Monitoring the Cost-effectiveness of Aerial 1080 and Ground Hunting for Possum Control

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Phil Cowan and Chris Pugsley

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1. Introduction

The possum control operations in 1992 done by the West Coast Conservancy at Paringa and Moeraki and by the Northland Conservancy at Puketi, were reviewed by Phil Cowan of Manaaki Whenua - Landcare Research and Chris Pugsley, Science and Research Division, Department of Conservation. The review was carried out in 1992/93 for the Director, Science & Research Division, Department of Conservation (DoC).

2. Background

A recent review commissioned by Estate Protection Policy Division, DoC, recommended that the cost effectiveness of selected control operations during 1992 should be monitored (Warburton *et al.* 1992, unpubl. FRI contract report). This involves both the control effectiveness of aerial versus ground hunting and their comparative costs, and is relevant to many Conservancies. The Warburton *et al.* review recommended that greater effort be allocated to monitoring cost-effectiveness, that goals be more tightly defined, and that methods and sampling design be refereed by research staff. This investigation applied these recommendations to the 1992 possum control operations on the West Coast (ground hunting) and in Northland (aerial 1080 poisoning).

A number of ancillary issues, such as the advantages and disadvantages of aerial poisoning and ground hunting, are not covered in this report. For that reason, it should be read in conjunction with Morgan & Warburton (1987); Warburton *et al.* (1992); and Morgan (1992) (all unpubl. FRI contract reports).

3. Objectives

- To visit control field sites and discuss operational and monitoring plans with Conservancy staff.
- To collate information from Conservancies on operational and monitoring plans for the 1992 Copland Valley, Windbag-Moeraki, and Puketi possum control, and report on implications of available data for monitoring their cost effectiveness.
- To analyse information on relative kills and costs of each operation.
- To complete a joint Landcare Research/DoC report.

4. Operational Plans

4.1 GENERAL DESCRIPTION OF OPERATIONS

Only brief details of the operations are given here: copies of full operational plans are lodged in DoC Science and Research Division File SAV 0173.

West Coast Conservancy : ground hunting

Copland Valley

The control area in the Copland Valley consisted of about 3500 ha of mixed hardwood forests and alpine scrub, ranging from 75 to 1000 m a.s.l. The primary concern was ongoing and increasing damage to southern rata (*Metrosideros umbellata*) forest.

The overall operational strategy for possum control in the Copland Valley involves reduction of absolute possum numbers to below an arbitrary target level, until such time as appropriate vegetation damage thresholds can be better defined. The operational goal of possum control in the Copland Valley in 1991-92 was to reduce possum numbers to below 1 possum/hectare over the control area. The numbers of possums killed/ha in the 1990-91 ground control operation and the percentage kill estimated from monitoring were used to calculate a target number of 2500 possums to be killed throughout the control area in 1991-92.

Control was carried out between February and June 1992 by four hunters on contract (paid a daily retainer and allowance, plus a bonus per possum) and one hunter on wages, using a combination of cyanide, soft-catch traps, and 1080 jam. Monitoring of the operation was limited to estimation of percentage kill, using trap-catch methodology as specified by FRI (Hickling 1991, unpubl. FRI file note). Monitoring was carried out by contractors hired specifically for the job, and supervised by DoC staff.

Performance monitoring was considered unnecessary for the Copland operation in 1991-92 because of ongoing investigations of the relationship between possum numbers and the health of rata forests in the Otira and Deception management areas. However, justification for extrapolation of these results to the Copland management area should have been clearly identified in the operational plan, because of the major differences in vegetation types, histories of possum control, and possum densities.

Paringa-Moeraki

The control area at Paringa-Moeraki consisted of about 4600 ha of beech and mixed hardwood forests, ranging from 50 to 1000 m a.s.l. The primary concerns were prevention of dieback of rata forest and loss of mistletoe (*Peraxilla colensoi, P. tetrapetala, Alepsis flavida*) in an area only recently colonised by possums.

The overall operational strategy in the Paringa-Moeraki aims to limit further immigration and expansion of the area occupied by possums, and to prevent an increase in possum numbers within the area. The operational goal for possum control in Paringa-Moeraki in 1991-92 was to extend the area of control to defined geographic boundaries that would help limit immigration and to kill sufficient possums throughout the control area to prevent an increase in numbers. Unlike the Copland operation, no target was set for the number of possums to be killed, largely because of the extremely low overall density (<0.5 possums/ha) suggested by results of the 1990-91 control operation. Although the operational plan set no target for possum kills, budgeting assumed a total kill of 1200 possums over a control area of 4660 ha.

Control was carried out between February and June 1992 by three hunters employed under the Task Force Green Scheme, supervised by DoC staff, using a combination of cyanide and soft-catch traps. Success of the operation was measured from percentage kill, using trap-catch methodology as specified by FRI (Hickling 1991, unpubl. FRI file note). Monitoring was carried out by contractors hired specifically for the job, and supervised by DoC staff.

Performance monitoring of the Paringa-Moeraki operation consisted only of a repeated assessment of mistletoe condition first measured in 1990-91. As good base-line monitoring data on possum browse on mistletoe were established in 1990-91, it would have been appropriate to specify quantified target levels of 'acceptable' browse in the operational plan. At a minimum, the target could have been to contain browse damage to the same levels as in 1990-91. This would have focused the rather vague operational goals of limiting immigration and keeping possum numbers at present levels on more measurable targets.

Northland Conservancy : aerial 1080 poisoning

Puketi Forest

The control area at Puketi consisted of about 10500 ha of Puketi Forest and 2500 ha of adjoining private land. Puketi Forest is one of the most floristically diverse in Northland and also contains a significant population of kokako (*Callaeas cinarea*). The primary concerns were vegetation damage resulting from increasing levels of possum browse, and competition between possums and kokako for food.

The overall strategy for possum control at Puketi was to achieve an effective reduction of possum densities over the whole of Puketi Forest by aerial 1080 poisoning. The operational goal was for at least an 80% reduction in possum numbers, using cereal pellet baits containing 0.08% 1080 poison sown at 5 kg/ha. The operation was carried out in late March 1992. Success of the operation was measured from percentage kill, using trap-catch methodology as specified by FRI (Hickling 1989, unpubl. FRI file note).

Performance monitoring of the Puketi operation consisted of measuring changes in foliage and browse levels and in kokako and invertebrate numbers in response to possum population reduction. Quantified performance goals should have been identified in the operational plan, at least for vegetation and kokako monitoring.

4.2 COMMENTS ON OPERATIONAL PLANS

Approval had been given by DoC Estate Policy Protection Division and planning for all three operations was well advanced when the present project was initiated. Direct discussion with Conservancies on operational plans was therefore limited to issues relating to the proposed monitoring programmes to assess percentage kills (see 5. Monitoring).

West Coast Conservancy

Copland

Because the target possum kill for the 1991-92 Copland operation was based on results from the 1990-91 operation, it is important to examine those results closely. Three sources of error could have significantly affected the estimate of kill required for 1991-92, and hence achievement of the operational objectives. The first was the estimate of percentage kill in the 1990-91 control operation. This was obtained using only two monitoring lines, a sampling intensity identified as inadequate by Warburton *et al.* (1992, unpubl. FRI contract report), in their review of West Coast Conservancy possum control operations. Insufficient sampling meant that the confidence limits associated with the estimate of percentage kill were unknown. An alternative estimate of percentage kill was obtained from the numbers of possums known to have been killed on a roughly estimated area, using an unsubstantiated estimate of initial possum density.

The second source of error was the estimate of the area over which control was carried out. This did not take into account the parts of the blocks not controlled or additional areas around the boundaries of the blocks from which possums were drawn. An additional technical problem is that of estimating ground areas accurately from maps where the terrain is particularly steep. Clear definition of the area actually controlled (rather than the nominal operational area) is essential.

The third source of error was the estimated increase in possum numbers between 1990-91 and 1991-92. This was based on an unsubstantiated breeding increment of 25% and made no allowance for immigration (which may initially contribute more to increase in numbers than breeding by survivors). As Warburton *et al.* (1992 *loc. cit.*) noted, if it is accepted that density estimates may become more precise by a series of successive measures of percent kills and numbers of possums killed, it may take 3-4 years before an accurate estimate is obtained or previous estimates are shown to be misleading. Even with intensive monitoring, however, accurate calculation of target densities is fraught with difficulty because of factors such as immigration, lack of precision and accuracy in monitoring, and changes in rates of reproduction and survival in response to reduced densities.

Paringa-Moeraki

It is difficult to judge the operational performance of possum control at Paringa-Moeraki because of the vague control objectives. The working target for possum

kills was subject to the same sources of error as the estimate used for the Copland operation, and for the same reasons. For example, sampling to estimate percentage kills in 1990-91 was inadequate, with only three monitoring lines in the 689 ha of the control area.

Northland Conservancy

Puketi

Planning for aerial poisoning is more complex than for ground hunting, because it requires coordination of a wider range of operational activities, compliance with more involved legal requirements, more extensive public relations activity and environmental monitoring. The use of a 'critical path' calendar of activities for the Puketi operation was an effective tool for planning and implementation, and ensured that the operation was carried out without problems, and within the planned time-frame. There was no suggestion that deficiencies with operational planning or implementation were responsible for the poor kill (Morgan 1992, unpubl. FRI contract report).

5. Monitoring

5.1 OPERATIONAL AND PERFORMANCE MONITORING

Operational monitoring measures results, as percentage kills, against operational objectives (e.g. kill targets). Performance monitoring measures achievement of operational goals resulting from operational success. Together they form the basis for evaluation of the cost-effectiveness of possum control operations (see Warburton *et al.* 1992, unpubl. FRI contract report, for a more detailed discussion). Operational monitoring is clearly a direct cost associated with control operations; whether performance monitoring should be considered in a similar way is subject to debate, and is discussed in Section 7.1.

5.2 OPERATIONAL MONITORING - METHODS AND ANALYSIS OF RESULTS

The ground hunting operations at Copland and Paringa-Moeraki, and the aerial poisoning operation at Puketi were each monitored by the trap-catch method. This involves setting soft-catch possum traps on 'best sign' at regular intervals of 20-40 m, with 20-30 traps per line. Lines are located randomly or systematically, with sufficient throughout the control area to give adequate samples. Traps are set for 3 fine nights before and after the control operation, and percentage kill is estimated by comparing pre-control and post-control rates of capture. Results were analysed by C. Frampton, biometrician at Landcare Research, using

methods detailed in Seber (1981), or the analysis programmes in the software package, Capture (Otis *et al.* 1978).

The monitoring protocol attempts to ensure that the assumptions inherent in the statistical estimate of population size are not violated (Seber 1981). Applied strictly, the method requires that (i) trapping effort is sufficient to ensure competition for traps does not occur; (ii) reasonable numbers of possums are caught (preferably >200); (iii) the probability of capture is the same for all individuals, remains constant from night to night, and exceeds 0.1; and (iv) the numbers of possums caught decline over successive nights. The protocol does not, however, explicitly spell out these assumptions, or provide guidance on the adoption of a flexible approach to monitoring, particularly to avoid problems of trap saturation. Using trap-catch data to provide a relative index (rather than estimates of absolute density) requires less stringent assumptions, principally no competition for traps and reasonable numbers of possums caught (C.Frampton, pers. comm.).

Copland and Paringa-Moeraki

Trap-catch monitoring was modelled on the protocols described by Hickling (1991, unpubl. FRI file note), using contractors hired specifically for the job. For the Copland operation, nine lines were used both pre- and post- control; four had 25 traps per line and five had 20 traps per line, with trap spacing on all lines of 20-40 m. Two other pre-control lines were not resurveyed. At Paringa-Moeraki, seven lines of 20 traps and two lines of 30 traps were used pre- and post- control, with traps at similar spacings. Two other pre-control lines were not resurveyed. Trap lines in each area were trapped for mostly 3 but up to 5 nights. Pre-control monitoring was done at Copland between 19 February and 2 March, and at Paringa-Moeraki between 16 January and 27 March. Post-control was done at Copland between 31 May and early August, and at Paringa-Moeraki between 20 May and 6 June.

Puketi

The monitoring protocol for the Puketi operation followed that recommended by Hickling (1989, unpubl. FRI file note). Ten trap lines were used pre- and post-control, with 20 traps per line at 20-30 m intervals. The same lure was used to attract possums to the traps on both occasions. All lines were to be trapped for 3 dry nights, or more if numbers of possums caught by then had not decreased by at least 50% from the highest number caught on any previous night (a level of reduction recommended by Hickling and Frampton 1991, unpubl. FRI file note). In practice, all lines were trapped for 4 nights. Pre-control monitoring was carried out simultaneously on all 10 lines during 18-21 February 1992, with post-control monitoring carried out by the same team of trappers during 27 April to 1 May 1992. Pre- and post- control monitorings were spaced about 4 weeks on either side of the control operation.

Comment on operational monitoring

Copland

Monitoring was generally adequate in relation to the area hunted, except that at least one monitoring line should have been sited in the Regina Creek area. Both pre- and post- control monitoring data showed systematic declines in total possums caught over the 3 nights, although there was much variation between lines. Two of the nine pre-control lines had at least 1 night with ≥50% trap success, indicating possible competition for traps.

Paringa-Moeraki

Monitoring was generally adequate in relation to the area actually hunted. Possum numbers were generally low, but the monitoring data both pre- and post- control showed systematic declines in total possums caught over the 3 nights. However, there was significant variation between lines, with four of the nine lines catching fewer than 10 possums pre-control. The low numbers resulted in estimates of the effectiveness of control with wide confidence limits.

Puketi

Monitoring revealed two problems in terms of the assumptions in the trap-catch methods, (i) there was probably some competition for traps in the pre-control monitoring, with six of the 10 lines having trap success of ≥50% on at least 1 night, and 34% of the trap sites with traps catching possums or sprung on at least 3 of the 4 nights; and (ii) the numbers of possums caught did not decline in any systematic way in either the pre- or post- monitoring; total catches were 63, 75, 69, and 87 possums pre-control, and 31, 49, 33, and 32 possums post-control.

5.3 GENERAL COMMENT

Review of the individual monitoring plans, discussions with Conservancy staff, and interaction with contractors carrying out the monitoring highlighted three areas where improvements should be made to current procedures. The main issue discussed with both Northland and West Coast Conservancies was appropriate numbers of sampling lines and the location of those lines in the treatment areas. Adequate monitoring is particularly important for ground hunting operations, because they are relatively untried; better information is needed on possum densities and distribution; and it is essential to ensure that target population reductions are being achieved and that the kill is achieved uniformly and not just in the accessible areas (Warburton *et al.* 1992, unpubl. FRI contract report).

Any comparisons of the operational effectiveness of aerial poisoning and ground hunting need to be cautious. Because of the nature of ground hunting, there is likely to be a more variable interval between actual control and post-control monitoring than for aerial operations, and the monitoring itself is likely to take place over a more prolonged period. Monitoring the Puketi operation took 4 days about 2 months after pre-control monitoring. At Copland monitoring was spread over about 2 months beginning 3 months after pre-control monitoring,

and at Paringa-Moeraki it was spread over about 3 weeks beginning 5 months after pre-control monitoring. Because of the longer time scale of ground hunting operations, immigration of possums into controlled areas, which would tend to reduce the apparent effectiveness of the control, could be a complicating factor. A partial solution would be to monitor sections of ground hunting operations at the same fixed interval before and after control. This would not, however, avoid the problem of the strongly seasonal nature of possum migration.

DoC needs to standardise one set of guidelines for Conservancies to use to design monitoring of possum control operations. Conservancies are using any one of several different versions of guidelines written by staff of the Forest Research Institute (now Landcare Research). These guidelines differ, particularly in recommendations of numbers of trap lines in relation to size of the control area and in the clarity with which the importance of achieving trapping targets to satisfy conditions of the statistical population estimator are described (e.g. need for 3 dry nights, minimum number of possums to be killed, probability of capture to exceed 0.1, numbers killed to decrease by 50% from nights 1-3). The Puketi monitoring results could not be analysed by either of the preferred methods because there was no decline in numbers in either the pre- or post-control monitoring; percentage kill was estimated by comparison of overall trap success (C. Frampton, pers. comm.).

Although we accept the need to balance effort against costs and statistical considerations against practicalities of operation in the field, the monitoring proposals of both Northland and West Coast Conservancies were heavily weighted by practical considerations and appeared to give little attention to sampling issues such as stratified sampling. Adequate sampling is essential to produce accurate and precise estimates of the success of control operations. DoC should consider holding Monitoring Workshops with Conservancy staff, to ensure that they have detailed understanding and appreciation of the issues involved in the design of adequate monitoring of possum control operations and the analysis of monitoring results. The inadequate pre-control monitoring at Puketi should have been identified at that time, and additional trapping carried out.

Using the trap-catch method to monitor ground control based mainly on trapping (as at Copland and Paringa-Moeraki) is of questionable validity. The possibility of an increase in the proportion of 'trap-shy' possums as a result of the control operation, and hence a change in probability of capture, cannot be discounted. Wherever practicable, monitoring and control should use different methods to sample the animal population.

Conservancies are required to produce control plans that detail both the conservation goal and the operational objectives *in quantifiable terms*. Plans of both the West Coast and Northland Conservancies were lacking in quantifiable conservation goals that could be related to success in achieving the operational objectives. At present, 'acceptable' levels of vegetation damage are unknown, but the process of defining such levels depends initially on setting quantified targets for browse or defoliation levels expected from quantified reductions in possum numbers. Greater emphasis must be placed on this approach in Conservancy control plans.

6. Operational Outcomes

6.1 POSSUM KILL

Copland

Results of monitoring suggested an overall kill of 57% (95% C.I. 35-77%) in the Misty Peak area and 60% (95% C.I. 44-75%) in the upper Copland Valley. A total of 2519 possums were killed in the Copland and Forks/Misty Creek blocks, and an additional 693 possums were killed in the Regina Creek block (but no monitoring was carried out there); 71% of the tally was achieved by trapping, the remainder by cyanide poisoning. The operational goal of reducing possum density to below 1/ha by killing 2500 possums was achieved. However, only about 50% of the management area was actually hunted, and hunting method was influenced by accessibility, with cyanide poisoning used in the less accessible areas.

Paringa-Moeraki

Results of monitoring suggested an overall kill of 63% (95% C.I. 51-75%). A total of 1855 possums were killed, so that the target possum kill of 1200 was achieved. About 89% of the management area was hunted, although only 6 man-days of hunting occurred on 11% of the area. About 38% of the area covered had also been hunted in 1990-91.

Puketi

Results of monitoring suggested an overall kill of 53% (95% C.I. 43-64%), significantly less than the target of 80%. The possible causes of the low success of the aerial poisoning operation were subsequently reviewed by Morgan (1992, unpubl. FRI contract report)

6.2 COSTINGS OF OPERATIONS

Direct and indirect costs

There has been considerable discussion about the inclusion of indirect costs (overheads) of a possum control operation into the overall estimates for cost comparison. We decided not to enter into this debate here, but instead have simply explained the source of the overhead category and carried out summary calculations with and without it. Further confusion arises because of the different definitions of items comprising 'overheads' in the Conservancies. There needs to be a standard definition of overheads - the simplest definition is that overhead is simply the salary-multiplier calculated figure. Other costs, for example supervising hunters, should be recorded separately as they are part of the direct costs of the operation.

This same strategy should also be applied to any of the easily identified direct time cost of journalists, Regional Conservators, advisory scientists, and other ancillary staff. If staff time cannot be clearly identified as belonging to a particular control operation, it is best left out. The overheads multiplier of 150% salary has been set to cover costs such as administrative support (wages, mail room, typing, receptionists). Obviously an element of discretion is required here. Extraordinary costs, such as large numbers of toll calls, large photocopy runs, legal costs/dispute settlements about contracts, should be recorded as additional direct costs. Notes to assist with the interpretation of our financial reports are given in Appendix 12.1.

West Coast Conservancy - ground hunting

Spreadsheet 1 (Appendix 12.2) shows the actual costs and budgeted costs for the two separate control operation included in this study. We received copies of every pay slip for all temporary hunters and monitoring staff, and therefore did our own calculations of costs from this raw data. We also had annotated copies of helicopter invoices. Despite discussions with the Conservancy about keeping detailed staff time sheets, the only cost categories we could derive from the information supplied were very broad. We also felt that some DoC staff time was not recorded; planning, supervisory, and monitoring times seemed low for these operations. No post-operational reporting or written reporting on monitoring results was done - hence the zero time recorded in this category.

Vehicle-running kilometres were recorded as part of the diary sheets. Apart from helicopter costs no other service/materials costs were recorded. Hunters were all hired on individual contracts (some as hourly paid workers, others as external contractors) and were given allowances to cover costs (such as travel, poison, and traps). The monitoring team (two people) were hired for a longer period to carry out a variety of other animal control monitoring jobs in other areas.

One of the features of the overall costings for the West Coast (Spreadsheet 2, Appendix 12.3) is that most costs fall into the operating column (non-DoC staff costs). Therefore they do not attract any overheads involved if the hunters had been permanent or long-term DoC employees.

Northland Conservancy - aerial 1080 poisoning

The Northland operation, in contrast to those on the West Coast, involved many DoC permanent or long-term contract workers, and invoiced transactions. We were provided with a full end-of-financial year annotated printout of all invoiced transactions, a set of individual time sheets kept specially for this project, and an assurance that all costs had been correctly coded to the one charge code for the Puketi operation. We recalculated all staff times from these diary sheets, but relied on the printout for all other costs.

Also in contrast to the West Coast, Northland embarked on an extensive monitoring programme. We have been careful to separate out some staff time costs used to contribute to FRI research strictly outside the normal operational requirements of the Puketi aerial 1080 operation. However, as with the West

Coast, no post-operational report or monitoring report on the poisoning was written.

Despite the large number of entries on the financial statement, most of the operational costs were for the poison and aircraft/helicopter time, and therefore relatively easy to crosscheck. Because of the large number of staff needed on the day of the operation, most of the staff costs were much easier to track than those on West Coast, where the whole operation was spread over 6 months. We were also able to break down the staff time into a number of discrete categories from the staff diaries. Not surprisingly, planning was a more prominent activity in the aerial operation than it was for the ground hunting operations - principally because of the need to contact all the surrounding landowners. There was also greater media interest in the aerial control operation, largely because of the ongoing controversy over the use of 1080 poison.

As a result of using DoC staff and not contractors, the Northland operation had much higher overheads than the West Coast operation. Spreadsheet 2 (Appendix 12.3) shows the totals for each operation with or without the overhead added. We feel that it is reasonable to include overhead costs when comparing the cost effectiveness of the two types of control operation, and therefore recommend that the overhead inclusive totals be used.

6.3 COST EFFECTIVENESS OF AERIAL POISONING AND GROUND HUNTING

Comparisons of cost effectiveness are not possible until there is agreement on the measures to use for the cost and effectiveness parameters. The costings given here are the most realistic we could obtain. More accurate or detailed cost data are probably unwarranted. However what is needed is an agreed national procedure and set of standards for reporting on all aspects of animal control operations, including financial details. In Spreadsheet 3 (Appendix 12.4) we have presented various measures of cost effectiveness together with cost per hectare, the only common measure currently in use.

However, there were real difficulties in calculating the actual area poisoned in ground control operations. West Coast staff estimated the actual area covered by hunters from recent air photos (not as was initially done - just measuring the green areas of the 1:50000 topographic maps). This gave the most accurate planning estimate of control area. After the operation they plotted each of the hunters trap lines on the air photos, and using assumptions about the catching areas of trap or poison lines, re-estimated the actual areas controlled. The actual areas controlled were up to 50% less than the carefully mapped air photo boundaries, and only one third of the even cruder estimate (the green areas of the 1:50000 maps) used for the original operational budget costings. These problems of estimating the actual control area detracted from the usefulness of a cost per hectare efficiency estimator, particularly when we attempted to relate actual costs to budgets; for example, various documents reported three different estimates of treatment area in the Copland, and two different targets for possum kill. A standard approach for measuring the actual size of the control area is required. Accepting this problem with cost per hectare measures, we

have made the estimates based on the best available data we could get from the Conservancies.

The low percentage kill of the Puketi 1080 drop was unpredictable but not unexpected. There are, however, limited data to give a proper assessment of the likely risk of failure. Warburton *et al.* (1992, unpubl. FRI contract report) used an estimated 1 in 5 failure rate in their calculations. Ground control operations are unlikely to fail as dramatically as an aerial operation, although their success can be severely compromised by weather. Until there are better data, we suggest that 20% of the estimated total cost of a 1080 operation be added on as a contingency to cover the cost of re-poisoning when failures occur.

Total cost of control per hectare (including overheads) did not vary greatly between the operations (Spreadsheet 3, Appendix 12.4). However 16% of the overall cost of the Northland operation was overheads compared with only 3.5% for the combined West Coast operations, so that inclusion or exclusion of overheads in the calculations had a marked effect on the apparent relative costs.

Given all these uncertainties, it is inappropriate to judge one operation as more or less cost effective than another. Each operation should probably be assessed independently, and the method that best fits local conditions be chosen. From the data gathered for this study, it will be difficult to argue from cost efficiency that ground hunting is any cheaper than a large-scale aerial 1080 poisoning. However, standardised data collection must be part of routine operational procedure and not just for "special investigations." Until this happens we will not get a sufficiently large and varied set of accurate data as a basis for conclusions about which circumstances cause the cost effectiveness of ground hunting and aerial 1080 poisoning to differ significantly.

6.4 ACTUAL AND BUDGETED COSTS

Using cost categories of (i) Operational expenditure; (ii) Monitoring; (iii) Planning, Supervision & Reporting; and (iv) Overheads in Spreadsheets 1 and 2 (Appendices 12.3, 12.4), we were able to examine major differences that might require revision of the budgeting processes used by the Conservancies.

West Coast Conservancy

For both the Paringa and Moeraki operations, operational and monitoring expenditure exceeded the budget estimates greatly, and large cost over-runs were avoided only because expenditure on Planning, Supervision and Reporting, and Overheads was markedly under budget. Overall the cost of the two operations was within 3% of the budgeted total. The additional operational costs resulted largely from greater than budgeted hunting effort and daily payments, with 249 and 316 actual hunter-days compared with the budgeted 240 hunter-days for Paringa and 260 for Copland, respectively. The additional costs of monitoring resulted from a combination of additional effort in response to our comments on the original proposal, and as a result of bad weather.

Northland Conservancy

Over-expenditure on the Puketi operation was almost entirely on Overheads, Monitoring, and Planning, partially balanced by under-expenditure on operational costs. Costs of monitoring vegetation had not been included in the budget, and costs of invertebrate sampling were markedly underestimated.

7. Discussion

7.1 COMPARISONS OF CONTROL OPERATIONS

It is unrealistic to expect an adequate assessment of the costs and benefits of aerial poisoning and ground hunting on the basis of a single sample. Before this can be done DoC need to:

- Design and institute consistent planning, costing, auditing, and review procedures for possum control operations.
- Assemble a database of aerial poisoning and ground hunting operations that have been subject to these procedures.

This process will be greatly facilitated by the formal publication of possum control operation reports, using a standard format to ensure coverage of all essential information and removing some of the confusion that results from differences between operational plans and the actual operational procedures and outcomes. It is of particular importance in ground hunting operations, for example, to define precisely the areas controlled, and how these relate to areas monitored.

We do not intend to discuss in any detail the advantages and disadvantages of the techniques of aerial poisoning and ground hunting. These are covered adequately in the unpublished FRI contract reports of Morgan & Warburton (1987), Warburton *et al.* (1992), and Morgan (1992). Rather we have focused on the requirements of DoC for its 1991-92 possum control operations that Conservancies applied greater effort to monitoring cost-effectiveness, defined more tightly the goals of the control operations, and had methods and sampling design refereed by research staff.

Cost effectiveness

In its most comprehensive form, a possum control operation consists of a number of related parts:

- killing possums
- measuring what kill was achieved
- measuring the effect on the conservation goal
- measuring impacts on non-target species and the environment.

Establishing the costs of each part is a definition and book-keeping exercise, but DoC needs to decide whether it is appropriate to include the costs of all these parts in its cost benefit analyses. For example, should the costs incurred in dealing with public response to the proposed aerial poisoning operation on Mt. Taranaki be treated as part of the costs of that aerial operation? We suggest that they should, and that DoC should adopt a 'total cost of operation' approach, and include both direct operational costs, and the costs of operational, performance, non-target species, and environmental monitoring. If each part of an operation was costed separately, then DoC would be able to make comparisons of costs on whatever basis it considered appropriate.

For DoC's purposes, the most appropriate measure of cost effectiveness is probably per hectare expenditure to achieve a specified percentage reduction in possum numbers. This was the basis of the calculations of the relative costs of aerial poisoning and ground hunting in the review by Warburton *et al.* (1992, unpubl. FRI contract report). The limited ability of Conservancies to specify percentage reduction to achieve the particular conservation goal in any operation will necessarily mean that, for the moment, certain arbitrary assumptions have to be built into any cost benefit analyses. Conclusions from comparisons of operations will thus need to be interpreted with caution.

Operational goals

In the absence of information relating possum numbers to damage to conservation values, both West Coast and Northland Conservancies placed the emphasis in their operational plans on quantified operational rather than performance goals. For Northland, the target minimum 80% kill appears to have been an expected outcome based on the rough 'average' of recent aerial operations, and one which would give a reasonably prolonged recovery time for possum numbers. For West Coast, targets were arbitrary and based on absolute densities for which there was little supporting scientific data because of previous inadequate monitoring. For the Copland Valley, however, 2 years of ground control achieving about 60% kills has probably resulted in about an 80% reduction in possum numbers in the areas hunted (although the areas covered have not exactly coincided in the 2 years).

7.2 OTHER ISSUES

Ground hunting

Accreditation of hunters

If ground hunting is to become an established part of DoC's overall possum management strategy, its effectiveness could be enhanced by the development of a system of DoC accreditation of hunters. This could allow DoC access to a pool of experienced and efficient hunters, while giving the hunters some advantage in negotiation of contracts and credentials recognised across Conservancies. Accreditation would need to be based not only on performance

in meeting Conservancy requirements in all aspects of possum control, but also on dependability and accuracy in record keeping.

Record keeping

Assessing the cost effectiveness of possum control operations requires accurate and truthful records. In aerial operations these records are mostly of the activities of DoC staff or invoices from contractors, or are produced by DoC staff (e.g. non-target monitoring). In ground hunting operations, however, the onus is on the hunters to collect and report accurate and truthful records of their activities (times and places hunted) and kills of both target and non-target species. There is also a need to keep more extensive records in ground hunting operations, to identify actual areas hunted and the distribution of effort from detailed information on trap line locations and trap success. For minimal additional effort, biological information useful to the Conservancy in planning possum control could also be collected (e.g., data on reproductive rates). Accreditation of hunters could resolve DoC's historical problems with such an honesty-based system. Requirements for record keeping in ground hunting operations should be specified in contracts with hunters, with DoC providing any training required to ensure uniform collection of information.

Self-monitoring of control

The results of some previous ground hunting operations have been compromised by hunters targeting the areas around monitoring lines (when payment was based on performance) or obtaining possums from outside the treatment areas (when there was a bounty payment). For the former reason, monitoring at Copland and Paringa-Moeraki was done independently of the possum hunters, with locations of monitoring lines kept secret. If the honesty issue can be addressed by accreditation of hunters, and if Conservancies can set soundly-based targets for numbers of possums to be killed, self-monitoring of control can be achieved and reported from records kept by the hunters.

Contracts

As DoC improves its forward planning of possum control operations, it should be able to offer multi-year contracts for ground hunting where it is considered appropriate and cost effective. Such a system was strongly favoured by the hunters, who saw it not only as providing some stability in their employment, but also as an advantage for DoC in increasing the likely retention of skilled hunters for their control operations.

Aerial 1080 Poisoning

Operational failures

Occasionally even the most carefully planned and executed aerial poisoning operations fail to achieve the operational objectives, as at Puketi. The probability of such failures can presently only be guessed at, but over the last 10 years has not exceeded the one in five estimate used by Warburton *et al.* (1992,

unpubl. FRI contract report) in their calculations (D. Morgan, pers. comm.). Such failures are, however, expensive; a one in five failure rate could increase average costs/ha of aerial poisoning by 15-18% (Warburton *et al.* 1992, *loc. cit.*). A strategy needs to be developed to deal with operations where the reduction in possum numbers is significantly less than the operational target. Although various computer models are available to predict the recovery times of possum populations, threshold damage levels are not yet known. It is thus difficult to judge whether the 53% kill at Puketi failed totally to address the conservation goal (in which case the operation should be repeated immediately) or failed partly (in which case it could be repeated in a few years). It is also not clear whether such failed operations necessarily create flow-on problems, such as increased levels of poison shyness in the survivors. Indeed the whole strategy of habitat protection by regular aerial poisoning at 5-7 year intervals is still to be validated.

Warburton et al. *(1992) recommendations*

In their report on the possum control operations of the West Coast Conservancy, Warburton *et al.* (1992, unpubl. FRI contract report) made a series of general recommendations for the improvement of the management of possum control which required action from both Conservancies and DoC Head Office. These are listed in Appendix 12.5. We consider it useful to examine how, if at all, these recommendations were implemented in the control operations we have reviewed because many of them mirror those of the present report.

In their 1991-92 operations, both West Coast and Northland Conservancies made an attempt to define and quantify goals, and produce operational plans for each control area (Recommendations 1, 2), although there is clearly room for improvement by clearer adoption of the models provided by Parkes (1990, unpubl. FRI contract report). We reviewed operational monitoring methods (Recommendation 3), but only after operational plans had been approved. Performance monitoring was not detailed in the operational plans, and was generally treated less adequately than operational monitoring. Defining treatment area as opposed to management area (Recommendation 4), particularly for the ground hunting operations, needs further clarification and standardisation if meaningful estimates of cost effectiveness are to be produced. Adequate recording of expenditure (Recommendation 5) is possible, as shown by the present data, but clear guidelines are still required relating to the apportioning of staff salaries, operational expenditure and overheads. Minimum standards for monitoring the impact of control methods have yet to be put in place (Recommendation 6).

DoC has taken heed of many of these comments and recommendations, and has addressed them in the Estate Policy Division Draft Plan (May 1993) "Managing Possums on Land Administered by the Department of Conservation - A Ten-year Wild Animal Control Plan. 1993-2003".

8. Conclusions

- Conservancy operational plans could be further improved, particularly in quantifying performance monitoring, and in the design and implementation of operational monitoring.
- DoC needs to standardize guidelines for Conservancies on methods of performance and operational monitoring.
- For the operations examined, generally adequate records were available from which the costs of control and of operational monitoring could be determined. Collation of these records into post-operation reports would have been valuable to assist with the operational reviews and with future planning.
- With some further refinement, current financial categories are adequate to capture all expenditure related to possum control operations. Comparisons of costs between operations will be influenced greatly, however, by DoC decisions on the inclusion or otherwise of these various financial categories in the calculations. The basis of calculation of relative costs requires further clarification, as there are basic differences between aerial poisoning and ground hunting in the distribution of costs between direct and indirect operational and overhead expenditure categories.
- A direct comparison of the relative costs and benefits of aerial poisoning and ground hunting was inappropriate for these operations, given the unexpected failure of the Puketi aerial operation, the need for DoC to rationalise clearly the basis on which it wishes to make such comparisons, and the lack of information on the 'worth' of benefits.

9. Recommendations

- DoC should (i) design and institute consistent planning, costing, auditing, and review procedures for possum control operations; and (ii) assemble a database of aerial poisoning and ground hunting operations that have been subject to these procedures.
- DoC should require formal publication of possum control operation reports, using a standard format to ensure coverage of all essential information.
- DoC should decide on the appropriateness of various financial cost categories for inclusion in any comparisons of costs and benefits of control methods.
- DoC should develop appropriate methods for measuring the financial worth of the benefits of possum control.
- DoC should hold a series of training workshops for Conservancy staff on performance and operational monitoring.

10. Acknowledgements

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12. Appendices

12.1 INTERPRETATION NOTES FOR FINANCIAL REPORTS

Both Conservancies

1 Vehicle running was calculated at 80c per kilometre for all vehicles (cars + 4WD's)

2 Staff costs were calculated from diaried time sheets kept specially for this study. The number of recorded hours has been multiplied by an average hourly rate of $15 for all staff regardless of actual salary/wages or overtime rates. This value was arrived at by taking an average annual salary of $30,000 applied to 2000 hours of work per year.

3. The overheads category is simply a multiplication factor of 1.5 times the permanent/long-term contract DoC staff and conservation worker's total salary i.e. the total cost of employment is $30k + 1.5 x $30k = $75k or $37.50 per hour. This is DoC's normal overhead factor and covers the full costs of employing a staff member involved in this type of work. It includes staff management, administration, cost of office space, capital items, telephones, photocopying, and computers. Overhead has not been added onto the cost of employing temporary workers (contract or wage-workers) who were hired for less than one year specifically to do this job. They spent all their time in the field and were not supervised on a day to day basis by DoC staff in the field, although occasional checks were made. The time taken to carry out any operational supervision (as opposed to monitoring) is found in the Operational section of the spreadsheet as DoC staff costs.

4 The budget columns given in the spreadsheets were copied from the information supplied by the Conservancies (with some minor re-classification explained below). We have not attempted to re-calculate staff overheads on Conservancy budgets.

West Coast:

1 Cost of traps and poison was covered by staff contracts/allowances

2 Accommodation costs were calculated for back country huts/Paringa Base at $4 per person per night.

3 The only vegetation monitoring carried out in the two areas was the 1991/2 mistletoe survey in the Paringa/Moeraki area. The cost given is for the two mistletoe monitoring lines established in 1991/2.

4 Helicopter costs at Paringa were allocated 33.3% to monitoring and 66.6% to possum control.

5 In their budget West Coast Conservancy included a category of "Administrative Support" - this is what we have simply transferred into the

overheads category. Direct supervision of staff (which they called part of their overheads) has been transferred to the supervisory category in our budget spreadsheet.

Northland:

1 DoC staff costs budgeted for on page 2 of the Conservancy Operational Plan ($26k) have been taken as being additional to the cost given in the Appendix of the same report.

2 DoC staff time recorded for the November bait acceptance trail have not been added into the totals given here. This trial was part of an FRI research project, and as such has no place in costing of an operation possum control operation. We calculated the cost of this work (excluding overhead) was 604 hours @ $15/hr = $9060.

3 The budget given includes the areas of bush (3500 ha) outside of the DoC estate which was paid for by the Regional Council. As it is impossible to separate this extra non-DoC part of the operation from the rest, we have simply included the total costs of the whole operation in the totals and shown the Regional Council's contribution as a credit in the final Overall Costs section of the spreadsheets.

12.2 COSTING DETAILS FOR CONTROL OPERATIONS

1991/92 POSSUM CONTROL COSTING COMPARISONS BETWEEN WEST COAST CONSERVANCY (PARINGA AND COPLAND GROUND CONTROL), AND NORTHLAND CONSERVANCY (PUKETI 1080 AERIAL POISONING)

WEST COAST (PARINGA: GROUND HUNTING)			WEST COAST (COPLAND: GROUND HUNTING)			NORTHLAND (PUKETI: AERIAL 1080)		
OPERATIONAL COSTS	DOC STAFF	OPER-ATING	OPERATIONAL COSTS	DOC STAFF	OPER-ATING	OPERATIONAL COSTS	DOC STAFF	OPER-ATING
Hunter wages (temp workers)/ contrtacts (poison, traps, vehicle)		40515	Hunter wages (temp workers) contracts (poison, traps, vehicle)		40805	Bait and toxin	150	119353
Hunter accommodation		1200	Hunter accommodation		3200	Transport of poison bait	150	8085
Helicopter transport to remote sites (incl huts)		915	Helicopter transport to remote sites (incl huts)		4527	Storage of poison bait	60	225
						Loading of poison bait	8405	2894
						Catering, misc. field supplies		2138
						Airstrip construction—cleanup	330	138
						Aircraft costs (incl contract setup)	375	57640
						Weather forecasts		
						Set up & calibrate equipment	1140	1500
						Toxic bait trial (inc. GPS hire)	4185	4100

					Bait coverage	240	
					Bait quality assurance testing		1500
Total	42630	Total		48532	Total	15035	197573

WEST COAST (PARINGA: GROUND HUNTING)			WEST COAST (COPLAND: GROUND HUNTING)			NORTHLAND (PUKETI: AERIAL 1080)		
MONITORING COSTS (INC. REPORTS)	DOC STAFF	OPER-ATING	MONITORING COSTS	DOC STAFF	OPER-ATING	MONITORING COSTS	DOC STAFF	OPER-ATING
Possum % kill	600	14908	Possum % kill	480	9429	Possum % kill (incl hunter contracts)	1260	4007
Vegetation monitoring (Mistletoe)		408				Vegetation monitoring	2400	
						Kokako monitoring		
						Invertebrate monitoring	10500	1950
						Analysis of 1080 in non-target kills/ waterways - vet services	195	650
Total	600	15316	Total	480	9429	Total	14355	6607

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