POSSUM MANAGEMENT IN NEW ZEALAND

Office of the
PARLIAMENTARY COMMISSIONER FOR THE ENVIRONMENT
Te Kaitiaki Taiao a te Whare Pāremata

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Preface

This investigation has confirmed the magnitude of the threat posed by possums, which should not be underestimated. New Zealand's native biota and natural values are at risk from the damaging effects of possums and, although the incidence of bovine Tb may not have serious financial effects on individual farmers, it could significantly affect the New Zealand economy. Ongoing possum control over more than a third of New Zealand, using current techniques, will be essential until there is a breakthrough in the search for new methods of control.

Managing the possum threat confers a national, regional and district benefit as well as a benefit to individual landholders. This will mean allocating costs equitably across all sectors which benefit from possum control.

The current public disquiet at large-scale poison operations is understandable. There is a risk from using 1080. However the risk to the environment and to public health is low and in some areas there is at present no alternative to aerial control operations using 1080. Public disquiet will be dispelled only if adequate information is supplied by agencies and every attempt is made to evaluate control options including alternatives to aerial use of 1080. Careful planning with the assistance of all affected parties can help to achieve public support and develop appropriate strategies for managing possums.

The current investment of $58 million per year to control possums must be protected. At the present time much research and innovation in control strategies is being developed by many of the public authorities, although there is considerable variation in techniques used in different regions. Where good practice is identified, it needs to be emulated. A number of recommendations are made about the need for training and the need to closely monitor possum population levels as well as assess the damage caused. New Zealand must establish what are 'safe' threshold populations of possums for the protection of conservation values and control of bovine Tb.

The investigation illustrates the complexity of many environmental issues that face the country. The scope of the investigation has had to expand from an examination of the use of 1080 for possum control to a much broader study that includes methods of controlling possums, managing the effects of possums, the statutory framework for managing possums and the management of feral animals carrying Tb. This was found necessary in order to answer the many concerns and claims made by the public. The information contained in this report thus represents a collection of facts not previously brought together. I believe the report is a valuable resource document.

Helen R. Hughes

Helen R. Hughes
Parliamentary Commissioner for the Environment

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I Background to this Investigation

In 1990 the Parliamentary Commissioner for the Environment investigated a complaint about the proposed aerial application of Compound 1080 to control possums on Rangitoto Island. In 1987, and again in 1991 following up implementation of her recommendations, the Commissioner investigated land management in the South Island high country, where aerial application of 1080 is a principal method of rabbit control.[1]

In 1993 the Commissioner received complaints about aerial application of 1080 to control possums in Taranaki, and media reports of public concern surrounding similar operations in the Wairarapa, the Catlins and near Ngaroma. She also received requests from the Department of Conservation, Ministry of Agriculture and Fisheries and Wellington Regional Council to investigate and provide an independent view of the use of 1080 and its alternatives in possum control.

In October 1993 the Commissioner initiated an investigation into possum management under sections 16(1) (b) and 16(1) (c) of the Environment Act 1986. The terms of reference as established by the Commissioner were:

1. Summarise information available on the risk posed by uncontrolled possum populations and the statutory obligations of public authorities and consents required in relation to possum management;

2. Assess the appropriateness of possummanagement methods (considering environmental and economic costs and benefits) and identify information gaps where more research is required (including 1080 and existing or proposed alternatives);

3. Assess the adequacy of public authority consultation, coordination, and decision-making on possum management in two case studies, Taranaki and Wairarapa, and compare with information from other areas where available; and

4. Determine which possum management methods appear to be most appropriate, in both an ecological and political sense, and provide advice to Parliament, public authorities and others as appropriate.

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1 Parliamentary Commissioner for the Environment, 1987, 1990, 1991.

2 Possum Impact and Agency Response

2. I Historical overview[2]

Possums were introduced and liberated throughout New Zealand from 1837 to 1922 by acclimatization societies and others (largely with Government sanction) to establish a national fur industry. Possumnumbers appear to have reached a natural peak in most areas between 1930 and late 1960 (about 30-40 years after local liberations),' and settled into fairly stable populations except in those few areas where they were still colonising. By 1980 it was estimated that possums occupied 91% of the country.

Possum damage to economic crops was noticed from 1910 but it was not until the late 1940s, when possums had greatly increased in numbers and damage became more evident, that the Department of Internal Affairs began control operations. A possum bounty scheme was initiated in 1951, but it ceased in 1961 when it was judged ineffective in controlling possums in problem areas.

In 1956 the control of noxious animals on Crown land was transferred to the NZ Forest Service, and the first trials of aerial poisoning with 1080 were conducted for possum control. There was public agitation against the use of 1080 and concerns about potential poisoning of deer (objected to by deerstalkers), non-target birds, and people, and in response the Minister of Forests called a meeting of concerned parties in 1958.[4]

With the cessation of the bounty scheme in 1961, the Rabbit Boards (which subsequently became Pest Destruction Boards under the Agricultural Pests Destruction Act 1967) were empowered (where possums were declared a pest of local importance) to impose a separate possum control rate. Therefore by 1967 the majority of the Boards had an interest in possum control, for the protection of commercial plantings. Control was attempted with 1080, cyanide and phosphorus poisoning, trapping and shooting.

From 1960 to the early 1970s, numerous large-scale aerial poisoning operations were undertaken by the NZ Forest Service, seeking to protect farmlands from the erosion risk from uncontrolled possum damage to vegetation in catchments, to control damage to the rata-kamahi forests, and to control damage in commercial pine forests.

In the 1960s opposition had arisen among hunters over the use of 1080 to control feral deer, and in the 1970s hundreds of non-target bird deaths were noted following some NZ Porest Service aerial- 1080 operations, and concern

2 Summarised from Agricultural Pests Destruction Council, 1977; Batcheler, 1978(a) and 1978(b); Batcheler and Cowan, 1988; Anon, 1986.

3 Batcheler and Cowan, 1988; Sutherland et Landcare Research, pers. comm., 1994.

4 Records of this meeting were not readily available during the course of this investigation.

increased about non-target kills of dogs and livestock. In 1976 the Commission for the Environment recommended that the use of 1080 should be investigated under the Environmental Protection and Enhancement Procedures. This did not occur, but enquiries were made into the use of 1080 for the Ministers of Forests and Agriculture, and for the Nature Conservation Council[5] In response to the non-target bird kills the NZ Forest Service devised new methods to reduce non-target impacts from operations (including screening carrot baits, dyeing baits green, and prohibiting raspberry lure) which were adopted by the NZ Forest Service from 1978 onwards, but were voluntary for Pest Destruction Board (PDB) operations (althoughmany PDB bait operations were screened).

Also in the 1970s some scientists were questioning whether possums were the primary cause of rata-kamahi forest decline, and it became obvious that the maintenance control required to keep possums at the necessary level for forest protection would impose enormous costs. By the late 1970s possum skin prices were improving. The need for large-scale possum control operations was questioned, and funding was reduced. Large-scale poisoning operations for watershed protection ceased altogether.

In the late 1960s circumstantial evidence indicated that possums were an important wildlife vector of bovine tuberculosis (Tb) (first discovered in possums in 1967), along with feral deer (also susceptible to Tb) which were being captured for farming operations and moved around the country. From 1972 the Department of Agriculture contracted the PDBs and the NZ Forest Service to conduct extensive possum control to 'eradicate' Tb from possums, and large-scale aerial- 1080 operations were undertaken for this purpose.

An important source of Tb infection is movement of infected livestock to non-infected herds and a compulsory Tb testing scheme was put in place for dairy cattle in 1961 (voluntary from 1945), for beef cattle in 1971, and deer (voluntary from 1985) in 1991. Movement control for cattle from herds that had Tb was introduced in 1977, but Tb status controls over sale and movement of all farmed deer and cattle were not significantly strengthened until 1993.

Over the years 1978-1981 the indicators of Tb in livestock declined significantly, and so did possum control funding from central government. In the early 1980s 'eradication' of Tb in possums was judged an impossible goal in Tb endemic areas, and 'cost-effective control' was introduced instead. Indicators of Tb infection in herds began steadily climbing again from 1982, but possum control funding did not again reach previous funding levels until 1988.

In 1987 the indigenous forest protection role of the NZ Forest Service was transferred to the Department of Conservation, and in 1989 the pest control functions of the Pest Destruction Boards were transferred to regional councils.

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5 Reports of those enquiries in Batcheler, 1978(a) and Harris, 1977.

In 1990 the Animal Health Board (AHB) was established from the Animal Health Advisory Committee. The AHB is an advisory board to the government, and it administers the Tb control programme. Under the Biosecnrity Act 1993, the AHB could become the pest management agency for bovine Tb, if a strategy is proposed and notified by a Minister, and approved by the Governor-General by Order-in-Council, on the recommendation of the Minister.

2.2 The present situation

Possnms are established in more than 91% of New Zealand, with the total population estimated at 60-70 million, two-thirds of which are in the North Island. Possnms are continuing to colonise remote areas of South Westland, South-east Piordland, Coromandel and Northland.[6] The density of possnrn populations and the associated risk is not uniform (see Table 2.1).

Table 2.1 Possum population densities and associated risk

Habitat	Density: possums/ha	Conservation Risk	Tb Risk	Other Risk
Mixed forest-scrub-pasture margins	5 - >15	medium	very high	
Tree-lined waterways on farmland	5 - 15	low	high	
Small isolated forest patches	5 - 15	medium - high	medium	Loss of tourism income with reduced biological/landscape diversity
Rata/kamahi and mixed hardwood forests	5 - 15	high	low	Loss of tourism income with reduced biological/landscape diversity
Lowland indigenous podocarp forests	2 - 5	low	low	
Alpine shrublands	2 - 5	low		
Exotic forests	1 - 3		low	Browsing of young trees, (increased cost of planting)
Beech forests	< 2	low	low	
Alpine grasslands	< 2	low		
Open pasture and cropland	< 2		high	Loss of farm production with pasture/crop consumption by possums
Erosion plantings	?		medium	Browsing of plantings: an increase in localised soil erosioı
Horticultural/ ornamental crops	?			Lost production (generally localised)

Density sources: **Department of Conservation, 1994(a), p.1; Cowan, 1991, p.75.**

[6] Batcheler and Cowan, 1988, p.4; Cowan, 1991, p.75.

Possum control seeks to address the problems of ecosystem damage and the spread of Tb infection, but possums are not the sole cause of either of these problems and other factors need to be addressed as well. If ecosystem damage and disease spread are not addressed in full, an exclusive focus on possum control will not solve these problems. However, the damage caused by possums to ecosystems and species, and the threat of bovine tuberculosis spread to cattle and deer, cannot be underestimated. The problems that possums cause will require continual intensive control to reduce the level of damage, and this will be ongoing and expensive. The relationship between possum control and other contributing factors is set out in Figure 2.1.

The principal public authorities that seek to control possum populations are the Department of Conservation (for the protection of indigenous species aud ecosystems), the Animal Health Board (for the control of bovine tuberculosis, on behalf of the cattle and deer industries) and the regional councils (contracted by the AHB, and on behalf of ratepayers). Crown funding for Tb control is provided to the AHB by the Ministry of Agriculture and Fisheries. Work skills and training schemes that involve possum control are also funded partially by the Department of Labour. These decision-making groups and inter-agency liaison structures are illustrated in Pigure 2.2, and available data on funding allocations are presented in Table 2.2.

The principal ministers with portfolios affected by possum control issues are the Ministers of Conservation, Agriculture, Local Government, Research Science and Technology, and Labour, and to a lesser extent, Health, Environment, and Education. The National Science Strategy Committee on Possums and Bovine Tuberculosis Control (NSSCP) was set up by Cabinet minute in October 1991, with its goal to identify, coordinate and promote national priorities for possum and Tb related research.

Since mid-l 993, coordination of operational and training aspects of possum control, has been provided by the National Possum Coordinating Committee (NPCC), with representatives from the Department of Conservation (DOC), Animal Health Board, Ministry of Agriculture and Pisheries (MAP), and the New Zealand Local Government Association (NZLGA). The creation of the NPCC was an interagency initiative at the national level, to ensure that control was undertaken effectively and efficiently. The NPCC is an ad hoc committee and has no statutory or ministerial authority.

The control of possums and Tb has been an evolving process in New Zealand in recent years, with increased recognition of the magnitude of the problem, increasedfunding, and a higher priority placed on research, control, information provision and training. The increase in funding by government for control and research is to be commended. New networks that have been established such as the NPCC, the NSSCP, the NZLGA Biosecurity Working Group and Technical Advisory Group, are important initiatives.

Figure 2.1 The relationship of possum control with other contributing factors

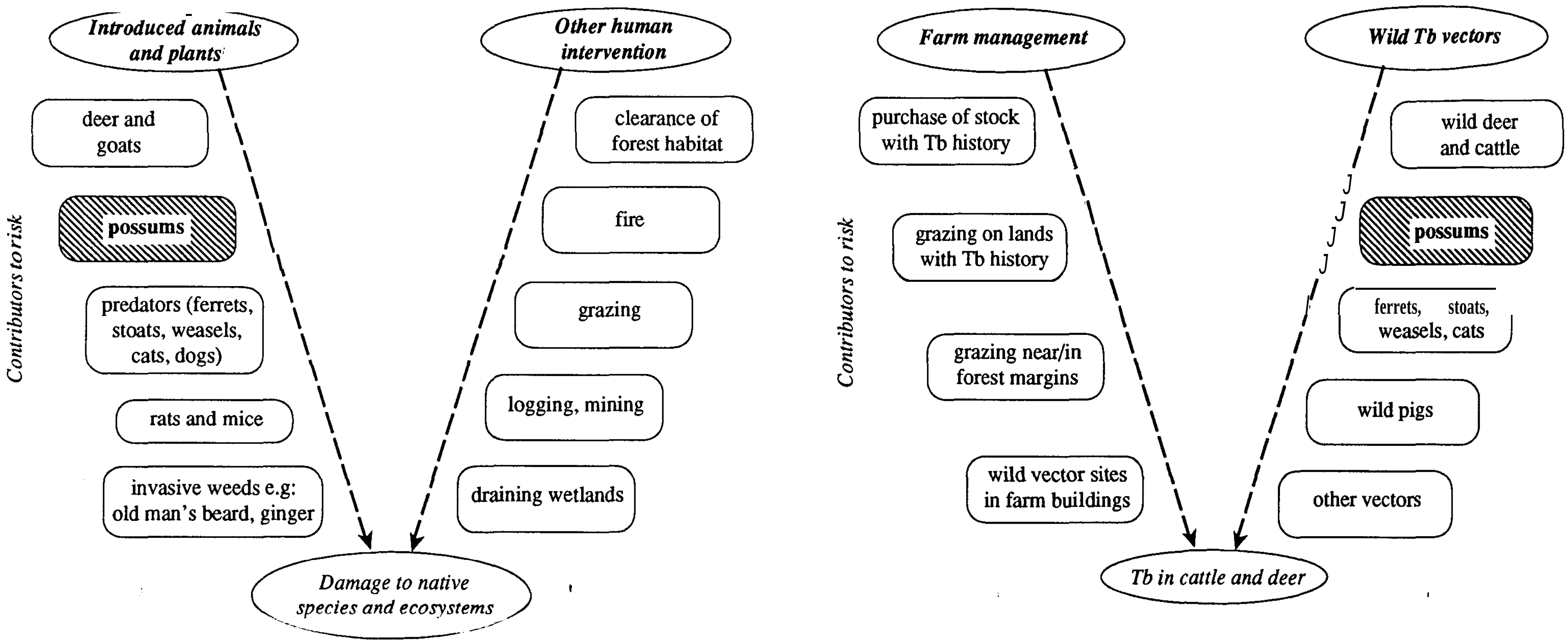

Figure 2.2 Schematic diagram of agencies involved in possum control, research and liaison structures

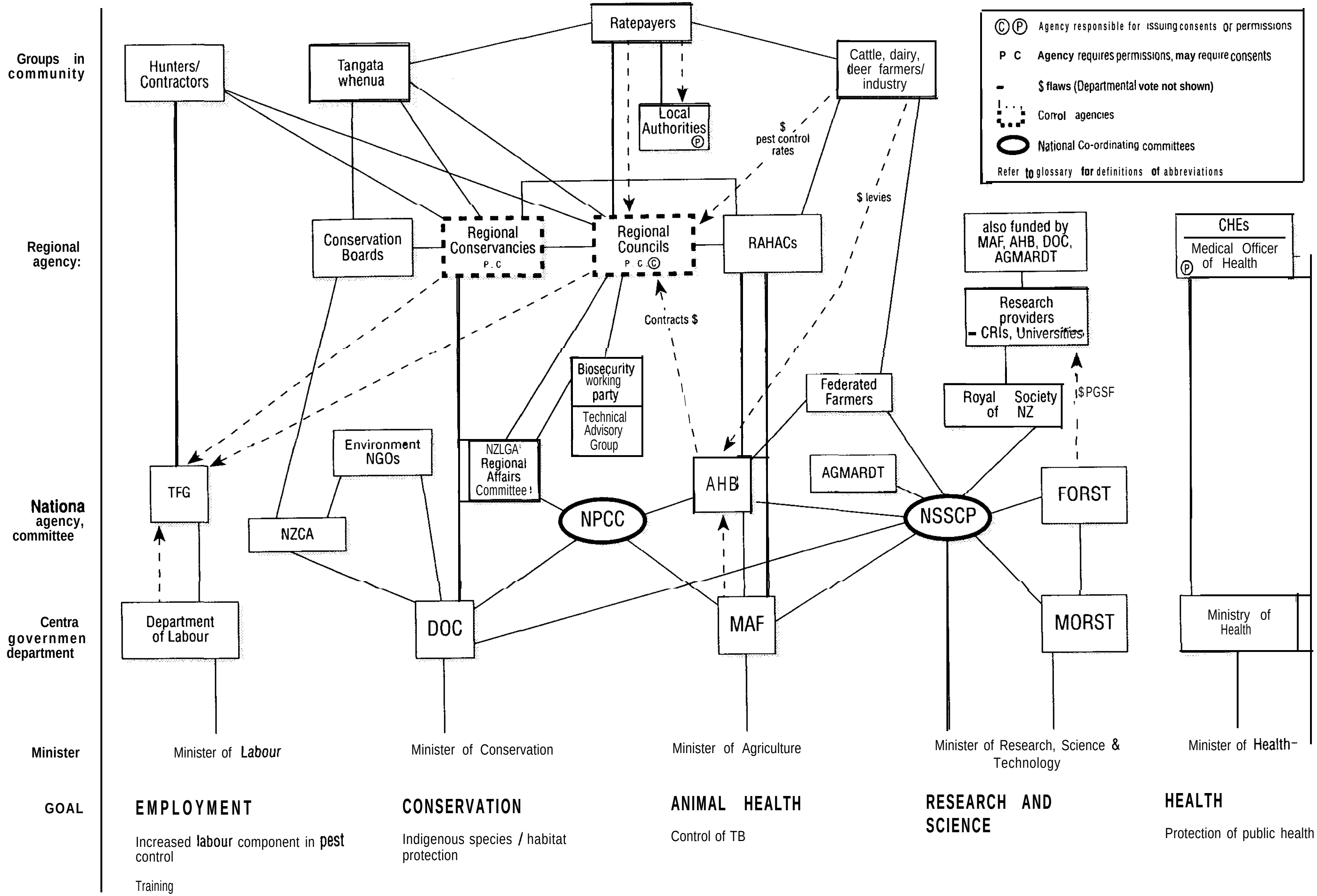

Table 2.2 Central government, farmer levy, and ratepayer funding for possum and Tb control and research, 1992193 and 1993194, in millions of dollars (GST inclusive).

	19920993			1993/1994		
	Purpose			Purpose		
ACTIVITY	Cons.*	Tb	Mixed	Cons.	Tb	Mixed
POSSUM CONTROL						
- Animal Health Board’		$4.97			$ 11.79[b]	
- Regional Councils		$3.5	?		$3.6	$4.0
- Department of Conservation	$ 3.0			$ 5.35		
- Department of Labour (enhanced Task Force Green)				$ 2.4	$3.5	
AHB”						
- Information/publicity		$0.45			$1.13	
- Administration		$0.37			$0.45	
MAF’						
- Tb testing		$8.44			)$ 13.39[c]	
- Administration/management		$4.28			)	
Reactor compensation’		$2.11			$2.14	
RESEARCH						
- FoRST - PGSF			$3.87			$4.51
- MAF						$2.6
- DOC	$ 0.4			$ 0.65		
- AGMART		$0.57			$0.55	
- AHB[a]		$2.03			$ 1.8	
- Other’						$0.15
SUB TOTAL	$ 3.4	$26.72	$3.87	$ 8.4	$38.35	$11.26
TOTAL	$33.99			$58.01 m		

a) Consisting of part slaughter levy, industry contribution and Crown contribution.
b) Includes $6 million Crown contribution for AHB operations on buffer zone on DOC estate and partial funding for regional council contract operations.
c) No breakdown available for 1993/1994.
d) AgResearch, Health Research Council, Universities, and the private sector.

In 1992/1993, farmer levies and industry contributions (GST inclusive) to AHB totalled $17.1 million and in 1993/1994 $19.57 million. In 1993/1994, regional council funding from rating and user charges for possum control was in excess of $6.2 million.

* Conservation.

Sources: DOC ‘Paw Print’ newsletter Sept. 1993; Livingstone, 1993; R. Phillips, Canterbury Regional Council, pers. comm., 1994; NSSCP, 1992 and 1993; W. Bayfield, Taranaki Regional Council, pers. comm., 1994.

Companies, private organisations and individuals also seek to control possum populations, in order to protect vegetation of economic, amenity and conservation value or to enhance the prevention of bovine tuberculosis in their livestock. The cost of this independent control has not been calculated but it is in addition to that in Table 2.2. and it is significant.

'Eradication' of the possum has been referred to by officials and the media as an appropriate control objective in the past, but it is not a realistic option with present resources and technology except on small islands. Eradication of the possum on Kapiti Island cost more than $430/ha in 1987 dollars (direct cost only). For the DOC and AHB high priority lands alone, this level of effort could cost approximately $1,000 million.' Even if this level of control was affordable for the whole of New Zealand, the necessary prerequisites for eradication could not be achieved, that is: no immigration from non-treated areas; all possums put at risk; the need to achieve kill rates that are greater than the naturalrate ofincrease at all densities.[8] Biological controls, ifthey become available, may reduce these costs, but are not likely to provide a full solution for eradicating the possum. It is suggested that eradication is still a viable research objective.[9]

2.2. I Conservation

Uncontrolled possum populations are a direct threat to vulnerable areas of the conservation estate and the diversity of New Zealand's flora and fauna. The cost of damage to the conservation estate is large, but many of these costs are difficult to value, such as the loss of diversity and the extinction of species.

Possums commonly prefer certain species and browse individual plants until defoliated, altering forest composition, contributing to the decline of rare plants, birds and animals, and competing with other animals directly for food. Forest canopies that have been weakened by browsing also become more susceptible to windthrow, pathogens, insects, and other climatic extremes.[10] Possums eat eggs, chicks, and nesting birds and interfere with the breeding of bird species such as kokako, kiwi, kaka and wood pigeon. They also eat invertebrates such as rare species of giant wetas and giant land snails." Flora and fauna at risk from possums are shown in Table 2.3.

Indigenous flora and fauna on offshore islands have recovered when possum populations have been eradicated or reduced to a low level. On Kapiti Island, the eradication of possums has provided for a distinct increase in vegetation regrowth, flowering and seeding, and subsequent increases in the bird population. On Rangitoto Island, a 90% reduction of the possum population allowed pohutukawa trees on the island to recover and flower profusely after suffering 50-70% defoliation.

In the central North Island, several seasons of intensive possum control in the Kaharoa and Mapara Districts has been linked to significant increases in kokako population levels (the only mainland populations known to be increasing at present).[12]

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7 Priority control areas AHB (1993/94) and DOC (10 year plan): 2,387,000 hectares @ $430/ hectare = $1,026,410,000.

8 Parkes, 1993, p.224.

9 R. Sadleir, DOC, pers. comm., 1994.

10 Payton, 1988.

11 Cowan and Moeed, 1987, p.163; Cowan, 1991; Department of Conservation, 1994(a).

12 Cowan, 1991, p.80; Miller and Anderson, 1992, p.105; J. Hay, DOC, pers.comm., 1994.

Table 2.3 **Major flora/fauna at risk' from possums, by DOC Regional Conservancy**

Conservancy	Flora/species at Risk	Fauna/species at Risk
Northland	Pohutukawa, Bartletts rata, kauri, *Coprosma* species, fuchsia, Northern rata forest	Kiwi, kokako, kaka, snail, long tailed bat, *red* crowned parakeet, bellbird
Auckland	Pohutukawa/rata hybrid forest (Rangitoto Island), podocarp/hardwood forest	Hochstetter's frog habitat preservation
Waikato	Northern rata, pohutukawa, king fern, kohekohe, coastal lowland forest, *Dactylanthus*	Kaka, kokako, stag beetle, short tailed bat
East Coast	Tawa forest, kohekohe, pohutukawa, kakabeak, *Dactylanthus*	Kereru, kokako, kiwi, kaka, falcon, whio, bats
Bay of Plenty	Pohutukawa, rata/kamahi forest, king fern	Kaka, kiwi, stag beetle
Tongariro/Taupo	Northern rata, podocarp forest, mistletoe, pohutukawa, *Pittosporum turnerii*	
Hawkes Bay	Tawa forest, tussock herbfields, Halls totara, kaikawaka, podocarp forest	Kiwi, snails
Wanganui	Rata/kamahi forest, *Dactylanthus*, kaikawaka, Halls totara, kohekohe forest	Kiwi, kokako, falcon, rare beetles and insects
Wellington	Fuchsia, kohekohe forest	Giant land snails
Nelson/Marlborough	Northern rata, coastal broadleaved forest, tawa, kohekohe	Snails, kaka, kiwi, yellowhead, weta
Canterbury	Podocarp/hardwood forest, seral scrub	Chatham Islands pigeon and tiako
West Coast	Northern & southern rata, kamahi, silver beech/mistletoe associations	Brown kiwi, kaka, kea, kotuku, snails
Otago	Rata, mistletoe, totara, matai, kahikatea, coastal vegetation (Catlins)	Kaka, mohua, yellow eyed penguin
Southland	Waitutu and Fiordland forests (to limit colonisation)	

*** The major flora/fauna/species at risk as identified for priority possum control funding by DOC.**

Source: Department of Conservation, 1994(a), Appendix 3, pp.59-68.

The *Department* of Conservation *'National* Possum Control Plan'

The Department of Conservation budget for possum control cannot provide for control on all of the conservation estate that is at risk. As specified in its National Possum Control Plan 1993-2002, DOC uses selective sustained control as a long-term possum control strategy, to protect the most vulnerable

endangered species and ecosystems.[13] The objectives of the DOC national plan are to:

- eradicate possums from certain island reserves where they threaten the native vegetation or wildlife;
- prevent or slow the spread of possums into areas still free of them;
- turn back recent invasions by possums from priority areas where their damage can be reversed;
- concentrate sustained control on those areas with high ranking native flora and fauna, or biological communities that are most at risk from possums.‘4

However, because of limited funding other conservation areas with a lower priority will be modified or destroyed, because they lack the required protection. Even with the recent government increase in funding for the DOC estate, there is no assurance that this funding will adequately protect the species and ecosystems targeted, if control of other damaging factors (e.g. goats, deer, pigs, ferrets, cats, rats) is not adequately achieved.

The DOC strategy divides conservation areas into management units based on geographic features (units may range in size from two to more than 20,000 ha) and then ranks them based on the vegetation and fauna at risk, and the vulnerability of possum damage. If primary rankings are equal, a secondary score takes into account such factors as the status of the possum population, the public use of the conservation area, the interval between control operations, and areas most in need of control. The highest ranked management units throughout New Zealand receive funding for possum control. The priority areas that can be targeted over the next ten years with the current budget allocation level comprise 712,985 ha or 9.2% of the DOC estate (see Appendix A, Table A.1 for further information).

The ‘at risk’ land (for conservation values) from medium to high possum densities,” can be approximated by categorising the 47 vegetation cover classes from the New Zealand Vegetation Cover Map. This gives a total of approximately 3.7 million hectares of ‘at risk’ land for conservation values (14% of New Zealand). This area cannot be divided into DOC/non-DOC land, but assuming between 50-80% of the area is held by DOC, this gives an estimate suggesting that 24% to 38% of the DOC estate is ‘at risk’. The estimated area of DOC estate ‘at risk’ is between 1,831,500 ha and 2,930,400 ha (see Appendix A, Table A.2).

2.2.2 Bovine tuberculosis

Bovine tuberculosis is New Zealand’s main animal health problem, requiring high quality hygiene standards and stringent levels of inspection of animal products. Most of New Zealand’s major trading partners require high quality

[13] Department of Conservation, 1994(a).
[14] Department of Conservation, 1994(a), p.7.
[15] It is acknowledged that possum densities are only one of several risk factors including species’ vulnerability and susceptibility.

standards of inspection and certification that a bovine tuberculosis control programme is in place. There is a risk that non-tariff trade barriers could be placed on New Zealand exports of beef, dairy, and deer products if other countries perceived that they were tuberculosis contaminated. The potential cost to New Zealand from the cessation of the Tb control programme in a worst case scenario (involving the loss of some overseas markets) has been estimated at $5 billion over ten years.[16]

While feral/wild animals have Tb they act as a source for reinfection of farm herds, threatening attempts to control Tb. New Zealand has been divided into endemic, special tuberculosis investigation areas (STIA), fringe and surveillance areas depending on the incidence of Tb reactors and the discovery of Tb in wildlife. Possums are considered by MAF and AHB to be the main wildlife vector of tuberculosis for cattle and farmed deer. Endemic Tb and STIA areas comprise 23% of New Zealand and Pringe areas another 17% (Appendix A, Tables A.3 and A.4). A map of the movement control areas and surveillance areas is shown in Figure 2.3.

There has been an upward trend overall in the last 10- 12 years for the number of cattle reactors and herds on movement control, with a decrease in the northern region and an increase in the southern region. A number of the southern region Tb outbreaks have not been traced to Tb possums, and other wild vectors such as ferrets, deer and pigs are suspected.”

Further discussion of the vectors of Tb spread and means of control are in Chapter 3.

The Animal Health Board Strategic Plan 1993- I 998

The mission of the Animal Health Board is ‘to eradicate bovine tuberculosis from New Zealand’ and the activities of the Board include organising continued possum control, coordinating research and ensuring the implementation of livestock movement controls. To achieve its objectives the AHB has appointed Regional Animal Health Advisory Committees (RAHACs) to coordinate the implementation of the national strategy at a regional level.

The objectives of the AHB five-year strategic plan are to:

- reduce the percentage ofmovement control herds within endemic areas by 30-50% and the numbers of reactors by 50-75%;
- reduce the percentage of movement control herds in non-endemic areas to 0.2% (i.e. the internationally recognised level for official freedom from tuberculosis);

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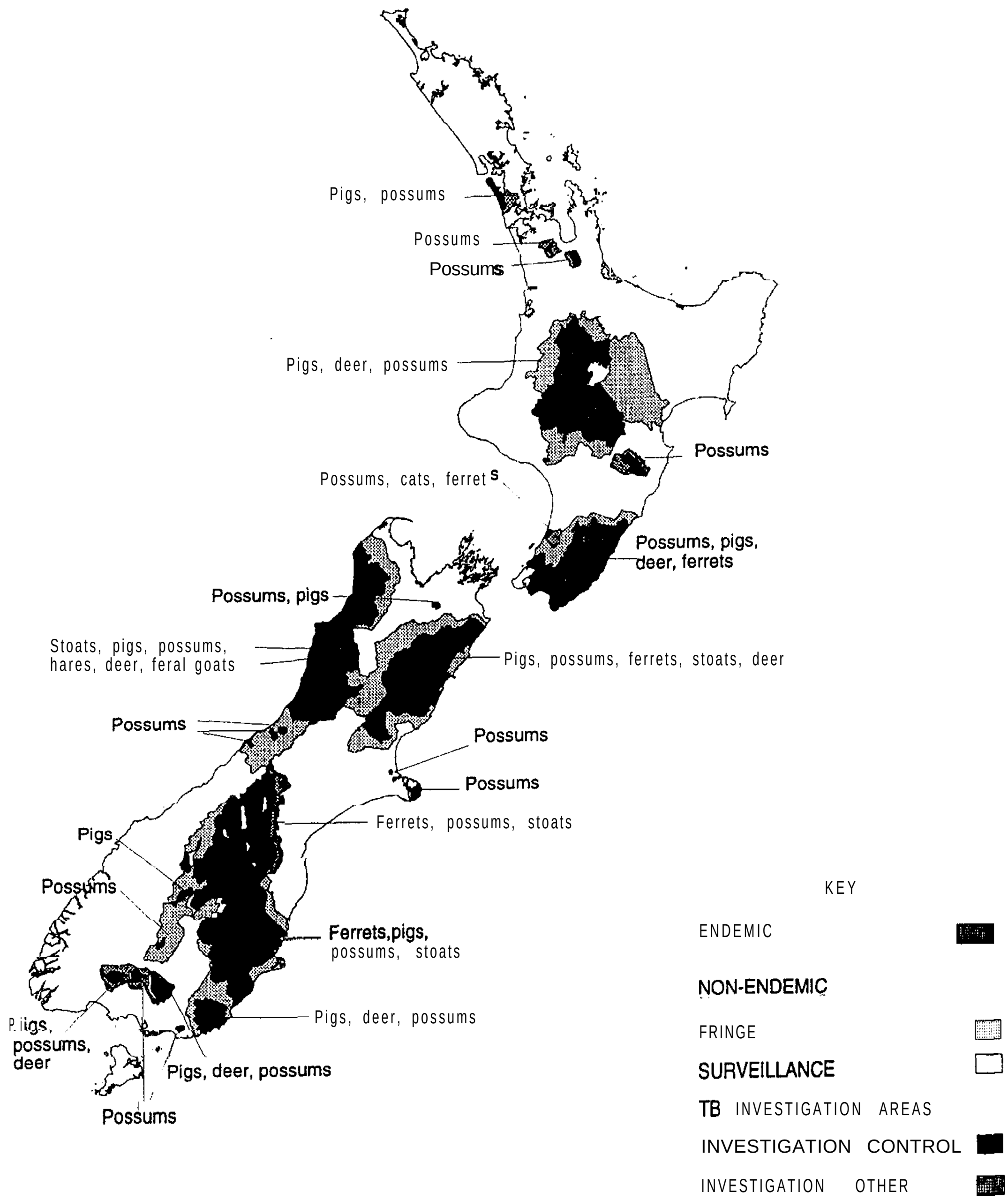
16 MAP Policy Services, 1993, p.33.
17 P. Livingstone, T. Ryan, MAP, pers. comm., 1994.

Figure 2.3 Map of Tb control areas and wild Tb vector species



Source : MAF Quality Management, Ruakura

- prevent the establishment of new endemic areas and expansion of existing endemic areas into farmland free of feral Tb reservoirs;

- encourage individual farmers to take responsibility for the control of Tb within their herds.[18]

These objectives were based on a AHB/MAF assessment of what wasrequired to reassure New Zealand's trading partners that effective measures were being undertaken to control Tb and to reduce the level of risk. The assessment of the level of funding was based on an assessment of the programmes needed to enable these goals to be achieved.[19]

The AHB strategy for the control of tuberculosis is based on Tb status testing and movement control for livestock, and targeted campaigns to reduce possum populations. The control of possums to reduce the chance of Tb spread occurs not only in high-risk areas, but also in Tb free areas and in fringe areas adjacent to movement control areas, in order to reduce the probability of Tb spreading through the movement of infected feral animals. Livestock controls have been tightened; as of 1 January 1994 all cattle and deer over three months of age in New Zealand are required to be accompanied by a Tb status declaration card before they are moved, and it is proposed that by July 1995 compensation (currently 85% of fair market value in designated movement control areas and 45 % in surveillance areas) for slaughtered Tb positive cattle will no longer be available.

The area to be targeted by the AHB for possum tuberculosis vector control in 1993/94 is approximately 1,433,000 ha and 1,675,000 ha in 1994/95. The majority of this land will be treated with 1080, usually by air for the 'initial knockdown', and by ground control for 'maintenance' work.[20]

2.2.3 Other possum impacts

The monetary value of the damage caused by possums to agricultural, horticultural, and forestry production, utility network operators (e.g. damage to power/telephone facilities) and catchment plantings, is difficult to accurately assess and value, but it is in the order of ***fens of millions of dollars per year.***

Exotic forestry

On average, it is estimated that the effects of possums on plantation forests result in a loss of l-2% of the value of the forest at rotation, largely through damaged terminal shoots of young seedlings and the need for intensive control of possums after initial planting.[21]

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18 Animal Health Board, 1993.
19 G. Rusbridge, D. Crump, MAF, 1994, pers. comm.
20 P. Nelson, pers. comm., 1994.
21 Keber, 1988.

Catchment plantings

Possums can cause severe damage to poplar and willow poles used for soil conservation purposes with young plantings especially vulnerable to attack.[22] Trees can be protected by sleeve barriers but at an additional cost.

The combination of deer and goats (which eat the understorey of forests) and possums (which can destroy the tree canopy) can restrict forest regeneration and threaten watershed protection forests, with enhanced erosion subsequently affecting downstream catchments. With high intensity rainstorms, even healthy forest can be threatened by erosion. With the current DOC ranking system for prioritising control areas, there is no funding available for control in catchment protection forests.

Agriculture and Horticulture

Horticultural and agricultural crops and amenity plantings are affected by possum browsing and foraging, causing locally significant damage. Pasture consumption by possums living in the bush/pasture margin has been estimated at 0.1 kg of pasture per possum per day.[23] This will significantly reduce pastoral production, with an associated loss of income.” Possums can also affect the production of honey from indigenous tree species because of their selective browsing of flowers.”

Giardia and other diseases

Possums (along with birds and other animals) can carry *Giurdiu intestinalis,* with the potential risk of contamination of public water supplies and catchments. Many communities have been required to purify water supplies by installing expensive filtration or chlorination systems to reduce the threat of human giardiasis. Human and animal strains of *Giurdiu* have been identified, but research still has to establish if animal strains of *Giurdiu* will cause giardiasis *in* humans. Many *Giurdiu* cases in humans are the result of poor hygiene, with transmission through faecal-oral contact rather than water.[26]

Possums (along with other animals) also act as vectors for *Cryptosporidium* and the risk from *Cryptosporidium* will intensify in the future, as it is 26 times more resistant to chlorine than *Giurdia* and has the potential to cause major water quality and public health problems.[27] The threat posed by this organism to public health has not yet been adequately researched.

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22 Cowan, 1991, p.79.

23 Taranaki Regional Council, 1994, pers. comm.; Harvie, 1973.

24 In 1987 it was estimated that ‘losses of export earnings from meat and wool production attributable to possums were about $12 million’. Cowan, 1991, p.83.

25 Cowan, 1991, p.80; Batcheler and Cowan, 1988, p.48.

26 Brown *et al, 1992,* p.281.

27 Massey University/Ministry of Health, 1993, Appendix 8.

Landcare Research in conjunction with Massey University has been researching *Giardia* and *Cryptosporidium* in wildlife, including possums. However the funding of this work was threatened in 1993194 and further work could be suspended. This is because two funding agencies (the Health Research Council and Foundation for Research Science and Technology (FoRST)) are involved, with both agencies considering the funding comes under the jurisdiction of the other agency.[28]

Possums may act as vectors for other parasites and diseases in farm animals (e.g. liver flukes, nematode parasites, leptospirosis and rota virus), but the linkages are uncertain.[29]

2.3 Research *framework*[30]

Funding for research on possum and bovine Tb control has increased markedly in the last few years, from less than $3 million in 1990/91 to about $9.9 million in 1993/94. Research funding by agency is summarised in Table 2.2. A significant portion (45 %) comes from the Public Good Science Fund (PGSF) through FoRST, where possum-related research is recognised as a priority, cross-output theme. It has been far less seriously constrained than other major areas of research on environmental management, and significant dissatisfaction with the overall level of funding for possum and Tb related research was not encountered during the investigation.

Provision of this research is dominated by two Crown Research Institutes, AgResearch and Landcare Research, who currently receive approximately 40% and 37% of funding respectively. The other main research providers are universities, principally Massey, Otago and Auckland.

Current research can be grouped into seven areas (in decreasing order of funding level): immunology (including vaccines); epidemiology of tuberculosis; baits, toxins and control technology; conservation impacts; pathogens and biological control vectors; possum physiology; ecology of animal tuberculosis vectors. All these areas are in the biophysical sphere. There is a need for more research into social and economic aspects of possum and Tb control, including risk perception and public attitudes to control. Other comments on research needs and priorities are made in later sections of this report.

Recognition of the importance of research on possum and Tb control was demonstrated by the establishment of the National Science Strategy Committee on Possums and Bovine Tuberculosis Control (NSSCP) by Cabinet decision in October 1991. Membership of the NSSCP is drawn from funders, stakeholders, the science community and MORST, with an independent convenor.

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28 Sutherland *et* al, Landcare Research, 1994, pers. comm.
29 Cowan, 1991, p.81.
30 Sources include Annual Reports of the National Science Strategy Committee for 1992 and 1993 (NSSCP, 1992. 1993(a)).

The Mission Statement of the NSSCP is ‘to identify, coordinate and promote national priorities for possum and tuberculosis related research in order that threats both to New Zealand’s export markets and to conservation values can be eliminated’. Its goals are:

1. To identify, coordinate, promote and disseminate research which will provide the information and techniques required to:

(a) keep economically important primary production areas and animal products free of Tb;
(b) reduce the spatial distribution and incidence of Tb in domestic and feral/wild animals;
(c) effect a permanent and general reduction in possumnumbers sufficient to ensure the sustainability of New Zealand’s native plants, animals and ecosystems;
(d) eliminate possums from New Zealand;
(e) eliminate feral/wild animal populations as reservoirs of Tb.

2. To conduct research into public and government views that could impinge on possum/tuberculosis research and its implementation.

The NSSCP pursues these goals by developing and reviewing the strategic framework for research, developing an integrated portfolio of research, promoting knowledge about relevant research, and provision of advice to the Minister of Research, Science and Technology and to a number of agencies.

Research priorities identified by the NSSCP have been published in its Annual Reports. Nearly 80% of total research funding is for Tb related research aud this is generally reflected in the NSSCP’s research priorities. However many of the top research priorities (including research into public attitudes) can relate to conservation as well as to Tb control goals. Much of the research required is long term in nature and the NSSCP has largely focussed on longer term strategies.

The effectiveness of the NSSCP after its first two and a half years’ operation has recently been reviewed.[31] The review has highlighted a number of important achievements of the NSSCP, including its effectiveness in attracting new research funding, and has recommended its continuation for another three years. It has made detailed comments and recommendations about the coordination of research, and NSSCP’s relationship to research funders and stakeholders. These comments and recommendations are endorsed and will not be commented on further, except to reinforce two points.

Firstly, the NSSCP does not itself allocate funding, having an advisory role only. Therefore the major research funders, especially FoRST, MAF and the

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[31] O’Loughlin, 1994.

AHB, also have an integral role in research coordination and there is likely to always be some tension between NSSCP's advisory role and the funding agencies' own processes and priorities. The present level of communication between these agencies is good and the research allocation process appears to be satisfactory, but there is a need to maintain this level of communication and to foster maximum openness in the allocation process.

Secondly, NSSCP's activities to date have been low profile and its coordination with other agencies informal. However, maximum coordination of control strategies, policy formulation and research is desirable.[32] The NSSCP is in a good position to contribute fully to such coordination but its input to policy does not seem to have been large. For example, there is only one person who is a member (fortuitously) of both the NSSCP and the National Possum Coordinating Committee and there is no formal interchange between these two committees. Although their activities appear to be quite distinct in practice, some confusion about the roles of two national coordinating committees was encountered amongst staff of several agencies both at national and regional level. Liaison between the NSSCP and regional/local government also appears to be weak and membership of the NSSCP does not include regional council representation; this appears to be a major gap since regional councils, as major possum control operators, are very significant stakeholders in research.

2.4 Training programmes

Current training and licensing procedures for possum control and the use of chemicals include:

- The 'Chemical Applicators Certificate' of the Contractors Federation;
- The 'Approved Operator's Licence' (administered by the Pesticides Board under the Pesticides Act 1979);
- The agricultural and chemical rating for aerial application of animal poisons (administered under the Civil Aviation Regulations 1953);
- Licences in respect of toxic substances under the Toxic Substances Act 1979, administered by the Ministry of Health through district Medical Officers of Health;
- The New Zealand Local Government Association (NZLGA) 'Agricultural Pest Management Officers stage one course' provided by The Open Polytechnic of New Zealand;
- Local Community Employment Group initiatives (to provide for localised employment and training);
- Various Task Force Green funded possum control programmes (including some training).

The New Zealand Qualifications Authority (NZQA) in association with the 'Conservation, Environment, and Resource Management Advisory Group' is

32 As for example achieved by the Rabbit and Land Management Programme.

currently working with education providers, Department of Conservation, New Zealand Local Government Association, Ministry for the Environment, and other advisory groups to prepare a national qualifications framework and required standards for training for pest control (including possum control). The development of the second stage of the 'Agricultural Pest Management Officers course' is almost completed, but itsrelease is on hold until framework standards have been developed. The Open Polytechnic of New Zealand also plan a stage three advanced management course.

The NZLGA is an Industry Training Organisation (ITO) in terms of the Industry Training Act 1992 which provides the framework for industry to control the development, implementation and management of industry training programmes. ITOs will:

- set national standards to be registered in the NZQA framework;
- develop the arrangements for the delivery of training (on and off the job);
- develop arrangements for monitoring the training and assessing trainees (on and off the job).[33]

Training is not only required at a certificate level but also in the form of workshops and seminars, so that the latest developments in research, technology and control can be made available to those people involved in possum control. The NPCC has been active in this area, ensuring that control operators and pest management staffhave workshops, seminars, manuals, and simulation control exercises, to assist in the development of training and to maintain quality standards.

Training and information are also required for land owners if they are to be successful in developing local self-help control initiatives. Farmmanagement needs to include 'total risk management' in decision-making with farmers requiring information on possum control, property planning, and the associated risks. The role of regional councils in facilitating this training and information provision will be crucial.

The NPCC has identified the dissemination of information along with training and development as key requirements to improve the efficiency and effectiveness of possum control operations and to reduce the risk of operator error. A joint approach to training by control agencies can also assist the management and operation of joint control operations.

Training and advice that will be facilitated by the NPCC has been separated into immediate, medium and long-term objectives. Immediate objectives involve workshops for field staff, and medium-term objectives include skills needs assessment (for the development of training programmes) and the development of manuals on toxins, operations and codes of practice. Long-term objectives include the alignment of training and licensing for pest

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[33] Education and Training Support Agency, 1993.

management with new legislation, and to bring all training under the jurisdiction of the NZQA.[34]

A DOC Possum Control workshop (1994) identified further training was required in the following areas: monitoring (operational and performance); consultation; contracts management; negotiation skills; legislation; control techniques; public relations; bait storage; and interagency cooperation.

There is a large investment in possum control, and in pest control generally. The risks from applying these funds inefficiently or causing adverse effects from unwise use of control techniques are increased when adequate training is limited or non existent. That no comprehensive or integrated training programme exists is unsatisfactory, and full support needs to be given to current initiatives to get a comprehensive training course established. In particular, a comprehensive training programme which targets all relevant areas (occupational safety and health, operating procedures, consultation skills, risks to non-target species, monitoring techniques, bait storage and security) needs to be given a high priority. Procedures need to be developed for work-based training and assessment and this information needs to be made available to self-help groups. A Code of Practice for all possum control operations and operators could help to ensure safe, responsible and efficient control.

Training in ground control techniques will be required (to ensure an adequate supply of ground operators in the future), if ground control is seen as an alternative control option, to be used as part of a suite of control measures. It is possible that without sufficient use of ground control, experience and knowledge obtained by contract hunters will be lost as hunters retire or change professions.[35] Although 1080 is more closely restricted as to who may use the poison than is the case for phosphorus and cyanide, the training and licensing for the 'Approved Operators Licence' for the use of all three poisons is currently a lifetime licence, with no re-examination required. Licences need to be re-examined and re-issued every five years, ensuring adequate operator and public safety and health.[36]

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[34] Kennedy, 1994.
[35] Charles Whiting, DOC, pers. comm.
[36] As noted in Parliamentary Commissioner for the Environment, 1993, p.28.

3 The Tuberculosis Link in Possum Control

3.1 The Possum as a Tb Vector

Susceptibility of possums to Tb

The possum is highly susceptible to bovine Tb as its immune system to the infection is deficient. In the field a possum infected by bovine Tb may take weeks or even years before obvious lesions develop, but then the animal is considered highly infective. Other susceptible animals which come in contact may develop the disease, including humans on rare occasions.[1] Development of lesions is accelerated when the animal is under stress and high numbers are observed after winter and in wetter forest environments.

Tb is self-sustaining in possum populations. Disease transfer within the possum population is considered to occur between a mother and her offspring, from competitive interaction among males, and during mating in February and March when social activity is at a peak, and possibly indirectly between individuals sequentially sharing dens. An example has been found of a den site with a possum resting on top of the carcasses of three dead possums from one of which Tb was isolated.[2]

Circumstantial evidence of transmission of Tb to livestock

Testing cattle and deer for tuberculosis and slaughtering the reactors seemed in the early to mid-1970s to be achieving eradication of the disease, but several areas did not seem to respond to the normal testing and slaughter procedures. In a search for non-bovine sources of infection, 12% of possums autopsied from farms with a persistent Tb problem at Cape Foulwind, West Coast, were identified as tuberculous. It was not until possum control was undertaken that a prolonged reduction in the cattle reactor rate was achieved in that area[3] (see Figure 3.1). This pattern was later observed in other Tb endemic areas such as the Wairarapa and Western Bays (Taupo).

Based on a number of different pieces of evidence including the correlation between the occurrence of Tb in possums and reactor rates in cattle herds,[4] and Livingstone's observation that cattle in special tuberculosis control areas are five to 13 times more likely to be slaughtered as Tb reactors than cattle in surveillance areas,[5] possums are regarded as the main wildlife source of the disease.

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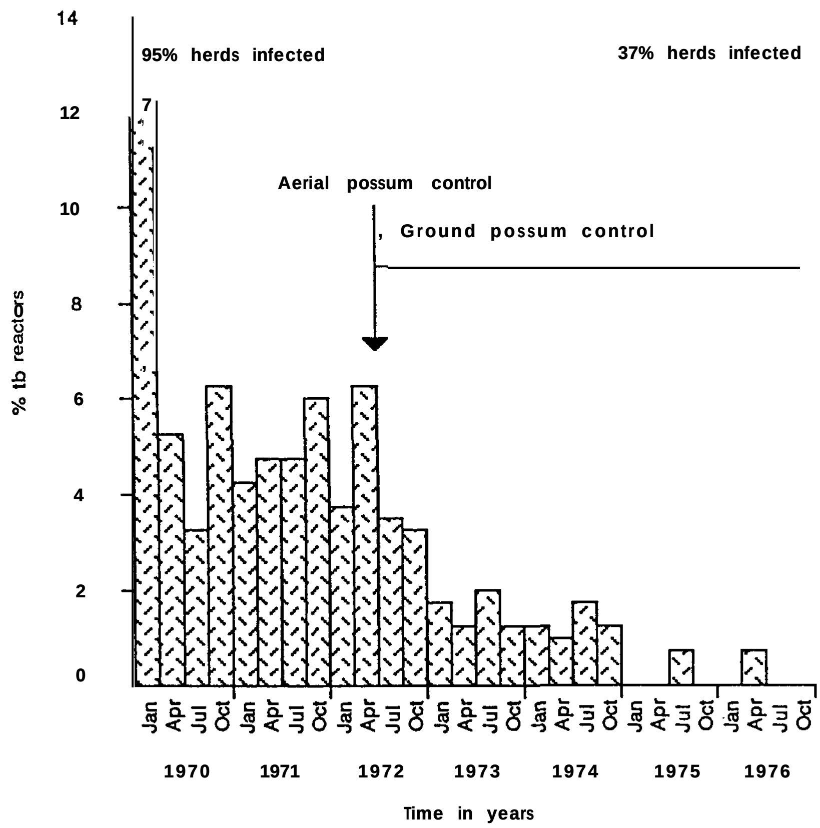
1 Nelson, 1992; Morris *et* al, in press.
2 Morris *et al,* 1993; Pfeiffer and Morris, 1991.
3 Anon, 1986.
4 Ryan, 1990.
5 Livingston, 1991.

Figure 3.1 Effects of possum control on cattle Tb reactor rate in Buller South, 1970-82



Source: Surveillance, 1986, Vol. 13 No.3, p.5.

It has now been established that a Tb endemic area may contain on average **2-5%** tuberculous possums but there are likely to be foci of highly infected possum populations with up to 60% infected with Tb in a small area, while a neighbouring group some 50 or so metres away may not be infected. Huge sample sizes are sometimes required to find tuberculous possums even in endemic areas, and routine monitoring for Tb in possums is expensive.[6]

Interaction opportunities between possums and livestock

Possum densities are higher in forest/pasture margin habitats (up to 25/ha) which provide good den sites and access to highly palatable vegetation, and the prevalence of Tb in such possums is higher in comparison to possums deeper in the forest where densities range from 2-10/ha depending on forest type. However possums within the forest will travel up to 1.5 kilometres through forests to feed on pasture.[7] Coleman has found, in contrast to previous studies, a possum population in which Tb appears to be widely spread through the possums in the area and the prevalence of infection did not

[6] Hickling, 1991.
[7] Coleman, 1988.

decline with distance (1.5 km) into the forest! The reasons for the observed spatial change in disease prevalence are unclear and further long-term study in the area is suggested. Possums denning near the pasture margin spend 50% of their time out on pasture, and Brockie found possums regularly moved 1.5 km from cover across cattle grazed land foraging over a home range of up to 105 ha.[9]

The spread of Tb between possums and cattle is believed to be direct and achieved by possums exhaling Tb bacteria in close proximity to cattle. Cattle being naturally curious may become infected by licking tuberculous possums found on pasture[10] or eating hay that has been contaminated from possums with open lesions.[11] Further research on Tb transmission is underway.

The behaviour of possums, their density, interaction with livestock and their susceptibility to Tb, together with population levels at the forest pasture margin and being highly infectious once Tb lesions have developed, contribute to the risk of possums as a vector of Tb.

3.2 Other vectors of Tb

Bovine Tb can occur in other wild animals such as deer, pigs, goats, cats, ferrets and stoats. Locations of tuberculous animals coincidental with outbreaks of Tb in livestock are summarised in Pigure 2.3. The role of these animals as true reservoir hosts, or simply as spillover hostsremainsuncertain. Spillover hosts may be dead end hosts or capable of transmitting infection as long as the disease is maintained by seeding of infection from true reservoir hosts. The true significance of these other hosts needs further investigation.[12]

Tb occurs commonly in feral deer which appear to be more infectious to other species than cattle are, possibly falling at the high end of the range of sources of infection for other species.[13] There is both clear cot and circumstantial epidemiological evidence fromvarious incidents in New Zealand of the deer's ability to initiate new foci of infection in possums. Also the mobility of deer suggests the potential to initiate new foci of disease a considerable distance from previous areas. Morris notes that live capture of deer and transfer to captive deer populations probably provided a means of introducing infection into areas which previously had been free of Tb.[14] A recent survey of feral deer for Tb, carried out predominantly in the wild animal recovery zone of the Hauhungaroa Range, found Tb-infected deer were widely distributed over the whole range with 27% of those shot being infected with Tb.[15]

A recent survey of new populations of mammals which have become established as a result of unintentional and deliberate liberations in New Zealand,

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8 Coleman et *al*, 1993.
9 Brockie, 1991.
10 Morris *et al*, *in* press; Moresby, 1984 p.89.
11 Nelson, 1992.
12 R.S. Morris, Massey University, pers. comm., 1994.
13 R.S. Morris,Massey University, pers. comm., 1994; Davidson, 1989.
14 Morris *et al*, in press; O'Hara, 1993.
15 Hutchins, 1993.

has determined that of the new populations (n=222), most (n=83) appeared to have resulted from farm escapes and (n=57) from illegal liberations. Of particular concern were sika deer spread by hunters, and farmed deer lost or released by farmers in endemic Tb areas. Covert movement of deer and pigs from areas where bovine Tb is endemic to previously clear areas has major implications for controlling the spread of Tb. A major education campaign and the requirement to report escapes and Tb status of deer was recommended.[16]

Wild cattle and those which escape from farms into bush areas have the potential to maintain a wild reservoir of Tb infection if they are not destroyed or recaptured.

High incidences of Tb in wild pigs have been found in some areas and the disease has also been found in feral goats, though rarely. The role of pigs and goats as transmitters of the disease is generally considered to be minor as their contact with other susceptible species is thought to be low. Sheep have also been infected but the incidences are so low as to be negligible."

The disease has also been diagnosed in ferrets, weasels, stoats and cats and it would appear that at least some of these animals catch Tb from eating tuberculous animals. Tuberculous ferrets were found associated with the expansion of one of the Tb endemic areas during 1992/93 and ferrets and cats have been associated with a number of cattle herd breakdowns in one of these areas.[18] The AHB now consider that in rabbit prone country, ferrets are likely to be the major vector of Tb for cattle and deer. Williams contends that there has been a relatively slow acceptance of the potential role of other vectors by veterinary interests.[19] He considers that the wide distribution of ferrets and the prevalence of Tb in ferrets in some areas highlights a potential additional vector problem which if required to be managed would lead to increases in rabbit numbers over extensive areas of New Zealand. Research into the tuberculous status of predators is being carried out. Interim results indicate that bovine Tb-infected predators appeared to be in localised areas and on properties with recent histories of reactor cattle, although not all properties with reactor cattle apparently had infected predators.[20]

3.3 *Tb* monitoring

The results of cattle and deer Tb testing can be used as an indicator of the location of the Tb 'front'. Where these animals are not available, for example in the Kaingaroa Forest, identification of the 'front' can be difficult. In such cases examination of feral deer and possum carcases is needed. However, because of delays in the development of clinical symptoms, such monitoring may underestimate the movement of the 'front' by two to five years and also would require examination of very large numbers because of the low preva-

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16 Fraser, 1994.
17 Ryan, 1990.
18 Allen, 1991; Livingstone, 1993.
19 M. Williams, MAF Policy, Lincoln, pers. comm., 1994.
20 Cowan, 1993(a).

lence of the disease. Predator species may offer advantages here because they tend to 'concentrate' infection (hence have higher prevalence) due to consuming other tuberculous animals.[21]

Detection of the spread of Tb in the feral population can also be signalled by identification of infection in a closed and previously clean herd. However there is a built-in time-lag, both from the frequency of testing and the extent of livestock/possum interaction. Allison notes that possum trapping and autopsy will give earlier warning of possum infection than cattle and deer testing if sufficiently large numbers of possums are examined.[22] The major reason for the extension of endemic areas is the migration of young infected possums, feral pigs and deer into adjacent Tb clear areas.

The sensitivity of the Caudal Pold test for bovine Tb in cattle is only 70-80% which means that on occasion up to 20-30% of tuberculous animals may be left behind in a herd at the time of any one test. But the test's sensitivity in diagnosing Tb in a *herd* rapidly increases to over 95% as the number of infected animals in the herd increases. However the test is considered to be 99.5% specific. That is, only about one animal in 200 without Tb will have a positive reaction to the test. Evaluation of alternative tests has not identified any which improve sensitivity while maintaining the high specificity of the current test. Work is also being carried out to improve the identification of Tb infected deer currently determined from cervical skin tests.

Only about 50% of the reactor cattle have visible Tb lesions identified at slaughter, but Australian research has shown that as many as one third of reactors without visible lesions at slaughter were infected with Tb. Therefore even if no lesions are found at slaughter, the conservative management of herds with strong diagnostic indicators of infection should continue.[23] The results of inspection for visible Tb lesions in reactor stock sent for slaughter are forwarded to the local MAP Quality Management office and these results are available to the farmer if requested.

Allison suggeststhat with the widespread infection ofpossums withTb being a constant source of reinfection of livestock in many areas, the main concern should be the control of the possum population rather than a concern over the moderate sensitivity of the Tb test."

Current regulations under the Animals Act 1967 (which have been saved under the Biosecurity Act 1993) require a herd in which Tb is believed or suspected to exist, as a result of testing or identification of lesions during carcass inspection of stock routinely sent for slaughter, to be placed under movement control. This requires all animals over three months of age leaving the herd to have a MAP-issued Permit to Move, and (except if going direct to slaughter) to have a Tb test before and after movement and be tagged with an

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21 R.S. Morris, Massey University, pers. comm., 1994.

22 Allison, 1993.

23 Ryan *et al*,1991.

24 Ibid.

official white eartag. Deer in an infected movement control herd[25] may only be sent direct to slaughter. Cattle and deer from Tb-free herds in a designated movement control area (determined on the basis of Tb risk), such as the Wairarapa, also require a pre-movement test but do not require a post-movement test or the white tag. Regardless of the herd or area status all movements of cattle and deer over three months of age must be accompanied by a Tb Declaration Card.

MAR considers that, despite concerns about the accuracy of the current Tb test and the possibility of leaving a source of infection in a herd, the current test and slaughter procedures, and sensitivity are adequate to eradicate Tb from a herd over a two to three-year period, given controls on reinfestation from outside the herd. This has been achieved in non-endemic areas of New Zealand and for countries where there is no feral reservoir of Tb.

MAR is continually monitoring herd ownership and checking districts to ensure all properties with animals of concern regarding their Tb status are identified, and the appropriate monitoring and control systems, such as ensuring the house cow is tested, are in place. The Tb control scheme relies on the surveillance of all eligible stock and farmers have a responsibility to ensure this occurs.

MAR Quality Management under contract to the Animal Health Board is instigating a detailed compliance monitoring of the new movement control regulations and particularly the use of the Tb Declaration Cards. These will include a daily comparative audit of cards and lines of stock delivered to meat works for slaughter, targeted monitoring of public sales, with priority accorded to sales in designated movement control areas, and a statistically determined procedure for monitoring trucking records, particularly targeting direct movement between properties (e.g. private sales) from declared movement control areas. Random checks to confirm the accuracy of Declaration Card information will also be carried out. The regulations and legislation provide the ability for inspectors to place a legal hold on stock not complying with the Tb Declaration Card requirements, including a requirement for their return to the farm of origin and for substantial fines.

3.4 Epidemiological models

A number of computer models have been developed and are being further refined to more accurately define what needs to be done to control Tb within both the possum and farm animal populations. The Barlow model depicts endemic Tb in possums and models the impacts and persistence of Tb in the population given the patchy location of the disease, and various population parameters and control efforts.[26] This model forms the basis of the current policy for Tb possum control operations: a possum knockdown of the order of 70% of the existing population density, followed by the maintenance of that reduced density through regular maintenance control to keep the popu-

[25] These are herds which are yet to have a clear herd test following the identification of lesions during routine inspection at slaughter, or a positive reactor during herd testing.

[26] Barlow, 1991(a) and(b),

lation below 40% of the initial pre-knockdown population for at least six to eight years, is postulated to eradicate tuberculosis within that population. The model also requires no further introduction of Tb into the population from outside sources such as migrating tuberculous possums or other wild animals, or contact with diseased livestock.

The concept of the model is that a disease will not spread if the population is maintained below the threshold of disease persistence, which is suggested to be 40% of the equilibrium density or carrying capacity of an area. This may be achieved by a large initial kill and regular 'maintenance control', or by the annual removal of 18% of the population assuming no immigration. It is suggested that the carrying capacity is based on the availability of denning sites rather than an absolute feed availability, and the impact of reducing the population will be to thin out the sharing of den sites and thus reduce the social interaction among possums.[27] Nationally an 18% kill is equivalent to 12.5 million possums per annum on the assumption of a total population of 70 million. The model has also been used to evaluate the likely success of vaccination[28] and biological control of possums,[29] and has been extended to predict epidemic spread and evaluate policies for containment for Tb.[30]

Hickling, in reporting on a trial evaluating whether annual control of possums in line with Barlow's model can maintain low levels of Tb among possums and cattle, found disease transmission in the residual possum population was reduced as was the incidence of Tb in cattle.[31] However in an interim report Hickling commented on the relatively small area being controlled and noted the rapid build-up of possums in the forest/pasture margins, which required a more intensive control effort to maintain the target population densities.[32] This faster than predicted recovery in preferred habitats suggests that in the long term, the proposed control may be less effective than Barlow's model predicted. Barlow has discussed the effect of buffer zones, noting that under the currently recommended intensity of control and the small size of areas covered, currently recommended buffer zone widths may, if possum densities are high, have little ultimate effect on disease spread.[33] Buffers which approximate the maximum juvenile dispersal distance (12 km) appear to be more cost effective than buffers of 3 km or less which are currently used.

MAP epidemiologists have prepared a second model, initially based on Hamilton veterinary district databases, which describes the epidemiological parameters required to manage and control Tb, and reduce the movement control prevalence in non-endemic areas to 0.2%. This model demonstrates that despite increasing testing and monitoring effort within herds, Tb cannot be eradicated below a certain level if there is continuing infection from an external source such as diseased possums or other feral vectors.[34]

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27 Barlow 1993.
28 Barlow, 1991(b).
29 Barlow, in press.
30 Barlow, 1993.
31 Hickling, 1993.
32 Hickling, 1991.
33 Barlow, 1993.
34 T. Ryan, MAF Quality Management, pers. comm., 1994.

A model which includes geographical characteristics is **PossPOP,** developed at Massey University. This model uses probabilities to simulate. the daily events a possum is exposed to which are considered important for Tb disease transmission and possum population dynamics. Further refinement of the model is required, but comparison with field research results suggests the model has potential for investigating the epidemiology of bovine Tb in possum populations at farm, district and regional levels?'

A further geographically based model, Geoposs, is being developed by Efford as a tool to help manage conventional possum control. This is a spatially explicit model of possum populations, with no epidemiological component. It is intended to identify locations and intensity of control required for particular conservation or farming objectives, by using annually updated possum density maps, derived in part from habitat maps which are a function of local landscape patterns and vegetation. These maps are extrapolated from one year to the next, on the basis of expected natural changes in the population or the effects of localised possum control operations such as a 1080 poison drop along a pasture edge, and in this regard may have a place in predicting the effects of recent control efforts.[36]

3.5 Farm management strategies to limit *Tb infection*

Farmers' perception of the risk of Tb to their enterprise will be modified by their past experience with the disease. Por cattle farmers the impact of an outbreak of the disease will have been mitigated by the compensation scheme for animals slaughtered as reactors. Currently this is 85% of fair market value for farmers in designated movement control areas, or 45 % of fair market value if in surveillance areas. The difference in compensation is intended to act as an incentive for surveillance area farmers to be more Tb risk averse, and maintain the Tb clear status of the area. Compensation for cattle reactors is proposed to cease in 1995 which will be a further incentive for farmers to avoid the risk of introducing Tb. Deer farmers, however, have never had compensation for reactor animals and so, at least while stock prices were high, may have been more consciously averse to the risk of introducing Tb into their herds. There is some market discrimination against stock with white movement control herd tags, with cattle prices being discounted in the sale yards by $30 to $70/head, and paddock sale cattle buyers have been known to cancel their visit if a property is on movement control.

The financial implication of a single Tb reactor for a cattle farmer is not great and in surveillance areas the probability of it occurring is less than four in 1000, so the perception of risk is correspondingly low. The probability of an incidence of Tb on a farm in an endemic area is much higher (16-20 chances in 100)[37] and farmers' awareness of the issue is greater. Where there are persistent problems, or the value financially or in terms of the breeding effort the farmer has put into the stock are high (e.g. dairy or stud stock), precautions

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35 Pfeiffer et *al, 1993.*
36 M. Efford, pers. comm., 1994.
37 P. Livingstone, pers. comm., 1994.

are more likely to be taken. As one farmer said, 'an individual farmer can survive with Tb • it probably wont send you broke, like rabbits can'.

Farmers can exercise the first point of quarantine in keeping their herd clear of Tb by knowing the Tb history of the stock they purchase. MAF will advise potential purchasers of cattle or deer of the current Tb status and the date of the last Tb test for any herd they are interested in. No stock should be purchased without a Tb Declaration Card. These cards were introduced in October 1992 for stock over 12 months of age inmovement control areas. Since August 1993 they have been required for all stock over three months of age regardless of the Tb status of their originating area.

Of particular concern is the movement of stock to grazing on, or adjacent to, areas with a history of Tb or a Tb-infected feral animal reservoir. If the properties have the same owners or occupiers, the precaution of testing before returning animals home may be overlooked.

Farmers can minimise the potential for wild Tb vector contact by isolating potential areas of feral infection, such as bush blocks, from their cattle and/or deer operations by fencing, provision of buffer areas, and running stock less susceptible to Tb (such as sheep) in these areas. Destroying preferred possum habitat such as old willow clumps and scrub areas (where ecologically appropriate) will remove denning areas and thus reduce the potential carrying capacity of possums. Work is underway at Massey University to develop decision aids for farmers to help them define property Tb risk areas and identify likely Tb possum hotspots where control should be targeted. The systems once developed will be extended to support regional and national possum management decisions. Efford considers pressures to use public money wisely and to minimise unnecessary use of 1080 require the development of precise and effective systems for a more targeted possum control effort.[38]

Hay barns and other infrequently used farm buildings may also provide denning sites, with the possibility of contaminating hay or other stored livestock feed. While in many cases it is not feasible to proof these buildings against wild animals, an active trapping, poisoning or shooting policy in their vicinity may reduce the risk of a Tb breakdown on the property, particularly in endemic areas or where there has been a Tb problem.

A further concern is the recreational hunting and capture of pigs without consideration of general disease hygiene principles. Feral pigs are taken for the table and are often captured for subsequent fattening on farms without consideration of their Tb status. Inadequate offal disposal methods may expose a range of animals to the opportunity for infection." Farmers can limit the extent to which scavenging feral animals such as ferrets, but also pigs and

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[38] M. Efford, Landcare Research, pers. comm., 1994.
[39] R.S. Morris, Massey University, pers. comm., 1994.

wild cats, may become tuberculous, by ensuring any livestock which die on the property are appropriately buried and scavenging animals do not have access to carcases or offal which may have tuberculosis infection.

3.6 Vaccination against Tb

Possums

It has been suggested that vaccination of a defined part of the possum population would lead to a reduction in the number of infected animals and therefore in the risk of cattle becoming exposed to Tb. Identification of a successful Tb vaccine and delivery system for possums is under investigation.[40]

A 'Tb free' possumpopulation, however, would not help protect native plants and animals and may create a healthier possum population and thus more damage to native species. Conversely possum numbers would not be expected torise because the low prevalence of Tb in the total possumpopulation is insufficient to make an impact on population numbers.[41]

Livestock

Development of a test capable of discriminating between infected and vaccinated stock would be an essential complement to the introduction of vaccination of domestic stock, otherwise a vaccination programme would inflate apparent Tb reactor rates.

Vaccination of livestock against Tb would also need to offer complete protection as they would continue to be exposed to new sources of infection if possums and other Tb vectors are not controlled.”

Research on improved testing and vaccination is underway. However epidemiological modelling is needed to determine what the most cost effective vaccination strategy is; possums only, livestock only, livestock and possums, or livestock and all vectors.

In common with vaccination of the possums themselves this approach would have no impact on the possum population and their effects on the diversity of New Zealand's flora and fauna, or on the spread of Tb within the possum population.

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40 Barlow, 1991(b); NSSCP, 1993(b).
41 R.S. Morris, Massey University, pers. comm., 1994.
42 Morris *et al, 1993.*

4 The Legal Framework For Possum Control Measures

4.1 Introduction

Tables B.l-B.3 in Appendix B indicate the complexity of the legal framework which has hitherto regulated possum control measures and which to a considerable extent still dictates the parameters for such operations as conducted by the Department of Conservation, local authorities, and the Animal Health Board.

It has been convenient to divide the statutory provisions as follows:

- Table B.l focuses on the provisions which provide the jurisdiction for possum control, in terms of conservation, agricultural management and environmental management;
- Table B.2 sets out the provisions which establish a regulatory framework relevant for possum control, whether as a responsibility of the Department of Conservation, of local authorities, or of the Ministry of Agriculture and Fisheries;
- Table B.3 deals with the provisions which regulate the means of possum control, in particular the use of pesticides, hunting and considerations of animal welfare.

The following sections address particular difficulties or legal issues which have emerged during the course of the investigation, and do not purport to deal with all the legislative provisions governing possum management, nor to deal with them with equal emphasis.

4.2 The principal statutory provisions

As Tables B.l-B.3 indicate, the legislation governing pest control has tended to develop by a process of accretion, relying on a cumulative approach. The philosophy and procedure now provided by the Resource Management Act 1991 (RMA) and the Biosecurity Act 1993, promote an integrated approach which may be applied to the problems and issues which arise in relation to possum control.

Cost-effective possumcontrolmay often require 'concerted and simultaneous action' of all the relevant authorities (in the words of the Wild Animal Control Act 1977), employing all the relevant statutory powers to deal with the possum problem from both a conservation and an animal health perspective. The Biosecurity Act facilitates that approach, since it does not override specified statutes, including the Wildlife Act 1956, the Animals Protection Act 1960, the Wild Animal Control Act 1977, the Reserves Act 1977, the National

Parks Act 1980, the Conservation Act 1987 and the RMA (section 7, Biosecurity Act). Thus, where a pest management strategy (PMS) is implemented, the provisions of those Acts will apply as well as those of the PMS approved under the Biosecurity Act. However, it should be noted that pest control or management are not mandatory under any existing legislation.

4.2.1 The Relationship between the Resource Management Act, the Biosecurity Act and other relevant Acts

The RMA sets up a philosophy of environmental management which is relevant to the issue of possum control. Although the Act gives no specific jurisdiction for pest control, in some circmnstances pest management may be a necessary aspect of a region's or district's sustainable management of its natural and physical resources.

The Act also sets the limits and restrictions on the use of natural and physical resources, and measures all activities in terms of their environmental effects. Thus, where possum infestation has effects in terms of land use, or where possum control measures involve the use of pesticides, the restrictions of the RMA as to land use, the use of the coastal marine area or of the beds of lakes and rivers, and as to discharges, may apply.

To give effect to the RMA, regional and territorial authorities are empowered to establish, implement and review objectives, policies and methods to achieve respectively integrated management of the resources of the region and management of the effects of the use, development or protection of land and the associated natural and physical resources of the district. Councils could therefore have an onus to provide policies and plans where possum infestation has adverse environmental effects, or gives rise to economic or health risks. That onus, however, is subject to the jurisdictional limitations of sections 30, 31, and to the analysis required by section 32. Regional council powers are also subject to the consent and approval of the Minister of Conservation under sections 30, 31 of the Wild Animal Control Act before undertaking or expending funds on wild animal control. There is thus a fundamental lack of clarity in the **RMA** as to the functions and responsibilities of regional councils and territorial authorities and the extent to which they can impose positive duties on landowners or undertake the functions of pest management except under other Acts. There needs to be clear and explicit wording in the **RMA** as to the jurisdiction of local authorities in respect of land use in the context of pest management.

Under the 1992 reorganisation of local government, pest management planning and operations became a function of regional councils in their role as successors to the former pest destruction boards. Section **37S(1)(b)** of the Local Government Act 1974, as substituted by section 6 of the Local Government Amendment Act 1992, gave the authority for that jurisdiction (see also Table B.2). The effect was to confer on regional councils the powers of pest destruction boards to undertake pest management and to recover the costs of operations. That authorisation has now been amended by the Biosecurity Act, which deletes the reference to the functions of pest destruction boards, and provides for the functions of regional councils and unitary authorities under the Biosecurity Act (section **168(1)** and Fourth Schedule). There is no transitional saving of the former jurisdiction of regional councils as successors to pest destruction boards. The Biosecurity Act may not, therefore, provide regional councils with the jurisdiction to undertake pest control except under a PMS. However, the Biosecurity Act does not rule out the functions of the regional council to undertake wild animal control under the Wild Animal Control Act, subject to the consent and approval of the Minister of Conservation pursuant to sections 30, 31 of that Act.

The Biosecurity Act provides the principal avenue for regional council involvement in pest management. This Act, which is administered by the Ministry of Agriculture and Fisheries (MAP) as the Ministry of the 'responsible Minister', establishes a framework for undertaking pest control measures and for assessing the benefits of suchmeasures. It empowers but **does not** compel *'the exclusion, eradication, and effective management of pests and unwanted organisms'*, by means of national or regional pest management strategies (PMS) which can be used to target any unwanted organism, including possums or the Tb organism or both. Where pest management is undertaken pursuant to such duties and discretions, and there is a relevant approved PMS in force, pest management must be undertaken in accordance with that PMS (section **55(** 1)).

Because of the operation of section 7 of the Biosecurity Act, if any given exercise of the powers under the Biosecurity Act involves activities which are restricted under the RMA, then they will be subject to the provisions of the RMA and the relevant plans and rules made under it. The same is true for activities subject to the other Acts preserved by section 7 of the Biosecurity **Act.** A PMS cannot override the provisions of the Acts listed in section 7. The requirements of the Wild Animal Control Act 1977, for example, will be imported into operations under the Biosecurity Act.

The Biosecurity Act does not contain any specific powers to impose an obligation on owners or occupiers of land to manage, eradicate or control pests that could have an adverse effect beyond the boundaries of that person's land. However, it is implicit that the Act contemplates such an approach since it requires a PMS, if it is going to impose such obligations, to be specific as to what those obligations will be (sections **60(f)** and 76(f)). In thisrespect the Act is less direct than the Wild Animals Control Act or the Agricultural Pests Destruction Act, both of which have (or had) specific powers to impose obligations on owners or occupiers (see Table B.2).

A pragmatic approach is needed to achieve integrated procedures for pest control. One such approach would be for regional and territorial authorities to formulate *rules in* plans classifying as *permitted* any activities required for the operation of a PMS or by DOC under its Acts, such as the use of pesticides. The rules could include performance standards to cover the requirements of other relevant legislation and measures needed to satisfy the reservations and objections of the public and of those who have the responsibility for pest control. In this scenario, environmental assessment and public consultation would be central to the process of preparing and changing regional and district plans, and full evaluation of the effects of the activities should precede the settling of the rules. As a back up, the enforcement and abatement procedures under the RMA enable the Planning Tribunal to make orders to uphold the general duty of section 17, including a requirement for positive action where there are adverse effects on the environment arising from an owner's (or occupier's) use of land (section 314(1)(da)).

4.2.2 Two levels of pest management under the Biosecurity Act

The Biosecurity Act envisages two levels or forms of PMS, national and regional, providing for a distinction based on the effects and implications of the particular pest being targeted.

Funding

At both national and regional level the Act promotes transparency as to the funding basis for a PMS. This is achieved by requiring information at the proposal stage on matters such as the extent to which the persons likely to benefit can be identified and the extent to which any persons, by their actions or inaction, contribute to the problem of the particular pest (sections 61, 77).

It is implicit in these provisions that there is jurisdiction to require persons to meet directly the costs associated with the implementation of a PMS, subject to the tests as to cost benefits and the effects of the pest on other persons (sections 61(2), 77, 97), and subject also to the consultative process that must take place before any PMS is approved (sections 62-68, 78-80).

There are also express provisions for funding a PMS, one by means of levies the other, which applies only to regional PMSs, by rates.

Levies: sections 90-96

Levies may be imposed by Order in Council on the recommendation of the responsible Minister, subject to the safeguard for those affected, that no order shall be recommended without the appropriate consultative process; nor without the Minister being satisfied that the levy is the most appropriate means of funding the PMS. A number of criteria are provided. The Act enables this method of funding to be applied to any PMS, national or regional, but a regional council may not impose a levy, other than as authorised by Order in Council on the recommendation of the responsible Minister.

Rates: sections 77, 97-99

Only regional PMSs may be funded by rates, provided that method is included in the proposal, and provided there has been adequate consultation with the occupiers of properties to be levied for rates. The rates for a PMS must be levied in a fair and reasonable way, the money so raised must be used in a way related to the interests of the occupiers, and the collective benefits must outweigh the collective costs, having regard to the benefits likely to accrue to ratepayers from the PMS and the extent to which the nature of the ratepayers' properties contribute to the problems of the particular pest. Where it is proposed to fund a regional PMS by rates, the strategy must specify among other things whether rates will be levied as a uniform charge or on a differential basis.

There is no equivalent express rating power covering a national PMS. Ambiguity arises from the fact that the Act, while it does not specifically enable councils to levy rates for this purpose, it does not expressly prohibit a regional council from contributing to a national PMS. This limitation in the Biosecurity Act certainly precludes the Crown from compelling regional councils to provide funding by way of rates for a national PMS. It may also preclude regional councils from contributing to a national PMS. The Crown may therefore fund a national PMS with money appropriated by Parliament for the purpose; or raise levies promoted by the responsible Minister and imposed pursuant to an Order in Council; or it may include in the PMS the funding requirements which are to be imposed on industry or on other interest groups for the purpose of implementing the PMS (sections 60(i), 61, 87, 90-96).

There is also an issue as to whether regional councils are authorised to fund a PMS out of *general* rates, as opposed to using a specifically targeted rate. Section 34A(5) of the Rating Powers Act 1988, as introduced by the Biosecurity Act (Pourth Schedule), excludes regional councils from making rates for funding pest management other than as authorised by section 34A. That provision requires the purpose of the rate to be identified, thus promoting a transparency in rates-based funding. The amendment does not expressly rule out the use of the general rating power for any PMS (as authorised by section 33 of the Rating Powers Act 1988). However, the scheme of the Act, with its clear distinctions between national and regional PMSs and emphasis on targeted rating, suggeststhat it was not intended that regional councils should use their general rating powers to fund national strategies.

The Ministry of Agriculture and Fisheries advises that amendment of the legislation is contemplated to clarify the ambiguity in respect of the power of regional councils to contribute to a national PMS.[1] The intention of the Act was that regional councils should be able to contribute to a national PMS by way of a targeted rating levy pursuant to s.34A of the Rating Powers Act.

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1 Pers.comm. from C.J. Boland, Deputy Chief Veterinary Officer, MAF Regulatory Authority, 6 April 1994.

4.2.3 Acts under which the Department of Conservation conducts operations

Tables B.l and B.2 set out references to the principal statutory provisions which give DOC its pest management functions and under which it may conduct operations. These are the Wildlife Act, the Wild Animal Control Act, the Reserves Act, the National Parks Act and the Conservation Act.

The Conservation Act provides a philosophy of environmental management directed towards the purpose of conserving New Zealand's natural and historic resources (section 6, Long Title). The other Acts noted complement the overarching purpose of the Conservation Act, and together they provide the framework against which the Department's approach to possum control must be viewed.

Although the Acts administered by DOC establish the means for achieving their conservation purposes,management of historic andnatural resources for conservation purposes will often involve activities coming within the ambit of the RMA and other relevant regulatory regimes such as the Pesticides and Toxic Substances Acts. Thus, where DOC's operations involve activities restricted under the RMA, the requirements of the local authorities will be relevant.

4.3 *Environmental effects* assessment and *Environmental* Protection and Enhancement Procedures

The focus of the RMA is on environmental effects and it relies on the assessment of environmental effects as the basis for its regulatory regime. Where councils prepare or change plans to accommodate the activities of a PMS, it must be done in accordance with the provisions of Part II of the Act (sections 66,76). Evaluation of the plan is also requiredin terms of its function in achieving the purpose of the Act, as set out in section 32. Whilst this provision does not specify analysis of environmental impacts, arguably it encompasses such an analysis no less than do the other provisions of the Act relating to the preparation or change of a plan.

When resource consents are sought, assessment of the environmental effects is required (section 88 and Fourth Schedule, RMA). The goal should be to provide the information necessary to give the community confidence that all environmental risks have been considered and dealt with, and to justify the choice of the particular method of pest management being advocated on the grounds of environmental benefits as well as minimisation of costs.

The Biosecurity Act requires attention to the environmental effects which are anticipated when a PMS is proposed, with a summary of possible side-effects of the PMS on the environment. The focus of these matters set out in the First Schedule is narrower than the environmental effects assessment required by the Fourth Schedule of the RMA, being limited to matters relevant to pest management.

Where the Crown is involved in pest management activities for which district plansrequire resource consents, assessment of environmental effects will take place in accordance with the RMA, unless the activities come within the narrow exemption to land restrictions available for the Crown under section 4(3) (see Table B.3). There is no exemption for the Crown under the Biosecurity Act except as to obligations and costs for a regional PMS unless those obligations are provided for by Order in Council.

If Crown-funded possum control operations are conducted outside the RMA and Biosecurity Act, or if resource consents are not needed under the RMA, the Crown is nevertheless bound by the duty imposed on government departments under the regime of environmental protection and enhancement procedures (EP&EP) to ensure that 'the process of environmental impact assessment and, where appropriate, environmental impact reporting is to be applied to the works and the management policies of all government departments which may affect the environment'.[2]

The requirement for that assessment applies to all works and policies of government departments or statutory boards, or which are otherwise funded by money appropriated by Parliament and 'which may affect the environment'. Adoption of the format of the Pourth Schedule of the RMA, in place of the format of EP&EP, could be a way to encourage consistency with the RMA procedures where they apply.

4.4 Pesticides as 'contaminants'

Debate has surfaced on the use of the pesticide 1080 in possum control operations, and in particular on whether its use constitutes a discharge of a 'contaminant' such as to require discharge permits in addition to the permissions required under the Pesticides Act 1979 and the Pesticides (Vertebrate Pest Control) Regulations 1983. This question only arises in practice in respect of the aerial application of pesticides, since in those operations there is a strong likelihood of the substance finding its way into water from an aerial drop.

The RMA defines a 'contaminant' on the basis of the effects of a substance, that is, by reference to whether it changes the land, air or water onto or into which it is discharged. DOC has taken the view that the scientific evidence of the effects of 1080 when it enters water does not support classifying the substance as a 'contaminant' for the purposes of the RMA: the impact is so minimal as to be outside the scope of the definition. If that approach is correct, then discharge permits will be irrelevant, since the restrictions of section 15 of the RMA only apply to 'contaminants'.

Arguably the definition of 'contaminant' is wide enough to include substances having no more than a minor impact on water quality. If the *de minimis* approach is not accepted, then discharge permits must be obtained if the contaminant could enter water, as is the case in aerial applications, unless regional plans contain rules which classify the use of 1080 in such circumstances as *permitted.* The implication of this provision is that without such rules in plans, discharge permits will be necessary for aerially applied 1080

2 Ministry for the Environment, 1987, p.1.

bait. However, if a regional council is satisfied that the discharge of 1080-impregnated bait would not create any of the environmental effects listed in section 70(1), then *the* circumstances for classifying its use as *permitted* would be met.

The position for ground-laid bait or for bait dropped aerially onto land would be different where the contaminant could not enter water. It would involve only a discharge to land and would come within the restriction of section 15(2), which requires a discharge permit only if the activity is restricted by rules in plans.

Other statutory restrictions

Where the use of 1080 by ground or aerial application is permitted by a rule in a plan or by a discharge permit, operators will still need to comply with the requirements of the Pesticides Act 1979 and the Pesticides (Vertebrate Pest Control) Regulations 1983, the Toxic Substances Act 1979 and Toxic Substances Regulations 1983, the Civil Aviation Act 1990 and Civil Aviation Regulations 1953, and the Health Act 1956. Moreover, those requirements have to be met whether or not the 1080 bait is a'contaminant' for the purposes of the RMA.

The controlled pesticides 1080 and cyanide are classified as 'deadly poisons' and phosphorus as a 'dangerous poison' under the Toxic Substances Regulations 1983. There are also strict controls on all aspects of the use of those pesticides imposed under the regimes of the Pesticides Act and Toxic Substances Act (see Table B.3). Although there may be a different statutory purpose involved under those regimes, it may be more consistent with those regulatory regimes to recognise 1080-impregnated bait and other controlled pesticides as 'contaminants' within the meaning of the RMA and to deal with them under the procedures of that Act, either within the resource consent process or by way of rules in plans, and where appropriate, subject to compliance with suitable performance standards.

Land use restrictions

If the relevant pesticides are not classified as 'contaminants' for the purpose of the restrictions on discharging substances, the activity of depositing them on land could be covered by restrictions on land use under section 9 of the RMA. The deposit of any substance on land is a land 'use' as defined in section 9(4), and therefore susceptible to control by local authorities, subject to the jurisdictional limitations of local authorities already noted.

Summary

The approach argued for in this section would ensure that the nature of possum control poisons as 'contaminants' is acknowledged, whilst also enabling local authorities to make their own rules on the basis of their interpretation of the significance of the environmental effects of these substances.

4.5 Statutory permissions for dealing with toxins

4.5. I Pesticides (Vertebrate Pest Control) Regulations 1983

Regulations 12(1) and (3) and 13 require permissions to be obtained by those undertaking pest management before any controlled pesticides such as 1080, phosphorus or cyanide may be applied to land aerially or by way of ground bait in 'restricted' areas, or in the case of aerial applications, to any other areas. That requirement is independent of any requirement to obtain resource consents under the RMA.

Where controlled pesticides are to be applied by any means, whether aerially or by ground-laid bait, to areas defined in regulation 12(1) as 'restricted', permission has first to be obtained from the Medical Officer of Health (MOH) for the district. The officer must be satisfied that the application will not contravene the requirements of the Health Act 1956, the Toxic Substances Act 1979 or the Regulations themselves. Where that test is satisfied, the MOH has no discretion but to grant permission (regulations 14, 15).

A second permission is required from the appropriate controlling authority as set out in regulation 12(3). In particular regulation 12(1)(d) and (3)(c) requires the controlling local authority, that is the regional, district or city council (as defined in the Local Government Act), to be responsible for permissions for the use of controlled pesticides inside or within 400m of the boundaries of areas or districts controlled by city, borough, district or town councils. This provision in the Regulations raises a question as to whether it requires approvals from both territorial and regional councils for every operation or just for operations within 400m of an urban boundary.

A further possible anomaly arises as to the scope of catchments as 'restricted areas, as set out in regulation 12(1)(f). For the purposes of the permission required from the MOH, the restriction applies to 'any catchment from which water is drawn for human consumption'. The area is not limited to areas of the catchment used for community water supply. The MOH's jurisdiction under the Health Act, however, relates to the water supply of a local authority (see Table B.3), and thus appears to benarrower than that under the Pesticides (Vertebrate Pest Destruction) Regulations.

Regulation 16 sets out a two-fold test to be applied by the appropriate controlling authority for any application of a controlled pesticide in restricted areas. First, whether permission has been obtained from the MOH; and second whether the application of the pesticide 'will cause harm or inconvenience to the public'. If those tests are satisfied, then the appropriate controlling authority must grant permission.

For ground application of controlled pesticides outside 'restricted areas', no permission is required under these Regulations, but for aerial applications outside'restrictedareas',permissionmust beobtainedfromthe MOH, andthe local police must be informed unless the controlled pesticide is being applied to land by the occupier of that land.

Both the MOH and the controlling authority may grant permissions subject to any conditions. Non-compliance is an offence under regulation 28(l)(c). The Regulations are silent as to where responsibilities lie for monitoring compliance with any conditions or for resourcing such monitoring. The penalty for non-compliance with the restrictions of regulations 12(1) and 13, including infringement of any conditions, is a fine not exceeding $2000.00 and $200.00 per day for a continuing offence. The point should be made that penalties under the Pesticides legislation are now well out of line with the scope of the penalties available under the RMA and Biosecurity Act.

Regulation 16 of the Pesticides (Vertebrate Pest Control) Regulations 1983 sets out the requirements for a permission from the controlling authority, that the authority must be 'satisfied' that application of the controlled pesticide 'will not cause harm or inconvenience to the public'. Interpretation of that test may be problematical, since the regulation does not specify how the authority is to ascertain whether the public will be harmed or inconvenienced, the kinds of 'harm' that will be relevant, the degree to which it must be experienced, nor from whose perspective it will be judged; the same is true for the test of 'inconvenience'. Certainly the test of 'harm or inconvenience' applies only to 'the public'; but the Act gives no assistance as to the appropriate level of consultation needed to ascertain whether there will be any 'harm or inconvenience'.

Whilst the test of reasonableness will often assist, the difficulties could be corrected if the regulation were to spell out criteria for the test of harm or inconvenience to the public, with assistance in terms of the consultation that must be undertaken, the relevant matters for consideration and the scope of the test to be applied. In the interests of certainty, measurable standards are needed for the guidance of authorities.

4.5.2 Duplication of permissions

Concern has been expressed that the requirement for permissions from both the MOH and the appropriate controlling authority involves an unnecessary duplication, in that both permissions are regarded as covering predominantly public health and safety issues. However, another perspective is to regard the regulation as providing for complementary supervision rather than a duplication of roles. Health and safety issues are not the exclusive focus of the controlling authorities as they are of the MOH. Since 'harm and inconvenience' are not defined in the legislation, they can include matters such as social and economic factors which are not encompassed in the MOH's jurisdiction.

Resource Management Act

In addition to the dual permissions required under the Pesticides (Vertebrate Pest Control) Regulations, there is also potential for duplication of matters to be considered in allowing the use of controlled pesticides where land use consents and discharge permits are required under the RMA. There is scope for a range of impacts on the environment to be taken into account, including factors such as public health and safety, and the social and economic wellbeing of people and communities.

A dual licensing *regime*

As shown in Table B.3, there are tworegulatoryregimes controlling who may use or otherwise deal with toxins such as 1080, phosphorus and cyanide. The Pesticides Act classifies these substances as 'controlled pesticides' and requires operators to be 'approved' by the Pesticides Board under that Act before they are able to apply for permissions to use those pesticides. Under the Toxic Substances Regulations 1983, 1080 and cyanide are classified as 'deadly poisons', and phosphorus as a 'dangerous poison'. The Act sets up a licensing regime under the administration of the district Medical Officer of Health for all who use, sell or deal in various other ways with such substances. A MOH, in determining an application for a permission under the Pesticides (VPC) Regulations, must check compliance with the Toxic Substances Act, including the licensing of persons who use and deal with toxins under that Act.

Summary

Consideration should be given to integrating the various regulatory regimes covering the use of toxins, so that unhelpful duplication of permissions is eliminated, while also ensuring that the legislation provides appropriately for all relevant matters to be considered. Similarly, rationalisation is needed of the requirements as to licensing or otherwise approving operators for the use and other activities associated with toxins.

4.6 Rights and responsibilities of 'neighbours'

In the context of pest management, issues as to the rights and responsibilities of adjacent landowners/occupiers to each other may arise in relation to neglecting pest control and equally to using pesticides for pest control.

These situations are principally governed by the common law of negligence and nuisance. The first imposes a duty to act as a 'reasonable and prudent person' in relation to one's 'neighbours'. In principle, negligence could arise where an occupier undertakes pest control so inadequately as to cause foreseeable damage to the property of others. It could also occur in the course of using methods of control, as by failing to take reasonable care to prevent pesticides being applied on a neighbouring property without giving notice. Nuisance entails either damage to private property or infringement of a public right which causes 'injury' to the public.

Experience indicates that in the management of pests, the scope and difficulties are such that public authorities need to be involved in the task, since coordination is integral to the success of the management strategy. Although landowners or occupiers are responsible for their own pest management, and have a duty not to cause damage to their 'neighbours', the reality is that regulatory arrangements are required because a *laissez faire* approach by one owner/occupier may well negate the benefits of management measures undertaken by adjacent owners/occupiers and by the wider community. The enforcement regime under the RMA may provide another option, of enforcing the duties which arise under section 17.[3]

Options for individual occupiers

A question has arisen as to whether occupiers can avoid any measures of a pest management arrangement put in place by any agency, or avoid a pest control scheme altogether if it imposes a method unacceptable to the occupier. The Animal Health Board, for example, has accepted that not all landowners want 1080 poison used on their properties.

Neither the Wild Animal Control Act nor the former Agricultural Pests Destruction Act makes explicit provision for occupiers to reject any particular method of pest control, nor ultimately the imposition of pest control on their land, although both Acts contain certain limitations on the powers of the responsible agencies, and both leave open the possibility of landowners putting in place other options for possum control.

In the case of operations conducted under the Wild Animal Control Act, the Director-General of Conservation may authorise entry on to private land to investigate and undertake pest control, with the permission of the owner/occupier or after due notice where permission is declined, provided the Minister is of the opinion that wild animals are causing or likely to cause injury or damage to land, native flora or fauna etc. (section 16; see Table B.2). The provision allows operations to be undertaken subject to prior consultation with the occupier as to what measures are authorised and provided the measures 'will not unduly affect farm management or cause the occupier undue hardship'. Other than that rider, there is no provision for occupiers to contract out of measures imposed under the Act, but the Act does not deny the option of occupiers reaching agreements with DOC agents as to the appropriate system of pest control, based on the results of environmental impact assessment.

The Agricultural Pests Destruction Act has now been repealed, but the transitional provisions of the Biosecurity Act saveuntil June 1996 most of the powers of the former elected pest destruction boards (and in certain circumstances officers of MAP) to enter any land and, subject to notifying the occupiers and obtaining their agreement, impose pest destruction measures on occupiers, including the Crown with the consent of the Minister. Costs were recoverable from occupiers as a debt due to the Crown, and from the Crown itself out of money appropriated by Parliament for the purpose. The powers of boards were wide, including the power to remove stock and obtain a Court order for the removal of stock so as to be able to undertake pest control. Under the Agricultural Pests Destruction Regulations 1979, boards could

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3 Section 314(1)(da) provides a relevant basis for such an action. The issue of enforcing a duty arising under section 17 has now been addressed by the Planning Tribunal *2000 Inc v Attorney-General* A16/94, per Principal Planning Judge Sheppard.

prohibit private hunting, trapping, shooting and poisoning of pests on private land for restricted periods of time.

While ultimately the democratic process protected the rights of occupiers, the Act was silent as to their rights to object to any particular measures being taken by boards or by the Ministry. Moreover, the Act created offences for obstructing authorised persons from exercising their powers under the Act. Those provisions suggest that the Act did not contemplate occupiers being able to avoid pest management measures imposed by boards or by MAP under this Act; nor did they prevent individual arrangements being reached, provided the necessary statutory powers were available for any collateral arrangements such as the imposition of costs.

It is known that prior to the Biosecurity Act coming into force some regional councils had established policies in line with recommendations of the Animal Health Board which enable individual occupiers to carry out their own alternative management of possums, subject to performance criteria, and additional funding requirements.[4]

In contrast to the former legislation which in general imposed pest management measures on owners and occupiers, the Biosecurity Act provides an approach which can be broadly described as an 'opting-in one. In principle, a pest management strategy will not come into effect without the cooperation of those affected; nor until there has been a full consultation process as required under the statute.

Balancing rights and responsibilities

The statutory provisions for pest management, whether for the purpose of conservation, or for agricultural, economic or other environmental goals, provide for the balancing of the rights and responsibilities of various persons or groups where there may be a conflict either through compensation or through the process of public involvement.

The Agricultural Pests Destruction Act made some provision for balancing the relative rights and responsibilities of landholders, particularly through arrangements to shift costs. Although at first sight the whole cost of compulsory pest destruction was the responsibility of the occupier (section 104), the Act

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[4] The Animal Health Board recommendations included criteria for landowners undertaking their own control programme. Landowners must undertake in writing: (i) to meet a required minimum target of a 75% reduction in relative possum population or some absolute minimal population level, as appropriate; (ii) that control be undertaken within a defined time period as negotiated with the regional council; (iii) to meet all costs associated with control and any additional monitoring above the estimated cost of the 1080 operation and apportioned share of monitoring; (iv) that if the required reduction is not achieved in the defined time frame, then the regional council is authorised to undertake the operation using any method the landowner requests until the target reduction is achieved, with the landowner paying for regional council control as well as any extra monitoring costs.

Wellington Regional Council adopted these criteria in its policy to allow individual occupiers to undertake possum control on their properties within bovine tuberculosis control operational *areas. Resolution 25 May 1993 of the Council's Rural Services and Wairarapa Committee.*

also gave extensive powers to pest destruction boards to raise funds by rates and levies, with provision for one occupier of any land who had been compelled to pay the costs of destroying pests on the land to recover the appropriate proportion of those costs from other occupiers of the land (section 113). In addition, the Act gave powers to levy differential rates where a ratepayer had undertaken voluntary control, or where there were greater or lesser benefits to be derived from pest destruction by any particular ratepayer for reasons such as the type of land involved (section 72).

The Biosecurity Act continues this approach. It makes a person's actions or inaction relevant to the funding of a pest management strategy (sections 61(l)(b); 77(b)). In the context of a national PMS, the Minister is unable to require persons to meet directly any costs of implementing it, unless satisfied that those persons will reap benefits outweighing any costs or that other persons will be significantly affected by the continued presence of pests on the subject land (section 61(2)). That last test, which must also be addressed in any proposal for a regional pest management strategy (section 77(f)), enables those propounding a PMS to weigh the relative rights and responsibilities of land owners or occupiers and where necessary to impose costs as a means of restoring the appropriate balance.

4.7 Issues of liability and compensation

Under the common law principles of negligence, a person who is found to owe a duty of care to others in carrying out an operation such as pest control, and who breaches that duty so as to cause damage, is liable for the damage so caused. There is also liability at common law for losses incurred by an individual as a result of damage which is the consequence of a nuisance being suffered.

Similarly, a public authority carrying out pest control operations and causing foreseeable damage through negligence or by creating a nuisance to a person could be liable in negligence or nuisance, unless the operation were carried out under statutory provisions which precluded liability on the part of the authority. That situation has been tested in the Court and a pest destruction board found liable for damages when an officer acted negligently in the exercise of statutory powers in relation to pest control.[5]

The defence of contributory negligence is available which could reduce an authority's liability in negligence, as in the situation where an occupier does not exercise the appropriate level of care by allowing animals to return to a poisoned area before it has been declared to be non-toxic.

Statutes authorising the exercise of powers and functions by public authorities have frequently included ouster clauses whereby those authorities will not be liable for damage caused by their officers acting in the reasonable

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[5] *Gordon-Glassford v. Upper Clutha Pest Destruction Board* unreported, DC Alexandra, 20 March 1987, per Judge A.A.P. Willy.)

exercise of their powers under the Act.[6] That exclusion of liability does not apply where negligence is proven and the common law principles of civil liability are applied.

The Civil Aviation Act 1990 addresses the issue of liability in terms of the lawfulness of any activity that might otherwise be the cause of a nuisance and thereby give rise to civil liability (s.97(1),(2)). Por example, there is no liability for nuisance where an 'aircraft' (which includes helicopters) is operated in compliance with the relevant rules in respect of noise or vibration.

However, it may be relevant in the context of possum control by aerial application of 1080 that there is provision for the owner of the aircraft to be liable absolutely for material damage or loss caused to property on land or water by 'any article' falling from an aircraft (section 97(3)). Damages are recoverable from the owner of the aircraft without proof of negligence, intention or other cause as if there had been fault, unless there is proof of contributory negligence by the person suffering damage or loss. The provision could have relevance in the context of stock losses following a drop of 1080-impregnated bait, subject to proof of causation. The provision also signals the need for public liability indemnity in the context of the aerial application of 1080.

This provision for the absolute liability of the owner of an aircraft is in addition to the offence provisions of the Act. These apply against 'any holder of an aviation document', including pilots, other operators or bodies corporate, who cause 'unnecessary danger to any other person or to any property' (sections 43, 44, 47).

The approach to liability and questions of compensation in the Biosecurity Act requires attention to those issues at the stage when a pest management strategy is being prepared. Specifically, the strategy must stipulate the basis, if any, on which compensation is to be paid in respect of losses caused by the implementation of a strategy (sections 60(1)(j), and 76(l)(j)). There are limits as to what compensation arrangements may be formulated at the preparation stage (section 86). Whilst provision may be made to pay compensation for loss of income derived from domesticated organisms that are necessarily destroyed in a PMS, compensation cannot be paid for loss of income from wild or feral organisms adversely affected by the implementation of a PMS, nor to a person who fails to comply with a PMS. These restrictions on compensation will not exclude a common law liability in negligence.

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[6] See, for example, s.116 Agricultural Pests Destruction Act 1967; s.10 Animals Act 1967 (both Acts have been repealed by the Biosecurity Act 1993); s.2 Wild Animal Control Act 1977.

5 Methods of Possum Control

The principal methods presently used for possum control in New Zealand are summarised in Table 5.1 below. Of these, the predominant (and most controversial) methods are poisoning and trapping, and they will be discussed in some detail in section 5.1. A range of lesser used and proposed new methods is discussed in section 5.2, and summarised in Appendix A (Table A.19). Criteria used in comparison of control methods are presented in Appendix C.

Table 5.1 Principal forms of possum control in New Zealand*

	Aerial application	**Ground control**			**Scale of operation** (approximate area in ha)		
		Bait feeders	Paste baits	Without poison	Large >500	Medium 100 - 500	Small <100
Poisons **Sodium** monofluoroacetate ('Compound 1080')	✓	✓	✓		✓	✓	✓
Sodium cyanide			✓		✓	✓	✓
Phosphorus			✓			✓	✓
Brodifacoum ("Talon')	✓ (b)	✓				✓	✓
Traps **Leghold,** e.g. **'gin', 'softcatch'**				✓	✓	✓	✓
Kill traps e.g. **Timms, Electrostrike**				✓			✓
Multiple capture				✓			✓
Shooting (night/spotlight)				✓			✓
Protective devices Fencing (electric, mesh)				✓		✓	✓
Sleeves on trees				✓			✓

* (a) Some controls have been excluded as it is unclear whether they are effective. ***BioDynamic 'peppering'*** is used by some practitioners, but reports of success are mixed (D.Wright (BioDynamic Farmers & Gardening Assn of NZ) pers. comm., 1993) and experiments have disproved any short-term deterrent effect (Eason and Hickling, 1992). ***New*** field ***trials*** have been proposed (Abel ***et al,*** 1992). ***Pindone*** (an anticoagulant poison) is recommended by some regional councils for landholder 'self-help' possum control using bait stations (e.g. Bay of Plenty Regional Council), but possums are relatively tolerant of this poison (Eason *et al,* 1993(a)).
(b) Other than 1080 the only vertebrate poison applied by air in New Zealand is **brodifacoum,** by the Department of Conservation under special permit for rat and rabbit control on islands.

5.1 Poisons and traps

In this section, Compound 1080, trapping, cyanide, phosphorus and brodifacoum are compared. **It is important to note that there is considerably more information available on 1080 than the other controls.** It may be argued that an emphasis on 1080 is appropriate, as 1080 is the method commonly used over the largest area, if both aerial and ground control are considered together. However, limitations in the information base for control methods other than 1080 mean that in the comparison between methods many questions remain unanswered.

5.1.1 Regulation and usage rates

The number of hectares treated by different control methods by the primary possum control agencies are summarised in Table 5.2, and shown in more detail in Appendix A (Tables A.1 and A.4). Bnviromnental impact and poisoning effect information on the principal poisons used forpossumcontrol in New Zealand is summarised in Table 5.3. Comparativedataonfielduseand regulatory status in New Zealand and other countries are provided in Table 5.4.

Accurate data on the total amount of poisons used for possum control are not readily available. Import data are not collected specifically for pesticides unless so mandated by government policy,[1] and manufacture, sales or use data are not required by law to be reported or collated nationally. Manufacturers of poisoned baits consider their production data commercially confidential. Pesticides sales data is collated voluntarily by members of the Agricultural Chemicals and Animal Remedies Manufacturers Association of New Zealand Inc. (AGCARM), but data are not released unless three or more companies are involved in order to protect commercial confidentiality. There are only two major manufacturers of vertebrate poison baits in New Zealand, Animal Control Products and Trappers Cyanide, and neither are members of AGCARM.[2] These companies are the prime importers of technical grade 1080.

It should be noted when comparing New Zealand vertebrate poison use to other countries, that our situation is unique in the world. We have only two native mammals (both bats) but several widespread non-native wild mammalpests which pose significant conservation and Tb disease risks. Therefore it cannot be assumed that all overseas restrictions on 1080 use, or the use of any other vertebrate toxin, is relevant to pest control in New Zealand.

Compound 1080

New Zealand is the largest user of 1080 in the world?[3] Regulations on 1080 use (see Chapter 4 and Appendix B) are stricter than those in Australia, the next largest user, but much less restrictive than in the United States of

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1 Import of sodium cyanide is recorded on request of the Ministry of Commerce (code 2837.11.00-00L), but not 1080 or other poisons used for possum control (M. Plant, Customs Dept., pers. comm., 1994).

2 I. Blincoe, AGCARM, pers. comm., 1994.

3 See Table 5.4. The major manufacturer, Tull Chemicals, estimates that our usage totals more than the rest of the world combined (P. Nelson, pers. comm., 1994).

Table 5.2 Possum control methods used by the Animal Health Board and the Department of Conservation in 1993/94, by hectares treated.

	Hectare-s treated *		
	Compound 1080		Other or mixed
	Aerial	Ground	
ANIMAL HEALTH BOARD 'Initial' control	289,080	*137,970*	10,950
'Maintenance' control	5,970	951,220	37,810
***percentage** of **AHB** total*	***21%***	***76%***	***3%***
DEPT. OF CONSERVATION	91,981		**188,714**[1]
*percentage of **DOC** total*	***33%***		***67%***
TOTAL	387,031	**1,089,190**	***237,474***
***percentage** of total*	***22%***	***64%***	***14%***

* Note: Area 'controlled' may be more than area actually treated, particularly for ground and maintenance control, and this data cannot be used to calculate accurate poison use data. For example, prime possum habitat in farm/forest margins may be targeted but the whole farm considered controlled.

[1] Includes some ground- 1080 control

Source: Animal Health Board and Department of Conservation. See Appendix A for more detail (Tables A.1 and A.4)

America. Both the United States and Australia have native mammals and birds potentially at risk from 1080 and other vertebrate control poisons.

The largest users of 1080 for possum control are the regional councils as contractors to the Animal Health Board (AHB), and the Department of Conservation (DOC). The areas treated with 1080 are summarised in Table **5.2. In** total, **aerial application was used on 26% of hectares treated by 1080 in 1993/94 in New Zealand.** The percentage of possum control areas treated by 1080 in total cannot be ascertained, as DOC ground control using 1080 is combined with other ground control methods in the data.

Cyanide

Only approved operators may use cyanide (sodium cyanide, potassium cyanide or calcium cyanide) in New Zealand, and 19,932 people hold these licences at the present time.[4] These are lifetime licences and do not need to be renewed. Accurate comparative use data was not available, but New Zealand appears to use significantly more cyanide for vertebrate pest control than both Australia and America.

[4] A. Foley, Agricultural Compounds Unit, pers. comm., 1994.

Phosphorus

New Zealand appears to be one of the last Western countries still using phosphorus in large quantities for vertebrate pest control. Restrictions on its use are comparable to those in Australia where it is only used for feral pig control. As for cyanide, only licenced persons may use this poison, and 2,014 people hold lifetime licences at the present time?

Brodifacoum (Trade Name 'Talon')

'Talon' is freely available for sale in New Zealand. Comparative usage data is not available for Australia or the United States where it is used for rodent control.

5.1.2 Effects on non-target species

Available data on individual non-target species effects in New Zealand are summarised in Appendix A (Tables A.8 to **A.10)**, and data on human poisoning events both here and overseas summarised in Table A. 11.

Comprehensive data on incidence of human and other non-target species poisoning does not exist in New Zealand. The only cases required by law to be notified are human poisonings which are brought to a hospital; such data was only summarised nationally in 1979-84 and details on circumstances of poisoning and follow-up information are not easily obtained. The National Poisons and Hazardous Chemicals Information Centre database only covers enquiries (whether or not connected with a verified poisoning event); symptoms are not necessarily recorded, and no information on the seriousness of the poisoning or fate of the poisoned individual is available. An Adverse Incidents Register of effects on public health from agrichemical use was recommended by the Parliamentary Commissioner for the Environment in **1993,**[6] and the Public Health Commission has contracted the National Poisons and Hazardous Chemicals Information Centre to investigate the feasibility of establishing such a register. Complementary information on non-human species and ecosystems is also required.

Research into the effects on human populations from trace levels of chemicals in the environment is in general faced with many impediments, principally the difficulty of separating out one chemical effect from another, the prohibitive cost of complex long-term studies, and sanctions against experimenting on humans. Inferences can be drawn from related studies but the true level of risk may be impossible to ascertain.

Results from 70 NZ Porest Service and DOC aerial-1080 possum control operations over the last 15 years have been analysed for non-target kills, and 35 population studies done. In contrast, very little non-target monitoring has been done on Pest Destruction Board and regional council 1080 operations.

5 **Ibid**

6 **Parliamentary Commissioner for the Environment, 1993. p.37.**

Monitoring the effect on non-target species from trapping, cyanide, **phospho-**rus and brodifacoum has been extremely limited, and this should also be borne in mind when making comparisons between methods. Data sources on individual species killed by methods other than **1080** are very limited in scope, and information on impacts to populations is not available.

The factors controlling likely non-target effect include: speed of toxin degradation; toxicity of degradation or metabolic byproducts; species food preferences and likelihood of encountering the toxin; tolerance for the toxin if ingested (including age, gender and health of organism); and synergism with other toxins in the environment.

The effect on individuals is not the same as a significant impact on the whole population. This depends on the numbers affected and the rarity and reproductive capacity of the species, and loss of individuals of non-target species must also be weighed against any benefits to the population from possumcontrol (e.g. enhanced food supply, reduced predation or competition for nesting sites). These benefits are, however, difficult to quantify.

In summary, information on population impacts is influenced by limitations in available research methodology, availability of adequate research funding, the complexity of ecosystems, and the difficulty of locating enough individuals of rarer species to get robust data.

One potential benefit of possum control is that rats are also killed, and their predation and food competition lessened. However, predators which would **normally feed on rats (stoats, ferrets, feral cats) may then switch their attention** to native species. The long-term effects from both aspects of 'prey-shifting' behaviour are inadequately understood.[7]

Research to better understand the long-term ecosystem dynamics of possums and the effects of possum control both by **1080** and its major alternatives in native forest ecosystems is required, and must be adequately funded Only a few long-term studies of possum ecology have been undertaken, notably in the Orongorongo Ranges[8] DOC is currently considering a major research proposal to investigate medium-term effects on forest biota and biodiversity of aerial-1080 and ground-trapping possum control operations ('Programme **96').**

Compound *1080*

Native species

Individuals from a wide range of native species have been found dead after possum control operations from 1080 (Appendix A, Table **A.8),** but it is

[7] E.g. in Mapara following 1080 possum control in 1990, the rat population fell significantly, and the ferrets switched their diet from primarily rats to primarily birds (including NZ pigeon). The rat population returned to normal seven months after the poisoning (Murphy and Bradfield, 1992). The long-term impact of such perturbations is unknown.

[8] Brockie, 1992.

important to make a distinction between modem methods and those used in earlier years. Large kills of non-target bird species were noted in the 1976-77 year, associated with poisoned chaff from unscreened and sometimes undyed carrot baits with raspberry lures. Prom 1978 the NZ Forest Service required screening of carrot baits andprohibitedraspberry lures. Prom 1983, cinnamon lures were added to repel birds, and green dye was required by regulation.[9] These NZ Forest Service conventions now apply to all DOC operations, but were voluntary for pest destruction boards. Some of their regional council successors that use carrot baits have only obtained screens recently.[10] DOC and MB also now require manufactured cereal baits to meet standards to minimise the content of broken pellets and small pieces of poisoned bait.

Analysis ofnon-target birdmortalities has been done for a sample of NZ Forest Service and DOC operations since 1978 using 1080 (70 operations over 15 years), and this is summarised together with other data in Table A.8. Fifteen of these 70 operations noted some dead birds. Pest Destruction Board and later regional council operations have not regularly monitored for non-target impacts, and data fromthese operations are largely anecdotal or from domestic animals submitted for poison analysis (see Tables A.9-10). The AHB has recently approved funding for monitoring of selected endangered birds or selected areas in connection with three 1080 operations.

Clear long-term impacts on ecosystems or populations have not been demonstrated from studies to date in connection with aerial-1080 operations in the DOC estate. Individual or population impacts from aerial-1080 operations by regional councils or the effects from ground control using 1080 have not been adequately studied. A small number of regional council's aerial- 1080 operations in forest areas will be monitored by the AHB in 1994/95 (one for a range of species in connection with higher bait toxin loadings, one for kiwi, and one for weka).

Since 1985 anecdotal evidence of kills attributed to 1080 and made known to this Office has all been from pest destruction board or regional council operations. Some of these observations suggest the possibility of long-term effects on bird populations."

However results for studies of bird populations following post- 1978 aerial 1080 operations in the DOC estate have shown no significant declines. Increases or decreases are not clearly correlated to the 1080 drop, or insufficient data has been available to draw conclusions (especially for rarer

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9 Spurr, in Press(a) p. 7; Pesticides (Vertebrate Pest Control Regulations) 1983, section 23.

10 Southland Regional Council purchased carrot cutter with screen in January 1994 (P. Lenihan, pers. comm., 1994), and the Otago Regional Council has not fully implemented screening (Otago Daily Times, 4 April 1994). Evans and Soulsby, 1993, p. 22. Canterbury Regional Council only uses screens on the 30% of carrot bait Possum control operations funded by the Animal Health Board (e.g. 70% possum control and all rabbit control with carrots unscreened); the Council considers history of forest bird loss with unscreened carrot irrelevant to their operations on grass/farmland (I. Lucas, pers. comm., 1994). However, grassland birds, lizards and insects may be at risk. Recent research suggests risk to quail and chukar populations (Evans and Soulsby, 1993).

11 P. Bamber, K. Kennedy, W. Payton, W. McGill, D. Korewha, pers. comm., 1994.

Table 5.3 **Environmental degradation, metabolism, mode of action, humaneness of death, antidote, and sublethal impacts of poisons used for possum control**

	Sodium monofluoroacetate (Compound 1080)	Sodium cyanide	Phosphorus	Brodifacoum (Talon')
Degradation in the environment	Can bind to soil, be absorbed by plants. Diluted by water, detoxified (C=F bond broken) by common micro-organisms. Not persistent or cumulative in enviromnent long-term. Stable in pure water, broken down in natural water by micro-organisms.	Unstable with moisture, degrades to hydrogen cyanide gas and dissipates. Not persistent or cumulative in environment long-term.	Unstable with air + moisture, oxidises to phosphoric compounds. Not persistent or cumulative in environment long-term.	Not water soluble. Binds to soil. Reported to biodegrade in soil after 14 months. Persistence in animals and environment not[4] fully studied.
Metabolism and excretion in poisoned animals	Excreted unchanged or as toxic and non-toxic metabolites.' The main breakdown mechanism is the conversion to flmocitrate with excretion primarily as that metabolite.	Exhaled as hydrogen cyanide or detoxified in body.	**unknown**	Excreted unchanged, or stored in liver.
Mode of action	Interruption of the 'Krebs Cycle' (the energy pathway in most organisms).	Inhibition of essential enzyme (cytochrome oxidase).	Damage to internal organs • liver poisoning.	Internal bleeding (anticoagulant)
Humaneness of death	Convulsions, cardiac or respiratory failure. During seizure may not be conscious of pain.	Very rapid death through respiratory failure.	Protracted and painful death (intense gastrointestinal pain).	May suffer poor condition for up to 3 weeks before toxic dose accumulated, then death within 24 hours.
Antidote	*None*	Amyl nitrite (partial • assists in recovery from mild poisoning)	None	Vitamin K
Impacts of sublethal doses ***(NOTE: Experimental doses high, and/or repeated. Impacts** of **trace** level **doses** not **studied or reported.)***	Damage to heart muscle (livestock, guinea pigs)." testes and fertility (rats, lizards),[3] and kidneys (rats).' Deposit of fluorine in bones (rats),' depression of metabolism in embryo may be teratogenic (rats),[6] oxygen loss in seizures may cause brain damage (humans).' Genetic resistance to 1080 after four generations (rats)?	No effects seen in lower doses (rats), congenital malformation with high doses (hamster). Headache, nausea, weakness (humans • occupational exposure)?	Bone formation impacts (rabbits)," liver damage (rabbits, guinea pigs), skin burns (humans), jaw gangrene (humans • occupational exposure)."	Increased rates of abortion and neonatal death (sheep)", storage in liver over 112-120 days (sheep).[13]

Sources: Hayes and Laws, 1991; Atzert, 1971; Batcheler, 1978; Gregory, 1991; Rammell and Fleming, 1978; Rowsell et al, 1979; M. Shirer, (ICI), pers. comm., 1993; and others as noted:

Notes for Table 5.3

1 Atzert, 1971, pp. 16-17; Rowley, 1963; p. 53; Eason ***et al,*** 1993(b).
2 Jubb and Kennedy, 1970 pp. 116-17; Allcroft and Jones, 1969; Allcroft et al, 1969; Shultz et al, 1982; Whittem and Murray, 1963; A. Seawright, pers. comm., 1993.
3 Atzert, 1971, p. 18; Twigg, King and Bradley, 1988.
4 Parkin et al, 1977. Also suspected kidney damage in humans (not proven).
5 Egekeze and Oehme, 1979, p. 413.
6 Spielmann et ***al,*** 1973, no teratogenesis; DeMeyer and DePlaen, 1964, foetal abnormalities with high dose; see discussion in Eason et ***al*** (in press). Teratogenic studies have not yet been done with modem techniques.
7 McTaggart, 1970; Trabes et ***al*** 1983.
8 Howard ***et al,*** 1973.
9 Hayes and Laws 1991, Vol. 3, pp. 646-49.
10 Tyndale-Biscoe, 1955.
11 Hayes and Laws, 199 1, Vo1.3, pp. 552-55.
12 Godfrey, 1984; and Godfrey, 1985 cited in Eason and Spurr, 1993.
13 Bell ***et al,*** 1987; Laas ***et al,*** 1985 cited in Eason and Spurr, 1993.
14 Eason, 1992 as cited in Towns et ***al,*** 1993.

Table 5.4 Field use and regulatory status of selected vertebrate poisons; New Zealand, Australia, USA, Japan and Germany

	Sodium monofluoroacetate (Compound 1080)		**Sodium cyanide**	**Phosphorus** (white or yellow)	**Brodifacoum** ('Talon')
	Major field use	Regulatory status'	Regulatory status[2]	Regulatory status[3]	Regulatory status
New Zealand[5]	**Possums, rabbits,** deer, **wallabies,** wasps ***(introduced)*** estimated ave. use: ***1972-1977 2,000* kg/yr** 19861989 926 **kg/yr** **1993/94 *3,400* kg/yr**	'Deadly poison' and 'Part I controlled pesticide': available **only** to approved operators, special permits and approval required for aerial application or use in sensitive areas.	**'Deadly** poison' and 'Part II controlled pesticide': available **only** to licensed persons. Estimated usage: 1978-1985 **9000 kg/yr** **1990-93 1500-2000 kg/yr**	'Dangerous poison' and 'Part II **controlled** pesticide': available **only** to licensed persons. **Est.usage:** 1984-1989 **120 kg/yr** **1990-1993 110 kg/yr**	'Poison': freely available on market as a wax block for **commensal** rodent control and as a pellet for possum control. A separate pelleted product is also available for restricted use for rabbit control.
Australia	**Rabbits,** foxes, **wild** dogs, feral pigs ***(introduced)*** **Dingoes, wallabies** (native) estimated ave. use **1985-1987** 595 **kg/yr** **1993/94 *300-400 k&r***	Schedule 7 poison. State regulations vary. In NSW, landholders may apply 1080 carrot baits prepared by registered users (subject to restrictions). In WA, some **aerial** application of dingo bait.	Schedule 7 poison, State regulations vary. **Principal** use for research.	State regulations vary. Used primarily to control feral pigs in NSW.	Registered in all states as 50 ppm rodent bait. Freely available on the market for this purpose.
United States	Coyotes, foxes, ground squirrels, gophers, prairie dogs (native). Wild dogs ***(inbvduced)*** estimated ave. use: 1968-1972 **1,170 kg/yr** 1986-1988 **44 kg/yr** **1988-1991** 0 2 **kg/yr**	Federal registration **cancelled** for predator control **1972,** renewed 1985 for **'LPC'** only. **Cancelled** for rodent control **1990. Cancellation** for **failure** to provide required information.'	Federal registration for use predator control **cancelled** 1972, reinstated for 'M-44' **device**[4] **only** 1975. **Cancelled** for rodent control 1987. Reasons as for 1080.	Federal registration **cancelled** for rodent control 1989.	Restrictions on use for **commensal** rodent control removed 1982. Aerial **application** for ground squirrel control allowed.
Japan	Field mice (use rate data not available)	'Specified poisonous substance': use for other than field mice or research prohiiited.	(no information)	Banned (due to chronic poisoning risk to people).	(no information)
Germany		Not registered as a pesticide. Use in **agriculture specifically** prohibited.	Not permitted in agricultural chemicals.	(no information)	(no information)

Use data is by **weight of active ingredient.** Total weight of baits applied in the field would be much higher.

Notes for Table 5.4

Sources: United Nations, 1991; Fagerstone et al, 1993; Kaukeinen, 1982; Jacobs, 1992; Nelson, 1989; Savarie, in press; Rammell and Fleming, 1978; Wade, 1986; Warburton and Drew, 1993; I. Logan, I. Shirer, P. Nelson, P. Prammer, pers. comm., 1994; product labels.

Note: Strychnine still available for limited field use in United States for vertebrate pest control but deregistered in New Zealand because of inhumaneness of death and difficulties in masking its bitter taste.

1 Other countries with restrictions on Sodium monofluoroacetate as at 1991 were: Belize, Mexico and Thailand (prohibited for reasons of extreme toxicity and possible environmental effects); Columbia (prohibited due to health risks from use); and the Philippines (banned) (United Nations, 1991). As of 1993, Mexico City was importing 1080 so Mexican restrictions may have eased. Other countries importing 1080 in 1993 but not shown in table were Israel, Qatar, Canada (British Columbia, for wolves) and Ecuador (Galapagos Islands, for cats and dogs) (Wigley, C. to Nelson. P., letter of 23 May 1993).

2 Other countries with restrictions on Sodium cyanide: Cyprus (registration withdrawn due to high toxicity and hazards with use); Panama (import and use prohibited for agriculture), and the Union of Soviet States (prohibited as pesticide because of high toxicity).

3 Other countries with restrictions on yellow/white phosphorus: Great Britain and Sweden (not allowed in matches): USA (not allowed in fireworks).

4 LPC = Livestock Protection Collar; poison in pouch on collar is released only when stock is attacked by predator. The M-44 is a device which fires the poison into the animal's mouth when it takes a meat bait. Both provide more accurate targeting of poison to predators than does broadcast of baits, and EPA data requirements not as strict. Under the Federal Insecticide Fungicide and Rodenticide Act 1972 (FIFRA), the US EPA must determine that pesticides will not have 'unreasonable adverse effects on the environment' in order to allow registration, and data collection costs can be high. Manufacturers of pesticides with limited domestic sales have in many cases considered data collection costs not economically justifiable, and abandoned re-registration under FIFRA. (USEPA, 1988 and 1990; Jacobs, 1992; K. Fagerstone, pers. comm., 1993).

5 Use according to label required by law in New Zealand. 1080, cyanide and phosphorus have absolute legal requirements to be met which may or may not be included on labels. All of the provisions of the Pesticides (Vertebrate Pest Control) Regulations are not repeated on labels as they require further explanation. Instructions include:

LABEL ADVICE	1080	Cyanide	Phosphorus	Brodifacoum
Keep away from children, foodstuffs; wear protective gear, keep hands from mouth, wash carefully after use	✓	✓	✓	✓
Avoid contamination of any water supply	✓	✓	✓	
Burn or burv residues and container after use	✓	✓	✓	
Report large spillage, loss to Police or Medical Officer of Health[1]	✓	✓		
Keep stock away (until bait weathered by rain or buried)	✓		✓	✓
Keep away from beehives (jam pastes)[2]	✓			

1 For controlled pesticides there is a legal duty to report all losses.

2 Label advice varies; 400 m for 0.15% pellets and 10% gel, lkm for 0.06% and 0.08% pellets

species). In four instances, increases in native bird populations were noted (Kapiti and Rangitoto Islands, Mapara and Kaharoa districts). Individual kiwi and kokako have beenmonitored during 1080 drops and no impact from 1080 shown.[12] More studies are planned and underway by DOC.

Kaka, kokako, kakariki, saddlebacks and weka have been observed consuming cereal and carrot baits in sufficient quantity to cause death if the baits had contained 1080.[13] It has been noted that baits can get caught up in the forest canopy after aerial- 1080 operations, and that kaka are naturally curious.[14] The Royal Forest and Bird Protection Society has recommended that aerial 1080 control should not be used in kaka habitat, carrot bait should not be used near kokako, and that generally ground control was preferred to aerial control.[15]

A number of hunters have observed kiwi and other ground-feeding birds feeding on maggots, and expressed concern about possible secondary poisoning via the maggots from 1080-killed possums. This aspect has not as yet been studied.

Studies to date of aerial- 1080 effects on native invertebrate populations have not shown clear long-term impacts. Available results suggest that no significant change was noted for studied species, and that some insect communities may be reduced in numbers, but degree of impact and length of recovery are uncertain.[16] Other research has shown that insects are: susceptible to 1080; can clear sublethal doses from their body; and at sublethal doses may suffer behaviour disruption causing them to be more susceptible to predation."

Concern has been expressed about short-tailed bats suffering from secondary poisoning through eating 1080 paste (jam) baits or 1080-poisoned insects, and studies are scheduled by DOC. The effect on native reptiles, amphibians and fish have not been directly studied, but in overseas studies these groups have proven relatively tolerant of 1080 poisoning.

Domestic animals

Dogs as a species are extremely sensitive to 1080, and despite warnings to owners and issuing of muzzles and emetics by regional councils, dogs still find and eat dead 1080-killed animals or eat baits and are poi-

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12 Spurr, in press(a) summarises these studies. J. Hay, Doc, pers. comm., 1994. Mapara and Kaharoa studies.

13 Spurr, in press(b).

14 DOC, 1994(b), p. 38.

15 Clark 1993.

16 Spurr, in press(b); Meads in Green, in press. The Spurr work (Puketi and Titirangi) shows no significant changes for 12 groups studied, with larvae and long-term effects (possible delay in reproduction) not yet analysed, and eight groups (including cockroaches and weta, known to eat baits and be poisoned by 1080) with insufficient data to draw conclusions. The Meads work (Whitecliffs) showed definite mortality from 1080, but long-term impact analysis prevented (unproven suspicion of delayed 1080 bait chaff drift into the no-1080 control area).

17 Notman, 1989; David and Gardiner, 1966; Hutcheson, 1989; Eason et al, 1993(b).

soned.[18] In some cases owners have been careless of official advice, but in others, precautions were taken and did not prove adequate.

Livestock (cattle, sheep, deer) find both carrot and cereal baits attractive, and although operations are planned in consultation with farmers and stock are kept out of the poisoned areas, breached fences, miscalculation by the pilot dropping the baits, andmiscalculation on the time needed to render baits non-toxic through rainfall and decomposition, has caused numerous incidents of livestock poisoning over the 40 years aerial-1080 has been used for control of rabbits and possums.

There have been recent cases and surveys of overseas literature which suggest a possible risk to livestock from initially sublethal doses of 1080 from errors in bait application or stock withholding periods on farmland, whether for rabbit or possum control, and whether aerial or ground applied. The New Zealand cases have caused some disquiet but have not yet been reported in the literature, so it is appropriate to summarise them here.

On several farms in Balclutha, carrot baits were accidentally sown in paddocks and eaten by sheep (carrots in stomachs of those that died soon after confirmed sowing error). Over the next three to four months, approximately 600 • 700 sheep from these flocks showed symptoms such as: a loss of condition, aborting of lambs (33% lambing vs 120% previous year), nervous system or heart disturbance, and ultimately death. Other stock experiencing the same pasturage and weather but not exposure to baits did not suffer these symptoms. Possible ailments other than 1080 poisoning were investigated but could not be proven.[19] Overseas studies were subsequently found that showed livestock exposed to sublethal doses of 1080 and related fluoroacetic compounds can show similar symptoms, and characteristic features of heart damage on autopsy.[20] Sublethal 1080 is cleared from livestock within four days[21] and any 1080 originally present in the sheep is unlikely to remain. Autopsies recently performed to check for other evidence of sublethal fluoroacetate poisoning showed no positive signs. Whether the observed symptoms in Balclutha sheep were from sublethal 1080 poisoning has been neither confirmed nor disproven at this time.

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18 All pest control officers and managers we spoke to (both in connection with possum control and with rabbit control using 1080) couldrelate examples of dogs and livestock poisoning, and a number were brought to our attention by the public and the media. *Also see Gordon-Glassford v. Upper Clutha Pest Destruction Board,* unreported, DC Alexandra, 20 March 1987, per Judge A A P Willy.

19 P. Mulholland, D. Copland, J. Smart, pers. comm., 1994.

20 Whittem and Murray, 1963; Allcroft *et al,* 1969; Allcroft and Jones, 1969; Jubb and Kennedy, 1970; Shultz *et al,* 1982. Characteristic symptoms include microscopic lesions and scars in heart muscle.

21 Eason *et al,* 1993(b).

Effects on **humans**

In New Zealand, the only documented human fatality from 1080 was apparently a suicide, but overseas accidental 1080 fatalities have occurred to both adults and children. Twelve non-fatal human poisonings from 1080 have been reported in New Zealand. However, the database is incomplete and it is unknown how serious these cases may have been or how they occurred (see Appendix A, Table A.1 1 for documentation).

Human poisonings from indirect sources (water, hilled animals) have *not* been documented in New Zealand or overseas. The amounts of 1080 theoretically possible in water and meat in worst-case pest control scenarios have been calculated to be non-fatal to humans.[22] The extremely low levels of 1080 reported from water monitoring[23] would certainly be non-fatal, and are minuscule compared to the dose levels that elicited sub lethal poisoning symptoms summarised in Table 5.3. However, although lethal doses of 1080 for humans have been determined, the 'safe' level for sublethal doses is not (and may never be) known.

Some people believe that as low levels of some chemicals have been linked to human illness, trace levels of 1080 must also be considered dangerous. This is not necessarily so, as trace levels of persistent poisons (e.g. DDT) accumulate in the body, but 1080 is not a persistent poison. However, as data was not available in the literature on effects on a human population of trace levels of 1080 in water supply, a parallel was sought overseas. Most of the water catchment for the city of Perth (Western Australia) contains native *Gastrolobium* plants, which naturally contain high levels of fluoroacetate and related toxic compounds. 'As the water supply since the days of settlement may theoretically have contained trace levels of fluoroacetate, enquiries were made to the water supply and public health agencies to see if traces of fluoroacetate are in the water and if epidemiological data is available on the relative health of the Perth population. However, as no health problem has occurred, that suggested to Australian officials that funding should not be spent on collecting fluoroacetate residue or epidemiological data. Such data is not available."

At our current level of scientific knowledge no danger to human health can be shown from the levels of 1080 detected in water monitoring. The present level of detection is 0.3ppb. It should be noted that 0.3 ppb is not a threshold for any 'safe' concentration, or any effect of 1080, but simply a measurement limit.

However, this does not address the issue of *choice*. If a person does not want certain chemicals in their environment or water supply, regardless of the real, perceived, or proven impacts this may have on their physical health, they may

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22 Rammell and Fleming, 1978; Batcheler, 1978(b); Peters, 1975; MAF, 1984.

23 See section 5.1.3 and Appendix A (Table A.13) for more information on water monitoring results.

24 D. King, pers. comm., 1993; letter from L. Twigg, Agriculture Protection Board of Western Australia, 5 January 1994; and letter from I. Rouse, Health Department of Western Australia, 2 February 1994.

well argue against imposition of those chemicals. Their inability to say no may affect their mental health, their organic certification and economic health if they are an organic grower, or their spiritual health and ability to exercise *kaifiakitanga* (guardianship) if they are tangata whenua.

The law does not provide the right for an exemption for persons in an area designated for pest control by regional councils or the Department of Conservation (see section 4.6). The existence of quite considerable legal powers is a powerful inducement to compliance. The Animal Health Board has recently proposed a model contract which councils may use at their discretion to allow a landholder to use alternative methods of control, but extra costs are imposed. It is unknown how 'fair' the process will be in practice after 1996 under the Biosecurity Act 1993. From the point of view of a landholder objecting to 1080 use on their land, this situation is not satisfactory. It also does not give any relief to the person who feels his or her environment is affected, but is not a landholder directly involved in a regional council operation.[25]

The most likely risks to human health from 1080 are from careless handling by control staff (label requirements must be followed) and access of unauthorised and untrained people and children to baits. Good controls are in place, but accidents have still occurred and there is no cause for complacency. The onus to protect the public should be on the possum control agencies. In this regard, it is worth noting the following:

> *'The manual says: "children should be kept away from all poisoned areas". Z believe it should read "poison should not be distributed in areas where children can gain access to it". In this case the practical effect, that is, spreading the poison only in remote areas and warning local inhabitants, may have been the same but it won't necessarily always be so.*
>
> *'...Zt denies the responsibility of the introducer of the hazard except to issue a warning; it denies the right of children to their habitat; it denies the practical impossibility of keeping children from all the hazards that keep being added to their environments.*
>
> *'The risk of 1080 is low and fades into insignificance beside passenger and pedestrian road traffic injuries, drownings . . . and so on. [However] it illustrates a problem which underlies many, perhaps to some extent all, of the childhood injury scenarios.'*[26]

Regulations require secure storage and clear labelling of controlled poisons such as 1080. Containers must be marked with a serial number to make them traceable and a register of movements kept, and it is illegal for anyone other than an approved operator to gain access to the poison?' Nonetheless there have been recent cases of 1080 baits being stolen, and being used by unauthorised persons for possum and wasp control.[28]

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25 For legal details and further discussion see Chapter 4.

26 Ian Hassal, Commissioner for Children, Winter 1993, p.1.

27 Toxic Substances Regulations 1983; Pesticides (Vertebrate Pest Control) Regulations 1983; Noxious Substances Regulations 1954.

The Department of Conservation is preparing a Toxin Manual as part of the Possum Control Operation Manual and this will include guidance on the secure and safe storage of toxins. The Animal Health Board Protocol for Bovine Tb Possum Control Operations does not make any comments about storage or security precautions to be taken with regard to toxins used in possum control operations. Toxic substance regulations address storage and precautionary measures, with these requirements included in the course notes for the Pesticides Act 'Approved Operators Licence'.

Effects on honeybees and honey

Reduction of possum populations can benefit honey production by allowing full flowering of important nectar and pollen sources such as rata, pohutukawa and kamahi. However, where 1080 paste (jam) baits are used for ground control of possums, there is a risk of damage to bee colonies, loss of income to beekeepers, and storage of 1080 in honey. As this issue has not been addressed adequately in the literature, a summary of the issue is provided in Appendix D.

In 1992 the Registrar of the Pesticides Board advised regional councils that a buffer of 3 km was recommended instead of the label requirements of 400 m from a beehive. In 1993, the Pesticides Board approved early action on requiring bee repellent in 1080 paste baits provided research establishes bee repellency and possum bait acceptance.[29] The Ministry of Health has recently proposed that the 1080 use permits from the Medical Officers of Health should stipulate that 1080 paste baits that do not contain a Pesticides Board approved bee repellant must not be laid within 4 km of beehives, but the text has not been finalised.[30]

Cyanide

The number of documented human fatalities in New Zealand from cyanide poisoning is much higher than from other possum control methods. The database is incomplete, but it is known that *11* people *died from cyanide poisoning during* 1979-1 984 *alone.* If the data for 1989- 1993 is typical, it appears that only about 25% of cyanide poisoning cases would be from suicide attempts. The database is inadequate to determine how many of these poisonings were from cyanide sources other than possum bait, or the full magnitude of cyanide poisonings for most of the time that cyanide has been available for vertebrate pest control in New Zealand.

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28 M. Goodwin, N. Wallingford, B. Bayfield, P. Nelson, pers.comm., 1993 and 1994; Daily News, 26 February 1994.

29 Goodwin and Ten Houten, 1991; Morgan *et al,* 1993; P. Nelson and D. Morgan pers. comm., 1994; Pesticide Board minutes for meetings of 16 September 1993 (item 6d) and 18 November 1993 (item 6f). In 1991 it was found that molasses and oxalic acid repelledbees, but molasses (concentrate) and oxalic acid were found to reduce palatability of the apple paste to possums, and molasses also turned baits black rendering the legally required toxic warning green dye ineffective.

30 Letter of 7 April 1994 from Ministry of Health, with final draft of 'Model Permit Conditions for the Use of 1080 Issued by the Medical Officer of Health', item 5.7.

As shown in Appendix A (Tables A.8-11), a range of non-target species has been killed accidentally by cyanide, both native and introduced. Data for domestic animals 1960-1976 show that 386 died fromcyanide poisoning, but how many of these were in connection with possum control operations is unknown. Unlike 1080, phosphorus and brodifacoum poisoning (delayed effect), any non-target lethal impacts are immediately obvious.

Kiwi and weka clearly are at some risk from cyanide use, at least to individuals where the species are present. Over 1971- 1980 and in a 1984 survey of 66 trappers, 103 kiwis were reported killed by cyanide, and it is considered that cases were underreported. It appears from the limited database that about half as many kiwi are killed by cyanide as killed through traps.[31] Numerical data were not reported for weka.

Analysis of native species likely to be attracted to paste baits suggests a wide range may be susceptible to poisoning.[32] No population studies have been done in association with use of cyanide, and long-term effects are unknown. Effects on non-target species from sublethal doses are also not well studied.

Phosphorus

Although phosphorus has been in use for rabbit and possum control for well over 40 years, data on non-target effects is extremely limited. Clearly non-target effects do occur, as 440 dead dogs, livestock, cats and birds tested positive for phosphorus poisoning during 1960- 1976. However, these were only from cases submitted for analysis, and it is unknown how many of these related to possum control operations.

Analysis of native species likely to be attracted to paste baits suggests a wide range may be susceptible to poisoning.[33]

No population studies have been done in association with phosphorus use, and long-term effects are unknown. Effects on non-target species from sublethal doses are also not well studied.

Brodifacoum (Trade Name 'Talon')

Monitoring of non-target effects of possum control using Talon' in bait stations has not been reported. Anecdotal evidence and results from rat and rabbit control suggest the risk may be greater than the absence of data suggests.

One monitoring exercise for Talon' paste, rather than cereal-based baits, and single-pulse rather than multiple-pulse baiting, has been reported. The

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31 **B. Reid, 1983, 1985 and 1987; McLennan, 1987; Spurr, 1991. One estimate gives 5 kiwis trapped for every kiwi killed by cyanide, another estimate is 1 kiwi trapped per every 3 trapper years vs 1 kiwi poisoned for every trapper year. It is estimated that 50% of trapped kiwi may survive trapping and release.**

32 **Eason and Spurr, 1993.**

33 **Ibid**

results showed a possible effect on the tomtit population and no clear effect on 15 other native bird species. Data on non-native birds were not analysed.[34] The single-pulse baiting study would have provided less potential exposure of the poison to non-target species than the multiple pulse baiting currently recommended for 'Talon' use in possum control.

Monitoring of birds, lizards and insects has been done by DOC in connection with rat eradication programmes on a number of offshore islands using 'Talon'. As these operations include aerial application of baits they are not strictly comparable to ground control for possums using bait stations, but they could be considered to provide a 'worst case scenario' for susceptibility to poisoning. In monitoring to date: individual saddleback mortality from 'Talon'has been estimated at l-5 % but breeding and population levels did not appear to be affected; a pukeko population was reduced by 90% (Tiritiri Matangi); and a weka population by **100%** (Tawhitinm Island); captured insects did not contain brodifacoum residues; mortality of blackbirds and sparrows was confirmed by residue testing; and other species found dead possibly as a result of poisoning included robins, morepork, kingfisher, brown teal and spotless crake.[35]

Concern has been expressed about the possibility of delayed fecundity impacts and secondary poisoning through brodifacoum residues in insects, and further studies have been advised.[36] The effect of longer-term sublethal doses on other species has also not been studied.

Insufficient population studies have been done in association with brodifacoum **use for possum control, and long-term effects are unknown.**

Trapping

Available data shows **that leghold** trapping can clearly pose a threat to individual kiwi, weka, kaka, NZ pigeon, morepork, and a range of other birds and introduced mammals. Trapped non-target animals might be killed, seriously injured, or released with little long-term damage. Unlike **1080,** phosphorus and brodifacoum poisoning, any non-target effects are immediately obvious along traplines.

Of particular concern is the threat to kiwi and weka, where trapping occurs in their natural habitat. The limited data available document the capture of at least 330 kiwis, many of which would have died or suffered serious leg or beak damage. Traps are five times more likely to affect kiwi than cyanide, **but cyanide is usually lethal.[37] Studies of impact on kiwi populations**

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[34] **Spun and Drew 1993.**

[35] **Towns *et al*, 1993; letters from Department of Conservation regarding Tiritiri Matangi (from G. Campbell, 30 September 1993 and from P. Cromarty, 29 November 1993); Eason and spurr, 1993.**

[36] **Towns et *al*, 1993, pp. 11.21.**

[37] **Reid 1983, 1985 and 1987. The majority of cases have probably not been reported.**

are inadequate, but it has been suggested that trapping and cyanide poisoning may in some circumstances have significantly affected North Island kiwi populations.[38] The trapping threat can be eliminated for kiwi and lessened for weka (but not other birds) through placing the traps above the ground.[39]

Damage to captured animals can be significantly lessened through use of the 'softcatch' trap, but design modifications are required to reduce escapes of possums. The Timms 'humane kill' trap catches as many non-target species as the 'soft-catch' trap, but all captures in the Timms are killed. Weka have been caught in both trap types.[40]

Estimates of native bird loss per hectare range from one native bird lost per 1434 ha trapped to one native bird per 35 ha for 1080 poisoning." However, this was during early hunting programmes when high kills were not required by contract; more intensive trapping may result in more comparable native bird kills.

Non-target effects from trapping for possum control will also apply to monitoring when performed by the trap-catch method.

No population studies have been done in association with trapping, and long-term effects are unknown.

5.1.3 Fate of poisons in the environment

As for the non-target effect data, the environmental degradation of 1080 has been much more thoroughly studied than have the other poisons used for possum control. However, as this issue has been a particular focus of public concern and opposition to the aerial application of 1080, a summary of available literature from New Zealand and overseas is provided below.

Biodegradation

Compound 1080

Sodium monofluoroacetate and related toxic compounds naturally occur in about 40 species of poisonous plants from Australia, Africa, South America and the Indian subcontinent, in quantities that equal or exceed the toxicity of 1080 baits used in New Zealand. However, the chemical was identified and developed as a pesticide before its natural occurrence was discovered." In

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[38] McLennan, 1987.

[39] For example, the method used on Kapiti Island, elevating traps 80 cm on sloping boards, trapped no kiwis despite over 1.3 million trap nights (Cowan, 1992).

[40] Miller, 1993.

[41] Reid, 1983; Spurr, 1991.

[42] Synthesised 1896, toxic nature noted 1934 and developed as a poison late 1930s in Poland, developed as rodenticide in England from 1942 and in USA from 1944, discovered in plants in South Africa 1944 and in Australiaand South America 1960s (Atzert, 1971, pp. l-2). It has beenstatedtbat 1080 was developed in Germany during World War II as a human water supply poison (signed statement from E. Fike to A. Sorley, 5 November 1993), but no documentation was found to substantiate this claim.

environments where fluoroacetates naturally occur in plants substantial livestock losses have occurred, but native species have high tolerances for 1080."

Detoxification in poisoned animals is a minor source of biodegradation of 1080.[44] The principal pathway appears to be adsorption in soil and vegetation or retention in the tissues of poisoned animals, followed by degradation to non-toxic compounds by micro-organisms. Soil microflora able-to detoxify 1080 are present in a wide range of soils, in areas that have never had 1080 applied (England, parts of New Zealand), areas that have had regular 1080 dosing (New Zealand), and areas that contain natural sources offluoroacetates (Australia, South Africa). Biodegradation of 1080 has also been demonstrated in aquaria inoculated with micro-organisms, and in grain-based, carrot and meat baits subject to natural degradation by ambient micro-organisms.[45]

New Zealand studies have shown that 1080 dissolved in water is stable at strong concentrations in closed containers in the laboratory, but after 2-6 days in a biologically active aquaria ceases to be detectable at 21" C and is 68% reduced at 11" C.[46] In the latter experiment some adherence to plants in the aquaria took place, and traces of 1080 were left in the plants at one week, but not at two weeks. Errors have been made by members of the public in extrapolating the earlier studies of stability of 1080 in water to field conditions. This is understandable as the fact that the 'stable' 1080 solutions were at much higher concentrations (approximately 25 times) than used in possum baits in the field was not adequately clarified in the original source.[47]

As 1080 is highly water soluble, in outdoor environments it will be prone to dilution. However, as it may be consumed by animals or be adsorbed by soil

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43 Twigg et *al*, 1988; King and Kinnear, 1991; McIlroy, 1986; Meyer and O'Hagan, 1992.

44 About 26% of sub lethal 1080 doses in rats is excreted as non-toxic metabolites; Carbon 14 tracing of 1080 showed 32% of 1080 was excreted in urine (of which 13% was 1080, 11% fluorocitrate, and 76% non-toxic metabolites) and 2% in respiration (demonstrating cleavage of C=F bond in animals). The remaining 66% was not reported on (Atzert, 1971, pp. 16-17). Human urine from sublethal dosage was toxic to hamsters (Rowley, 1963, p. 53). In sheep and goats, 7.5 to 33.9% of 1080 was excreted unchanged, and 1080 in plasma and tissues reduced to trace level after 18 hours (goat) and 96 hours (sheep) (Eason ef al, 1994). Biodegradation of 1080 in rats can result in fluorine being deposited in bone (Egekeze and Oehme 1979, pp. 413-14).

45 Atzert, 1971; Batcheler, 1978(a); Rammell and Fleming, 1978; Eason et al, 1993(b); Preuss *et* al, 1968; Egekeze and Oehme, 1979; Walker and Bong, 1981; King *et al,* 1993; Meyer et al, 1990; David and Gardiner, 1966; Parfitt et *al,* in press; Wong *et* al, 1991; Flemming and Parker, 1991.

46 Rammell and Fleming, 1978, p.15; Eason *et al,* 1993(b); Parfitt *et* al, 1993. The demonstrated length of stability (breakdown less than 5%) in the laboratory was 10 years for 1080 dissolved in distilled water, and at least a year when 'stale algae-infested water' was used to dilute concentrate to create a 2% 1080 solution. Any algae and micro-organisms present are not expected to have been active at this latter concentration (Rammell and Fleming, 1978, p.15; C. Rammell, pers. comm., 1994). Note 2% concentration 1080, vs 0.08% dosing in baits, distributed at 1 bait per $12m^2$.

47 References have also been made to stability of 1080 water baits used for rodent control. These were previously used in the United States (and caused a number of accidental deaths) but these were also relatively high concentrations, and were used indoors (references in footnote 4 in Table A.1 1). Extrapolation of this to field poisoning of possums is inappropriate.

and/or plants[48] its entry into surface and ground water seems most likely where baits or 1080-killed animals fall directly into streams. The five New Zealand tests done to date on ground and surface water after aerial-1080 operations, Waipoua, Rangitoto, Taranaki, Central Otago and Wairarapa, have found in the great majority of samples from poisoned catchments no traces of 1080 at the detection limit of 0.0003 milligramsperlitre (= .0003 parts per million). The two exceptions, Taranaki and Central Otago, were at trace levels. The positive Otago samples were attributed to some baits having dropped directly into streams, and the positive Taranaki samples (some of which were from non-poisoned catchments) were attributed to contamination of sample bottles by poor handling and transport technique and from baits dropping into watercourses.[49] Results are summarised in Appendix A (Table A.13).

Some opponents of 1080 use have claimed that water samples were taken too long after poison drops, and that contaminated water could have gone downstream or percolated into groundwater by the time the samples were taken and so escape detection. Although delays occurred in the Waipoua and Rangitoto monitoring, they did not for the Central Otago, Taranaki or Wairarapa monitoring. The Central Otago data indicates, that *(with higher than average toxic loadings, under winter conditions in dry open grassland)* some traces can be detected in water draining the area immediately after a 1080 drop, but not several days later.

Some people have challenged the accuracy of water monitoring data, but this investigation has found no evidence to doubt the findings. In some instances deliberately spiked 'blind' samples were included as a check on procedure, and demonstrated accurate testing and reporting of results.

Detoxification of 1080 in plants occurs in some species, but in others it adheres or can be translocated, and at experimental dosage levels has been proven toxic to insects or livestock feeding on the plant.[50] Until plant parts holding the toxin die and are broken down by micro-organisms, there is risk of secondary poisoning if a sufficient dosage is adsorbed by the plant and eaten by the non-target species. However, this aspect has not been studied in connection with possum control operations because the risk is thought to be insignificant with the low levels of toxin that are applied.

Studies and anecdotal evidence of 1080 remaining intact and potentially toxic in the environment can result from 1080 baits, 1080-killed carcasses, or vegetationthat has absorbed 1080 which have not yet been subject to dilution

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48 Atzert, 1971, p. 20; Rammell and Fleming, 1978, pp. 61-62; Parfitt et al, in press; Walker, in press; Preuss *et al*, 1968. Binding in soils was demonstrated in the late 1970s, but recent work has found 1080 leached through the soil types tested. Tendency to bind may depend on soil type and level of organic matter present.

49 Eason, Batcheler and Wright 1991(a) and (b); Taranaki Regional Council, 1993(a); Hamilton and Eason (in press); Meenken, 1994;(a) Parfitt *et al*, in press.

50 Atzert, 1971, pp.20,24; Rammell and Fleming, 1978 pp.61-62; Eason et al, in press; Hutcheson, 1989; David and Gardiner, 1966; Cooke, 1976. Also in connection with concentrated waste from a factory making 1080 and 1081; Allcroft and Jones, 1969; Allcroft *et al*, 1969.

by rain or degradation by micro-organisms. The greatest risk is to dogs finding 1080-killed carcasses. In warmer periods and after heavy rain, the toxicity of baits may significantly decline after several days or weeks, but in winter and/ or dry areas may take many months. A summary of data on this aspect is presented in Appendix A (Table A. 14).

A potential source of later illness and death from 1080 poisoning results from the delayed impact of sublethal doses ingested by livestock. This has been suspected in several New Zealand cases involving 1080 poisoning for rabbits. The delayed impact of multiple sublethal doses has been demonstrated in countries where livestock feed on plants naturally containing fluoroacetates (Africa, Australia). It appears that the 1080 is no longer in the environment or the animals concerned, but heart and other damage contributes to death later, especially when the stock are driven or stressed.[51]

It has been suggested that aerially-dropped 1080 (either as baits or bait chaff) can be caught up in the forest canopy and washed down in subsequent rain, causing non-target deaths (in this case to native insects) four to six weeks after poisoning.[52] However, this possible explanation for experimental results has been not been proven or disproven.

The soil micro-organisms that can detoxify 1080 appear to be ubiquitous in the environment, and 1080 is unlikely to be persistent in the environment over the long-term, but the biodegradation process may not be 'rapid'.[53] Biodegradation of 1080 depends on factors such as temperature, moisture, species of micro-organism present, availability of nutrients and the toxin to the micro-organisms, and under some conditions may take several weeks or months.

It is not so well known what happens to degradation products of 1080, particularly fluorocitrate which is the active toxic agent synthesised from 1080 by organisms and likely to be present in bodies of animals poisoned by 1080. It is presumed that micro-organisms able to break carbon-fluorine bonds and detoxify 1080 can also break the carbon- fluorine bond in fluorocitrate, and fluorocitrate is therefore assumed by scientists not to be stable in the environment. However, to dispel any doubt on the matter it has been recently recommended that New Zealand research on this aspect be undertaken.[54]

Concern has also been expressed about the introduction of fluorine to the environment from the degradation of 1080. Fluorine naturally occurs in soils

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51 Jubb and Kennedy, 1970 pp.1 16-17; Dr. A. Seawright (Centre for Environmental Toxicology, Brisbane), pers. comm., 1993; Harris, 1977; p.8; *see also Gordon-Glassford v. Upper Clutha Pest Destruction Board,* unreported, D.C. Alexandra, 20 March 1987, per Judge A.A.P. Willy, for discussion of Balclutha cases, see section 5.1.2, on 1080 impacts to livestock.

52 Meads, in Green, in press.

53 The 1080 biodegradation process has been described as 'rapid' in the popular media, and by regional council field staff when liaising with the public. It is only 'rapid' when compared with persistent poisons.

54 At the Royal Society Science Workshop on 1080, Christchurch, December 1993.

and in the bones of animals in New Zealand,[55] and is added to some water supplies to improve dental health of the human population. Laboratory studies have shown that fluorine from 1080 dosing will accumulate in the bones of rats.[56] Water sampling before and after the Taranaki and Wairarapa aerial- 1080 operations showednatural variability of fluorine in surface water. Levels of fluorine in all samples of natural water in both 1080 treated and untreated catchments did not vary significantly pre- and post-treatment and were well below the levels in domestic water treated with fluorine by water supply authorities.[57] There is no evidence to suggest that aerial-1080 operations add significantly to fluorine levels in water supply sources.

Cyanide and Phosphorus

Both of these compounds are highly unstable in the presence of moisture and air, and are not considered persistent in their original form in the environment. However, data from studies describing the degradation time in various possum control field conditions were not available.

Cyanide baits form a toxic by-product, hydrogen cyanide gas, which dissipates. Elemental phosphorus can oxidise into phosphoric compounds so rapidly that it may cause a fire risk. Phosphates and other compounds with elemental phosphorus are common components in the environment.

Brodifacoum (Trade Name 'Talon')

Brodifacoumis not water soluble, binds to soil, and can be retained in the liver of poisoned animals for over 120 days. It has been estimated that biodegradation in the soil may take three months, and concern has been expressed about retention in insects and other animals and the long-term effects of sub-lethal doses on health and reproduction.[58]

5.1.4 Humaneness of control methods

For both target and non-target species, cyanide at lethal doses causes a very rapid death, and could be considered the most humane of the practical large-scale possum control methods available. Kill traps such as the 'Timms' and 'Electrostrike' cause a rapid death in most cases,[59] but due to bulk and cost are not practical for possum control except in small areas.

As summarised in Table 5.3, all other control methods involve some period of stress or pain prior to death for both possums and non-target animals.

55 E.g. Stewart *et* al, 1974.
56 Egekeze and Oehme, 1979.
57 Taranaki Regional Council, 1993(a); Meenken, 1994(a).
58 Towns *et al*, 1993, pp. 5,21.
59 Death by the Timms trap may be from strangulation rather than broken neck, and evidence of less than instantaneous death is available (e.g. Miller, 1993; B. Warburton, pers. comm.). Comparable test data for the Electrostrike trap was not available.

With 1080, possums and rabbits display symptoms that suggest a relatively quiet death, or convulsions without conscious feeling of pain.[60] However, different species display different symptoms of poisoning, and the period before death can vary depending on dosage. Over the 40 years that 1080 has been in use in New Zealand, many people have witnessed the symptoms, experienced by dogs accidentally poisoned by 1080, which involve convulsions and signs of distress. Researchers have suggested that during such episodes the animals are in a state analogous to epileptic seizure andunaware of pain,[61] but certainly the dog owners to whom we have spoken found it painful to witness.

Brodifacoumcauses death through internal bleeding, and it is likely that some stress and pain is involved. Loss of condition prior to death has been described as 'aesthetically disturbing', but pain or distress was not demonstrated.[62] As death may be relatively rapid (within 24 hours for possums after onset of symptoms) this method may be considered moderately humane.

Phosphorus causes death after a prolonged period involving intense gastric pain. It has been argued that modem methods of bait preparation (finely divided phosphorus rather than chunks) means modem baits cause less pain, but no evidence is available to dispute the conclusion that phosphorus still causes death in an inhumane way. The DOC Ethics Committee prohibits the use of phosphorus to poison possums, except where it is approved by the Director of the Estate Protection Policy Division.[63] The Pesticides Board has considered a proposal to deregister phosphorus baits, but some regional councils have argued against it as phosphorus is viewed as a valuable poison for use by landholders in self-help maintenance possum control.[64] Cyanide and phosphorus (with a licence) and brodifacoum are available to landholders, but cyanide has bait-shyness problems and brodifacoum is relatively expensive.

Legholdtraps without padded jaws can cause fractures and other damage (and thus pain) to the part of the target or non-target animal caught in the trap. By law traps must be checked every 24 hours,[65] which significantly shortens but does not eliminate the period that pain must be endured. 'Soft catch' leghold traps significantly reduce damage and thus pain to captured animals compared to 'gin' traps, but improved design or setting method is required to decrease the number of possums that escape.[66] For the last six years New Zealand has participated in a process to develop international standards for humane trapping, and if parties cannot reach agreement a national standard may be an option to pursue.[67]

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60 APDC, 1977, p.19; Rammell and Fleming, 1978, pp.29,32.
61 E.g. Gregory, 1991; Rowsell *et al*, 1979.
62 Rowsell et al, 1979p. 8.
63 DOC, 1994(a)p. 32.
64 A. Foley, P. Nelson, pers. comm.
65 Section 6, Animals Protection Act 1960.
66 Warburton. 1992; Miller, 1993.

5.1.5 Bait, poison and trap avoidance

Compound 1080

Although for many years **1080** was considered to be odourless and tasteless, it is now known that it has a slight odour and taste reminiscent of acetic acid (i.e. vinegar, to which it is chemically related) and that 1080 and/or its impurities can be detected by possums. Research has now demonstrated that possums receiving a sublethal dose of 1080 can associate ill effects with the poison and/or the bait, and avoid taking poisoned baits in future.[68]

It seems that this is most likely to occur where sublethal doses may have been received by possums, such as in connection with South Island rabbit poisoning where standard field doses for rabbits are lower than for possums. However, possible 1080 shyness has now also been noted in connection with possum control in the Mapara forest in the Waikato Conservancy.[69] Although 1080 has been used for possum control for 40 years and continues to be effective in 'knockdown' intermittent operations, its usefulness in keeping populations low enough to protect native ecosystems and locally eradicate Tb risks may be in question.

Successful 1080 poisoning operations may leave behind a population not only of possums that did not encounter baits and those that experienced sublethal doses of 1080, but those which chose not to approach or eat baits. Frequent poisonings of rabbit populations with 1080 have already produced intractable bait-shy populations in Central Otago and 1080-shy rabbits in the Mackenzie.[70] The possible risk of developing bait andpoison-shy populations of possums through too-frequent use of 1080 may have obvious and serious **implications for future control operations.**

Another possible risk is the development of genetic tolerance of 1080 created by years of intense selection pressure for survivors of poisoning. Although this has not been shown to take place with wild rabbits in Australia, development of geneticresistance from single doses of 1080 and reproduction of survivors over only four generations has been demonstrated with rats in the laboratory. Possums and other Australian species that have evolved in the presence of natural sources of fluoroacetates have significantly higher resistance to 1080. It is unknown whether genetic resistance to 1080 has or may occur with field poisoning of possums in New Zealand.[71]

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67 Gilbert, 1991; J. Dearsley, B. Warburton, pers. comm.

68 Hickling, in press. It is not certain what are the main cues that the possums are picking up (toxin, impurities, bait, or combinations).

69 This operation was not typical of 'initial' controls, but may have serious implications for the efficacy of 1080 for 'maintenance' control at low possum population levels. The initial control (70+ to 90% kill) was through trapping in 1989. The first 1080 application in 1990 achieved a 79% reduction, but in 1991 only a 7% kill. In contrast, use of brodifacoum in 1993/94 achieved high kill percentages, and these residual possums may have been 1080 bait or poison shy (S. Kelton, Department of Conservation, pers. comm., 1994).

70 Bait shyness through 'neophobia' (avoidance of new objects in the environment); Bell and Williams, 1981 and Fraser, 1985, cited in Parliamentary Commissioner for the Environment, 1987. 1080 shyness; D. Ross, M. Williams, P. Nelson, pers. comm., 1991.

71 Wheeler and Hart, 1979, cited in Hickling, in press ; Howard, Marsh and Palmateer, 1973 (summary data on genetic resistance presented in Appendix A (Table A. 15); Twigg and King, 1991.

Cyanide

Cyanide has a distinctive bitter-almonds odour and taste. Poison shyness with cyanide is a well-known phenomenon in ground control operations, and where cyanide baits have been used in the past the proportion of the cyanide-shy possums has been estimated at 20-54%, vs a 12- 13% aversion in cyanide-naive populations. It has been shown that it is the cyanide rather than the bait which is avoided, and that this is caused from direct experience only in some areas. It has been proposed that perhaps 10% of possums may have a natural aversion to cyanide and that intensive hunting pressure in the period of high possum skin prices may have selected these animals to survive and reproduce.[72] Some teaching of learned cyanide-aversion may also be occurring: a mother possum has been observed in the field showing her young to avoid cyanide bait.[73] Research into coating of cyanide in order to reduce shyness is underway (see section 6.5).

Traps

Studies done to date suggest that possums are much less likely to become trap shy than toxic bait shy. The continued susceptibility of possums to repeated trapping has been demonstrated in the Kapiti Island possum eradication programme, and the level of trap shyness in trapped possum populations has been estimated at less than 10% .[74]

Other methods

No information available.

5.1.6 Ground and aerial operations; costs and efficiency

A summary of an analysis of more than 100 ground and aerial possum control operations that were performed in New Zealand since the late 1980s is shown in Table 5.5 (the complete list of operations is in Appendix A, Table A.16). Many of the operations studied did not accurately report all control costs, making comparisons based on cost effectiveness difficult. Variable possum densities, access, terrain, technology, weather, personnel, skill, and other factors also make comparisons between aerial and ground control operations difficult, and this information was unevenly reported in the available literature. For these reasons only the range of costs and percentage reductions has been examined, rather than average values. Within these provisos, the data nevertheless indicates that **aerial and ground operations can both achieve 70-80% reductions in possum populations over considerable areas, and the cost and effectiveness of aerial and ground operations can be similar.**

72 Warburton, 1991; Warburton and Drew, 1993.
73 I. Logan, pers. comm., 1993.
74 G. Hickling, pers. comm., 1994; Cowan, 1992; Frampton, 1994.

Table 5.5 Range of costs, effectiveness and area covered for aerial and ground control operations

	No. of Operations	Control Area (ha)	Cost per hectare $/ha *	Percentage reduction
Aerial-1080 (initial)	27	101 - 18,000	@ $10/ha - $54/ha	31% - %%
Mixed - Ground and aerial-1080 (initial)	19	2,506 - 21,426	@ $7/ha - $28/ha	54% - 99%
Ground 1080 (initial)	7	742 - 7,800	@ $7/ha - $26/ha	81% - 95%
Ground 1080 (maintenance)	29	695 - 14,520	@ $2/ha - $15/ha	52% - 97%
Ground Control (initial) (trapping, cyanide, and/or bait stations)	25	75 - 14,122	@ $4/ha - $62/ha	40% - 90%

* Direct costs only.
This table does not include mixed control maintenance, ground control maintenance, successive operations, or experimental operations. For full information on all operations see Appendix A.16.

Both aerial and ground control methods have advantages and disadvantages associated with their use, but used correctly both can contribute towards more efficient and effective possum control in New Zealand. Evaluation of alternative control strategies needs to take into account all the factors mentioned above, in some detail. For example, terrain and other factors contributing to an overall 'ease of ground control' assessment include steepness, degree of dissection, altitude, height of tree canopy, nature of undergrowth and ground cover, tree density, number of fallen trees, underfoot conditions, distance between tracks, huts and road ends, etc. For optimal assessment of alternatives, management units may need to be broken into smaller terrain units.

A summary of the relevant costs, benefits and limitations is displayed in Appendix A (Table A.17). To enable more accurate assessment of the cost effectiveness of different control methods, reporting of operations should include not only direct operational costs, but also indirect costs. Indirect costs that should be accounted for and made 'transparent', include:

- planning;
- supervision:
- monitoring (performance and operational);
- public consultation;
- relevant consent procedures;
- provision for repeat of failed operations;
- administration and overhead;
- the cost of any liability arising from an operation (e.g. liability for the death of livestock).

The cost and effectiveness of ground control (trapping and hunting) can vary as it is dependent on the skill, experience and bushcraft of ground operators, but it has been a successful alternative in smaller areas and can be used effectively for large operations (e.g. Department of Conservation, East and West Coast Conservancies). Many maintenance operations have used 1080 for ground control, and the Northland Regional Council uses this control method for most operations (both initial and maintenance). One problem associated with ground control contract operations is that each operator has to be monitored, and this can increase the cost of monitoring compared to an aerial operation.

Aerial-1080 poisoning over large areas may be more cost efficient in a comparison of direct costs, but there are increased indirect costs and overheads such as consent procedures, consultation, risk of an authority being held liable for any operator error during an operation, and the requirement to pay the majority of costs regardless of the success of an operation. ***Performance contracts require accurate operational monitoring, but all operations should be performance-based and be fully monitored as well.***

5.1.7 Performance based contracts

The effectiveness of ground control by hunters has frequently been criticised by reference to earlier years, when hunters worked only to harvest skins for sale and did not keep populations sufficiently low. Commercial hunting for skins in the late 1970s to early 1980s in many cases targeted easily accessible and high density possum areas, with commercial hunting often only reducing the population by 30-50% before moving on to more easily attainable possum populations. However, in other areas commercial hunting also lowered possum densities and reduced forest damage compared to non-hunted areas.[75]

The level of control from commercial hunting would not be sufficient to achieve the conservation and Tb goals of control agencies today. However, the use of performance contracts for hunting has, in some regions, successfully provided a suitable mechanismto target high-risk areas, ensured accountability for control authorities, and created some employment. The use of performance contracts for possum control is essential to increase efficiency of ground control contract operations, and they have been used successfully for ground-1080 operations by the Northland Regional Council (requiring 80% kills) and for ground hunting by DOC East Coast Conservancy and West Coast Conservancy (requiring 70% kills). The main advantages and disadvantages of performance based contracts are shown in Table 5.6.

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[75] Brockie, 1982, p. 21; Clout and Barlow, 1982, p. 30; K. Reeves, DOC Wanganui, pers. comm., 1993.

Table 5.6 Advantages and disadvantages of performance based contracts

Performance Based Contracts:	Advantages	Disadvantages
1) The full contract is paid only after the successful completion of the contract.'	Provides authority with accountability and control as only pays contract if operation completed. If operation fails to meet a set target, then can tender for a new or recovery operation.	Difficult for hunters to finance operation or provide for on-going expenses while completing a contract. Uncertainty reduces the incentive for people to pursue hunting as a fulltime occupation and to further develop skills and experience in the industry.
2) A weekly retainer with a performance incentive based on the actual performance achieved, e.g. DOC West Coast, late 1980s.	A high reduction in density (95%), is paid more than a low reduction (75%), which encourages performance. Allows hunters to pay for on-going expenses, while allowing the authority to have some control of the operation.	An authority has difficulties in budgeting for a series of operations in any year, as costs may escalate if a high percentage kill is achieved, without the available funding to pay for the control. Monitoring of any operation has to be able to establish true performance levels, to enable the appropriate incentive to be paid.
3) A weekly retainer with au incentive payable on completion of the contract e.g. DOC East Coast.'	Allows hunters to pay for on-going expenses and for authorities to retain some control of the operation. An efficient mechanism to obtain a reduction in a possum population to a targeted level.	Authority loses some control over payment for au operation.

Notes:

1: Gross and Cathcart, 1993.

2: East Coast Conservancy pay a $450 retainer and $150 performance incentive on achieving 70% reduction. Department of Conservation, East Coast Conservancy, 1993. Ground Contract Possum Control, unpublished paper, reference SPR706.

5.2 Other control measures

5.2. I Biological control

Biological control is the control of an organism by biological (rather than chemical or physical) means. It may occur naturally through predation or the effects of existing pests or diseases of the organism, or be developed by breeding for resistance, introduction of natural pests or diseases of the same or a related species, or genetically modifying a pathogen of the target organism to make it more virulent or to disrupt some natural process such as reproduction in the target organism. In high population densities a biological control agent could spread rapidly and have a significant impact but when the population drops, the control agent may not spread so well. A sexually transmitted control agent is suggested to offer the best chance of success at lower population densities as animals actively seek partners in the breeding season.[76]

[76] Jolly *et* al, 1992; Jolly, 1993.

Unfortunately there is no known natural biological control agent which would give an adequate level ofpossumcontrol either in New Zealand or their native Australia. An agent may have to be genetically engineered and viruses appear to be the most suitable class of vector for this approach, particularly if the possum reproductive system is to be targeted."

A successful biological control agent for possums needs to be species specific, infecting only possums, have a high prevalence among possums, have a possum specific mode of action and a high level of impact on each individual, be unable to survive away from possums, and be humane. The unique marsupial features of the possum are a positive factor in the development of a biological control strategy, as they enhance the likelihood of developing biological controls specific to the possum.

Immuno sterilisation, a form of biological control, would involve the creation in the possum of an immune reaction to key proteins involved in the hormonal control of reproduction, in sperm and egg development and transport in the reproductuive tract, in fertilisation and implantation or in lactation.[78] Techniques to introduce a contraceptive 'vaccine' have yet to be developed though research is underway in New Zealand and Australia and could include oral administration by the use of baits, or transmission by a virus specific to the possum (virally vectored immrmosterilisation (WI)) which relies on animal-to-animal contact of some description, or possibly an ecto or endo parasite to spread the 'sterilising gene' among possums. A range of possum parasites has been isolated, and if this method is used the parasite may not need to be possum specific, but the 'sterilising gene' must be.[79]

Although immuno sterilisation is a new field of science, the scientific skills are present in New Zealand and Australia. Allison considers they should be brought together and focused on the possum.[80] This is being achieved in part by the National Science Strategy Committee on Possums and Bovine Tuberculosis (NSSCP) strategy for biocontrol and by new research funded by MAP Policy. It is expected to be at least 10-16 years before a cost-effective, environmentally acceptable and humane biological control agent for possums such as a vector transmitted immunocontraceptive is ready for release in New Zealand.[81] However, this is considered to offer the best hope of a sustainable nationwide control technique. It is unlikely to be the 'final answer', and ultimately the best control strategy will probably be an integration of traditional and new techniques.

Science managers expressed the view that the resources, particularly appropriately skilled people, were not available to make use of a large increase in funding for biological control research, although some aspects may benefit from additional funding. There is a very poor knowledge base for the possum

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77 Jolly, 1993; Batcheler and Cowan, 1989; Allison, 1993; Jolly et al, 1992.
78 Jolley et al, 1992; NSSC, 1992.
79 Jolly 1993; Batcheler and Cowan, 1989; Allison, 1993.
80 Allison, 1993.
81 Livingstone, 1991; Jolly 1993.
82 J. Rodger, University of Newcastle, Australia, pers. comm., 1994.

in most areas critical for the development of any currently conceivable biological control strategy.[82] Much of the work has a long timescale and there is no linear relationship between funding and the rate at which results will be achieved.

However, consistent funding over at least the next three to four years needs to be confirmed. Much of the research is medium term and continuity of funding is needed before post-graduate students will be employed and the needed skills developed. Flexibility in funding and constant monitoring of whether additional funds are required, would allow science managers to react to promising opportunities without threatening the existing science infrastructure. Innovative and unexpected alternative strategies for control, which may be unique to marsupials, are likely to arise from chance research findings simply because of the poor current understanding of the animals' system.[83]

Public opinion in 1991 concerning use of biological controls showed low public support, and public concerns regarding the use of genetically modified organisms will have to be allayed if it is to be successfully introduced once developed." A community liasion group with members from the major interested parties has been convened by Landcare Research Ltd to develop and monitor its research programme, and a programme of research into public attitudes has been initiated.

New Zealandguidelines for considering genetic engineering research and the release of genetically modified organisms have been prepared and are administered by two separate committees, both supported by the Ministry for the Environment, **viz the Advisory Committee on Novel Genetic** Techniques and the Genetically Modified Organisms Interim Assessment Group. These committees currently have an advisory function, with no ability to insist on compliance with their guidelines or recommendations especially by the private sector, and possibly even in private research contracts with Crown Research Institutes.

The forthcoming HSNO legislation is expected to address the need for statutory controls on research and release of genetically modified organisms.

5.2.2 Bounties and markets

The use of bounty schemes, work programmes and increased marketing of possum products, have all been proposed to increase the use of ground-based possum control and generate local employment. The advantages and disadvantages of these alternatives are summarised in Appendix A (Table A. 18).

A variety of bounty and 'possum lotto' schemes have been recently proposed,[85] but as noted in section 2.1, a bounty scheme, tried in 1951-1961, was abandoned when it proved ineffective in controlling possums in high-risk areas. Over 8.2 million bounties were collected at a cost of more than $2

83 J. Rodger, ibid.

84 Allison, 1993; Livingstone, 1991; Sheppard and Urquhart, 1991.

85 NZ Shooters* Association, 1993, B. Parker, 1993, G. Navratil, 1993, pers. comms.

million ($24 million in 1993 dollars), with the scheme having little impact on the size of the possum population or the rate of migration. No bounty proposals have yet come forward that offer effective ways to target Tb or conservation priority areas, where limited funds need to be targeted to high-risk areas.

Neither the Department of Conservation, the Ministry of Agriculture nor the Animal Health Board has as their statutory responsibility the- creation of employment. In 1993/94, the Government has directly subsidised possum control programmes. However the Department of Labour generally funds work programmes to assist the unemployed in gaining work experience and skills, and is reluctant to assist the creation of employment that will not be sustained by the economy in the long term."

The world fur market is subject to large fluctuations in demand and the price available for furs. Possum hunting for furs became less economic after 1988, when fur prices decreased from an average of $8 a fur, to $2 in 1990. The decrease has been attributed to the increasing influence of the anti-fur lobby, the general world economic downturn, the promotion of synthetic furs, an increase in Korean labour rates (for processing of furs), and several warmer winters in the Northern Hemisphere.[87] The depressed world fur market has continued for four to five years but there are signs that prices are beginning to increase again.

In the future, export markets to Asia, Eastern European countries, and Scandinavia could be targeted, with one possible marketing strategy involving the promotion and marketing of possum products as environmentally sound products. However, the commercialisation of hunting to provide possum products, cannot be allowed to subsume the primary purpose of control of possums, that is habitat and species protection and the control of bovine tuberculosis. When fur prices decrease because of market fluctuations and hunting deaeases, there is the associated problem of control agencies being expected to take over the control of possums, when they may not have the required support network or expertise.

In New Zealand there has been 'no large-scale coordinated attempt to promote and market possum fur overseas as a fashionable quality garment fur'.[88] The lack of available funding for marketing or promotion of possum products, the lack of a representative possum marketing group, and varying levels of interest in the market from both suppliers and purchasers of products have contributed to this situation.

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86 L. Cox and R Wills, Department of Labour, pers. comm., 1994; The Evening Post, 4 January 1994; 132 positions in DOC programmes and 282 positions in Employment Service Programmes (mostly regional council).

87 Allan, 1993, p.4; Thorsten Fridlizus, 1993, pers. comm.

88 Batcheler and Cowan, 1988; p.72; B. Warburton, Landcare Research, pers.comm.

5.2.3 Fences

It is proposed that the migration of possums to peninsulas and ecologically valuable mainland'island' reserves could be prevented by electric and barrier fences, as a temporary measure to protect endangered species until another more efficient control method is developed, At Cape Lambert in the Marlborough Sounds, 220 hectares of the peninsula has been fenced off by the Department of Conservation using a 2 km long Gallagher electric fence with four 'hot' wires powered by a 8000 volt solar panel. Electric fences have been proposed for the Northern Coromandel peninsula at Moehau and parts of the Northland Conservancy.[89] The problems in establishing an electric fence in the Coromandel suggest that obtaining agreement on the location of a fence from all land owners can be an impediment and prohibit the cost-effective use of fences.

A multi-purpose barrier fence (either partially buried in the ground or using a skirt, with netting and an electric wire on top) has also been proposed to enclose the 180 hectare Karori Reservoir in Wellington."

Damage to fences from falling trees, short circuits, human interference, and 'determined' possums mean fences would only keep out an estimated 95% of all possums. If fences are used in conjunction with permanent bait stations and intensively controlled buffer zones they may be a valuable additional control measure in appropriate areas.

5.2.4 Technical improvements

Navigation systems

Accurate navigation is an essential component of any aerial operation to ensure even and accurate spreading of poisoned bait, but until recent years the targeting of aerial control operations was primarily by line-of-sight flying, with resulting gaps and duplicate dosing.

The Differential Global Positioning System (DGPS) vastly improves the targeting of bait coverage through computerised satellite navigation. AD GPS system with computer printouts can enable auditing of flight paths and the area targeted, and will assist improvements in operation management. However, only four firms have DGPS available to agencies at the present time, which is inadequate for all the aerial operations by both D OC and AHB. Three additional fii may have DGPS systems and another 12 have expressed some interest in possibly installing systems in future, so the situation may improve if there is a stronger demand by agencies.[91]

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89 Hawes, 1994; A. Saunders, DOC, pers. comm.; Cape Lambert fencing $4,200/km plus labour, solar panel $1,400.

90 Forest & Bird, November 1993, p. 9; Allan Saunders, DOC, pers. comm.; Estimated cost of fencing the 180 ha reserve $1.2 - $1.8 million.

91 P. Nelson, 1994, pers. comm.

Alternative toxins and baits

Eighteen potentially useful toxins have been assessed by Landcare Research to determine their toxicity to possums and to birds, and methods of enhancing their palatability and efficacy against possums considered. Cholecalciferol and gliftor are two effective compounds and further research into the susceptibility of native birds and insects, the potential for secondary poisoning and persistence in the environment, are well advanced. An application for registration of cholecalciferol is expected to be made mid to late 1994.[92]

The current baits for possum control are cereal-based pellet baits or carrot baits. These are not durable, and research to develop water resistant formulations for pellet baits has identified several surface treatments which improve water resistance without reducing bait palatability. However, coating would also increase the time required for biodegradation of 1080, and it is proposed to use them away from farmland where stock exclusion was not required. Research has focused on developing gel and sachet baits for farmer use. Initial results have been good, and gel and sachet baits are durable and relatively safe to humans and non-target species because of the packaging. Field testing and non-target effect monitoring are planned.[93]

5.3 Maintenance operations

A key decision for any possum control operation is whether to have a programme of sustained control (e.g. a high initial 'knockdown' followed by regular maintenance operations) or a programme of periodic intensive control (e.g. cyclic 6-10 year intensive control with a high 80-90% 'knockdown').

There are different risk strategies involved with these two control approaches. Central and Industry bulk funding with centralised decision-making can facilitate large-scale operations when a problem is acute. This creates a high-risk strategy in terms of allowing possum numbers to increase over a period of years, and then applying intensive control. If control is not successful for any reason, immediate follow-up operations are required. The individual land owner is not able to finance periodic operations because of the large cash flow injection (even at 6-8 yearly intervals) and the time required for planning.

In contrast, the maintenance of low density populations by continual control encourages individual ownership of the problem, allows accommodation of the control within overall farmmanagement, and provides for better management of cash flows. However, in order to undertake maintenance operations, high density populations do need to be reduced initially and in some locations, because of terrain, vegetation, and access constraints, maintenance operations may not be an option, with periodic control the only solution.

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92 Eason, *et al*, 1993(a); Sutherland et al, Landcare Research, pers. comm., 1994.

93 Morgan, *et al*, 1993.

There are also technical difficulties associated with accurately monitoring low density populations and evaluating the success rate of maintenance operations. With low density populations the effects of possums are reduced, but the marginal cost of monitoring and the cost of control, can be much greater than for high density populations.

Recolonisation of the forest/pasture margin after a control operation can be rapid, because of the combined effects of immigration and breeding. Immigration is particularly significant in small control areas with extensive margins of uncontrolled habitat.[94] Survivors of operations may also breed twice a year if the previous population was under 'feed stress' which was then relieved by the control operation.

Barlow (as discussed in Chapter 3), in modelling different options for Tb control, has suggested that widespread poisoning or a single intensive operation followed by maintenance control can be highly effective, offering a means of rapidly reducing tuberculous possum densities. This is assuming there is no immigration of infected feral animals as this would increase the time-scale for successful control.[95]

The maintenance control required to protect at-risk conservation values will depend on what values need protection and the risk of damage. For example, vulnerable species of plants, birds or invertebrates may require virtually total removal of local possum populations, for the species to have the opportunity to survive. This would require intensive and/or frequent control.

For medium-to long-term Tb control and conservation protection, there are many unknowns associated with current theory and the computer models. Hickling, in a study at Hohotaka, central North Island, has documented the results of the first five years to assess if annual control of possums can maintain low levels of Tb among possums and cattle. Control has been shown to be effective in reducing the number of cattle reactor rates, but it is less effective in reducing the number of herds on movement control.[96]

Once an area has been initially targeted for Tb control, subsequent maintenance operations are required. This means that an additional 200,000 ha per year will need to be added to the total area under control.[97] This has significant implications for both funding and the public acceptance of control methods being employed, over an ever increasing area.

The lack of ongoing maintenance operations by control agencies can bring them into conflict with land holders and local councils, if the agencies are perceived to be not performing their share of maintenance control or the duties of a 'good neighbour'. All parts of a contiguous area require maintenance control for it to be cost-effective. The success of a control strategy demands an

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94 Hickling, 1993, p. 18.
95 Barlow, 1991(b), p. 803.
96 Hickling, 1993, p. 5.
97 P. Nelson, 1994, pers. comm.

ongoing political and financial commitment by all agencies and land holders.[98] Maintenance of lower densities of possum populations (for Tb vector control and the prevention of possum damage to trees, crops, and pasture) is likely to depend on the efforts by individual land holders. The establishment of 'self-help' maintenance control operations using land holders, can help a community maintain reduced possum population densities on an ongoing basis.

The Commissioner has previously noted that the 'owners' of a pest problem such as rabbits are those best able to find solutions to the problem.[99] The successful establishment of Landcare Groups in other parts of New Zealand provides a useful model for sharing information, controlling possums, and reducing Tb vectors and agricultural damage. Central and regional government has a role in facilitating and coordinating the development of skills through providing training (with access to operational manuals and research findings), bulk purchasing of equipment for control operations, and providing information for these groups.

It is recognised that many regional councils are facilitating land owner groups and this needs to be encouraged. In recent years, several community based programmes for possum control such as land care, possum clubs, or 'Project Crimson pohutukawa protection schemes' have also emerged. The failure of these groups is often because of a loss in continuity when key organisers leave a district, and the loss of interest. Agencies can also become frustrated with differing levels of control and breakdowns inmaintenance control operations. For momentum to be sustained, the focus of a Landcare group needs to be on sustainable laud use, rather than a single focus on Tb, conservation values, or possums. There is also some merit in having such groups assisted financially by local government. The continuity of a group then has a better chance of success which is to the land owners' and councils' advantage. With a broad focus approach, community groups can play a major role in not only reducing the amount of damage from possums, but in conserving the land for the future. A summary of the advantages and disadvantages of self-help maintenance operations is presented in Appendix A, Table A.20.

5.4 Public opinion on possum control methods

Public opinion on pest control in New Zealand was surveyed in detail in 199 1, and results relating to possums are summarised in Appendix A (Table A.21). Generally, the majority of respondents felt that possums were a serious problem, the problem was getting worse, and not enough was being done about it.

The most suitable possum controls were seen by respondents as shooting and trapping, followed by introduction of a possum-specific disease. Use of 1080 and cyanide did not have more than 45% support. Opposition to use of

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98 Gross and Cathcart, 1993, p.8.

99 PCE, 1987, 1991.

poisons (1080 and cyanide) was higher among women than men, and support for trapping was higher in rural areas.

Public perception about the use of possum controls is likely to be a reflection of the information the public has available on which to base a judgement. For example, the control method that attracted the highest public support, shooting, is one which pest control professionals consider to be one of the *least* effective in reducing possums to the levels necessary to protect conservation values and reduce the spread of bovine Tb.[100] If public opinion is considered by officials to be ill-informed, it may in part be because the necessary information has not been made adequately accessible.

A 1992 survey of public views in the Manawatu-Wanganui region found that although 98% were aware of possums being a problem, and 80% valued possumcontrol, the dollar value placed by the rural community was twice that of the non-rural community.[101]

The New Zealand population is now predominately urban and may not have direct experience or understanding of the seriousness of the risks posed by uncontrolled possums on the Conservation estate and to rural industries. This implies the need for better public information, particularly in popular media such as television.

The public view of the risks (real, unknown or perceived) of using pesticides is also influenced by a history of 'safe' chemicals proven 'unsafe' or persistent in the environment over time (e.g. DDT, Thalidomide, PCBs, PCP, Agent Orange). Regardless of the specifics of each case, this has in general reduced the level of public trust in government officials and scientists. This erosion of public trust cannot be repaired simply by demonstrating 1080 is biodegradable.

The use of aircraft to distribute 1080 in some operations also influences public opinion. There appears to be a widespread public perception which views aerial application as 'indiscriminate' in comparison to hand application, bait stations and traps. That there is no scientific proof of significant long-term effects to water or populations of non-target species from modem aerial- 1080 operations does not diminish the requirement for precision when dropping poison baits from aircraft. Control agencies do, except in cases of equipment or human error however, keep poison within designated control boundaries, and DGPS navigation gear can improve this focus. Accurate placement of toxins (hand baiting, bait stations) can narrow the scope of resources and species that may be exposed to *potential* risk.

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[100] Night shooting is considered able to assist in assessing population levels, and reducing already low populations (AHB, 1992, section 10.2.2). With high populations it is considered to reduce the populations at best by about 30% vs the 70+% required. In small areas, the method may be more effective where lures such as willows and brassica crops are used (P. Nelson, pers. comm.).

[101] Lock, 1992.

It is important that control agencies seek out and attempt to work in harmony with the views of tangata whenua for proposed possum control programmes. The Maori tribes with traditional connections to an area still feel a strong sense of *kaitiakitanga* (guardianship) regardless of whether they own the land in the legal sense, and will have views about how best to protect the integrity and health of the land, water, native ecosystems and human communities, and may want a direct hands-on role. Unanimity of opinion should not be expected (see Taranaki case study in section 7.2) and individual hapu will need to be consulted.

In 1993/94 the possum control and research agencies employed public relations techniques to explain to the public the Tb and conservation risks posed by possums, the need for control, and the reasons why methods such as aerial-1080 have been chosen. Purther initiatives are planned by the National Possum Coordinating Committee and by agencies directly involved in control operations for 1994/95.

Views held by our overseas trading partners are also relevant, particularly with the potential for non-tariff trade barriers:

- whether there is a Tb risk from New Zealand products;
- whether aerial broadcast of broad-spectrum poison (1080) over a significant proportion of New Zealand is consistent with a ‘clean and green’ image;
- whether possum fur is a ‘green’ product (as possum control helps the conservation estate), vs perception that it is inhumane to capture fur animals in traps.

Information on the unique New Zealand possum problem and efforts being made to address it may need to be made available to overseas countries, perhaps through embassies, marketing boards, and environmental and consumer groups with international links.

5.5 Summary of control methods

There are many ways to kill, deter or capture possums, but only a few can offer the opportunity to lower possum populations enough to protect conservation values or reduce the spread of bovine Tb on medium to large scales. These are Compound 1080 (aerial or ground application), cyanide, traps, phosphorus and brodifacoum, which are compared in Table 5.7.

For considerable areas with very difficult terrain and poor access, there is not at present a cost-effective alternative to aerial-1080. If biological alternatives become available, this situation may change.

For the majority of New Zealand other options do exist, all of which are already in use to some extent.

Possum hunting is not the only method that is labour-intensive and thus creates jobs. Ground-baiting with 1080, phosphorus and brodifacoum is also labour intensive. However, hunting requires more going back to check the traps or cyanide, and so can be more labour-intensive. It also can produce a marketable product (skins) to offset control costs.

For performance hunting to be a viable option for more areas of New Zealand, more trained people are required, and expansion of this approach is therefore a medium-to long-term proposition. Performance contract hunting requires much more than the harvesting that most possum hunters are familiar with from the days of high skin prices.

The risk of developing bait and poison-shy populations may be significant, and the heavy reliance on 1080 over the medium to long-term or a heavy reliance on cyanide is unwise. Alternatives are required as part of possum control strategies, particularly for 'maintenance' operations.

Compound 1080 is biodegradable and thereforenot persistent in the environment over the long-term. The other poisons have not been as fully studied, and in particular the fate of brodifacoum ('Talon') in ecosystems requires further clarity.

All possum killing methods can affect non-target species, and all require better monitoring of both control effectiveness and long-term effect on non-target populations.

Table 5.7 Summary of possum control methods

	1080		Performance contract hunting		Brodifacoum ('Talon')	Phosphorus	Bounties and/or markets
	Aerial	Ground	Traps	Cyanide			
ADVANTAGES **Can achieve 70+% kills**	✓	✓	✓	✓	✓	✓	
Can target high-risk areas	✓	✓	✓	✓	✓	✓	
Cost-effective: **- accessible terrain**	✓	✓	✓	✓	?	✓	
- very difficult terrain	✓						
Many years of field experience	✓	✓	✓	✓		✓	
Labour-intensive (=jobs)		✓	✓✓	✓✓	✓	✓	✓
Saleable resource (skins)			✓	✓			✓
Control without poisons			✓				
DISADVANTAGES **Non-target kills possible**	✓	✓	✓	✓	✓	✓	✓
Persistent in environment					?		
Relatively expensive			*		✓		
Bait/toxin/trap shyness risk	✓	✓	✓	✓	✓	✓	✓
Inhumane death (both possums & non-targets)	?	?	✓**		?	✓✓	?
Better monitoring required	✓	✓	✓	✓	✓	✓	✓
More trained people required	✓	✓	✓✓	✓✓	?	✓	

* Initial outlay for traps expensive, but not if cost averaged over life of traps.

* Significantly more humane if soft-catch traps used.

For information on mode of application and size of area, see Table 5.1

A commonly proposed alternative is the creation of a bounty and/or enhancement of possum markets. This has been added to the table for comparison, but as it is not possible to target high-risk areas, it is not considered capable of delivering cost-effective control.

Measures such as fences (conservation protection) and reducing livestock exposure to high possum populations (Tb protection) do have the potential to reduce risk but only in localised areas, and so have not been included in the comparison.

6 Monitoring of Possum Control

6.1 Why is monitoring important?

Given the number of possums in New Zealand and the seriousness of the risks posed by uncontrolled possum populations, it is obvious that successful control needs to be based on coordinated and focussed strategies. Ongoing monitoring of possum control is central to the design, implementation and improvement of control strategies, by:

- measuring the success of possum control operations, both in terms of numbers killed and values protected (see below);
- assessing the trends in possum populations during maintenance operations or in times when no control is being undertaken;
- assessing the level of maintenance required after a knockdown operation;
- comparing different control methods or operations.

Monitoring is also essential as an audit tool, often acting as the basis of payment to possum control operators in a contractual relationship.

In terms of the present investigation, consideration ofmonitoring is necessary as part of the assessment of appropriateness of possummanagement methods, because without reliable measures of success or failure, such an assessment is rather meaningless. As an experienced scientist has warned:

> 'There is very little evidence to date to demonstrate that the benefits of possum control - reduced Tb spread and ecosystem damage - can be *sustained.* Until we have such evidence the whale edifice of possum control in New Zealand sits on shaky ground. Personally, I believe that much of the money spent controlling possums may prove to be wasted because the level and duration of control is inadequate. The only way to determine whether or not this is the case is through adequate monitoring."

6.2 Operational and performance *monitoring*

The goal of possum control should be not to kill possums per se, but to reduce the undesirable effects of possums. Therefore, more important than the *number killed* is the *number surviving,* because this determines the likelihood that the operation will be effective in reducing the undesirable effects of possums. However it is extremely difficult ta assess absolute numbers or densities of these nocturnal, largely arboreal, relatively wide-ranging animals. Absolute density measurements have only rarely been gathered and then only in well-resourced experimental situations. Most commonly, a *relative estimate* of possum numbers killed or surviving is obtained, by compar-

1 GJ. Hickling, Lincoln University, pers. comm.

ing indices of pre-operation and post-operation population levels. This results *in* a *percentage kill* or *percentage* survival *rate.* Most operations aim to achieve the maximum possible kill rate, and a population reduction of 75-80% is usually considered to be an acceptable performance standard.

Almost all the currently used monitoring methods measure control operations in terms of the percentage reduction in possumnumbers, i.e. the efficiency of control. This can be termed operational monitoring. There are many available techniques of *operational monitoring.* Features of the most commonly used techniques are summarised in Table 6.1.

Performance monitoring, on the other hand, measures the reduction in undesirable possum effects, such as changes in vegetation or threatened species, or reduced Tb transmission rates as reflected in cattle herd Tb reactor rates. Operational and performance monitoring should be seen as complementary.[2] Among control agencies there is a general trend towards performance rather than operational monitoring as it is seen as more directly related to the goals of possum control, i.e. it assesses the effectiveness of control rather than merely its efficiency. However, performance monitoring can never be a direct measure of possum control because possum effects are only one of a number of factors contributing to the environmental threats being addressed by possum control? Also it may take several years after possum control to show an improvement in environmental qualities being protected. For these reasons operational monitoring is likely to remain the basis of payment in contractual relationships.

At this stage routine techniques are still being developed for performance monitoring of possum control operations for conservation goals. It is unlikely that performance monitoring techniques can be fully standardised as conservation goals differfromarea to area. Performance monitoring for conservation goals undertaken to date has principally been by assessing vegetation condition as an indicator of possum browse levels.[4] Methodologies for canopy assessment (from the ground or using aerial remote sensing) and using key indicator species are currently being developed.*

Documentation of possum effects on threatened animal species is still in its infancy and is based largely on indirect assessments of effects, such as dietary overlap between possum and threatened bird species' diets.[6] The ultimate performance measure for possum control in this context is abundance of the threatened species in question, but to date, few such monitoring studies have been completed. One example comes from several seasons' monitoring of

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2 A further type of performance-related monitoring is the survey of condition and trend of at risk values in the absence of any management action. This could be termed 'surveillance monitoring' (J.P. Parkes, Landcare Research, pers. comm., 1994).

3 In terms of Fig. 2.1, operational monitoring measures the efficiency of control of just the possum factor, while performance monitoring measures changes in the values at risk (bottom of diagram) which are affected by all the other factors shown.

4 Meads, 1976; Batcheler and Cowan, 1988; Pekelharing and Batcheler. 1990.

5 Payton, 1994.

6 Leathwick *et al,* 1983.

kokako populations in the Mapara and Kaharoa districts after prolonged control of possums and rats. Increases in the adult population in the 1993-94 season, following earlier increases in breeding success, have been linked to lower possum population levels.[7] The Department of Conservation is currently drawing up proposals for a medium-term study which will incorporate performance monitoring of some possum control operations, (see section 5.1.2).[8]

Performance monitoring for Tb control is done by testing for incidence of Tb in livestock. It relies on two critical assumptions; that the Tb reactor test is accurate, and that cattle Tb infection and reinfection has a direct relationship to possum population levels. Although these assumptions are usually reasonable for management purposes, neither holds true in all cases. The reactor test is about 80% accurate (see section 3.3). There is no demonstrated relationship between possum population levels and prevalence of possum Tb, and there are a number of other contributing factors to the incidence of Tb in livestock, so that falling reactor rates may be associated with other contributing factors even when many possums are being killed. Monitoring for Tb control is further discussed in Chapter 3.

Monitoring for direct possum impacts to agricultural and forestry production is usually undertaken directly by the resource owner. This person usually requires an estimate of percentage possum kill, undertaken by a simple method such as spotlight counting or bait interference, coupled with a subsequent assessment of the values being protected, such as improved tree survival or less crop damage. Some large mobile bait stations used for protection of horticultural or forestry blocks incorporate an automatic counter to register the number of animal visits. This is primarily used to assess when to introduce poison bait, but can also be used as a simple monitoring technique by comparing pre-and post-poisoning visits.

6.3 Estimation of critical possum population thresholds

A strategy of selective possum control is based on the premise that there is a population density below which the possum's undesirable effect is acceptable, i.e. a *threshold level.* A threshold population density is in turn linked to a threshold level of effect. Threshold levels of effects would be suitable performance standards for control operations, especially if they can be monitored using indicator species. Por example, monitoring of vulnerable plant species in northern forests (northern rata, kohekohe, fuchsia, etc.) is based on the assumption that 'providing these key indicators are not being visibly or measurably damaged by possums [the threshold], it is likely that the forest ecosystem as a whole will retain its integrity'?

In practice, such thresholds have not been experimentally confirmed for any possum populations, not even intensively studied ones, Present knowledge

7 J.R. Hay, Department of Conservation, pers. comm.
8 R. M. Sadleir, Department of Conservation pers.comm.
9 Department of Conservation, 1994(c).

Table 6.1 Summary of possum control operational monitoring methods

Method & Principle	Advantages	Disadvantages	Relative cost	Principal Use(s)	Variations and Notes
TRAPCATCH **Number of possums caught** in traps over successive nights **can provide** index of abundance before and after control.	• Monitoring **contributes to the kill.** • Other species caught can be recorded. • Non-treatment block not required. • Hunters can assist with monitoring. • Carcasses available for post-mortem. • Direct, relatively unambiious results. • Results (catches/100 trapnights) can be comparable between areas.	• **Animal welfare groups** oppose leg-trapping. • Trap shyness can interact with control and bias result. • High equipment requirement. - Wet weather can influence results. • Catchability varies. • Effort required to carry, place and shift traps. • Need to shift traps between PRE- and POST- surveys introduces error. • Risk to non-target species. • Inaccuracies from sprung traps or non-target species catch.	Medium	First **developed** and still very widely used method. DOC's method of choice.	Many variations to basic techniques, principally use of cyanide poison stations instead of traps. Cheaper and easier but unreliable in cyanide-shy populations. Technique can give relative density measures (catches/100 trapnights)
BAIT TAKE Abundant non-toxic bait made available to possums at self-feeding bait stations along transects. Amount of bait consumed gives index of **abundance before and** after control.	• Relatively few bait stations required. • Usable in low density populations. • During maintenance phase, permanent stations can also be used for control. • Farmers can assist with monitoring. • Can be used in most habitat types.	• Cost of stations and bait. • Numerous visits to stations required (especially where densities high). • Susceptible to interference by non-target species. • Bait shyness can bias results. • Results sometimes subject to unexplained variability. • May require non-treatment block.	Medium	Principal AHB audit method.	Need for non-treatment block currently being assessed.

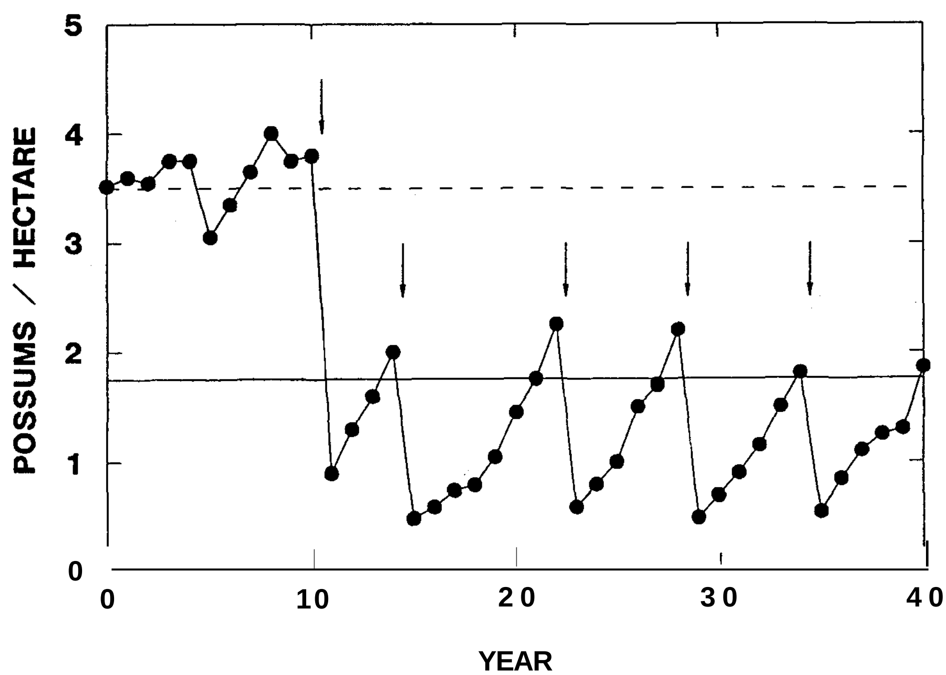
Method & Principle	Advantages	Disadvantages	Relative cost	Principal Use(s)	Variations and Notes
BAIT INTERFERENCE Similar to bait take but uses large numbers of single non-toxic baits along transect. Numbers of baits consumed or interfered with gives index of abundance before and after control.	▪ Simple technique. ▪ Can be applied in all environments. ▪ Usable in low density populations. ▪ During maintenance phase, permanent stations can also be used for control. ▪ Farmers can assist with monitoring.	▪ Interference by non-target species. ▪ Ability of single possum to eat > 1 bait is large source of error. ▪ Bait shyness biasses results. ▪ Results subject to considerable variability. ▪ May require non-treatment block.	LOW	Method of choice for most RCs because of ease/low cost.	Many variations of bait placement technique. Use of > 1 bait per station can give more accurate results. Spacing of baits critical.
SPOTLIGHT COUNTING Number of possums seen over several successive nights, continuously or from specified points over standardised route, provides index of abundance before and after control.	▪ Direct, unambiguous results. ▪ Other species' presence can be recorded. ▪ Does not require non-treatment block. ▪ Very low material/transport cost. ▪ Independent of control method.	▪ Requires all-weather access, preferably by vehicle. ▪ Subject to considerable variabiity especially affected by weather. ▪ Impossible to undertake in some weather. ▪ Only usable in open land.	Low - Medium	Suitable for 'self-monitoring' (forest, orchard owners). Often used to check bait interference results.	Relatively cost-effective in open country if precise results not critical.
FAECAL PELLET COUNTING Abundance of faecal pellets provides estimates of abundance before and after operation.	▪ Independent of control method. ▪ Very low material/transport costs. ▪ Transects only visited twice. ▪ Relatively uninfluenced by weather. ▪ Can be calibrated to absolute density.	▪ POST assessment may have to be delayed several months. ▪ Non-treatment block required. ▪ Imprecise especially in low density areas and if PRE and POST counts cross seasons. ▪ Immigration biasses results. ▪ Not suitable for maintenance phase.	Medium - High	Used commonly by DOC. Most suitable method for very remote or large areas.	'Cleared plot' variation involves more visits but gives quicker results.

* Adapted from: Feral Animal Control Team - South Island. 1991, Animal Health Board, 1992; Department of Conservation, 1994(a).

suggests that thresholds vary markedly between ecosystems and even individual communities.[10] The linkage between threshold impact and population level is unlikely to be linear and therefore impact thresholds have to be calibrated from absolute population densities if possible." Figure 6.1 shows how the concept of a threshold (in this case of population density) can be used to help design a control strategy. A threshold of 50% of carrying capacity has been selected for the initiation of control.

This type of model (or related geographically-based models, see section 3.4) is potentially very useful in the design of maintenance strategies (section 5.3). However, even if experimentally verified, it would still have to be linked to threshold impact levels to be able to be used as a performance measure. With present levels of understanding of ecosystem dynamics in New Zealand, the only practicable approach to establishing impact thresholds would seem to be empirical: continued monitoring of ecosystem responses to different possum population levels.[12] Such an approach is of course long-term and, in the case of critically threatened animal species, potentially risky if the control method poses risks to non-target individuals.

Figure 6.1 Simulated female possum population changes over 40 years. Initially at carrying capacity of 3.5/ha, subject to stochastic demographic and environmental changes (years 0-10), then initial control at 80% kill level, followed by maintenance control at 80% kill level in every year in which density exceeds 50% of carrying capacity (years arrowed).



Source: 'DDPoss' age-structured model, M. Efford, Landcare Research, 1994, unpublished.

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10 Department of Conservation, 1994(a).

11 M. Efford, Landcare Research, pers. comm.

12 Implying that at least for verification, both impacts and population levels have to be measured (M. Efford, Landcare Research, pers. comm.). See also Parkes, 1993 for further discussion.

Thresholds are related to • but not the same as • *vulnerability* to possum damage which is now routinely ranked for conservation management units by the Department of Conservation. The difficulty is in relating vulnerability, which is in theory an absolute notion (i.e. can be expressed for a single species, community or ecosystem by a specific possum density), to a possum control operation target which is usually expressed as percentage reduction, i.e. a relative measure.

One advantage of the trapcatch monitoring methods is that possum population levels can be approximated in a relative density unit such as catches per 100 trapnights. Such a unit would be comparable between ecosystems or operations. Operational goals could thus be related to specific levels, for example, 5 catches/100 trapnights, rather than percentage reductions from an unknown base population. However, further research is required to ascertain what the target level of catches/100 trapnights would be for individual conservation ecosystems. An alternative to relative density targets may be for percentage reduction targets to be calibrated against changes in conservation or Tb status established through effective performance monitoring.

There seems to be no reason why a comparable measure using the bait interference or bait take approaches could not be developed, i.e. define target kill by residual bait interference or bait take percentages. However this would require considerable standardisation: both these types of monitoring, as well as trapcatch methods, are subject to significant seasonal, spatial and operator variability.

Note however that neither type of target (relative density or percentage reduction), are in themselves thresholds, but simply empirically set operational goals. Whatever monitoring units are adopted, it is obvious that considerable work still needs to be done to establish robust relationships between possum population levels and various types of biological indicators that might be used for performance monitoring.

With respect to Tb control, population modelling work by several researchers[13] suggests that the establishment of possum population thresholds for control operations may be realistic, and moreover that these thresholds can be related to a percentage possum population reduction rather than an absolute density level. This means that control operations can aim for a percentage 'knockdown' target followed by maintenance at a target density (expressed in relative terms), regardless of initial density, to maintain a possum population where tubercular possum-possum interactions are too rare for Tb infection to persist.

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13 Spurr, 1981(b); Barlow, 1991(a) and (b); Hickling, 1993; see section 3.4 for further discussion.

6.4 Controversy *over monitoring* results

The Commissioner has encountered a significant lack of confidence in agencies' monitoring methods and results in a number of cases." Control agencies have significantly different recommendations and procedures for monitoring, which can clearly benefit from more consistency. An extreme example from the Wairarapa is described in detail in section 7.1.7. It shows the difficulty in evaluating control operations when monitoring results cannot be used with confidence. Both anti- 1080 campaigners and members of the public have alleged significant deficiencies in agencies'inonitoring procedures, and cited their own anecdotal observations which appear to contradict monitoring results. However such allegations are sometimes contradictory. Por example, in the Wairarapa, hunters alleged very poor kills and no apparent reduction in possumnumbers. By contrast, land owners have provided anecdotal evidence of useful reduction in possum populations.[15]

In other cases agencies have criticised other agencies' monitoring procedures. The Animal Health Board (AHB) do not generally accept regional council monitoring results using bait interference methods because of doubts over their scientific validity.[16] Conversely, some regional councils have concern about the lack of monitoring being carried out on behalf of the AHB, confusion over who should be monitoring council operations and a lack of monitoring direction." Some of the variability that is the subject of controversy is undoubtedly caused by the large number of monitoring methods in use around the country, despite recent and ongoing work by both AHB and DOC to standardise methods.

From an auditing point of view, there is also cause for concern that contract workers may have the opportunity to Inflate monitored kill rates, for example by concentrating trapping in areas where monitoring lines are known to be placed. Monitoring lines should not be permanently marked; the use of D GPS (section 5.2.4) or other electronic navigating systems should make this feasible. Prom an auditing point of view, those undertaking monitoring should have no particular stake in the results of the monitoring.

6.5 Selection of methods

One of the most controversial aspects of monitoring is the selection of method for operational monitoring. All methods have important advantages and disadvantages. Complete consistency, in the sense of all agencies using only one method, is not a realistic goal. What is essential is general agreement between agencies on which method is appropriate in which circumstances, and consistency and standardisation of operation for each method. Ten years ago, testing and calibration of monitoring techniques were identified as the most important research requirements for possum control at the time.[18] These

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14 J. M. Williams, MAF, (pers. comm.) has noted with reference to rabbit populations in the South Island High Country, that controversy frequently arises when monitoring indicates trends which threaten widely held understandings or beliefs.

15 D. Meenken, Wellington Regional Council, letter to PCE, 10 December 1993.

16 P. Livingstone, AHB, pers.comm.

17 M. Bowden, Canterbury Regional Council, letter to PCE, 29 March 1994.

18 Brockie *et* al, 1984.

areas are still of thehighest priority. Stakeholders also need to understand the purposes, principles, and limitations of the main approaches to monitoring so they can have confidence in monitoring results. In some cases, particularly for self-help type maintenance control programmes, direct landholder involvement in monitoring is an important aspect of maintaining motivation. However, regional councils also need to monitor in order to obtain a regional perspective. Performance monitoring methods are not subject to the same degree of controversy as it is recognised that they need to be significantly adapted to specific goals of control.

DOC's Possum Control Plan 1993-2003[19] should greatly assist standardisation of monitoring for operations on conservation land, with preferred methods of monitoring (trapcatch, two specified types of faecal pellet count, and spotlight counting in special circumstances) being nominated, and a decision tree provided to aid managers select the most appropriate method. A useful follow-up to this development would be the development of a detailed protocol for each of the preferred methods, to improve consistency between conservancies. Bearing in mind the general principle that the same method should not be used for both killing and monitoring of possums, the Department may also need to examine more generally applicable alternatives to trapcatch monitoring if possum control operations involving trapping become more common. DOC has held a number of workshops on monitoring for its staff.

For Tb-related possum control, recommended methods are also specified[20] and MAP Quality Management (MQM) staff undertaking monitoring since 1992 have all had training. Most monitoring by MQM uses bait take or spotlight counting. The most common monitoring methods for regional council staff are bait interference, bait take, spotlight counting and to a lesser extent, trapcatching. Bait take and faecal pellet counting methods have been formally validated against each other, and work on validation and calibration of trapcatch methods is underway.[21]

Bait interference techniques are in general the cheapest monitoring techniques available and regional councils justify their use on grounds of cost-effectiveness. However, scientific opinion sought by the Commissioner expressed, without exception, very strong reservations about bait interference monitoring techniques. These reservations are on the grounds of scientific validity[22] and on the inconsistency of methods and results around the country. It is accepted that some of these deficiencies can be minimised by experienced operators. Informal trials have shown good correspondence of bait interference results with spotlight counting and trapcatch results in some instances.[23]

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19 Department of Conservation, 1994(a).

20 Animal Health Board, 1992.

21 Hickling *et* al, 1990(b); B. Warburton, Landcare Research, 1994, pers. comm.

22 The theoretical mathematical model on which the technique and subsequent modifications (Bamford, 1970; Jane, 1981) are based, the possibility of one possum eating many baits (contagion) and the difficulty of distinguishing interference by some non-target species (E. Spurr, Landcare Research, unpublished data).

23 G. Gallop, Taranaki Regional Council, R. Howard, Carter Holt Harvey, Dargaville, pers. comm.

If bait interference is to continue as a standard method, it requires firstly, verification of its theoretical basis, comparison with other techniques and the development of some independent means of verification, and secondly, far greater rigour and consistency of application across the country. Some research on the first aspects is now underway." An ideal monitoring method would be a *fatal* interference technique, such as a coated cyanide bait. This would combine the advantages of present trapcatch and bait interference techniques without cyanide shyness problems, and would also be a suitable control method in some circumstances. Research on coated cyanide baits is also underway.[25]

Regardless of the choice of monitoring method, there are some important statistical considerations necessary for conducting robust monitoring. These concern aspects such as sample size, sampling strategy, data collection, calculation of confidence limits, etc. They are well summarised in recent MAP Quality Management training material.%

Joint agency possum control operations pose special monitoring problems. It may not be possible for the same method to be used throughout the control area if significant areas of both forest and farmland are involved, but consideration should be given to a joint monitoring team to plan and execute the whole programme.

Most methods discussed in this chapter are clearly more suitable for high possum population densities. Accurate methods for monitoring of relatively low-density populations, especially for designing and evaluating maintenance operations, appear to be a significant gap in both research and operations at present. For example, during possum eradication on Kapiti Island, dogs proved to be the only reliable means of monitoring the presence or absence of possums at low densities,[27] but this is a quite different monitoring approach from any discussed in this chapter.

6.6 Resources for monitoring

It is essential to view monitoring as an integral part of possum control. This is just as true for maintenance as it is for initial control. With present techniques, the relative cost of monitoring at lower population densities is higher, yet the need is often just as great, especially for conservation management involving vulnerable species or ecosystems. Landcare researchers have recommended that 10% of the control budget be spent on performance monitoring alone,[28] and the Department of Conservation Possum Control Plan suggests that up to 10% of the control budget (but more if new techniques are being trialled) be spent on monitoring (operational and performance). DOC now includes operational and performance monitoring as a budget item for all operations except very small ones. The percentage of

24 E. Spurr, Landcare Research, 1994, pers. comm.
25 B. Warburton, Landcare Research, 1994, pers. comm.
26 Feral Animal Control Team-South Island, 1991.
27 Sherley, 1992.
28 Warburton and Coleman, 1992.

the total control budget spent on monitoring is very variable but is estimated to average 5-10%.[29]

AHB spends about 7% of its total control budget on selected operational monitoring, essentially for audit of its contractors' (mainly regional councils) performance. This amount does not include any of the money spent on herd testing (i.e. performance monitoring for Tb control). AHB chooses about 25 % of funded operations to monitor, on the basis of cost, strategic importance and public interest. These operations are fully monitored right through their maintenance phases."

However the budget for many control operations, especially those carried out by regional councils but either not monitored or not funded by the AHB, appears to be considerably lower than the above levels. For example, Wellington Regional Council's budget for monitoring control operations has fallen as low as 1.7%.[31] The results from the monitoring technique trialled in the Woodside operation (section 7.1.7) suggest that not only has monitoring at this intensity been a waste of time, but that it is impossible to judge the success or otherwise of the control operation. It is possible that a similar conclusion could be reached about many other operations.

The investigation team heard more than once from control agencies the opinion that because of previous 'successful operations' (as judged from uncertainmonitoring results!), fewer resources should be given to monitoring in the future. An attitude that appears to be still commonly held is that every possumcontrol dollar not spent killing possums is wasted. This is analogous to the justifications often advanced for a bounty system of possum control. These attitudes are of great concern. It appears **clear** that **failure to give adequate resources to monitoring jeopardises the success of the whole control strategy,** for the reasons outlined in section 6.1. This observation applies equally to maintenance control as to initial knockdown operations.

Further consideration needs to be given to the question of the optimal level of resources to be allocated to control operations of all types. In the meantime, it appears that to derive monitoring results that can be used with confidence, agencies should be prepared to spend up to 10% of the control budget for monitoring (or even more in exceptional circumstances), often not significantly less, and never less than 5%. It would also seem prudent to allocate these resources as part of the control budget rather than attempt to cover them as agency overheads. The difficulty faced by regional councils in resourcing monitoring, especially when the control operation but not the monitoring aspects have been funded by the AHB, is appreciated.

When individual landholders choose to use other control methods than those preferred by councils (see sections 4.5 and 5.1.2), at their own cost, the level

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29 Warburton and Cullen, 1993; K. Janson, DOC, pers. comm.
30 P. Livingstone, AHB, pers. comm.
31 D. Meenken, Wellington Regional Council, pers. comm.

of monitoring of such control, and the payment of costs incurred, have been matters of contention. So as not to compromise the control programme for the region, agencies need to know that alternative control is keeping possum populations to the level sought on other properties. Therefore some monitoring of all 'alternative' properties is required, even if the council's scheduled monitoring lines do not pass through these properties, and this will often impose extra monitoring costs above the council's average for the control area.

In such cases, all monitoring costs should be borne by the council, in recognition of the landholder's payment of rates and levies. On larger properties, monitoring costs are not large in relation to control costs which the council is saving. On smaller properties, although the monitoring costs are larger in comparison to control costs (and in exceptional cases may exceed them), they are not large in absolute terms. Because of the smaller population involved, it would be costly to get the same statistical confidence as for a large operation; however a lower standard of rigourmay often be sufficient because the risks to the overall control strategy are small even if monitoring results are erroneous.

In summary, the present status quo for monitoring is clearly unsatisfactory. It is essential to have better developed and standardised monitoring methods and procedures, as well as adequate resources, so that:

- agencies, the public and stakeholders can have confidence in operational performance;
- payments for contract operations are fair;
- operations and methods can be compared and improved.

7 Case Studies

Two case studies were selected to investigate in more depth the adequacy of agency response to perceived possum problems. The case study areas selected were Wairarapa (principally the Woodside operation, Wellington Regional Council) and Taranaki (principally Operation Egmont, a joint operation between the Department of Conservation and the Taranaki Regional Council). These case studies were selected from among a number of aerial-1080 control operations which attracted public controversy in 1993.

Investigation team members made a series of visits to the regions concerned, and met key stakeholders (control agencies, landholders, anti- 1080 groups, groups proposing alternative control methods). Criteria used in analysis of case study information are shown in Appendix C.

7. I Wairarapa

7.I.I Nature of possum problem

The Wellington Regional Council (WRC) considers possums to be a pest of both economic and environmental concern in their region. The Department of Conservation has identified about 8000[1] ha of high altitude fuchsia forest in the Tararua Porest Park subject to ongoing damage from possums as a priority area for protection.

The incidence in the Wairarapa of Tb in feral animals has been documented in possums since 1968, pigs since 1972, deer since 1975, and ferrets since 1990. Infected possums have been caught at over 140 different sites.[2] The Wairarapa therefore, is considered a Tb endemic area with nearly ten times the DOC priority area treated in 1993. The driving force for possum control in the Wairarapa is to control a vector involved in the spread of bovine Tb among farm animals.

7.I.2 Overview of possum control

In the northern Wairarapa annual possum control work is targeted to maintain a Tb-clear buffer strip (established during 1986-91) and a feral populationfree ofTb between the Wairarapa and southern Hawke's Bay. Other strips designed to control possums and Tb infection are to be established against the Rimutaka, Tararua, and Haurangi Forest Parks and will include a forest margin strip up to 3 km wide and a farmland strip of 1 km.

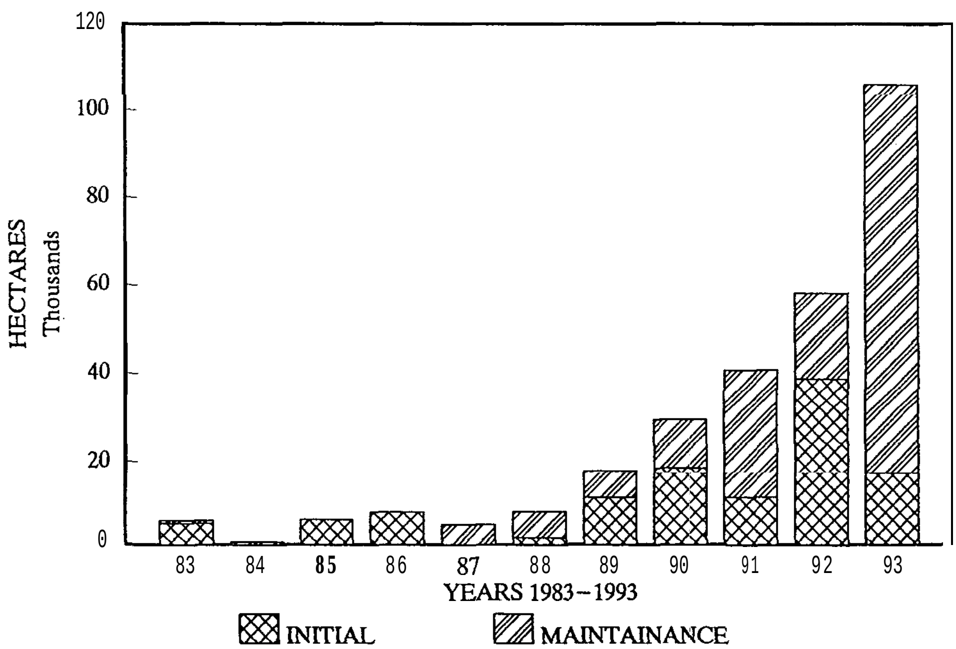
Between 1976 and 1980 large-scale possum control operations using mostly 1080 carrot bait were carried out in ten zones covering 190,000 ha in eastern and southern Wairarapa. Following these operations Tb livestock reactor

[1] Department of Conservation, 1994(a).
[2] Wellington Regional Animal Health Committee, 1993.

numbers fell in each zone by 50% in the first year, by 80% in the second to fourth but began to rise again after five years and were back at pre-operational levels seven to eight years after the original operation. Follow-up control work involving ground control methods was not carried out unless the original operation was shown (by non-reduction of Tb reactor rates) to be ineffective.

Between 1980 and 1988 the area controlled for possums dropped to around 5,000-7,000 hectares treated annually, but since 1989 has increased with about 70,000 hectares being treated in the 1992 year. Current and proposed possum control operations are driven by the Regional Animal Health Committee and its efforts to meet the national Animal Health Bovine Tuberculosis control targets (see Figure 7.1).

Figure 7.1 Hectares of initial and maintenance control for possums in the Wairarapa



Source: MAF Quality Management and WRC Masterton

The Wellington Regional Animal Health Committee has prepared a Regional Operational Plan for Bovine Tuberculosis covering five years from July 1993 which is approved by the Animal Health Board (AHB). A reduction of 50% in the number of cattle and deer movement control herds in the Wairarapa by 1998 is the committee's main objective.

These operations are based on an epidemiological model which requires a 70% initial reduction in possum numbers, followed by maintenance of possum numbers below 40% of the original population for a period of five years (see section 3.4). The AHB contracts the WRC to implement approved control operations and the Council is expected to assist with maintenance operations. The financial commitment this imposes is a source of concern to the Council, especially as the area to be covered under maintenance is rapidly increasing. The sustainability of these maintenance operations is of concern when AHB-approved maintenance operations for the 1994/95 financial year in the Wairarapa total nearly $650,000, of which the Council's share is nearly $370,000.

The Council also supports individual and group possum control initiatives, encouraging the development of self-help groups and providing information, training and, to land owners or occupiers who are approved operators, appropriate pest control materials 'at cost'. Council staff have suggested that the areas that have been subjected to some seven to nine years of maintenance control, and where possums numbers are relatively low, could become the responsibility of local land owners' self-help groups and provide some relief to the Council's operations.

7.1.3 Woodside possum control operation

Background

The Woodside possum control area is in the South Wairarapa district of the Wellington region. It is an area of 4,617 hectares between Featherston Borough and the Waiohine River, covering 83 properties within the river and road boundaries to the area and a narrow strip totalling approximately 248 ha of the DOC-managed Tararua Forest Park. The area includes the flat farmed land at the base of the Tararuas and the foothills which have gorse, scrub and native regrowth.

Justification for a poison programme for this area was the existence of pastoral areas with a history of Tb in livestock, the reservoir of potentially infectious feral animals in the Forest Park and the need to link areas to the north and south which had been treated previously. The WRC decided to aerially apply 1080 pellets to 1,050 ha being 250 ha of DOC estate and approximately 800 ha of steep privately owned land. Ground-based control operations on the remaining 3,567 ha included the application of hand-laid pellets of 1080 in isolated areas of bush and river edges; ground-laid paste baits of 1080 on pasture areas; and trapping on the margins of Featherston and Greytown and around private dwellings.

An Environmental Impact Assessment (EIA) was prepared to cover the application of 1080 to the DOC land involved; the necessary Medical Officer of Health and South Wairarapa District Council approvals were obtained; farmers and neighbours were notified and public notices placed in newspapers. Objectors made their views known to both the Regional and District Councils and a few individual landowners discussed alternative forms of control for their properties with the WRC.

Protest

A small (10-12 people) 'Citizens Against 1080' group was formed shortly after the public announcement of the intention to apply 1080 appeared in the news media at the end of April. At a public meeting on 8 May the group obtained a two-week postponement of the start of the operation in the area south-west of the Tauherenikau River, while they gathered extra material which they hoped would reverse the WRC's decision to use 1080. A 1080 fact sheet was produced dated 23 May and used at a residents meeting called by the Citizens Against 1080 on 26 May. Meanwhile the WRC, having not received additional information, started ground-bait applications in the area on 21 May. Although consistent with the operational plan to move from the plain to the hill, the start point was as far from the properties of the two main-objectors in the operation area as possible. The WRC states that no new information which would affect their decision on the use of 1080 has been made available to it. A public meeting in protest was organised by the Citizens against 1080 and held on 16 June - a day after the aerial application. The authorities considered this meeting, attended by about 50 people (including approximately 16 representatives of various agencies and 10 Citizens Against 1080 representatives) to be unproductive as the experts available to provide additional information and answer questions felt they did not get a good hearing.

The Citizens Against 1080 group is still active in promoting alternatives to the use of 1080 and other toxins. Some land owners, who wished to opt out of the WRC operation and carry out their own control activities, were concerned at the Council's requirement to ascertain the effectiveness of the land owners' control efforts and the cost recovery policies associated with this. The WRC was concerned to ensure the integrity of the operation was maintained and no untreated reservoir of possums was left within the treatment area.

Operation

Ground application of paste baits on farmland in the Woodside area started in early May and in some cases preceded the aerial application by up to five weeks. Aerial application, to be done by a Wanganui Aero Work helicopter using a navigational guidance system, was postponed several times because of a continuing period of wet weather and also delays so that the anti-1080 group could provide additional information. When the 1080 was ultimately applied (16 June) the navigation equipment was not available and flight lines were assessed visually. The Citizens Against 1080 considered that because application was made immediately after a prolonged period of heavy ram and was followed by 1 mm of rain on the sixth night and 4 mm on the seventh night after application, the effectiveness of the aerial drop was in question. The WRC believes that there were sufficient dry nights after the operation for bait to have been taken, and that soil moisture at the time of the drop would not have affected the operation. Also since possums do not feed extensively during heavy rain, WRC staff believe active feeding would have occurred on the dry nights following the aerial application.

A partial assessment of the kill results was made and as required in the conditions to the approvals from the Medical Officer of Health and the South Wairarapa District Council, detailed water monitoring was carried out. No detailed monitoring of the distribution of the aerially applied bait pellets was made. However operational boundaries, and a number of water supply creeks and walking tracks, were checked for bait distribution and carcases.[3] No bait overshoots were identified and any baits found on walking tracks were removed. Residents have advised that signs concerning the operation were in place and the required media notices published.

Sequel to operation

Planning is now underway for an operation in 1994 covering virtually the whole length of the foothills of the Rimutakas through to the Ruahines and extending 3 km into the forest and 1 km out into the pasture margin. This is to create a buffer and is part of a 'good neighbour' approach with regard to controlling Tb possum in DOC lands for which $6 million has been allocated nationally. Continuing annual maintenance to control possums in the Woodside area has been approved at a cost to the WRC of about $22,300 in 1994195.

7.1.4 Approvals process

Approvals were required from the following agencies:

- DOC for approval to put poison on DOC land (confirmed 28 May 1993);
- South Wairarapa District Council for permission to lay poison baits for possum control in water supply intake areas, and was given subject to any conditions specified by the Medical Officer of Health (confirmed 19 April 1993);
- Public Health Service of the Wellington Area Health Board for permission to lay poison for possum control both as hand-laid baits and by aerial application in areas specified in the Pesticides (Vertebrate Pest Control) Regulations 1983 (confirmed 28 April 1993);
- The WRC did not deem it required a discharge consent under the Resource Management Act 1991.

7.1.5 Decision-making process

The Animal Health Board specifies the procedures to follow in planning a possum control operation for Tb control in the Board's 1993 publication 'Bovine Tuberculosis Possum Control: a Protocol'.

The protocol requires that planning must be in response to a request by a MAP Quality Management (MQM) veterinary officer in the district. The report (which was provided by the Masterton office of MQM[4] documented the recent increase in TB reactors within the proposed operation area, and indicated the controlprogramme would be uneconomical purely on the basis of cost savings for cattle reactor compensation, but should continue because of its part in the total control strategy for the area.

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[3] Wellington Regional Council, 1993(a).
[4] Atkinson, 1991.

The WRC prepared its own report which was circulated to MQM and the AHB, defining the problem, the area to be involved in a control operation and the method(s) of control. Budgets for the direct costs of the operation were included and these estimated the cost per hectare for aerial at **$18.50** and ground application at **$11.13.** Actual final costs were $17.26/ha and $11.50/ha respectively. The WRC's procedure for approval of operations is via the Annual Plan process. Prior to public consultation and adoption by the full Council Committee, new or initial Tb possum control work is subject to assessment not only by senior management, but by both the Rural Services and Wairarapa Committee, and by the Policy and Finance Committee.

The WRC prepared summaries of the information on 1080 available to them from the AHB, MAF and Landcare Research for distribution to Councillors, the South Wairarapa District Council and public enquirers.

An assessment of the environmental impact of a poisoning operation was prepared for the DOC area by the WRC in accordance with the protocol specified by the AHB. The risk to public health and to non-target species was considered minimal on the basis of research information referenced in the report, and previous experience with similar operations in the past. The WRC staffhave commented that with the science restructuring which has occurred, relevant research funded by others may not be seen. Also WRC research needs are not being coordinated.

The rationale for the use of aerial poisoning with 1080 pellets on the DOC area was that 'given the steep terrain and limited accessability in the Tararua Forest Park, the most effective method is aerial poisoning'.[5] Hunters were not considered able to give a cost-effective control in the area and had not been approached to work this area.

Animal Health Board financial approvals were given and notified to the WRC on 18 February 1992.

7.1.6 Public consultation and interaction

The WRC considers there is strong support from farmers for the use of 1080. In the Woodside area, out of 83 holdings, only three land owners were unwilling to allow use of 1080 on their properties.

Farmer self-help control groups largely using land-based control methods have existed in varying numbers throughout the Wairarapa since the 1970s. These fluctuate from area to area depending on perception of the possum/Tb risk, the level of WRC activity, and the enthusiasm and interest of local farmers. Currently the WRC has five active 'Possum Advisory Committees'.

The Citizens Against 1080 group had a number of general concerns about the use of 1080, the possum/Tb/cattle linkage, possum monitoring techniques and the independence of agencies and individuals associated with 1080

[5] Wellington Regional Council, 1993(b).

which were raised with the authorities. Previous sections of this report cover these general issues. Specific issues raised by the group about the Woodside operation, and discussed in this chapter, included their concerns about:

- The dates notified for the operation and the actual date of aerial application;
- Whether water supply intakes in specified catchments were closed for maintenance fortuitously or as a precaution against contamination by 1080;
- The adequacy of the environmental impact assessment of the use of 1080 which covered DOC land and the lack of an EIA for the remaining 95% of the treated area;
- The requirement for land owners to pay for any monitoring costs in excess of those which would normally have been spent on their properties in the course of the programmed operation if they chose to use some self-applied alternative possum control technique to the programmed 1080 operation;
- The validity of WRC decisions based on information sources that the group considers to be biased towards 1080.

Dates for the operation were first published on 24 April 1993. The published notice said the '. ..operation should be completed by 11 June 1993', but aerial application occurred on 15 June 1993. However, regulation 18(3) of the Pesticides (Vertebrate Pest Control) Regulations 1983 states that such notices become invalid if the controlled pesticide has not been applied within two months after the date of publication of the notice. This 'expiry date' would thus have been 24 June 1993. In addition, the District Council approved an extension of seven days (until 18 June) to its consent to lay poison baits for possum control which coincided with the expiry date of the Medical Officer of Health's approvals for both ground and aerial application of 1080.

Advice as to the anticipated completion date is not necessary under regulation 18(2) and has no legal status for the purpose of any offence under regulation 28(2). Confusion can occur when authorities do not make it clear that circumstances such as weather can delay operations.

The South Wairarapa District Council advised that at no time were water supplies discontinued because of public health concerns associated with the possum eradication programme. The Pesticide Board in a comment on the closure advised that generally it may be a precautionary measure. Confusion can occur when the agency with the management responsibility for water supplies is not the agency making statements about supply decisions.

Public concern and suspicion is greatest when there is inadequate information supplied by public authorities. This was the cause of several of the

Group's complaints. It also related to a lack of understanding by landowners as to why monitoring costs should be met.

Two local trappers did not consider the possum to be a major component of the Tb problem and believe cattle movement must be more strictly controlled. They have developed a proposal for a trapping scheme which would involve using unemployed people, paying them a bounty on skins in lieu of the Unemployment Benefit and monitoring their performance.[6] They consider that trapping and hunting in foothills of the Tararuas could be as effective as aerially applied 1080.

A small independent group of individual farmers discussing the use of 1080 generally identified the fear that aerial application of 1080 was too indiscriminate and felt that ground control was much better, although people doing it needed to be appropriately trained. They also thought alternative methods of control should be considered, but acknowledge that constant vigilance against the possum was needed. The group seemed unaware that the results of post-slaughter inspection for visible lesions of Tb reactor stock sent to the works could be obtained from their local MAF office, or that information on the Tb status of stock they may wish to purchase was available from MAF.

Consultation with the Tangata Whenua

In discussion with Maori attending a meeting called by DOC and the Regional Council about the buffer strip operation planned for 1994, concerns over the use of 1080 in the Wairarapa were specifically related to water contamination, especially the potential for impact on Lake Wairarapa and its biota. However there was also recognition of the dangers of Tb and possums, and that Maori medicinal plants were also being destroyed by possums. Formal consultation with the tangata whenua had not occurred prior to the Woodside operation although, there is now a charter of understanding between Te Tangata Whenua o Te Upoko o Te Ika a Maui and the WRC which is designed to assist the development of a meaningful relationship between the WRC and the tangata whenua.

7.1.7 Evaluation of operation

The aerial spread of baits was to be guided by Differential Global Positioning System (DGPS) navigation equipment, but as it was not available the baits were applied by line-of-sight methods. Uneven bait coverage may have occurred but no detailed distribution monitoring was undertaken. The criteria for effectiveness of the operation is a reduction in Tb reactors and herds under movement control in the operation area. This needs time to occur and has not yet been assessed.

Monitoring was carried out by the WRC both of water for 1080 presence and of possum kill.

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[6] B. Parker, 1993, pers. comm.

Water monitoring

Following the aerial application eight independent water sources were surveyed with one creek monitored as a non-treatment catchment control. The sampling programme which was agreed upon with Landcare Research, was a blend of fixed time period and flexible sampling based on rainfall events.

Testing for 1080 and fluoride (as a breakdown product of 1080) was carried out by Landcare Research and Wellington Regional Council Laboratory respectively. Sixty-six samples were analysedfor 1080 residue and none was detected given the limits (0.0003 ppm of 1080 in water) of the current detection techniques and fluoride concentrations were not significantly different in treated areas from the control catchments.

Coliform and faecal counts were also taken to determine whether possum carcases in water sourceslead to a large short-termincrease in these organisms and faecal coliform counts were not statistically significantly different between the treated and non-treated areas.

Possum kill monitoring

The WRC had intended carrying out an intensive long-term monitoring of possum numbers in the Woodside area. Unfortunately funding was not available so to gain experience, and as a trial, the 'apple on a wire' non-toxic-bait interference method was applied to the ground application area of the operation.

Wire hooks holding an apple quarter off the ground but accessible to possums were placed along the same lines for both pre- (420 hooks) and post- (530 hooks) assessment and monitored for three consecutive nights on each occasion. The results indicated a kill of 22% was achieved which is considerably below the standard normally expected.

Night shooting throughout the area has indicated that possum numbers are low on all but one of the properties treated.

Assessment by WRC staff of the monitoring results suggests:

- Because of the lack of labour resources, the areas targeted for monitoring were largely easily accessible, low possum density areas and not necessarily representative of the area. It was noticed on an area which gave a significantly poor monitoring result that on two night shoots after the operation only one possum was shot;

- The surveillance officer notes that interference by non-target species such asrabbits and/orhares which were seen in abundance on two night shoots after the operation is a potential source of error and the monitoring method used is, as a result of this trial, not considered an appropriate monitoring technique in this instance;

- Because of the extended time of the operation - up to 45 days elapsed between ground-based application and the aerial application on the forest margin - some reinfestation from the forest margin may have taken place.

The WRC's preferred monitoring method is bait take from pellet bait stations with monitoring being repeated on an annual basis. When the purpose is to control Tb, and significant and persistent drops in the cattle Tb reactor rates are achieved after possum control operations,[7] despite discredited or apparently poor monitoring results, there is little incentive for detailed monitoring especially if resources are limited and therefore likely to bias the result.

Overall the WRC feels the operation was jeopardised by delays to the operation caused by WRC's efforts to accommodate the objectors, and then a period of bad weather.

7.2 Taranaki

7.2.1 Nature of possum problem

Possums are clearly regarded as the most serious pest problem in Taranaki.[8] The nature and seriousness of the problem differ significantly between the conservation estate (responsibility of DOC) and the rest of the region (responsibility of the Taranaki Regional Council (TRC)) and it is difficult to directly compare them.

In the conservation estate, Egmont National Park is ranked among the top priorities for possum control in the Wanganui Conservancy, and has the second highest priority ranking score for conservation areas in the country. Possum densities are thought to be high, ranging up to >11/ha, over much of the National Park and are identified as threats to significant flora and fauna values, and contribute to the collapse of large areas of kamahi forest.[9]

The region is free of endemic Tb in cattle and possums, in spite of a few local, successfully contained outbreaks linked to cattle movement. No tuberculous possums have been isolated. Therefore possums are regarded as a potential carrier of Tb rather than as an existing reservoir. The aim of the regional operational plan for Tb is to completely eliminate Tb from the region,[10] but no direct ranking of areas of risk has been made. Direct impacts of possums on pastoral production and exotic forest establishment are regarded as very serious, especially in the eastern hill country.

7.2.2 Overview of possum control

The scene for possum control in Taranaki has been set by the Regional Pest Management Plan, approved by TRC in May 1992 after a process that included

7 D. Meenken, Wellington Regional Council, 1993, pers. comm.
8 Taranaki Regional Council, 1991, 1992.
9 Application to distribute 1080 poison: part Egmont National Park, DOC Wanganui Conservancy, 26 February 1993.
10 Taranaki Regional Animal Health Committee, 1993.

pub&submissions on a discussion paper. The Plan[11] willbereviewedin 1997 or sooner if Tb becomes established in the region. It does not go into any detail on control methods. The strategy outlines roles of three major players:

Taranaki Regional Council: Principally operates under Agricultural Pests Destruction Act 1967, pursuant to its pest destruction role conferred by section 37S of the Local Government Act 1974 (as amended in 1992) requiring the Regional Council to undertake control of declared pests. The Plan outlines TRC's pest management functions, objectives and field programmes. It puts strong emphasis on 'self-help' possum maintenance control, embracing voluntary cooperative control and cost sharing by TRC and land owners (see section 5.3 and Appendix A, Table A.20). The TRC has had insufficient resources to put much control effort into the extensive Eastern Taranaki hill country, in spite of high possum densities there.

Ministry of Agriculture and Fisheries (MAF) and the Taranaki Regional Animal Health Committee (TRAHC): MAP and the Animal Health Board are responsible for bovine Tb control in cattle and deer, through Tb control schemes established under the Animals Act 1967. The TRAHC is the regional representative for the AHB and has representatives of all major regional agencies and stakeholders. It has put out a Regional Operational Plan for bovine Tb.[12] This recognises an ongoing need for education and stock control as well as for possum control.

Department of Conservation: A major focus of Wanganui Conservancy's pest control activities is Egmont National Park (ENP), including goat control. DOC's pest management is undertaken principally under the Wild Animals Control Act 1977, the National Parks Act 1980 and the Conservation Act 1987. Prior to Operation Egmont, possumcontrol wastmdertakenprivately through trapping and cyanide poisoning permits, but was perceived by DOC to do no better than hold the status quo in easily accessible areas, even in times of good skin prices.[13] DOC employs trappers in high priority scenic reserves. DOC's priorities for possum control are outlined in a wild animal control plan prepared in 1989 and in the current national 10 year possum control plan.[14]

7.2.3 Operation Egmont[15]

Background

In July 1992 the Minister of Conservation approved a three-stage control operation in Egmont National Park. TRC agreed to undertake complementary control on land adjoining the Park (referred to as the buffer zone). A joint working party was set up to plan and execute the operation (known as Operation Egmont). Stage I involved 17,200 ha (4,100 pasture, 13,100 bush) including the northern sector of the Park between the Stony and Waiwhakaiho

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11 Taranaki Regional Council, 1992.
12 Taranaki Regional Animal Health Committee, 1993.
13 W. Fleury, DOC Wanganui, pers. comm.
14 Department of Conservation, 1994(a).
15 Sources for this section primarily Taranaki Regional Council, 1993(b), Department of Conservation, 1993(b), and field interviews.

Rivers, and the Pouakai and Kaitake Ranges. Bush areas were to be treated by aerial 1080 by DOC (acting as agents for TRC outside the Park) and pasture areas by ground application of 1080 by TRC. Consents and authorities were identified and obtained and all land owners contacted. Preliminary monitoring was undertaken, contracts for bait supply and aerial application let. Publicity was arranged and discussions with interested parties held between September 1992 and March 1993.

Pro test

Individuals and groups opposed to 1080 use became aware of the planned operation in March 1993. Initial meetings with TRC and DOC staff were unsuccessful in resolving the dispute and protests escalated, including marches, petitions and a publicmeeting 14April. 'People Against 1080' (also known as 'People Againt Poisons') formed as a coalition against Operation Egmont. First contact by People Against 1080 with the Parliamentary Commissioner for the Environment was on 27 April. A court injunction to halt the aerial operation was declined on 25 May.

Operation

The TRC ground operation began on 3 May. DOC aerial work was due to start early April but was delayed till 23 May. Flying took place on nine days between 23 May and 3 July. TRC ground control was completed in August.

Sequel to Stage I

A high level of disquiet amongst People Against 1080 was evidenced by plans for alternative control, legal moves to prevent later stages, and to take the case to the Waitangi Tribunal. The TRC released monitoring results for water quality and operational effectiveness on 20 October 1993. Plans for stages II and III in 1994 were approved by the TRC on 15 December, and by DOC on 31 March. Consents were applied for and received. Stage II of the operation commenced on 1 February 1994 (ground control), and late March (aerial control). TRC undertook a survey in early 1994 of 89 out of 96 Stage I landholders. Interview questions covered adequacy of information dissemination, concerns over 1080, staff performance, awareness of the possum problem and of TRC's role in possum control.[16]

7.2.4 Approvals process

Relevant agencies and approvals

Operation Egmont was subject to permissions and authorisations under the Pesticides (Vertebrate Pest Control) Regulations (VPCR) 1983, Agricultural Pests Destruction Act 1967 and Resource Management Act 1991. Applications for Stage I were made to the New Plymouth District Council, the Taranaki Medical Officer of Health and the Director-General of Conservation

[16] J. Hutchings, TRC, pers. comm.

under Reg.12 of the VPCR, and all land owners notified. All consents were granted. Specific authorisation to discharge a contaminant under RMA s.15 was obtained through the Transitional Regional Plan for Taranaki. Because of the timing of the Minister of Conservation's approval for Operation Bgmont, TRC's involvement in Stage I was not notified in the Council's 1992-93 Annual Plan.

Jurisdiction and roles

The Commissioner encountered differences of opinion and some confusion about possibly overlapping or inappropriate roles of the Medical Officer of Health and District Councils in granting permissions. The Medical Officer of Health considers applications from a public health perspective. District councils consider applications for water supply areas, public roads and adjacent areas. Both are essentially public safety issues, so their roles are complementary, although their perspectives and regulatory powers are distinct, and the District Council also has a test of public inconvenience to consider (see section 4.5). However, New Plymouth District Council staff considered their involvement in administration of the VPCR as redundant, and felt that Regional Council consent to 1080 application under RMA would be preferable.

Difference of opinion between agencies was illustrated by South Taranaki District Council's role in the permissions process for Stages II and III. District Cotmcillors received submissions against 1080 and sought to thoroughly review the issue prior to making a decision on applications by DOC and TRC to apply 1080. Permission was granted for ground application by TRC, but the Council initially deferred consideration of DOC's and TRC's applications for aerial 1080 application until February 1994. The Council had apparently been concerned about some aspects of repeated use of 1080 and also about DOC's lack of commitment to ongoing control around the National Park boundary. However the operating agencies clearly felt that the District Council's role should be limited to consideration of *public safety* aspects of 1080 application onto public areas. Following legal advice, the Council reversed its deferral and approved the applications on 24 December 1993.

Injunction against operation

This was taken out by one individual from People Against 1080 against both TRC and DOC under Reg.22 of VPCR, concerning the requirement to adhere to instructions on pesticide containers. The applicant considered that it would be impossible in aerial operations to adhere to the direction not to apply 1080 into watercourses. Following submissions that neither the Crown nor the TRC should be named as a party to the application, the application was dismissed.

Responsibility *for joint operation*

Under the terms of the joint operating agreement, DOC had clear responsibility for the National Park, while TRC had clear responsibility for rateable land, with DOC acting as TRC's agent for aerial control of some of this land. While this situation is clear in hindsight, at the time there appeared to be **widespread** confusion over responsibility for the joint operation, resulting in frustration on several grounds. People Against 1080 felt that there was no focus of responsibility for the operation, while TRC felt that it was widely perceived to be responsible for the aerial drops.

The nature of the public notification of the operation, in the *Daily News* in late April, was probably one cause of confusion. DOC advertised notification on 24 April. However, TRC's notice on 24 and 26 April was much more prominent, including a map of the whole Stage I area including the National Park, and made no mention of DOC's aerial control of the National Park. It would have been quite reasonable to conclude from this advertisement that the entire operation was being carried out by TRC.[17]

7.2.5 Decision-making process

Overall, decision-making by both authorities was guided by their analysis of the possumproblem as one of very high priority and of the required operation as large scale in difficult terrain. Although aerial and ground application of 1080 was not an automatic choice of method, the considerable previous experience of and information available to staff of both agencies lead them to the conclusion that these were the preferred methods.

Consideration of alternatives

Costs and effectiveness of some alternatives to 1080 control were considered by both agencies but in an informal way and without reference to set criteria. TRC's analysis concluded that 'the likelihood of alternative methods of control ... achieving this level of control [85-90%] with consistency is considered unlikely . . . 1080 remains the most effective and cost-efficient means of achieving possum control on farmland'.[18] TRC have been developing a new bulk feeder station which gives the potential for larger bush areas to be controlled by ground operations more cheaply than by air. (In Stage I almost all fenced bush areas were treated aerially.) This type of bait station may have the potential to be used for poisons other than 1080, although at present it cannot beused for cyanide or phosphorus, the two most widely used alternatives. Currently the bait stations are not being used because of thefts of bait from them. TRC also considered a proposal for a trial on biodynamic control but referred this to the Animal Health Board. TRC reached agreement with four landholders for alternative (trapping) control, following verification of their organic status from the Biological Producers' Council.

TRC's analysis was based on the strategy presented in the Regional Pest Management Plan. Criteria considered important in choosing the method of control include reliability, cost-effectiveness and safety.[19]

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17 One third of Stage I landholders were unclear as to which authority had carried out the aerial operation (TRC survey, J. Hutchings, TRC, pers. comm.).

18 Taranaki Regional Council, 1993(b).

19 J. Hutchings, R.L. Allen, Taranaki Regional Council, pers. comm.

DOC considered alternatives to aerial 1080 application in its environmental impact assessment (EIA). They were given only briefconsideration in the EIA to Stage I but the choice of method in the Stage II BIA is much more thorough: ground-based alternatives are discussed over two pages, with reasonably detailed analysis of costs and effectiveness. However there is little specific information available from Taranaki to assess costs of ground control, and the hunting alternative, under a performance contract system.

The main alternative offered to aerial 1080 control in Bgmont National Park is a proposal from the Ngaruahine Iwi Authority in association with hunters, for combined trapping and ground cyanide poisoning on a 3,000 ha trial block (including 500 ha of private land) within the Stage II area. The proposal included a training element. This proposal was presented to DOC on 10 December 1993. It was rejected by DOC, principally on the grounds of cost, doubts about feasibility, and difficulties of coordination with the TRC operation in the buffer zone. DOC is at present negotiating with iwi representatives on possibilities for restricted ground-based control in the vicinity of heavily used areas in the eastern part of the National Park. It would be desirable for this type of local involvement to be included in ongoing possum control, although in this case the main reasons for so doing (e.g. *kaitiakitanga,* employment) are primarily not environmental.

Prom the information available to the Commissioner, DOC's analysis of the Iwi Authority's proposal is supported for much of Egmont National Park that is steep and rugged and has dense undergrowth. However, much of the Park below about 600 m is on gently sloping topography, and has a relatively open forest cover (rimu-rata/kamahi), with dense undergrowth vegetation confined mainly to a relatively small number of river gorges.[20] In terms of terrain, vegetation and climate this area is at least of comparable accessibility for ground control as extensive areas in the North Island East Coast and the South Island West Coast where ground control has been extensively used.

For Operation Bgmont, the Park was divided into 3 segments with river boundaries, each running from the Park boundary to the summit. If Mt Taranaki (excluding the Kaitake Ranges) were instead to be divided by the 600 m contour line into two concentric portions, it appears *possible* from the above analysis that ground control may be physically feasible in the lower portion. This analysis has been made only in terms of physical factors: it does not take into account cost, labour availability or coordination criteria. Nor would it be able to use natural river gorge boundaries to reduce reinfestation. It is presented merely to illustrate the point that the division of control areas into management units can have a considerable bearing on the analysis of control options.

An BIA for Stage II was included in DOC Wanganui's application to DOC Head Office for approval to distribute 1080 by air.[21] This was reasonably comprehensive in scope, presenting clear objectives and justification for

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20 Clarkson, 1986.
21 Letter of 26th February 1993.

control. However the choice of technique and toxin was only very briefly discussed. An EIA was not undertaken by TRC: staff consider that information presented in the Regional Pest Management Plan and applications for consents were equivalent to an informal EIA. However the Plan has very limited discussion of methods for pest control (for example, 1080 is only mentioned once in passing), and consent under the Resource Management Act (Transitional Plan) was by General Authorisation; therefore decision-making specifically for Stage I was not subject to formal public process. The short notice for Stage I, although outside TRC's control, precluded inclusion in the 1992-93 Annual Plan. However the public was able to make submissions on Stage II through the 1993-4 Annual Plan, and throughout 1993 councillors and staff received submission from various parties.

7.2.6 Public consultation and interaction

Obligation to consult and extent of consultation

Neither operational agency was legally obliged to consult specifically over Operation Egmont. TRC's Regional Pest Management Plan and its Annual Plan process involved public consultation. It received and acknowledged some submissions to its draft 1993-94 Plan against 1080 and in favour of alternatives. However, as noted, both plans have very little specific discussion of 1080 control. DOC's preparation of the conservancy's Conservation Management Strategy involves public consultation, but progress on this was to some extent overtaken by Operation Egmont.

DOC and TRC arranged several meetings in early 1993 with interested parties (Pederated Farmers, groups of landholders, Porest and Bird, affected iwi, National Park users, beekeepers, Regional Conservation Board), plus a public meeting at Oakura. General support for Operation Egmont was noted by TRC at these meetings.[22] It should be noted that these meetings were primarily for notification and discussion rather than consultation per se, although as a result of the meetings a few operational modifications were made; for example 1080 was not used in a few areas close to concentrations of beehives.

For the permissions process, neither the Medical Officer of Health nor the and District Council has a legal obligation to consult. The New Plymouth District Council permission for Stage I was processed by staff. South Taranaki District Council's permission for Stages II and III went to Council for the first time, following strong public interest.

Degree of opposition and support for *genera1* pest control strategy

Submissions to the RPMP showed strong support, especially from rural ratepayers, for TRC's general policy on possum control and for significant ratepayer-funded council involvement. Early support for the self-help programme has been very encouraging to TRC. TRC also notes lack of opposition to earlier 1080 operations in the region. Public attitudes to DOC's general

[22] Taranalci Regional Council, 1993(b).

strategy is difficult to assess until the draft Conservation Management Strategy is open to submissions. The Taranaki-Wanganui Conservation Board has strongly argued the need for possum control in the past, and although some members expressed concern about the need for repeated 1080 use, has since supported Operation Egmont.[23]

Degree of opposition *and support* for Operation Egmont

There was no opposition noted in early planning for Operation Egmont, and generally strong interest group support. The intensity of opposition which emerged in late March and April took both agencies by surprise. The extent of this opposition is strongly disputed. Expressions of 'mass' opposition include a total of about 250 people at three protest marches in New Plymouth, Stratford and Hawera, and 70 people at a strongly anti-1080 public meeting at Mangorei, and a petition with 150 signatures presented to DOC. A further petition opposing 1080 was circulated widely and is claimed to have attracted 6,500 signatures,"[24] but has apparently not been presented. Although staff from both agencies have received considerable criticism, Taranaki Regional Councillors received very few personal approaches from people opposed to 1080 use.

Consultation with tangata whenuo

TRC's formal consultation with tangata whenua is through Te Putahitanga o Taranaki, a standing committee of council, with representatives from eight Taranaki iwi. Te Putahitanga has discussed Operation Egmont on several occasions during 1993. DOC's consultation with tangata whenua has been through the Taranaki Maori Trust Board and the Aotea District Maori Council, with whom Operation Egmont has been discussed in the course of consultations over the Conservation Management Strategy. Both agencies were advised by these Maori groups to consult with individual hapu and iwi. For Stage I these were Te Atiawa and Taranaki. The agencies have received written support from these iwi, although the extent of support among these iwi has been disputed.[25]

Reaction by Maori to Operation Bgmont canvassed by the Commissioner could be summarised as very mixed, ranging from strong support, mainly on grounds that possums are destroying the mana of Maunga Taranaki, to equally strong opposition, mainly on the grounds that use of 1080 poison is destroying the mana of the mountain and its waterways. Opposition to 1080 use appears to be strongest in the south of the region, especially from some hapu of Ngaruahine. Some opposition from Maori has raised issues of sovereignty and decision-making power over the mountain, and Maori generally wish to exercise *kaitiakitanga* over the mountain regardless of disagreement about the means of doing so. The agencies are at present consulting with all iwi over Stages II and III.

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23 M. Bayfield, pers. comm.; letter to PCE, 22 December 1993.
24 B. Power, People Against 1080, pers. comm.
25 Letters to Daily News, 17 May 1993.

Interaction between operating agencies *anti* People *Against 1080*

Relationships and communications between the two sides became very strained. For example, a public meeting was planned for May 6 but had to be cancelled, evidently because neither side could agree on arrangements for speaking rights, chairmanship, etc. A meeting related to Stage II, organised by the South Taranaki District Council in Hawera on 1 November 1993, was only the second public meeting to take place once the controversy-was strong. Although not well attended, and no agreement was reached, it appears to the Commissioner that this meeting was helpful in informing some public and councillors, and possibly in lessening the degree of polarisation.

Agency staff were subjectedto significant obstruction and abuse by protestors during Stage I. Some complaints have been laid to the police regarding personal threats against agency staff and families, and alleged illegal acquisition and placement of baits. In other cases, conflicting and unresolved allegations have been made to the Commissioner. The Commissioner's media files record the controversy reasonably faithfully, and Stage I landholders generally perceived the media as being unbiased and independent,[26] but local media have been accused of serious bias by both sides. Both sides of the argument feel that they have acted in good faith but that their sincerity has not been accepted by the other side. It can only be concluded that this degree of polarisation exacerbated the controversy and obscured the substantive issues of disagreement.

7.2.7 Evaluation of operation

Possum *kill* monitoring

Both agencies had an operational target of 80% reduction in possumnumbers. Monitoring by TRC was primarily by bait interference from bait stations on 21 line each 1 km long, with night counting also used to check bait interference results. Average results were 87% (bait interference) and 89% (night counting) reduction. Perceptions of possum populations reduction by landholders and other observations were generally positive but indicated some variability of kill rates and possibly some degree of reinvasion.[27]

Monitoring by DOC used the trapcatch method, undertaken separately in eight vegetation zones. Average result was 77% reduction (95% confidence limits 71-84%). There was quite high variability between vegetation zones, with reductions in each zone ranging from <0 to >90%. The poorest monitor-

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26 TRC landholder survey (J. Hutchings, TRC, pers. comm.).

27 Eight-five percent of Stage I landholders felt that possum numbers had decreased on their properties since theoperation and 15% felt there had been no change in numbers (TRC survey, J. Hutchings, TRC, pers. comm.). Comments in a survey of nine residents on Carrington and Upper Pitone Roads carried out by People Against 1080 ranged from 'quite a reduction in possums' to 'my dog has been locating possums and I have been shooting them at a rate little changed from before'. An unsolicited letter to the Commissioner from a land holder at North Egmont who describes herself as 'someone in the middle [of the controversy] who is trying to keep an open mind' states that 'initially we thought that quite a good kill had been achieved . . . however, 1 now feel that the kill has not been as successful as was fist thought, and that the possum numbers are still too high to expect the local farmers to cope with').

ing results and highest variability came from the Kaitake Range (two vegetation zones) which had abnormally low trapcatch rates that were at variance with observations of high possum density and damage to vegetation. Further monitoring has been done in these zones using cyanide poison lines, suggesting population reduction of about 90%. The average post-operation 'relative density' from three night's trapping, has been calculated at 4.0 catches/100 trapnights, compared to the target of <5 catches/100 trapnights."

Performance monitoring

None has been done to date. DOC intends to follow up operational monitoring with monitoring of vegetation canopy condition, using existing vegetation condition data as a baseline. Improved flowering of rata and other palatable plants has been noted. Performance monitoring for Tb control using present methodology is not possible on farmland in areas without Tb. Performance monitoring for other farmland values could be carried out by measuring pre- and post-operation pasture production.

Cost Effectiveness

The total cost for Stage I in the buffer zone farmland was $32/ha, including all TRC staff time, monitoring costs and Taskforce Green costs.[29] This also includes several one-off costs towards ongoing work, notably farmer training for maintenance under the self-help programme. TRC believes that subsequent maintenance costs under the programme will be significantly lower than average AHB-funded maintenance programme costs. Budgeted costs for Stages II and III of Operation Egmont are considerably lower than for Stage I.

DOC's budgeted costs for aerial treatment for Stage I were $20/ha including monitoring, but not including permanent staff time. Actual costs were $21/ha. Costs for rateable bush land outside Egmont National Park (1,900 ha) were similar. Budgeted costs for Stages II and III are also lower, at a budgeted total of $18/ha and an estimated $16/ha available operational costs.

Water monitoring

A total of 159 samples, comprising surface water, raw and treated water supplies and groundwaters, were tested for a variety of physical, chemical and biological characteristics, including 1080 and fluoride presence. Sampling was undertaken by several laboratories under TRC's coordination. Except for two samples deliberately spiked for calibration, no measurable concentrations[30] of 1080 were found. Traces (<0.3ppb) of 1080 were detected in 18 samples from a variety of sites including some from outside the operational area. Sources of these trace concentrations were ascribed by TRC and the

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28 W. Fleury, DOC, pers. comm.

29 Taranaki Regional Council, 1993(b); TRC memo PD1/18, 13 December 1993.

30 Level of accurate measurement was 0.0003 mg/l, equivalent to 0.3 parts 1080 per billion of water.

sampling laboratory to pellets falling into streams during aerial operations, and/or contamination of some sample batches by faulty handling **techniques** after collection. It can only be concluded that the concentration of 1080 in sampled waters was extremely low and at a level that cannot be linked to any known adverse effects on the environment or to human health (see sections 5.1.2, 5.1.3).

Fluoride sampling showed low average concentrations but some variability, comparable to that occurring naturally. Biological monitoring results were interpreted as showing no impact of possum control operation on benthic macroinvertebrate communities.

Non-target species

Three dogs and two cows are officially reported to have died of 1080 poisoning. Further deaths of small numbers of non-target species, including sparrows, hawks, cats and dogs, allegedly from 1080 poisoning, have been reported to the Commissioner.[31] People Against 1080 reported several unexplained human illnesses at the time of the operation. No links with 1080 have been established in any of these cases.

Operational aspects

The TRC's operation appears to have run reasonably smoothly and was completed to target standards on schedule. This was a considerable achievement considering the size of the job and the short time available for planning. Some additional costs were incurred through assistance to DOC for track clearing and security, and some minor delays occurred through coordination problems with DOC.

DOC's operation was subject to significant delays in starting and throughout. These delays were associated with helicopter non-availability, poor weather, substandard quality of some of the bait delivered necessitating resupply, delays in contacting and notifying adjacent land owners, and protest action. Some problems in coordination between DOC and TRC have been acknowledged by both agencies. Some of these are attributable to the delays experienced by DOC. There appears to be some potential for DoC's internal channels of communication and decision-making (between Head Office, Wanganui Conservancy and Stratford Field Centre) to lead to coordination problems, but clear areas of responsibility within the joint working party, both between TRC and DOC and within DOC, were laid down at an early planning meeting. At any rate it is not evident that the delays and coordination problems experienced adversely affected overall operational effectiveness, although as a general comment it is possible that poor coordination in the field between bush edges and farmland buffer zones may lead to faster rates of reinvasion unless follow-up treatment is targeted to these areas.

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31 Submissions from People Against 1080, 18 November 1993.

Records from the DGPS navigation system used and from bait spread assessments undertaken by DOC suggest that good bait coverage and distribution was achieved during the aerial operation.[32] Some areas in the Kaitake Range were observed by field staff to have uneven coverage and small areas there were supplemented by handspread baits.

7.2.8 information available

To operating agencies

There appeared to be adequate information available, including information from People Against 1080. The main gap appeared to be an up-to-date compilation of ground-based operations (see section 5.1.6) around the country, which probably hampered the fullest consideration of alternatives.

To consent agencies

Basically the same range of information was available as to the operating agencies. South Tarauaki District Council expressed concerns about the availability of reliable toxicological information, but the Medical Officer of Health had access to this from Ministry of Health and the Communicable Diseases Centre. Both operating and consent councils had briefings from various technical experts and the exchange of information between consent and operating agencies was good. Elected councillors from both operating and consent councils appeared to have had full access to necessary information.

To public, including People Against 1080

The quantity and quality of operating and consent agencies' information made available to the public was good and no complaints were received on this aspect. TRC operational and monitoring reports were published in October 1993. A DOC report on the operation, and the DOC EIA reports have been available to interested parties although not publicly released. TRC also made much factual information available through its self-help programme. Both operating agencies widely circulated a Waikato Regional Council report on 1080,[33] which is balanced but now a bit dated. TRC staff considered in hindsight that information presented to the public for Stage I was somewhat fragmented and generalised, and have taken a more coordinated and proactive stance to information dissemination for Stages II and III.[34]

7.3 Summary and discussion

Information from the case studies is summarised in Table 7.1. This table includes general comments and some contrasting examples from possum control operations in other parts of the country. From limited information

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32 People Against 1080 have disputed DOC's assessment of bait coverage: two members claim to have observed baits being dropped twice in the same area, including waterways, on the Pouakai tops. DOC staff observe that some overlap of swathes occurs normally (W. Fleury, pers. comm.).

33 Huser, 1990.

34 Taranaki Regional Council, 1993(b).

Table 7.1 Summary of case study information

	Wairarapa	Taranaki	General Comments hot limited to case studies)
General Nature of possum problem	• Endemic Tb area: Tb possums for > 25 years • Tararua forest margin seen as critical buffer against feral infection • Scattered forest areas seen as Tb hotspots	• No endemic Tb in cattle or possums • Forest margin control seen as buffer against infection of feral population • Egmont National Park control high conservation priority • Impact of possums on pasture productivity seen as significant	• Relative importance of type of problem varies widely: is Tb endemic, number of priority conservation areas, area of exotic forests, etc • Declaration of possums as pest of local importance determines if RC undertakes control independently
Overview of general possum control up to 1993	• AHB management strategy • Extensive control on farmland; little DOC involvement • Self-help approach established but interest fluctuates • Mixed aerial/ground-based poisoning and trapping	• Approved Regional Pest Management Plan & AHB Management Strategy • Self-help control approach new and successful • Localised ground-based poisoning on farmland • Localised trapping by permit or contract on conservation land	• Pest Management Plans in some regions: content varies • Self-help approach active in some regions but agencies wary of fluctuating support • Trappers have kept local possum populations in check at times
Public awareness/involvement	• High farmer concern over Tb; some uncertainty over possum-lb linkage • Little apparent opposition to 1080 prior to 1993	• Public involvement in Peat Management Plan process • Little apparent opposition to 1080 prior to 1993	• Urban population generally less aware of possum impacts, more wary of poisons use (section 5.4) • Trend towards agencies issuing more information and mounting sophisticated PR campaigns • Opposition to 1080 comes from a 'coalition' of different groups
Specific Operation **Operational area and method**	• Aerial (1,100 ha) and ground-based (3,500 ha) 1080 poisoning and trapping • Farm land abutting on forest and 1 km forest buffer • 4,600 ha total (including 250 ha DOC land); all by WRC	• Aerial-1080 over National Park (DOC) and larger private bush areas (DOC for TRC): 13,100 ha • Ground-based 1080 on remainder (TRC): 4,100 ha	
Direction and funding	• Initiative from AHB • Executed by WRC • Funding AHB	• Initiative from DOC • Executed by DOC and TRC as joint operation • Funding DOC and ratepayer	• RC response to AHB initiatives leaves ratepayers liable for maintenance costs • Concern at lack of Government commitment to buffer areas if not DOC priority
Consents and authorities	• Agency acting under Agricultural Pests Destruction Act • Permissions under VPC Regulations obtained • Consent under RMA not applied for	• Agencies acting primarily under APDC (TRC) and Wild Animals Control Act (DOC) • Permissions under VPC Regulations and RMA (General Authorization) obtained • Application for injunction under APDC against aerial 1080: hearing declined	• Inconsistent approach to RMA s.15 (1080 as a contaminant?) • MOH and District Council permissions at times controversial and subject to stringent conditions • No successful legal challenges to aerial-1080
Decision-making process	• Primarily followed AHB protocol and procedure; no guidance on choice of method • WRC prepared EIA for DOC land • Decision-making and choice of method informal; based on prior experience	• DOC prepared EIA for ENP • Decision-making & choice of method informal, based on prior experience	• Need for EIA not widely accepted • Some DOC conservancies have detailed decision-making process

	Wairarapa	Taranaki	General Comments (not limited to case studies)
Consultation	• No specific consultation with Maori • Public information meetings (with outside experts) before and during controversy • Access to information not seen as problem	• Consultation with Maori through existing channels • Public information meetings and consultation with some interest groups before controversy • Access to information not seen as a problem	• Some DOC conservancies have set consultation procedures • Need to deal with individual iwi/hapu • Allegations of officious RC approaches to landholders regarding alternatives
Public awareness and involvement	• Agencies perceived general acceptance • Active opposition to aerial-1080 from small group • One protest meeting	• Agencies perceived general acceptance • Active opposition to aerial-1080 from small group • Protest meetings, marches, petitions • Public confusion over nature of joint operation	
Alternatives to 1080	• Alternative control on 2 farms negotiated (monitoring costs disputed) • No apparent formal assessment of alternatives to aerial-1080 • No trapping proposal presented	• Alternative control on 4 farms negotiated • Limited assessment of alternatives to aerial-1080 • Informal discussions on trapping possibilities; rejected by agencies	• Trapping used extensively in some areas, but very dependent on training and availability • Use of contractors verses agency staff becoming more common
Operational features	• Significant delays (to aerial operation) due to weather and attempts to accommodate Citizens Against 1080 • Line-of-sight navigation; bait spread may have been uneven • Bait deterioration soon after application (rain) • AHB protocols followed	• Significant delays to aerial operation due to weather and logistical problems; some coordination problems • DGPS navigation; adequate bait spread • Internal protocols followed	• Many aerial-1080 operations experience logistic problems and delays caused by high demand for DGPS and experienced pilots • Security problems for 1080 increasing • Some RCs use poisoned carrots
Environmental impacts	• No detectable 1080 in water samples; fluoride and faecal coliform levels not significantly different from controls • Non-target species kill: few reported impacts (2 dogs?)	• Trace concentrations of 1080 in 18/159 water samples; fluoride levels and number of stream invertebrates not significantly different from controls • Non-target species kill: 3 dogs, 2 cows (official), sparrows, cats, hawks (alleged)	• All tested water samples had zero or very low 1080 residues • Ambiguous results on 1080 effects on native non-target species (birds, invertebrates)
Effectiveness and **efficiency**	• Monitoring of ground operation only; dubious results • Reported average kill rate 22% • Reported costs $11.40/ha (net) • Delay and reinfestation likely to have hindered effectiveness	• Reported average kill rate; 88% farmland, 77% forest • Reported costs $32/ha (gross) farmland, $21/ha (net) forest • Effectiveness appprently not hindered by operational problems	• Controversy over compensation for stock losses
Follow-up	• Ongoing poisoning by WRC • Joint WRC/DOC 4 km buffer strip control proposed 1994, with ongoing (3-yearly) maintenance	• Ongoing self-help maintenance on farmland • Forest populations difficult to control at low densities; repeat poisoning envisaged • Proposals for contract hunting on small areas in ENP being negotiated	• Huge variability in monitored operational efficiency and confidence in monitoring results

obtained in the course of this investigation, it appears that the two case studies encompass many of the important issues encountered in the rest of the country. The following section discusses some general issues arising out of the case studies, but not confined to them.

7.3. I Some operational issues

While maximum reduction of possum numbers was the aim of both operations, their objectives varied. In the Wairarapa the sole purpose was to reduce possums as a vector in the transmission of Tb to livestock. In Taranaki, the initial objective was the protection of high priority conservation values and, coincidentally, to maintain non-endemic Tb status and reduce possum impacts on pasture production. Therefore the agencies involved and their responsibilities and funding sources are different in the two areas. The possum-bovine Tb link is the driving force behind many control operations, but there is concern about other factors in Tb spread, especially uncontrolled movement of at-risk animals. New herd control regulations are an improvement but need considerable backup by way of cooperation of the various groups concerned, education and enforcement (see section 3.5).

Operational monitoring results for the two case studies indicate considerable variability in operational success (between operations and between vegetation zones on Mt Taranaki) even allowing for the large uncertainty over the Walrarapa results. This point is reinforced nationally by results of bait take, spotlight counting and trapcatch monitoring of a large number of DOC and AHB funded operations, as shown in Table 7.2. These results are drawn from a relatively long time period, and they undoubtedly reflect variability of monitoring results as well as success of control, nor is it possible to differentiate the two types of variation. However, more of the vat-lability is thought to reflect control rather thanmonitoring variability.[35] This degree of variability indicates that there is still some way to go to maximising the chances of a successful control operation, regardless of the method chosen.

When the purpose is to control Tb, and significant and persistent drops in the cattle Tb reactor rates are achieved after possum control operations, despite apparently poor monitoring results, councils may have little incentive for detailed monitoring, especially if resources are limited. However, for strategic control of all possum impacts in a region such as aimed for in a Regional Pest Management Strategy, both operational and performance monitoring is essential.

Continuing maintenance operations to maintain low possum populations after an initial operation is a significant issue in both case studies (see section 5.3). It is clear that in the conservation estate further development of strategies and methods is required for maintenance of possum population densities at the low levels necessary for many conservation goals. Some of this work is underway. In other regions, where Tb control is the main aim, such as the

[35] P. Livingstone, AHB; E. Spurr, Landcare Research, pers.comm.

Table 7.2 Variability of monitoring results for Animal Health Board and Department of Conservation control operations

Monitoring Method	No. of Operations monitored	Percentage Survival		
		Range	Mean	95% confidence limits on mean
Bait Take	36	1-78	22.3	17-28
Spotlight Counts	40	o-137	23.2	18-32
Trapcatch	15	7-43	26.4	20-33

Source of data:
Baittakeandspotlightcount methods: MAFQual spotcheckdata Baittakedataexcludes 3 operations with high percentage survival where monitoring was known to be faulty. (P. Livingstone, AHB, 1994, pers. comm.). Trapcatch method: This report, Appendix A, Table A. 16.

Wairarapa, the area to be maintained is constantly growing, which puts a financial strain on regional councils' forward planning. Also maintenance operations requiring repeated 1080 application especially by air will be of public concern. Therefore ground-based trapping alternatives may have their greatest potential for maintenance control, especially in buffer zones where the terrain is reasonable. There is also a potential to hand back the problem when areasonable level of control has been achieved to the local land owners, who through cooperative action and some agency support could continue maintenance operations.

One concern is the criteria for landholder exemption from regional council operations to conduct possummanagement using alternative methods. Most such exemptions to date have been for landholders with organic or BioDynamic status. It is reasonable for the council to verify this independently. Councils also need to be confident that the integrity of their operation is maintained by the 'alternative' operations (section 6.6).

Furthermore, as discussed in Chapter 4, regional councils are not required by law to consider alternative methods and have considerable powers under transitional provisions of the Biosecurity Act to back up their pest control strategies. Councils are often following, under contract, the policies and procedures set down by the Animal Health Board which has introduced an optional procedure for landholders to 'contract out' of standard control methods, providing they pay any additional monitoring costs incurred to confirm the efficacy of their alternative control methods. However, a significant number of allegations have been made to the Commissioner regarding a variety of councils which were perceived to be overly authoritarian in their approach towards landholders hesitant about 1080 control methods for a number of reasons. It would seem obvious that reasoned argument should be used and cooperation towards common goals attempted, before recourse to legal threats.

7.3.2 Overall assessment of agency performance

In the Taranaki case study, the key decisions reached for Operation Egmont were sound and the efficiency of the operation was also satisfactory. Although Taranaki Regional Council's costs for Stage I appeared high in relation to DOC's, they included many overhead items not included in D OC's (and many other agencies) costs, and are more likely to reflect true costs of possum control. DOC is moving towards a similar approach to costing. However, coordination, consultation and public information strategies could be improved.

In the Wairarapa case study, the operational decisions, including the use of 1080 for both aerial and ground application, were soundly reached on the basis of existing information. However while the Council holds information for a range of ground control methods, to an outsider, evidence of the extent to which alternatives to the aerial application of 1080 were formally considered is not apparent.

On the basis of the monitoring undertaken, the outcome of the Woodside operation is uncertain. The potential for reinvasion was recognised in an annual maintenance requirement and the 1 km buffer strip was an Animal Health Board specification who set the strategy and priority for the operation. This last year has seen a move to increase the width of buffer strips following persistent Tb problems along bush boundaries.

In both case studies the operational agencies fulfilled their statutory obligations for operation and notification. They also assessed the environmental risks of the use of 1080 on the basis of available information and deemed these risks acceptable in relation to benefits. No evidence has been found in this investigation to doubt is decision for either case study.

In both case studies, the control agencies' decision-making processes relied heavily on the experience of key management staff. They were also able to produce considerable amounts of information to support their decisions. However, because decision-making was not done within a special protocol, this wealth of information available as a background was not in all cases apparent when discussing how or why a particular decision was reached. In other words, the transparency of decision-making could be improved.

Consultation with Maori was actively pursued in Taranaki where the mountain has considerable mana with the tangata whenua. This consultation was not as apparent in the Wairarapa, and there appears to be a need to for the Council to be more proactive in meeting the tangata whenua on their ground, in a consultative rather than information disseminating role.

A feature of both case studies was the mobilisation of lobbies against the use of 1080. The two groups communicated and exchanged information. Voluntary groups often do not have the resources to prepare background information on an issue, especially if it is technically complex. However some of the information on 1080 on which the anti- 1080 lobbies based their concerns was dated, generalised and in some cases only marginally relevant to New Zealand. The agencies are to be commended for their willingness to supply information to the groups. Although the numbers of active members of these lobbies were small, they comprised a range of 'sub-groups' whose primary interests included avoidance of all poisons, avoidance of some poisons, promotion of employment, accountability of public agencies, and issues of *rangatiratanga* and *kaitiakitanga.* This coalition of interests indicates the breadth of anti-1080 concerns, and made it difficult for agencies to respond to all concerns.

7.3.3 Information, consultation and decision-making

Agreement between agencies and some lobby groups on the need for 1080 use will not always be possible, but for agencies to be confident of majority public acceptance of possum control strategies, they must ensure that their consultation, information dissemination and decision-making processes are sound. The information available to both sides of the argument in the case studies appeared to be the same, and the agencies agreed to make public research information supplied to them from Landcare Research contract reports and other sources, which may not have been otherwise readily available to the opponents of 1080 use.

There was conflicting interpretation of such information and on the part of active anti-1080 lobbyists an unwillingness to accept research evidence from disinterested parties. Some lobbyists expressed concerns about the independence of research done under contract to control agencies, specifically by Landcare Research, and about the ownership of 'intellectual property' acquired during such research. These concerns are not unique to possum research and partly reflect the current structure for research funding in New Zealand. However there is no evidence to suggest that any scientists or science managers involved in research relevant to this investigation have been biassed or have acted improperly in any way.

Controversy over research results may have been compounded on occasions by conflicting interpretations from representatives of different agencies. It points to the need to coordinate the public information process so the person with the knowledge is identified as the contact point and such person resists the temptation to comment on matters beyond their responsibility or area of expertise. In general, agencies are improving the quantity and quality of information made available to the public and at the same time are making a more coordinated and sophisticated 'public relations' effort to explain and justify their strategies.

It is certainly desirable for this to happen. However it is important that such activities do not replace a sound internal and external decision-making process. It has been concluded above that informed decision-making procedures for possum control, particularly those for assessment of options for control methods, were not sufficiently transparent and reported in both case studies. It appears likely that this is a general situation.

What is needed are protocols for decision-making including criteria for the evaluation of alternatives (see section 5.1.6 for examples of criteria). Criteria are likely to differ according to the purpose of control. A recent DOC report on its proposed Moehau possum control operation[36] is a good model of the information and assessment suggested. This document both fulfils EIA requirements and allows thorough scrutiny of how decisions were reached, especially concerning selection of control methods. Animal Health Board protocols could be expanded to provide more guidance in the evaluation of alternative methods as provided in the DOC report. It may be that a single comprehensive assessment for a region or a group of operations is prepared with criteria against which individual operations are assessed.

The public needs to be involved in this process, at least to the extent of being able to see the basis for the decisions made including an assessment of alternatives. Such involvement in no way abrogates the mandate and responsibilities that public authorities have for environmental management, but at least enables justification of agencies' decisions and at best involves the public in ownership of the problem. Section 5.4 has noted the need for agencies to involve the public, numbers of whom have doubts about 1080 (and other control methods), if the agencies want to retain acceptance of their strategies. This was pointed out previously by the Commissioner regarding possum control on Rangitoto Island[37] but improvements are still required. This process is likely to require a relatively long planning horizon, such as provided by comprehensive Pest Management Plans/Strategies and Conservation Management Strategies.

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[36] Department of Conservation, 1994(c).
[37] Parliamentary Commissioner for the Environment, 1990.

8 Conclusions and recommendations

1. **New Zealand is the only country in the world with a possum problem.** It is also the only country where a number of introduced mammal species (possums, rabbits, deer, ferrets, stoats, rats and goats, to name a few) pose serious and diverse risks to natural and economic values. Our unique problem requires unique solutions. Perhaps it is not surprising then that New Zealand is the world's largest user of 1080, and possibly also cyanide and phosphorus, for vertebrate pest control.

2. **The possum problem is very serious.**
   - Possums definitely contribute to the spread of bovine tuberculosis, and the risk of non-tariff trade barriers against meat and dairy exports will always be with us as long as the incidence of this disease in New Zealand is above international standards.
   - Unique native species and ecosystems have already suffered considerable damage from possums and some (such as mistletoe and land snail species) are at risk of being lost. Under current funding allocations for possum control to protect conservation values, some ecosystems will continue to suffer damage. If adequate resources are not provided to control possums in sensitive areas, the loss will continue, and be permanent.
   - Possums reduce agricultural and forestry production and possibly contribute to the spread of waterborne disease.

3. **The possum problem is not new.** Possums were considered a serious enough problem to undertake a national bounty scheme over 40 years ago, and the risks to native forest and of Tb spread have been understood for well over 20 years. In most areas of New Zealand the possum population peaked 30 to 60 years ago. What is new is that we now have many more explicit examples of damage to native ecosystems, the areas of endemic Tb have spread, and wild Tb vectors other than possums are recognised.

4. **Possums cannot be eradicated from New Zealand, and control costs will be ongoing.** Possums have only been eradicated on small islands, at a very high cost per hectare. With current control methods and knowledge, the cost of keeping possum populations down to levels that pose no significant threat to the conservation estate and the spread of bovine Tb will be ongoing, and probably higher than at present.

5. **Possums are not the only threat to native ecosystems and to the control of Tb.** Other pests threaten conservation values, there are other wild vectors of Tb besides possums, and livestock management is a

major influence on Tb risk. These other risk factors must also be given continued full attention, as possum control alone will not achieve the desired result.

6. **Better understanding of how to control wild Tb vectors more cost-effectively is required.** Both 'knockdown' and 'maintenance' work for possums and other wild Tb vectors over increasing areas means an increase in costs, and if effective control is to be achieved there is an urgent need for effective targeting of funds. The Animal Health Board targets broad control areas, but within those areas *all* possums are targeted. Research to identify the 'safe' threshold and high-risk 'hot spots' posing the greatest risk of Tb transmission to livestock must be maintained.

7. **The possum risk is high only in specific areas. Possum control must be targeted to these areas to achieve population levels that will actually reduce the risk long-term.** Pest control professionals have been effectively 'knocking down' possum populations for well over 40 years, but we still do not know what the 'safe' threshold population level of possums is for either conservation or Tb control. Populations always recover in the absence of sustained maintenance control. Monitoring of long-term changes in possum populations and their effect on resources is a continuing need.

8. **The present situation with monitoring of possum control needs to be improved, particularly for Tb control.** The success of all operations needs to be measured and assessed, both in terms of possums killed and conservation, Tb or other risks reduced. To ensure we are obtaining cost-effective possum control, that payments for contract operations are fair, that control methods can be compared, and that long-term risks to ecosystems and populations can be assessed, it is essential to have better developed and standardised monitoring methods and adequate resources devoted to monitoring.

9. **The majority of possum control operations involve poisoning by 1080.** About three quarters of the area treated is by ground application and one quarter by air.

10. **For possum control over areas of very difficult terrain and poor access, a more cost-effective control than aerial-1080 is not available at the present time.** However, aerial application of poisons, no matter how well targeted, is widely perceived as 'indiscriminate' and public opposition is not likely to go away.

11. **Current evidence on the environmental and human health effects of 1080 can not prove absolute safety but the risks of using 1080 are acceptable in relation to the benefits of use.** Pest control operators in New Zealand have used 1080 for over 30 years. Compound 1080

poses known and unknown risks that must be compared with the risks posed by possums. Compound 1080 is biodegradable over time. Loss of individuals of non-target species (especially dogs) does occur from 1080 use, but loss of individuals needs to be balanced against recovery of habitats and their populations of native species. The risk of significant contamination of human water supply from 1080 use is very low.

12. Continuing heavy reliance on 1080, or any other single toxin, is not advisable over the long term. Even if other environmental risks of 1080 use are not felt on balance to be significant, the risk of developing bait and poison shy populations must be considered. Widespread use of 1080 may not be viewed as 'clean and green' by our trading partners. Biological controls or other breakthroughs in technology might offer sustainable alternatives over the long term. In the meantime other control methods are available as alternatives to 1080 use where appropriate.

13. Cost-effective possum control *can* be achieved by possum hunters operating under *performance contracts* over considerable areas of accessible terrain This has been clearly demonstrated in recent years on some large areas of conservation land. For this option to be viable over a significant part of New Zealand in the medium to long term, more adequately trained hunters are required, more site-specific paired trials (comparing hunting and 1080 poisoning) initiated, and a code of practice developed.

14. Possum control through hunting under performance contracts is not the same thing as fur price or bounty-driven possum hunting practices of the past. Confusion between these very different approaches has been found among pest control officers, possum hunters, and the general public. When skin prices were high in the 1980s, a certain level of possumcontrol was exerted in some areas, but this level of control is not enough to achieve the conservation and Tb control goals of agencies today, and bounties cannot be successfully targeted to high-risk areas.

15. Possum hunting using traps and cyanide involves non-target risks too. Cyanide is a humane poison, but has killed at least 11 people in New Zealand, traps as presently used are viewed by some as inhumane, and both methods can kill or injure individuals of non-target species.

16. Researchers might develop an effective possum-specific biologicai control in 10-15 years. This may offer a cost-effective method to supplement or even largely replace present control methods. If this potential is to be realised however, ongoing long-term research funding must be guaranteed.

17. All **possum control poisons (e.g. 1080, cyanidle, brodifacoum, phosphorus)** are capable ofchanging the physical, chemical or biological condition of land, water or air and can therefore be considered 'contaminants' under the Resource Management **Act** 1991. When poison is applied aerially it is impossible to avoid small watercourses and therefore aerial operations can be considered to involve the discharge of 'contaminants'to water. However, whether this discharge is considered to cause a significant effect is a separate issue, which will determine how the discharge is dealt with in plans and rules, and/or by resource consent requirements.

18. **Landholders should be allowed to control possums in their own way if 1080 or other methods preferred by control agencies are unacceptable, as long as required levels of control are achieved.** The inability to prevent the imposition of unwanted pesticides may affect mental if not physical health, certification for organic growers, and the ability of tangata whenua to exercise ***kaitiakitanga.*** Although the law does not provide for exemptions the Animal Health Board has proposed a model contract for landholders wishing to carry out alternative management methods.

19. **Control of possum and other wild animal vectors is an essential part of Tb control,** but **on its own** will **not achieveacceptable levels of Tb control.** Continuing attention also needs to be given to stock movements within and out of infected areas, and other farm management strategies to limit Tb infection. More fundamentally, Tb control requires 'ownership' of the problem by all landholders and other stakeholders in the agricultural sector.

20. **Clarification is required as to the jurisdiction of regional councils** to be involved in national pest management strategies under the Biosecurity **Act** 1993 and to make financial contributions to such strategies; and to undertake pest management under the Resource Management Act 1991.

21. **The permissions needed for the use of controlled pesticides under the Pesticides (Vertebrate Pest Control) Regulations 1983 provide appropriately for supervision by the Medical Officer of Health and the relevant controlling authority,** although there is potential for unhelpful duplication where resource consents under the Resource Management Act 1991 are also required. Clarification of the Regulations is required as to the monitoring and enforcement of conditions; criteria are needed for the test of 'harm or inconvenience to the public', and the penalty provisions under the Pesticides legislation should be consistent with those of the Biosecurity and Resource Management Acts. Adjustments may be most appropriate as part of the forthcoming Hazardous Substances and New Organisms legislative review.

RECOMMENDATIONS

Major progress in identifying the risks, developing control strategies and research programmes and improving operational procedures has been made by the Animal Health Board, Department of Conservation, Ministry of Agriculture and Fisheries, local government, Crown Research Institutes and coordination committees. However improvements to the government system are possible.

Recommendations are made in the knowledge that in some instances one if not several agencies have already initiated action to improve procedures. These recommendationsserve to reinforce the initiatives taken and to encourage other agencies to follow suit.

RECOMMENDATIONS to the Minister of Agriculture:

1. Amend the Biosecurity Act 1993 to:
   a. clarify the ambiguity identified in respect of regional councils' powers to be involved in and to contribute to the funding of a national pest management strategy;
   b. clarify the ambiguity identified in respect of using general rating powers for funding a pest management strategy;
   c. define the term 'occupier' to include owners as well as occupiers in relation to every place, whether or not there is also a person in physical occupation;
   d. include a specific power whereby a pest management strategy may include a direct obligation on owners/occupiers as to the management, control or eradication of the relevant pest.

(sections 4.2.1, 4.2.2)

2. With regard to the Pesticides (Vertebrate Pest Control) Regulations 1983:
   a. make specific provision for compliance monitoring of the conditions (if any) imposed by the Medical Officer of Health and/or the appropriate controlling authority in respect of the use of controlled pesticides in restricted areas and where they are applied aerially, and for the resourcing of that monitoring, so as to provide a regime consistent with that of the Resource Management Act 1991;
   b. develop criteria for the test of 'harm or inconvenience to the public' for the guidance of the controlling authority, together with requirements as to the consultation to be undertaken in applying the test;
   c. amend the penalty provisions in relation to the use of controlled pesticides so as to reflect the level of penalties available under the Resource Management Act 199 1 and Biosecurity Act 1993;
   d. limit Approved Operators Licences for the use of controlled pesticides (e.g. 1080, cyanide, phosphorus) to a term of five years and provide that ongoing registration be dependent on review and upgrading of operators' training.

(sections 2.4, 4.5)

RECOMMENDATION to the Minister of Agriculture and the Animal Health Board:

3. In order to improve control of bovine Tb, ensure the adequate provision of:
   a. ongoing education of the farming community on the legal requirements for Tb testing and movement control;
   b. monitoring for compliance with and effectiveness of testing and movement control measures;
   c. enforcement of testing and movement control rules;
   d. development and promotion of on-farm measures that can be used to lessen the risk of Tb outbreak and transmission from both livestock and wild vectors;
   e. vector control.

(chapter 3)

RECOMMENDATIONS to the Minister for the Environment:

4. In development of the Hazardous Substances and New Organisms legislation and regulations, ensure that:
   a. recommendation 2 above relating to the Pesticides (Vertebrate Pest Control) Regulations 1983 or their equivalent be carried over into new legislation;
   b. provision is made for a national database on adverse effects to ecosystems and non-human species from the use of hazardous materials, to complement the Adverse Incidents Register being developed for public health issues by the Public Health Commission;
   c. release of genetically modified organisms (such as those envisioned for biological control of possums) not be allowed without formal approval based on an evaluation of likely environmental and social effects and public submissions.

(sections *2.4, 4.5, 5.1.2, 5.2.1)*

5. Amend the Resource Management Act 1991 to clarify the jurisdiction of local authorities in respect of land use in the context of pest management measures.

(section 4.2.1)

RECOMMENDATION to the Minister of Research, Science & Technology:

6. With regard to the National Science Strategy Committee on Possums and Bovine Tuberculosis:
   a. extend the term of the Committee for a further three years;
   b. include a Regional Council representative (possibly a member of the Local Government Association's Biosecurity Technical Advisory Committee) on the Committee.

(section 2.3)

RECOMMENDATIONS to *the* Animal Health Board and the Department of Conservation:

7. In order to improve accountability and transparency and facilitate comparison between different control methods, and until such time as possum control is undertaken in accordance with the cost-benefit analysis requirement of the Biosecurity Act 1993:
   a. ensure that costings of all possum control operations explicitly include both direct and indirect costs (including administrative staff time, monitoring, consultation and consents procedures, the cost to repeat failed operations, transport, and other overheads), and be publicly available; and,
   b. move toward the use of performance-based contracts for all possum control operations.

(sections 5.1.6, 5.1.7)

8. In order to ensure that cost-effective possum control is being achieved:
   a. develop guidelines for the level of resources and methods required to adequately monitor both possum kill and effect on ecosystems and Tb spread, for different types of operations; and,
   b. allocate funding for monitoring in line with these guidelines as part of Animal Health Board and Department of Conservation funded possum control operations.

(chapter 6)

9. In order to provide for auditing of operations, accurate targeting of poison baits, and total quality management, require Differential Global Positioning System or equivalent navigation equipment to be phased in as a matter of urgency for all Animal Health Board and Department of Conservation funded aerial operations.

(section 5.2.4)

10. In order to promote possum hunting performance contracts as a viable means of possum control:
    a. include information on performance contract experience to date and instruction for initiating, supervising and monitoring new possum control performance contracts in staff training and manuals; and,
    b. undertake a series of paired trials of performance contract hunting and present control methods in a variety of terrains and regions, fully monitored and documented, and share the findings with possum control field staff and the New Zealand Opossum Fur Producers Association;
    c. develop standards for contract hunting.

(sections 5.1.6, 5. 1.7)

11. Develop a public decision-making and reporting protocol which includes evaluation of control options, permits scrutiny of how decisions were reached, and produces documentation that is publicly available.

(section 7.3.3)

12. In order to reduce the risk of tmauthorised persons gaining access to deadly poisons, revise protocols and manuals to provide specific guidance on means to ensure security of baits during transport and storage.

(section 5.1.2)

13. In order to make 1080 paste (jam) baits unattractive to bees, require in all possum control contracts that the paste bait contains a bee repellant (isovaleric acid or more effective compound) or has its sugar content removed, or baits are made unattractive to bees by some other means.

(section 5. I .2; Appendix D)

RECOMMENDATIONS to the Animal Health *Board:*

14. In order to facilitate full landholder participation in helping to reduce bovine Tb risk in their communities, continue to work together with individuals, landholders, groups, and agricultural sector service industries to:
    a. improve dissemination of Information on farm and livestock management activities that can help reduce Tb risk to livestock;
    b. fund further research on ways to identify high-risk areas and avoid livestock contact with all potential wild Tb vectors, and promptly disseminate new information to control agencies and landholders as it becomes available.

(sections 2.4, 3.5, ***7.1.2,*** 7.2.2)

15. Require data on non-target effects (suspected, documented by testing, or reported by the public) as part of all Tb vector control contracts, collate on a national basis, and make available to the Department of Conservation, the Ministry for the Environment, the Public Health Commission, and the public.

(section 5.1.2)

RECOMMENDATION to the Deportment of *Conservation and all regional councils:*

16. **Recognise** that under section 4 of the Conservation Act 1987 and Parts II, V and VI of the Resource Management Act 1991, consultation may be required with tangata whenua on resource management proposals that could affect valued resources, and that it is important to attempt to work in harmony with the views of tangata whenua, including those of Individual hapu, for proposed possum control operations.

*(sections **5.1.2, 5.4,** chapter 7)*

RECOMMENDATIONS to all *local* authorities:

17. In order to ensure that possum control poisons are appropriately controlled:
    a. consider treating all such poisons as 'contaminants' under section 15 of the Resource Management Act 1991; and reflect the significance of their effects on the environment by rules in plans and/or by resource consent requirements;
    b. subject to clarification of the Resource Management Act 1991 as to the jurisdiction of local authorities (recommendation 5 above), if possum control poisons are ***not*** dealt with as 'contaminants' consider establishing their use as a restricted land use under section 9 of the Resource Management Act 1991, and reflect the significance of their effects on the environment by rules in plans and/or by resource consent requirements.

(sections 4.4, 5.1.2, 5.1.3)

18. In order to make possum control decisions transparent to ratepayers:
    a. develop a public decision-making and reporting protocol which includes evaluation of control options and basis of costings, permits scrutiny of how decisions were reached, and produces documentation that is publicly available;
    b. ensure that insofar as possible the protocol be consistent with protocols and procedures of the Department of Conservation and the Animal Health Board (see recommendations 7 and 11).

(section 7.3.3)

19. In order to encourage landholder participation in reduction of Tb risk in their communities, continue and enhance efforts to facilitate landholders assisting with maintenance of Tb vector control after 'initial knockdown' operations, including:
    a. advice on a ***range*** of possum control methods, provision of at-cost materials, and information on monitoring methods that landholders can use to gauge their progress;
    b. in conjunction with MAF Quality Management, information on the full range of stock and farm management precautions available for reducing risk of Tb infection;
    c. disseminating new research results on improved techniques as these become available.

(sections 3.5, 7.1.2, 7.2.2; TableA.20)

20. In order to ensure that cost-effective possum control is being achieved;
    a. allocate funding for and monitoring as part of all control programmes, consistent with monitoring guidelines developed by the Animal Health Board and the Department of Conservation (see recommendation 8);
    b. in design of monitoring programmes note the outcome of research on the theoretical model underpinning the bait interference monitoring method (see recommendations 25b and 26);

c. move towards the use of performance-based contracts for all **possum** control operations:

d. document non-target effects of poisoning operations and make results available to ratepayers and to national databases (see recommendations 4b and 15).

(chapter 6; section 5.1.2)

21. Provide an option for any landholder who wants to control possums by methods other than those preferred by the council, on condition that:

a. the landholder agrees to keep the possum population to the level sought by the council in that area so as not to compromise the control programme;

b. all possum control costs are to be borne by the landholder, including any follow-up required by the Council if the agreed possum population level is not attained; and,

c. all monitoring costs are to be borne by the Council (in recognition of the landholder's payment of rates and levies), but if the landholder disagrees with findings they may seek an independent evaluation at their own cost.

*(sections **4.6, 5.1.2**)*

22. In order to make 1080 paste **(jam)** baits unattractive to bees, require in all possum control contracts that the paste bait contains a bee repellant (isovaleric acid or more effective compound) or has its sugar content removed, or baits are made unattractive to bees by some other means.

*(section **5.1.2;** Appendix D)*

RECOMMENDATIONS to the National Science Strategy Committee on Possums and Bovine Tuberculosis:

23. Work with research funders and providers to ensure that for all applied research allocations, provision will also be made for effective and timely transfer of research results to possum control field staff, landholders, and the public.

*(sections **2.3, 3.5, 5.4**)*

24. Ensure that in research prioritisation, continuity of adequate long-term funding of biological control (including immuno-contraception) is not compromised.

25. Reassess its research priorities in the light of the conclusions of this report, in particular giving higher priority to the following:

a. technical development for cost-effective trapping/poisoning ground control (in consultation with the New Zealand Opossum Pur Producers Association and regional councils);

(section 5.1.6)

b. **improvements and standardisation of monitoring techniques, especially bait interference techniques;**

(chapter 6)

c. **the role of mustelids (ferrets, stoats, weasels) and feral deer, pigs and cats in the spread of Tb and the effects of mustelid and cat control on rabbit populations;**

(section 3.2)

d. **identification of high risk pockets of wild Tb vectors and means of targeting control to those areas;**

(sections 3.4, 3.5)

e. **social and economic aspects of possum control, including public attitudes to control methods, and risk assessment;**

(sections 2.3, 5.4)

f. **Tb epidemiology, including validating and refining the epidemiological/possum control model and linkages between possum and other Tb vectors;**

(sections 3.2, 3.4)

g. **strategies and methods for maintenance/low density control;**

(sections 5.3, 6.6)

h. **better understanding of threshold population levels for different impacts;**

(section 6.3)

i. **improvements in bait technology, including work on bait/toxin shyness;**

(section 5.1.5)

j. **risks of control methods on native species and ecosystems.**

(section 5.1.2)

26. In order to improve the accurate monitoring of possum control, work with research funders and providers to ensure that:

a. **research is undertaken urgently to validate the theoretical model underpinning the bait interference monitoring method;**

b. **if justified from research results:**

   i. **bait interference results are calibrated to other monitoring methods;**

   ii. **protocols and training materials are revised to ensure that methods are consistently applied; and**

c. **disseminate research results promptly to pest control staff.**

(chapter 6)

RECOMMENDATION to the National Science Strategy Committee on Possums and Bovine Tuberculosis ond to the Local Government Association Biosecurity Working Group:

27. In order to facilitate research of practical use to regional councils, initiate regular formal liaison.

(section 2.3)

RECOMMENDATION to the National Science Strategy Committee on *Possums* and Bovine Tuberculosis and *to the National Possum* Coordinating Committee:

28. In order to better integrate policy formulation and research aspects of possum control, initiate regular formal liaison.

(sections 2.2, 2.3)

RECOMMENDATION to the National Possum Coordinating Committee:

29. Accord a higher priority to the development of a possum control module within the pest control matrix under the New Zealand Qualifications Authority framework, and ensure it includes:
    a. monitoring techniques (percentage kill, effect on conservation or Tb control objectives, and effect on non-target species);
    b. performance contracts;
    c. trapping methods (to be developed in conjunction with the New Zealand Opossum Fur Producers Association);
    d. on-farm Tb risk management techniques for landbolders.

(sections 2.4, 3.5, 5.1.6, 5.1.7; chapter 6)

RECOMMENDATION to the Health Research Council:

30. Provide adequate funding for research to clarify the connection between wild vectors and human outbreaks of waterborne diseases, in particular differentiation between human and animal forms of *Giardia* and means to reduce risk of spreading *Cryptosporidium* infection.

(section 2.2.3)

RECOMMENDATION to the Pesticides Board:

31. De-register 1080 paste baits that are attractive to bees.

(section 5.1.2; Appendix D)

RECOMMENDATION to *the New Zealand Opossum Fur* Producers Association:

32. In order to promote possum hunting performance contracts as a viable means of possum control:
    a. liaise with the Department of Conservation, the Animal Health Board and Landcare Research in order to share information, develop training programmes, and help set up more pilot projects and paired trials;
    b. offer workshops for their members and other interested possum hunters on possum hunting performance contracts and monitoring methods;
    c. develop a register of hunters who have successfully worked under possum control performance contracts and those who have attended performance contract workshops; and,

d. develop a code of practice to maximise possum control effectiveness and humaneness while minimising non-target impacts.

(sections 2.4, 5.1.6, 5.1.7)

RECOMMENDATION to Ministry of Agriculture and Fisheries, the Animal Health Board, Federated Farmers, New Zealand Stock and Station Agents Association, Agriculture New Zealand, the New Zealond Society of Farm Management, and the New Zealand Veterinary Association:

33. In order to maximise community participation in the fight against Tb, continue to give priority to publicity and education programmes concerned with Tb, stock movement, wild vector control, and on-farm measures that can be taken to reduce Tb risk.

(chapter 3)

RECOMMENDATION to Federated Farmers, the Deerstalkers Association, and New Zealand Sports Shooters Association:

34. Make every effort to inform their members of the Tb risk posed by the release, loss or introduction of deer and pigs to forest areas, especially animals from endemic Tb areas, and encourage immediate reporting of new populations and tuberculous animals to the Ministry of Agriculture and Fisheries or the Animal Health Board.

(chapter 3)

Appendix A

Tables of *background in formation*

Table A.1 Department of Conservation targeted areas for possum control

		Area targeted in DOC 10 year Plan		1993/94 Control operations	
Department of Conservation Conservancy	Area of DOC Land in Conservancy	Possum Control Area (ha)	% of Conservancy	Aerial-1080 control (ha)	Ground control (ha)
Northland	150,000	99,200	66.13	33,200	30,966
Auckland	42,140	860	2.04	427	
Waikato	269,250	71,264	26.47	12,812	16,742
East coast	500,000	135,099	27.02		38,088
Bay of Plenty	181,100	10,046	5.55		6,770
Tongariro/Taupo	185,000	4,875	2.64	350	3,500
Hawkes Bay	170,000	4,963	2.92	3,050	2,418
Wanganui	280,000	85,062	30.38	19,910	12,369
Wellington	176,000	18,972	10.78	3,600	672
Subtotal - North Island	1,953,490	430,341	22.03	73,349	111,525
Nelson/Marlboro@	996,400	95,770	9.61		21,379
Canterbury	771,200	1,150	0.001	400	1,600
West Coast	1,846,900	157,980	855	16,916	53,098
Otago	390,000	7,744	1.99	1,316	472
Southland	1,802,200	20,000	1.11	-	640
Subtotal - South Island	5,806,700	282,644	4.87	18,632	77,189
TOTAL - New Zealand	7,760,190	712,985	9.19	91,981	188,714

Ground control includes trapping, cyanide poisoning, bait stations, talon, 1080 paste, electric fencing
Total DOC possum control area 1993/94 = 280,695 ha = 1% of New Zealand.

Source: DOC National Possum Control Plan Spreadsheet 1994; Department of Conservation, 1994(a).

Table A.2 Conservation land 'at risk' from possum damage

Vegetation classes fully at risk		vegetation classes partially at risk			
Class	**Area (thousands of ha)**	**Class**	**Area (thousands of ha)**	**% area at risk**	**Modified Area (thousands of ha)**
S 1	362	GF 1	340	25%	85
FS 1	47	GF 2	133	25%	33
FS 2	446	F 4	1,399	50%	700
FS6	177	F 7	114	25%	29
F 2	1,091	GS 1	856	25%	214
F 5	205				
F 8	223				
Subtotal	2,602				1,861
Total	2,602 + 1,861 = 3,663				

Source: The Vegetative Cover of New Zealand, Newsome, P.FJ., 1987.

Calculation of 'at risk' conservation land area:

3,663,000 ha / 26,800,000 ha = 13.7% of New Zealand at risk for conservation values.

Department of Conservation estate = 7,760,190 ha
If 50% of 'at risk' area is DOC land = 1,831,500 ha or 24% of the DOC estate
If 80% of 'at risk' area is DOC land = 2,930,400 ha or 38% of the DOC estate

The 'at-risk' area was calculated by selecting vegetation classes from the Vegetative Cover of New Zealand Map where there were assessed to be medium to high possum densities which would pose a threat to these ecosystems. This calculation can only give a broad indication of the area 'at-risk'. It is acknowledged that possum density is only one risk factor that determines the effect of possums on conservation values, with the vulnerability of species also a key factor. There are areas of high vulnerability and low density (e.g. some beech forests with rare mistletoe) which would be additional to the 'at-risk' area calculated.

Broad Vegetation Classes

GF 1 - Pasture and podocarp-broadleaved forest.
GF 2 - Pasture and broadleaved forest.
S 1 - Mixed indigenous scrub.
F 2 - Lowland podocarp-broadleaved forest.
F 3 - Highland podocarp-broadieaved forest.
F 4 - Lowland podocarp-broadleaved-beech forest.
F 5 - Highland podocarp-broadleaved-beech forest.
F 7 - Beech-broadleaved forest.
F 8 - Broadleaved forest.
GS 1 - Grassland and mixed indengous scrub.
FS 1 - Kauri and *leptospermum*/mixed indigenous scrub.
FS 2 - Podocarp-broadleaved forest and scrub.
FS 6 - Broadleaved forest and scrub.

Table A.3 Incidence of bovine tuberculosis in New Zealand, 1992/93

	% of New Zealand	% of infected livestock		% of herds on movement control	
		cattle	deer	cattle	deer
Endemic	21.5%	> 87%	61%	78%	58%
Special Tb Investigation Areas (STIA)	1.5%	4%	28%	5%	13%
Fringe	17%	•	•	7%	10%
Surveillance	59%	•	•	95%	19%

Some: Livingstone, 1994.

Table A.4 Animal Health Board funded work for possum Tb vector control

	'Initial' control			'Maintenance' Control			Total Control Area	% of NZ
	hectares	% aerial	% 1080	hectares	% aerial	% 1080		
1993/94 North Island	267,000	61%						
South Island	171,000	73%						
TOTAL	438,000	66%	97.5%	995,000	0.6%	96.2%	1,433,000	5.3%
1994/95 North Island	176,000	43%						
South Island	229,000	69%						
TOTAL	405,000	58%	n.a.	1.270.000	0.8%	n.a.	1,675,000	6.3%

Source: P. Nelson, pers. comm., 1994. n.a.: not available

Note: In 'maintenance' and non-aerial control, the area 'controlled' may be more than the area actually treated with 1080 (e.g. only patches may be poisoned but a whole farm considered controlled). Therefore these totals cannot be used to estimate accurate figures for 1080 use. Major 1080 use by regional councils, including significant amounts of aerial application, also occurs for rabbit control in the South Island. Total 1080 usage figures in Table 5.4 in the main text will include both possum and rabbit control estimates.

Table A.5 Relative toxicity of possum poisons

LD_{50} mg active ingredient/kg bodyweight

	1080				
	LD 50 (mg of 1080 per kg of bodyweight)	**Relative toxicity (Dog=1)**	**Cyanide LD 50 (mg of cyanide per 43 of bodyweight)**	**Phosphorus LD 50 (mg of phos. per kg of bodyweight)**	**Brodifacoum ('Talon') LD 50 (mg of brod. per kg of bodyweight)**
Possum	**0.79 - 1.6**	**8 - 16**	**15**	**9**	**0.17**
Rabbit	**0.4 - 1.0**	**4 - 10**	6	**4**	**0.2**
Humans	**0.7 - 2.1**	**10 - 21**	3	**1**	**?**
Dogs	0.07 - 0.1	1	8	**?**	**0.25 - 3.56**
Cat	0.2	2	?	**?**	**>25.0**
Sheep	0.25 - 0.5	2.5 - 5.0	?	**?**	**5 - 25**
Cattle	0.2 - 0.4	2 - 4	?	**?**	**?**
Rat	**0.2 - 2.2**	**2 - 22**	?	**?**	**0.26**
House sparrow	**3.0**	**30**	?	**?**	**>** 6.0
Blackbird	**2.0 - 3.0**	**20 - 30**	?	**?**	**>3.0**
Magpie	0.6 - 1.3	6 - **13**	?	**?**	**?**
Weka	**8**	**80**	?	**?**	**?**
Harrier hawk	± 10.0	100	?	**?**	**10.0**
Duck (Mallard)	**8** - 10	**80 - 100**	**?**	**?**	2 - 4.6

Sources: Rammell and Fleming, 1978, p.74: Sodium monofluoroacetate, Cyanide, Phosphorus.
I. Shirer, product data, pers. comm.; Godfrey, 1985 (ii Eason and Spurr, 1993), p.9: Brodifacoum.
Atzert, 1971, pp.8-14; Batcheler, 1978(b), p.12: Sodium monofluoroacetate.
? = data not available

This data demonstrates relative sensitivity to the active ingredient of the poison. To calculate the dose that would need to be ingested for a 50% chance of mortality, multiply the LD_{50} by the average bodyweight. To calculate the amount of poisoned bait that would be required, then divide by the concentration of the active ingredient in the bait (e.g. 0.08% for possum pellet baits).

Note: This table uses LD, (50% of population likely to be killed) rather than LD,, (100% likely to be killed).

Table A.6 Sowing rates and toxicity of 1080

Auimai	**Lethal Dose LD₁₀₀ (mg of 1080/kg of bodyweight)**	**Average Weight (kg)**	**Amount of Toxin required for Lethal Dose (mg)**	**Number of 6 gm Baits for Lethal Dose at 0.15% 1080**	**Number of 6 gm Baits for Lethal Dose at 0.08% 1080**
Dog	0.08	25	2	0.2	0.41
Sheep	0.45	50	225	25	4.7
Possum	2.2	3 - 4 (max)	6.6 - 8.8	0.7 - 1	1.4 - 1.8
Human					
- Infant	2 - 5	10	20 - 50	2.2 - 5.6	4.2 - 10.4
-Child	2 - 5	25	50 - 75	5.6 - 13.9	10.4 - 15.6
- Adult	2 - 5	70	140 - 350	15.6 - 38.9	29.2 - 72.9

***Source*:** Department of Conservation, 1994(a); Department of Conservation, 1993(b); Huser, 1990; Peters, 1975.

Note: The required intake of baits for a single lethal dose for an adult ranges from 15 to 40 six gram baits at 0.15% toxicity, and 29 to 73 six gram baits at 0.08% toxicity, and the effect will vary according to the individual's physiology. Particularly sensitive individuals' may succumb to a lower dose.

Table A.7 Active ingredient of 1080 applied with aerial application of pollard baits

	Bait Application Rate (kg/ha) (assuming 6 gm baits)		
	Current 'standard' @ 5 kg/ha *1 bait pet 12 m^2*	**Rangitoto Operation @ 12 kg/ha** *1 bait pet 5 m^2*	**Old Rate 1960 - 1970s @ 25 kg/ha** *1 bait pet 2.4 m^2*
Toxic Loading in bait	Average Toxic Load of 1080 **(mg/m^2)**		
0.08% (0.8 mg 1080/gm)	0.4 mg/m^2	O.% mg/m^2	2.0 mg/m^2
0.15% (1.5 mg 1080/gm)	0.75 mg/m^2		

Table A.8 **Impacts to individuals of non-target species associated with possum control poisons and methods in New Zealand**

✓ at least one documented case of poisoning or trapping
✓✓ impacts on individuals frequently noted
(b) observed eating non-toxic baits; possible risk of poisoning with toxic baits

	Traps	Cyanide	1080	Phosphorus	Brodifacoum (Talon)
Introduced species					
humans		✓	[1]	[1]	
sheep, cattle			✓✓		
deer			✓[2]		
dogs			✓✓	✓[3]	✓[3]
cats	✓	✓	✓		
stoats, ferrets	✓	✓			
rats, mice	✓✓	✓✓	✓✓[4]	*	✓
hedgehogs	✓✓[5]	✓✓[5]			
birds[6]	✓✓	*✓	✓✓	*	✓
insects		*	✓[7]	✓[7]	*
Native species - birds					
Kiwi[8]	✓✓	✓✓	(b)*	*	
Kaka	✓		(b)*[9]	*	
Kakariki	✓	*	(b)*✓	*	
Kokako	✓	*	(b)*[10]	*	
NZ Pigeon	✓✓	*	(b)*✓[9]	*	
Weka	✓✓	✓✓	✓	*	[11]
Harrier	✓		✓[12]		[12]
Morepork	✓		✓	[12]	[11,12]
Robin	✓	✓	✓		[11]
Tomtit	✓	✓	✓✓[13]		
Fantail	✓		✓		
Tui		✓	✓	*	
Bellbird	✓	*	*	*	
Others	✓[14]		✓[14]		[11,14]
Native species - other[15]					
Bats		✓[15]	[15]	*	[15]
Lizards		*	*[16]	*	
Insects[17]		*	✓	*	[17]

Notes:

Non-target effects of trapping, phosphorus and brodifacoum have not been as fully studied as 1080. Lack of data does not necessarily indicate lack of effect. The effects of delayed-action poisons (1080, phosphorus, brodifacoum) may be less obvious in the field than from fast action or capture methods (cyanide, traps).

All data **for 1080** is **post-1978.** Prior to this date, unscreened, undyed, and non-cinnamon lured baits were used, causing some **large** bid mortalities. **Virtually all** monitoring is in relation to NZ Forest Service or Department of Conservation operations. The effects of Pest Destruction Board, Regional **Council,** or Animal **Health** Board operations on native species is unknown.

The death of individuals does not necessarily cause an impact on the overall population of a species. The impact depends on the rarity and reproductive capacity of species, and must **also** be compared with benefits to populations from possum control. Unless otherwise noted, data is summarised from Spurr, 1991, in press (a), and in press **(b);** Cowan, 1992; Reid, 1985; Tables A.9 to **A.11.**

* **Analysis** of attractiveness of paste (jam or icing sugar) baits **generally** suggests ***possible*** (not demonstrated) risk to these species (e.g. Eason and Spurr, 1993). However, for rarer species, chance of encountering baits not used by DOC (e.g. phosphorus) may be very low.

1 Accidental poisonings of humans have occurred with 1080, **cyanide** and phosphorus in New Zealand, but accidental human deaths **only** with cyanide (see Table A.ll).

2 Both feral and farmed deer (Tables A.9, **A.10;** D. **Drummond,** pers. **comm.,** 1993).

3 ***Phosphorus:*** **Gumbrell (n.d.).** ***Brodifacoum:*** M. Thomas, pers. **comm.** Dogs **will** eat **Talon** baits (and presumably other grain-based baits) **like** dog biscuits. Two cases of poisoning (treated and recovered). Overseas tests of **Talon** rat baits (wax blocks, not cereal **pellets)** have shown non-target dog deaths (Hoque ***et al,*** 1986, Tongtavee ***et al,*** 1986).

4 Aerial-1080 possum control operations have dramatically reduced rodent populations, but these **build** back up rapidly in **mainland** populations (e.g. Mapara and Kaharoa: nearly 100% reduction, but 6.5 months later back to pre-poison levels: **Innes** and **Williams,** 1991).

5 Reid, 1985; Warburton, 1992. Sometimes taken in 'moderately high numbers' at bush edge.

6 ***1080:*** **especially blackbirds** and chaffinches (34 and 14 respectively found dead after 70 monitored post-1978 aerial-1080 operations), magpie; **also** song thrush, goldfinch, greenfinch, house sparrow, hedge sparrow, **skylark, redpoll (E.** Spurr, **Landcare** Research, pers **comm); Also** chukar and **quail** in association with 1080 rabbit poisoning operations (Evans and **Soulsby, 1993,** Appendix 1). ***For traps;*** blackbirds, song thrush, magpie, **quail, little** *owl.* ***Brodifacoum (aerial*** use): **blackbirds,** sparrows (confirmed from **residues)(Towns** ***et al,*** 1993). ***Cyanide;*** **blackbird,** starling.

7 A wide range of invertebrates prone to 1080 poisoning (e.g. spider mites, **springtails,** cockroaches, aphids, beetles, moths, houseflies, fleas, ants, bees, wasps, **slugs,** and **snails.** Cockroaches that ate **1080** baits had normal predator response suppressed **(Notman,** 1989). Bees are attracted to paste (jam) baits, and whole colonies of honeybees have been **killed from 1080** paste use **(M.** Goodwin, D. Morgan, M. Reid, T. Roberts, N. **Wallingford,** pers. **comm.).** Phosphorus jam baits have been reported as unattractive and relatively non-lethal to honeybees (Reid, 1977).

8 In a 1984 survey, 66 trappers reported catching 141 kiwi in traps and **killing** 37 kiwi. This is one kiwi per three trapper years for traps and one kiwi per ten trapper years for cyanide. It has been estimated that there are five kiwi trapped for every kiwi poisoned with cyanide, but 50% of trapped kiwi survive. (Reid, 1983, 1985; **McLennan,** 1987; Spurr, 1991). In monitored DOC trapping operations, rates of kiwi take were low (e.g. seven kiwi per **500,000+** trap nights; DOC, **1984),** or non-existent when traps elevated (Cowan, 1992). In a monitored 1080 operation in Waipoua kiwi took baits (non-toxic) but **all** radio-tagged kiwi studied in association with aerial-1080 use survived, except one which died of physical injury rather than poisoning (Pierce and Montgomery, **1992).** Kiwi monitored in connection with aerial brodifacoum use (not typical for possum control = 'worst case scenario') **all** survived (Towns, pers. **comm.,** 1994).

9 Dead kaka and NZ pigeon **only** found after use of unscreened carrot prior to 1978. However, anecdotal evidence suggests lower numbers of pigeon and kaka after more recent 1080 operations **(D.Hooper,** J. Fowler, pers. **comm.,** 1994).

10 Three of 11 kokako monitoring studies in association with aerial-1080 operations had some missing kokako (2 out of 89 missing in Pureora, 2 out of 12 missing in Waipoua). Cause of disappearance unknown. Kokako also observed eating baits (non-toxic) (Innes and Williams, 1991).

11 In connection with aerial use of brodifacoum for rat control on islands (not typical of possum control, but 'worst case scenario' for susceptible species if baits fall from bait stations). Saddleback losses small (1-5% of population on Stanley Island), but some large mortalities of pukeko (90%, Tiritiri Matangi) and weka (100%, Tawhitinui Island). Other species found dead: paradise shelducks, brown teal, spotless crake, kingfisher, silvereye (Towns et *al*, 1993; letters from G. Campbell 30/9/93 and P. Cromarty 29/11/93 (DOC).

12 After rabbit poisoning operations with brodifacoum, 70-80 harriers were found dead; also reported 25% of population lost (J. Bell, unpublished research results by E. Spurr, pers. comm., 1993; Godfrey, cited in Eason and Spurr, 1993). One falcon territory monitored before and after aerial-1080 for possum control still occupied. Raptors (hawk, falcon, owl) may feed on poisoned animals. Overseas studies have shown raptors more susceptible to anticoagulants than to 1080 (Colvin, *et al* 1988).

13 A dramatic drop in tomtit population was noted in the Hokonui Hills in 1977 following aerial-1080 operation using unscreened carrot, but three years later the population had returned to previous levels (Spurr, 1981(a)). In 70 aerial-1080 operations since 1978, 15 tomtits have been found dead.

14 ***Traps*** : pukeko, paradise shelduck, brown teal, pipit, long-tailed cuckoo, black-backed gull (Cowan 1992); ***1080***: whitehead, grey warbler, rifleman, pukeko, kea, silvereye, pipit; the effects on waterbirds have not been studied. Known to take ***1080-type baits:*** saddlebacks.

15 One dead bat found, cyanide suspected. Short-tailed bats may be attracted to paste (jam) baits or eat poisoned insects, long-tailed baits only at risk from insects. Calculations of 1080 residues in insects, typical feeding patterns, and likely LD_{50} for bats gives cause for concern about short-tailed bats, and further monitoring is planned by DOC (B. Lloyd, pers. comm., 1994). If brodifacoum is cumulative in the food chain, secondary poisoning risk from insects may exist.

16 Native lizards studied in Australia were seen to take baits and lizards and frogs may theoretically take poisoned insects. LD_{50} for 1080 in reptiles, amphibians and fish very high; resistant to poisoning. Sublethal effects of 1080 on lizard fertility noted in Australian skinks (Twigg, King and Bradley, 1988).

17 Insects are killed by aerial-1080, but there are mixed results on whether the long-term impacts on populations are significant (Spurr 1993(a); Meads in Green, in press). A study of wetas found 50% killed by 1080, and 100% had behaviour disrupted (e.g. out in the day more prone to predation)(Hutcheson, 1989). Centipedes, millipedes, beetles, cockroaches and ants kept in enclosures with 1080 baits were alive, and contained low 1080 residues (0.05 - 0.07 mg 1080/g); kauri snails had no detectable levels of 1080 (Pierce and Montgomery, 1992). Traces of brodifacoum found in insects associated with bait feeder use, and uncertainty as to whether anticoagulants persist in food chain (Wright and Eason, 1991, cited in Towns et *al*, 1993, pp. 11,21). Kauri snails studied in Waipoua 1080 drop did not contain detectable 1080 or reduce in abundance (Pierce and Montgomery, 1992).

Table A.9 Animal deaths from field use of vertebrate poisons in New Zealand, as confirmed by laboratory testing and/or poisoning symptoms, 1960-1976.

Poisons: 1080, cyanide, phosphorus, arsenic and strychnine.

		Number of dead animals						
Poison	**Cases**	**Dogs**	**Sheep**	**Cattle**	**Cats**	**Fowl**	**Other**	**TOTAL**
1080	271	254	2,102	125	9	25	10	2,525
Cyanide	47	25	268	54	1	30	8	386
Phosphorus	180	117	107	116	34	19	47	440
Arsenic	427	78	823	520	7	29	22	1,479
Strychnine	189	199	-	-	12	7	-	218

Source: Rammell and Fleming, 1978, p. 82. Data were summarised from Animal Health Reference L&oratory records, Wallaceville. Some cases contained multiple individuals.
Are likely to be underestimates as such events may not have been notified.

Arsenic and strychnine are no longer registered for use as vertebrate poisons in New Zealand. The sources of arsenic poisonings in many cases was not confirmed, and may have been from dips, sprays, or timber preservatives rather than vertebrate pest control. Strychnine poisonings were also attributed to malicious acts.

Table A.10 Animal deaths from field use of vertebrate poisons in New Zealand, as confirmed by laboratory testing and/or poisoning symptoms, 1979-1992

Poison: 1080 only, number of *cases* (may be multiple individuals in each case)

	1979-85	1986	1987	1988	1989	1990	1991	1992	TOTAL
Cattle	17	1	4	4	3	2	3	12	46
Sheep	12	1	2	6	9	9	5	3	47
Dogs	52*	8	9	10	8	4	16	17	124
Deer	2*	1	2	2				5	12
Pigs		1		3					4
Cats	1*						1		2
Goats	1*	1							2
Birds				1					1

* actual number of confirmed 1080 poisonings.

Source: Orr and Bently, 1993; Bruere *et al*, 1990.
Cases recorded by the Animal Health Laboratory Network.
Are likely to be underestimates as such events may not have been notified.

Table A.11 Documented human poisonings from vertebrate poisons, New Zealand and overseas

1080	**New Zealand:** Overseas:	1 death (suicide) + 1 suspected chronic poisoning (rabbiter).’ 4 cases child poisonings **1979-84** (none **fatal).**[2] 8 enquiries with poisoning symptoms to National Poisons Centre, **1989-93** (and another **12** enquiries with concerns or queries)? ***USA:*** 18 cases **(12** fatal) **1946-49, 2** fatal suicides 1959 and 1970, 1 accidental non-fatal 1975; ***Australia*:** 1 non-fatal (with **lasting** damage) 1970; ***Israel:*** 111 cases (3 fatal) 1971-81; ***Taiwan*: *5 cases*** (non-fatal) **1975-81.**[4]
Cyanide	New Zealand: Overseas:	39 poisoning cases, 11 of them fatal, **1979-84.**[2] 24 enquiries with symptoms to National Poisons Centre, 1989-93 (6 of these apparent suicide attempts)? **Fatal and non-fatal cases of accidental, suicide and occupational** poisonings (number not specified), most fatal cases from suicide.6
Phosphorus	New Zealand: Overseas:	2 enquiries with symptoms to National Poisons Centre, **1989-93.**[2,5] 56 cases, most fatal (suicide, accidental, murder) up to **1961.**[6]
Brodifacoum	New Zealand: Overseas:	No cases documented.’ 2 non-fatal poisonings, both attempted suicide.6

Sources:

1 Batcheler, ***1978(b) p.9; Parkin et al, 1977; Ramsay, 1977;*** Peters, **1977; Rammell,** Fleming and **O'Hara,** 1977. The suspected chronic poisoning may have been **influenced** by other sources of fluorine and use of other poisons such as arsenic.

2 Department of Health National Poisonings Data (only available for **1979-84),** pers. **comm.** Only reports cases coming to hospital. No details available on how poisonings occurred or on follow-up.

3 National Poisons and Hazardous Chemicals Information Centre, 1994. No details available on how poisonings occurred or on follow-up.

4 Hayes and **Laws,** 1991, pp. **1275-77; Brockman,** et *al,* 1959; Harrison ***et al,* 1970; McTaggart,** 1970; Reigart et al, 1975.

5 Some cases may be in aggregate Department of Health data **1979-84;** all anticoagulants 145 cases, other vertebrate poisons; 71 cases (none fatal).

6 Hayes and Laws, 1991, pp. **553-54, 647-48, 1300.**

Table A.12 Documented human cases of tuberculosis caused by *Myobacterium bovis* (bovine Tb) 1976-1984

	‘76	‘77	‘78	‘79	‘80	‘81	‘82	‘83	‘84	TOTAL
number of new cases	2	3	2	2	7	2	4	1	1	24

Source*: *Anon, 1986. In most cases source of infection unknown.
Compare to 1951 data: 59 new cases, 25 of which infection traced to cattle.

Table A.13 1080 content in water after aerial-1080 pest control operations

	No. test samples	Surface water	Ground water	Sample period	Time before first sample	Limit of detection	conditions	Fmdings
Possum control operations								
Rangitoto 1990	39	✓	✓	6 months	? (within **first** month)	0.001 **mg/l** = **ppm**	spring (Nov.) forest, broken volcanic rock **12** kg/ha baits = 9.6 **g/ha** 1080	No 1080 detected.
Waipoua 1990	**36**	✓		**4** months	'immediately' after **1080** drop, and after **first** rainfall	0.001 **mg/l** = **ppm**	spring (Sept.) dense forest 5 kg/ha baits = **4g/ha 1080**	No 1080 detected.
Taranaki 1993	100	✓	✓	up to 73 **days**	One station continuous, others 1 day after)	0.0003 **mg/l** = **ppm**	winter (May-July), forest, 5 kg/ha baits = **4g/ha** 1080	No 1080 detected in majority of samples. 18 samples showed 1080 at trace levels. Three of these were from outside the 1080 drop zone **and** poor handling **techniques** are suspected.
Wairarapa 1993	**66**	✓	✓	4 months	**same day**	0.0003 **mg/l** = **ppm**	winter (June), forest **&** scrub, 5.7 kg/ha bait = 4.6 n/ha 1080	No 1080 detected.
Rabbit control operations								
Central Otago 1993	**29**	✓		1 month	One station every 3 hours, from drop to 3 days later	0.0003 **mg/l** = **ppm**	winter (July), dry grassland and bare **ground, 16-60** kg/ha bait = **6.2-13.8** g/ha 1080 Note: high application rate compared to possum control operations	No 1080 detected in 16 of 29 samples. 1080 traces detected in **13** samples, including all sample sites immediately **after** drop. Two samples quantifiable; 0.006 **mg/l 3** hours after drop, and 0.0003 **mg/l 2** days **after** drop. No traces of 1080 at any sites 4 days later.

Sources: Eason, et *al*, 1991(a) and **(b)**; Taranaki Regional Council, 1993(a); Hamilton and Eason, **(in** press); **Meenken,** 1994(a).

Table A.14 Time required for biodegradation of 1080 in different conditions

Source	conditions	Change or effect measured	Time
Eason, et *al,* **1993(b).**	laboratory, **20°C** field	• 1080 no longer detected • aquaria water • plants in water • elimination of **1080** traces in **wetas** and cockroaches	 after 1 day after 7 days 2-8 weeks
King ***et al,*** **in** press.	**laboratory,15-28°C,** 11% soil moisture	1080 reduction in soil • 50% • up to 87%	**6 days** 23days
Parfitt ***et al,*** in press.	laboratory, at **23°C** at **10°C** at **5°C** laboratory, at **21°C**	time for 50% reduction of 1080 in soil (Kaitoke Silt Loam), and level remaining at end of experiment elimination of 1080 in water	10 days (none after 27 **days)** 30 days (traces after **120 days)** 80 days (traces after **120 days)** 2-6 days
Gooneratne, in press.	laboratory, **warm**	**1080** in **1080-killed** rabbit	1080 still present after 3 weeks
Wong ***et al,*** 1991.	laboratory, warm, moist	loss of **1080** from baits • oat baits, 71% loss • meat baits. 14% loss	 4 weeks 4 weeks
Griffiths, 1959.	**field, dry,** followed by rain	Loss of bait toxicity • carrots • oats	3 weeks still toxic ***after 7 weeks***
Harris, 1977, (p.7).	field, winter	loss of dog from eating poisoned carcass	still toxic at 5 weeks
Legal case,* 1987.	field, winter	sheep killed by baits	still toxic at 6 weeks
Fleming and Parker. 1991.	field, winter	loss of 1080 from meat baits • 75% -85%	7 weeks 32 weeks
David and Gardiner, 1966.	laboratory, warm, moist	loss of toxicity to aphids feeding on plants in **1080-treated** soil • at 10 ppm 1080 **- at 50 ppm** 1080	 2 weeks 11 weeks
Tull, 1980.	indoor use • warehouses	toxicity of dried up bodies of **1080-**killed rats	'indefinite' (as long as dried)

* ***Gordon-Glassford*** *v. Upper Clutha Pest Destruction Board,* **D.C.** Alexandra, **20** March 1987, per Judge **AAP Willy.**

Table A.15 Genetic resistance to 1080 developed in rats from single sublethal doses under laboratory conditions

1080 dose mg/kg	% survival at that dose	
	original stock	F_4 generation
1.5	80%	100%
2.5	26%	83%
3.0	14%	56%
4.0	14%	40%
5.0	8%	30%
6.0	4%	19%
7.0	0%	3%
8.0		0%

***Source*:** Howard, Marsh and Palmateer 1973. Laboratory rats were given a single dose of 1.5 mg/kg of 1080; the estimated LD_{50} is 2.0 mg/kg and 80% survived. Survivors were mated, and the process repeated for 4 generations (= F_4).

Table A.16 Schedule of **aerial and** ground operations; costs and efficiency

OPERATION & contract **Type**	Other detalls associated with the operation	**Area (ha)**	Possum **Kill (total)**	cost **$/ha**	**%** reduction **+/-** 95% **C.I** **&** Monitoring Method	**Pre-** Density **Pos/ha**	**Post- Density Pos/ha**	ha / day	**Terrain/** Vegetation
Ground Control Operations									
Tahakopa **(Catlins)**[1] - Otago Regional **Council/Taimex** Traders 1993 • Contract	Trial to assess if sale of **furs** could reduce cost to council	**1,200**	**3,409 T, C**	**@$11.00/ha** **$8.23/ha**[a] D	80% +/- 5%				Coastal end of valley
• Land **owner/Task** Force Green 1993		**3,000**	**Pellets/BS**	**$8.00/ha** D	76% +/- 5%				Valley floor
Mt **Karioi**[2] **1993** DOC - Raglan **Contract P on C. if** < 10% trap occupancy	Operation failed to meet set target, hunters could not complete contract within time period	924 (interim block of **1,862)**	2,946 T 1,135 P 4.4 **Pos/ha**		40% T/C 100 **T,** 2 lines, 3 nights	11 **Pos/ha**	6.6 **Pos/ha**	2.7	Steep terrain, dense undergrowth
Otari Botanic **Gardens**[3] Wellington **1993**		67 **8**	672 total **C, T** **BS Tal**	**$53.00/ha**[b] **$58.00/ha**	56% (t) 3oBs 64% 10 BS				Rimu, tawa, regenerating forest **&** scrub
Ground Contract Operations' 1990-1992									
• Tautuku Bay, Otago		**520**		**$24.00/ha** D	81%	2 **Pos/ha**		105	Flat **terrain, podocarp** forest
-Wisp Range, Otago		1%		**$33.00/ha** D	85%	5.1 **Pos/ha**		14	Fairly steep, podocarp **hardwood** forest

[a] **Does not include $2123 paid to a hunter for the possum skins or a commission and handling fee paid to Taimex. ORC intends to recoup these costs upon the sale of the skins. Including these totals increases the cost/ha to more than $10.00.**

[b] **$33.00/ha if skin recovery**

OPERATION & contract **Type**	Other details associated with the **Operation**	**Area (ha)**	Possum **Kill (total)**	cost **$/ha**	**% reduction +/- 95% C.I & Monitoring Method**	**Pre-Density Pos/ha**	**Post-Density Pos/ha**	**ha/ day**	**Terrain/ Vegetation**
• Warepa, Otago		256		$29.00/ha D	81%	7 Pos/ha			Undulating terrain, podocarp forest
- Hina Hina, Otago		120		$38.00/ha D	86%	6 Pos/ha		8.5	Mainly flat terrain, one steep face, podocarp forest
• Forest Hill, Southland		750		$30.00/ha D	90%	5 Pos/ha		4.5	Remnant limestone outcrop, kamahi, podocarp, shrubland, rolling terrain
• Forest Hill, Southland	Repeat of 750 ha operation (above)	570		$6.00/ha D		< 2 Pos/ha		28.5	(as above)
• Koutunui, East Coast, DOC - East Coast[5], 1991		357		$24.00/ha D $19.47/ha O C	85% T/C: 60 T 3 nights (180 trap nights)	4 Pos/ha		9	Steep, bluffs, ridges, pohutukawa/kohekohe /tawa forest
• Orokawa, Bay of Plenty		320		$21.00/ha D	-	5 Pos/ha		6.5	Very steep terrain, regenerating scrub/gorse
• Homanga, Bay of Plenty		113		$62.00/ha D	72% T/C	5 Pos/ha		3	Steep topography, even canopy of large trees
• Ohinekoao, Bay of Plenty	Coastal pohutukawa	17.8		$53.00/ha D		-		4.5	Pohutukawa, steep cliff, gentle topography
• Northern Ureweras East Coast		14,122		$8.00/ha D	63% T/C	2.9 Pos/ha		18	Open kamahi/beech forest
• Eastern Raukumaras East Coast		11,998		$4.00/ha D	68% T/C	3.7 Pos/ha		42	Mixed bush, tawa/rimu steep terrain higher up
• Whakatane, East Coast		4,000		$22.00/ha D	75% T/C	7.7 Pos/ha		14	Open kamahi/beech forest

OPERATION & contract Type	Other details associated with the Operation	Area (ha)	Possum ' (E l)	cost $/ha	% reduction +/- 95% C.I & Monitoring Method	Pre-Density Pos/ha	Post-Density Pos/ha	ha / day	Terrain/ vegetation
Copland Valley[6,7] **1991/1992**	2nd operation of two **3,500** targeted, 2,782 actual	**2,782** actual	2,519	**$14.00/ha** D **$22.33/ha**	**60% T/C**	**2 - 3 Pos/ha**			**Mixed hardwood** forest (dense understory) **&** alpine scrub
Moeraki **Valley**[6,7] **1991/1992**	1st operation of two, blocks of **300-900** ha/hunter, 4,600 targeted, 3,635 actual	3,635 actual	1,856	**$8.00/ha** D **$17.43/ha**	63% **T/C**	< 2 **Pos/ha**			Beech/mixed **hardwood** forest **50-1000m a.s.l**
Copland Valley48 **1990/1991**	1st Operation of **two**	**3,500**	**9,520**	**$18.78/ha** D **$27.50/ha**	68% T/C 2 tines	4 - 5 **Pos/ha**	1.6 **Pos/ha**		Mixed hardwood forest (dense understory), scrub
Otira[8] **1990/1991**	Retreatment of Otira 1989 and Deception 1988	6,800	**5,904**	**$19.58/ha**	58% T/C, 6 lines	15 **Pos/ha**	0.8 **Pos/ha**		steep forested slopes, open understory
Paparoa[8] **1990/1991**	Targeted control only, tines of bait stations through targeted stands, **cyanide/traps** on ridges	**4,500**	5,137	**$20.20/ha**	57% T/C, 3 **lines**	2 **Pos/ha**	1.1 **Pos/ha**		Moderate to steep coastal forests, open stature forest and dense supplejack areas
Moeraki Valleys **1990/1991**	Large blocks **surveyed,** control only concentrated where **possums** found	**10,500**	**609**	**$8.78/ha**	23% T/C, 3 tines	< 1 **Pos/ha**	0.2 **Pos/ha**		**Easy** to steep forests, wide valley floors, open understory
Silverstream Catchment, **Dunedin** City **Council**[9], 1998	Trapping in **Dunedin** City Council water catchment	4,900	8,000 T Estimated						Bough terrain, **broadleaf-scrub-tussock**
Otira Catchment **1989**[8,6] CD-performance based	Whole area treated twice Blocks of **500ha** per hunter	**2,230**	3,958 1.8 **Pos/ha**	**$29.82/ha** **$18.65/ha** D	84% **+/-** 12% **Pellet** count	3 - 4 **Pos/ha**			steep forested **slopes,** open understory
Deception **Valley**[6,10] **1988** performance based	Whole area treated **twice** Blocks of **500ha** per hunter	**1,738**	**6,107** T,C 35 **Pos/ha**	**$24.19/ha** D	93% **+ /-** 4% Pellet count	4 **- 5 Pos/ha**			steep forested slopes, open understory
1988 and 1989 **Pureora Forest** Trials" - Mapara - Mangapehi	Total for combined operations		5.76 **Pos/ha** 4.82 **Pos/ha**			7.68 **Pos/ha** 6.42 **Pos/ha**	1.92 **Pos/ha** 1.6 **Pos/ha**		**Open** access, **tawa/kamahi forest**

OPERATION & contract Type	Other details associated with the operation	**Area (ha)**	Possum Kill **(total)**	cost **$/ha**	**%** reduction **+/- 95% C.I** & Monitoring Method	**Pre-Density Pos/ha**	**Post-Density Pos/ha**	ha/ day	Terrain/ vegetation
1989 Follow up to 1988 **Pureora** Forest Trial” **- Mapara/Mangapehi** Contract hunters - DOC Hunters, **1989**	4 blocks 1 block	1,650 217	3,128 **T,** 317 P 2.1 **Pos/ha** 545 **T,** 21 P 2.6 **Pos/ha**		**70+ %** **T/C** 9ot % **T/C**	2.7 **Pos/ha**	0.1 **Pos/ha**	6.8 0.6	**Open access, tawa/kamahi** forest
1988 Pureora Forest[13] - Mangatu **- Mapara** - Mangapehi Combined Total		1,182 **1,097** 330 **2,609**	1,729 **T,C** 1.46 **Pos/ha** **3,220 T,C** 2.93 **Pos/ha** 810 T,C 2.45 **Pos/ha** 5,759 T,C		72% t/-9% Pellet count 31% **+/-** 22% Pellet count **5%**[c] **+/-** 31% Pellet count 43% **+ /-** 14%	2.05 **Pos/ha** 9.46 **Pos/ha** 45.4 **Pos/ha**[c]	059 **Pos/ha** 6.53 **Pos/ha** 42.95 **Pos/ha**[c]		**Open access, tawa/kamahi** forest
1987 Northern Pureora Forest Trial” Contract Hunters	Partofapairedtrialto assess ground hunting verses aerial, 5 blocks	1,434	5,018 T,C	$16.45 **/ha**[d]	80% t **/-** 9.3% Pellet Count	437 **Pos/ha**	0.87 **Pos/ha**	22 **hrs/ wk**	Open **understory,** good **access, tawa/kamahi** forest

[c] The high density values reflect problems with monitoring and do not accurately estimate the population.

[d] Assumption: Hunters needed to obtain 200 skins/week at $6 skin = $1,200
Therefore at 22 **hrs/week,** requiring 9 **skins/hr** = > 9 **skins/hr @** 22 **hrs/week** = 198 skins
Only obtained 5,018 skins, should have obtained 8,267 Deficit of 3248 skins @ $6 = $23,589
Cost required to fund operation = **> $23,589/1434** ha = **$16.45/ha**

OPERATION & contract Type	Other details associated with the Operation	Area (ha)	Possum Kill (total)	cost $/ha	% reduction +/-95% C.I & Monitoring Method	Pre-Density Pos/ha	Post-Density Pos/ha	ha/day	Terrain/vegetation
Aerial operations									
Operation Egmont[15] 1993 DOC - Taranaki 5 kg/ha		@13,000		@$21.00/ha D	77%				
Tahakopa Operations Catlins 1993[1] - Maclennan Forest DOC 5 kg/ha - ORC/AHB 5 kg/ha (carrots)		3,600 3,000	@24,000 7.2 Pos/ha	$13.26/ha D,L $16.20/ha	88% +/- 5% T/C D 88% +/- 5%	8 Pos/ha	0.8 Pos/ha		
Aerial Operations 1990-1992[4]									
- Rangitoto Island 12 kg/ha	Initial control with goal of eradication	2,300		$54/ha D	93%				
- Waipoua,[8] Northland 5 kg/ha		18,000		$19.22/ha D	86%				
- Isolated Hill Nelson 4 kg/ha		3,426		$17/ha D	89%				
- Kakaroa Bay of Plenty 11 kg/ha		440		$47/ha D	66%				
- Whitecliffs Wanganui 6 kg/ha		1,500		$21.80/ha D	91%				
- Ngaurukahu Wanganui 5 kg/ha		105		$34/ha D					
- Paengaroa Wanganui 5 kg/ha		101		$45/ha D					
- Titirangi Wanganui 5 kg/ha		311		$24/ha D	96%				

OPERATION & contract Type	Other details associated with the **Operation**	**Area (ha)**	Possum **Kill (total)**	cost **$/ha**	**% reduction +/-** 95% **C.I** **&** Monitoring Method	**Pre-** Density **Pos/ha**	**Post-** Density **Pos/ha**	ha/ day	Terrain/ vegetation
- **Rotokahu** Wanganui 5 kgjha		**500**		**$33/ha D**	-				
• Taramoukou Wanganui 5 kg/ha		700		**$21/ha** D	-				
• Mapara, Waikato 9wha	**Successive** operations, low density control **trial**	**1,500**		**$25/ha** D	32%				
- Mapara, Waikato **8 kg/ha**	Successive operations, low density control **trial**	**1,500**		**$24/ha D**	0%				
- Craig **Rankin,** Otago 10 kg/ha		226		**$26/ha** D	**80%**				
• Waipapa EA Waikato 10 kg/ha		**5,000**		**$25/ha D**	61%				
Puketi Forest 1992 Northland' 5 kg/ha		**13,400**		**$22.03/ha D**	53%				
Otira Catchment **1989**[8] 10 **kg/ha**		**6,800**		**$26.12 /ha**[e]	**80%**				
Otira Catchment DOC **1989**[6] 6 **kg/ha**		**1,100**		**$21.22/ha D**	**84% estimated**				
Deception Valley DOC **1988**[6]		**700**		**$22.11/ha** D	**93%** estimated				
1988 **Pureora** Forest **Trial**[13] 9 **kg/ha**		**3,800**			**31% +/- 19% Pellet count**				
1987 Northern Pureora Forest Trial" 10 **kg/ha**		**7,400**		**@$19.50/ha** D	80% **+/-** 8.1% Pellet count	6.6 **Pos/ha**	1 **Pos/ha**		

[e] **Based on shadow costing of overhead from Department of Conservation, West Coast**

OPERATION & contract Type	Other detalls associated with the Operation	Area (ha)	Possum Kill (total)	cost $/ha	% reduction +/- 95% C.I & Monitoring Method	Pre-Density Pos/ha	Post-Density Pos/ha	ha / day	Terrain/ vegetation
Ground Control - 1080									
Northland Regional Council[16] 1990/1991 Contract P on C.	Area protected not area controlled	20,000	Ground 1080/T	$25.60/ha	Target of at least 80% Bait take				Brush, scrub, open farmland
Northland Regional Council[16] 1991/1992 Contract P on C.	Area protected not area controlled	80,000	Ground 1080/T	$14.55/ha	Target of at least 80% Bait take				Brush, scrub, open farmland
Northland Regional Council[16] 1992/1993 Contract P on C.	Area protected not area controlled	144,000	Ground 1080/T	$9.54/ha	Target of at least 80% Bait take				Brush, scrub, open farmland

A.16 **continued:** the **following section** of the table applies to Animal **Health Board** operations **only**[17]

OPERATION and contract **type:** Animal **Health** Board”	**Area (ha)**	cost **$/ha**	**% reduction +/-95% C.I.**	**ha/day**	**Terrain/vegetation**
Aerial Control: Initial operations monitored with self feeding bait stations					
- Tahakopa: **A/C:** Otago RC	**4,900**	$10.26	91% **+/- 5.9%**	m	Heavy bush
• **Mangaokewa 1993:** A/C Waikato RC	**5,938**	$14.12	82%	40	Bush cover, farm boundary
• **Matiri** 1991: **A/C:** West Coast RC	4,140	$24.00	**96% +/-** 2%	**71**	Heavy cover and gorse
Mixed control: Initial operations monitored with self feeding bait stations					
• **East/west** Waimiha **1992:** A/C, **A/P,** paste: **Manawatu/Wanganui** RC	**11,265**	**$22.24**	83% t /- 4.3%	14	Heavy bush and farm land
• Lakeside Reserve 1991 **Kinlock:** A/P, paste: Waikato RC	**5,889**	**$12.55**	87% t /- 5.9%	**50**	Bush reserve and farmland
• Mangakahu 1993: A/C, paste: **Manawatu/Wanganui** RC	21,420	**$15.52**	**54%**	22	Heavy bush and farmland
• **Moerangi 1993:** A/C, paste: Waikato RC	14,750	**$20.70**	**98.9%**	43	Heavy bush and farmland
• South Turangi **1992:** A/P, paste: Waikato RC	**3,000**	$22.40	75% t /- 9.8%	23	Steep bush clad country, farmland
• Mohaka 1991: A/C, pellet, paste: Hawke’s Bay RC	8,178	$16.06	94% +/- 5.990	23	Bush, pine-s, farmland
• Ohai **1989:** A/F’, paste: **Southland** RC	10,660	**$8.90**	89% **+/- 3.9%**	39	Bush, pines, farmland
- Raetaihi Otaranui 1991: A/C, paste: **Manawatu/Wanganui** RC	**2,506**	**$27.90**	89%	**15**	Bush, gorge country with farmland
• Owahanga **1990:** A/P, paste: **Manawatu/Wanganui** RC	**4,702**	**$9.23**	67% +/- 11.8%	?	Farmland bordering bush scrub
• South **West** Bays **1990:** A/C, paste: Waikato RC	**12,999**	**$13.15**	73% **+/-15.7%**	30	Bush clad country, farmland
• Taringatua **1990:** A/C, paste: Southland RC	3,414	$7.03	78% +/- 11.2%	?	Bush, pines, farmland
• Taringatua **extension 1991: A/P, paste: Southland RC**	7,213	$10.99	77% +/- 7.8%	99	Bush, pines, farmland

OPERATION and contract type: Animal Health Board[17]	Area (ha)	Cost $/ha	% reduction +/-95% C.I.	ha/day	Terrain/vegetation
Mixed Control: Initial operations monitored with spotlight					
• Kaukaupo Stream 1993: A/P, paste: Manawatu/Wanganui RC	4,408	$19.21	77%	19	Scrub and farm hill country
• South West Bay Kuratau 1992: A/P, paste: Waikato RC	12,299	$9.48	85%	28	Heavy bush and farmland
• North Titiraupenga 1992: A/P, paste: Waikato RC	8,381	$14.73	90%	21	Farmland with scrub and bush
• South Waiau 1991: A/C, paste: Canterbury RC	2,898	$7.18	77%	52	Bush cover, farm boundary
• Waituhi 1991: A/C, paste: Manawatu/Wanganui RC	2,742	$27.84	83%	10	Heavy bush, farmland
• South Kaipara St 6 & 7 1991: A/P, paste: Rodney DC	8,055	$6.82	90%	24	Pines and gorse
• South Kaipara St 3 & 4 1989: A/P, paste: Rodney DC	7,042	$10.33	89%	?	Pines, bush, farmland
Mixed Control: Maintenance operations monitored with self feeding bait stations					
• Mohaka 1993: A/C, paste: Hawkes Bay RC	13,123	$10.20	72% +/- 9.8%	45	Bush, pines, farmland
Ground Control: Initial operations monitored with self feeding bait stations					
• Arahura South 1992: paste: West Coast RC	742	$12.08	82%	51	Farmland with scrub
• Mikonui 1990: paste	812	$25.66	81% +/- 29.4%	62	Farmland, scrub and bush
• Ruru 1990: paste: West Coast RC	1,965	$6.80	80%	44	Scrub and bush country, farmland
Ground Control: Initial operations monitored with spotlight					
• Okains/Le Bona Bay 1991: paste: Canterbury RC	2,129	$14.75	87%	21	Bush reserves and farmland
• South Kaipara St 1 & 2 1988: paste: Rodney DC	3,000	$11.47	94%	?	Pines, bush, and farmland
• South Kaipara St 5 1990: paste: Rodney DC	1,325	$10.78	95%	?	Pines, bush, and farmland
• South Kaipara St 8 & 9 1992: paste: Rodney DC	7,800	$9.07	87%	?	Pines, bush, and farmland

OPERATION and contract **type: Animal Health Board**[17]	**Area (ha)**	coat **$/ha**	5%**reduction** + **/-95% C.I.**	**ha/day**	Terrain/vegetation
Ground **Control:** Maintenance operations monitored with self feeding bait stations					
- **Ahaura** Plains **1993:** paste: West Coast RC	**1,345**	$7.42	**71%**	46	Farmland bordering bush country
• **East/west** Waimiha **1993:** paste: **Manawatu/Wanganui** RC	**14,520**	$4.10	83% **+/-** 5.3%	59	Heavy bush and farmland
- **Arahura** South **1993:** paste: West Coast RC	**1,378**	**$15.00**	94%	25	Farmland with scrub/bush boundary
• Little Wanganui **1992:** paste: **West** Coast RC	6%	$14.44	93%	27	Bush reserves and farmland
• Taramakau 1991: paste: West Coast RC	**1,039**	**$4.58**	87%	58	Bush cover farm boundary
• Taramakau **1992:** paste: **West** Coast RC	**1,039**	**$4.54**	75%	59	Bush **cover** farm boundary
• Matiri **1993:** paste: West Coast RC	**1,960**	**$7.21**	90% **+/- 3.9%**	49	Heavy cover and gorse
- Matiri **1993:** paste: Tasman DC	**1,960**	**$7.21**	82% **+/-** 7.8%	**50**	**Heavy** cover and **gorse**
- Mohaka **1992:** paste: **Hawke's** Bay RC	13,123	$5.42	52% **+/-** 11.8%	43	Bush, pines, **farmland**
• Raetaihi extension **1992:** paste: **Manawatu/Wanganui** RC	**1,529**	**$5.73**	93%	58	Bush **reserve,** ***scrub,*** farm ***country***
• Owahanga 1991: paste: **Manawatu/Wanganui** RC	**4,702**	**$3.39**	67% **+/-** 11.8%	69	Farm country bordering heavy cover
• Owahanga **1992:** paste: **Manawatu/Wanganui** RC	**4,702**	**$3.39**	66% **+/-** 13.7%	m	**Farm** country bordering heavy cover
- Owahanga **1993:** paste: **Manawatu/Wanganui** RC	**4,702**	$3.62	57% **+/-** 9.8%	m	Farm **country** bordering heavy cover
• Taringatua **1992:** paste: Southland RC	3,414	**$2.99**	68% **+ /-** 9.8%	68	Bush, **pines,** farmland
• Whataroa **1992:** paste: **West** Coast RC	1,218	**$6.80**	87%	**55**	Farmland bordering bush and scrub
- Whataroa **1993:** paste: West **Coast** RC	1,218	**$7.14**	80%	**49**	Farmland bordering bush and scrub
Ground **Control:** Maintenance operations monitored with spotlight					
- North Titiraupenga 1993: paste: Waikato RC	**8,381**	**$8.34**	**70%**	**29**	Farmland with scrub and bush
• Waituhi **1992:** paste: **Manawatu/Wanganui** RC	2,742	**$3.94**	43%	63	**Heavy** bush and farmland
• South Kaipara St 6 **&** 7 **1993:** paste: Rodney DC	8,055	**$5.58**	93%	**45**	Pines, gorse and farmland
• South Kaipara St 1 **&** 2 **1989:** paste: Rodney DC	**3,000**	$2.37	67%	?	Pines, bush and farmland

OPERATION and contract type: Animal Health Board[17]	Area (ha)	Cost $/ha	% reduction +/-95% C.I.	ha/day	Terrain/vegetation
- South Kaipara St 3 & 4 1990: paste: Rodney DC	7,042	$5.25	87%	?	Pines, bush and farmland
- South Kaipara St 5 1992: paste: Rodney DC	5,283	$5.01	93%	?	Pines. bush and farmland
- South Kaipara St 5 1993: paste: Rodney DC	5,283	$5.43	97%	52	Bush, pines and farmland
- South Kaipara St 3 & 4 1991: paste: Rodney DC	7,042	$5.26	92%	52	Bush, pines and farmland
- South Kaipara St 3 & 4 1992: paste: Rodney DC	7,042	$5.26	95%	53	Bush, pines and farmland
- South Kaipara St 3 & 4 1993: paste: Rodney DC	7,042	$5.27	95%	54	Bush, pines and farmland
- South Kaipara St 3 & 4 1994: paste: Rodney DC	7,042	$5.28	95%	54	Bush, pines and farmland
- West Whangaehu 1992: paste: Manawatu/Wanganui RC	2,229	$6.82	76%	38	Scrub. bush and farmland
- West Whangaehu 1993: paste: Manawatu/Wanganui RC	2,229	$7.27	80%	36	Scrub, bush and farmland

Code

Control methods: A/C = aerial carrot A/P = aerial pellet BS = Bait Station P = Poisoning C = Cyanide
T = Trapping **Tal** = Talon

Monitoring methods: T/C = trap catch monitoring PC = Pellet count monitoring

Costings: D = Direct operating cost only, does not include overhead L = Does not include **labour** cost
OC = Operating cost only CH = Contract Hunters Contract P on C. = Contract payable on completion

a.s.l. = above sea level RC = regional council

Notes

Additional Source: Department of Conservation Head Office Possum Management Team, 1994, pers. **comm.**

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4. Warburton B. and Cullen R., *Cost-effectiveness* of *Different Possum Control Methods*, Landcare Research Contract Report LC9293/101 prepared for Department of Conservation, June 1993.

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15. Department of Conservation, 1993, *Opemtion Egmont, 1993. Report on Possum Control Operations Conducted During winter 1993.*

16. Gross, M., and Cathcart, B., 1993, 'Possums can be Beaten', unpublished paper, Northland Regional Council, Cathcart, B., Northland Regional Council, pers.comm., 1994.

17. P. Nelson, 1994, details of Animal Health Board contracts and results, pers.comm.

Table A.17 Benefits/advantages and costs/limitations of aerial and ground control

Control method	Benefits/advantages	Costs/limitations
Aerial poisoning with 1080.	Targets large areas quickly allowing rapid knockdown of a population. Little affected by terrain. Most possums put at risk simultaneously over a short period. If DGPS navigation systems are used can ensure total coverage of area. Control authority responsible for entire process. Standard costings are available for budgeting for control operations.	Effects on non-target species. Dependent on weather, as wet weather will put operations at risk. The cost of failed operations - high percentage of sunk (non-recoverable) costs. Increased liability if operator error results in deaths of livestock. Cost of movement of stock out of control area (borne by landholder). Increased cost of consultation and consent process - EIA process, notification and hearings. Public opposition to the aerial application of poisons. Only a few firms have DGPS systems.
Ground Control (including trapping, poisoning, and the use of bait stations).	Increased flexibility, less disruption to farm management. Promotes conservation interests in the community and can provide information on the environmental condition of conservation areas and wildlife. Payment can be withheld by authority until target is achieved, reducing financial risk if an operation fails. Sale of furs can reduce control costs. Maybe more suitable for maintenance operations or in areas with low densities. Can be used in sensitive locations e.g. water catchments. Employs a greater number of people.	Effects on non-target species. Poor weather/steep terrain/difficult access/dense vegetation can slow operations or make required level of control prohibitively expensive. Damage to vegetation from track clearance. Longer control operations. Authority has less direct control of workers with operational monitoring of hunters increasing costs of operations. Limited availability of skilled hunters. Some land owners may object to hunters having access to property. Public opposition to the use of poisons. Increased risk to operators through use of cyanide, With many operators toxins stored in different locations, with potential security problems. Maori concerns about operators having access to areas of waahi tapu.

Sources: Letter from C. Miller, Department of Conservation West Coast, 13/1/94; Department of Conservation, East Coast Conservancy, 1993, Ref. SPR706; Moore, M., 1994. NZOFPA Submission; Department of Conservation, Wanganui Conservancy, 1993; Department of Conservation, 1994(a), p.63; Warburton, Cullen and McKenzie, 1992; Cowan and Pugsley, 1993.

Table A.18 Alternative approaches for supporting ground control

	Advantages	Disadvantages
Bounty System' - Hunters bring in token (e.g. ears or tail, which confirms a kill) to an assessment centre and receive a bounty e.g. $2 per token.	Assesses the number of possums killed for a specific cost. Hunter responsible for control method. Control authorities have lower overhead/ supervision costs, scheme flexible, a yearly bounty may be set. Some employment.	Targets high density/accessible areas, may not include high-risk areas, reductions in densities may not reach safe threshold levels. Because specific areas cannot be targeted, open to fraud. Hunters will only operate in an area if it is economic for them to do so. No coordinated control.
Employment schemes/ Training programmes:	Can generate employment over the short-term. Some training provided. Provides recent work experience/work record for unemployed. Contractors can take on TFG workers even if control agencies are not prepared to.	Extra costs of establishment, supervision, and administration for control authorities.[2] Control authorities main focus is pest control, not creation of employment. Control authorities obliged to use TFG workers even when the operation could be contracted out at a reduced rate. Varying levels of motivation and skill of workers reduces efficiency. Workers can only remain on TFG scheme for 12 months, may develop skills but then cannot be used by an authority. TFG programmes limit the re-entry of hunters to the control market, as TFG programmes are used for operations that could be tendered for and use funding that could be targeted for contract hunting?
Enhancement of markets for possum products	Possum control could be subsidised from the sale of possum products. Increased employment. Incentive for increased 'self-help' control. Increased exports and value added products from the sale of furs and possum products.	New Zealand dependent on the world fur market. Demand for possum furs fluctuates markedly. Wild furs are of variable quality, but poor quality handling and processing reduce the value of any product'.

1 A bounty scheme was used in New Zealand from 1951 to 1961, but it was abandoned when it proved ineffective. Over 8.2 million bounties were collected at a cost of more than $2 million (> $24 million in 1993 dollars), with the scheme having little impact on the size of the possum population or the rate of migration. (Batcheler & Cowan, 1988, p.61; Agricultural Pests Destruction Council, 1977, p.10.)

2 Gross and Cathcart, 1993.

3 Moore, 1994, Possum Management Investigation - Commentary for the Parliamentary Commissioner for the Environment, NZOPPA Submission, pers. comm.

4 Allan, 1993; Taylor, C., Taimex Trading Ltd, 1994. pers. comm.

Table A.19 Alternative possum control methods and related proposals

Control Method	**Drawbacks**	unknowns	Benefits
Biological Control/ Immuno sterilisation	**Irreversible** and cannot be contained. May encourage complacency about follow-up controls. Public concern regarding the use of **genetically** modified **organisms.**	No known species-specific biological control agent for possums. **The** length of time to develop a biological control. The length of time the virus **vector** would be effective in the field. What effect low densities would have on the transmission and success of biological controls.	Biological rather than chemical control. If effective, likely to cost less than chemical or mechanical control alone, although some follow-up would be required.
Shooting	**Labour** intensive and costly, requires access to control areas. Limited use in urban areas - safety issues. Not adquate to lower high populations. Not a cost effective control measure, at most can only target **5-30%** of the population. Possums become light shy after initial shooting Causes suffering unless possum shot cleanly.		Can provide a follow-up measure to maximise effect from primary control method. Can **provide** employment. **Where** willows or poplars are budding in early spring, shooting can target possum population feeding on these species
Alternative toxins	Public opposition to the use of poisons.	Fate of these chemicals in the environment. Effects on non-target species.	Additional toxins to use in a suite of control measures. **Non-overconsumption** of bait once a lethal dose is taken. e.g. Cholecalciferol and **Gliftor.**
Alternative baits	Longer-Iii baits may threaten non-target species for longer periods. Problems with spillage. from half-eaten sachets.	Effectiveness in practice. **Long-**term costs and benefits. Non-target effects.	Gel, capsules, and sachet baits are durable and relatively safe to humans. Water resistant formulations wig prevent baits decomposing
Chemical contraception - The inhibition of ovulation or other **disruption** of reproduction by a bait based contraceptive.	Would have to be **re-administered** on a regular basis. Ineffective for bait shy possums. No appropriate chemical yet developed for possums. If possums consume bait, why not kill them instead with a toxic bait,	Effectiveness in field conditions. Effects on non-target species.	Gould reduce fertility in possums: possible long-term lowering of population. Potential to be more humane than other methods.

Control Method	Drawbacks	unknowns	Benefits
Semi-permanent bait stations - Including automatic pellet feeders, mobile bait stations, electric bait stations, and cut-down 44 gallon drums.	Control ineffective at > 150m from bait station? Require regular servicing - hold limited quantity of bait. Problems with bait security and public interference.		Effective for control within a radius of 150m (> 80% kill).[6] Ongoing control available. A 300m grid pattern of bait stations can ensure most possums targeted. Alternative treatment for small areas or large areas with adequate access.
Electrostrike Possmn Trap - Delivers an electric shock to a possum lured to a special bait station.	Control ineffective at > 150m from bait station? High initial cost ($766 excluding GST plus extra cost of optional solar panel).	Effectiveness in practice. Long-term costs and benefits.	The possum is killed humanely, and as no poisons or traps are used, no damage to non-target species or the environment. No poisons involved so safe for operators. Station can be solar battery powered.
Mobik **Bait Station (MBS)** - Large bait station, with several entry ports and an automatic feeder. Attracts possums for a set period with a lure, then uses toxic baits for control.	Control ineffective at > 150m from bait station! High initial cost (Ryan Bait Feeder $1080). Difficult to move through rough terrain or dense bush. Large amounts of bait are kept in one location with the risk of public interference.	Long-term costs and benefits.	Non-labour intensive, is lockable, and has extra storage capacity for bait. A built-in counter can indicate the number of visits by possums. Above ground, Siting the number of deaths of non-target species.
Fences	No 100% 'possum proof' fence developed, some will always get through. Electric fences require high pulse rate (as possums return to fences) and a back-up charge/warning system if breakdown. High initial establishment cost, require frequent maintenance, which is labour intensive and costly. Damage to fences from falling trees, water erosion, short circuiting of electric fences, reduces effectiveness. The need to obtain land owner consent for the location of the fence can delay and increase the cost of establishing the fence. No effect on possum numbers.	Effectiveness in practia. Long-term costs and benefits.	Can prevent possum migration to valuable ecological areas and peninsulas. Local eradication inside the protected area, can allow recovery of vegetation and wildlife. If maintained and used in conjunction with intensive control in a buffer zone and/or permanent bait stations, effective as a temporary barrier. Electric fences can be solar powered.

[5] **Meenken, 1993.**

[6] **Hickling and Thomas, 1990.**

Control Method	**Drawbacks**	Unknowns	**Benefits**
Protective sleeves • e.g. plastic or metal sleeves on indigenous trees, power poles, catchment protection plantings.	**Costly** for large applications. Not all **trees/poles** can be banded. Can **damage** the **tree** and prevent **growth.** No effect on possum numbers.		Physical barriers around the trunks of **trees/power** poles can prevent **possums climbing** them, reducing damage. No **labour** intensive control required. Does not use poisons or traps..
Biodynamic 'peppering' • **involves** scattering highly diluted ash **from** possum skin and testes.	Requires faith in a method as yet incomprehensible to modem science. Needs to be renewed on a regular basis. **Labour** intensive process may be costly if **labour** has to be employed.	Whether it is effective. Scientific tests have disproven deterrent **effect.**[7] Reproductive effect unknown.	Claimed to be effective by **biodynamic** farmers. Does not **involve** toxins.
Sonic Devices • **These** devices have now been banned for **sale** in **U.S.A.** as proven to be ineffective.	Experiments have found no **differences** in the amount of bait consumed, or the number of possums in an area, with or without the sonic device switched **on.**[8] Possums driven from one area, will cause problems elsewhere.	What frequency and intensity of sound could deter possums.	**Does** not use poisons or traps. **Labour** intensive.

7 **Eason and Hickling, 1992.**

8 **Spurr** and **Drew, 1992.**

Table A.20 Advantages/benefits and disadvantages/limitations of self-help maintenance operations

	Advantages/benefits	Disadvantages/limitations
Self-Help Maintenance operations	Provides ongoing maintenance of control. Efficient and effective use of limited resources. Flexibility in coordinating farm management and pest control operations. Regional council can target high density areas, initial control operations, and monitor effectiveness. Reduces the need for increases in council pest management staff/equipment. Regional council can intervene to provide compulsory control if required. Regional council retains direction of the programme.	Requires effective coordination and training of operators. May not be sustained in the long term as communities iose interest. May not achieve target reductions. Cost of monitoring many operators. Some landholders: • Do not want responsibility for control operations; • Have insufficient time; • Are apprehensive about control operations; • Have small properties where the cost of establishing control is greater than the control required.
By Landholder • A landholder can be trained to undertake control by a council. A contract is signed to ensure on-going maintenance occurs on their property.	Community actively supports pest control operations with shared responsibiity for pest management between the community and council.	Lack of skill and/or equipment. The cost of control for small landholders e.g. the cost of an 'Approved Operator's Licence'. Restrictions on toxins able to be used, 1080 not generally available for use by individual landholders.
By Contractors • Landholder selects approved contractor from council register, arranges work, and pays for it. Council delivers chemical to contractor and charges landholder.	If landholders do not want to carry out control operations, contractors can be used. Provides employment for contractors. Reduces cost for small landholders. A register of approved operators can be used by authorities, allowing landholders to be confident that contractors meet required operating standards.	Contractors may charge landholders for work not performed (accountability problems). Contractors may not achieve target reductions and undertake work not required.

Sources: Bayfield, 1993; Taranaki Regional Council File PD1/16/1, 18/8/93; Taranaki Regional Council File PD1/18, 13/12/93.

Table A.21 Public opinion of possum control in New Zealand

1: Seriousness of possum as a pest in New Zealand as a whole:
Very serious 56.4% + Serious 33.5% = 89.9%

2: Is there a possum problem where you live? Yes: Rural 48.8%
Town 24.4%
City 14.6%

3: Has the possum problem changed lately? Become worse 76.0%

4: Is enough being done to control possums? No 64.6%

5: Suitable possum control measures:
'suitable' and 'very suitable' :

shooting	69.2%
trapping	57.2%
Possum-specific disease (e.g. virus)	49.0%
1080	44.4%
cyanide	43.7%
predators	15.7%

6: If a disease could be identified and introduced to hill possum iu New Zealand how do you feel about the idea?

Good idea	29.8% }	
OK idea	24.4% }	54.2%
Opposed		41.7%

7: Significant variations in opinion on possum control methods by gender and place of residence.

	By Gender		By location	
	Women	Men	Rural	City/Town
support for 1080	37.7%	53.7%	n.s.	
Support for cyanide	33.3%	57.7%	n.s.	
Support for shooting	72.1%	653%	n.s.	
Support for virus	43.8%	56.0%	n.s.	
Support for trapping	n.s.		70.5%	55.4%/53.2%

n.s. not supplied

Source: Sheppard and Urquhart, 1991, pp. 28-39. Data from a survey of'100 adults throughout New Zealand. The validity of the survey results have been questioned with regard to some of the questions beii of a 'leading' nature (Sutherland et *al*, Landcare Research, pers. comm., 1994).

Appendix B

Tables of legislation governing possum control activities

Table B.1 Legislation which provides the jurisdiction for possum control

(a) *Conservation* focus

WILDLIFE ACT 1953 (Admlnlstered by DOC)

- Protects all wildlife unless spedflcally excluded.
- Defines 'wildlife' to exclude animals of species specified in Sixth Schedule; which includes 'opossum (family *Phalangeridae*)' as animals subject to Wild Animal Control Act 1977: s.2 and 6th Schedule Wildlife Act.
- Declares possums to be noxious animals and subject to the Wild Animal Control Act 1977 (formerly Noxious Animals Act 1956): s.7A and 6th Schedule.
- Director-General may authorise occupier of land included in wildlife refuge to destroy noxious animals (s.14(2), (2A)), or DOC officers may hunt where animal causing damage to area or wildlife in it (s.14(2A)).
- Enables Minister to promulgate plans to eradicate harmful species of wildlife (s.41(e)).
- Director-General may authorise in writing occupier of any land or DOC officers to hunt or kill by any means any animals, where satisfied they are causing injury or damage to any person, land, stock, crops, chattels or other wildlife: s.54(1).

WILD ANIMAL CONTROL ACT 1977 (Administered by DOC)

- Provides for control of harmful species of introduced wild animals.
- Declares all wild animals to be property of Crown, and defines 'wild animals' to Include possums.
- Applies to all land for purpose of controlling wild animals generally and eradicating wild animals locally 'where necessary and practicable, as dictated by proper land use' : s.4(1).
- Provides for access to any land where wild animals are causing or likely to cause damage to the land, adjacent land, persons, animals, crops or chattels: s.16(1)(a).
- Enables 'concerted action' to be taken against the damaging effects of wild animals on vegetation, soils, waters and wildlife: s.4(2); and provides the powers to do so: s.10.
- Minister may consent to expenditure of money by local authorities for wild animal destruction and approve plans for purpose: ss.30, 31.

RESERVES ACT 1977 (Administered by DOC)

- Purpose of Act is to provide for preservation and management of areas of recreational, environmental, natural, scenic, historic, scientific or other values, for benefit and enjoyment of public, ensuring as far as possible survival of all indigenous species of flora and fauna: s.3(1).
- Minister may acquire interest in land for reserves: s.12; local authorities may declare by resolution land vested in it to be reserve within meaning of Act, and Minister must consider such resolution and exercise discretion as to whether to gazette the resolution.
- Reserves are managed by DO C or by administering body, including any other Minister, appointed under Act: Part III.
- Act requires administering body to submit management plans for approval of Minister: s.41(1).
- For reserves managed by administering body, plans must provide for use, enjoyment, maintenance, protection and preservation as appropriate for purpose of reserve, subject to process of public participation: s.41(3),(5),(6).
- Where DOC is responsible for reserves, they are managed under Reserves Act in accordance with Conservation Management Strategies (CMS) prepared under Part IIIA Conservation Act 1987 for integrated management of natural and historic resources: Reserves Act, ss.40A, 40B.
- Reserves shall be classified by Minister according to their primary purpose as defined in Act (ss. 17-23), to ensure control, management, development, use, maintenance, and preservation for appropriate purposes: s.16.
- Although purposes for which reserves are held vary according to classification, Act provides in most cases for the protection of the natural environment or features of reserves, and for water, soil and forest values.
- In scenic, nature and scientific reserves, Act promotes survival of indigenous species of plants or animals within natural communities and habitats, by exterminating exotic plants and animals as far as possible (ss.19, 20, 21, 22, 23).
- In recreation and historic reserves, wildlife and indigenous fauna and flora are to 'be managed and protected as compatible with purpose of reserve, subject to provisions of Wildlife Act. Reserves Act defines 'wildlife' to excludeanimals listed in 6th Schedule of Wildlife Act, therefore possumsare not protected in recreation or historic reserves: ss.2, 17,18.

continued . . .

NATIONAL PARKS ACT 1980 (Admlnlstered by DOC)

- Requires preservation of national parks in their natural state as far as possible; and, except where Authority determines otherwise, introduced plants and animals to be exterminated as far as possible; parks to be administered to secure the protection and well-being of native plants and animals (long title: ss.4,43).

CONSERVATION ACT 1987 (Administered by DOC)

- Function of DOC is 'to manage for conservation purposes all land, and all other natural and historic resources, for the time being held under this Act . ..:' s.6.
- Gives the Director-General of Conservation power (but not a duty) to control introduced species causing damage to any indigenous species or habitat: s.53(3)(g).

(b) Agricultural Management focus

LAND ACT 1948 (Administered by DOSLI)

- Places responsibility on all holders of leases or licences for farm land or pastoral land to keep the land free of wild animals and comply with the Agricultural Pests Destruction Act 1967: s.99(1).

MINISTRY OF AGRICULTURE AND FISHERIES ACT 1953 and ANIMAL HEALTHBOARD

- Animal Health Board established pursuant to s.13 to advise the Minister, with ability to collect levies under s.44 Meat Act 1989.
- Board no longer Crown entity, since becoming registered society under Incorporated Societies Act 1908 with specific powers in relation to pest management, and as delegated by Minister of Agriculture, Director-General of MAF or Chief Technical Officer under Biosecurity Act.

AGRICULTURAL PESTS DESTRUCTION ACT 1967 (Administered by MAF)

- REPEALED BY BIOSECURITY ACT but transitional arrangements apply until 1996, including provisions of ss.30, 55 as to existence and functions of pest destruction boards, but not power to declare 'pests'.
- Provided for Governor-General on advice of Minister given on recommendation of Agricultural Pests Destruction Council set up under Act to declare to be 'pests' of national or local importance animals which threatened agricultural production or were likely to do so : ss.3, Is.
- Made provision for pest destruction boards to destroy declared 'pests': ss.30, 55(1).

ANIMALS ACT 1967 (Administered by MAF)

- REPEALED BY BIOSECURITY ACT but transitional arrangements continue to apply until 1996.
- 'Animals' deflned to include possums : s.2.
- Provided for the control of Tb in stock (s.32); and allowed MAF to destroy diseased or infected animals (s 35(1)).

BIOSECURITY ACT 1993 (Administered by MAP)

- An enabling Act, facilitating an integrated approach to management of unwanted organisms, in that it provides a system for their effective management or eradication by means of pest management strategies (PMS); it does not mandate any operations in respect of pest management; but where there is a relevant PMS in force, management and eradication of pests must be in accordance with the PMS: s.55(1).
- Provides powers for regional councils to do surveillance and monitoring for pests and unwanted organisms, to propose, notify, approve and implement regional PMSs, appoint or act as pest management agency and take any action necessary for giving effect to Act: s.13
- Provides for territorial authorities to take actions available to natural persons in respect of pest management, act as pest management agency, and take actions required or provided for under PMSs: s.14.
- Confers statutory powers to limit individual rights and create legal obligations: see Table B.2.
- Enables measures to be taken against any organism specified as a 'pest' in a PMS.
- Does not derogate from or affect the provisions of the Wild Animal Control Act, Wildlife Act, Conservation Act, Reserves Act, National Parks Act or RMA which will therefore continue to apply to measures undertaken under the Biosecurlty Act.

(c) *Resource* management focus

RESOURCE MANAGEMENT ACT 1991 (Administered by MFE)

- Promotes the sustainable management of natural and physical resources; requires matters of national importance such as areas of significant vegetation and habitats of indigenous animals and plants to be recognised and provided for: ss.5,6.
- Local authorities have responsibilities for control of land use which could, subject to jurisdictional limits of ss 30, 3 1, involve issues relating to pest management.

Table B.2 Legislation which provides the framework for possum control

(a) DOC-administered

WILDLIFE ACT 1953

- Minister may authorise occupier of land in wildlife refuge to destroy possums etc. (**s.14(2)**) or may authorise DOC officers to hunt or **kill** possums where causing nuisance or damage to refuge or wildlife on refuge: **s.14(2A).**
- Director-General of Conservation may authorise in writing occupier of any land or DOC officers to hunt or kill any animals, where satisfied they are causing injury or damage to any person, land, stock, crops, chattels or other wildlife: **s.54(1).**

WILD ANIMAL CONTROL ACT 1977

- Provides for DOC to prepare general policy and wild animal control plans and/or Conservation Management Strategies (CMS) under Conservation Act, to coordinate policies and operations of DOC, public authorities and land owners; to establish control operations; to pay bounties etc.: **ss.5, 5A, 5B.**
- Permits hunting or killing of wild animals anywhere in NZ by any person, subject to regulations under this and other Acts, and subject to the permission of land owners/occupiers; with **wide** powers for Minister to direct wild animal control operations on land other than land held under statutory power, after consultation and public notice: **s.8.**
- Minister has power to ensure 'concerted and simultaneous action' against wild animals: **s.10.**
- Gives powers to DOC to inspect Crown-owned land for purposes of Act (**s.14**), and to enforce wild animal control measures on private land owners and lessees of Crown land, provided Minister satisfied wild animals causing or likely to cause damage to any land, adjacent land, persons, animals, crops or chattels: **ss.14, 15,** 16.
- Wide powers of entry, search and seizure to catch, hunt, kill or poison and other functions necessary for wild animal control, upon notice to private land owners, or with prior consultation with controlling authority of Crown-owned land: ss.13, 14, 15, 16, 17, 18.
- With prior consent of Minister and approval of plans, local authorities may apply money for wild animal destruction: **ss.30,** 31.
- Biosecurity Act does not derogate from Wild Animal Control Act, which may override a PMS relating either to DOC land or to private land.

RESERVES ACT 1977

- Reserves are classified by Minister and managed by administering body appointed under Act or by Crown: Part III.
- Act requires administering body to submit management plans for approval of Minister: **s.41(1).**
- Plans must provide for use, enjoyment, maintenance, protection and preservation as case requires so as to ensure compliance with purpose of reserve, subject to process of public participation: **s.41(3);** Crown-administered reserves managed in accordance with CMS prepared in accordance with Part IIIA Conservation Act: **ss.40A,** 40B.
- Plans for scenic, nature and scientific reserves may provide for extermination of introduced fauna where necessary to protect indigenous fauna or flora: **ss.19, 20, 21.**
- Minister **or administering** body may authorise any specified fauna to be taken or killed (poison is not mentioned; and in general no such power covering indigenous fauna for commercial purposes): **s.50.**

NATIONAL PARKS ACT 1980

- Management plans are required for all parks: **s.45.**
- Conservation management strategies must be prepared as necessary to establish objectives for management of inter alla national parks: **s.17D** Conservation Act; **s.44A** National Parks Act.
- Management plans shall not derogate from provisions of conservation management strategy: **s.44A(2).**

CONSERVATION ACT 1987

- Conservation management strategies and **conservation** management plans may cover wild animal destruction on DOC land where preservation of natural state of area requires extermination of introduced fauna (subject to any requirements under other Acts covering particular classes of DOC land: **s.53** (3)(g); may also use wild animal control plans under powers of **ss.5A,** 5B Wild Animal Control Act.

(b) Local authority managed

RESOURCE **MANAGEMENT ACT 1991**

- No **specific** requirements.
- Regional and territorial authorities may include management of the effects of pests, and of the effects of pest control in their planning, as consistent with their functions and powers under **ss.30,** 31.

LOCAL GOVERNMENT ACT 1974

- Bnables regional councils and territorial authorities to assume functions of Crown in region or district under contract: **ss.37S(2), 37T(2).**

(c) MAF-administered

AGRICULTURAL PESTS DESTRUCTION ACT 1967

- Repealed by Biosecurity Act but s.179 saves arrangements in force at 30 June 1993 relating to inspectors, pest destruction boards, powers of boards to levy and take rates for pest destruction, powers of inspectors to enter any land, private, Crown-owned or Maori, and require or undertake the destruction of pests and to recover costs for work done: **ss.55-60, 63.**
- Functions of former pest destruction boards were taken over by regional councils when local government was reformed **(s.37S(1)(b)** Local Government Act **1974),** now amended by **s.168(1)** and 4th Schedule Biosecurity Act which confer on regional councils functions, duties and powers under Biosecurity Act.
- Arrangements in force at June 1993 continue until 30 June 1996 or until a relevant pest management strategy (PMS) under the Biosecurity Act comes into effect, whichever is sooner.

ANIMALS ACT 1967 and ANIMAL HEALTH BOARD

- Act repealed by Biosecurity Act but s.178 saves until their expiry date notices, directions or requirements of **D**-G under Animals Act as to testing, movement control, or slaughter of cattle and deer for Tb, and compensation provisions where cattle are slaughtered: **ss.13A,** 53, **53A, 53AA, 53C, 53E,** 53H.
- Transitional provisions of Biosecurity Act do not save former **s.107(4)** whereby regulations setting maximum amounts of compensation to be paid for cattle slaughtered under Act could only be made on recommendation of **Minister** who could not do so except on recommendation of Animal Health Board.

BIOSECURITY ACT 1993

- Part V is a code which sets up comprehensive system of pest management strategies (PMS) for management and destruction of pests where organisms are declared to be ‘pests’. PMS has legal status of regulations.
- National PMS (NPMS) may be proposed by any Minister **(s.56)** on own initiative/at request and cost of any person **(s.58),** and may impose obligations and costs on Crown ‘according to its tenor’ **(ss.87(1));** approved by Governor General by Order in Council, on recommendation of proposing Minister **(s.68).**
- Regional PMS (RPMS) may be proposed by regional councils or submitted by any persons to councils **(ss.71, 74);** approved by proposing **Council (s.80);** and **will** only affect the Crown if so provided by Order in Council **(s.87(2)).**
- Prerequisites for proposing PMS: **ss.57,** 72
  - benefits must exceed costs after taking into account likely consequences of inaction
  - net **benefits** of NPMS must outweigh those of RPMS; and net beneflts of RPMS must outweigh those of individual action
  - the organisms to be controlled must be capable of causing serious adverse effects on economic, biological, ecological, cultural, recreational and health values.
- Contents of PMS must include matters set out in **ss.60, 61, 76, 77;** and regard must be had to matters included in First Schedule **(ss.60(2), 76(2)):**
  - effects on environment, trade, international obligations, long-term management of the **pest,** animal welfare, tangata whenua
  - economic evaluation; costs of implementation; source of funding; process for negotiating allocation of costs
  - technical feasibility of proposed strategy
  - beneficiaries; whether inaction by any person is creating need for PMS
  - management agency to be used - may be govt dept, local authority, or body corporate
  - any compensation arrangements; obligations of all parties involved, including occupiers
  - monitoring and measurement of performance
  - regulatory and enforcement arrangements and legal powers required for purposes of PMS.
- Procedures: notification, appointment of board of inquiry (NPMS); hearings, commissioners (RPMS); hearing, reports, recommendation to Minister (NPMS); approved by Order in Council on recommendation of Minister and **laid** before House (NPMS); approved by special resolution of regional council on recommendation **of commissioners** (RPMS).

continued. . .

- **Implementation: by nominated management agency, whose appointment depends on accountability, acceptability to those providing the funds, capacity and competence.**
- **Duration: PMS cease to have effect when so declared by Minister, or after 5 years or shorter time as specified, or when revoked after review.**
- **Enforcement: Powers of entry, inspection, destruction etc. set up by Part VI must be imported into PMS specifically: ss.60, 76, First Schedule, clause 12.**
- **Penalty regime: Act provides for penalties up to $75,000 for corporations or imprisonment for individuals for offences in relation to inspectors or authorised persons or for non-compliance with directions or requirements of those persons: ss. 154, 157.**
- **Review of PMS: mandatory after 5 years or earlier if the specified circumstances arise: s.88.**
- **Funding of PMS - by levy for any PMS: permitted by Order in Council on recommendation of responsible Minister after consultation as required by the Act; on the basis of the relevance and cost benefit of the PMS to the persons paying, and provided payment by way of levy will better target persons likely to benefit from the PMS and persons whose actions or inaction contribute to the problem: ss.90-96.**
  - **for regional PMS only - by rates, after consultation with ratepayers and on basis of tests as to cost benefit and relevance to ratepayers: s.97.**
  - **rates may be, levied as uniform annual charge or on differential basis: s.34A Rating Powers Act 1988 as amended by Biosecurity Act.**
- **Consultation**
  - **impliedly required whenever effects must be assessed: ss.57, 60, 76 and First Schedule; where assessment as to funding implications is required: ss.61, 77, 92, 97; or for appointment of management agency: s.85.**
  - **a formal requirement where submissions are authorised and there is a hearing: ss.64ff, 78ff.**
  - **expressly required between a regional coundl which proposes a RPMS and the relevant Minister, local authorities and tangata whenua: s.73.**
- **Small-scale management of unwanted organisms: s.100.**
  - **open to any Minister or regional council to undertake small-scale management**
  - **must be capable of providing effective control within 3 years because distribution of organism is limited and technical means are available**
  - **must offer cost benefits in comparison with PMS, and costs must be within limits prescribed for PMS by Order in Council**
  - **must be no significant impact of small-scale management on public as provision dispenses with consultation process of PMS.**

Table B.3 Legislation which regulates the means of possum control

(a) Pesticide use

PESTICIDES ACT 1979 (Administered by MAF)

- Defines 'pesticide' as any substance used for eradication of 'pests' (defined to include 'unwanted mammals'). Act binds Crown.
- Only pesticides registered by Pesticides Board may be imported, sold or applied commercially: s.21.
- Use of pesticides can be restricted on grounds such as relative toxicity and environmental effects: s.24.
- Use of 'controlled pesticides', which include 1080, phosphorus and cyanide, as set out in First Schedule, is restricted to operators approved and licensed by Board for use of particular pesticide, or under supervision and control of such an operator: s.4.
- Pesticides Board has advisory role under Toxic Substances Act 1979 in respect of pesticides restricted as toxic substance: s.12(3) Toxic Substances Act 1979.
- Licences are issued on basis of examination administered by Pesticides Board, to persons not less than 18 years of age; licences remain in force indefinitely, subject to licensee nbt being disqualified: ss.45-52.
- Application of 1080 not generally available for landowners except by operators approved and licensed for use of 1080 under the Act: s.44.

PESTICIDES (VERTEBRATE PEST CONTROL) REGULATIONS 1983

- 1080 may only be supplied for resale or to approved operators employed by Ministry of Forestry, MAF, regional councils, or to persons approved by Pesticides Board, and employed directly for vertebrate pest control: Reg. 4(1); sale and supply of phosphorus and cyanide also restricted: reg 4(2).
- Principal restrictions are as follows:
  - Reg 12(1): Without appropriate permissions, no 'controlled pesticide' shall be used in 'restricted areas', whether by ground or aerial application.
    'Restricted areas' are defined as:
    - public roads or places of public access or within 60 m thereof;
    - catchment areas from which water is taken for human consumption;
    - within boundaries of 'communities' or of areas controlled by local authorities (or within 400 m of boundaries).
  - Reg 12(3): Prior written permission from:
    - MOH in every case. Permission must be granted if use will not contravene Health Act, Toxic Substances Act, Pesticides (VPC) Regulations; otherwise must be declined.
    - The authorities with specific Jurisdiction over restricted areas, including government departments, community and territorial authorities, who must grant permission if satisfied that:
    - permission has been obtained from MOH; and
    - use of the controlled pesticide 'will not cause harm or inconvenience to the public'.
  - Reg 12(1): Any conditions may be imposed by MOH and controlling authorities with every permission granted.
  - Reg 12(2),(4): Where controlled pesticides are used in places of public access or within 60m thereof by persons operating under delegation of Secretary of Forestry, Commissioner of Lands, or by or on behalf of MAP, Ministry of Forestry, pest destruction boards or persons approved by the Pesticides Board, It is enough that there be consultation between the appropriate officers and district MOH, provided also the operation carried out in accordance with conditions (if any) imposed by MOH, without permissions required under reg 12(1). That exception does not apply to any of the other 'restricted areas' as defined in reg.12(1).
  - Reg13: 'Controlled pesticides' shall not be applied *aerially* to *any* land other than 'restricted areas' except with the permission of the district MOH. Reg. 12 applies to *aerial* applications in 'restricted areas'.
  - Reg 18(1)-(5): For all *aerial* applications of 1080, public notice must be given in local newspapers at least two weeks in advance of the intended date of application, with details as to pesticide being used, area involved, etc. The notice becomes invalid if operation not carried out within two months. Except in the case of an occupier applying a controlled pesticide from an aircraft to own property, local police must also be notified of an intended aerial drop: reg 18(5).
  - Reg 18(6),(7): Approved operators or persons under their supervision shall not apply phosphorus or *cyanide* by any means without *notice* being given to relevant district pest destruction board; except that this restriction does not apply where approved operator is occupier of land or is employee of Ministry of Forestry, MAP, regional councils or persons approved by Pesticides Board and employed directly for vertebrate pest control, or on forest land or land leased/managed by Minister of Forestry.
  - Reg. 21: Whenever any 'controlled' pesticides are to be used, conspicuous notices must be erected at places where public has access to affected land.
- The Regulations control matters such as purchase and sale of controlled pesticides, colour, packaging, labelling, storage, numbering, register of sales, disposal and loss of stocks.
- The Regulations also control licensing arrangements for operators.
- There are offences for non-compliance with regulations or with conditions attached to permissions by MOH or controlling authorities.

continued . . .

TOXIC SUBSTANCES ACT, 1979 (Administered by Ministry of Health)

- Defines 'toxic substances' as including 'any pesticide'.
- Enables classification of toxic substances as 'deadly poison', 'dangerous poison', 'harmful poison', or 'harmful substance', depending on degree of toxicity and need for control: s.7.
- 1080 and cyanide classified 'deadly poison': s.7, reg 3 and 1st Schedule Toxic Substances Regulations 1983; phosphorus classified 'dangerous poison': s.7, reg 3 and 2nd Schedule Toxic Substances Regulations 1983.
- Toxic Substances Board has advisory functions relating to manufacture, sale, handling etc. of toxic substances, protection of human health and environment from harmful effects of toxic substances.
- Act restricts use, sale, packing, labelllng etc. of toxic substances to those authorised under Act and provides licensing regime under jurisdiction of district MOH: **ss.19-34.**
- **Licences,** issued in respect of particular activity in relation to particular substance, are valid for 12 months, and are issued by MOH on basis of applicant being 'fit and proper person' to deal with toxic substance; MOH must keep register of **licences** issued: **ss.5-40.**
- The Regulations set out the detailed requirements for all aspects of the packing, storing, handling, labelling, importation and carriage of **toxic** substances.
- Ministry of Health officers, including MOH, customs and police officers, have powers of entry, search, and seizure.
- Pesticides Board, not Toxic Substances Board, has competence to advise Minister or Director-General on matters within jurisdiction of Pesticides Act.

HEALTH ACT 1956

- The Act makes it an **offence** to pollute a water supply of a local authority so as to make water dangerous to health, offensive or unfit for domestic use **s.60(1).**

BIOSECURITY ACT 1991

- Contains no specific provisions to regulate use of pesticides.
- A proposed pest management strategy must include specific information on 'actual or potential effects, beneficial or detrimental' that PMS could have on matters such as environment, long-term management of relevant pest and any other pest or unwanted organism, including information under **First** Schedule relating to ecological problems, effects on physical environment, pollution, residue problems, public health, mitigation measures and monitoring arrangements.

RESOURCE MANAGEMENT ACT 1991

- Local authorities have function to make provision for regulating storage, use, disposal or transportation of hazardous substances: **ss.30,** 31.
- Sets up restrictions possibly relevant to use of pesticides:
  - (a) Section 9: use of land, as by deposit of any substance on land, is permitted unless rule in plan restricts such use.
    - **If** rule classifies activity as ***controlled, discretionary,*** or ***non-complying,*** resource consent must be obtained.
    - Crown is exempt from restrictions imposed by district plans on uses of land **in areas** held or managed under Acts administered by Conservation Department, subject to there being a conservation management strategy or plan with which proposed use is consistent, and to there being no significant adverse effects beyond boundaries of conservation areas: **s.9(2).** This exemption does not apply for restrictions set up by regional councils under **s.9(3).** This is the only exemption extended to Crown for otherwise restricted activities.
    - RMA does not distinguish between aerial and ground methods of depositing substances; it is ***effects of use*** which are relevant.
  - (b) Section 12: use of **coastal marine** area, as by deposit of any substance on the foreshore or seabed in a manner likely to have an adverse effect, is ***prohibited*** unless expressly ***permitted*** by a rule in a regional **plan** or by resource consent.
    - Where there is no regional rule, resource consent will be needed, and will be decided as discretionary activity under **s.105(1)(b)** after having regard for matters of **s.104.**
  - (c) Section 13: **use of beds** of rivers **or lakes,** as by deposit **of any** substance on bed, **is *prohibited,*** unless expressly allowed by rule in regional plan or by resource consent.
    - This restriction may be relevant where pesticide baits are laid on dry river bed areas or reach the beds of water bodies.
  - **(d) (i)** Section 15: **discharge of contaminants** into water, or onto land so that it could enter water, is ***prohibited,*** unless expressly ***permitted*** by rule in regional plan, or by resource consent;
  - **(d) (ii) discharge** of contaminants to land or into air from any place (other than industrial or trade premises) ***permitted*** unless rule in a regional plan restricts such discharge.
    - Where there is such a rule, a resource consent must be **obtained.**
- **'Contaminant' defined** very broadly to include any substance which, when discharged, changes or is likely to change the physical, chemical or biological condition of land, air or water to which substance is discharged. This **definition** wide enough to include substances which may have only a minor impact on water quality.

continued . . .

- Where resource consents applied for, environmental effects assessment required: s.88 and 4th Schedule. In case of DOC land, purpose for which the land is held will be a relevant consideration.
- Regional councils may include rules for discharges of contaminants to water as ***permitted*** uses: (s.70(1)), subject to tests as to water clarity, odour, adverse effects on aquatic life, safety of the water for stock, production of scum, film or suspended materials on/in the water. That exception is equivalent to the 'general authorisations' under former s.22 Water and Soil Conservation Act 1967, deemed to be rules for ***permitted*** activities in regional plans: RMA, ss.368(2)(d) and 369(1).
- Notification requirements for resource consents are as follows:
  - notification not required for ***controlled*** activities if written approval obtained from all persons who could be adversely affected, unless plan expressly excludes requirement for such approvals, or unless unreasonable to obtain all such approvals.
  - notification not required for ***discretionary*** activities if plan expressly restricts council's discretion and permits consideration without obtaining approval of all persons who could be adversely affected.
  - notification not required for ***discretionary*** or ***non-complying*** activities, if council satisfied adverse effects on environment will be minor, and written approval obtained from all persons who could be adversely affected, unless unreasonable to obtain all such approvals.
- Regulations may be made by Minister for Environment authorising exemptions to s.15: s.360(1)(h), RMA.
- In addition to requirements under RMA, restrictions and requirements of the Pesticides (Vertebrate Pest Control) Regulations are applicable.
- Restrictions under Act or imposed by means of rules in plans can be enforced through enforcement and abatement procedures: ss.314, 322.

CIVIL AVIATION ACT 1990 and CIVIL AVIATION REGULATIONS 1953

- Operations involving aerial application of pesticides are subject to the Act and Regulations which cover matters of aviation safety and licensing.
- Dropping of animal poisons permitted as exception to general rule against dropping of anything from aircraft, provided pilot holds chemical rating (regs. 32(2), 255); and without an appropriate agricultural rating, no person shall act for hire or reward as pilot in command of an aircraft which drops poison baits or lays poison: regs. 46A, *2.54.* It ***is prohibited*** to drop anything from an aircraft wllfully or negligently in manner that creates hazard to persons or property below aircraft (reg. 32(3)).
- Pestiddes (Vertebrate Pest Control) Regs also cover requirements for aerial application of 1080 and other 'controlled' pesticides.

(b) Hunting

WILD ANIMAL CONTROL ACT 1977

- Enables entry onto any land by DOC officers or agents, for hunting or killing, with permission of owner/occupier in case of private land; and without permission where offence against Act is suspected. If permission refused, Minister may authorise entry: ss.13, 14, 15, 16.
- Minister may authorise such operations on land held under DOC legislation.
- Wild animal recovery hunting is provided for by separate arrangements (Part II), subject to licences or permits/ concessions.
- All hunters subject to Arms Act 1983.

CONSERVATION ACT 1967

- Director-General may issue permits for hunting in conservation areas, if in accordance with any management plan, and having regard for public safety; without permit, hunting and related activities are offences (s.38).

(c) Animal Welfare Matters

ANIMALS PROTECTION ACT 1960

- Althoughpossumsare not included in definition of 'animal' in Act, it is offence to set traps for purpose of catching ***any*** animals, (and possums expressly included), without inspecting traps every24 hours and removing any living creature found trapped: s.6.

Appendix C

Criteria used in this investigation

A. For assessing appropriateness of possum control methods

1. Effectiveness of method, as measured by percent of possum population reduction (bearing in mind the relationship between possum population level and the desired conservation or bovine tuberculosis control outcome).
2. Cost per hectare, including consideration of intervaluntil control repeated (e.g. cost over time, not just per operation).
3. Data (or lack of data) on non-target species' impacts and residues in the environment (including residues in soil and water supply).
4. Note information on complicating variables (to ensure data is comparable):
   a. size of area, and whether island;
   b. terrain (ease of access and coverage);
   c. bait type and size (andreductionin size through preparation, delivery, weathering);
   d. type and spacing of traps or bait stations;
   e. bait and/or toxin avoidance by possums.
5. Practical availability of the method, and security of supply for necessary resources.
6. Any related side effects (e.g. whether sublethal 1080 doses may increase possums' susceptibility to tuberculosis; whether tuberculosis vaccination of possums may increase possum impact on native vegetation).

B. For analysis of case studies

1. Are agencies fulfilling their statutory responsibilities with regard to possum management?
2. Did they have criteria for decision-making on possum management, and were these criteria reasonable and made public?
3. Did they analyse alternative options for possum control, including cost-effectiveness, resource availability and likely environmental and social impacts, prior to control operations taking place?
4. Were all interested parties contacted, kept informed, consulted? Adequacy and timing of consultation/liaison methods employed.
5. What technical information did concerned parties receive, particularly on the environmental and social costs and benefits of the preferred and alternative methods of possum control?

Appendix D

Background information on 1080 risk to honeybees and honey[1]

Bees are strongly attracted to the sweetness of 1080 paste baits when nectar sources are scarce particularly in spring and autumn. Bee death from 1080 is delayed for about two hours and there is sufficient time for bees to carry back up to four loads of poisoned jam paste and recruit other bees to the harvest.[2] Although early studies suggested no danger to honeybees and honey with normal field use,[3] the experiences of beekeepers over the last eight years, including the loss of colonies from 120 hives in one incident, suggest otherwise.

The Animal Health Board advises pest control operators that beekeepers must be given adequate notice to move their beehives before poisoning begins,[4] and lists of registered apiaries can be obtained from the regional MAFQual Registrars of Apiaries. Beekeepers are required to register their hive sites as apiaries (Apiaries Act 1969), but may not register new sites immediately, and some (usually hobbyists) do not register at all. Requested lists of apiaries may not fully cover the necessary area because the radius requested is too small, references given are road access rather than actual placement, or an up-to-date list is not sought prior to poisoning.

The AHB protocol notes the 400 metre spacing rule on the label and advises a 500 metre distance, but bees are known to fly three or more km in search of food sources,[5] and the Registrar of the Pesticides Board advised regional councils in 1992 that a 3 km radius should be used.[6] The Ministry of Health has advised Medical Officers of Health that '1080 paste (jam) baits that do not contain a Pesticides Board approved beerepellant must not be laid within four kilometres of beehives without three months prior notice to all registered beekeepers in the operational area.[7]

Even if adequate notice is received, beekeepers have found that it is often too late, or they cannot find a suitable area to place their hives in time. Costs to beekeepers include not only those associated with shifting hives if notice is received (direct cost and loss of production), but loss of vigour or whole hives and thus future honey and pollination income if 1080 poisoning occurs.

1. In addition to those specified, sources for this section include G.M. Reid, T. Roberts, C. Van Eaton, S. Ogden, and N. Wallingford, pers. comm. 1993/94.
2. Goodwin and Ten Houten, 1991.
3. McIntosh et al, 1964.
4. Animal Health Board, 1992b, section 7.1. Beekeepers are considered like other livestock owners under section 56 of the Agricultural Pests Destruction Act 1967.
5. Ten km has been advised as a precaution for avoiding toxic honey from tutu (MAF Aglink, FPP 827), and the furthest documented case of bee flight was 13.7 km in adverse conditions with no closer sources of food or water (Eckert, 1933; cited by N. Wallingford, pers. comm.).
6. Form letter to all Regional Councils, 21 May 1992, from A. Foley, Registrar of the Pesticides Board.
7. Form letter setting out model conditions for permits issued by Medical Officers of Health, issued by D. Curry, Ministry of Health, 2 May 1994.

Beekeepers are also concerned about public perception of their honey product, even if the risks of 1080 contamination are small. Green honey the same shade as the 1080 bait dye has on two documented occasions been found in wax frames of beehives, and tested positive for 1080.[8] In addition one of these cases appears to have been the result of illegal use of 1080, demonstrating another loophole in legal notice provisions.

The green 1080 honey so far found has been clearly visible in new wax frames, but as it would not be so easily detected in old darker frames, and there are also natural sources of greenish honey,[9] contamination might not be detected. It is likely that any 1080-laced honey inadvertently extracted by commercial beekeepers would be highly diluted in large batches, but the beekeepers are nonetheless keen to eliminate any potential sources of contamination.

Although honey is a moist environment (17-20% moisture), its antibacterial properties would limit the presence of micro-organisms capable of degrading 1080, and 1080 in *honey is unlikely to biodegrude.*

Hobbyist beekeepers may face additional risk in that they keep fewer hives and any 1080 contamination would be less diluted, particularly if they eat honey from the comb rather than extract it and blend it with other honey. Also, they are less likely to have registered their apiaries with MAF and are thus less likely to receive notices of 1080 poisonings planned in their area.

As the legal notification procedure is not foolproof, it is essential 1080 paste baits are not attractive to bees, which may be achieved by removing their sugar content,[10] including a bee repellant, or by some other means. Research by HortResearch and Landcare Research to locate a suitable bee repellant has suffered technical and funding difficulties, but recent studies have found very promising results for isovaleric acid. In trials to date the compound repels bees 80-90% and has no negative effect on attractiveness of baits to possums. Final results from eight field trials by regional councils are expected to be available by June 1994.

[See chapters 5 and 8 for further discussion of this issue.]

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8 Letters of 3 July 1987 and 16 May 1988 from G.M. Reid, National Apicultural Officer MAF to J. Bassett (1080 in green honey samples: l.Oppm in 1987; 2.2 mg/kg in 1988); Another case of apparent 1080 in honey was traced to faulty gas chromatograph calibration, but 10 mg/kg of 1080 was confirmed in dead bees (letter of 17 July 1989 from T. Percival, MAP Animal Health Laboratory, Wallaceville to G.M. Reid, MAP).

9 E.g. bronze heath/patotara (Cyathodes fraseri) and common fennel.

10 J. Hutchings, Taranaki Regional Council, pers. comm., 1994.

Glossary

1080	**Sodium fluoroacetate or sodium monofluoroacetate (from Compound 1080, the original registration name in USA).**
aerial-l 080	**Sowing of baits containing 1080 by aircraft.**
AGMART	**Agricultural and Marketing Research and Development Trust.**
AHB	**Animal Health Board.**
APDC	**Agricultural Pest Destruction Council.**
DOC	**Department of Conservation.**
cyanide	**Sodium cyanide, potassium cyanide, or calcium cyanide.**
EIA	**Environmental Impact Assessment.**
endemic Tb Area	**An area where Tb is found in wild animals and Tb persists in farmed cattle and deer, despite killing Tb reactors in herds.**
ENP	**Egmont National Park.**
EP&EP	**Environmental Protection and Enhancement Procedures (Ministry for the Environment 1987 Revision) .**
feral	**Wild population of a species which is also domesticated (eg cattle, deer, cats).**
FoRST	**Foundation for Research, Science and Technology (allocates Public Good research/science funding).**
DGPS	**Differential Global Positioning, System • satellite and computer based aircraft navigation system which can accurately record bait application in aerial poisoning operations.**
ITO	**Industry Training Organisation.**
kaitiakitanga	**Stewardship, guardianship. As defined in section 2(1) of the Resource Management Act in relation to a resource, 'includes the ethic of stewardship based on the nature of the resource itself'.**
Krebs Cycle	**A series of enzymatic reactions that constitute the second stage of respiration in aerobic organisms, providing the main source of energy for cells in the form of ATP (adenosine triphosphate).**
LD_{50}	**Dosage that will kill 50% of a test population; used as an expression of the toxic level of a particular substance for a particular species. An LD_{100} will kill 100%.**
MAF	**Ministry of Agriculture and Fisheries.**

MOH	Medical Officer of Health.
MQM	MAP Quality Management
MoRST	**Ministry** of Research, Science **and Technology** (policy advice to Government on research/science funding).
Movement Control Area	An area where pre-movement Tb testing is compulsory for cattle or deer, aged 3 months or older.
NPCC	National Possum Coordinating Committee
NSSCP	National Science Strategy Committee on Possums and Bovine Tuberculosis Control (to enhance coordination of research programmes on possums and bovine tuberculosis control).
NZLGA	New Zealand Local Government Association.
NZQA	New Zealand Qualifications Authority.
PDB	Pest Destruction Board (pest control functions of **PDBs** were transferredto regional councils in 1989).
Performance contract	A contract between a control authority and a pest control operator that specifies as a minimum: the target to be achieved; the timing and duration of the operation; the basis of payment; any conditions to be met; and, the level of monitoring agreed to verify the achievement of target and justify payment.
PGSF	Public Good Science Fund.
PMS	Pest Management Strategy, promulgated under the Biosecurity Act 1993.
pollard	Gram wastes used in commercial preparation of baits. Pollard baits are also called cereal baits.
Possum	The introduced Australian brushtail possum, *Trichosurus* ***vulpecula.*** 'Opossum' refers to the native American marsupial ***Didelphis*** *virginiana.*
ppb	parts per billion (1000 million).
RAHAC	Regional Animal Health Advisory Committee.
RMA	Resource Management Act 19 9 1.
RPMP	Regional Pest Management Plan.
STIA	Special tuberculosis investigation areas.
tangata whenua	People of the land; the Maori iwi or hapu which has **mana** whenua (customary or traditional authority) and kaitiakitanga over a particular area.
Tb	Bovine tuberculosis • an infection caused by a bacterium *Myobacterium bovis* (may infect cattle, deer, humans, feral animals - possums, deer, ferrets, pigs, cats).
TRC	Taranaki Regional Council.
Vector	Agent of disease spread, e.g. the possum is considered a vector in the spread of bovine tuberculosis.
VPCR	Vertebrate Pest Control Regulations.
WRC	Wellington Regional Council.

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