SCIENCE & RESEARCH SERIES N0.46

ERADICATION OF BRUSHTAIL POSSUMS (*Trichosurus vulpecula*) ON KAPITI ISLAND, NEW ZEALAND: TECHNIQUES AND METHODS

by

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

ISSN 0113-3713
ISBN 0-478-01384-1

National Library of New Zealand
Cataloguing-in-Publication data

Sherley, Gregory H. (Gregory Howard), 1956 –
Eradication of brushtail possums (Trichosurus vulpecula)
on Kapiti Island, New : techniques and methods /
by G.H. Sherley. Wellington, N.Z. : Head Office,
Dept. of Conservation,
1 v. (Science & research series, 0113-3713 ; no. 46)
Includes bibliographical references.
ISBN 0-478-01384-1
1. Trichosurus vulpecula--Control--New Zealand – Kapiti Island.
2. Opossums--Control—New Zealand – Kapiti Island. I. New Zealand.
Dept. of Conservation. II. Title. III. Series: Science & Research no. 46.
632.692099341

Keywords: Possum-brushtail, *Trichosurus vulpecula,* eradication, pest control, planning, NZMS260/R26

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ABSTRACT

Nearly 20 000 brushtail possums (Trichosurus vulpecula) were removed from Kapiti Island (1967 ha) between 1980 and 1987, the majority in the first 2 years of work. The task of removal evolved from control to successful eradication. This report documents the resources outlayed and the methods and techniques used by trappers, shooters and dog-handlers. It describes the problems encountered and the lessons learnt which should be relevant to other island mammal eradication programmes. These lessons include: deciding on eradication and not control as a policy from the outset (because methods used in control seriously compromise eradication); trials on methodology should not be done on the target population; techniques for monitoring the target species at low densities are required; research on methodology and the resulting advice is invaluable throughout the eradication campaign and, most importantly, staff at all levels must be totally committed to eradication.

1. INTRODUCTION

Kapiti Island lies about 5 km off the west coast of southern North Island of New Zealand ($40^{o}51'$ lat, long). It has a long history of Maori and European human occupation along with their exotic animals (domestic farm animals, cats and rats). Europeans introduced the brushtail possum (*Trichosurus vulpecula*) in 1893 to help establish a local fur trade. Since the island became a nature reserve in 1912, all feral domestic animals and cats have been eradicated. Until 1987 possums, Norway rat (*Rattus norvegicus*) and kiore (*Rattus exulans*) were the only remaining mammal species on the island. Now that possums have been eradicated, only the latter two species remain. Cowan (1992) has summarised the attempts to control possums prior to the eradication. The idea to eradicate possums stemmed from a desire to remove the need for perpetual control, accelerate the recovery of the island, and enhance the habitat for native (mainly bird) species. The eradication campaign itself and its costs are summarised by Cowan. The purpose of this publication is to document how the eradication was achieved: the methods, organisation and materials used. Hopefully, documenting the lessons learnt from Kapiti Island will benefit plans for eradicating mammals from other large islands. The control versus eradication debate has

to be resolved unequivocally before staff actually want to eradicate a species and before any institution wants to finance a large operation.

2. THE BRUSHTAIL POSSUM (*Trichosurus vulpecula*)

A thumb-nail ecological description from Cowan (1990)

The brushtail possum has a thick bushy tail, a pointed snout and a darkly stained sternal gland on the chest. The fur is thick and woolly. Like most marsupials, possums have a fully formed pouch within which young suckle until they are fully furred and able to cling to their mother's back. Adult total length ranges from 650-930 mm and weigh from 1440-1600 g. Possums are opportunistic herbivores, feeding mainly on leaves. They also take buds, flowers, fruits, ferns, bark, fungi and invertebrates, and at times any one of these may comprise most of the diet.

Possums are nocturnal and largely aboreal although they may spend 10-15% of their time on the ground, feeding and moving about. Feeding may last 1-2 hours starting about 2 hours after sunset. Males have larger home ranges (mean 1.9 ha, range 0.7-3.4 ha, length 295 m) than females (mean 1.3 ha, range 0.6-2.7 ha, length 245 m), but both are known to extend normal occupied areas to exploit locally abundant food sources. Scent gland exudations are used for individual recognition and scent-marking territory. During the breeding season females may he accompanied by one, sometimes two consort males for 30-40 days before oestrus. Males are sexually mature at 1-2 years old, but maturity is variable in females from one year onwards. Adult females are polygamous and polyoestrous with an oestrus cycle lasting 26 days (about 8 days longer than a pregnancy) with a second smaller and more variable season in spring. Thus possums have an ecology that well suits them as an invasive colonising species: reproductive potential, generalist feeders and a physiology tolerant to most climates experienced in New Zealand.

3. KAPITI ISLAND

The island covers 1965 ha and is roughly oval. More than 80% of the terrain consists of steep, forested hillsides. Eleven major catchments (some extremely steep) lead up to a ridge which runs along the main northeast-southwest axis of the island. Most of the island faces southeast while the northwest facing portion is mainly steep cliffs. Two significant flat areas occur at Rangitira Point and the north end. Here, and at Te Mimi and the head of the Taepiro catchment (Fig. 1), large grass-scrub areas occur. The forest is varied in composition, reflecting mainly the degree of clearance during historical human occupation, and soil fertility. Hence all stages of succession occur from areas of open grassland to original forest.

There are no roads on the island, only a few permanent walking tracks. Unless a helicopter is used, the only means of transport around the island is by foot or boat. The latter form of transport is often compromised by southerly or south westerly weather to which the island is directly exposed. The above physical characteristics all created practical constraints on eradication activities.

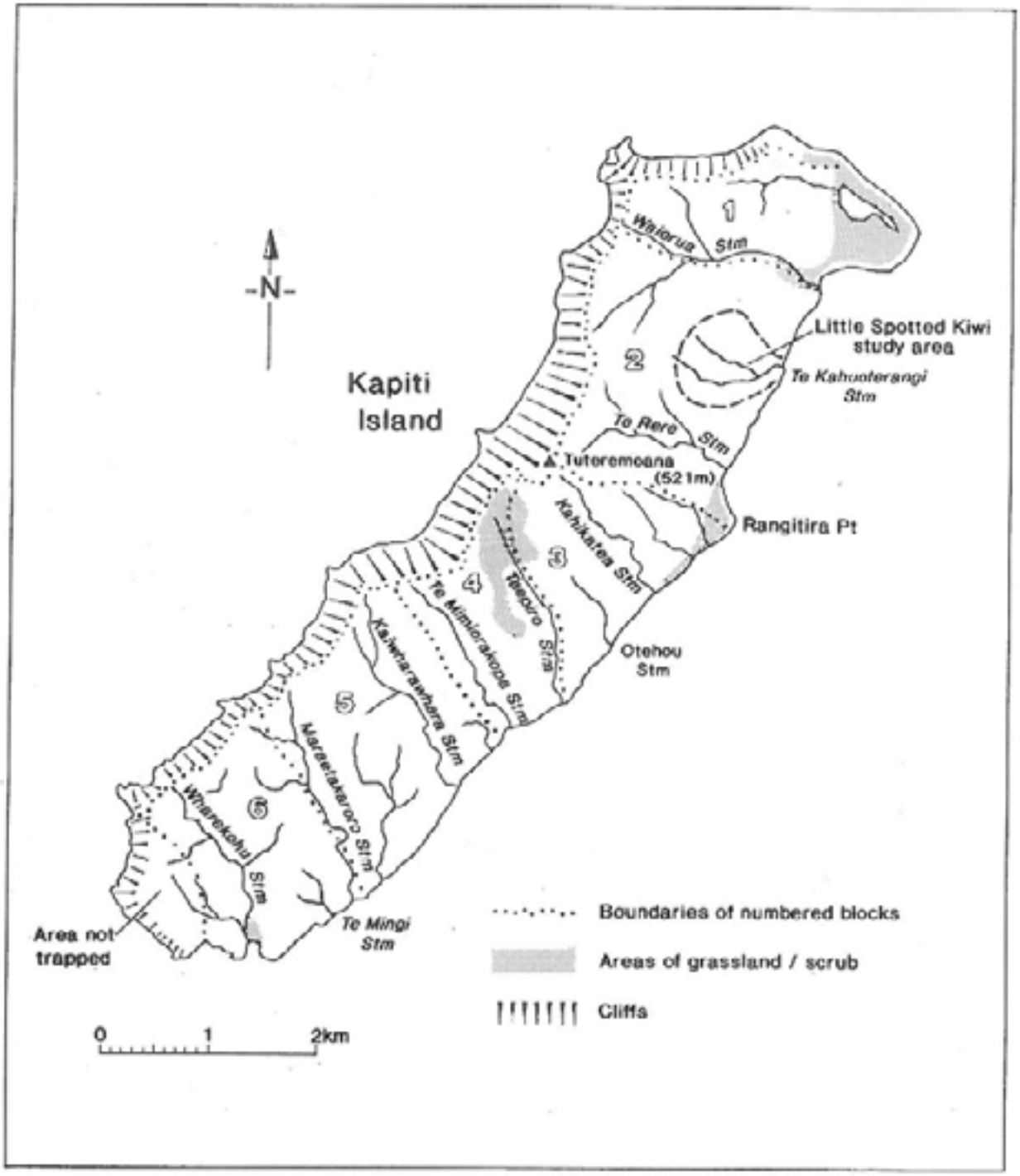

Fig. 1 Kapiti Island: major catchments and block boundaries used during possum control/eradication.

Since whalers left Kapiti Island, most human occupation has been restricted to rangers following the creation of a reserve in 1912. Kapiti Island is a Nature Reserve under the Reserves Act 1977; the highest level of protection for a natural area allowed by New Zealand legislation. It has been used for the safe-keeping of protected rare plant and bird species including recently: takahe (Porphyrio mantelli), Saddleback (*Philesturnus caranculatus*), and stichbird (*Notiomystis cincta*).

4. HISTORY OF POSSUM CONTROL ON KAPITI ISLAND

Ten black Australian brushtail possums (*Trichosurus vulpecula*) were introduced to Kapiti Island from Tasmania in 1893 by the Southland Acclimatisation Society. Records indicate that introductions were made at the north end of the Island. Since 1914, various attempts have been made at controlling possums on Kapiti. Bennett trapped possums between 1914 and 1923 and noted dispersal towards the south end. Wilkinson records that between 1923 and 1943 intensive control was carried out by 2 full-time trappers. Between 1943 and 1952 successive caretakers undertook some light control. Two reports in 1948 and 1952 from the Department of Internal Affairs stated that possum damage was light. In 1953 and 1955 the Wildlife Division of the Department of Internal Affairs killed 1340 and 2547 possums.

Two surveys in 1957 and 1958 indicated that possum numbers had risen to pre 1955 levels and that 30-40% of female possums in one study area on Kapiti had two breeding periods per year. In 1959 various control techniques were considered but 1080 was not acceptable because of the risk to protected birds on Kapiti Island. Between 1960 to 1964, two trappers were employed who took 8638 possums. The New Zealand Government archives, from which the above information comes state that possums were in low numbers and causing slight damage during these years. Between 1966-1968 two trappers took 6646 possums yet surveys in 1969 and 1970 suggested possum numbers were high.

From 1969 to 1980 a moratorium on possum control existed while monitoring of possums and their effect on vegetation was carried out. Between 1980 and 1982 commercial trapping killed 15 631 possums. In February 1983 an intensive control programme was started which culminated in eradication in 1986. In this report the commercial trapping (1980-1982) and especially the eradication techniques used (1983-1986) are described.

5. CONTROL OR ERADICATION?

Before an eradication starts it is necessary to debate and analyse the costs and benefits of eradication versus control for habitat restoration. If debate is resolved clearly in favour of eradication, there need be no doubt about the approval of a formal policy of eradication. The analysis is essential for at least two reasons:

1. The funding and organising authority (usually Department of Conservation in New Zealand) must be certain that the cost-benefit analysis is in favour of eradication to ensure its administrators continue funding throughout the duration of the programme. Eradication means continuing effort until the last animal is removed.

2. The field-staff employed to carry out the eradication need to be convinced of the importance of the eradication since this will be the only reinforcement and motivation available when kill rates are low; which is most of the time during an eradication campaign.

Parkes (1990a) considered some of the criteria which must be met for successful eradication. These included:

1. All pest animals must be placed at risk.
2. The rate of killing must exceed the rate at which an animal can replace itself.
3. The chance of re-invasion (natural, accidental or malicious) must be zero. This includes island security (landing procedures, public use, etc.).
4. Institutional motivation and commitment to eradication. While the latter criterion is subjective, it is crucial because the tenure of staff assigned to a given project might be uncertain.

A cost-benefit analysis of control versus eradication needs to address the following questions.

1. Which plant and/or animal species are being threatened by the continuing presence of the pest?
2. What other threatened species may be translocated to the island if the pest is removed?
3. What are the values to national conservation objectives of the native species in 1 and 2 above?
4. Will control at a given level allow the survival of important species at acceptable levels?
5. Will the costs addressed in 4 exceed eradication costs over, say, a 10 year cycle?

The cost-benefit analysis should compare an eradication campaign with at least two control strategies: 1: annual sustained control, and 2: occasional sustained control (Parks (1990a). The former involves choosing a density of pest species which causes levels of damage which are acceptable. The animals are reduced to this level and the annual increments are killed off in perpetuity. Occasional sustained control means a large initial single effort at control and then monitoring vegetation until possum damage is again unacceptably high. Both strategies require knowledge of the relationship between the possum and the vegetation and that funding in perpetuity will be available. If the latter is not possible this strategy should never be embarked upon (Parkes 1990a). Sustained control requires accurate methods of measuring success (or performance monitoring). This task is technically difficult and expensive. However, the expense is reduced if goals are set precisely.

One reason for not pursuing long-term control is the difficulty of maintaining funding in perpetuity. On a forested island such as Kapiti, maintenance costs include track cutting, huts and transport. The former amounts to a large monetary cost, and compromises the purpose of the reserve by the destruction of vegetation. Other on-going costs include paying trappers (unless commercial trappers are used), administering the operations, monitoring results, and the cost to the Island's native community of low numbers of possums. Obviously opting for eradication removes the above ongoing costs which must be balanced against the cost of eradication and the benefit of a community free of mammalian browsers. There is also the opportunity cost of an eradication programme-other conservation projects that could have been funded had the resources been used elsewhere. If, however, funding cuts must be sustained, Parkes (1990b) points out that budget cuts should be at the expense of eradication campaigns, not control programmes.

Finally, sustained or occasional sustained control methods lead to an inherently unstable ecosystem (browser/predator and food/prey species fluctuating) whereas eradication will lead to an inherently stable ecosystem (Parkes 1990a). The latter may well be the preferred option if the (pre-determined) conservation values are to be retained. For example, one of the main lessons learned from eradicating possums on Kapiti Island is the importance of establishing a firmly agreed policy, right at the outset: eradication or control? The difference is fundamental, and profoundly affects decision-making because some control methods seriously compromise eradication methods.

6. COMMERCIAL TRAPPING (CONTROL)

Seven commercial trappers, with the right to sell all skins acquired, were used between February 1980 (start of trapping) and September 1983. Up to 1 December 1982 they operated up to 120 traps each for 65, 866 trap-nights and caught 15,631 possums (Cowan pers. comm.) While these figures are approximate they illustrate the successful use of commercial and hence profit-motivated trappers. Through trapping, about three quarters of the possum population was destroyed before it became commercially non-viable and other eradication methods were required. By initially removing the bulk of the population using commercial trappers, there was no temptation afterwards to try to pursue commercial trapping or kill techniques that compromised the eradication objective. It is worth noting that the commercial trappers would not have been successful had there not been a high market value for possum skins over the period they operated.

The overriding consideration influencing the choice of eradication techniques was that of not killing native birds, especially little spotted kiwi *(Apteryx owenii*). At the time of possum control there was almost nothing known of the status of the species on Kapiti except that it was the only viable population of this endangered species. Thus poisoning (see later) and trapping had to be conducted in such a way as to minimise killing ground dwelling birds such as little spotted kiwi and weka (*Gallirallus australis*) as well as arboreal species. Another constraint was the then current research into the competition between kiwi and possums which was occurring in part of the island and which prevented control measures there.

Accidental killing of ground birds was minimised by setting traps on "sets" -a length of wood lent against a tree that the possum climbed and where it got caught (details of design are shown in Fig. 3). Five traps were tested including live-capture cage traps. Note that testing traps (or any control technique) on possums from the population that one eventually wants to eradicate is a serious mistake. The reason is that in doing so one may be creating a pool of trap-shy or neophobic animals that are infinitely harder to kill than naive animals. Hence eradication will be made even more difficult. This did happen on Kapiti -where Victor Oneida, Bigelow and Lanes Ace brand gin traps were all tested. The first two do not have serrated jaws and therefore were considered less damaging to birds. However, Lanes Ace gintraps do have serrated jaws and are therefore potentially more damaging to birds. On the other hand serrated jaws hold possums better than those without teeth. In order to minimise the risk of damage to birds the spring tension on Lane's Ace gin traps was reduced. However, no evidence of a reduction in damage was

found, although there remained a number of escaped possums that were probably trap-shy. For this reason trialling of new techniques should always be carried out on a non-target population of the pest species.

There is much controversy about the relative effectiveness and humaneness of different traps. While no trials were conducted in a scientific manner (controls, replicates, large sample size, etc.), the Bigelow trap was discarded because too few possums could be drawn to it, it was difficult to mount on sets, and it required the use of baits. The reason why baits were not used on these or other traps was because of the increased risk of catching birds which might he attracted to a potential food source. Hence the principle of trapping exploited on Kapiti was to take the trap to the possum rather than attract the possum to the trap. This decision was partly made because using lures to attract possums to the trap was unsuccessful (see later). On the other hand, it was believed that a reason traps on sets worked was that the possum became curious: It found an unusual object in its territory, climbed to inspect it, and got caught in the process.

Considering the huge number of trap-nights, the number of birds caught during the commercial trapping period was small (Table 1; Cowan 1992). For example, between Febuary 1980 and December 1982 (period for which data are available) 6 kaka (*Nestor meridionalis*), 12 morepork (*Ninox novaeseelandiae*), 20 weka and 1 long tailed cuckoo (*Eudynamys taitensis*) were caught in 65,866 trap-nights. Given that 15,631 possums were caught over this time (at night), the proportion of traps catching diurnal birds was 27/65,866 = 0.04%. For example, if one accepts that on average half a trap-night is lost in catching a possum, the proportion of traps catching morepork (a nocturnal owl) was 12/58,000 = 0.02%. Obviously the number of birds accidentally killed using set mounted gin traps was very low.

Tracks were cut on all ridges and spurs such that the spacing between them was no more than 100 m (Fig. 2). Trap-sets were deployed at 50 m intervals so that, theoretically, there was a trap set within 50 m of every possum. The island was divided into blocks based on catchments (see Fig. 1). Most trappers worked lines with 80 -120 traps although sometimes longer lines of up to 200 traps were worked (when return rates had dropped).

The design of sets is also a job better done on a non-target population, even though the process is less likely to produce trap-shy animals than did experimenting with different traps. It should be noted that there exists a fundamental conflict between commercial trapping (control oriented) and eradication practices. During eradication the most extreme measures are taken to avoid creating trap-shy animals: traps are set in generally-agreed optimum ways (e.g. degree of hair triggering on the plate). These standards are monitored and enforced by the members of the eradication team. However, among the four commercial trappers used on Kapiti Island at one time, there was marked variation in technique. Variations centred around locating sets, set angle from vertical, locating sets on food trees, etc., and this the chances of creating trap-shy animals is increased. In normal commercial trapping this is an accepted risk, but not if the aim is eradication. If commercial trapping is used in the early phase (assuming eradication has been planned

Table 1 Numbers of non-target birds caught during possum trapping on Kapiti Island 1980-1987.

Species	Numbers trapped
New Zealand pigeon (*Hemiphaga novaeseelandiae*)	70
Morepork (*Ninox novaeseelandiae*)	47
Weka (*Gallirallus australis*)	29
Kaka (*Nestor meridionalis*)	16
Pukeko *(Porphyrio melanotus*)	3
Harrier *(Circus approximans)*	2
Southern black-backed gull *(Larus dominicanus)*	2
Tui *(Prosthemadera novaeseelandiae*)	2
Blackbird* (*Turdus merula)*	1
Bellbird *(Anthornis melanura*)	1
Paradise shelduck (*Tadorna variegata)*	1
Brown teal (*Anas chlorotis)*	1
Robin (*Petroica australis*)	1
Long-tailed cuckoo (*Eudynamys taitensis*)	1
Song thrush* (*Turdus philomelos)*	1
White-backed magpie* (*Gymnorhina tibicen*)	1
TOTAL	181

* = introduced species.

for in advance), quality control must be enforced at the outset of operations. While operator variation can be reduced by alternating trappers in different areas (this was done on Kapiti) this does not remove the problem if different techniques create shy animals.

Perhaps the most extreme example possible of how commercial trapping practices can compromise eradication objectives is the practice of farming pest species. At one point on Kapiti it was found that a commercial trapper was releasing small or juvenile animals rather than killing them because their skins were worth so little. This practice will create a trap-shy and human-shy population, compounding the difficulties of eradication. It is not that the trapper was at fault, because at that stage there was no **policy** of eradication. This illustrates the importance of setting up appropriate policy objectives before any field work starts.

Trappers also varied the way they deployed their sets. Some spaced their trap-sets at fixed 50 m inte5rvals. Others placed their trap-sets in what they judged to be likely spots, (e.g. food trees, and on runs), averaging out their trap-set intervals at 50 m. The latter trappers were more successful. When an area was not yielding an economical return (subjective

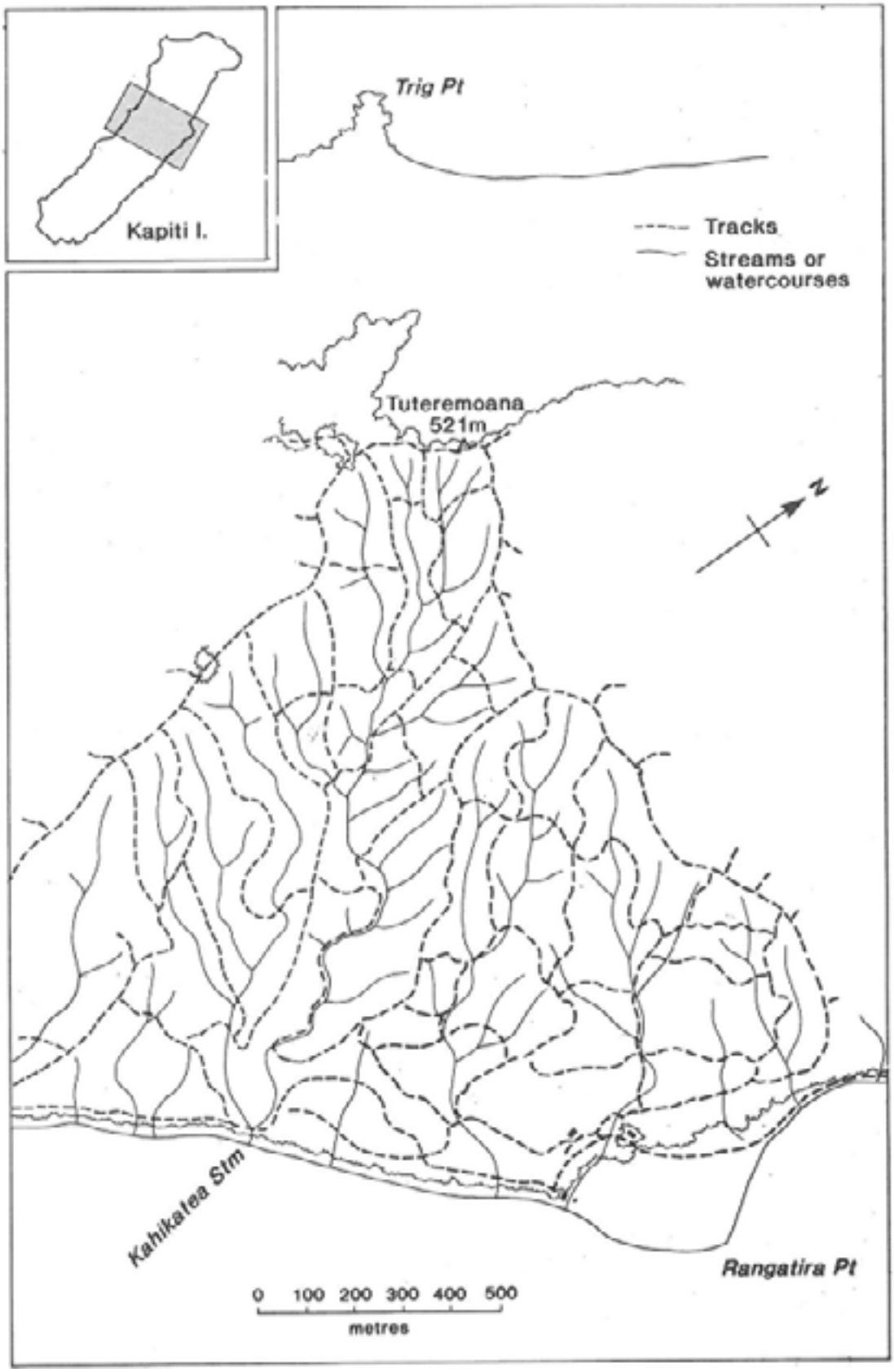

Fig. 2 An example of how catchments on Kapiti Island were divided up into track networks. Inset is the position of this catchment on Kapiti.

decision), the traps were moved (sets left in place) so that a continuous wave of traps moved over the habitat. The idea was to stop re-invasion back into trapped areas from the (presumably) denser population. Trap-sets were laid out on runs. (Routes possums frequent during their normal course of movements.) Identifying runs is a question of field experience: basically they are worn paths leading to preferred shelter or food trees. Hence sets are usually built against the sides of important trees. These trees may be identified because foraging possums often scatter hundreds of leaves on the ground having eaten only the base of the petiole (e.g. five finger), or leave scratch or chew marks on the trunks and branches.

Generally, the commercial trapper day (working 80-120 traps, hence 1.3 km return) involved starting at about 0700 hours. Possums killed were collected in groups of 3 and hung. Since for the first two years trapping only occurred for 2 months (March to early April), it was necessary to spray the carcasses to prevent them being fly-blown. For the rest of the day traps were relocated as required and new tracks cut. On return to base, that day's kill was carried back and hung. Finally, the previous day's kill was skinned and stretched. Summer trapping was preferred initially because the quality of the skins was better, the island was less slippery and access was less difficult. Also, in winter the possums were less mobile and therefore harder to catch.

During the commercial trapping phase from 1983 onwards, particular trees that were important to possums were often targetted with densities of traps higher than those already mentioned. Large kohekohe, rata and were well known preferred food species for possums on Kapiti. Groves of these trees or even individuals (in the case of rata especially) were often singled out for extra trap-sets. Given that at certain times of the year these (and karaka) trees acted as "sinks" for surrounding possums, it was well worth the extra effort of targetting these localised abundant food sources.

The principle of targetting localised super-abundant food sources became more important late in the eradication phase. By then possums should have been absent over most of the island, but when karaka trees were heavy with fruit they were traditionally visited by possums from far afield. The significance of dogging at this time was that possums were forced to walk some way on the ground because of the long distances involved. In doing so they left a ground scent which was more likely to be picked up by the dog teams. Thus, the behaviour of possums massing on a traditional (temporarily and spatially abundant) food sourcewas used as a tool for detection at extremely low densities.

6.1 Lures

Lures are scents that attract the target species either to a poison station or a trap. On Kapiti 9 lures were trialled - the percent catch "per lure" being taken as the measure of effectiveness of the lure (Table 2).

Only the lure essence itself was used; they were not mixed with carrying agents such as flour. The reason for this was to avoid the risk of attracting birds to the traps. Essences were applied directly with droppers or dabbed on the tree or stake about 25 cm above the point where the set touches the tree which meant that when the possum was

Table 2 Possums caught using various lures on Kapiti Island during 1981.

Lure	Trap nights	Possums caught	Percent catch
Bergamot	882	172	19.67
Gingerine	546	140	25.64
Molasses	909	246	27.06
Aniseed	1996	308	15.43
Cinnamon	1782	467	26.20
Spearmint	3735	810	21.68
Almond	1516	373	24.60
Nutmeg	564	140	24.82
Pimento	1091	267	24.47
Gingerine & Cinnamon	960	193	20.10

scenting the lure it would place its rear foot on the plate of the trap. On Kapiti, operators replaced the lure after about 5 days or after rainfall.

While the figures of percentage catch might be interpreted to show some lures work better than others, it should be borne in mind that the trials were not done with proper controls or under standardised conditions (e.g. equal possum densities, or similar forest type per lure-trial). Lures cannot be discounted on the basis of the above results because (1) the trials were poorly designed, (2) mixtures may work better than pure essences and (3) the effect of lures may be substantially enhanced with the use of baits and or carrying agents which may be available for other eradication programmes. The volatility of lures, and hence their longevity, may be enhanced by using baits.

Lures were also used to try to attract possums to bird-proof poison stations (see later) with no resulting improvement in their use. Trials were done in 1984 when possum densities should have been considerably lower than those in 1980 when commercial trapping started. The usefulness of lures with poison stations (effectively bait stations) may be quite different when possums are at higher densities. Once again it may be misleading to trial techniques on the target population since, on Kapiti, the possum population may have behaved quite differently earlier, when it was not under such trapping and hunting pressure.

7. PLANNING ERADICATION

The eradication of possums from Kapiti Island evolved from a period of 2 years of intensive control involving commercial hunters trapping for the fur trade. An eradica-tion proposal was compiled on behalf of a working group in June 1982 by Dr Phil (DSIR). In it he proposed that eradication should proceed in two phases:

1. "An initial high intensity control programme lasting 2-3 years, involving intensive trapping, use of poison bait stations and aerial poisoning.

2. "Sustained pressure on the few remaining possums, involving continued use of bait stations, some trapping, spotlighting and shooting, use of trained dogs and other suitable methods."

Cowan estimated the programme would last five years. Except for the timing, the above was what actually happened.

7.1 Planning decisions

Cowan (1985) identified the following areas which needed planning decisions:

7.1.1 Staff requirements including the need for a project leader who understood the implications of eradication and could interface between field workers and administrators.

- Use of volunteers to assist in the extremely labour intensive tasks track cutting and maintenance).
- Employment of a core unit of the same full-time staff to work on the project from start to finish.
- Monitoring using different staff from those involved in eradication so that eradication effort was not reduced.

7.1.2 Preparation Semi-permanent accommodation for staff in strategically placed sites over the island.

- Tracks cut to allow desired density of traps and/or poison stations.
- Pre-campaign monitoring of possum densities to assess effectiveness after eradication has started.

7.1.3 Data collection Recording effort in a set format so that effectiveness could be calculated, areas where further effort is required identified, how effective operators and/or techniques were, and how much eradication effort was distributed.

- Data collection for scientific enquiry of relevance to eradication (e.g. the age distribution of possums caught, change in productivity of possums and home range changes at progressively lower densities).

7.1.4 Design of the eradication procedure Details of how things were done on Kapiti Island are detailed later, however, planning covered: track/trap densities, avoiding compromising other interests on the island, aerial poisoning, bait station use (coverage, baits, lures).

7.1.5 Monitoring A system for monitoring was designed to assess possum densities after eradication got underway.

7.1.6 Dogs The use and training of dogs was planned, initially as one man-dog team.

7.1.7 Advisory group An overseeing group was set up including representatives from funding Departments (New Zealand Forest Service, Department of Lands and Survey, Department of Internal Affairs Wildlife Service) technical institutions (Ecology Division, Department of Scientific and Industrial Research) the Kapiti Island manager (Peter Daniels) and the eradication team (project leader). Other organisations involved included

The NZ Nature Conservation Council and the NZ Royal Forest and Bird Protection Society. The responsibility of the group was to assist with planning, practical advice, check that progress was satisfactory, and advise funding Departments.

7.1.8 Planning and implementation The eradication of possums had to be consistent with the Kapiti Island Nature Reserve Management Plan.

There were five applications of possum killing effort over the entire area of Kapiti Island between February 1980 and September 1986: (1) commercial trappers (except western cliffs), (2) traps only, (3) traps followed by dogs, (4) man-dog teams only, walked all tracks, and (5) one man-dog team walked all tracks. Work from 2 to 5 was carried out by the eradication team from September 1983.

Reference to commercial trapping (=intensive control) and the eradication phase suggests that the two tasks were planned separately While this is the ideal way such a programme should be conducted, it was not so for Kapiti. Instead the commercial trapping (1980-1982) was used to drastically reduce possum numbers and prompted the idea that eradication was possible. A proposal was written which in stimulated an eradication plan (Cowan 1985). Eradication was not approved immediate-ly. Instead a two year "trial" of intensive control between 1983 to 1985 was agreed to which served as the basis for deciding whether to try and eradicate possums. At the end of 1985 Cowan estimated that the number of possums remaining was and finally eradication was attempted.

Before 1985 there was some time when the field staff viewed the projects aim eradication despite the lack of official sanction - a eradication project. In other words, in eradication campaigns field communications must be efficient and there can be no room for disagreement on such a fundamental issue.

8. ERADICATION

8.1 Tracks

Pivotal to the success of the commercial and eradication phases was a network of tracks covering the entire island-including the cliffs on the western side (see Fig. 2 for an example of track layout). At the peak of eradication efforts the 1957 ha island had about 800 km of tracks. Managing, maintaining and cutting this length of track accounted for a large percentage of total effort and materials used in the entire operation.

Tracks were mainly cut along ridges and spurs because possums were considered to use these features in their movements. Ridges and spurs were relatively dry compared to gullies. Valleys and sidling routes along contours were also used so that the maximum spacing between tracks was 100-160 m, and every point on the island ultimately had a track within 50-80 m of it. Some man-made tracks coincided with original possum runs

and possums used man-made tracks as regular access routes. Thus tracking enhanced trap success by effectively leading possums to traps.

Tracks were cut with chainsaws and scrub-bars, then maintained with these or slashers. All tracks were uniquely marked. Marking conventions were used to delineate major access tracks, minor connecting tracks, track intersections, and trap numbering was consecutive uphill and south to north. At junctions, the directions of the connecting tracks were indicated. Major tracks were marked with red reflector discs which were highly visible at night when illuminated. Venetian blind squares were used for subsidiary tracks and coloured plastic tape for minor tracks. All tracks were assigned a label which appeared on track junctions.

Establishing tracks started with surveying and marking the route. Tracks were cut by sawing up-hill by one person while another moved debris off the side of the track. Tracks were cut just wide enough to allow a pack-frame loaded with sets through. Grass or bracken fern areas were cut with a scrub-bar.

During the commercial phase approximately 3 man-years were outlayed clearing about 400 km of track. Between February 1983 and February 1985 about 4.5 man-years were spent clearing a further 400 km of track, and maintaining the first 400 km. Between February 1985 and March 1987, 2 man-years were spent on track maintenance (800 km of track at this stage). The effort outlayed on tracks during 1983-1985 was typically spent over 10 hour days and 6 day weeks for 48 consecutive weeks (conservative figures).

8.2 Trapping techniques

8.2.1 Trap deployment Traps were placed on sets (wooden boards; see Fig. 3) about every 40 m along the track or on likely locations (see earlier discussion) whichever was the sooner. Even locations off the tracks were used if they were considered suitable. Tracks were continually modified with diversions if, for example, a stand of kohekohe trees were found that might harbour possums. The eradication team especially avoided becoming rigidly fixed to traditional routes so that newly discovered likely locations were not missed.

Between 1980-1983 (commercial trapper phase) traps were continually moved to different points on the tracks if initially they did not catch possums or their catch rate had declined. This sort of practice illustrated the policy of the possum eradication team–one of continual flexibility. The distances traps were moved around was 40-50 m to maximise the chances of encountering a new possum territory. During 1984-1986 inclusive, traps were left set *in situ* for up to 7 months in order to better guarantee encountering all the possums in an area.

A set was lent against a tree about 38° from the horizontal. Experience showed that smaller trees were often used by possums to climb into larger trees, even though the latter may have been a food or shelter site. Sets were placed on small trees so the access up the tree was only via the set and because small trees were often climbed by possums so they could reach across to an adjacent tree which might be fruiting. Sets were not placed

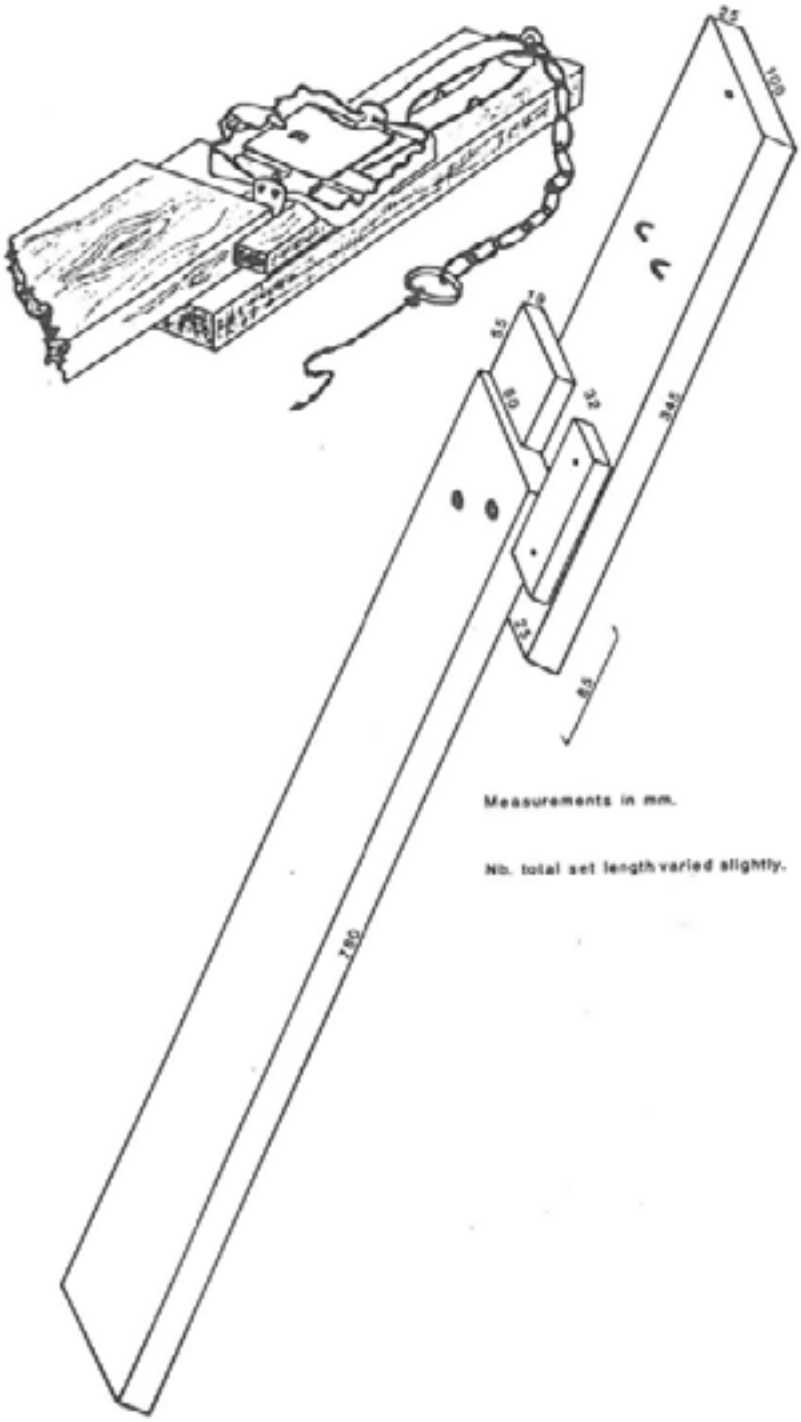

Fig. 3 The final design for possum trap set used on Kapiti Island

against a lone trunk of wide girth because climbing possums could easily miss encountering the trap. As well as food and shelter trees, trees that provided access to the canopy were also successfully used for sets.

No sets were placed against fern trees or lianes because possums avoided plants that would get them wet and the staples and nails holding the trap and set were considered

too easy for a struggling possum to pull out. One of the most significant considerations in placing a set was to locate it in such a way that the set itself was the most convenient, perhaps only, access into a preferred location. This might mean removing the odd dead limb or even a whole tree to restrict accessibility to the set. Removing this vegetation also meant that possums were deprived of purchase if they were struggling to pull themselves free of the trap.

8.2.2 Set design The set was made of two 10 x 5 cm boards joined so that the trip-plate of the trap was level with the upper surface of the bottom section of the set (see Fig. 3). This ensured only the foot of the climbing possum struck the tripping plate, not part of the head, belly, or upper leg.

The trap was located on the top third of the set because possums often leapt up the first third before they started climbing. The possum's gait and climbing pattern was exploited by the offset design of the upper part of the set. As possums climbed the sets, their front paws clasped the edges of the set and the hind paws dug into the upper, wide, flat surfaces. Hence two opportunities occurred for the possum's paws to hit the trip-plate: first, as the front right paw reached for a grip on the wider upper part, and second, one of the rear feet stood an extremely high chance of hitting the trip plate, especially if the front paws have missed. Unfortunately, no data were kept on Kapiti to compare which paws were being caught. However, data from another project using the same sets as used on Kapiti suggest that the right paws are in fact involved in most (66%) trap-set captures (Table 3).

Table 3 Possnm legs caught in Lanes Ace and Victor traps at the Block, King Country 19-22 December 1991.

Trap type	Legs					
	Front left	Front right	Rear left	Rear right	Front left & rear right	Front right & rear right
Lanes Ace	5	9	5	14	2	1
Victor (1 ½ or 1)	2	4	1	6	0	1
Total	7	13	6	20	2	2
% Total	14	26	12	40	4	4

Note: Traps set = 38 Lanes Ace, 35 Victor

The design is offset to the right (set leaning against its tree) because the key which crosses the jaw of the trap and engages the trip-plates' release lug is situated on the left of the trap as the trap sits on the set. This minimises the chance of the possum's paw hitting the trip mechanism (as opposed the trip-plate itself) and failing to set the trap off. This also means that maximum leverage is placed on the trip plate from the right hand side.

The bolt in the join between the two halves provides extra strength to the glued joint. Staples each side of the spring ensure the trap remains in place if the possum interferes with the trap chain. The trap's braided nylon chord was tied to another staple nailed to the set's tree. The set itself was nailed to the tree to secure it.

8.2.3 Setting traps Traps fitted into the sets as shown in Fig. 3 and were nailed to the tree. Self-tightening knots were used on braided nylon to ensure traps were not dragged off by possums. When the spring was depressed for setting the operator checked that the steel had not lost any of its original tensile characteristics and hence holding ability. As with all traps, the mechanism was regularly lubricated with CRC lubricating/penetrating oil. Any excess was wiped off.

As the jaws dropped with depressing the spring, the operator checked to make sure the jaws' lugs were located correctly in their pivot points so that when the trap was sprung the jaws closed tightly on the possum's leg. When the trip-plate was engaged on its release flange the height of the plate was checked to ensure it rested at the same height as the jaws. This helped ensure the reach of the jaws was adequate to catch the possum's leg. Finally, the geometry of the trap was checked as follows. The operator ensured that the planes of the jaws and spring coincided so the trap lay flat on the set and did not rock. Traps were not hair-triggered, instead they were set hard enough that robins, leaves, and twigs would not set them off. It was crucial to ensure the firm placement of the possum's foot on the trap was required to trigger it. This avoided traps springing, missing the animal, and creating trap-shy possums. The prepared trap was placed on the set, which has recesses to receive it, and checked so there were no constraints on the trap when it was sprung. A gin trap jumps when it goes off and it is important to preserve this characteristic to ensure trap catchability.

Sets placed on cliffs (often with no trees to speak of) were propped up against a stake. Sets were placed on promontories or easily seen spots so that they could be checked from a distance if necessary. In exposed situations, the traps were set harder to avoid wind buffeting setting off traps and to ensure a definite catch when a possum used the set. On exposed locations on the cliff face a bush was placed at the base of the set, wherever possible, so that caught possums could shelter until found by the operator. This minimised the chances of the possum dying from over-heating. Apart from minimising suffering, the shelter reduced the degree of struggling and hence the chances of the possum escaping. While trapping the cliffs, special care was given to placing the sets so that all regions of the cliffs were exposed to trapping-a difficult objective in dangerous terrain.

8.3 Dogging

The need for a killing technique which would be effective when possums had reached extremely low numbers was recognised early in the campaign. The use of trained dogs to find and kill possums was considered the most effective method. Dogs are most effective when possums are at low densities. At high densities dogs are likely to move from one scent trail to another rather than hunting down one target animal. Further, at high densities the chances of escapes were higher because, (1) dogs had a greater chance of encountering more than one possum at once and hence allowing one possum to escape

and (2) the increased chances of dogs chasing one possum, then encountering another and leaving the first. Thus, in each case, the first possum is left alive and potentially human/dog shy. With only one possum territory in question the hunter can plan an efficient strategy for hunting that single animal based on what has been learnt of that individual's territory and habits.

Justification for the use of dogs was necessary because Kapiti Island is a Nature Reserve under the Reserves Act 1977, and the little spotted kiwi (an endangered species) and the North Island brown kiwi *(Apteryx australis*) are present. Dogs are notorious for killing kiwis, so a ministerial exemption was required. On 4 March 1984, Jack (a Jack Russell terrier) was landed on the island, and by 8 May 1985 3 dogs were kept on the island. Dog packs were not used because of the higher risk of losing control of individual dogs when several were working with one man. Initially one dog per person was used at one time, but this evolved to two dogs per person towards the end. Using more than one dog meant that individual dogs could be rested. Two dogs hunting as a team often proved more efficient at out-manouvering an escaping possum. Working two dogs meant that a greater range of skills were contributed to the hunt, for example, some dogs were better at trail barking than holding.

8.3.1 Breed of dog Some dogs used were adults retrieved from the pound, but 4 of the 7 key dogs were young dogs bought from private owners, 1 came from NZ Forest Service (adult) and one was a juvenile acquired from the pound. Short-haired small to medium body size dogs were used because they were less prone to over-heating and they could pass easily through thick undergrowth. Light coloured dogs were more of an advantage while hunting at night. Fox terrier and fox terrier crosses, Jack Russell, black cross and Australian terrier breeds were mainly used.

With experience, dog handlers agreed that Labrador crosses were more effective at finding possums and were more responsive to handler instructions than terriers. The latter are more bred to kill a variety of animals whereas the labradors are solely bird dogs. While it is an apparent contradiction (because of the specific purpose of the dog's breeding), it was easier to condition a Labrador out of chasing birds – especially kiwi and weka. The larger size of the Labradors gave them an advantage in speed over broken ground. Terriers were more noisy and inclined to trail-bark, hence they were easier to find during the chase, especially at night.

8.3.2 Training First, standard techniques were used to train obedience (see Moxon 1978), then specialised training followed. Essentially, desired behaviour was conditioned using positive reinforcement. For example, the dogs' first lesson was teaching the dogs the meaning of 'yes' and 'no' at feeding time. Dogs were only allowed to eat on hearing 'yes' or stopped with 'no'. The 'yes/no' commands formed the basis of all future training. The trainer for a given dog was also its controller on Kapiti Island. Behaviour was taught in a series of successive approximations. In the early stages, aggression between dogs was quashed by handlers since it was felt that any fighting on the job would compromise the dogs' effectiveness as hunters.

Most of the dog training was achieved over 5 weeks (3 spent at Mt Bruce and 2 at Pairaki, Wairarapa) using three men to train with 3 dogs. After this time the dogs started work

on Kapiti Island.

Tasks were taught in the following order: killing possums, barking on scent or sight of possum, follow scent trails, find and kill. Dogs were first fed on dead possums and any interest they subsequently showed was encouraged. Killing hehaviour was enhanced by laying scent trails using possums and thereby creating an interest in possum scent which was quickly reinforced. While the above appears as a sequential account it should be remembered that, in practice, the dog acquired the skills simultaneously.

One of the biggest problems in training possum dogs was teaching them to look up trees. Possums were placed at the foot of a tree at ground height, then the dog was reinforced as it tried to follow the possum scent up the tree. Every contingency that could occur on Kapiti Island was catered for on the mainland in terms of training dogs in the typical terrain, forest type and non-target species. Any interest whatsoever a dog showed in a non-target species was met with severe negative reinforcement: anything from 'No' to physical violence, depending on the severity of the case. However, the use of beating and other violent forms of discipline (e.g. for interest in a kiwi, weka or rat) were used with caution and restraint since it was recognised that over-use, especially with some individual dogs, could create a rift between the dog handler and the dog. Non-target species training was strict because training dogs not to chase kiwis could only be done on Kapiti Island, (no kiwis occurred at either of the two training areas). After the Mt Bruce and Pairaki training the dogs were taken to Kapiti for 2 ½ months intensive training on non-target species (e.g. rats, kiwis, wekas). At the end of this time it was found that the man-dog teams were working efficiently.

All dog chases of possums at Pairaki (as well as at Kapiti where possible) were followed up with killing the possum and consequent positive reinforcement to create maximum eagerness to succeed. Hence the dogs were indoctrinated with killing possums as the norm of expected behaviour - nothing less. This strategy helped ensure the maximum effort from a dog. However, it must he remembered that dog-hunting effort was greatly facilitated by the dog's desire to please it's handler. Once the dogs realised that maximum positive reinforcement was linked to killing only possums, the task of training was largely complete and only required maintenance with regular positive reinforcement.

As the numbers of possums on Kapiti Island decreased, the opportunity for reinforcing the dog's interest in hunting possums declined. Hence dogs were brought back every 2-3 months to Pairaki where there was a high density of possums. For one to two weeks the dogs were exposed to intensive hunting of possums under strict control. Pairaki was selected because of the open nature of the vegetation and topography. The hunter could see the dogs at work and easily see mistakes and check on obedience to commands. The hunter could also study possum/dog behaviour during a hunt and design strategy and commands to improve hunting performance.

When the dogs were first used on Kapiti, muzzles were fitted. Commercially made muzzles were found to be ill-fitting and uncomfortable because they were not designed to be worn by a working dog all day. Custom made muzzles were used which proved adequate until the handler was confident that their dogs were not interested in kiwis. These muzzles did not hamper breathing and allowed the dog to drink. The muzzle balanced on the dog's nose (for maximum comfort) and the strap fitted behind the neck

so that it did not slip. The muzzle was made as small as possible to obstructing the dog's movement through vegetation. Only one little spotted kiwi was killed in the entire exercise, despite the massive effort spent on dogging.

8.3.3 Hunting technique In both day and night hunting the dog was kept in sight so the handler could observe the dog and learn from it's behaviour (see comments on scenting below). In this way the dog (or its sensory ability) was used as a sort of monitoring device. Twelve gauge shotguns (using #6 shot) were always taken when hunting with dogs to ensure no possums escaped. The rough treatment the firearms received, meant that using rifles with telescopic sights was impracticable. Besides, using shotguns was more desirable in situations were there was little time for sighting rifles properly.

One of the most useful features of dogs is their ability to signal information about the presence or absence of their target species. Changes in posture and level of excitement (or alertness) can indicate whether the dog is detecting wind or ground scent and how fresh the scent is. The importance of having this sensitivity for detecting presence/absence in an eradication programme cannot be over-emphasised. All presence/absence type information relating to possum movement and its recency was mapped. Inferences were drawn about remaining possums' territory and hence where to direct hunting effort. At low densities, especially, the information gathered over successive nights work could be pooled so the hunter could gauge territory boundaries of a resident possum and even most frequented areas within a territory. Clues to the presence of possums were also drawn from the occurrences of traps sprung (possums not caught). Where these occurred, the dog-team followed up with searching for a possum and destroying any found.

Some characteristics about scent were discovered. The length of time scent lasted depended on weather conditions and the type of substrate. Relative humidity and rain were probably the most important climatic factors. High humidity increases and heavy rainfall reduces the period scent will last. Hard, or rocky ground did not retain scent as well as softer or more porous substrates. While areas of scent on the ground could be detected, scent tended to be lost up trees and open rocky ground, especially if the ground was exposed to the sun. Generally, dog-detectable possum scent lasted up to 5 days. However, some spots of scent lasted up to 1 month. These periods were important for the hunter to know to interpret the scenting behaviour of the dogs. Hunters found that dogs could follow a scent trail to its source if the scent was less than a day old.

Hunters attempted to remain with the dogs when tracking a possum but also relied on the dogs to signal by barking when they had located a possum. Almost all dog-killed possums were killed the first or second time a dog located a possum and none were encountered more than four times before being killed. It is extremely important that possums are killed on the first encounter, to avoid creating dog/human shy possums. The chances of killing on first encounters were considered best when possums occurred at low densities. Hunters could always confirm a kill because the dogs were trained to retrieve the possum.

Possum scent was used occasionally to try and attract others into a convenient hunting area. Dead females were sometimes left hanging above traps near where they were killed in the hope of attracting their recent independent young or perhaps adult males. Similarly, live possums were caged and their cage placed above a treadle operated cage trap. Neither technique was used either extensively or to great success, although the cage trap method received visits from possums and these possums were successfully located and killed by dogs.

8.3.4 Daytime hunting with dogs On the first day of daytime hunting in a block, the whole area was relatively quickly walked to familiarise dogs and handler with the terrain. This also gave the handler an idea of the presence or absence of possums in the area. Thereafter the blocks of about 45 ha were hunted intensively for about one week. This included walking all tracks and through the forest between tracks. The latter involved walking the terrain in a grid pattern such that every point of ground was covered on a 40 m grid. All three dog-handler parties separately hunted each block so that all the various abilities of dogs and personnel were exploited.

Despite the systematic quartering, 26 (78%) of 32 dogged possums were killed outside of the blocks being currently hunted. These possums were only chased on an opportunistic basis as people moved about the island on other business. Obviously any opportunity to kill a possum was always taken. Three possums were caught in blocks visited for some reason unrelated to hunting. Only two possums were dogged in the block currently hunted. The presence of one had been known for sometime before its block was hunted. This possum was located and killed on the first day the block was hunted. The chances of encounters outside of systematic hunting of blocks was increased by hunters taking various routes (with their dogs) on regular visits between localities. Shotguns were carried at all times when dog-teams were walking the island. Once a man-dog team had hunted an area no more possums were ever caught there.

8.3.5 Night-time hunting Hunting with dogs, spotlights and shotguns at night was important because possums are nocturnal, with an active feeding period 2-3 hours after dusk which at some stage involves travel on the ground. Hence most night time hunting was done in the first 3 to 4 hours after dusk for three fine nights per 45 ha block. Only the tracks were walked unless a dog chased a possum and dogs were always kept just in front of the handler. A spotlight was used to search for possums in the canopy and a torch for illuminating the walking track. Vantage points were used as often as poss-ible, usually to get the observer as high as possible. If the animal itself was not seen, its eye reflections were - a white or reddish reflection from the tapetum layer on the iris. Other cues to possum presence were the sounds of them feeding, such as the seeds of kohekohe fruit hitting the forest floor.

Two dogs were generally considered better than one because one could flush and the other hold and kill or chase. Often one dog was better at trail harking than the other. At the very least two dogs afforded more opportunity for team work and hence higher efficiency.

Of 21 dogged possums autopsied 18 (86%) were over 6 years old - a significantly larger ratio than those caught in possum traps (52%). Further, more than 50% of the possums caught by dogs were male (Cowan 1986). Cowan suggested that the explanation for the

above may be because (1) immature males lack functional scent glands and/or that young males may have less detectable scents than older animals, (2) older animals may be trap-shy and (3) males usually range over larger areas than females and hence may be more readily detected by dogs.

8.3.6 Possum behaviour Possums do not favour wet nights to be active, so only dry nights were hunted. Most fleeing possums moved downhill through the canopy which was useful for anticipating where to get a new scent for continued chasing. Not all possums fled. Some tried to avoid detection by freezing. On the ground, possums also fled down-hill but usually only within their home-range. Hence their movement was often circular implying that even a chased possum was reluctant to leave its home-range.

Home-range size appeared to expand as the density of the possums was reduced, however, there appeared to be a limit on this. Adult female territories were estimated at around 80 m in diameter at low densities. Adult males apparently moved larger distances than females. Juveniles appeared to stay in or near their natal territory. Possums habitually use the same paths, hence these can be used to predict their location or direction of movement. Much of the home-range behaviour of possums is based on scenting and vocalisations. The latter can be imitated by hunters to great effect to reveal the location of a possum. Females in season attract males (probably because of scenting) so hunters searched for males on the periphery of female territories.

Young possums stay clinging to their mother's backs for some time, even beyond the stage when they could support themselves. If these mother/offspring couples are chased, the latter may leave the mother and still be quite able to survive. It was policy to check back for any young, especially if the female was lactating, had a stretched pouch or had fur missing from its back (the latter caused by young clinging on). Similarly, if a female with furred young was trapped the latter was killed first since its escape could mean it survived.

8.4 Shooting without dogs

In retrospect it was decided that shooting by spotlight without dogs should not have taken place. The reason is that shooting alone is open to a higher risk of error--escaped, wounded animals may result which will be human-shy. Shooting should only be carried out at low possum densities for the reasons outlined in dogging practices. In higher densities groups of possums mean it is too difficult to deal with every possum seen and shy animals may result.

8.5 Work management during trapping and dogging

Much of the success of the eradication was due to the day to day teamwork and organisation coupled with the commitment of the team (usually numbering 5) members. With commitment so high the need for supervision was practically zero. Planning and organisation were the main management tasks. These were generally done co-operatively (there were many transient volunteers and casual workers), with each of the regular team members contributing. Two men (Geoff Alexander and Bob Cairns) led, but it was an informal arrangement. Every night an informal meeting was held since the team lived together unless some were at other huts. Living and working together definitely improved

the degree of communication. Regular communication was kept up between the resident ranger on Kapiti (Peter Daniel) who, in many ways, was the conduit between the eradication team and the organisations officially involved (i.e paying) in the eradication: Department of Lands and Survey, Forest Service, Wildlife Service and the inter-departmental advisory group. Ecology Division (Department of Scientific and Industrial Research) was involved in an advisory capacity as well as with research.

Temporary staff were employed or seconded from the contributing government departments on a demand basis according to occasional large tasks that arose. For example moving sets and traps en masse was done by workers moving them to staging points from which a helicopter could ferry them to the next blocks. Helicopter hire was always dove-tailed into other tasks such as carrying LPG cylinders or building a hut. Staff movements always involved carrying items (e.g. traps and sets) so that the maximum benefit of worker time and effort was achieved.

Basically one of the leaders was responsible for the trapping, and one for the dog work although there was a great deal of overlap. For example, in continuous heavy rain the dog handlers would help shift traps or cut tracks. In principle the various tasks were shifted around as many different workers as possible.

8.6 Poisoning cliffs with 1080

In the early stages of planning it was considered that the accessibility of the western cliffs on Kapiti Island would prevent dogging or trapping. Hence aerial poisoning over 330 ha of cliffs was carried out using carrot baits with 1080 (sodium monofluoro acetate). In the end the eradication team did trap part of the cliffs before the poison drop and dogged and trapped afterwards. This work netted 264 possums over 3 months of the 1983/84 summer. Given the thorough nature of these techniques in destroying possums and hence the likely high percentage kill, it is probable that the actual number of possums resident on the cliffs was 6 possums per hectare (Cowan pers. comm.).

One only pre-feed of non-lured diced carrot was spread on the cliffs a week before the poison drop. Unfortunately the quality of the pre-feed was poor since the carrot was old and somewhat rotted. The idea behind pre-feeding a bait is to condition the possums into taking the new food item and so that any aversion to a new item is minimised when the poisoned laced baits are dropped.

The poison drop was carried out in August (winter) 1984 since possum numbers would theoretically be at their lowest and food scarcest. Pre-feed carrot was distributed by helicopter at a rate of 10 kg per ha one week before poisoning. Diced carrot impregnated with 1080 at 0.15% w/w was dropped at a rate of 15 kg per ha. Six fine nights followed the poison drop: ideal conditions to expose as many possums as possible to poison carrot. No lure such as cinnamon was used and the preparation process eliminated most fines (under standard size pieces of carrot). Because of their high surface area to volume ratio, fines contain relatively high amounts of poison. This coupled with their small size makes them attractive to non-target species such as birds (Harrison 1978). The risk to non-target species, especially birds, was minimised by dying the carrot green which lessens its attractiveness to birds (Harrison 1978). However, given that 4.5 tonnes of pre-feed and 5.2 tonnes of toxic bait were dropped, the chances of no fines being dropped was virtually nil.

The effect of the 1080 drop on was assessed using a subjective descriptive approach. This non-robust technique was deemed adequate because the principle aim was to check that no unforeseen heavy mortality occurred and the numbers of birds on the exposed, wind swept cliffs was low. A team of people recorded all birds observed a week before the 1080 drop and made subjective assessments of abundance of each species observed. A similar survey was made a week Three dead birds were found (whitehead, blackbird and tui) but these may have died due to other causes. Hence the poison drop apparently had little effect on birds, a result consistent with what little published data occurs in literature (see Harrison 1978 and Spurr 1991).

As with all major poisoning operations, effectiveness was also measured. Given the similarities in technique to monitoring elsewhere on the island, this is dealt with below.

8.7 Monitoring possum numbers

Two major methods of monitoring possums involve either faecal pellet analysis on plots or gin-trapping. There is an extensive literature on the methods and relative merits associated with these techniques which is not worth repeating here (e.g. Baddeley 1985). Data from a mark-recapture study and monitoring studies will he published by Dr P. Cowan elsewhere. Here the technique used to monitor possums during the 1080 poisoning on the cliffs and during the remainder of the eradication programme is described.

The main technique used to monitor possums on Kapiti Island cliffs was the cleared plot pellet technique whereby the recruitment of new pellets before and after control was recorded in order to gauge the percentage decline in the number of possums. These data were corrected for changes in the natural rate of defaecation during the interval between poisoning and assessment. On 23 randomly placed lines, 40 2 m^2 plots were distributed at 5 m intervals. Six hundred plots were established on the cliff face and 320 on the cliff edge. All pellets were cleared from the plots. After 7 days all pellets were again cleared and the number of new (recruited) pellets were counted. This same procedure of clearing plots, waiting for 7 days, and counting newly recruited pellets was repeated after the poison operation. Data gained for analysis include mean number of pellets recruited per hectare per night before and after control operations.

Elsewhere on the island on similar plots presence/absence of pellets and point distance data were collected from 2 m^2 plots spaced every 20 m along 22 randomly located transects spread evenly between the six control blocks (not including the cliffs, see Fig.1). Presence/absence data revealed the percentage occurrence of pellets within plots which could be compared between any two points in time and interpreted against rate of decay information. Point distance data described the distance of pellets from the centre of the plot. Increasing distances reflected diminishing density.

At low densities the point distance and presence/absence data only indicate the latter, not relative density. Allied data were also collected: vegetation plots (regeneration or time series type study), walk through tunnels, capture/recapture and bait interference. On the basis of cleared plot data a significant reduction in possum numbers occurred on the cliffs to 73% of initial numbers (Jenkins 1984, Morgan and 1984). Exactly how many possums were killed by 1080 poisoning however remains in question because of doubt of the

accuracy of monitoring techniques. For example, the faecal monitoring counts placed the post poison population on the cliffs at 990-1155 (Morgan and Copland 1984), whereas the dog-trapping effort over the whole island subsequent to poisoning killed only 80 possums (48 trapped, 32 dogged).

8.8 Poison bait stations

Poisoning possums using bait stations was used in an attempt to kill those surviving the trapping. As with trapping, the safety of non-target species was one of the prime considerations. A commercially made bait station was modified on the basis of experiments to improve its safety for non-target species. A 100 x 100 mm tray with sloping sides about 25 mm at the highest (hinged) end was nailed to a tree. The station is essentially a box with a lid which the possum has to lift to access the bait (see Fig. 4). The bait used was equal amounts of apple pulp, sugar and water with green dye, 1080 poison (concentration 0.15% w/w) and lure added (Robinson 1983). The mixture was made up to approximate the consistency of soft jam.

Robinson reports on trials of the stations set at two heights with 10-15 g of bait mixed with polystyrene pellets. Cage traps were set nearby to capture animals that may have

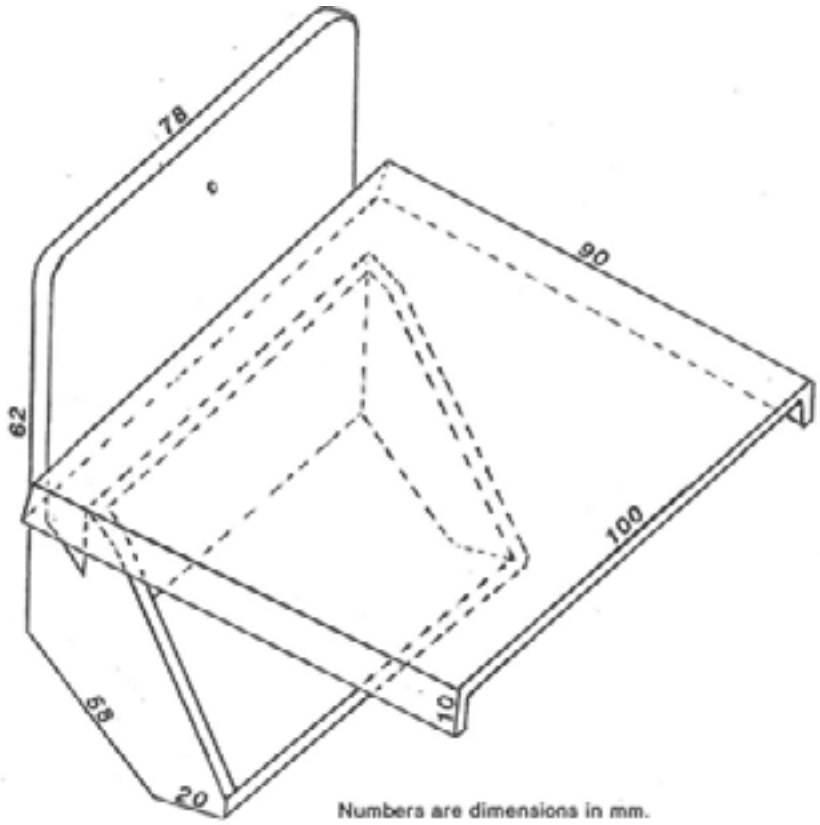

Fig. 4 Modified 1080 poison bait station used for possums on Kapiti Island.

used the poison stations. Trials were also done on captive kiwis to see how high they could reach and so ensure that the height poison stations were set (40 and 60 cm) was in fact out of reach. Only 2 records occurred of a captive male brown kiwi taking kiwi meat (a special preparation of ox heart and cooked rolled oats) from a closed poison station. However, one record occurred of meat being taken at 65 cm by one of a pair of brown kiwi which was taken as the maximum height able to be reached with the incentive of a conditioned food type. A brown kiwi about the size of a typical adult little spotted kiwi could not reach higher than 53 cm and could not extract food from higher than 30 cm. Since weka (the only other ground living bird on Kapiti) were about the same size as brown kiwi, it was assumed they would not be able to reach any higher. While kaka showed they could reach into a bait station, they only did so with the stimulus of jam evident on the outside.

The other means by which it was thought non-target animals might get exposure to poison (barring human error) would be (1) spillage from possums eating bait, (2) insects eating bait and birds consequently getting secondary poisoning, and (3) birds eating toxic possum carcasses. It was concluded that the risk to non-target avian species on Kapiti of poison bait stations was minimal, especially since kaka interest in bait was much reduced if it was dyed green.

Experience of actual use of 1080 indicated that poison bait stations were hardly used at all by possums on Kapiti. Despite best efforts in varying the method of setting up poison stations (presentation, location, timing, etc.), the rate of use was unchanged and minimal. In the end the use of poison stations was given up. The reason given for the lack of success of the poison stations was that poisoning was tried when possum density was extremely low (estimated at about 0.04 possums per hectare), hence the chances of possums encountering stations was minimal.

On the other hand, poison bait stations trailed in a 160 ha block of non-dogged and untrapped forest in the southern end of Kapiti Island also received little attention from possums which presumably were present at a density close to the original pre-control level. In both situations high levels of food availability could have diminished the attractiveness of a bait, especially in areas of low possum density. Another factor which might have been important is possum aversion to any new (alien) food source. This might have been offset by using a naturally occurring food, like fruit, in the bait. Another possible reason for the apparent failure of the bait stations is that their placement out of the way of kiwi may have compromised possum access to them.

8.9 Human effort

The number of trap-nights (traps set x nights) and of possums killed are shown in Table 4 (Cowan 1986, 1992). Between 1985 and 1987 32 possums were killed using dogs (in nearly 5000 man/dog hours) making a total of 19 644 possums killed on Kapiti Island using dogs and traps since 1980. Unfortunately it will never be known for certain how many possums were killed on the Western cliffs during the 1080 poison drop.

Between March 1985 and March 1987 dog teams operated on a total of 403 days during the day and 194 nights. Over that time 4136.5 hours were spent using the dogs during daylight and 797 hours during the darkness. These figures equate with an average of 10.3 hours per day of dog use and 4.1 hours per night.

Table 4 Trap-nights and possums killed in the three phases of eradication of possums that involved trapping.

Phase of operation	Trap-nights	Possums killed
Commercial trappers 1980-1982	65 866	15 631
Eradication: First entire island sweep 1983-1985	589 336	3 933
Eradication: Second entire island sweep 1985-538	743 538	48
Total	1 398 740	19 612

Possum/trap night = 0.014

Each of the 5 blocks shown in Fig. 1 received an average of 68.8 hours of daylight and 15.2 hours of night searching, usually spread over several weeks and usually done by 3 different dog/handler teams. The corresponding possum kill returns with the effort described above includes 12 possums located and killed during daylight systematic searches of blocks by man/dog teams; 6 possums during night-time systematic block searches; 9 possums killed by dogs while moving about the island (i.e. in transit) during the day; and similarly, 5 at night.

The regular (5 man) eradication team worked on average (conservative) 10 hour days for 6 days a week for 48 weeks per year. During the first trapping sweep (February 1983 to February 1985) I estimate (conservatively) that 4.5 man-years were spent cutting about 400 km of track and maintaining another 400 km of existing track cut during the two years of commercial trapping. Within this period another 6 man-years were spent in trapping work (setting traps, monitoring them, building and placing sets, maintenance, etc.).

Between February 1985 and the end of March 1987 (second sweep), 7 man/dog(s) team years were spent hunting possums. Two man-years were spent cutting and maintaining tracks and 4 man-years trapping (including moving sets). Note when dog-handlers could not hunt they helped with track and trap work. During both sweeps the number of men on the job at any time averaged around five with a maximum of eight. Unfortunately the effort that went into: monitoring possums, allied people advising, administering the Kapiti Ranger, mainland staff), or conducting research, was not recorded. All these peripheral functions are important, and should be borne in mind when costing an eradication programme.

8.10 Capital investment

The following dollar estimates for budgets refer to expenses related directly to the Island eradication programme. No account is taken of the Kapiti Ranger's salary or of mainland staff, some of whom must have spent a considerable amount of time on Kapiti Island possum eradication affairs. I have crudely estimated that 2 man-years of the Kapiti Ranger's time was involved, between 1980 to 1986, 5 man-years of NZ Forest Service, Lands and Survey and Wildlife Service staff and 2 man-year of researcher's time (Ecology Division DSIR). One could assume that, on average, these Public Service staff had 10-12

years seniority in the Service.

If the reader tries to equate the quoted dollar totals (Table 5) with current dollar values, then in real terms, devaluation of the dollar due to inflation should be taken into account. Corrections can be made using Consumer Price Index figures which are published every year. Actual materials are also listed (as far as practical) in the next section. Figures for the financial years 1980 to 1983 are not shown, because this was the commercial phase, the trappers paid for themselves, although salaried staff were employed for about 4 man-years to cut tracks.

Table 5 Possum control/eradication budgets for Kapiti Island.

Financial year	1983/84	1984/85	1985/86	1986/87
Total	$58 488	$113 000	$120 000	$157 000
% spent on wages (number of workers)	45 (2)	- -	57 (4)	85 (5)
% spent on helicopter	13	-	8	4
% spent on huts	-	-	12	-
% spent on materials & supplies	37[1]	-	23	5
% spent on monitoring	-	-	-	4
% spent on other	5[2]	-	-	3

[1] = 8% bait stations, 14% 1080 bait and non-toxic bait, 15% fuel and oil.
[2] = money spent supporting volunteer
No data are available to break down the 1984/85 total which in itself is an estimate since records are missing for that financial year.

8.11 Materials and equipment

Most of the significant items used in the eradication programme are mentioned below. I have included this list so that should the reader be unable to translate the quoted dollar totals in Table 5 to today's values, at least some idea can be gained of the volume of materials required.

8.11.1 Huts Two new huts were built which, with the whare at Rangatira point, meant that most of the island was within two hours walking of accommodation. Hence the amount of time wasted in transit was minimised. Huts were prefabricated and flown to the island by helicopter. At least seven 8-hour flying days using a Bell Jet Ranger were spent either getting huts to Kapiti, moving huts on Kapiti or moving sets and traps. The helicopter time could have been lessened if huts had been more strategically placed at the outset.

8.11.2 Sets and traps 1800 gin traps were used on 10 000 sets. The sets used approximately 100 x 25 1000 mm tanalised timber, bolted (two galvanised 25 x 5 mm), nailed to trees (2 x 10 kg boxes, each of 25 mm and 50 mm galvanised flat-head nails).

Staples (4 x 10 kg boxes, 2 each of 60 mm and 30 mm) were used to fix traps on to the sets.

Three thousand poison stations were bought, but they were not used in earnest. Concentrated lures used in an attempt to attract possums cost $100 per 200 mL bottle (1986 prices, 15 types bought).

Equipment and supplies bought to service eradication work included one portable Kubota diesel generator (240 V, 50 Hz AC), 17 frame packs, 4 spotlight units and batteries, 2 side-by-side 12 gauge shotguns, 1 semi-automatic 12 gauge single shot gun, one 0.222 inch bolt action repeater rifle, one 0.22 single shot rim fire/shotgun (12 gauge) under and over combination, 3 Swedish made (60-80 cc) chainsaws, one scrub bar, and a full workshop of tools to service the above.

Materials included 4 x 44 gallon drums of diesel, 5 x 44 gallon drums of Super grade petrol, one 44 gallon drum of scrub-bar oil, one 44 gallon drum of two-stroke oil, 20 x 200 lpg gas cylinder refills, and various paints and markers to mark tracks.

While there are certainly items not mentioned, the above at least covers the bulk of equipment and materials and, together with the capital investment and effort, give the some idea of the scale and overall cost of the eradication programme.

9. SUMMARY AND LESSONS

A crucial consideration in deciding whether to eradicate or not is knowing whether monitoring techniques available are sensitive enough to detect the target animal at very low densities. A satisfactory answer to this problem is required before success can be verified and eradication started.

9.1 Decision

From the outset, a decision must be made on one or other course of action--control or eradication. This is because control methods irreversibly compromise eradication methods.

9.2 Planning

- Administration needs to be aware of the implications of an eradication. Most of the expense will be on killing the last few animals. The last 80 possums on Kapiti cost about $300 000 to remove (1986 dollars).
- Knowledge of the ecology of the target species is of priceless value in planning an eradication programme. Gaining this information may require some research in advance of the eradication programme.
- Trials of eradication methods, wherever possible, should not he done using the target population. When things go wrong one may seriously compromise eradication creating trap-shy animals).
- Planning should primarily centre on the people actually doing the eradication. Plans will need to be flexible. They will have to be able to cope with unexpected contingencies.

9.3 Personnel

At the end of the day only staff committed to eradication will succeed. Workers need to be prepared for prolonged concerted effort. This is an important consideration since continuity of staff will make a lot of difference to efficiency and staff relations.

9.4 Monitoring

Monitoring mammals at low densities is extremely difficult. Only presence/absence information is required when eradication is nearly achieved. However, even this can be difficult. Hence techniques for monitoring need to be well established before eradication starts. The success or failure of the whole programme revolves around the ability to monitor. On Kapiti dogs proved the only reliable means of monitoring presence and absence of possums at low densities.

9.5 Research

- Management agencies must ensure that sufficient forewarning is given of research requirements for control/eradication so that the research can be started well in advance.
- Continuing research during eradication can greatly help the design of methodology for both existing and future programmes. Animals may change behaviour at low densities, and technical advice that can be given to the eradication team will greatly enhance their success.
- Research into the benefits to the natural community of eradication should be planned and started before the eradication programme. *Post priori* data are not nearly as useful as baseline data gathered *a priori* which can serve for scientific comparisons. Information on how the community improves with eradication is priceless for advocacy work, for continuing support of the current programme, and for other programmes that might be carried out. These data also show how the pest species affected the natural community in the first place.

9.6 Publicity and advocacy

Credit should be given to participants, and progress reported so that the general public can have the opportunity to take an interest in the programme. A well-run programme will need public support, even to the extent of providing volunteers.

9.7 Trapping sweeps

In retrospect, the third sweep of the island with traps was probably unnecessary. The number of possums caught by traps was extremely small for the number of trap nights. Dogging alone would probably have been sufficient, and perhaps could have even been substituted for the second trapping sweep of the island. The reason the second trapping sweep was retained was because people did not believe the first trapping sweep could be so successful.

10. ACKNOWLEDGEMENTS

Kerry Brown, Jeff Alexander, Bob Cairns, Marcus James and Peter Daniel supplied extensive information, both written and oral. Their information and that of Dr Phil Cowan (Land and Resources Division, DSIR) on the effort outlayed on various activities, formed the basis of most of this report. Ian Flux and Phil Cowan gave permission to use their data in Tables 1 and 3 respectively. My thanks to Phil Kerry Brown, and Ian Mackenzie, who greatly improved drafts of this report. To Kerry Brown, special thanks for prodding me to complete the first draft. Sean Hutton, Chris Edkins and Ian Flux drew the figures.

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