby) from Rangitoto and Motutapu Islands, New Zealand

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Abstract In 1990 the New Zealand Department of Conservation began an operation to eradicate the common brushtail possum (*Trichosurus vulpecula*) and brushtailed rock wallaby (*Petrogale penicillata penicillata*) from Rangitoto and Motutapu Islands in the Hauraki Gulf of Auckland. The operation began with a 1080 aerial drop on Rangitoto Island, achieving an estimated 93 percent kill of possums and wallabies. This was followed from 1990 to 1997 by ground work on both islands to complete the eradication of both species. Methods used were trapping, cyanide poisoning, dogs and spotlight shooting. This was followed by several years of ground monitoring and mop-up operations. Aerial surveillance, using a Forward Looking Infrared (FLIR) camera, was also conducted on two occasions to detect surviving animals. A Differential Global Positioning System (DGPS) (a navigational aid) logged flight lines and animals sighted. This was then interfaced on video footage so that survey data could be displayed in real time. The hunting team and their dogs were expected to operate under the harsh conditions of Rangitoto Island's rugged volcanic terrain. There were successes and failures with the multiple field methods employed in this operation. Results from a recent survey have indicated that the eradication of an estimated 21,000 possums and 12,500 wallabies was achieved in the eight years of the operation. The eradication operation has been successful in restoring the previously degenerating *Metrosideros* forest on Rangitoto and Motutapu Islands.

Keywords Brushtailed rock wallaby, *Petrogale p. penicillata;* brushtail possum, *Trichosurus vulpecula*; animal pest eradication; DGPS, differential global positioning system; FLIR, forward-looking infra-red; 1080 poison; aerial poison operation.

INTRODUCTION

Rangitoto Island (2300ha) is a dominant feature of the landscape of Auckland, New Zealand, recognisable from many places in the city. In turn Rangitoto provides from its summit a panoramic view of the Hauraki Gulf and the Auckland metropolitan area (Fig. 1). The recent basaltic volcanic cone of the island, formed *c.* 650 years ago, supports unusual native plant communities with a high level of endemism (Miller *et al.* 1994).

The majority of the forest canopy on Rangitoto consists of a unique association of pohutukawa (*Metrosideros excelsa*), northern rata (*M. robusta*) and their hybrids (hereafter referred to as '*Metrosideros* forest'). Only two other volcanic islands in the world support *Metrosideros*-based communities at a similar successional stage (D. Bellamy pers. comm.). These are located in the Galapagos and Hawaiian Island Groups. The ecological significance of Rangitoto is reflected in its status as a separate Ecological District by the New Zealand Department of Conservation (Department of Conservation 1993).

Motutapu Island (1550ha) is immediately adjacent to Rangitoto (Fig. 1). It is an older landform and its landscape of rolling green pastures and coastal *Metrosideros* forest differs markedly from its neighbour.

Two herbivorous marsupial species from Australia were introduced to the two islands. The brushtailed rock wal-

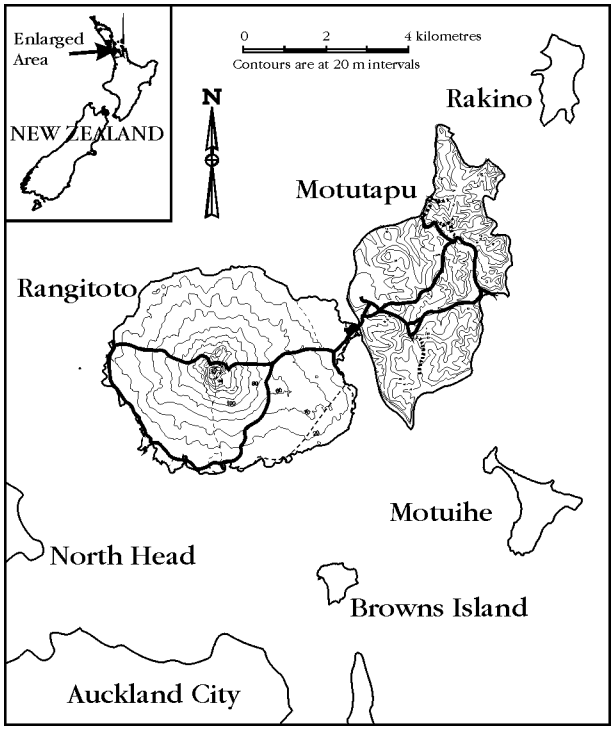

Fig. 1 Rangitoto and Motutapu islands and their proximity to Auckland City.

Pages 226-232 In Veitch, C. R. and Clout, M. N. (eds.). *Turning the tide: the eradication of invasive species*. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

laby (*Petrogale penicillata penicillata*) was liberated on Motutapu Island in 1873 and from here the animals were able to move freely to Rangitoto at low tide. By 1912 they had reached high numbers on Rangitoto (Warburton *et al.* 1990). The common brushtail possum (*Trichosurus vulpecula*) was introduced to Rangitoto pre-1900 and to Motutapu Island in 1868 (Cowan 1990).

Browsing by possums and wallabies was recognised as early as the 1970s as a significant threat to Rangitoto Island's flora and fauna. The Hauraki Gulf Maritime Park Board (which administered the islands at the time) first made a request to the New Zealand Forest Service for advice on controlling possums and wallabies in July 1981.

The decline in forest health became more marked in the late 1980s with massive forest dieback, species loss and tree death common on both islands, all caused by severe mammal browsing (Department of Conservation 1990). About two-thirds of the *Metrosideros* forest had been so severely defoliated that it had died. As a consequence of the loss of vegetation cover, coastal cliffs were showing signs of severe erosion.

Previous control attempts had failed to contain the herbivorous mammal populations and decrease the browsing pressure. Since 1921 wallabies and possums had been controlled on Rangitoto Island using hunting and trapping. Population estimates in the late 1980s indicated possums had increased in abundance by 200% and wallabies by 33% since 1984 (Pekelharing 1991).

With this background the Hauraki Gulf Maritime Park Board resolved in 1987 to develop a work programme for eradication of possums and wallabies on Rangitoto and Motutapu Islands.

Since the islands are linked by a narrow causeway and bridge, any eradication operation had to cover the total area of 3850 hectares. Eradication of both possums and wallabies was established as the target because of the long-term benefits, relative to sustained control. Before the operation the Department of Conservation estimated there were 21,000 possums and 12,500 wallabies on Rangitoto and Motutapu islands (C. Pekelharing pers. comm.).

In 1990 funds were made available by the New Zealand Government for the possum and wallaby eradication programme to begin. Rotary International District 292 (Auckland) were major sponsors of the initial eradication phase which involved aerial poisoning.

METHODS

The Rangitoto-Motutapu Islands eradication operation started in September 1990, with employment of six full-time staff, including a supervisor. This Wild Animal Control (WAC) team was resident on the islands from Monday to Friday from 1991 to 1999.

Rangitoto Island

Several methods were used to eradicate marsupials from Rangitoto. These included aerial poisoning, cyanide bait stations, trapping and dogs.

Aerial poisoning

It was decided to apply cereal pellets containing 1080 (sodium monofluoroacetate) to kill possums and wallabies. Important factors in this decision were the rugged terrain and the need to quickly reduce the critical level of vegetation damage. Rangitoto Island is basaltic lava, much of which is jagged and loose, making it difficult and dangerous to traverse for ground hunting. Furthermore ground hunting can be difficult to control in terms of cost, time and performance (Department of Conservation 1990).

To meet public concerns over use of 1080 poison, the planned toxic loading in the bait was reduced to 0.08%, the lowest acceptable level for an effective target kill. Invertebrate and bird surveys were conducted which indicated a low level of risk to all species inhabiting the island; and the risk of contamination of the fresh groundwater lens was assessed as minimal.

In November 1990, after a series of public meetings and some very vocal opposition, 28.5 tonnes of 1080 pollard pellets (cinnamon-lured) were aerially distributed over Rangitoto Island. The sowing rate was 11.8kg per hectare and the true toxic loading was 0.073%.

This aerial operation was the first large poison operation to employ the assistance of a navigational guidance system for the helicopter. This was a Decca system working off triangulated radio beacons. The estimated kill-rate from this operation was 93%; approximately 20% higher than the average for aerial poisoning operations (Pekelharing 1991). This clearly demonstrated the benefit of navigational guidance for aerial baiting. This system also provided a method of auditing the aerial operation to determine the extent of bait cover on the ground (Fig. 2). These

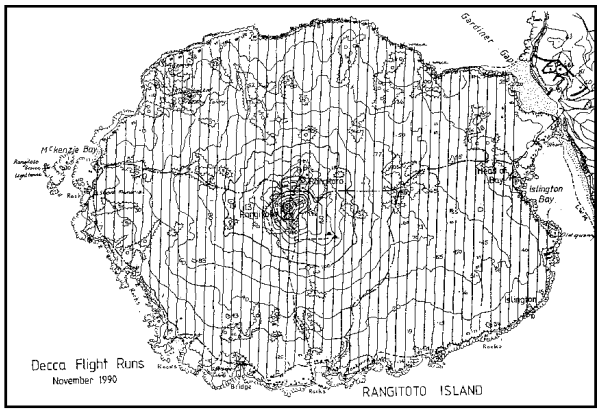

Fig. 2 Flight lines over Rangitoto Island during the 1080 bait drop in November 1999 as printed from the Decca navigation system.

systems have since been replaced by more effective Differential Global Positioning Systems (DGPS).

Cyanide bait stations

Paste containing cyanide poison (sodium cyanide) was laid in bait stations on Rangitoto Island from April l99l.

Animal activity at the bait stations gave a good indication of the location of residual animals. Even a few months after the aerial operation, animals were still exhibiting bait shyness. Bait shyness was evident in that some lines had to be pre-fed with non-toxic baits up to nine times to attract any possums or wallabies to the bait, before the toxin was applied. The pre-feed was lured with a fruit-based lure so animals would not associate it with the cinnamon lured 1080 poison.

Trapping

Initially, a trapping trial was conducted to identify the most effective trap available. At the time only Timms traps (KBL Industries, NZ) had been approved for humane reasons as a specific requirement of the major sponsor. Timms kill traps were compared with Victor No. 1.5 soft catch leghold traps (Woodstream Corporation, Lititz, P.A., U.S.A.). Victor traps were subsequently selected as they caught more animals and were more portable. Soft catch jaws were also used because of public pressure for humaneness.

From February 1991 Victor No. 1.5 soft catch traps were set out at 50 m intervals on 200 m interval parallel grid lines across the whole of Rangitoto Island. During wet winter days possums and wallabies often pulled out of the soft catch traps. Subsequent modifications failed to noticeably improve the performance of the trap set. After appropriate consultations a decision was made to change to steel jaw traps with Victor No. 1 leg-hold traps for possums and Victor No. 1.5 and No. 3 leg-hold traps for wallabies. The catch rate for both species increased markedly as a result of these changes (Department of Conservation 1992). However, it continued to be difficult to trap wallabies on Rangitoto Island given the lack of suitable sites for placement of traps.

For the 1992-1993 season the distance between grid lines was reduced to 100 metres for the second and third sweeps, with a total of 61 trap-lines being set across Rangitoto Island. A ‘rolling front’ method was used whereby trap-lines were leapfrogged into un-trapped areas, with 10 trap lines set at all times. Six lines were set within the new area and four lines remained in the trapped area as a buffer zone, to minimise any chance of animals moving back to the cleared areas. Hunters found that a large number of the possums trapped during these sweeps had previously escaped from soft catch traps.

Trapping on the 100 metre grid lines continued until mid-1996, when the tally for the year was down to one possum and 32 wallabies. Wallabies were targeted specifically along their preferred coastal habitat, with Victor No. 3 traps in double sets on the runs used by the wallabies.

Dogs

Dogs were used on Rangitoto Island in conjunction with the trapping operation. They worked along all trapping grid lines and where concentrations of animals had been found. Dogs proved invaluable for locating animals that had pulled out of traps and for locating fresh sign where additional traps could be placed. Possums that were found by the dogs were usually down holes in the lava and had to be dug out by hand. Wallabies were also located by the dogs, but only infrequently, as these animals were generally too fast for the dogs on the rough terrain.

Motutapu Island

The animal eradication programme on Motutapu Island focused on an immediate reduction in possum and wallaby numbers. A buffer zone approximately 1000 metres wide was cleared around the causeway between Motutapu and Rangitoto Islands to reduce the risk of r-einvasion. This was achieved using a combination of four methods – traps, poison, shotgun, and dogs.

Motutapu Island was divided into five blocks. Four blocks contained large coastal areas and the fifth block contained the conservation area in the centre of the Island.

Cyanide bait stations

Bait stations containing cyanide poison were used throughout all five blocks on Motutapu Island, from 1990 to 1992. Poison was laid in bait stations (a flower pot, or tin lid) with some conventional ground and tree baiting. As the cliffs were very steep, bait stations were set along the top of the cliffs at 50 metre intervals and, where possible, placed further down the cliff. All coastal areas and tree plantations were covered with the exception of an area left for trapping trial work. The poison was pre-fed a minimum of three times and lure was changed frequently to minimise bait shyness.

This method was successful in rapidly reducing the population of wallabies and possum. It was supplemented with extensive ground shooting. However, it proved difficult to target the two species concurrently. Wallabies fed during the day and removed bait before they were available to possums, which feed at night. This problem was overcome by pulsing (laying bait twice each day) the poison to target each species individually and by shooting wallabies before poisoning for possums.

Cyanide poison was effective in obtaining a quick knockdown of animals along the coastal areas and inland plantations. Combined with other methods, it relieved browsing pressure on trees along the coast.

Hunting

Initially the hunting of possums and wallabies on Motutapu Island was undertaken using three different methods: (a) dog and gun; (b) spotlight shooting; and (c) hunting in the evenings and driving the animals. To minimise interference with bait, all three methods were used to quickly reduce the wallaby population before a cyanide poison operation.

Spotlight shooting proved very effective for possum and wallaby control following the poison operations. It was also very effective in and around the small tree plantations on Motutapu Island, as the plantations were open and allowed for good animal recognition by shooters. Trapping would have been more effective, but at that time the operation did not have permission to use leg-hold traps.

In the coastal margins – and particularly along cliff edges – dogs and multiple hunters driving the animals was an effective method to quickly reduce the wallaby population. At times this resulted in more than 100 wallabies killed per hour. Shooting was undertaken using both 12 gauge shotguns and .22 calibre rifles. As the animal populations decreased, the use of dogs on Motutapu Island was important for checking all den and nesting sites.

The hunting operation had to be carefully monitored to ensure it did not interfere with other users of the island, including recreational fishers and boats.

Trapping

Victor soft catch traps (No. 1, 1.5, and 3) were used along the buffer zone once approval had been obtained, as the area had been poisoned four to five times and the residual animals were showing no interest in the bait. The trapping programme met with immediate success with initial lines removing the bulk of the remaining animals.

Initially, problems were experienced with wallabies pulling out of leg-hold traps. This was rectified by different approaches to setting the traps and the purchase of Victor No. 3 traps. Once an effective method of trap setting to target the wallabies had been found, the catch ratios doubled. The Victor No. 3 traps are a large trap and wallabies caught held well, with no pullouts. These traps were expensive but proved their worth as the animal numbers decreased and the risks of losing an animal through pullouts and trap shyness became more of a problem. Trapping in conjunction with dogs was the most effective method for total eradication.

The last possum and wallaby were caught on Motutapu Island in the 1993/1994 operational year.

Monitoring programme

Ground Operations

The monitoring phase of the eradication operation began in 1995. On Rangitoto Island, lines of leg-hold traps were set randomly at right angles to the original 200 metre grid lines. These monitoring lines were left in place and checked daily for eight weeks.

In addition, all grid lines were checked by the dog teams. Each grid line was checked for three days by each dog team, so that each grid line had nine person days of checks using dogs. This work was very hard on the dogs and turnover was fairly high. A dog would work well for a short period and then would lose interest in the work. However, if taken to the mainland for a short period to hunt where possums were common, the dog would work well again and with great enthusiasm.

Random lines were trapped three times and previous 'hot spots' were checked with traps and dogs. From 1994 to 1999, the hunting team monitored Motutapu Island using traps, dogs, and spotlighting.

Forward Looking Infra-red

Final monitoring of Rangitoto Island was completed by helicopter using a Forward Looking Infra-red (FLIR) camera to look for animals at night when the surrounding lava had cooled down. A Differential Global Positioning System (DGPS) navigational aid was interfaced to the FLIR so that video footage could be viewed and animal sightings plotted accurately using the DGPS information.

Table 1 Possum and wallaby kills on Rangitoto Island

Year	Possums per year	Wallabies per year	Trap Nights	Trap Nights per kill
1990	17,000[1]	8500	airdrop 93% kill[1]	
1990/91	182	10	180,000	937
1991/92	558	6	262,500	465
1992/93	268	17	239,800	841
1993/94	114	39	375,000	2450
1994/95	17	82	330,000	3333
1995/96	1	32	330,000	10,000
1996/97	0	4	240,000	60,000
1997/98	0	0	126,000	0
1998/99	0	0	42,000	0
TOTAL	1140	190	2,125,300	1598 *trap nights per kill*

[1]Estimated by Forest Research Institute

RESULTS

Possum and wallaby eradication

Tables 1 and 2 summarise the success of the operation on Rangitoto and Motutapu Islands from 1990-1999. The number of kills per trap night and the total kills for both target species indicate there was rapid population knock-down. This was followed by very long periods of time between kills. This had a significant effect on staff morale.

New Zealand Forest Research Institute (FRI) scientists estimated that the initial 1080 poison drop achieved a 93 percent kill, spread reasonably evenly over both target species (Pekelharing 1991). This represents about 17,000 possums and 8500 wallabies killed on Rangitoto Island during the first year of operation.

In the following six years annual possum kills ranged from 558 down to the final possum in 1996 (Table 1). Wallaby kills continued until 1997 when the last four were killed. On Rangitoto Island there was a total of 2.1 million trap nights, over nine years of eradication and monitoring. Catching the last possum and 32 wallabies in 1995/1996 required about 10,000 trap nights for each animal.

The main populations of wallabies and possums on Motutapu Island were found in the coastal band of approximately 400 hectares. The Motutapu Island tallies of animals killed include only the number of bodies picked up on some operations along the cliffs, but the hunting team estimated that up to 20 percent of the animal bodies were not recovered. Estimates from the ground operations during 1990 indicate that more than 3500 possums and 3500 wallabies were killed. Subsequent years saw the annual tallies drop off dramatically, with around 900 possums and 950 wallabies killed from 1991 to 1994 (Table 2). No further kills occurred and no animals were sighted from 1994 onwards.

Table 2 Possum and wallaby kills on Motutapu Island

Year	Possum[1]	Wallaby[1]	Method
1990/91	2989	3179	Poisoning, shooting
1991/92	660	637	Poisoning, shooting, trapping
1992/93	85	155	Shooting, trapping, dogs
1993/94	5	4	Shooting, trapping, dogs
1994/95	0	0	Trapping, dogs
1995/96	0	0	Trapping, dogs
1996/97	0	0	Trapping, dogs
1997/98	0	0	Trapping, dogs
1998/99	0	0	Trapping, dogs
TOTAL	3929	3768	

[1] It is estimated that up to 20% of the bodies were not recovered (Mowbray pers. obs.)

Two monitoring operations were flown over Rangitoto Island with the FLIR camera in 1997 and 1999. The first operation found two wallabies that were subsequently trapped using leg-hold traps. The 1999 survey was flown at a reduced height, enhancing the resolution of the camera. This second sweep found no sign of either wallabies or possums.

Since no animals were seen or caught in the extensive ground trapping monitoring operation (1995-1999) or during the final FLIR monitoring operation, both Rangitoto and Motutapu Islands are now declared free of possums and wallabies.

Effects of the eradication

The initial 1080 aerial operation also had an effect on the local rodent population which comprises Norway rat (*Rattus norvegicus*), ship rat (*R. rattus*) and house mouse (*Mus musculus*) (Department of Conservation 1990, Miller and Miller 1995). While rodents were not specifically targeted, they were reduced by the poisoning and there may have been a short-term benefit of reduced predation on bird eggs and chicks. The hunting team observed that if there had been a noticeable effect on the rodent populations that this period was very short, as by-catch of rodents was a problem with the trapping regime throughout the operation.

The eradication operation also resulted in a proliferation of several weed species (Wotherspoon 2002). This illustrates the need to anticipate and prepare for such changes following animal eradication projects.

Following the removal of possums and wallabies, rapid canopy and understorey recovery was evident on both Islands. Before the eradication of possums, heavy damage was inflicted on the young shoots and flowers of the *Metrosideros* forest on Rangitoto Island. Ironically, the increased flowering following possum and wallaby eradication was reflected in an increase in honey production from introduced honey bees (*Apis mellifera*). Bees may deplete the nectar resources available to the indigenous avifauna of the islands.

The Waitemata Honey Company has had beehives on Rangitoto Island since 1957 and has kept fairly accurate records of production. From the late 1970s to around 1985 production per hive ranged from 34 to 60kg. From 1986 honey production started to decline steadily and this was blamed on the damage to nectar-producing *Metrosideros* trees by possums. By the summers of 1988-1989 and 1989-1990, production was down to around 7-8kg per hive. After the aerial poison operation and the start of ground operations on Rangitoto Island, honey production rose to around

25kg per hive. This trend has continued, despite some variations that are attributable to other factors such as weather. The 1997-1998 production season saw a harvest of 81kg of honey per hive.

DISCUSSION

The people employed were the most important part of this operation. Although 20 different people worked during the entire operation (1990-1999), there was a core of staff involved in most of the eradication. Rangitoto Island is a hard environment to work in, with difficult terrain and extremes in temperatures due to the lava. Boots lasted only between four and six weeks on Rangitoto Island, as they were literally shredded from the hunters' feet by the lava.

As the eradication programme progressed, the low tallies affected motivation. So, periodically trips were taken to areas on the mainland where the hunters would have more successes.

Sustained motivation is one of the most important prerequisites for any eradication programme. A successful eradication operation must have consistent commitment from management and motivated staff to achieve the vision.

With hindsight it would probably have been easier to conduct the operation with a larger hunting team. This would have decreased the amount of time spent completing each sweep with the traps and dogs.

Use of FLIR for monitoring has the potential to become a very effective tool in eradication operations. However, there are a number of issues which need to be addressed when choosing to use FLIR. These include:

1. Availability of suitable systems (infra-red and DGPS) which are able to be integrated;
2. Operator experience in the use of DGPS (owner-operated or leased) and the ability to provide on-site print outs;
3. Ensuring the helicopter type is suitable for the operation and can operate effectively in the conditions. In the Rangitoto-Motutapu FLIR trial the camera was mounted to a Hughes 300. This was not an ideal helicopter for the operation as it had great difficulty maintaining the correct speed for survey while flying down wind, due to lack of power. During the actual FLIR survey the camera was mounted on a Hughes 500 and Squirrel helicopter, providing more stable all-weather platforms;
4. Helicopter operators must have sufficient time to set up the equipment for infra-red survey work.

The use of the FLIR camera by the New Zealand Department of Conservation is so far fairly limited, but work already undertaken has shown great potential for the monitoring or detection of a large variety of animal species. Infra-red monitoring has the potential to be a very cost-effective way of monitoring all animal populations.

The initial decision to use soft jaw traps, rather than steel jaw traps, added at least two years to the operation. The soft jaw traps were less efficient and the animals that escaped were often subsequently trap shy. Long periods of time were spent trying to catch trap-shy animals. One of the last wallabies caught had signs of being trapped at least three times previously. The decision to use soft jaw traps was made by management and not at an operational level. This decision could have compromised the whole operation and certainly added to the final cost.

Rock wallabies were a "wild card" for the whole trapping operation, as no work had been undertaken prior to the eradication operation, to ascertain if traps were an effective method to eradicate wallabies. The targeting of wallabies and possums at the same time also posed some problems. These were resolved, however, while the programme was underway. It may have been better if wallaby trapping trials had been completed prior to the operation commencing.

An opportunity exists to repeat the pre-eradication surveys of Rangitoto Island vegetation condition and avifauna (Miller and Anderson 1990; Miller 1992), to further quantify the apparent changes to the island ecosystems. The success of this operation as an exercise in ecological restoration is evident from the mainland in the proliferation of pohutukawa flowers and the visible greening of Rangitoto Island.

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