Cost-effectiveness of exclusion fencing for stoat and other pest control compared with conventional control

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ABSTRACT

The costs of exclusion fencing for stoats (*Mustela erminea*) and other pests using the Xcluder™ design of multi-species pest-proof fence and conventional pest control were compared for a variety of scenarios. Cost-effective pest control can be achieved by exclusion fencing in reserves of 5000 ha or more, and on peninsulas. The cumulative cost of conventional control would exceed the initial cost of a fence plus maintenance costs after as few as 4 years. Fencing may be a cost-effective option for pest control in reserves of 100–1000 ha, depending upon cost factors such as the fenceline length to reserve area ratio, numbers of gates and water crossings, site work required to install the fence, access to the fence for maintenance, the number of abutting fences, the presence of stock outside the reserve, and the current costs of materials and freight. Smaller reserves are unlikely to be cost-effective to fence, even though conventional control is likely to cost more per hectare at these sites than in larger reserves. Despite the higher costs, fencing may still be a viable option for these sites, because it allows for a pest-free status not achievable by conventional methods. The costs of a non-electric barrier fence were also compared with those of an electric fence. The Xcluder™ fence would cost a similar amount to an electric fence, but would exclude more pest species, and be less prone to failure. The advantages and limitations of using exclusion fencing for pest control are outlined. Non-electric fences are recommended for pest control in large reserves and on peninsulas. More work is required to develop accurate costs for conventional pest control and reliable monitoring systems for the assessment of the efficacy of different pest control systems. The impact of exclusion fencing and conventional control on non-target species, the environment and social issues also needs to be assessed.

Keywords: pest control, *Mustela erminea*, fence, electric, barrier, non-lethal, poisoning, toxin, trapping.

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1. Introduction

1.1 BACKGROUND

Cost-effective pest control strategies are required for public conservation land managed by the Department of Conservation and other reserves in New Zealand. Any pest control system that either reduces the cost of pest control and continues to provide effective pest control, or leads to improved conservation outcomes, should be seriously considered. Exclusion fencing has been used to exclude specific pests from small reserves in New Zealand, but with limited success. Effectiveness was limited because of faulty design, poor construction, or lack of maintenance. For example, the design of the exclosure fences used to protect kaki (black stilt, *Himantopus novaezelandiae*) from predation in the Mackenzie Basin proved not to be totally mustelid- or cat-proof (K. Brown pers. comm.). Mice re-invaded the Karori Wildlife Sanctuary in Wellington despite a pest-proof fence because of initial faults in fence construction. These limitations of exclusion fencing can, however, be overcome when fence design takes into account the behaviour of the pest species to be excluded, and with careful construction and adequate monitoring. A fence that comprises high-quality components (the Xcluder™ fence) has been successfully excluding pests from a 16-ha bush reserve in Karapiro since February 2000 (Day & MacGibbon 2001). The Karori Wildlife Sanctuary fence has never been breached by anything other than mice, and is now mouse-proof (Anon 2001).

Fences that rely upon the responses of animals to electric wires have been used extensively overseas for pest control (McKillop & Sibly 1988). Two such fences are in use in Northland at present, for the control of various pests (excluding mustelids). Electric fences are effective against some mammal pests, e.g. rabbits (McKillop et al. 1993) and foxes (Minsky 1980); but possums can quickly breach a fence during power failure (Cowan & Rhodes 1992; Clapperton & Matthews 1996). Cowan & Rhodes (1993) found that neither poisoning nor an electric fence produced effective buffers to reduce juvenile possum dispersal. Stoats can move so quickly up a fence that they can pass the electrified wires between pulses (T. Day unpubl. data). When possums and cats are sufficiently motivated, electrified wires do not prevent either species from crossing fences (Clapperton & Matthews 1996; T. Day, unpubl. data). This is a major weakness of the electric fence design, a weakness that is not present in the non-electric Xcluder™ fence designs described here.

Exclusion fences are likely to be cost-effective in situations where the area to be enclosed or excluded is large relative to the length of fenceline required. Fencing off a peninsula is an obvious example. This approach has been used at North Cape and Cape Brett. Other sites can use fencing as effective pest control where initial pest eradication is possible, and a clear space can be left outside the fence to prevent animals climbing over it from surrounding vegetation. While these criteria are usually easily met in isolated bush reserves, they are not restricted to such sites. Areas of outstanding conservation value within large stretches of forest could also be worthy of fencing. Fencing one area of forest could also be of value for the adjoining forest, by removing one source of dispersing juvenile pests. This could be of particular importance when sites targeted for eradication and fencing are pest 'hotspots', as found for stoats (Murphy et al. 1999) and rabbits (Moller et al. 1997), which could be major sources of individuals re-invading a controlled area. A fence could also allow more-effective eradication techniques to be used as there would be less impact on the surrounding area. Moribund pests would not be able to wander out of the area and die where they may be a threat to non-target species, livestock and domestic animals. If pest eradication is done within fenced-off areas before threatened native fauna are re-introduced, even-more-effective poisoning regimes could be used, without the risk to critical non-target species.

Once a fence has been constructed and pests eradicated from the area enclosed by it, the conservation outcome for that site is likely to be better than if pest numbers are just suppressed but not eliminated. For example, at the Mainland Island project at Boundary Stream, mustelid catch rates show that stoat numbers can be kept low, but reinvasion is always a threat. This is demonstrated by the higher catch rates of perimeter traps than interior ones (Saunders 2000). In the case of areas where initial eradication of all pests is not feasible (e.g. the 6000 ha of Hurunui Mainland Island Project), a fence could still be useful in restricting immigration of pests from uncontrolled areas into intensively controlled areas.

Exclusion fencing has the advantage over conventional control in that it provides effective multi-species pest control. There is no need for various trapping and poisoning regimes for rodents, mustelids, ungulates and possums—the one fence can be an effective barrier to all these species. Many pest species are usually targeted in a reserve. For example, ten species are controlled at Boundary Stream (Saunders 2000), and 14 at Karori Sanctuary (Anon 2001). While only possums are targeted at Paengaroa Scenic Reserve, and only stoats and possums at Hurunui, a fence could exclude rodents, cats and ungulates as well, for no additional cost. While the main aim of this report is to compare the cost-effectiveness of fencing and conventional methods for the control of stoat predation; in fact, this cannot be viewed in isolation from other pest control programmes.

Exclusion fencing has another potential advantage over conventional pest control. It is a non-lethal means of control, following the initial pest knockdown. It may, therefore, be more acceptable to the public than the extensive use of toxins or traps.

Preliminary studies suggest that an Xcluder™ fence will cost the equivalent of no more than 10 years of conventional control (Day & MacGibbon 2001). The fences are designed to last for 15–25 years without major reconstruction. This suggests that, in situations where these cost estimates are reliable, exclusion fencing will be a cost-effective pest control strategy compared with conventional control systems. In this report we look carefully at factors that could increase the real cost of fence construction and maintenance. These factors include aspects of the topography and geography of the site, its accessibility, and the required conservation outcomes. In our cost calculations we assume an eradication programme will be conducted initially, irrespective of the type of pest control to be employed subsequently. The cost of this eradication is assumed to be the same for either fence or conventional control, and thus we do not include it in the cost figures for either control option. This assumption may not be always true as eradication efforts inside a fenced area will probably be less costly than in the same area, with the constant pressure of immigration of pests from the outside. This is offset by the fact that, if a fence is not to be used, a large-scale eradication programme probably would not be attempted. Instead, a slightly lower level of control, to reduce pests to very low densities, would be implemented.

We do not provide a cost-benefit analysis for the different control systems. While this has been attempted before (Upasena 2001), only indirect benefits could be ascribed to the pest control. There is insufficient data to conduct any meaningful cost-benefit analysis in terms of monetary benefits from different forms of pest control.

1.2 OBJECTIVES

We aim to compare the cost-effectiveness of exclusion fences and conventional control for protecting threatened fauna from stoats (*Mustela erminea*) and other pests in localised areas. To achieve this aim, we briefly describe the forms of pest control used currently by the Department of Conservation. We describe exclusion fences produced by Xcluder™ Pest Proof Fence Co. We describe the cost factors that determine the relative cost-effectiveness of the different control systems. We calculate the relative costs of conventional control and exclusion fencing under various scenarios, including different circumference to area ratios, site characteristics and conservation outcomes. These calculations provide a model from which managers can predict situations where exclusion fencing will be a cost-effective control system relative to conventional control. We also compare the cost-effectiveness of a currently operating electrified pest control fence with the Xcluder™ design fences.

2. Methods

2.1 CONVENTIONAL CONTROL SYSTEMS

Department of Conservation staff use double Fenn trap sets under wooden or plastic covers, with egg or meat baits to kill mustelids in Mainland Island reserves (Saunders 2000). Traps are spaced 100–200 m apart, and/or at key sites, for example below kaka (*Nestor meridionalis*) nests. Diphacinone-injected hen eggs are used under covers at poison-bait stations at some sites, and at some times of the year. Mustelids are also killed by secondary poisoning from consumption of poisoned possum and rat carcasses (Murphy et al. 1998a, b, 1999; Gillies & Pierce 1999).

Ferrets are specifically targeted in areas where they pose a potential risk as vectors of bovine tuberculosis to livestock. They are controlled by trapping using Fenn, Victor or KBL tunnel traps, or diphacinone toxin in a fish-paste bait

(Clapperton & Meenken 2000). Feral cats are caught in soft-catch leg-hold traps, or shot. Feral ungulates are controlled by ground hunting. Possums and rats are poisoned using a range of aerially- or ground-laid toxins in various baits (Saunders 2000).

2.2 CONVENTIONAL CONTROL COSTS

The major costs of running a pest control operation are labour, transport, materials and freight. The highest of these costs is labour. Material costs will be low if traps, tunnels etc. are already available. Transport costs will be very site-specific. However, in most cases we do not have a breakdown of the cost of the various components of conventional pest control. It is also difficult to divide the Department of Conservation pest control costs up by species group, e.g. predators, rodents and possums, ungulates. Because we are comparing the costs of conventional pest control with a system (fencing) that will control all of these pests, this breakdown of costs is not essential. Estimates of the cost of pest control and species recovery work in the Mainland Island Projects range from **$81–$135 per ha per year** (A. Saunders pers. comm.). At Trounsen Kauri Park in Northland (one of the Mainland Island Projects), predator control costs about **$95 per ha per year** and possum/rat control costs **$43 per ha per year** (M. Leach, pers. comm.). At Puketukutuku Peninsula at Lake Waikaremoana, where there is intensive pest control for kiwi protection, predator trapping costs **$49 per ha per year**, and possum/rat control is in the order of **$26 per ha per year** (J.A. McLennan, pers. comm.). All of these costs are for control operations that maintain pest populations at very low target densities (Saunders 2000). To be conservative, we estimate multi-species pest control in our models to be between **$40 and $135 per ha per year**.

2.3 FENCE DESIGNS

Two fence designs produced by the Xcluder™ Pest Proof Fencing Company are described by Day & MacGibbon (2001). One design is intended to exclude mustelids, cats, rats, mice, possums, rabbits, hares and hedgehogs. It consists of wire mesh to a height of 900 mm, topped by 500 mm of tin sheet with a rolled cap. Above this, 1500-mm-long fibreglass rods support bird mesh. This structure is attached to standard fence posts, and the wire mesh has a skirt that extends 300 mm from the outside of the fence, just under the surface. A single electric outrigger will deter sheep, cattle and horses. The second fence is designed to exclude deer and goats in addition to all the other mammals listed above. It is a 2-m-high mesh fence with a 300-mm mesh skirt and a 350-mm-wide rolled-metal cap.

The electrified fence at Cape Brett consists of wire mesh and an array of electric outriggers. The design has been tested on possums (Clapperton & Matthews 1996), but is not suitable for excluding mustelids and rodents. Replacing the existing wire mesh with one of a smaller gauge would prevent these animals from passing directly through the fence. They may, however, still be able to scale the fence past the electric wires.

2.4 FENCE COSTS

Both the Xcluder™ fence designs cost the same per metre (Day & MacGibbon 2001). While the standard fence can be attached to an existing pole and wire fence, the deer fence would have to be constructed from scratch. The costs quoted here assume there is no existing fence. The costs of fencing include the initial construction costs (labour, material and freight, and transport inclusively), and ongoing fence maintenance. The cost, in current (year 2001) New Zealand dollars, is **$50–$85 per metre of fenceline** (Day & MacGibbon 2001).

Annual fence maintenance cost is estimated at **1%–4%** of the initial construction cost, with an additional cost of **$5 per metre** after 15 years, for wire mesh replacement. The maintenance cost includes regular (at least fortnightly) checks for breaches of the fence.

2.5 COST DETERMINANTS

There are numerous factors that will determine the exact cost of fence construction at any particular site, and may cause additional costs over the estimates quoted above. Most of these factors are site-dependent, while others are dependent upon the desired conservation outcomes for the site, or factors outside the control of either the fence constructor or the site owner (Table 1). The specific fence components required to deal with some of these factors are listed and priced in Table 2.

TABLE 1. FENCE COST DETERMINANTS.

SITE-DEPENDENT FACTORS	SITE-INDEPENDENT FACTORS
Size	Vehicle access
Shape	Public access
Rivers, streams and drains	Species to be controlled
Topography	Deliberate damage to fence
Abutting fences	Deliberate pest re-introduction
Site clearance or restoration work	Material costs
Soil type	Exchange rate
Accessibility	Inflation
Subsidence risk	Freight costs
Presence of stock	

TABLE 2. FENCE COMPONENT COSTS.

COMPONENT	PRICE
Elevation at abutting fence	~$450
Abutting fence reattachment	~$400
Waterway crossing	~$100–$10 000
Vehicle gate	~$3250
Public access gate	~$4160
Electric wire for stock	$5 per metre

Size and shape of the reserve to be enclosed will obviously be major determinants of costs of the fence as they directly determine the number of metres of fence required. Rivers, streams and drains require specific structures that must be very carefully constructed to be mammal-pest proof, but still allow the passage of invertebrates and fish. The topography of the land, especially the steepness, and number of gullies, will impact on both the time spent in fence construction (labour costs), and amount of materials required. Additional costs are incurred by junctions with other fences. At every fence junction, the height of the pest-proof fence must be raised by the height of the abutting fence, and the abutting fence must be reattached. The quoted costs do not include any site preparation work, e.g. stripping old fences, earthworks or removal of vegetation. The location and accessibility of the site will determine transport and freight costs. Additional fence monitoring, and reconstruction work may be needed if the fence is built on land very susceptible to subsidence and landslides. The presence of stock on the outside of the fence may require the addition of a single electric outrigger wire.

Gates for vehicles and people are a major additional cost to the basic fence cost (Table 2). There is, therefore, a trade-off between cost of fence construction and ease of access which, in turn, affects the cost of maintaining the reserve. The number of gates required will also be partly determined by the type of reserve and its required level of public access. While having more gates may be useful for access, the risk of pest reinvasion is increased if any gate is left open. The species of pest that the fence must control is not a large determinant of fence cost. For example, 6-, 10-, 13- and 50-mm mesh are all similar in cost per metre (within a few dollars), but larger mesh will allow small pests (such as mice and/or rats and mustelids) to pass through the fence. Mesh is one of the cheapest components of fences, so for a fence like the Xcluder™ deer fence it would be almost as cost-effective to control all pests as to control just larger pests (e.g. possums and cats). Some sites may be more prone to either environmental or deliberate fence damage. At these sites, a higher cost may have to be calculated for fence maintenance. Some sites may also suffer deliberate re-introductions of pest species.

2.6 COST MODELS

To compare the costs of conventional pest control and exclusion fencing, various models were set up, using the different cost determinants for reserves of 100, 500, 1000 and 5000 ha, to provide 'best' and 'worst' scenarios for each size. These cover the range of sizes of the Mainland Island Project reserves, except Hurunui, which is c. 6000 ha (Saunders 2000). We also model two peninsulas, comparing the costs of fencing 750 ha and 1150 ha with the same distance across the 'neck'. These areas and fenceline length were chosen as they approximate the area of Puketukutuku Peninsula and Cape Brett, respectively. We also include figures for the Xcluder™ fence at Karapiro, which encloses 16 ha.

The cost-determinants in the models are: reserve shape (fenceline length), number of vehicle gates, number of stream crossings, abutting fences, site work (site preparation and/or restoration), the need for an electric outrigger for stock, and maintenance costs. The criteria for each scenario are listed in Table 3.

TABLE 3. COST-DETERMINANTS USED IN THE VARIOUS SCENARIOS.

SIZE (ha)	SCENARIO	FENCELINE[1] (m)	BASIC COST[2] ($/m)	GATES (n)	WATER CROSSINGS[3] (n)	ABUTTING FENCES[4] (n)	SITE WORK ($/m)	ELECTRIC WIRE (m)	MAINTENANCE (%)
Circular reserves									
16	Best	1418	50	1	0	0	0	0	0.01
	Worst	2836	85	2	1	1	2	2836	0.04
100	Best	3545	50	1	0	0	0	0	0.01
	Worst	7090	85	3	1	2	2	7090	0.04
500	Best	7927	50	2	0	0	0	0	0.01
	Worst	15 854	85	3	2	3	2	15 854	0.04
1000	Best	11 209	50	2	0	0	0	0	0.01
	Worst	22 418	85	3	3	4	2	22 418	0.04
5000	Best	25 066	50	3	0	0	0	0	0.01
	Worst	50 132	85	5	5	6	2	50 132	0.04
Peninsulas									
750	Best	2500	50	1	0	0	0	0	0.01
	Worst	2500	85	2	1	2	2	2500	0.04
1150	Best	2500	50	1	0	0	0	0	0.01
	Worst	2500	85	2	1	2	2	2500	0.04

[1] Worst scenario is 100% longer fenceline than the perfect circle used in the best scenario

[2] Basic costs as quoted in Day & MacGibbon (2001)

[3] Priced at the upper estimate ($10 000)

[4] The basic costs allows for one abutting fence per 250 m

The costs for conventional control begin in the third year after the fence construction year. This is because we assume in our model that a pest eradication programme will be operating during the first three years under either control system, at a fixed cost.

We provide the details of costs of the installation and maintenance of the electric fence at Cape Brett, and model the costs for an Xcluder™ fence of the same length.

3. Results

3.1 FENCING VERSUS CONVENTIONAL CONTROL

The total costs of fencing versus conventional control after 25 years for each scenario are given in Table 4. Fencing is probably a cost-effective solution for pest control in reserves of greater than 1000 ha, and on peninsulas, irrespective of the fenceline to area ratio. Fencing costs over 25 years are slightly more than conventional control in the best case scenario for a 500 ha reserve, but our worst case scenario fence is double the cost of the worst case scenario for conventional control. For 100 ha, the best-case scenario for fencing is less than the worst-case conventional control. The fence enclosing the 16 ha at Karapiro will have cost anything between 2 and 24 times the cost of conventional control over 25 years.

TABLE 4. TOTAL COST AFTER 25 YEARS OF FENCING VERSUS CONVENTIONAL CONTROL.

RESERVE SIZE (ha)	BEST SCENARIO ($)		WORST SCENARIO ($)	
	FENCE	CONVENTIONAL	FENCE	CONVENTIONAL
Circular				
16	100 915	14 720	362 232	49 680
100	244 488	96 000	1 388 370	310 500
500	545 473	480 000	3 061 366	1 552 500
1000	767 007	920 000	4 328 762	3 105 000
5000	1 707 555	4 600 000	9 501 418	11 675 000
Peninsula				
750	173 950	690 000	512 540	2 328 750
1150	173 950	1 058 000	512 540	3 570 750

The fence could become financially viable after as little as 5 years in the 5000 ha circular-reserve model, after 7 years for the 1000 ha model, and after 9 years for the 500 ha model (Fig. 1). For either peninsula model, the break-even point comes as early as 4 years (Fig. 2).

3.2 ELECTRIC VERSUS NON-ELECTRIC

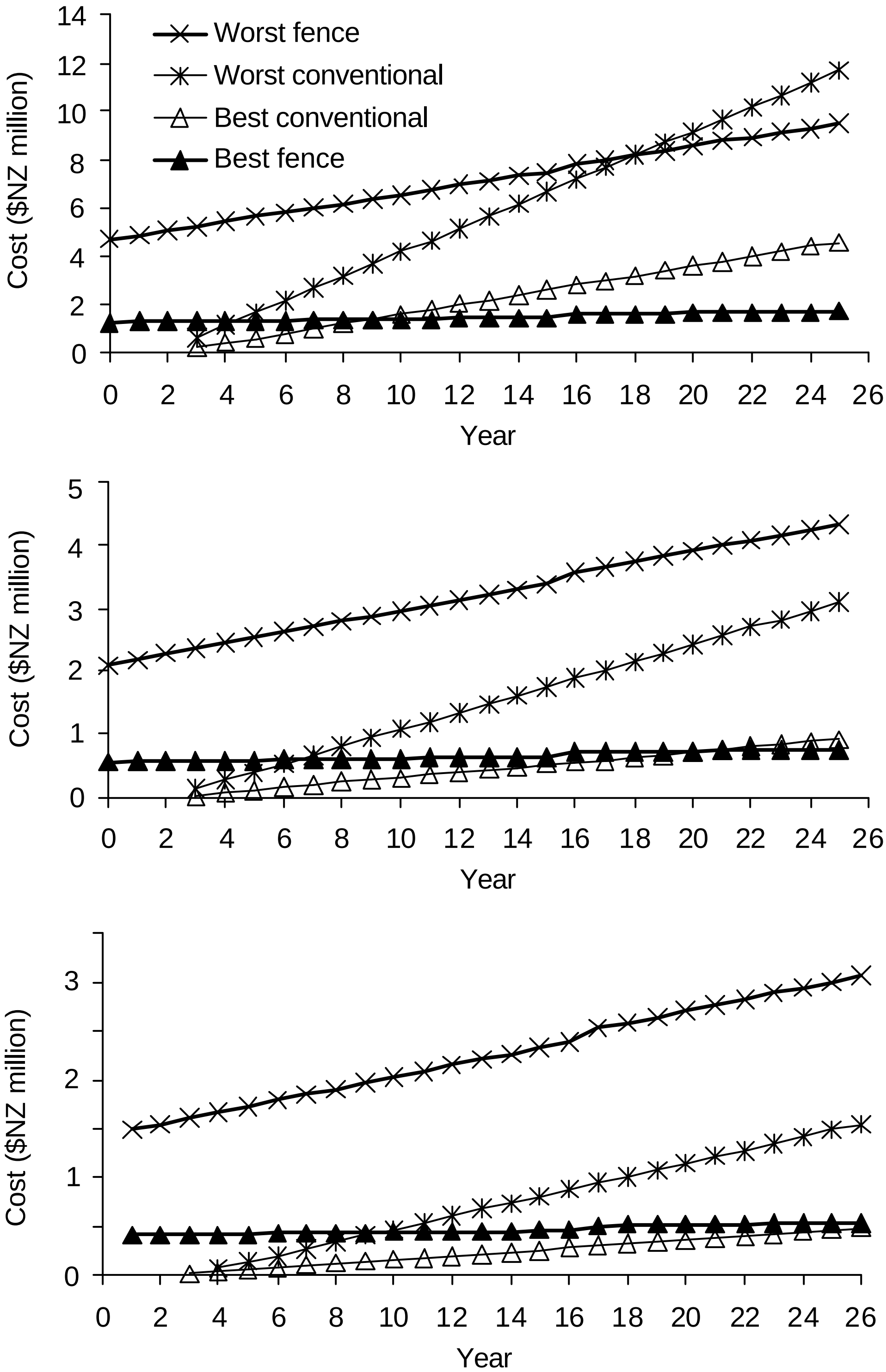
The electrified fence installed at Cape Brett is 2500 m long. It effectively excludes possums from a peninsula of 1150 ha. It cost just under $200 000 ($75 per metre). Maintenance costs of $3500 per year (2.7% of initial cost) include power and access by boat as well as repair works (C. McGee, pers. comm.). A non-electric fence of the same length, that would exclude all pests, would cost $129 000–$250 000 to install. We can assume that the maintenance costs would be close to those for the electric fence, as although there would be no power bill, access and repair costs would be similar.

4. Discussion

4.1 FENCING VERSUS CONVENTIONAL CONTROL

As expected, the cost of both construction and maintenance of the pest control fencing was strongly dependent on the length of fence. The peninsula situation lends itself particularly well for fencing because of the small fenceline to area ratio. The topography of New Zealand means that there are numerous peninsulas, for example in the Marlborough Sounds, and in Northland. Some of these peninsulas have difficult access. Although this will add to the transport costs involved in fence construction and maintenance, it will have just as much impact on the costs of ongoing conventional control. It should be noted, however, that some of these sites have only short stretches of water between them and adjacent land. The potential for re-invasion of stoats and other strong-swimming species should be included in any assessment of the feasibility of pest control strategies for these sites.

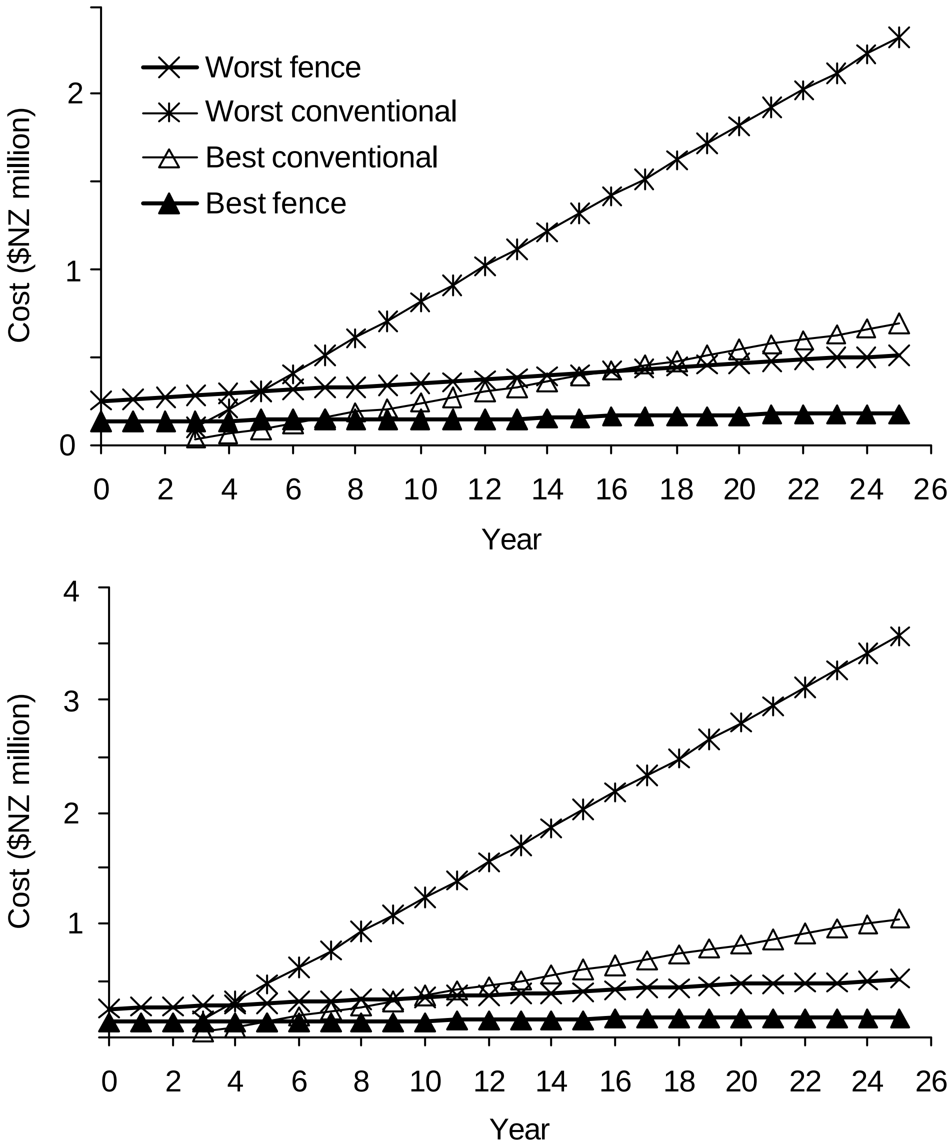
Figure 1. Annual cumulative costs of fencing and conventional control for (A) a 5000-ha reserve; (B) a 1000-ha reserve; and (C) a 500-ha reserve. Note the difference in vertical scale.



The fenceline to area ratio also works in favour of fencing for large reserves. This is offset by the fact that a large reserve is more likely to have more additional costs for fence construction. Also, the most cost-effective means of pest control can usually be used in large tracts of land (i.e. aerially-sown poison baits).

In the smaller reserves, conventional control is more likely to involve labour-intensive ground-based methods. It is therefore reasonable to assume the worst-case scenario conventional control (which was still conservative). Our model suggests that fencing should not be ruled out for pest control of reserves of 100 ha. Smaller areas cannot be cost-effectively fenced, as illustrated by the

Figure 2. Annual cumulative costs of fencing and conventional control for (A) a 750-ha peninsula; and (B) a 1150-ha peninsula. Note the difference in vertical scale.



Xcluder™ fence at Karapiro. At this site, although maintenance costs are probably overestimated, as the landowners easily do fence inspection, the initial cost of fence construction was at least twice the estimated amount to be spent on conventional control over 25 years.

4.2 COST ESTIMATES

There was large variability between the best- and worst-case scenarios for the fencing options. The worst cases may have been gross overestimates of costs for most real sites. Doubling the length of the fenceline over that of a true circle would require very rugged terrain, or convoluted boundaries. For example, the Xcluder™ fence protecting the 16-ha reserve at Karapiro is very convoluted and is 2300 m long. This is only 1.6 times the length of a circular fence protecting the same area. It is also very unlikely that the maintenance costs would ever be as high as 4% of the initial cost. Maintenance costs may often be lower than the 1% estimate, especially where there is involvement of local communities or other voluntary labour. It is likely that volunteers will play a significant role in small reserves. Additional costs from water crossings, gates etc. are only minor factors in determining the cost of the fence. For example, doubling the costs of all the additional cost factors in any of the models would change the final cost over 25 years by less than 10%.

4.3 LIMITATIONS OF FENCE OPTIONS

Even if fencing is cost-effective relative to conventional control, there are other limitations on using this option for pest control. Fencing involves a high capital investment. A tall fence makes a significant visual impact on an area that may not be acceptable to the community. Problems in acquiring consent from adjacent landowners and/or the local iwi for site clearance and fence construction may make the fence option untenable at some sites. There are similar social issues, however, associated with the use of toxins.

We know little about the impact of fencing on non-target species, for example flightless birds and invertebrates. While a fence will restrict dispersal of juveniles, this may be an advantage at some sites, preventing them from spreading out into areas where they will be easily targeted by predators.

For a fence to act as an effective pest-control system, it requires both effective initial pest eradication programmes, and reliable monitoring systems. While such systems are available for rodents and possums (Innes et al. 1995; Saunders 2000), they are still under development for mustelids (Brown & Miller 1998; Department of Conservation 2000; Robbins, Murphy & Clapperton unpubl. data). Monitoring costs may be lower for conventional control. For example, covers for the tracking tunnels may be already available if they were used for trap or bait station covers, and trap captures during the control programme can be used to assess changes in pest numbers.

The requirement for the fenced area to remain pest-free may be difficult to fulfil at some sites. For example, it is thought that wild pigs have been deliberately liberated over the fence at North Cape Scientific Reserve (Baigent-Mercer 2001).

4.4 ELECTRIC VERSUS NON-ELECTRIC

The $75 per m cost of the electric fence at Cape Brett is intermediate between the upper and lower cost estimates for an Xcluder™ fence, and maintenance costs are comparable. The Xcluder™ fence is therefore a better option because it has the advantage of excluding a wider range of pests (including stoats), and it is less prone to failure.

4.5 LIMITATION OF THIS STUDY

We have used reliable estimates of costs of fence construction, but we can only guess in our scenarios on the labour costs of fence construction, the length of fenceline, and number of additional cost items. Our models are also dependent on the reliability of the cost estimates provided by the Department of Conservation for conventional control.

The study is limited to a comparison of costs of the different control techniques, because of the lack of reliable information on the relative benefits of the control systems. We do not attempt to assess the impact of the different control systems on either numbers of pests or conservation outcomes (e.g. survival and breeding success of threatened species). We assume for our models that pests have been eradicated from the site. We are probably underestimating the value of fencing in that this control system is much more likely to provide an ongoing pest-free environment than would conventional control. Kiwi will soon be released into the fenced reserve at Karapiro, something that would be unlikely to happen in a similar area protected by conventional pest control. Fencing is therefore likely to have a greater positive impact than conventional control on conservation outcomes. For example, stoat control at Puketukutuku Peninsula costs $49 per ha per year, but in some years it does not protect the kiwi population from damaging levels of predation (J.A. McLennan, pers. comm.). In addition, fencing will have less direct impact on the threatened species than trapping and poisoning. These latter techniques carry a risk to the survival of non-target species. Fencing of even small reserves (e.g. at Karapiro) may produce the best outcome, worthy of the higher costs.

Our cost comparisons are presently valid, but we cannot predict how long they will remain so. The cost of constructing and maintaining a fence will vary with inflation, and changes in the exchange rate, and costs of materials, including new, improved materials. Conventional control costs may also change with these factors. In addition, improvements in trapping and poison techniques could lead to better cost-effectiveness.

4.6 CONCLUSIONS

Fencing is definitely a cost-effective pest control option for peninsulas and reserves of 5000 ha or more. Reserves between 100 and 1000 ha can probably be fenced cost-effectively, depending upon the topography of the site, the costs of conventional control, and the desired conservation outcomes. Even if fencing costs considerably more than conventional control, the likely enhanced conservation outcomes achieved in a totally pest-free site may make fencing the preferred option. This is particularly true for stoats, which are extremely difficult to control using currently available trapping and poisoning techniques. Not only will fencing provide more effective control, it is also likely to have less adverse environmental impacts than conventional methods.

Xcluder™ fences are as cost-effective as electric fences, and will exclude a wider range of pest species. Both electric and non-electric fences require a commitment to maintenance. Stoats, in particular, are likely rapidly to breach a fence if vegetation encroaches on it, if there are gaps in the mesh or, in the case of the electric fence, if there is a power failure.

Conventional control will continue to be the best option in situations where pest eradication is not necessary, or where only a few pest species are to be targeted. For example, ferret and possum control for the reduction in spread of bovine tuberculosis will probably be achieved as cost-effectively using conventional control as by fencing. Conventional control will also be preferred at sites where ground-dwelling fauna need to move beyond the limits of the reserve without human intervention.

5. Recommendations

- Exclusion fencing should be considered as an option for peninsulas, reserves of 5000 ha or more, smaller reserves with a topography that lends to a small fenceline length to area ratio and/or where effective conventional control is expensive, and any site where assured pest-free status is desirable.
- Accurate assessments are needed of the cost of conventional control.
- Information on the efficacy of both conventional control and exclusion fencing is needed before we can compare cost-benefit analyses of the different control systems. This will require reliable pest monitoring systems.
- We need information on the costs of both conventional control and exclusion fencing in terms of impact on non-target species, the environment, and social concerns.

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