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# MANAGEMENT OF EXOTIC VERTEBRATES: SOME OF THE NEW ZEALAND EXPERIENCE

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**ABSTRACT:** Within New Zealand there have been more than 150 successful operations to eradicate exotic vertebrate pests from islands and many hundreds of operations to control exotic vertebrate pests on the mainland. This paper draws on this experience to discuss the justification and objectives for management of exotic vertebrate pests, selection of management methods and the measurement of success. The need to understand the biology of both the target species and potential non-target species is considered along with possible changes to inter-specific interactions following management of the target species. A variety of the tools that are available for management—from planning processes through traps to poisons and public consultation—are discussed along with their impact on the environment, the target and non-target species. The need to measure, record and report results is emphasized.

**KEY WORDS:** management, New Zealand, animal damage control, exotic species

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## INTRODUCTION

Prior to the arrival of humans, New Zealand was a forested land devoid of any terrestrial mammals. Thus the forest evolved without significant browsing pressure and the fauna without the influence of predatory mammals.

Polynesian migrants reached New Zealand about 1000 yr B.P. and brought with them the Pacific rat (*Rattus exulans*) (McGlone 1989). Circumstantial evidence indicates that this small rodent, alone, caused the local extinction of some bird and lizard species, serious depletion of many insect species and significant modification of floral assemblages (Holdaway 1989).

Predatory and browsing mammals were introduced to the country, deliberately and accidentally, by the European explorers of the late 1700s but few established feral populations. European migrants, who began arriving in the 1800s, brought with them, and deliberately released into the wild, many more species. The total list of 55 vertebrate mammals introduced to New Zealand is given in Table 1. Many of these species are now found country-wide and on off-shore islands, others remain within a limited range, some failed to establish in the wild while others remain as pets with a perceived ability to establish in the wild. Deliberate translocation of some of these species within New Zealand continues today, particularly those species used for recreational hunting. New introductions of vertebrate mammals are now very rare.

Each of the introduced species has caused change to New Zealand ecosystems. Some changes are not readily perceptible while others are dramatic. Bird and insect species have been locally and totally exterminated, some over a very short time-span. Forest areas have been reduced to shrublands while others are now devoid of understory and regenerating canopy species.

From the outset there was opposition, initially confined to a few individuals, to the introduction of many of these species. Today, with an increasingly informed public and supportive legislation, there is wide recognition of the damage done and disease carried by many of the introduced vertebrate pests. This is, however, tempered

by the attraction of "warm fuzzy" species such as cats (*Felis catus*) and ferrets (*Mustela furo*) and the desire to retain larger animals such as deer (Cervidae) and pigs (*Sus scrofa*) for recreational hunting.

The damage caused by these introduced mammals continues today despite intensive management efforts. Eradication of pests from islands has been successful with the removal of 16 species in at least 156 operations on 102 islands up to 11,000 ha in area (Veitch 1995). The annual cost of all pest species to the New Zealand economy is estimated at 1% of Gross Domestic Product (Bertram 1999) with vertebrate pests probably comprising less than half of this cost. The ongoing costs of lost natural ecosystems and environmental conservation have not been quantified.

An example of the intensive work being undertaken to manage vertebrate pests in New Zealand is the brushtail possum (*Trichosurus vulpecula*) which was introduced from Australia from 1858 onwards to establish a fur trade (Cowan 1990). It is now found throughout New Zealand and on a number of offshore and outlying islands. It has been eradicated from six islands up to 2321 ha in area. Annual control work on mainland New Zealand covers some 3.5 million hectares at a cost of some NZ \$60 m (approximately US \$30 m). This area is about 13% of the total land area or 50% of the remaining forest area. Many people consider there should be more possum control activity.

Legislation exists to control new introductions but the process is presumptive, not prescriptive. Legislation also requires that pest species be removed from protected areas such as national parks but this is dependent on levels of funding. There is legislation to control the use of toxins and other pest control methods. In general terms, central government manages border control but has little direct management responsibility for established pests. This is delegated to regional councils who, through the mechanism of a regional pest strategy, choose the control strategy and proposed actions. The law, case law and public pressures demand that an array of permissions and public consultations be undertaken before most major pest management operations begin.

Table 1. Vertebrate mammals introduced to New Zealand (after King, 1990). The status codes shown are: E, extinct; L/R/V, localized, rare or vagrant; NE, never established; W, widespread.

Species	Source	Reason	Status
<b>ORDER MARSUPIALIA</b>			
<b>Family Macropodidae</b>			
<i>Macropus eugenii</i> Dama wallaby	Australia	Sport	L
<i>M. r. rufogriseus</i> Bennett's wallaby	Australia	Sport	L
<i>M. parma</i> Parma wallaby	Australia	Sport	L
<i>M. dorsalis</i> Black-striped wallaby	Australia	Sport	E
<i>M. robustus</i> Roan wallaby	Australia	?Sport	NE
<i>Petrogale p. penicillata</i> Brushtailed rock wallaby	Australia	Sport	L
<i>Wallabia bicolor</i> Swamp wallaby	Australia	Sport	L
Unidentified wallaby	Australia	?Sport	NE
Unidentified kangaroo	Australia	?Sport	NE
<b>Family Phalangeridae</b>			
<i>Trichosurus vulpecula</i> Brushtail possum	Australia	Fur	W
<b>Family Potoroidae</b>			
<i>Potorous tridactylus</i> Long-nosed potoroo	Australia	?	NE
<b>Family Dasyuridae</b>			
<i>Dasyurus</i> sp. Marsupial cat	Australia	?	NE
<b>Family Paramelidae</b>			
<i>Isodon obesulus</i> Southern brown bandicoot	Australia	?	NE
<b>Family Pseudocheiridae</b>			
<i>Pseudocheirus peregrinus</i> Ringtail possum	Australia	?	NE
<b>ORDER INSECTIVORA</b>			
<b>Family Erinaceidae</b>			
<i>Erinaceus europaeus occidentalis</i> West European hedgehog	Britain	Pest Control	W
<b>ORDER LAGOMORPHA</b>			
<b>Family Leporidae</b>			
<i>Oryctolagus c. cuniculus</i> European rabbit	Britain	Sport, meat	W
<i>Lepus europaeus occidentalis</i> Brown hare	Britain	Sport, meat	W
<b>ORDER RODENTIA</b>			
<b>Family Muridae</b>			
<i>Rattus exulans</i> Kioie, Polynesian rat	Polynesia	?Meat, stowaway	L
<i>R. norvegicus</i> Norway rat	Europe	Stowaway	L
<i>R. rattus</i> Ship rat	Europe	Stowaway	W
<i>Mus musculus</i> House mouse	Europe	Stowaway	W
<b>Family Sciuridae</b>			
<i>Tamias striatus</i> Gray chipmunk	North America	?	NE
"Brown California squirrel"	North America	?	NE
<b>Family Caviidae</b>			
<i>Cavia porcellus</i> Guinea pig	?South America	?	NE
<b>Family Chinchillidae</b>			
<i>Chinchilla laniger</i> Chinchilla	South America	Pet, fur	NE
<b>ORDER CARNIVORA</b>			
<b>Family Canidae</b>			
<i>Canis familiaris</i> <sup>2</sup> Kuri, Polynesian dog	Polynesia	Pet, ? meat	E
European dog	Europe	Pet, utility	L
<b>Family Mustelidae</b>			
<i>Mustela erminea</i> Stoat	Britain	Pest control	W
<i>M. nivalis vulgaris</i> Weasel	Britain	Pest control	L
<i>M. furo</i> Ferret	Britain	Pest control	W
<b>Family Felidae</b>			
<i>Felis catus</i> House cat	Europe	Pet, pest control	W
<b>Family Viverridae</b>			
<i>Herpestes edwardsi</i> Indian grey mongoose	?India	?Pet	NE
<b>Family Procyonidae</b>			
<i>Procyon lotor</i> Raccoon	North America	?Pet	NE

Species	Source	Reason	Status
<b>ORDER PERISSODACTYLA</b>			
<b>Family Equidae</b>			
<i>Equus caballus</i> Feral & domestic horse	Europe	Utility	L
<i>E. zebra</i> Zebra	South Africa	?	NE
<b>ORDER ARTIODACTYLA</b>			
<b>Family Suidae</b>			
<i>Sus scrofa</i> Feral & domestic pig	Europe	Utility	W
<b>Family Bovidae</b>			
<i>Bos taurus</i> Feral & domestic cattle	Europe	Utility	L
<i>Rupicapra r. rupicapra</i> Chamois	Europe	Sport	W
<i>Hemitragus jemlahicus</i> Himalayan tahr	Asia	Sport	L
<i>Capra hircus</i> Feral & domestic goat	Europe	Utility	W
<i>Ovis aries</i> Feral & domestic sheep	Europe/Australia	Utility	L
<i>Connochaetes gnou</i> Gnu	South Africa	?	NE
<i>Pseudois nayaur</i> Bharal, blue sheep	Asia	Sport	NE
<b>Family Camelidae</b>			
<i>Lama glama</i> Llama	South America	?	NE
<i>L. pacos</i> Alpaca	South America	?	NE
<b>Family Cervidae</b>			
<i>Cervus elaphus scoticus</i> Red deer	Britain	Sport	W
<i>C. elaphus nelsoni</i> Wapiti	North America	Sport	L
<i>C. nippon</i> Sika deer	East Asia/Britain	Sport	L
<i>C. u. unicolor</i> Sambar deer	Sri Lanka	Sport	L
<i>C. timorensis</i> Rusa deer	Indonesia/ New Caledonia	Sport	L
<i>Axis axis</i> Axis deer	India/Australia	Sport	E
<i>Dama d. dama</i> Fallow deer	Britain/Tasmania	Sport	L
<i>Odocoileus virginianus borealis</i> White-tailed deer	North America	Sport	L
<i>O. hemionus</i> Mule deer	North America	Sport	NE
<i>Alces alces andersoni</i> Moose	North America	Sport	R
Unidentified South American deer	?	?	NE

## MANAGEMENT OPTIONS

While all the introduced vertebrate pests are known to damage the New Zealand natural environment or economy in some way, the options available for management vary from place to place, species to species and over time. There are few species that are not considered for management at some place or time.

Generally eradication is the only option considered for vertebrate pests on islands. In mainland areas eradication is possible for recently established populations with a limited distribution but vertebrate pests rarely fall into this category. Control to a pre-determined level is, therefore, the usual management option and this must be maintained or repeated from time to time.

## THE PROCESS

The process described here is not always followed as previous operational history, permissions already granted and slight variations in the legislative framework influence exactly what is done in different areas.

A key to effective management is sufficient knowledge of the target species to know when it is most vulnerable to a particular management method and how vulnerable it will be to various management methods. Often this is food-related as food items will be used either to attract the animal to a trap or to convey a poison. So, if natural food is abundant, artificial food may be less attractive.

Sexual attractants are less common and can usually be used only with traps. If there are significant annual fluctuations in abundance of the target species then these also need to be understood so that management effort is not wasted on animals which are going to die of natural causes in the near future.

This knowledge of seasonal change is particularly valuable for the control of predators such as rats (*Rattus norvegicus* and *R. rattus*), cats and mustelids (Mustelidae) at bird breeding areas. Removal of territory holding adults in late winter and early spring allows the first nests of the birds to succeed. As summer progresses there is an influx of young predators from surrounding areas and it is usually difficult to reduce this invasion as by this time natural food is abundant. The wise action, therefore, is to concentrate resources on pest control in winter and to do nothing after early summer.

In the course of most management there will be some impact, both positive and negative, on species which are not the target of the operation. These non-target species may be trapped or take a bait directly; they may benefit immediately from removal of the target species; they may suffer at a secondary level from things such as consumption of a poison carrier or the increase in abundance of other species.

It is possible that management of one vertebrate pest will cause a series of changes and other species

interactions which will result in a situation which is unacceptable to ecosystem managers. You need to have sufficient understanding of the species within the ecosystem, both flora and fauna, to endeavor to predict future short-term changes which may result from management of vertebrate pests.

Examples of this are seen on Raoul Island. Goats were removed from this 2943 ha island over the period 1973 to 1986. Well before that time a variety of introduced plant species had been identified as present and some of those had been accepted as weeds threatening the natural ecosystem. What was not considered at the time of goat eradication was whether any of the other exotic plants would become weed problems when goat browsing ceased. Two plant species did become major problems and others to a lesser degree. It was nearly ten years after goat removal before effective measures were established for control of these weeds. Eradication of feral cats was instigated at the time of goat eradication but then lapsed. A subsequent examination of cat diet (Fitzgerald et al. 1991) resulted in a recommendation that cat eradication would be beneficial only if the two introduced rodents present on the island were also removed. This recommendation was based on the observation that cats did not control the rat population and predation of birdlife by the rats would continue to reduce existing bird populations and stop re-colonization by sea birds. It is now proposed that both rats and cats be removed in a single sequential operation. Removal of the rats first will deprive the cats of their major food source and this will enhance removal of the cats. Removal of the rats will result in a significant increase in seed and seedling survival of both native and exotic plants. Thus a further eight plants which are not currently a serious weed threat are receiving serious control actions to reduce possible future spread.

With this knowledge or prediction of changes to target and non-target species abundance resulting from management action it is possible to set objectives for management. The prime objective is the level of management of the target species. Ideally this will be management to a level at which the ecosystem will continue to function but it may be influenced by many factors.

For an island, eradication of the target species is likely to be the best objective. For mainland areas it is desirable to control the pest species to a predicted density or until a keystone species or particular threatened species survives or recovers. Control of the pest may be to a predicted density on a one-off basis, sustained by regular work, or allowed to fluctuate between measurable levels.

Unless the pest population is particularly visible or well known, removal of a particular number or percentage of the target species should not be used as a project objective as this is likely to result in an unknown abundance and impact of the target species that remain. Justify the choice of your management objective by detailing the damage done, not numbers of the pest present. Then justify the proposed level of management by predicting the recovery of keystone or threatened species.

Before, during, and after your pest management action you will need to have sufficient knowledge about the

impact of the target species to justify your action and subsequently know that your work has been successful. Therefore, certain aspects need to be monitored to demonstrate change. You will need to monitor the abundance of surviving target animals over the short-term of the operation to demonstrate that your management methods are removing the pest species. Counting numbers removed is usually no indication of the numbers that remain.

In the longer-term you should not be monitoring the abundance of the pest species, but you should monitor the impacts of the pest on the ecosystem. With time and knowledge you will reach a point where you can define allowable limits to this damage and hence parameters for controlling the pest based on their numbers. But monitoring of the ecosystem should continue as a measurement of pest abundance alone is often not sufficient.

The manager needs to decide on the appropriate tools for management of the pest. There may be many options; for example, see Table 2. The manager will need to ensure, in the first round of decision-making, that the best method is chosen which will fit within the budget and legal requirements. Later pressures and considerations, as discussed below, may change this choice but the manager must take great care to ensure that an operation is not forced into a position where it will fail due to the use of inappropriate methods. The available options and reasons for each choice should be written down as they are likely to become part of the many papers needed later.

Consideration must be given to possible future management actions. If the management is to be ongoing then the methods used in early operations should not preclude use of other methods in future. Initial actions such as establishment of access routes or bait stations should be done in a manner that will enhance future work.

Be honest about environmental impacts and benefits from the proposal. Write your case fully so that a reader can be so well informed that they do not have to question the statements made or turn to other documents to check the accuracy.

Non-target species are always likely to be an issue. Endeavor to be honest about expected detrimental and beneficial effects. Consider the non-target species at a population level, not as individuals. There may be a number of species with individuals which will be killed during a control operation but if the effect on the population is considered over a longer period, usually just one or two years, then the control operation will be seen as beneficial to those populations.

For example, Powlesland et al. (1999) compared populations of North Island Robins (*Petroica australis longipes*) in parts of Pureora Forest Park before and after large scale poison operations using 1080-carrot baits. In one poorly managed operation there was 43% mortality of territorial birds and in another correctly managed operation there was less than 10% mortality. The operations targeted possums with an expected non-target rat kill. Both possums and rats prey on nesting robins and rats compete for food. In both areas, one year after the poison operation there were greater numbers of robins

Table 2. Some commonly used control methods for vertebrate mammal pests in New Zealand.

Species	Method
Rabbit ( <i>Oryctolagus cuniculus</i> )	1080 in carrot, aerial 1080 in carrot, ground brodifacoum in cereal pellet, ground burrow gassing biocontrol, rabbit calcivirus disease
Possum ( <i>Trichosurus vulpecula</i> )	1080 in carrot, aerial brodifacoum in cereal pellet, bait station cholecalciferol in cereal pellet, bait station cyanide in paste or pellet, bait station leg-hold trap kill trap
Rats ( <i>Rattus</i> spp.)	brodifacoum in cereal pellet, bait station brodifacoum in wax block, bait station bromadiolone in wax block, bait station other anti-coagulents
Goat ( <i>Capra hircus</i> )	shooting
Stoat ( <i>Mustela erminea</i> )	kill trap

present than before and this had been achieved through recruitment from within the area, not migration from other areas.

A second key to effective management is public support. From the outset there is a need to inform the public. This can be done as a response to demands or planned ahead. The plan ahead method is preferred as this can be planned by the manager, disseminate information in an appropriate order and with emphasis on damage the pest is doing. Relying on responses to demands often gives the appearance that you don't want to be forthcoming, and the journalist will usually ask questions about methods before understanding the background information and reasons for the project. A planned information campaign needs to begin by painting a good picture of the damage done by the pest. The pest needs to be seen as a "baddie" in this place at this time. Often news media do not want to write about things which do not include humans and bloodshed so other means of information dissemination may be needed. When the public accept the pest species as a "baddie" the possible control measures can be discussed with appropriate interest groups. Note that I use the term "discussed." The project manager may already have a preferred option. So discussion needs to progress to a point where interest groups accept the proposal or the project manager revises the preferred option.

Public meetings are avoided whenever possible. These tend to bring out undesirable elements and make little or no positive contribution to the project. Public information days, where material is displayed and information leaflets handed out have been held with success in some areas.

The results of an operation must be measured and reported on at an early stage. These results are not a count of the pests killed, but a measure of recovery of the ecosystem, keystone species or threatened species. The reports should be released to the public and written in understandable language. It may be necessary to establish monitoring methods such as photo points which allow simple reports to be produced rather than reports accompanied by a mass of statistical jargon.

## METHODS

The actual methods used to control vertebrate pests vary from place to place and from operation to operation. For management of some species there are well proven and generally accepted methods (Table 2), other methods remain open to contention and for some species no methods are known which will reliably result in an adequate level of management.

Many of these are methods that have been developed in New Zealand and are not directly applicable to other places. The use of helicopters and light aircraft to spread bait has evolved out of the necessity to get bait over large, rugged and forested areas. Bait quality and spreading standards keep detrimental impacts within acceptable limits. The absence of native mammals also enhances the ability to target introduced mammals.

Licences or special approvals are required for some methods, particularly aerial spread and the use of 1080 and cyanide, but land owners generally still have an array of pest management options available to them without any need to seek permission.

There are constraints on the way some traps can be used in areas inhabited by flightless birds such as kiwi (*Apteryx* spp.).

## DISCUSSION

A common difficulty with pest management operations is the attitudes of people to the killing of animals. The need for the pest to be seen as a "baddie" and the need to educate the public on all aspects of the operation are an integral part of the operational plan. Attitudes of the project management team also need to be managed. On the one hand the project manager and all the staff involved need to be seen as caring and careful; on the other hand the project should be calculated, swift and efficient. It is the calculated act of some short-term detrimental impact for a longer-term gain that is often difficult for managers and observers alike to accept but, if pest control is to succeed, it is a necessary part of the equation.

Planning and preparatory work needs to be complete and careful. The ideal plan will be prepared in such a manner that every reader is fully informed and no questions need to be asked. This is rarely possible. It is, however, desirable to aim for this ideal for once your plan is seriously questioned it may be seen by others as a flawed plan and each detail is then further questioned and decisions challenged.

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