RESEARCH REPORT

Hatepe Trial -
Comparison of Ground and Aerial
Tb Vector Control Methods

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December 2003

Contents

Executive Summary

The operational effectiveness (including standardised cost per hectare and timeframes to complete) of controlling possums to meet Animal Health Board specified Residual Trap Catch Index (RTCI) performance targets using a range of modern control methods were compared at Clements Road in the northern Kaimanawa Forest Park during the winter of 2003.

The operational area is typical of control areas often funded by the Animal Health Board for bovine tuberculosis (Tb) vector control using aerial application of sodium monofluoroacetate (1080) baits, being moderately large[1] heavily forested, with difficult and / or remote access to parts.

The control methods compared included:

- application of 1080 baits via bait stations (pre-fed)
- application of cholecalciferol (FeraCol®) baits in bait bags (pre-fed)
- encapsulated potassium cyanide (Feratox®) and trapping
- contractors choice of ground control method (Feratox®, trapping and dogs)
- application of aerial 1080 baits (pre-fed).

The operational area was split into four large blocks of approximately 1,300 hectares. Each of these blocks was in turn split into five similar sized study units or 'sectors', a total of 20 sectors in all. The five treatments were then allocated one sector within each of the four larger blocks.

Pre-operational possum catch rates were assessed in February 2003 using one hundred (five per sector) ten trap, Victor Soft Catch® Coil-Spring No. 1 leghold trap lines set to National Possum Control Agencies (NPCA) residual trap catch (RTC) protocol. This resulted in an average pre-operational RTC of 21.17 percent ± 2.35 percent. The same lines were used for post operational monitoring, where possible within two weeks of the completion of control operations, within each sector. A one-off assessment of post operational rodent indices was also undertaken using standard rodent tracking tunnel methodologies across all sectors within one of the blocks, to gauge the relative secondary environmental benefits of each method in terms of the rat by-kill.

[1] 5,241 hectares.

Statutory approvals and consultation were undertaken as a single co-ordinated operation allowing individual contractors to focus on operational aspects. During the approvals / consultation process, issues were raised regarding the potential by-kill of deer from aerial bait application methods in a very popular recreational deer hunting area - the formally gazetted Kaimanawa Recreational Hunting Area. The use of a newly developed deer repellent was eventually negotiated with the Department of Conservation (DoC) and numerous hunter interest groups; however, there remained significant public opposition to the Hatepe Trial.

Contractors began control operations on 28 May 2003. The last contractor completed work on 13 November 2003. Contractors were asked to provide data on the amount of labour, bait, materials, vehicle running, camping, helicopter time and other operational costs incurred as part of each contract. Contractors were also asked to account separately for time and resources used in undertaking various management activities relating to the trial itself[2] allowing comparisons of direct possum control operating costs to be made. A consistent standardised costing was then used to compare the relative cost effectiveness of the five methods.

Overall, the operation was successful in achieving a combined post operational RTC of 1.65 percent ± 0.51 percent across all sectors, a 92.2 percent reduction. Aerial application of 1080 baits was the most time, operational and cost effective method, taking eight days to achieve a 0.17 percent RTC (a 99.05 percent reduction) at a cost of $26.25 per hectare. This time and operational effectiveness was significantly better than any of the ground methods, and almost half the cost of the next most operationally effective method, even with the added cost of a deer repellent. There was, however, significant hunter ill-feeling towards the use of 1080 and this ill-feeling was further fuelled by the confirmed death of sika deer from 1080 poisoning within the operational area, despite attempts to avoid this with the deer repellent.

Of the four ground treatment methods, 1080 in bait stations was the most operationally effective taking 115 days to achieve a 1.32 percent RTC, a 93.66 percent reduction. However, at $43.45 per hectare this was less cost effective than other ground based methods.

[2] Such as co-ordinating meetings, liaison and boundary marking.

Cholecalciferol failed to meet performance targets in two of the four sectors treated with this method. It took 66 days to achieve an overall post operational result of 3.54 percent RTC (a 79.29 percent reduction) for a cost of $37.46 per hectare, proving to be time effective and relatively cost effective compared to other ground control methods in those sectors where it did achieve performance target. There seemed no obvious reason for the inconsistent operational results using cholecalciferol. Discussions with the manufacturer suggested this method has limited operational effectiveness where possum populations exceed 15 percent RTC, and insufficient bait in localised areas may have been an issue.

Feratox® and trapping and the contractor's choice (utilising Feratox®, trapping and dogs) were the least operationally and time effective overall, with extremely inconsistent results across the different sectors. This method appeared to be hampered by wet weather, poor coverage, bait bag interference by rodents and perhaps bait aversion in localised possum populations. From the data provided there seemed little use of traps or dogs in the initial treatment. Trapping tended to occur only during re-works after failing initial post operational monitoring. More use of these additional techniques in the initial treatment may have improved the overall performance of the Feratox® based methods. Overall Feratox® based methods took 142 days (Feratox® and trapping) and 131 days (contractors choice) to achieve the 3.0 percent RTC target (average 90.3 percent reduction), for a cost of $43.80 per hectare and $36.77 per hectare respectively. Nevertheless, in most of the four (of eight) sectors where Feratox® did meet performance targets on the first treatment, it appeared to be very cost and time effective against all other control methods. These sectors tended to have lower pre-operational trap catch, be further from Clements Road, and be in higher altitude habitat which appears to have had fewer rodents.

Computer modelling was also used to determine the most cost effective of the five control methods at maintaining possum populations at low levels over a ten year period. The accumulated discounted cost per hectare over ten years for each method showed aerial 1080, at $55 per hectare, to be more than twice as cost effective in the long term as all other ground control methods, and four times more effective than cholecalciferol ($205 per hectare).

Additional environmental benefit in the form of rat by-kill was significant for aerially applied 1080 bait, 1080 baits in bait stations and cholecalciferol baits, but not in the sectors where Feratox® and trapping were the primary methods of control.

Introduction

Background

In today's social and political environment the use of toxins for pest control, particularly aerially applied 1080, is becoming increasingly controversial and unacceptable to many people. This is particularly so in areas where deer hunting is a popular pastime.

The Hatepe Trial builds on work carried out at Kaweka Forest in Hawke's Bay in 1996/97 comparing the operational and cost effectiveness of aerially applied 1080 baits to ground laid baits and trapping.

Since 1997, a range of new products and techniques have become available within the pest control industry which have improved the cost effectiveness of ground based Tb vector control in many operational areas. Up-to-date information is needed to assess the relative cost effectiveness, timeframes for completion, environmental risk, performance and limitations of a range of modern pest control methodologies, to allow managers to make informed decisions about future operations and to reassure the public.

Objective

To compare the effectiveness, including standardised cost per hectare and timeframe to complete, of controlling possums to meet specified RTCI performance targets[3] of a range of control methods within an Animal Health Board funded operational area that is typical of areas normally controlled by aerial 1080 poisoning.

Methods to be compared included:

- application of aerial 1080 baits
- application of 1080 baits via ground application methods[4]
- other ground control methods.

[3] Three percent with no individual line catching more than four possums.
[4] Due to the presence of short-tailed bats, 1080 paste was not permitted by the Department of Conservation, limiting this method to 1080 pellets in bait stations.

Study Area

A suitable operational area, Sector 1A of the VA014 (Hatepe) Tb vector control area in northern Kaimanawa Forest Park within the Waikato Region, was identified as being typical of an operational area often treated using aerial 1080 baits in terms of size[5] and habitat[6]. In addition, Tb vector control was scheduled for this area during the 2002/03 financial year.

The area is located 20 kilometres south-east of Lake Taupo and encompasses the headwater catchments of the Waitahanui River and the eastern tributary catchments of the Hinemaiaia River. The whole operational area is managed by DoC Turangi, as Kaimanawa Forest Park, under the Conservation Act (1987). This part of Kaimanawa Forest Park is formally gazetted as the Kaimanawa Recreational Hunting Area.

Habitat is generally mixed silver / red beech forest, with silver beech dominating higher altitudes and red beech the warmer lower altitude sites. Scattered podocarp and hardwood components occur depending on altitude and aspect. Altitude varies from 600 metres to 1,200 metres above sea level. Access is via Clements Mill Road which winds for 19 kilometres through the operational area. Two formal walking tracks maintained by DoC provide access to southern parts of the block while Lake Taupo Forest pine plantation borders the operational area to the north providing good access along its northern boundary. A number of unofficial hunters' tracks occur throughout the operational area, increasing access.

The area is heavily utilised for recreational hunting of sika deer. Red deer and pigs can also be found in low numbers through the area. Ship rats and mice can reach very high density when environmental conditions allow. Stoats are the primary introduced predators but hedgehogs, ferrets and cats are also present.

[5] 5,241 hectares.
[6] Heavy beech forest cover.

Methodology

The operational area was split into four blocks of approximately 1,300 hectares: Western (W), Central (C), Eastern (E) and Southern (S). Each of these blocks was in turn split into five 230 to 300 hectare study units or sectors giving a total of 20 sectors in the trial.

The five treatments were then allocated one sector within each of the larger blocks, such that there would be four replicates of each treatment in the 5,241 hectares. This allowed the opportunity for each treatment to have some sectors in steep, more remote or dense habitat areas, while other replicates fell within areas that were less steep, remote or dense and where less travel time was involved.

The five methods of control compared and their respective sector allocations were as follows.

1. 1080 in bait stations (0.15% w/w RS5 1080 pellets following pre-feeding with RS5 starter pellets). This method occurred in Sectors W1, C1, E1, and S1.

2. Cholecalciferol in bait bags (20 gram 4.0% w/w cholecalciferol blocks following pre-feeding with 20 gram pre-feed blocks). This method occurred in Sectors W2, C2, E2, and S2.

3. Feratox® and traps. This method occurred in Sectors W3, C3, E3, and S3.

4. Contractor's choice (Feratox®, trapping and dog teams). This method occurred in Sectors W4, C4, E4, and S4.

5. 1080 aerial (0.08% w/w 1080 deer repellent carrots at five kilograms per hectare following pre-feeding with five kilograms per hectare deer repellent carrots). This method occurred in Sectors W5, C5, E5, and S5.

A map of the operational area showing block and sector boundaries has been included as Appendix One.

Each method was tendered by Environment Waikato (EW) as four separate operational sectors in one contract. While it was left up to the contractors to work the blocks as they saw fit, they were required to meet an overall post operational performance criteria of three percent RTC in each sector with no individual line to exceed 16 percent RTC[7].

[7] No more than four possums.

Utilising one operational area which could be split into smaller sectors provided the opportunity to simultaneously compare the five methods across an area of similar habitat, possum density and accessibility and, therefore, allow a valid comparison of the various methods.

Auditing and Boundaries

Auditing was carried out on random sectors regularly throughout the trial to ensure that contractors were meeting contract and trial requirements. Boundaries were also checked to ensure full coverage and to reduce the risk of cross-overs or gaps.

The use of global positioning system (GPS) units was difficult, except where helicopters were used for aerial application, due to poor satellite coverage under the heavy beech canopy in the operational area and the initial requirement for GPS tracks of bait station, bait and trap lines was abandoned.

On boundaries where defined ridges or rivers were not present as block boundaries, hip chain cotton, bait bag or bait station lines replaced GPS way-points to mark boundaries.

Monitoring

Pre and post operational monitoring was carried out to determine possum densities before the trial, to gauge final residual possum indices and to compare operational effectiveness between methods.

The NPCA residual trap catch protocol was followed for all monitoring. Five lines of ten traps were used per sector. A total of 100 monitoring lines were, therefore, used to assess the 5,241 hectare trial.

Pre-Operational Monitoring

Soft-catch leghold traps were used for the pre-operational monitoring to allow all possums caught to be released so that the same monitoring lines could be repeated for the post operational monitoring. This sampling technique ensured that the results of the trial were not distorted, which could have occurred if possums caught during pre-operational monitoring were killed.

All monitoring line starts were randomly allocated by EW staff and located on a bearing of 337 degrees (grid north). No lines were located where traps would come within 200 metres of the boundary of individual sectors. However, the 200 metre boundary strip on random sectors was audited to establish that control had been implemented right up to operational sector boundaries.

A map of line locations is contained in Appendix Two. Results of pre-operational monitoring, by sector have been included as Appendix Three.

Post-Operational Monitoring

The post-operational monitoring used standard leghold traps and any possums caught were killed. Attempts were made to ensure all post-operational monitoring occurred within two weeks of completion of each sector wherever possible, weather permitting.

However, it was found that possums were taking up to three weeks to die after consuming cholecalciferol baits. Accordingly, on the manufacturer's advice, latter sectors where this method was used were left for almost a month before post-operational monitoring occurred.

Monitoring on the most remote aerial sector occurred almost four months after treatment due to the efficiencies of combining the monitoring of a number of remote sectors in this area.

Where sectors or individual post-operational monitoring lines failed to meet performance targets, reworks were required. All reworks were re-monitored with lines either running from the original line start point but at a bearing 180 degrees less than the original bearing, or if boundary rules did not allow for that, on the same bearing but 200 metres east or west of the original line start.

Contract Structure

Each method, targeting four separate operational sectors, one within each of the four blocks, was tendered by EW as an individual contract. Epro Ltd was not eligible to tender for any of these contracts ensuring independence in the management of the trial.

The contract allocations by sector and by method are shown in Table One. Performance and reporting criteria formed part of all contracts. Contract specifications for contractors are included as Appendix Four. Contractors called for monitoring on individual sectors as they were completed. If performance targets were not met, contractors were required to rework the sector.

Table 1: Sector and Method Allocations by Contractor

Sectors	Method	Contractor
C1, E1, W1 S1	1080 in bait stations (pre-fed)	Central Trappers (Neil Philpot)
C2, E2, W2, S2	Cholecalciferol in bait bags (pre-fed)	Eradaposs NZ (Dave Bedford)
C3, E3, W3, S3	Feratox® and trapping	Trappers NZ Ltd
C4, E4, W4, S4	Contractors choice (Feratox®, trapping and dogs)	Trappers NZ Ltd
C5, E5, W5, S5	Aerial 1080 carrot bait with deer repellent (pre-fed)	EcoFX Pest Solutions Ltd

Statutory Approvals and Consultation

Statutory approvals and consultation were undertaken independently by Epro Ltd as a single co-ordinated operation. This required:

- the preparation of an Assessment of Environmental Effects (AEE) for the full range of methods proposed
- DoC approval for all methods
- Medical Officer of Health (MOH) (Rotorua) approval[8]
- Taupo District Council approval for all methods involving controlled pesticides.

Resource consent was not required for the aerial application of 1080 baits as the aerial contractor, EcoFX Pest Solutions Ltd, currently holds a resource consent from Environment Waikato to undertake the aerial application of 1080 baits throughout the Waikato Region. This consent remains operative until 2010.

Epro prepared and distributed an Operational Fact Sheet, and arranged for large information boards to be erected at strategic locations within the operational area. It was left up to individual contractors to reinforce these information boards with toxin warning signs that met legal requirements warning the public of specific toxins in specific sectors.

[8] For all methods involving controlled pesticides.

During the approvals / consultation process, issues were raised by stakeholder groups regarding the potential by-kill of deer from aerial 1080 bait application in what is a very popular recreational deer hunting area. Epro Ltd staff met with a range of hunting interest groups including the Game and Forest Foundation, Hunters and Habitats and the New Zealand Deerstalkers Association.

The use of a newly developed deer repellent was eventually negotiated with DoC and numerous hunter interest groups, although there remained significant public opposition to the trial even after all approvals were obtained.

Epro Ltd liaised with local search and rescue staff and hunting groups to arrange a search for deer carcasses in one of the aerially treatment sectors (W5) following the application of toxic bait.

Other Assessments

Deer By-Kill

Due to the fact that the operational area is within a gazetted recreational hunting area and is extremely popular with hunters due to its sika deer population and relatively accessible nature, the by-kill of deer within the aerial 1080 bait application sectors was a significant issue for many hunters.

While a new deer repellent was used on the 1080 carrot baits, the repellent had not been previously trialled over sika deer and the likely outcomes were, therefore, largely unknown. However, captive sika deer showed a strong aversion to their familiar maize feed when treated with the repellent[9].

A co-ordinated search for deer carcasses was organised nine days after aerial 1080 bait application utilising the skills and resources of local search and rescue groups and recreational deer hunters.

To gauge the effectiveness of the search, 100 numbered paper sacks stuffed with leaf litter were placed at random within Sector W5 three days prior to the search. However, during the search it became apparent that only 90 of the 100 sacks had been placed within the actual targeted search area.

[9] Murray Matuschka, pers.comm.

Twenty search teams involving 61 searchers under the control of a number of co-ordination, administration and management staff, covered the target area using a new search technique known as 'purposeful wandering', attempting to locate and log the GPS position of any non-target species.

Rat By-Kill

On 15 October 2003, a Black Trakka rodent tracking tunnel was placed at each RTC monitoring line start and line finish on the five established RTC lines within each of the five sectors of Block C, a total of ten tunnels per sector. These tracking tunnels were lured with peanut paste and opened for a single night.

The following day the tracking tunnels were removed and the tracking cards assessed for rat and mouse footprints.

Computer Modelling of Ongoing Control Costs

Computer modelling was used to determine the most cost effective of the five control methods at maintaining possum populations at low levels over a ten year period.

The methodologies used are reported separately in Appendix Five.

Results

Contractors began control operations on 28 May 2003. The last contractor completed work on 13 November 2003, a total of 171 days. Post-operational monitoring results, by sector and method are included as Appendix Six.

Overall, the operation was successful in achieving a combined post operational RTC of 1.65 percent ± 0.51 percent across all sectors.

A summary of the outcomes are shown in Table 2. This is followed by a detailed sector-by-sector analysis of the outcomes of each of the five methods.

Table 2: Summary of Results for Possum Control Methods Used in the Hatepe Trial

Method	Size of Area Treated (hectares)	Time to Complete (Days)	Amount of Toxic Bait Used	Reworks Required	Post Operational Rat Index[10] %	Final Result (% RTC) All Sectors Combined	Standard-ised Cost ($ per hectare)
1. 1080 in bait stations (pre-fed)	1,016	115	405 kilograms 0.15% w/w 1080 pellets (of which 195 kilograms were recovered uneaten)	Two of 20 monitor lines identified needed additional work	0	1.32 (All sectors passed)	$43.45
2. Cholecalciferol in bait bags (pre-fed)	1,003	66	200 kilograms FeraCol® baits at 4.0% w/w cholecalciferol	10 of 20 monitor lines identified needed additional work	10	3.54 (Two sectors failed)	$37.46
3. Feratox® and trapping	1,068	142	24,200 Feratox® pills	Multiple re-works required (across three of four sectors)	70	2.56 (One sector failed)	$43.80
4. Contractors choice (Feratox®, trapping and dogs)	1,081	131	29,170 Feratox® pills	Re-work required on one sector (5 of 20 monitor lines)	60	1.34 (All sectors passed)	$36.77
5. Aerial 1080 carrot (pre-fed) - deer repellent	1,073	8	5.2 tonne 0.08% w/w 1080 deer repellent carrot	None	0	0.17 (All sectors passed)	$26.25[11] $20.25[12]
Total Trial	**5,241**	**171**				**1.65**	**$37.74**

[10] For the five sectors in Block C only.
[11] Costs include Epro deer repellent.
[12] Cost of standard 1080 carrot without Epro deer repellent.

Application of 1080 Baits via Bait Stations

Sector W1

Work began on 5 June 2003 and was completed on 14 July 2003, a total of 39 days. A total of 260 bait stations, of which half were Philproof feeders and half were Sentry bait stations, were established systematically within the sector providing every possum present access to a bait station within a minimum of approximately 100 metres.

The larger Philproof feeders were used where access was better while Sentry bait stations were used for more remote parts of the sector. The stations were pre-fed twice with approximately 500 grams of RS5 starter pellets per pre-feed (a total of one kilogram) before being filled with 500 grams of 0.15% w/w 1080 toxic RS5 pellets.

Post-operational monitoring between 2 and 5 July 2003 resulted in four possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 2.66 percent.

All bait stations were subsequently removed and 60 kilograms of remaining toxic bait disposed of.

Sector C1

Work began on 12 June 2003 and was completed on 20 August 2003, a total of 38 days. A total of 250 bait stations, of which half were Philproof feeders and half were Sentry bait stations, were established systematically within the sector providing every possum present access to a bait station within a minimum of approximately 100 metres.

The larger Philproof feeders were used where access was better while Sentry bait stations were used for more remote parts of the sector. The stations were pre-fed twice with approximately 500 grams of RS5 starter pellets per pre-feed (a total of one kilogram) before being filled with 500 grams of 0.15% w/w 1080 toxic RS5 pellets.

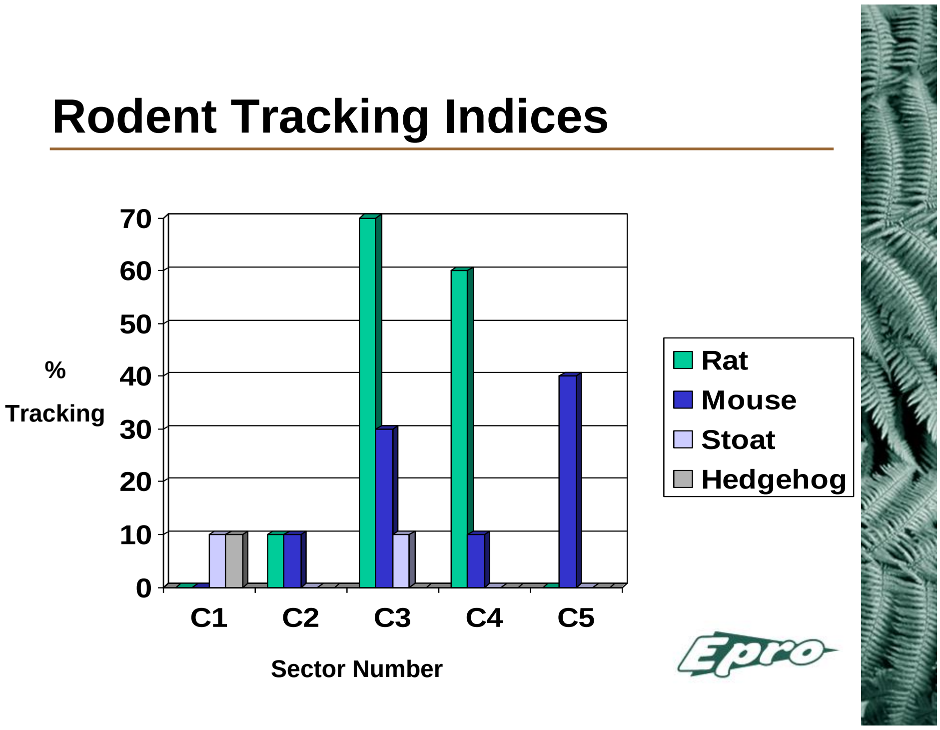
Post-operational monitoring between 14 and 16 July 2003 resulted in four possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 2.66 percent. However, three possums were caught on the first four traps of one monitoring line in what appeared to be a gap on the edge of the sector.

Additional stations were subsequently established in the identified gap, pre-fed once and filled with toxic bait. The gap was re-monitored with a single line 200 metres parallel to the original line (line 72A) during the period 1 to 3 August 2003 which caught no possums giving a final RTC of 0.66 percent.

All bait stations were subsequently removed and 70 kilograms of remaining toxic bait disposed of.

Sector C1 was also subject to comparative rodent tracking indexing. Ten tunnels were opened for one night on 15 October resulting in rat tracking in no tunnels, stoat tracking in one tunnel and hedgehog tracking in one tunnel[13]. Results of all rodent tracking indices are shown in Figure 1.

Figure 1



Sector E1

Work began on 14 July 2003 and was completed on 5 August 2003, a total of 22 days. A total of 253 bait stations, of which half were Philproof feeders and half were Sentry bait stations, were established systematically within the sector providing every possum present access to a bait station within a minimum of approximately 100 metres.

[13] Rat tracking index of zero percent.

The larger Philproof feeders were used where access was better while Sentry bait stations were used for more remote parts of the sector. The stations were pre-fed twice with approximately 500 grams of RS5 starter pellets per pre-feed (a total of one kilogram) before being filled with approximately 300 grams of 0.15% w/w 1080 toxic RS5 pellets.

Post-operational monitoring during the period 14 to 16 August 2003 resulted in six possums being caught from 150 trap nights. No escapes, no non-target catches but one sprung empty trap was recorded giving an RTC of 4.01 percent. Five possums were caught on two adjacent traps on a single trap line that went through a part of the bait station network where bait station interference was apparent[14].

These stations were replaced, pre-fed once and refilled with toxic bait. Re-monitoring of the line, on the same bearing but 200 metres to the west, resulted in a single possum being caught during the period 30 September to 2 October 2003 giving a final RTC of 1.33 percent.

All bait stations were subsequently removed and 35 kilograms of remaining toxic bait disposed of.

Sector S1

Work began on 6 August 2003 and was completed on 27 September 2003, a total of 53 days. A total of 250 bait stations, of which half were Philproof feeders and half were Sentry bait stations, were established systematically within the sector providing every possum present access to a bait station within a minimum of approximately 100 metres.

The larger Philproof feeders were used where access was better while Sentry bait stations were used for more remote parts of the sector. The stations were pre-fed twice with approximately 500 grams of RS5 starter pellets per pre-feed (a total of one kilogram) before being filled with approximately 300 grams of 0.15% w/w 1080 toxic RS5 pellets.

Post-operational monitoring during the period 16 to 18 August 2003 resulted in one possum being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 0.66 percent.

All bait stations were subsequently removed and 30 kilograms of remaining toxic bait disposed of.

[14] Human urine was noted in three bait stations.

Summary

The sectors subject to 1080 in bait stations required a total of 115 days to complete the combined area of 1,016 hectares. All sectors passed performance monitoring with an average post operational RTC of 1.33 percent ± 0.93 percent.

Application of Cholecalciferol Baits in Biodegradable Bait Bags (Pre-fed)

Sector E2

Work began on 28 May 2003 and was completed on 12 July 2003, after re-working the block, a total of 45 days.

A total of 3,500 pre-bagged pre-feed baits were established systematically at an average density of approximately one bait per 10 metres squared across the sector. Attention was given to areas of higher sign, gully-heads, ridges and spurs. In flat terrain 75 metre transects were established. A week to ten days after pre-feeding, pre-feed baits showing takes were replaced with FeraCol® baits (4.0% w/w cholecalciferol in 20 gram blocks). Due to high rat takes, most pre-feed baits were taken requiring the use of approximately 2,500 toxic baits.

Post-operational monitoring during the period 25 to 28 June 2003 resulted in eleven possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 7.33 percent. The sector was re-worked and re-monitored during the period 21 to 24 July 2003. Four possums were caught off 50 traps but 19 of the 50 traps were deliberately set off by persons unknown on the third night resulting in a final RTC of 2.85 percent.

Sector C2

Work began on 13 June 2003 and was completed on 8 July 2003, a total of 25 days.

A total of 4,500 pre-bagged pre-feed baits were established systematically at an average density of approximately one bait per 10 metres squared across the sector. Attention was given to areas of higher sign, gully-heads, ridges and spurs. In flat terrain 75 metre transects were established. A week to 10 days after pre-feeding, pre-feed baits showing takes were replaced with FeraCol® baits (4.0% w/w cholecalciferol in 20 gram blocks). Due to high rat takes, most pre-feed baits were taken requiring the use of approximately 2,500 toxic baits.

Post-operational monitoring during the period 1 to 3 August 2003 resulted in 11 possums being caught from 150 trap nights. One escape, one sprung empty trap and two non-target rats were also recorded giving an RTC of 7.43 percent.

The monitoring contractor made the observation that the possums caught were skinny, in poor health and very lethargic suggesting that possums had eaten bait but had not yet died. This was discussed with the bait manufacturer who advised that a minimum of four weeks should be allowed between toxic application and monitoring due to the slow acting nature of cholecalciferol. The block was left for another two weeks and re-monitored during the period 14 to 16 August 2003 resulting in 10 possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 6.66 percent. No further work was undertaken by the contractor.

Sector C2 was also subject to rodent indexing. Ten tunnels were opened for one night on 15 October resulting in rat tracking in one tunnel and mouse tracking in another[15].

Sector W2

Work began on 11 July 2003 and was completed on 25 July 2003, a total of 15 days.

A total of 4,500 pre-bagged pre-feed baits were established systematically at an average density of approximately one bait per 10 metres squared across the sector. Attention was given to areas of higher sign, gully-heads, ridges and spurs. In flat terrain 75 metre transects were established. A week to 10 days after pre-feeding, pre-feed baits showing takes were replaced with FeraCol® baits (4.0% w/w cholecalciferol in 20 gram blocks). Due to high rat takes, most pre-feed baits were taken requiring the use of approximately 2,500 toxic baits.

Post-operational monitoring during the period 20 to 22 August 2003 resulted in five possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 3.33 percent. No further work was undertaken by the contractor.

Sector S2

Work began on 18 July 2003 and was completed on 1 August 2003, a total of 14 days.

[15] Rat tracking index of 10 percent.

A total of 2,500 pre-bagged pre-feed baits were established systematically at an average density of approximately one bait per 10 metres squared across the sector. Attention was given to areas of higher sign, gully-heads, ridges and spurs. A week to 10 days after pre-feeding, pre-feed baits showing takes were replaced with FeraCol® baits (4.0% w/w cholecalciferol in 20 gram blocks). Due to high rat takes, most pre-feed baits were taken requiring the use of approximately 2,500 toxic baits.

Post-operational monitoring during the period 29 to 31 August 2003 resulted in two possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 1.33 percent.

Summary

The sectors subject to cholecalciferol required a total of 66 days to complete the combined area of 1,003 hectares. Two sectors failed the performance monitoring target of three percent RTC. The average final post operational RTC of the four sectors was 3.54 percent ± 1.99 percent.

Feratox® and Trapping

Sector E3

Work began on 25 June 2003 and was finally completed after two re-works on 13 November 2003, a total of 142 days.

A total of 6,550 pre-bagged Feratox® baits were laid through the sector, together with 200 traps set for two nights (during the second re-work only) targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The initial post operational monitoring occurred during the period 1 to 3 August 2003 and resulted in seven possums being caught from 150 trap nights. One escape, one sprung empty trap and one non-target (rat) catch were recorded giving an RTC of 4.7 percent.

Following additional work in early August, a re-monitor occurred resulting in five possums being caught from 150 trap nights. No escapes or sprung empty traps were recorded but there was one non-target (rat) catch giving an RTC of 3.34 percent.

Following further work in October a second re-monitor occurred resulting in one possum being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 0.66% percent.

Sector C3

Work began on 7 July 2003 and was completed on 26 September 2003 after re-working the block, a total of 51 days.

A total of 4,500 pre-bagged Feratox® baits were laid through the sector targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The initial post operational monitoring occurred during the period 22 to 24 July 2003 and resulted in seven possums being caught from 150 trap nights, three of these were on one line. No escapes or sprung empty traps were recorded but there was one non-target (rat) catch giving an RTC of 4.68 percent.

Following further work around the high line in early August, two additional re-monitor lines were established 200 metres parallel (east and west respectively) to line 64 (lines 64A and 64B). This resulted in one possum being caught from 60 trap nights. No escapes or sprung empty traps were recorded but there was a further non-target (rat) catch giving a final RTC for the whole sector of 2.22 percent.

Sector C3 was also subject to rodent indexing. Ten tunnels were opened for one night on 15 October resulting in rat tracking in seven tunnels and mouse tracking in three (rat tracking index of 70 percent).

Sector W3

Work began on 24 July 2003 and was finally completed on 13 November 2003, after re-working parts of the block, a total of 122 days.

A total of 9,550 pre-bagged Feratox® baits were laid through the sector, together with up to 100 traps sets for five nights (during the re-work only) targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The initial post-operational monitoring was called before ground crews had actually completed the sector so it had to be re-monitored during the period 14 to 16 July 2003. This resulted in six possums being caught from 150 trap nights, three of these were on one line. No escapes or sprung empty traps were recorded but there was one non-target (stoat) catch giving an RTC of 4.01 percent.

Following further work around the high line in early October two additional re-monitor lines were established 200 metres parallel (east) of Line 90[16]. This resulted in two possums being caught from 60 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving a final RTC for the whole sector of 3.34 percent.

Sector S3

Work began on 6 October 2003 and was completed on 8 October 2003, a total of three days.

A total of 3,600 pre-bagged Feratox® baits were laid through the sector targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The post-operational monitoring occurred during the period 4 to 6 November 2003 and resulted in one possum being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 0.66 percent.

Summary

The sectors subject to Feratox® and trapping required a total of 142 days to complete the combined area of 1,068 hectares. The average post operational RTC of the four sectors was 1.84 percent ± 0.51 percent.

Contractors Choice of Ground Control Method (Feratox®, Trapping and Dogs)

Sector E4

Work began on 09 June 2003 and was completed on 26 June 2003, a total of 18 days.

A total of 8,970 pre-bagged Feratox® baits were laid through the sector, targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs. A total of ninety trap nights were also used.

The post-operational monitoring occurred during the period 20 to 23 July 2003 and resulted in no possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of zero percent.

Sector C4

Work began on 14 July 2003 and was completed on 14 October 2003, after completely re-working the block, a total of 62 days.

[16] Lines 90A and 90B.

A total of 10,600 pre-bagged Feratox® baits were laid through the sector, targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The initial post-operational monitoring occurred during the period 1 to 4 August 2003 and resulted in fifteen possums being caught from 150 trap nights. Two escapes and one non-target (rat) catch was recorded giving an RTC of 10.01 percent.

Following additional work in September, a re-monitor occurred resulting in one possum being caught from 150 trap nights. No escapes or sprung empty traps were recorded but there was one non-target (rat) catch giving an RTC of 0.67 percent.

Sector C4 was also subject to rodent indexing. Ten tunnels were opened for one night on 15 October resulting in rat tracking in six tunnels, mouse tracking in one tunnel and stoat tracking in one tunnel[17].

Sector W4

Work began on 11 August 2003 and was completed on 22 August 2003, a total of 12 days.

A total of 6,000 pre-bagged Feratox® baits were laid through the sector, targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The post-operational monitoring occurred during the period 13 to 15 September 2003 and resulted in three possums being caught from 150 trap nights. One non-target (rat) catch was recorded giving an RTC of two percent.

Sector S4

Work began on 29 September 2003 and was completed on 17 October 2003, a total of 19 days.

A total of 4,800 pre-bagged Feratox® baits were laid through the sector, targeting preferred possum habitat. Attention was given to areas of higher sign, gully-heads, ridges and spurs.

The post-operational monitoring occurred during the period 4 to 6 November 2003 and resulted in four possums being caught from 150 trap nights. No escapes or sprung empty traps were recorded but three non-target (rat) catches were recorded giving an RTC of 2.69 percent

[17] Rat tracking index of 60 percent.

Summary

The sectors subject to contractor's choice (Feratox®, trapping and dogs) required a total of 131 days to complete the combined area of 1,081 hectares. The average post operational RTC of the four sectors was 1.34 percent ± 0.94 percent.

Application of Aerial 1080 Baits (Pre-fed)

The aerial treatment sectors were treated all at the same time with the application of five kilograms per hectare of non-toxic deer repellent carrot bait on 18 June 2003 followed eight days later on 26 June 2003 by an application of five kilogram per hectare 0.08% w/w 1080 deer repellent carrot bait that met DoC specifications for chaff and colour content. Differential global positioning system flight lines of the toxic application are contained in Appendix Six. Toxin analyses of carrot bait samples are included as Appendix Seven.

Sector W5

Post-operational monitoring during the period 14 to 16 July 2003 resulted in no possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of zero percent.

Sector E5

Post-operational monitoring during the period 15 to 17 July 2003 resulted in one possum being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of 0.66 percent.

Sector C5

Post-operational monitoring during the period 14 to 16 July 2003 resulted in no possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of zero percent.

Sector C5 was also subject to rodent indexing. Ten Black Trakka tracking tunnels were opened for one night on 15 October, resulting in tracking in none of the tunnels (zero percent index).

Sector S5

Post-operational monitoring during the period 3 to 6 November 2003 resulted in no possums being caught from 150 trap nights. No escapes, sprung empty traps or non-target catches were recorded giving an RTC of zero percent.

The delay in monitoring this block was due to the remote nature of the sector and the efficiency of monitoring this sector together with neighbouring sectors once they were completed. These sectors were not completed until October.

The sectors subject to aerial 1080 bait application required a total of eight days to complete the combined area of 1,073 hectares. All sectors passed performance monitoring with an average RTC of less than 0.17 percent ± 0.35 percent.

Deer By-Kill

A deer carcass search was conducted on 5 July 2003, nine days after the aerial application of toxic 1080 carrot bait. A summary of the search is contained in Appendix Eight.

The search effectively covered 137 hectares of the 245 hectare treatment area (Sector W5) and found five dead deer including two mature females, one sub-adult female and two juvenile males. All were confirmed as poisoned by 1080 by toxin analysis[18]. This equated to 3.65 dead deer per square kilometre treated. Extrapolating this figure to all four sectors treated with aerially applied 1080 baits (10.73 square kilometres), it is possible that as many as 40 deer were poisoned as part of the trial, although there was only one other deer, a sika female, reported dead despite a large number of hunters, contractors and monitoring staff being present in the operational area over a sustained period during the course of the trial.

Nevertheless, the estimated kill of 40 deer across four aerial treatment sectors represents approximately 13 percent of the estimated 300 deer living within the operational area (DoC unpublished data). This caused significant ill-feeling with many in the hunting fraternity who were opposed to the trial for that reason.

The deer carcass search also found three dead tomtits, two dead blackbirds, two dead ship rats and a dead stoat, as well as numerous dead possums. A toxin analysis of the dead birds found is referred to in Appendix Nine.

[18] Refer analysis report in Appendix Nine.

Costings

A cost efficiency comparison between the five methods was made by applying a standardised costing to the information provided by contractors which identified all operational resources required to complete each method across all four sectors. The standardised cost per hectare is based on the total operational costs divided by the total size of the four relevant sectors.
These costs include an hourly rate allowance of $20.00 per hour of staff time, $20.00 per man-day camping allowance, $0.62 per kilometre for vehicle running, standard catalogue prices for bait, bait stations, helicopter hire, for example, and standard re-monitor line costs of $350 per line. All costs are exclusive of GST.

The standardised cost per hectare does not include contractor's time for management[19] of the trial. It also excludes the cost of statutory approvals / consultation, which were obtained in one overall operational application.

It can be assumed that the costs of consultation and statutory approvals would need to be added to the costs listed to obtain a true operational cost for each method, as the use of controlled pesticides such as Feratox® and 1080 requires MOH approval, and the use of any toxin on land managed by DoC requires a full AEE and toxin application to be prepared.

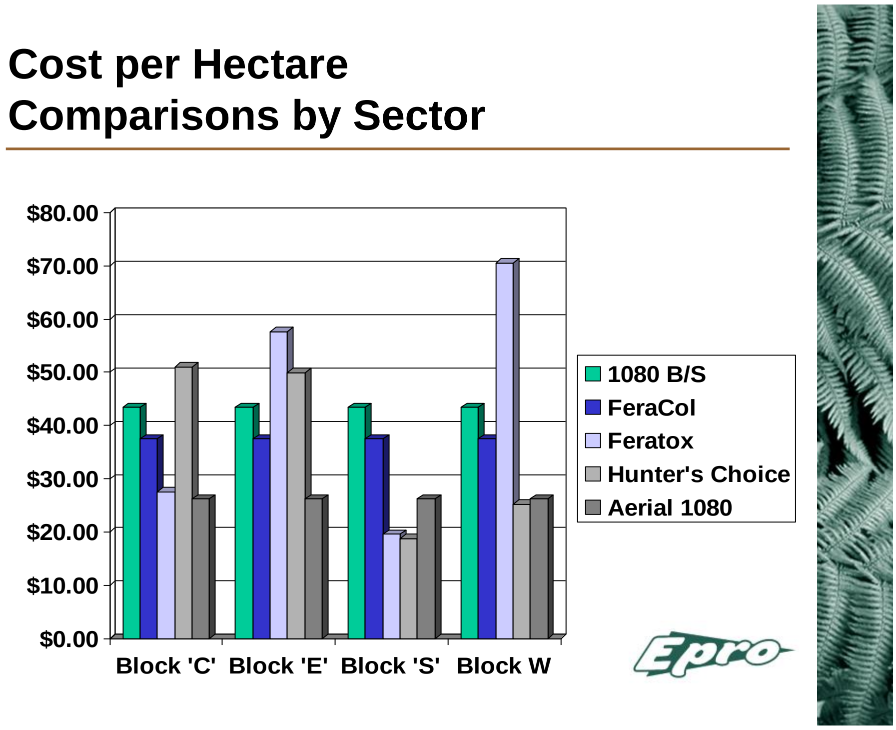
In addition, the consultation process for this particular Tb vector control area, due to its high profile and public use, would have needed to be extensive, regardless of the nature of the control, so these costs would have been incurred whatever method was used.

A comparison of costs identifying standardised costings for the resources required to complete the four sectors using each of the five methods is shown in Table Three on the following page.

Comparative costs by sector are shown below in Figure 2.

[19] For example, co-ordination, liaison and boundary establishment.

Figure 2



Computer Modelling of Ongoing Control Costs

The results of a detailed analysis of accumulated discounted cost per hectare over a ten year period for all five methods based on computer modelling of the data gathered from the Hatepe Trial are reported separately in Appendix Five.

Aerial 1080 (at an accumulated discounted cost of $55 per hectare) was more than half that of the cheapest ground control option (contractor's choice at $128 per hectare). Cholecalciferol had the highest accumulated discounted cost of all methods at $208 per hectare, due to the lower efficacy of this method (79.3 percent reduction), while '1080 in bait stations' and 'Feratox® and Trapping' had intermediate accumulated discounted costs over ten years at $154 and $155 respectively.

Table 3: Cost Comparisons of Possum Control Methods Used in the Hatepe Trial

Method	Total Area (hectares)	Labour Costs ($20 per hour)	Bait Costs	Vehicle Costs (62 cents per kilometre)	Other Costs	Helicopter Costs ($1,200 per hour)	Re-Monitor Costs ($350 per line)	Total Cost per Hectare
1080 bait stations	1,016	1,600 hours $32,000	1 tonne RS5 pre-feed ($2,038) 0.4 tonne 0.15% w/w 1080 RS5 ($2,638) 250 bait stations at $10.00 each 260 bait stations at $7.75 each Total $7,610	6,200 km $3,844	Nil	Nil	Two lines $700	$43.45
Cholecalciferol bait bags	1,003	1,030 hours $20,600	15,000 pre-feed baits at 20 cents each 10,000 toxic baits at 74 cents each Total $10,400	4,960 km $3,075	Nil	Nil	10 lines $3,500	$37.46
Feratox and trapping	1,068	1,147 hours $22,940	24,200 Feratox® pills at 57 cents each Total $13,794	3,309 km $2,052	Nil	0.83 hours $998	20 lines $7,000	$43.80
Contractors choice (Feratox®, trapping and dogs)	1,081	898 hours $17,970	29,170 Feratox® pills at 57 cents each Total $16,626	3,750 km $2,325	Nil	0.9 hours $1,078	Five lines $1,750	$36.77
Aerial 1080 bait application	1,073	211 hours $4,220	5.2 tonne pre-feed carrot 5.2 tonne 0.08% w/w 1080 toxic carrot Total standard bait $4,641 Total deer repellent bait $11,079	1,308 km $811	Toxin samples, newspaper adverts and Met forecasts $535	9.6 hours $11,520	Nil	$20.25[20] $26.25[21]

[20] Costs of standard carrot bait without Epro deer repellent.
[21] Costs including Epro deer repellent.

Discussion

The aerial application of 1080 baits was the most operationally, time and cost effective method used in the trial, at half the cost of some ground treatment methods, even with the added cost of the deer repellent.

Aerial application of 1080 bait was undertaken in a timeframe an order of magnitude faster than all ground methods trialled and resulted in significant additional environmental benefit in terms of rat by-kill. There was also evidence of a secondary kill of mustelids with a freshly dead stoat observed during the deer search, although this animal was not analysed for toxins. The highest mouse tracking index came from the monitored aerial sector (C5). This is most likely a response in the mouse population to the removal of predators, including ship rats, in the four months between toxic application and the post operational rodent indexing.

Despite its success, aerial application of 1080 bait was the method that drew the most public opposition and concern during the trial, primarily from hunting interests. Many of those opposing the trial suggested that the whole job should have been undertaken with Feratox® and trapping.

While seeming to be the hunting public's preferred method, Feratox® and trapping had very inconsistent results through the trial with some sectors proving to be the least operationally, time and cost effective of the trial. A combination of poor coverage by the contractor[22], rat interference, bad weather and possibly bait aversion as a result of the long history of extensive cyanide paste use at Clements Road[23], appear to have contributed to significant operational failures across many sectors where Feratox® was a significant part of the control methodology.

From the data provided by the contractor there also seemed little use of traps or dogs with either method, except where trapping was used for re-working sectors that had failed their initial, and in some cases second, post-operational monitor. More use of these techniques in the initial treatment, in accordance with the original operational design proposed by the contractor, may have improved performance.

[22] As established by random audit.
[23] DoC files, Turangi.

In the sectors where Feratox® and trapping met operational targets on the first monitor, it appears to have been very cost and time effective compared to all other methods. However, overall there was considerable inconsistency in results. The method appeared most effective where pre-operational trap catch was relatively low and in sectors well away from Clements Road.

Sectors close to Clements Road appeared to have a certain degree of bait shyness in the possum population. During the second rework of one sector a possum was caught in a trap amongst 12 Feratox® bait bags[24], suggesting the possum had had plenty of opportunity to access bait.

The higher altitude habitats where Feratox® seemed to perform best appeared to have lower rodent interference, which was a major problem in other lower altitude sectors. The rodent problem in some sectors may also have been the result of luring bait bags with flour[25]. There was no evidence of any additional environmental benefit in terms of a rodent by-kill in sectors treated with Feratox® based methods compared to all other methods. Rat tracking indices of 60 percent and 70 percent were recorded in the two sectors, C3 and C4, where this method was used.

Despite problems encountered in some sectors, the target specific nature of Feratox® and trapping may provide some explanation as to why the hunting public find favour with it, even where it is not cost or time effective. Target specificity of possum control methods may be more important to deer hunters than cost-effectiveness.

While cholecalciferol offered a moderately time effective and cost effective control option relative to the other ground methods, it failed to meet operational targets on two of the four sectors. The inconsistency in performance of this method, even with extensive pre-feeding, did not appear to be a result of operator error as the contractor achieved good coverage of all sectors as established by random audit and monitoring contractor feedback.

The failure appears more related to the product itself, although insufficient bait may have been an issue in localised sites, especially favoured possum habitat, as some possums were reported behaving in a manner consistent with sub-lethal poisoning[26].

[24] Leith Harley pers. comm.
[25] Leith Harley pers. comm.
[26] Glenn Ballinger pers. comm.

Discussions with the manufacturer suggest this method has limited operational effectiveness where possum populations exceed 15 percent RTC. Despite the limitations of this method / product for possum control in this trial, cholecalciferol appeared to achieve significant additional environmental benefits in terms of rodent by-kill with low post operational rodent tracking indices in the C2 sector monitored.

The use of 1080 in bait stations offered the best operational effectiveness of all the ground based methods but was not time effective when compared against some other methods. There were significant additional environmental benefits from this method as determined by the post operational rodent indexing (C1) and there is some evidence of a secondary poisoning effect on mustelid populations with a dead stoat observed in the C1 sector by the contractor[27]. While 1080 in bait stations was the most operationally effective ground control method trialled, it was one of the least cost effective.

The majority of public concern expressed over the trial came from the use of 1080, especially the aerial application. Primarily concerns were from deer hunters regarding the effect 1080 baits would have on the numbers of highly valued and sought-after sika deer present in the operational area, and the secondary poisoning risk to hunting dogs. Effects on water quality and non-target native wildlife were also cited as reasons why 1080 should not have been used.

No water sampling was required by the MOH and accordingly none was undertaken to validate or exclude concerns about water, although there is a large amount of scientific information to suggest the aerial application of 1080 baits has negligible effect in terms of water contamination[28]. The dead birds found during the deer carcass search, confirmed as containing 1080 residues, perhaps give some legitimacy to concerns about the non-target wildlife effects of aerially applied 1080 bait, especially since there were no reports of dead birds in any of the other methods. However, there were not large numbers found and there is documented scientific evidence of benefits to native birds following aerial application of baits, despite the recording of small losses during such operations[29].

[27] Neil Philpott pers. comm.
[28] Seawright and Eason (1994), Eason et al (1993).
[29] O'Donnell (1994), Montegue (2000), Powlesland et al (1998).

While it was hoped the use of a deer repellent would reduce public opposition to the use of aerially applied 1080 baits as part of the trial, hunters appeared sceptical about the repellent as it was still under development. The scepticism appears to have been justified as, despite the use of the deer repellent, aerially applied 1080 carrot bait still killed some deer in this trial, even if it is hard to determine the significance of the by-kill in terms of the overall population from the limited data collected.

One explanation for the by-kill is that the deer repellent mixture used in the trial did not adhere properly to the carrot bait. This together with the 70 millimetres of rain that fell in the first eight days after bait application may partly explain the deer by-kill. In addition, sika deer are a small deer species, therefore requiring only small amounts of toxic bait to die, and their feeding habits are such that they seek forage like litter-fall and fruits off the forest floor more than some other deer species[30] making them particularly susceptible to aerially applied 1080 baits.

The repellent mix has subsequently been changed and was used extremely effectively to eliminate the by-kill of red deer during an operation using five kilograms per hectare of 0.08% w/w 1080 carrot bait applied by helicopter at Wakeman's Clearing in the Waipunga River catchment in July 2003[31].

While the aerial application of 1080 baits remains the most operationally, time and cost effective method available for controlling possums in moderate to large, heavily forested operational areas, managers need to balance its efficacy with the strong public opposition to the poisoning of deer that results from this method of possum control.

The computer modelling simulations highlight that efficacy is an extremely important consideration for longer term control (for example, the ten year period used for the model in Appendix Five) and one that managers must be mindful of when planning pest control operations. Control methods with low efficacy (<80 percent) require additional operations to maintain possum populations below target densities over a sustained period of time. Accordingly while FeraCol®, in this trial, is not significantly more expensive for a one off control operation than some of the other ground control methods used, the initial kill of around 80 percent has significant implications for future control. Not only will additional control be required to meet targets, but bait shy survivors are likely to remain. These survivors will become harder and more expensive to control in the future.

[30] Fraser 1991
[31] Nugent et al in press

In addition, it is not good pest control practice to overly rely on a single control technique for sustained control of a pest population.

The information presented in this report, from a range of alternative possum control options currently available in the modern pest control industry used simultaneously across similar habitat within the same operational area, provides managers with up-to-date information on the relative costings, operational effectiveness and timeframes for the various methods trialled.

This information will help managers explore options, with stakeholders, that are both acceptable and which have sufficient efficacy to provide cost effective control when planning possum control operations.

Managers need to use the information presented in this report in the context of the specific circumstances relevant to each individual operational area where possum control is being considered, including desired outcomes.

Recommendations

- Pest managers should remain aware of strongly negative public attitudes towards 1080, especially when it is applied by aerial means, fuelled by the non-target deaths of native wildlife, hunting dogs and feral deer in previous operations. They will need to balance these attitudes with the efficacy this method provides, on an operation by operation basis.

- Pest managers should note that efficacy plays an important role in the choice of method for sustaining pest control at a given site. FeraCol®, in its current formulation, should not be used exclusively for sustained control operations where possum density is above 15 percent RTC.

- Pest managers concerned primarily about pest control for environmental reasons should consider other or additional methods of controlling possums rather than relying exclusively on Feratox® and trapping.

- Pest managers need to view the information contained in this report in the context of the specific circumstances relevant to each individual operational area where possum control is being considered, including desired outcomes over time.

Acknowledgements

Pest control, especially where toxins are used, is a controversial issue. We hope this trial has helped to increase the industry's awareness of the public's genuine concerns about possum control and to provide information on options for cost-effectively managing some of these issues in the future. Only by proactive investigation will the industry be able to evolve to meet the needs and aspirations of New Zealand society.

The efforts of all the following contractors involved in the trial are gratefully acknowledged:

- Neil Philpott and his team from Central Trappers
- Dave Bedford and his team from Eradaposs New Zealand
- Leith Harley and his team from Trappers NZ Ltd
- Tim Dinsdale and his team from EcoFX Pest Solutions Ltd
- Ian McKavanagh and his trap catch monitoring staff.

Epro Ltd also acknowledges the effort put in by Dave Combre and the search and rescue volunteers from the Taupo and Turangi Search and Rescue Groups. The Game and Forest Foundation, Hunters and Habitats Club and local branches of the New Zealand Deerstalkers Association are thanked for their contribution and support. Statistical advice and computer modelling was provided by James Ross of Landsdowne Ventures Ltd.

Finally, we acknowledge the concerns of the many hunters and local people who opposed the trial. This opposition was expressed through letters to the editors of various publications, by graffiti on various mediums in and around the operational area, and by actions such as the removal of warning signs, interference with traps and bait stations, and attempts to make Clements Road non-functional through culvert sabotage.

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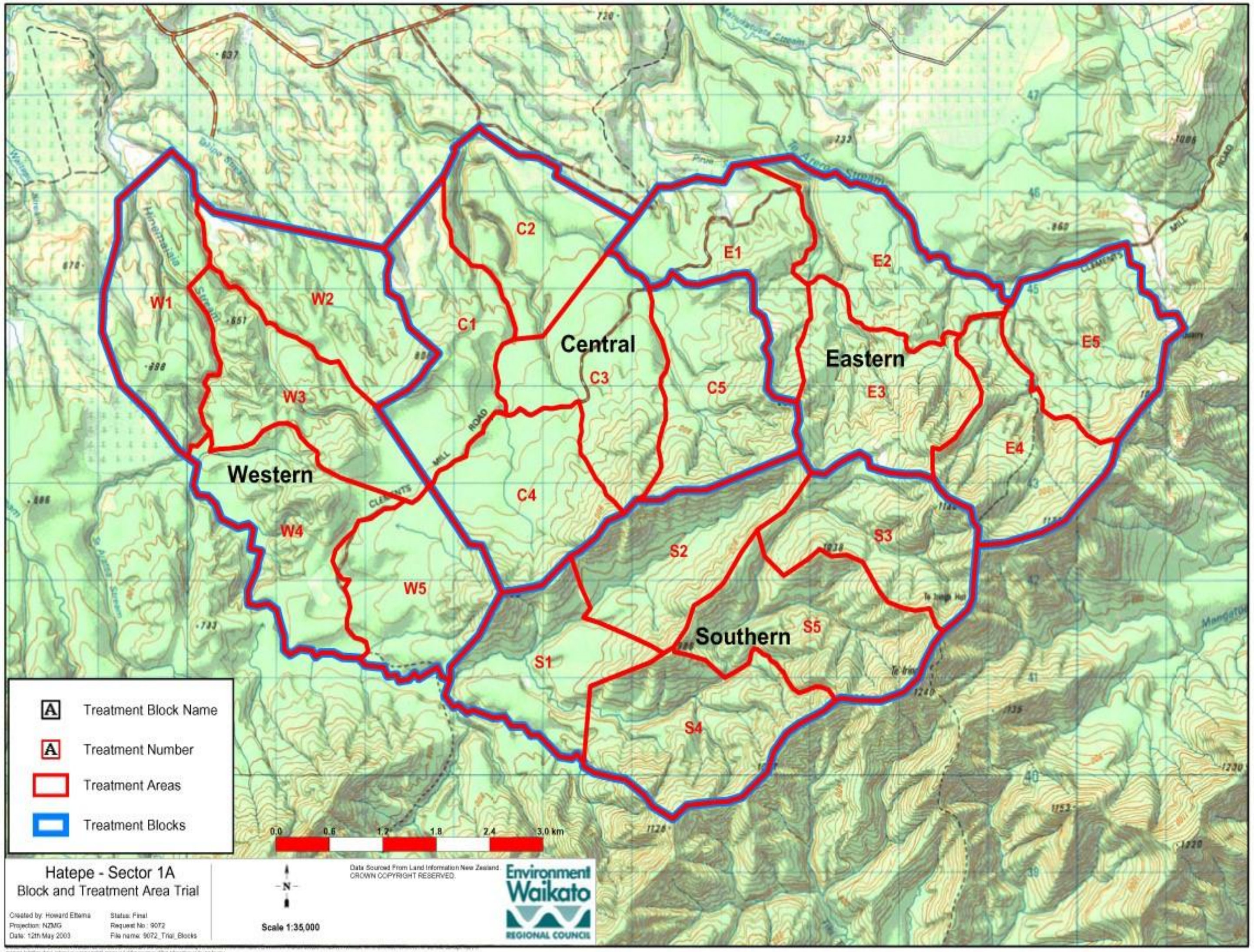
Personal Communications

- Bellinger, Glen - Monitoring Contractor
- Harley, Leith - Field Manager (Trappers NZ Ltd)
- Matuschka, Murray - Deer Farmer, Taupo
- Philpott, Neil - Central Trappers

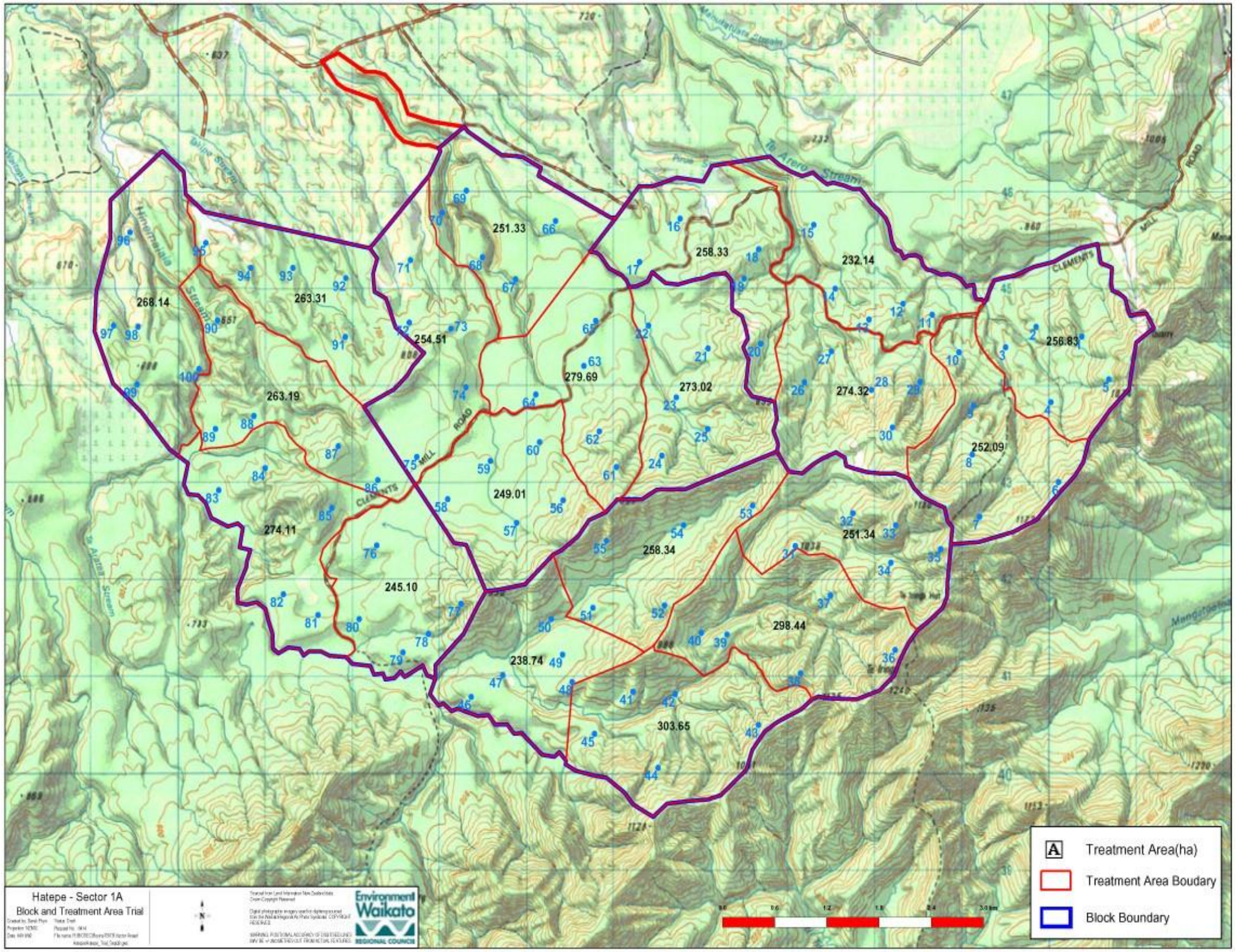
Appendices

The appendices that form part of this research report are all independently prepared documents, and accordingly they are not page numbered.

Appendix One - Sector / Block Boundaries



Appendix Two - Monitoring Line Locations



Appendix Three - Pre-Operational Monitoring Results

Appendix Four - Operational Specifications for Contractors

Contract Requirements

1. Applications for all statutory approvals for the Hatepe trial have been made by Epro. Copies of subsequent approvals will be made available to all contractors. All relevant conditions must be met by contractors.
2. Where sector boundaries are not clearly defined by rivers, roads or ridges, sector boundaries are to be marked with hip-chain cotton at chest height. This is to be done co-operatively by neighbouring contractors so both work to the same boundary. Flagging tape will be tied to the hip-chain cotton at periodic intervals identifying directions or landmarks to aid navigation. Time spent marking sector boundaries should be recorded separately as this is related to the trial part of the operation, not the vector control.
3. Weekly liaison with, and reporting to Epro management in relation to progress or other operational issues will be required.
4. Warning signs and public notices will be posted or published by individual contractors for each of their sectors, as per Vertebrate Pest Control regulations, where the public may gain access to bait. Notwithstanding, Epro will place large information board type signs explaining the whole operation at the entrance to Kaimanawa Forest Park on Clements Mill Road, at the Te Iringa car park, and in the Cascade Hut car park at the end of Clements Mill Road.
5. Sectors may be worked as individual contractors see fit. Co-ordination of timing will not be required. However, it is anticipated that the aerial sectors will be treated in early June to allow ground contractors to work up against aerial boundaries for as many sectors as possible for the majority of the trial.
6. Post operational monitoring will be undertaken a maximum of fourteen days following notification by individual contractors of the completion of each sector. Five lines of ten traps will be used to monitor each sector. Target density is a residual trap catch not exceeding three percent, with no single line catching more than four possums.
7. Documented information that will be required from contractors at the completion of the trial includes the following parameters on a sector by sector basis:
   - labour hours
     - including travel, wet time, lost time and boundary
     - marking (boundary marking must be recorded separately)
   - travel
     - kilometres
   - materials
     - quantities (bait, pre-feed, numbers of bait stations, trap nights, dog days)
   - accommodation
     - whether camping on block or travelling
   - mapping
     - Sector maps showing all bait, bait-station trap or flight lines. (Note: A3 sized colour topographical. Sector maps will be supplied by Epro. These will have scale bars, sector numbers and sector boundaries shown on them. These maps must be submitted following completion of the trial with the above operational detail)

Appendix Five - Cost Effectiveness of Different Possum Control Methods

THE COST-EFFECTIVENESS OF DIFFERENT POSSUM CONTROL METHODS

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INTRODUCTION

The purpose of this modelling exercise was to compare the cost-effectiveness of five alternative methods of controlling brushtail possum in New Zealand over a 10-year period. Biological model values were obtained from previous research (see below) and the efficacy and cost of each control method was estimated using field data collected by Epro Ltd. This field data was derived from a number of study sites within a 5,000 ha operational area located near Hatepe in the central North Island.

MODEL PARAMETERS

Biological growth

The biological growth of the possum population was modelled using a rightwards-peaked θ-logistic equation (Equation 1; Gilpin *et al.* 1976). Ecological studies investigating population dynamics suggest that brushtail possum populations are regulated by density-dependent mortality, intensifying near carrying capacity (Barlow 1991). This implies that the possum population growth curves are asymmetrically rightward-peaked (Barlow and Clout 1983).

$$\frac{dN}{dt} = r_m N_0 \left(1 - (\frac{N_0}{K})^{\theta} \right) \qquad \text{Equation 1}$$

Theta

The value for θ was obtained from an empirical study monitoring population recovery following a major poisoning operation. The results of this study suggest that a θ value of 3 most accurately modelled population recovery in an area of indigenous forest habitat (Hickling and Pekelharing 1989).

Maximum intrinsic growth rate/year (r_m*)*

Possums have a significant birth pulse in autumn and sometimes a smaller one in spring, which is referred to as double breeding (Batcheler and Cowan 1988). Empirical estimations of r_m vary from a low of 20% (Hickling and Pekelharing 1989) to 59% (Keber 1985). Most of the values used in previous possum modelling simulations have been in the range of 20-30%, with variation dependent on habitat. In this modelling exercise we used a value of 30%, which should be appropriate for the 5,000 ha study site.

*Carrying capacity (*K*)*

Estimated values for carrying capacity vary from less than 1 possum/ha in unfavourable scrubby farmland to over 25 possums/ha in blocks of highly favourable habitat adjacent to pasture on the West Coast, South Island (Clout 1984; Cowan 1991). In this model, the control population is assumed to be located in indigenous forest habitat in the central North Island. Population studies suggest that this type of habitat often supports dense populations (Brockie *et al.* 1987; Coleman *et al.* 1980; Green and Coleman 1986) for which previous modelling simulations have used an upper value of 10 possums/ha.

Maximum immigration rate

An estimate for immigration back into the control area was derived from a number of studies. In a total removal experiment, possums began re-colonising a 24 ha pine plantation (Kinleith Forest, North Island) within one month of the control operation. After 1 year the density was 1.6 possums/ha, which is 55% of the original population (Clout 1984). In another total removal experiment, a 12 ha area in the Orongorongo Valley (1200 ha) was re-colonised by 12 possums after one year (Barlow 1993). In an experiment in the South Island, possums were removed from a block (125 ha) of indigenous forest in Westland. The pre-control density was 10.7 possums/ha and 3 years later this population was back to 26% of the pre-control density (Green and Coleman 1984). In a more recent study 255 possums (90% kill) were removed from swamp and willow habitat (23 ha) in the Hawkes Bay (North Island). Five years later the population had recovered to 136, which is a density of 5.9 possums/ha (Cowan *et al.* 1997). These studies suggest that the maximum rate of possum immigration, under a variety of conditions, is approximately 1.2 possums/ha/yr.

Acute-acting toxin bait shyness

Pen trials have demonstrated that the majority (>60%) of possums will develop an aversion (hereafter referred to as bait shyness) following a sub-lethal dose of 1080, cyanide or cholecalciferol (O'Connor *et al.* 1998; O'Connor and Matthews 1995; O'Connor and Matthews 1996). Such pen trials have also demonstrated that bait shyness can be long lasting (>24 months) and has the potential to dramatically effect the efficacy of future control operations (Morgan *et al.* 1996). The most striking field example of this comes from Mapara Forest (North Island), where the estimated annual aerial 1080 possum kill declined from 79% to 32%, and then to 0% over a period of three years (Warburton and Cullen 1993). In this modelling exercise I included bait shyness as a model parameter for simulations using 1080 and cholecalciferol. This means I assumed most of the survivors would avoid similar bait in future encounters; however, the number of bait-shy possums decreases in the absence of further control (see Ross 2000). For the control work using Feratox I relaxed this condition as contractors were also using traps to mop up any ‘bait-wary’ possums.

Efficacy of control

The field data indicated that control methods using 1080 had the highest efficacy (Table 1). Control using cyanide (Feratox) with trapping was next, followed by control using cholecalciferol (Feracol). Pairwise comparisons of the kill estimates indicated no significant difference between 1080 and cyanide; however, aerial 1080 control had significantly higher efficacy than Feracol (Z=2.01, P = 0.02).

Table 1: Percentage kill (± SE) for the five different control options.

Control type	$Mean_{pre}$	$Mean_{post}$	Kill (%)
1080 bait stations	0.210	0.013	93.66 ± 2.93
Feracol	0.172	0.036	79.29 ± 7.96
Feratox & Trapping	0.154	0.018	88.04 ± 5.12
Contractor’s choice[1]	0.180	0.013	92.56 ± 3.61
Aerial 1080	0.175	0.002	99.05 ± 1.36

[1] Contractor’s choice – Generally Feratox followed by trapping

Cost of control

The field data indicated that aerial 1080 was substantially cheaper than all other control methods. Interestingly there was little difference in the mean cost of the other control options; however, there was considerable cost variation for Feratox ranging from a low of $18.74 to a high of $70.53/ha. The cost of control for the aerial and ground-laid 1080 was consistent because there was little re-monitoring and no further control required. The cost of Feracol was fixed because the contract was for service only, with no requirement for additional control if targets weren’t met (C. Speedy pers. comm.).

Table 2: Cost/ha for the five different control options.

Control type	Mean Cost	Low	High
1080 bait stations	$43.45	-	-
Feracol	$37.46	-	-
Feratox & Trapping	$43.80	$19.57	$70.53
Contractors choice	$36.77	$18.74	$51.03
Aerial 1080	$20.25	-	-

Discount rate used in the simulations

All of the model simulations for the different control methods used the mean values from Table 2. These figures were then discounted to determine the net present value of the different control strategies, using a 10% discount rate that has been typically used in New Zealand for analysis of government-funded projects (Forbes 1984). This value has also been used in previous possum control modelling simulations (Warburton 1993; Barlow 1991) and is still appropriate for this modelling exercise.

Goal of modelling simulations

Most possum control aims to reduce the density to less than 5% RTCI. Previous modelling work suggests that a sustained kill of 80% should ensure that the possum population is not allowed to recover after the initial ‘knock-down’ control operation (Ross 2000). An initial kill of 79% using Feracol resulted in a 3.6% RTCI (Table 1). Accordingly, maintaining the population at this level (i.e. 2 possums/ha) should maintain the density comfortably below the 5% RTCI threshold.

Time frame of the simulation

Previous possum models have run over a simulated time frame of 5 (Barlow 1993; Roberts 1996), 8 (Barlow 1991), 12 (Hickling 1995) and 28 years (Pfeiffer 1994). Hickling (1995), who was the first to investigate the implications of behavioural resistance on the efficacy of 1080 control operations, argued that a 10-year period is the minimum required to gauge the effectiveness of multiple-poisoning campaigns on a possum population. Accordingly, we ran all our model simulations over a 10-year period.

RESULTS

Aerial 1080

The most cost-effective strategy achieving a sustained 80% kill was 3-yearly control operations. This strategy had an accumulated discounted cost of $55/ha (Table 3) and maintained an average population density of 2.07 possums/ha (Figure 1).

Table 3: Accumulated discounted cost of possum control strategies attempting to achieve a sustained 80% kill using aerially-broadcast 1080 bait; here and in all tables that follow, the most cost-effective strategy is in bold and the accumulated discounted cost/ha has been rounded to the nearest dollar.

Strategy	Average density/ha	Accumulated Discounted cost/ha
99% 1080 kill every 2 years	1.49	$72
99% 1080 kill every 3 years	**2.07**	**$55**
99% 1080 kill every 4 years	2.59	$44

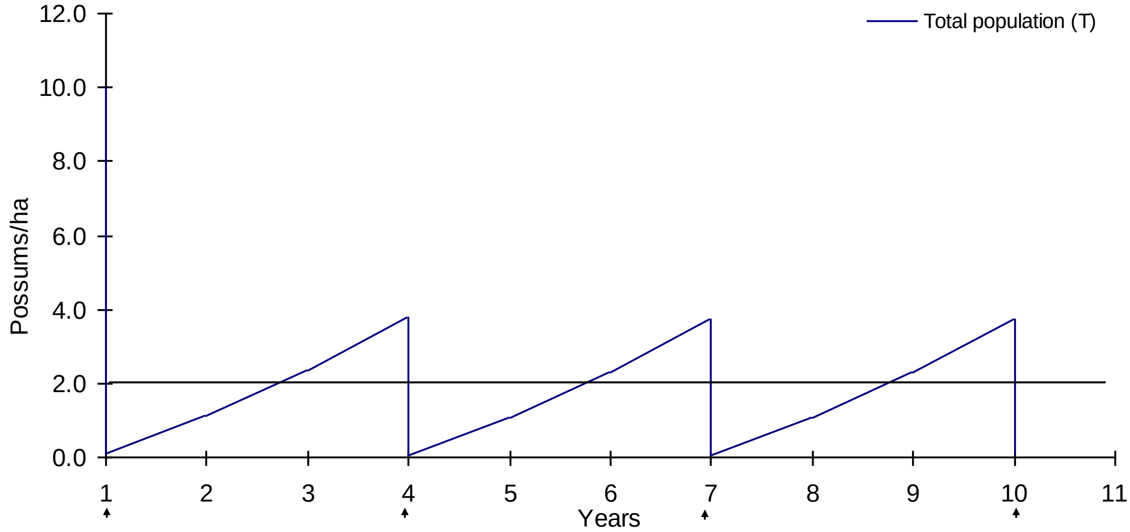

Figure 1: Possum population density following aerial control with 1080 (↑). Starting population density was 10.0 possums/ha (- line denotes target population density).

1080 Bait stations
The most cost-effective strategy achieving a sustained 80% kill was 2-yearly control operations. This strategy had an accumulated discounted cost of $154/ha (Table 4) and maintained an average population density of 1.76 possums/ha (Figure 2).

Table 4: Accumulated discounted cost of possum control strategies attempting to achieve a sustained 80% kill using 1080 in bait stations.

Strategy	Average density/ha	Accumulated Discounted cost/ha
94% 1080 kill every year	1.16	$294
94% 1080 kill every 2 years	**1.76**	**$154**
94% 1080 kill every 3 years	2.47	$119

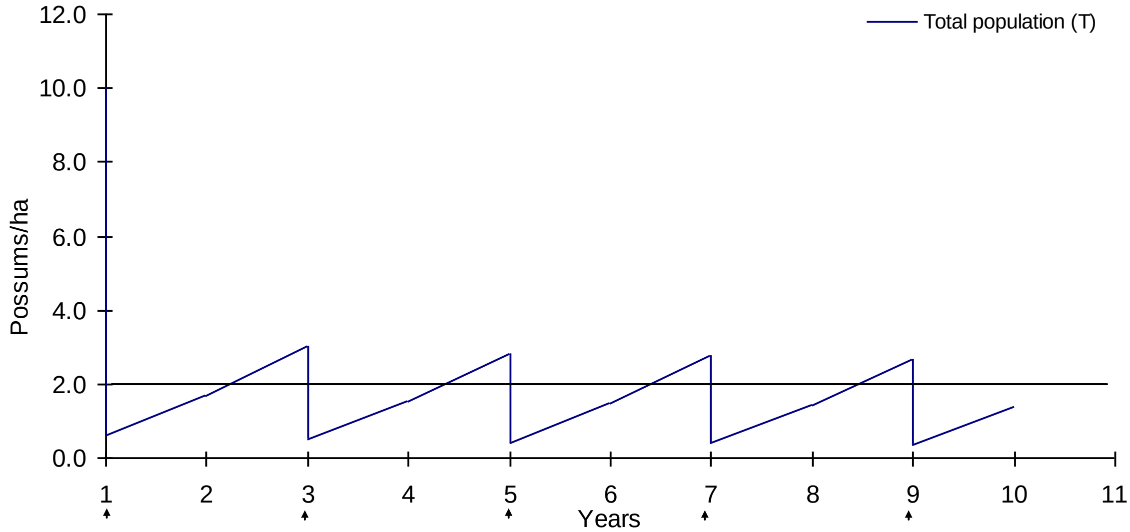

Figure 2: Possum population density following control with 1080 in bait stations (↑). Starting population density was 10.0 possums/ha (- line denotes target population density).

Feracol

The most cost-effective control strategy achieving a sustained 80% kill was 8 possum control operations over the 10-year period. This strategy had an accumulated discounted cost of $208/ha (Table 5) and maintained an average population density of 1.99 possums/ha (Figure 3).

Table 5: Accumulated discounted cost of possum control strategies attempting to achieve a sustained 80% kill using Feracol in bait bags.

Strategy	Average density/ha	Accumulated Discounted cost/ha
79% 1080 kill every year	1.77	$246
79% 1080 kill – 8 years	**1.99**	**$208**
79% 1080 kill every 2 years	2.70	$129

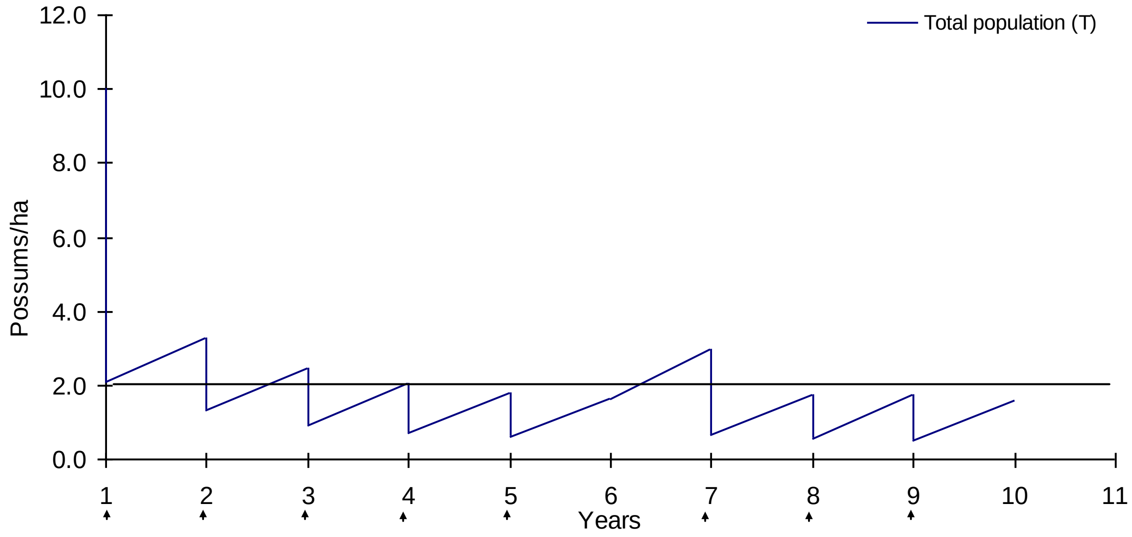

Figure 3: Possum population density following control with Feracol in bait bags (↑). Starting population density was 10.0 possums/ha (- line denotes target population density).

Feratox and trapping

The most cost-effective strategy achieving a sustained 80% kill was 2-yearly control operations. This strategy had an accumulated discounted cost of $155/ha (Table 6) and maintained an average population density of 2.03 possums/ha (Figure 4).

Table 6: Accumulated discounted cost of possum control strategies attempting to achieve a sustained 80% kill using Feratox and trapping.

Strategy	Average density/ha	Accumulated Discounted cost/ha
88% 1080 kill every year	1.28	$296
88% 1080 kill every 2 years	**2.03**	**$155**
88% 1080 kill every 3 years	2.91	$120

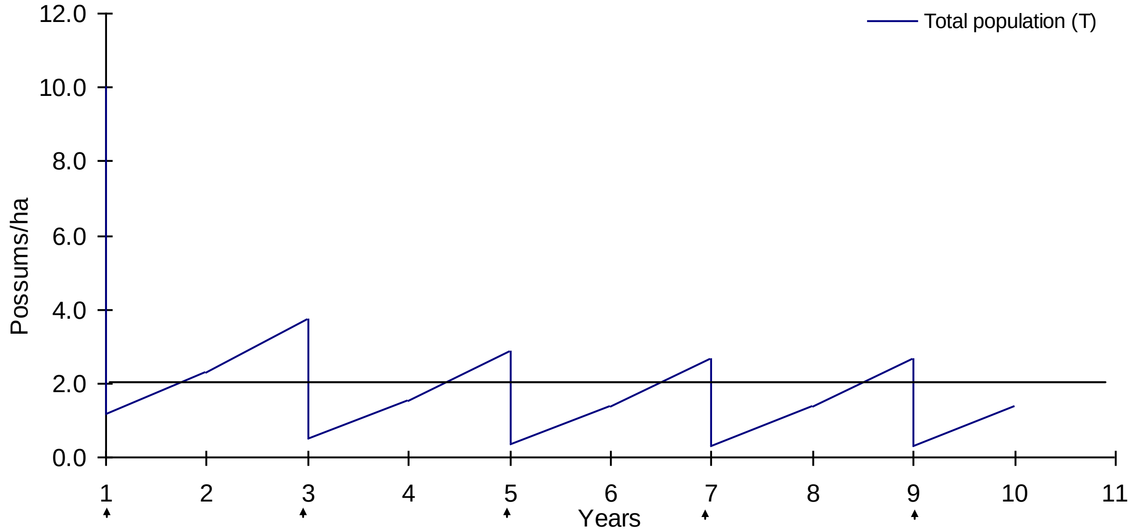

Figure 4: Possum population density following control with Feratox and trapping (↑). Starting population density was 10.0 possums/ha (- line denotes target population density).

Contractor's choice
The most cost-effective strategy achieving a sustained 80% kill was 2-yearly control operations. This strategy had an accumulated discounted cost of $128/ha (Table 7) and maintained an average population density of 1.78 possums/ha (Figure 5).

Table 7: Accumulated discounted cost of possum control strategies attempting to achieve a sustained 80% kill using Feratox and trapping.

Strategy	Average density/ha	Accumulated Discounted cost/ha
93% 1080 kill every year	1.14	$245
93% 1080 kill every 2 years	**1.78**	**$128**
93% 1080 kill every 3 years	2.54	$99

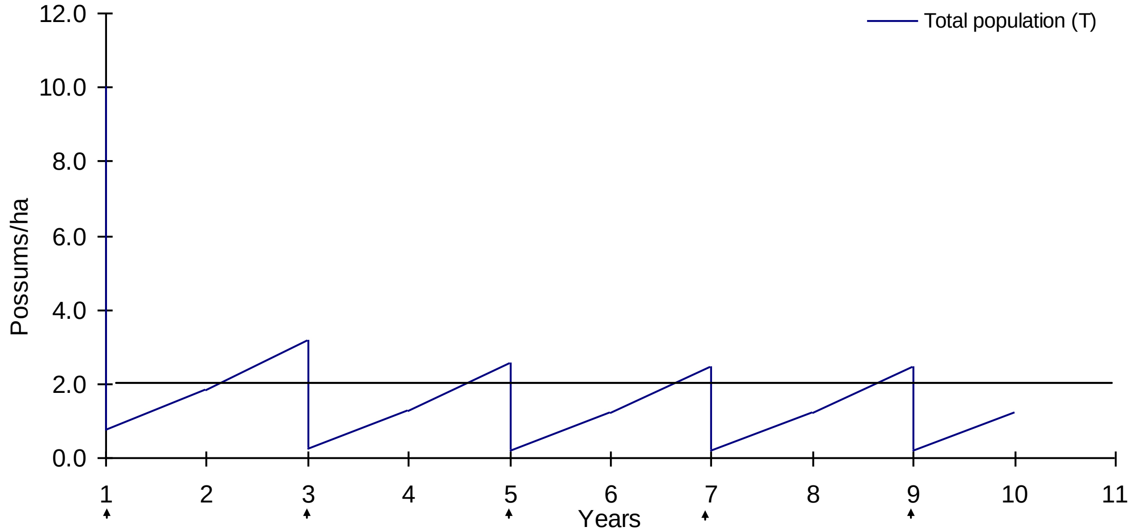

Figure 5: Possum population density following control with Feratox and trapping (↑). Starting population density was 10.0 possums/ha (- line denotes target population density).

Cost-effectiveness of the control options
The most cost-effective strategy of achieving a sustained 80% population reduction was aerial 1080 with an accumulated discounted cost of $55/ha over the 10-year period (Table 8). Interestingly, contractor's choice was the next cheapest option; however, the costs associated with this technique were variable and the same control method (Feratox and trapping) had a cost very similar to 1080 pellets in bait stations. Feracol was substantially more expensive than the other control options, mainly due to its lower control efficacy. This meant that additional control operations were necessary to maintain the population density below target threshold.

Table 8: Accumulated discounted cost of the five different control strategies

Control Option	Strategy	Cost/ha	Average density/ha
Aerial 1080	3-yearly control	$55	2.07
Contractors choice	2-yearly control	$128	1.78
1080 Bait Stations	2-yearly control	$154	1.76
Feratox and trapping	2-yearly control	$155	2.03
Feracol	8 years of control	$208	1.99

CONCLUSIONS
What the modelling simulations highlight is the importance of control efficacy. Control methods with low efficacy (<80%) required additional operations to maintain the population below the target density. Accordingly, while Feracol isn't much more expensive in a one-off control situation, field managers need to be aware that an initial kill of only 80% will have implications further down the track. Not only will additional control be required to meet target objectives, but you may have to deal with bait-shy survivors. These bait-shy survivors may become difficult to control using baiting techniques and managers may then have to switch to a more expensive control method (e.g. trapping) to deal with the problem. Previous simulation modelling suggests that the most cost-effective way to control possums is to 'hit them hard' in the initial control operation (Ross 2000). Aerially-delivered 1080 bait killed 99% of possums in the study area. This meant that only 3-yearly control was required to meet the target objectives, as the population took longer to recover. Also, when you achieve this high level of control efficacy you have few bait-shy survivors who may compromise the efficacy of future control using toxic baits.

The most cost-effective control strategy was aerially-delivered 1080 bait. Aerial 1080 had a discounted cost of $55 per hectare and this was less than half the cost of the other ground-based methods. As detailed above, this was partially the result of high control efficacy, but it also reflects the lower costs of 1080 bait and aerial delivery. This result is not terribly surprising as considerable research effort has gone into perfecting aerial delivery (e.g. GPS technology) and developing 'best practise' for this method. Accordingly, the cost of aerially-delivered 1080 hasn't significantly changed over the past decade (Warburton and Cullen 1993). Even adding in the cost of a deer repellent would only increase the cost of this strategy to $72/ha over the 10-year period. This is still considerably lower than the other ground-based control strategies.

If aerially-delivered 1080 bait is not 'politically acceptable' then Contractor's choice was the next most cost-effective method; however, there was considerable variation in the reported cost of this control option (Table 2). Some of these reported costs were highly competitive, but the mean value was not significantly different 1080 in bait stations. Part of the reason for the cost variability was that some contractors used Feratox exclusively and then resorted to trapping only after failure to meet performance goals (C. Speedy pers. comm.). Accordingly, the additional cost of trapping, and subsequent re-monitoring, inflated some of the Feratox cost estimates. The low efficacy of Feratox in some blocks may have been the result of poison shyness, rodent interference or a lack of experience by field staff. This cost variation may also reflect differences in the level of control effort by some contractors, and highlights the need for clear performance targets before contract work commences.

In conclusion, the cost variability of Feratox and the low efficacy of Feracol is of concern. If 1080 is not able to be used, then this research suggests alternative ground-control options are likely to be much more expensive. Perhaps part of the problem is lack of 'best-practise' research for Feratox. This product has been on the market for several years, but lacks the in-depth field research that has been conducted on bait containing 1080. Current Feratox research is focusing on methods of reducing rodent interference and determining the optimal spacing of bait bags and stations (Thomas *et al.* 2003). This research may improve the efficacy and cost-effectiveness of Feratox in the near future. Feracol could be a cost-effective alternative to 1080 (and Feratox) for ground control operations; however, more research is required to improve field efficacy. Earlier field trials using cholecalciferol cereal bait also reported kills of approximately 80% (Eason *et al.* 1994). An effective possum bait needs to have kills above the 90% mark. Failure to achieve this is will only facilitate the development of bait shyness and faster population recovery.

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Appendix Six - Post Operational Monitoring Results

Appendix Seven - Flight Lines for Aerial 1080 Application

Appendix Eight - Carrot Bait Toxin Analysis

Appendix Nine - Deer Carcass Search Summary

Appendix Ten - Deer and Bird Carcass Toxin Analysis