Predator Free Banks Peninsula: Scoping Analysis

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Contents

Introduction ........................................................................................................................................... iii

Chapter 1 Background......................................................................................................................... 1
  1.1 Methods of analysis .................................................................................................................... 1
  1.2 Banks Peninsula ....................................................................................................................... 1
  1.3 Predators targeted .................................................................................................................... 2
  1.4 Predator free definition ........................................................................................................... 3
  1.5 Lessons learned ....................................................................................................................... 3

Chapter 2 Social................................................................................................................................... 5
  2.1 Support and opposition .......................................................................................................... 5
  2.2 Volunteers ............................................................................................................................... 5
  2.3 Financial support .................................................................................................................... 6
  2.4 Survey ................................................................................................................................... 6
  2.5 Legislation .............................................................................................................................. 6

Chapter 3 Technical............................................................................................................................. 9
  3.1 Introduction ............................................................................................................................. 9
  3.2 Grids ....................................................................................................................................... 9
  3.3 Predators ................................................................................................................................ 9
  3.4 Predator removal methods .................................................................................................... 11
  3.5 Broad scale strategies .......................................................................................................... 17
  3.6 Barriers .................................................................................................................................. 20
  3.7 Biosecurity ........................................................................................................................... 23

Chapter 4 Economic............................................................................................................................ 25
  4.1 Predator removal scenarios .................................................................................................... 25
  4.2 Predator-proof fence ............................................................................................................. 30
  4.3 Biosecurity ........................................................................................................................... 30
  4.4 Total cost and timeframes .................................................................................................... 31

Chapter 5 Summary and Conclusions ............................................................................................... 35

References .......................................................................................................................................... 37

Appendix 1 Current Banks Peninsula mammalian pest control programs....................................... 43
Appendix 2 Inventory of ongoing and completed predator control projects .................................... 45
Appendix 3 Predator Free Banks Peninsula Survey ............................................................................ 53
List of Tables

Table 1  Invasive mammalian species on Banks Peninsula and their distribution ......................... 2
Table 2  Traps considered for removing predators from Banks Peninsula ................................. 12
Table 3  Costs of constructed and proposed predator proof fences in New Zealand .................. 21
Table 4  Comparison of the proposed Half Moon Bay project and a potential Banks Peninsula project ................................................................. 25
Table 5  Cost of predator removal: Scenario One ........................................................................ 26
Table 6  Time for predator removal: Scenario One ................................................................. 27
Table 7  Cost of predator removal: Scenario Two .................................................................... 27
Table 8  Time for predator removal: Scenario Two ................................................................... 28
Table 9  Cost of predator removal: Scenario Three ............................................................... 28
Table 10 Time for predator removal: Scenario Three .............................................................. 29
Table 11 Cost of predator removal: Scenario Four ................................................................. 29
Table 12 Time for predator removal: Scenario Four ............................................................... 30
Table 13 Setup and ongoing costs of monitoring for predator incursions ................................... 30
Table 14 Estimated total cost (including GST) and time for predator free Banks Peninsula ....... 33
Table 15 Comparison of total initial costs of predator removal .................................................. 34

List of Figures

Figure 1  Pre-2006 Banks Peninsula District and Christchurch City District boundaries (Christchurch City Council, 1999) ................................................................. 1
Figure 2  Extent of proposed predator free Banks Peninsula ....................................................... 18
Figure 3  A simplified example of a rolling front predator removal operation on Banks Peninsula ......................................................................................................................... 20
Figure 4  The extent of a proposed predator-proof fence .......................................................... 22
Introduction

There has been considerable public interest and enthusiasm over predator control following the release of the government’s goal to make New Zealand predator free by 2050 (Kirk, 2016). For a number of reasons predator free Banks Peninsula is an attractive starting location.

There is only a small strip of land connecting Banks Peninsula to the mainland relative to the total area of the Peninsula. Many native species vulnerable to mammalian predators inhabit Banks Peninsula (Haley, 2015). These factors make the removal of predators from Banks Peninsula worthy of investigation.

Fenced ecosanctuaries and island eradications demonstrate that positive outcomes are achievable with current predator control technology. Despite these positive outcomes, ability to eradicate predators from large mainland areas contiguous with other land presents additional challenges and so is less likely to be successful. The public’s perception of predator control capabilities in these contexts may currently exceed what is possible (Cox & Haley, 2015). Achieving a predator free Banks Peninsula, considering both the scale and complexity such an initiative would entail, and the difficulty of preventing reinvasion, particularly while allowing continuous public access.

The Rod Donald Banks Peninsula Trust commissioned this research to identify the realistic steps for achieving the goal of a predator free Banks Peninsula using existing technology, along with estimating the likely cost and timelines.

This report also includes a review of the groups currently engaged in mammalian pest control programmes on Bank Peninsula (Appendix 1), a review of previous predator control and eradication projects in New Zealand and overseas (Appendix 2), and a survey for Banks Peninsula landholders (Appendix 3). The purpose of the landholders’ survey is to assess community support for the predator free Banks Peninsula concept and to identify barriers preventing the community from becoming involved, and barriers that the community may pose to implementation.

This report has four sections. The Background section discusses the broad parameters of predator free Banks Peninsula. The Social section discusses the challenges associated with achieving community support for a predator free Banks Peninsula. The Technical section discusses the technical challenges and potential methods for achieving a predator free Banks Peninsula. The Economic section discusses likely costs and timelines of the proposed methods.

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1 See Appendix 2 Mainland islands and peninsula ecosanctuaries
2 See Appendix 2 Islands
Chapter 1
Background

1.1 Methods of analysis
A review of completed and ongoing predator control and eradication projects identified the broad scale parameters and lessons. A subsequent review of predator control literature identified viable methods. Finally, interviews were undertaken with local experts in the predator control field. The information derived from these sources was synthesised to create this report.

1.2 Banks Peninsula
Banks Peninsula is on the east coast of New Zealand’s South Island. Banks Peninsula was once a separate territorial authority (see Figure 1). However, it amalgamated with Christchurch City in 2006 (Statistics New Zealand, 2006). The pre-2006 Banks Peninsula District was 115,600 ha (Christchurch City Council, 1999) and had a population of 8,235 (Christchurch City Council, 2016). Banks Peninsula is a largely rural area, with a wide variety of land uses. Many different groups own and manage land, including private owners, the Christchurch City Council (CCC), the Department of Conservation (DOC). Covenants, including Queen Elizabeth II National Trust (QEII) covenants, protect some areas.

Figure 1
Pre-2006 Banks Peninsula District and Christchurch City District boundaries
(Christchurch City Council, 1999)
1.3 Predators targeted

Fifteen invasive mammalian pest species currently inhabit Banks Peninsula (Table 1). Many of these species are already under some level of control. Appendix 1 provides an overview of the current Banks Peninsula mammalian pest control programmes. The most successful of these programmes is probably the Wildside Project, which was initially set up for the protection of native pelagic bird breeding sites in the Banks Peninsula south-eastern bays.

An ecological definition of a predator is “An organism that kills and partially or entirely consumes another individual” (Ricklefs & Relyea, 2014, p. G8). Banks Peninsula is home to a variety of both native and invasive predators. This report considers removal of five invasive mammalian predators; Norway rats, ship rats, Australian brushtail possums, stoats and ferrets, which have significant negative impacts on the abundance of New Zealand native biodiversity (Norton, 2009; Scofield, Cullen, & Wang, 2011). These five species are those the Rod Donald Banks Peninsula Trust being is considering for removal from Banks Peninsula and we refer to them as “predators” throughout this report.

Other mammalian predators having negative impacts on the native biodiversity of Banks Peninsula include cats, hedgehogs and weasels (Parkes, 2009). Failure to remove cats and weasels from Banks Peninsula will impede successful reintroduction of native birds (Marie Haley, BPCT Wildside coordinator, personal communication, January 14, 2017). This report does not address cats, hedgehogs, or weasels. However, methods used for targeting stoats often kill weasels (Parkes, 2009).

Interspecies relationships are very complex. For example, mice and rats compete with each other for resources (Parkes, 2009). Therefore, the complete removal of rats from Banks Peninsula may lead to an increase in mice abundance (Ruscoe et al., 2011). Stoats and ferrets are predators of rabbits and hares. Therefore, removal of stoats and ferrets from the Peninsula is likely to increase the abundance of rabbits and hares. There may be other unforeseen consequences on the biodiversity of Banks Peninsula by removing the predators. Assessment of all the potential consequences is beyond the scope of this scoping study.

Table 1
Invasive mammalian species on Banks Peninsula and their distribution
(Adapted from Parkes (2009). Shaded cells are the target species for this study)

<table>
<thead>
<tr>
<th>Species</th>
<th>Banks Peninsula distribution</th>
<th>Main habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possum (Trichosurus vulpecula)</td>
<td>Widespread</td>
<td>Most habitats</td>
</tr>
<tr>
<td>Ship rat (Rattus rattus)</td>
<td>Widespread</td>
<td>Mostly in forest</td>
</tr>
<tr>
<td>Norway rat (Rattus norvegicus)</td>
<td>Local</td>
<td>Usually commensal</td>
</tr>
<tr>
<td>Stoat (Mustela erminea)</td>
<td>Widespread</td>
<td>Most habitats with rodents</td>
</tr>
<tr>
<td>Ferret (Mustela furo)</td>
<td>Patchy</td>
<td>Mostly grassland with rabbits</td>
</tr>
<tr>
<td>Rabbit (Oryctolagus cuniculus)</td>
<td>Patchy</td>
<td>Grassland</td>
</tr>
<tr>
<td>Feral goat (Capra hircus)</td>
<td>Patchy</td>
<td>Most habitats</td>
</tr>
<tr>
<td>Feral cat (Felis catus)</td>
<td>Widespread</td>
<td>Most habitats</td>
</tr>
<tr>
<td>Hare (Lepus europaeus)</td>
<td>Patchy</td>
<td>Grassland</td>
</tr>
<tr>
<td>Mouse (Mus musculus)</td>
<td>Widespread</td>
<td>Most habitats</td>
</tr>
<tr>
<td>Weasel (Mustela nivalis)</td>
<td>Unknown</td>
<td>Most habitats with mice</td>
</tr>
<tr>
<td>Hedgehog (Erinaceus europaeus)</td>
<td>Widespread</td>
<td>Mostly in grassland</td>
</tr>
<tr>
<td>Red deer (Cervus elaphus)</td>
<td>Local</td>
<td>Mostly in forest/scrub</td>
</tr>
<tr>
<td>Fallow deer (Dama dama)</td>
<td>Local</td>
<td>Mostly in forest/scrub</td>
</tr>
<tr>
<td>Feral pig (Sus scrofa)</td>
<td>Local</td>
<td>Most habitats</td>
</tr>
</tbody>
</table>
1.4  Predator free definition

In this report the definition of “predator free” is control of predators at population densities of zero. An alternative to control of predators at population densities of zero is eradication. Eradication essentially means that predators will not reinvade following the stopping of control programs (Bruce Warburton, Landcare Research wildlife ecology and management research leader personal communication, November 29, 2016).

The following elements are required for successful species eradication:

- Every individual of a target species must be exposed to an effective control method (Parkes & Murphy, 2003).
- The target species must be killed faster than they can reproduce (Parkes, 1990).
- There must be zero immigration of the target species (Parkes, 1990).

Ensuring an eradication programme has all of these elements and proving the eradication was successful can be challenging. For such reasons the eradication of predators is normally only possible on New Zealand’s remote offshore islands. Due to the scale, complexity, and attachment to the mainland, eradication of predators from Banks Peninsula is not possible as some level of immigration is unavoidable.

Mainland ecosanctuaries attempt to mitigate immigration with predator-proof fences. However, these sanctuaries often leak and require active control to maintain targeted pest species at zero densities (Scofield, Cullen, & Wang, 2011; Innes et al., 2012). Control includes fence maintenance, monitoring and trapping. Existing mainland ecosanctuaries do not achieve eradication because of the ongoing control required (Bruce Warburton, personal communication, November 29, 2016).

Control of predators on Banks Peninsula at zero densities (similar to that of mainland ecosanctuaries) is technically possible. Therefore, in this report we define Banks Peninsula to have achieved predator free status when predators are controlled at population densities of zero.

An alternative is control of predators at low densities. Control at low densities accepts a persistent predator population. The advantage of control of predators at low densities is the initial predator removal operation is often much less expensive compared to eradication or control at zero densities. For example, an operation removing 95% of possums in an area is around $20-$30 ha⁻¹, while an operation removing 100% of possums from an area is around $400 ha⁻¹ (Bruce Warburton, personal communication, November 29, 2016).

Considering control of predators both at zero densities and at low densities have ongoing costs, control at low densities could prove a more cost effective solution long term. However, because control of predators at low densities does not achieve predator free status it is not considered further in this report.

1.5  Lessons learned

There have been numerous eradication and control projects targeting rats, possums, stoats and ferrets both in New Zealand and overseas. Eradication projects have been predominantly on offshore islands. The largest successful New Zealand eradication of predators is the eradication of Norway rats from the 11,330 ha Campbell Island (McClelland, 2011). The success of the 2001 Campbell Island eradication was the catalyst for the South Georgia Norway rat eradication initiated in 2011. With a total area of 375,000 ha and a treatment area of 108,423 ha, South Georgia is the largest successful rat eradication project in the world (South Georgia Heritage Trust, 2014). The treatment area is comparable in size to Banks Peninsula.

There has been increasing success controlling predators at zero densities on mainland New Zealand through the use of predator-proof fences to create “mainland islands” (Beaven, 2008). The largest
successful mainland island is the 3,400 ha Maungatautari Ecosanctuary where predators are controlled at zero density (Speedy, Day, & Innes, 2007). The control of predators at zero densities has also been successful on mainland peninsulas such as the 500 ha Shakespear Sanctuary and the 550 ha Tawharanui Sanctuary (Maitland, 2011).

All mainland islands and peninsula ecosanctuaries have had periodic reinvasions and have required ongoing vigilance to maintain predators at zero densities. Peninsula ecosanctuaries are vulnerable to reinvasion via the gaps that occur at low tide between the ocean and the predator-proof fence. The vast majority of successful eradications used aerial broadcast brodifacoum to kill predators. This method is not suitable for areas inhabited by humans or livestock, such as the majority of Banks Peninsula and in projects such as Cape to City.

The area within the Hawkes Bay Cape to City project has many similarities to Banks Peninsula, including a relatively large area (26,000 ha) and many different land uses (Glen et al., 2016). A major challenge for Cape to City is the impact a lack of participation by large landholders has on success of the project (Glen et al., 2016). Discussion of the possible challenges this raise for a predator free Banks Peninsula occurs in the next section.

A more detailed review of notable predator control and eradication projects is located in Appendix 2.
2.1 Support and opposition

The community will have a significant impact on the success of predator free Banks Peninsula through their political support, volunteer labour, financial support, and provision of land access. A community’s support for pest management programs is dependent upon personal interests, the goal of the programme, the characteristics of those participating and control methods used (Glen et al., 2016).

A particularly controversial predator control method used in New Zealand is the aerial broadcast of toxic baits containing sodium fluoroacetate (1080). There was low support for such a method from full-time Stewart Island residents, with only 18% supporting the use of aerial broadcast toxin for the proposed removal of predators on the Island (Coats, 2014). Although Banks Peninsula and Stewart Island residents’ values could differ, it is likely that a significant proportion of Peninsula residents will not support particular predator control methods. The Banks Peninsula community is particularly concerned with the potential impact of toxins on dogs and the water supply (Marie Haley, BPCT Wildside coordinator, personal communication, January 14, 2017). A method that may become viable for predator control on Banks Peninsula in the future is genetic engineering. In our discussions with experts, several voiced the opinion that genetic engineering for predator control is also likely to be particularly controversial. Some methods used to prevent reinvasion, such as the construction of a predator proof-fence, may also be resisted by member of the community.

Some landholders may only permit the use of specific methods of predator control on their property. Identifying and employing supported methods of predator control will require working closely with the community and landholders. Further, opposition to predator free Banks Peninsula may occur because of other values of the targeted species. For example, there may be opposition to removal of possums because of the economic value derived from possum fur harvesting.

Individual landowners have the capability to limit the feasibility of eradication projects (Parkes, Byrom & Edge, 2017) by denying or obstructing access to land or through sabotage. Non-eradication of predators on some properties, resulting in reinvasion from unmanaged areas may reduce the success of control at a landscape scale (Glen et al., 2016). The Banks Peninsula feral goat control programme illustrates the impact of not undertaking control on some properties; protective and obstructive landholders have allowed goats to re-establish themselves in previously cleared areas (ECan, 2016).

Placing traps around the edges of land not subject to predator control can mitigate the reinvasion of stoats and ferrets from uncontrolled areas to controlled areas. However, this is less effective for areas greater than 800 ha (Glen et al., 2016). Therefore, establishing good relationships with the holders of large land areas is particularly important. Rats and possums have much smaller home ranges than stoats and ferrets, so for rodents even a relatively small amount of excluded land could provide a source stock from which reinvasion could occur.

2.2 Volunteers

Volunteer labour makes up a large proportion of many New Zealand predator free initiatives. Zealandia Ecosanctuary has 400 volunteers, the equivalent to 35 full-time staff, the Maungatautari Ecosanctuary has nearly 500 volunteers (approximately 15 full time equivalents), and the Orokonui Ecosanctuary has 100 volunteers, equivalent to 6.5 full time staff (Karori Sanctuary Trust, 2016; Maungatautari Ecological Island Trust, undated; Orokonui Ecosanctuary, undated).

Important tasks often performed by volunteers include trap checking and monitoring the predator proof fence for damage or signs of intrusion. Such efforts by volunteers increase the effectiveness of
ecosanctuaries. Volunteers could also make up a significant component of predator free Banks Peninsula project. For example, one suggestion is for the residents of each Akaroa street to take responsibility for checking a trap line. (Marie Haley, PBCT Wildside coordinator, personal communication, January 14, 2017).

2.3 Financial support

Some community members may provide financial support for predator free Banks Peninsula. Sponsors make up a significant proportion of the funding for ecosanctuaries such as Zealandia and Orokonui (Karori Sanctuary Trust, 2016; Otago Natural History Trust, 2016). Evaluation of funding availability for predator free Banks Peninsula is beyond the scope of this report.

2.4 Survey

Because of the critical role of the community in success of predator eradication, it is important to gauge the level of community support, the key community concerns, and the broader effects of the eradication programme to identify barriers. One method for doing so is to survey the community. To that end, we have developed a draft survey of Banks Peninsula landholders to identify such factors (Appendix 3). Amongst other things, this survey seeks to identify the motivations of the community, and the methods of predator control that are currently acceptable to the community.

2.5 Legislation

For a successful predator eradication project there can be no objectors to the project on private or public land who have the power to enforce their objections (Parkes, Byrom & Edge, 2017). The initial removal of predators from Banks Peninsula is essentially the same as eradication. An adequate legislative framework may restrict the impact of objectors to predator free Banks Peninsula. In cases where landholders deny or obstruct access to land for predator control, or attempt sabotage, enforcement actions may be possible if appropriate planning provisions exist.

Pests on Banks Peninsula are managed under the Biosecurity Act 1993, the National Pest Management Strategy for Bovine TB and, principally, the Canterbury Regional Pest Management Strategy 2011-2015 (CRPMS. Ecan, 2011), which has had its life extended until implementation of a new plan. The CRPMS lists rats, possums, stoats, and ferrets as follows:

- The strategy classifies ferrets, stoats, and possums as containment pests in high-value environmental areas only, and for possums in community initiative programmes. The objective for containment pests is “to minimise the actual or potential externality impacts of the pest or to prevent their spread to new or neighbouring areas or properties” (Ecan, 2011, p.9). This objective falls below the long-term objective of eradication for pests classified as eradication pests.
- The CRPMS does not identify specific objectives for control of stoats or ferrets.
- The CRPMS has an objective to maintain possum populations at <10 per cent Residual Trap Catch within Community Initiative Programme areas; and some provisions are made for the regional council to carry out control without explicit agreement with land occupiers (ECan, 2011, p. 39). However, this is only within Community Initiative Programme areas.
- The CRPMS classifies both Norway and Ship rats as organisms to be controlled. The CRPMS states: “Such organisms are not accorded pest status and control of them will only be undertaken in conjunction with co-operating land occupiers” (Ecan, 21011, p.11).

The absence of clear objectives relating to stoats and ferrets, and the requirement for land occupier agreement for rat control operations on their properties, limit the ability for using the current CRPMS to support key actions required for predator free Banks Peninsula. Environment Canterbury is currently reviewing the CRPMS (ECan, 2015; Ecan 2016a). The proposed Regional Pest Management
Plan is due for release in June 2017, to be operative by June 2018 (Ecan, 2016b). However, Ecan has signalled the new plan will support a new direction “Environment Canterbury is proposing a change in the way we undertake pest management, focusing more on preventing new pests entering the region” (Lambie, 2016). At this point, it is unknown whether the new plan will provide adequate powers to ensure completion of essential predator free Banks Peninsula projects. Failure to do so would present a significant risk to a predator free Banks Peninsula programme.

Resource consent under the Resource Management Act 1991 will be required for the construction of any predator-proof fence, and for aerial application of toxins.
Chapter 3
Technical

3.1 Introduction
Effective predator control requires exposing each individual to an effective and humane control method, killing predators faster than they can reproduce, and preventing immigration, or detecting and eliminating immigrants. The second of these is addressed in a later chapter. We begin this chapter by considering present control activities and requirements for exposing all individuals to a control method by examining the grid concept. Discussion then moves to management of immigration.

3.2 Grids
Grids are an important concept in predator control and apply to the layout of traps, bait stations, broadcast toxins, and monitoring devices. For effective exposure of every individual predator to a control item, the grid density must be smaller than the individual predator’s minimum home range. If a grid is not dense enough to intercept an individual predator’s minimum home range the individual may never encounter a trap or bait station. Hence, it is critical to understand every species’ home range. Habitat type, population density, and feed availability, amongst other things, affect home range size and we do not have that level of detail for the variety of habitats on Banks Peninsula. A pilot study identifying the Bank Peninsula predator home ranges would help to confirm the appropriate grid densities.

3.3 Predators
Each predator has its own specific challenges. With current aerial and trapping technology only ferrets, stoats, cats, and possums are currently considered controllable on Banks Peninsula and only in specific areas (Cox & Haley, 2015). This section discusses the specific challenges posed by each predator.

3.3.1 Rats
Banks Peninsula is home to both Norway rats (Rattus norvegicus) and ship rats (Rattus rattus). Active control of rats occurs only in a few specific Banks Peninsula locations considered particularly vulnerable to these species. Three sites that use targeted bait stations are located within the Wildside Project (Haley, 2015). Between 2009 and 2014, rats accounted for 10% of the total kills in the Wildside predator control programme (Cochrane, 2014). Rats can reach densities of 6.2 ha⁻¹ (Innes, 2005), so Wildside Project kills are unlikely to have had a meaningful impact on the rat population.\(^3\)

The swimming ability of both Norway and ship rats means that significant areas of the Banks Peninsula coastline would be vulnerable to reinvasion. Such risk could be mitigated by extending a predator proof fence or buffer zone along the Peninsula coast. Another consideration is that rats can be neophobic (Cox & Haley, 2015), fear new or unfamiliar objects, including traps, which may result in selection for rats displaying this trait.

Norway rats (Rattus norvegicus)
Norway rats primarily live in towns and intermittently in forests (Parkes, 2009). Norway rats are very competent swimmers; hence, they are often called “water rats”, they can swim up to 1 km (Russell et al., 2008).

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\(^3\) Maximum rat density of 6.2 ha⁻¹ applied to the whole of Banks Peninsula would equate to over 700,000 rats. The true rat population will likely be fewer due to the less than favourable grassland habitat that covers much of the peninsula. Given rat’ high reproductive rate this indicates the potential scale of annual kills required to eliminate the population.
Ship rats (*Rattus rattus*)

Ship rats are likely to be present in all forest and scrub habitats on Banks Peninsula (Parkes, 2009). Ship rats are capable swimmers but not to the same extent as Norway rats. Individual ship rats can swim up to 500 m (Beaven, 2008). Ship rats are also very good climbers (Parkes, 2009). This can make them particularly adept at penetrating obstacles such as predator proof fences.

Rat grid

The minimum home range of rats is very small relative to the other predators. Therefore, rats require a relatively dense grid to ensure exposure of all individuals to the control method. The recommended grid density for removing rats varies slightly among experts and agencies. The Department of Conservation and Landcare Research both suggest grid densities for controlling rats of 100m x 50m (2 ha⁻¹) and 100m x 25m (4 ha⁻¹), dependent on the habitat (DOC, 2011; Landcare Research, undated). Tim Sjoberg, ZIP Animal behaviour technician, suggests a grid density of 50m x 50m (4 ha⁻¹) for the eradication of rats (personal communication, November 28, 2016).

A grid density of 50m x 50m (4 ha⁻¹) is the most conservative of those above, we therefore assume a grid density of 4 ha⁻¹ for removing rats from Banks Peninsula.

3.3.2 Possums

Possums are found almost everywhere on Banks Peninsula, with higher densities in scrub and forest habitats (Parkes, 2009). There is limited control of possums through the Banks Peninsula Community Initiated Possum Programme, managed by Environment Canterbury since 2006. The programme encompasses the majority of the Peninsula (93,000 ha) and had eradicated at least 21,997 possums by 2014 (ECan, 2014b). The overall effect has been small, with an average annual possum kill of about 0.03 ha⁻¹. However, areas considered to have high biodiversity value (such as Wildside) have received intensive possum control, which resulted in a Residual Trap Catch (RTC) of 1.4% in the core Wildside area (2,543 ha) (ECan, 2014a). Between 2009 and 2014, possums accounted for 5% of the total kills in the Wildside predator control programme (Cochrane, 2014). Landholders also conduct their own possum control throughout the Peninsula, supported by the Banks Peninsula Pest Liaison Committee (ECan, 2012).

Possum grid

The Department of Conservation’s official best practice grid for controlling possums is 150m x 150m (0.44 ha⁻¹) (DOC, 2013). The proposed Halfmoon Bay (Stewart Island) project recommended a 100m x 100m grid (1 ha⁻¹) for removing possums (Ewans, 2014). Since the goal of the proposed Halfmoon Bay project, control at zero densities, is the same as for Banks Peninsula, we assume a grid of 100m x 100m (1 ha⁻¹) is necessary for Banks Peninsula possum removal.

3.3.3 Stoats

Stoats are distributed throughout Banks Peninsula, with densities that vary with the season and the presence of rodents (which are the primary prey of stoats) (Parkes, 2009). Stoats are the principal species targeted by the Wildside project and accounted for 7% of kills between 2009 and 2014 (Cochrane, 2014).

Stoats are excellent swimmers, with the ability to swim up to 3km (Veale et al., 2012). Therefore, large areas of Banks Peninsula are vulnerable to reinvasion from stoats.

Stoat grid

The recommended grid size for control of stoats varies. The Department of Conservation’s official best practice standard is a 200m x 1000m grid (0.05 ha⁻¹) (DOC, 2013). However, more intensive operations, such as the Moehau kiwi recovery operation, have applied a 100m x 1000m grid (0.10 ha⁻¹) (Landcare Research, undated). James Ross, senior ecology lecturer at Lincoln University, suggested a similarly intensive grid of 300m x 300m (0.11 ha⁻¹) (personal communication, November 23, 2016). We assume a required grid density of 0.10 ha⁻¹ for removing stoats from Banks Peninsula.
3.3.4 Ferrets

Ferrets have patchy distribution over the Peninsula and are in highest densities where rabbits are also present (Parkes, 2009). Rabbits are the primary prey of ferrets and preferred rabbit habitat is grassland. Ferrets are controlled within the Wildside predator control programme, where they accounted for 1% of kills between 2009 and 2014 (Cochrane, 2014). Ferrets are capable of swimming significant distances and are very good at digging (Ragg, 2010). These abilities give ferrets the potential to both swim around and dig underneath predator-proof fences, increasing the risk of them reinvading.

Ferret grid

The appropriate grid for ferrets is dependent on habitat and many other factors. Furthermore, as with other species, there are differing opinions on the appropriate grid size. Landcare Research suggests a grid of 200m x 800m-1000m (0.06-0.05 ha⁻¹) (Landcare Research, undated). Ragg (2010) has suggested placement of 10 traps or bait stations per square kilometre (0.10 ha⁻¹) in strategic locations, rather than following a uniform layout. We assume a required grid density of 0.10 ha⁻¹.

3.4 Predator removal methods

There are few proven effective methods for large, human-occupied, landscape scale pest control (Cox & Haley, 2015). This section discusses the methods considered most likely to achieve the goal of removing predators from Banks Peninsula.

3.4.1 Traps

There is a vast array of conventional (non-toxic) traps available. In New Zealand, traps are regulated under the Animal Welfare Act 1999 and the National Animal Welfare Advisory Committee (NAWAC) guidelines. Table 2 outlines traps considered suitable for targeting Banks Peninsula predators. The majority of these traps are single use and require manual resetting after each kill. Two are gas powered self-resetting traps.

There is no single trap on the market that complies with NAWAC guidelines and that also can effectively kill all the target species (rats, possums, stoats and ferrets). Therefore, a combination of traps would be required. Ineffectiveness does not imply the trap does not kill the target species, but simply that that type of trap is unreliable, or is incapable of complete control. There will be bycatch with any type of trap. Hence, failure to attain NAWAC approval for a particular species does not mean that type of trap will not contribute to control of that species when deployed to target other species. However, we recommend the use of only NAWAC approved traps.

Advantages of trapping

The use of traps does not release toxins into the environment, making trapping a relatively socially acceptable predator control method (Brown et al., 2015). Conventional trapping has relatively low by-kill because traps can be set up to prevent access by non-target species. Furthermore, using a variety of lures can mitigate, but not eliminate, some target species becoming bait averse. However, trap aversion can still present a challenge when relying on one control tool.

Disadvantages of trapping

Trapping has successfully eradicated rats from islands of less than 15 ha (Howald et al., 2007). However, trapping is relatively unproven in large-scale eradication projects.

Trapping has successfully controlled (rather than eradicated) large predators, such as stoats and possums, at low densities at large scales, but rarely for large-scale control of rats (Brown et al., 2015). A reason for the limited success of traps for control of rats beyond 10 ha is the high density of traps required (Brown et al., 2015).
Another potential disadvantage is trap aversion, which can occur if an animal survives a trap encounter, an event that is more likely with incorrectly set traps (Cox & Haley, 2015). Trapping can also have some environmental impact through the creation of access and trapping routes.

Table 2
Traps considered for removing predators from Banks Peninsula

<table>
<thead>
<tr>
<th>Trap name</th>
<th>Trap type</th>
<th>Cost Including GST</th>
<th>Rats</th>
<th>Stoats</th>
<th>Possums</th>
<th>Ferrets</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC 150</td>
<td>Single use</td>
<td>$72.45</td>
<td>Passes NAWAC</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>DOC 200</td>
<td>Single use</td>
<td>$78.20</td>
<td>Passes NAWAC</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>DOC 250</td>
<td>Single use</td>
<td>$149.50</td>
<td>Passes NAWAC</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
<td>Passes NAWAC</td>
</tr>
<tr>
<td>Sentinel</td>
<td>Single use</td>
<td>$30.48</td>
<td>Ineffective</td>
<td>Ineffective</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Victor Easy Set</td>
<td>Single use</td>
<td>$6.79</td>
<td>Passes NAWAC</td>
<td>Fails NAWAC</td>
<td>Ineffective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>(Modified) Victor</td>
<td>Single use</td>
<td>$13.69</td>
<td>Passes NAWAC</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Nooski Trap System</td>
<td>Single use</td>
<td>$19.89</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
<td>Ineffective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Warrior</td>
<td>Single use</td>
<td>$37.38</td>
<td>Ineffective</td>
<td>Ineffective</td>
<td>Passes NAWAC</td>
<td>Fails NAWAC</td>
</tr>
<tr>
<td>Timms</td>
<td>Single use</td>
<td>$54.05</td>
<td>Inffective</td>
<td>Ineffective</td>
<td>Fails NAWAC</td>
<td>Fails NAWAC</td>
</tr>
<tr>
<td>Trapinator</td>
<td>Single use</td>
<td>$51.75</td>
<td>Ineffective</td>
<td>Ineffective</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Goodnature A12</td>
<td>Self-resetting</td>
<td>$171.93</td>
<td>Ineffective</td>
<td>Ineffective</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Goodnature A24</td>
<td>Self-resetting</td>
<td>$171.93</td>
<td>Passes NAWAC</td>
<td>Passes NAWAC</td>
<td>Ineffective</td>
<td>Ineffective</td>
</tr>
</tbody>
</table>

4 Cost of single trap and box (including GST) (Predator Traps, 2014)
5 Landcare research NAWAC trap tests results (Landcare Research, 2013)
6 DOC 150 traps are only designed for rats, hedgehogs and stoats (DOC, 2015a)
7 DOC 200 traps are only designed for rats, hedgehogs and stoats (DOC, 2016)
8 DOC 250 traps are only designed for rats, hedgehogs, stoats and ferrets (DOC, 2015b)
9 Sentinel specifications and price (including GST) (Pest Control Research, undated c)
10 Cost of single Victor easy set trap (including GST) (Pest Control Research, undated e)
11 Victor Easy Set rat traps are designed only for rats (Victor, undated)
12 Cost of single modified Victor easy set trap (including GST) (Pest Control Research, undated f)
13 Cost of single Nooski trap (including GST) (Pestgard, undated)
14 Nooski traps are designed only for rats and mice (Nooski Ltd, undated)
15 Warrior trap specifications and price (including GST) (Combined Industries, undated)
16 Timms trap specifications and price (including GST) (Pest Control Research, undated d)
17 Cost of single trap if purchasing 21+ (including GST) (Pest Control Research, undated a)
18 Trapinator traps are only designed and NAWC approved for possums (CMI Springs, undated)
19 Goodnature A12 trap specifications and price (including GST) (Goodnature, undated)
20 Evaluation of Goodnature A12 Humaneness (Jansen, 2010)
21 Evaluation of Goodnature A24 Humaneness (Jansen, 2011)
22 Goodnature A24 trap specifications and price (including GST) (Goodnature, undated)
**NAWAC approval**

Three traps do not have approval for species for which they could be effective. The Timms trap is not recommended because, despite its ease of use and effectiveness against cats, it is ineffective against rats and stoats, and does not have NAWAC approval for possums or ferrets. The Warrior trap would be effective against ferrets, but is not NAWAC approved for this species. That would not prevent use of Warrior traps to target possums, however, because ferrets and stoats require different baits, so there is no significant bycatch of ferrets in traps set for possums. The unmodified Victor Easy Set rat trap is NAWAC approved for rats, but not for stoats. Significant stoat bycatch would occur with this trap, raising questions about its suitability. However, these questions are of low relevance given the opportunity to use modified Victor Easy Set rat traps, that are NAWAC approved for both rats and stoats, at little extra cost.

**Single use traps**

The DOC 250 trap can effectively target rats, stoats and this is the only trap capable of humanely killing ferrets (Predator Traps, undated). This trap is deployed in a box that provides weather protection, and prevents bycatch of other species, particularly native birds. The box is a simple wooden tunnel with mesh grills. It is heavy and cumbersome to transport. At $149.50 including GST each, a stainless steel DOC 250 in box is much more expensive than the other single use traps considered (Predator Traps, 2014). Therefore, a cheaper alternative trap to supplement the DOC 250 for targeting rats and stoats is likely to be more cost effective than using DOC 250s exclusively for targeting these species.

The Modified Victor Easy Set rat trap has proven effective at targeting rats and stoats (Landcare Research, 2013). The Modified Victor Easy Set rat trap is also only $13.69 including GST (Pest Control Research, undated f). However, Modified Victor Easy Set rat traps do not offer a box as standard so are prone to killing native birds (Pest Control Research, undated). The lack of a box as standard also exposes the Modified Victor Easy Set rat trap to the weather elements.

Both boxed DOC 150 and DOC 200 have proven effective at targeting rats and stoats (Poutu & Warburton, 2015). Furthermore, the DOC 200 has already proven to reduce by-kill of non-target species in the Wildside project compared to other traps (Haley, 2015). A stainless steel DOC 150 in box is $72.45 including GST and a stainless steel DOC 200 in box is $78.20 including GST (Predator Traps, 2014). Considering its effectiveness, price, and the presence of a box, the DOC 150 is the single use trap recommended for targeting rats and stoats on Banks Peninsula.

For targeting possums, the Trapinator and Sentinel traps are considered the most effective single use traps (Ewans, 2014). At $30.48 including GST, the Sentinel trap is considerably cheaper than the $51.75 including GST Trapinator trap (Pest Control Research, undated c; Pest Control Research, undated a). However, the Trapinator is considered easier to use than the Sentinel kill by many people (Ewans, 2014). Considering that labour is probably going to be the largest cost in freeing Banks Peninsula of predators, and that volunteers may contribute a significant portion of that labour, ease of use is likely to be important. Therefore, the Trapinator is the single use trap recommended for removing possums from Banks Peninsula.

The following configuration is recommended for removing predators from Banks Peninsula if only single use traps are utilised:

- **DOC 150** (targeting rats and stoats: 4 ha⁻¹)
- **DOC 250** (primarily targeting ferrets but also likely to kill rats and stoats: 0.10 ha⁻¹)
- **Trapinator** (targeting possums: 1 ha⁻¹)

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23 Pest Control Research supply a stainless steel 200 trap with the box for $92 including GST, and a zinc coated steel version for $67.85 including GST. However, zinc coated traps are unlikely to be as reliable as the DOC200 full stainless steel traps.
Self-resetting traps

Some labour cost savings are possible by using self-resetting traps, such as the gas powered Goodnature A12 and A24 traps. The number in these trap models represents the number of uses before requiring new gas. Therefore, theoretically, these traps would require a service once per 12 or 24 kills respectively. However, bait replacement will probably be required before the gas runs out. The Goodnature A12 traps are effective against possums and the Goodnature A24 is effective against rats and stoats (Goodnature, undated). Replacing the Trapinator kill traps with Goodnature A12s and replacing the DOC 150 with Goodnature A24s may be more cost effective if they prove reliable over long periods in the field. Self-resetting traps such as the A12 and A24 may also have non-target by-kill, which is yet to be reported because the systems are relatively new.

There is currently no self-resetting trap on the market effective against ferrets. Therefore, DOC 250s would be required to supplement the Goodnature A12 and A24 to also remove ferrets from Banks Peninsula.

The following configuration is recommended for removing predators from banks peninsula if primarily self-resetting traps are utilised:
- Goodnature A24 (targeting rats and stoats: 4 ha⁻¹)
- Goodnature A12 (targeting possums: 1 ha⁻¹)
- DOC 250 (primarily targeting ferrets but also likely to kill rats and stoats: 0.10 ha⁻¹)

3.4.2 Aerial broadcast toxins

Aerial broadcast of toxins is the distribution of toxic baits from aircraft, usually helicopters. There is a variety of toxins available for controlling predators in New Zealand. However, only brodifacoum, sodium fluoroacetate, and pindone are approved for aerial broadcast (PCE, 2011).

Advantages of aerial broadcast toxins

Aerial broadcast of toxins is the cheapest method of predator control in comparison to the other options considered in this report. Some aerial broadcast toxins, such as brodifacoum have also proven very effective in eradications (Parkes et al., 2016).

Disadvantages of aerial broadcast toxins

Some aerially broadcast toxins have a relatively high level of non-target species by-kill and some toxins, such as brodifacoum and pindone, can persist in the environment for long periods of time (Green, 2004). Aerially-broadcast toxins also tend to have a low level of social acceptability, particularly sodium fluoroacetate (1080) (Coats, 2014). Therefore, acquiring landholder permission for the use of aerial broadcast toxins could be challenging.

It is dangerous to use aerial broadcast toxins on areas with livestock or with human habitation, so it would probably require the temporary relocation of Banks Peninsula people and livestock in order to treat certain areas.

Aerial broadcast brodifacoum

Brodifacoum is a second-generation anticoagulant commonly used in New Zealand for domestic rodent control. Aerial broadcast brodifacoum has been used for the majority (by area) of island rodent eradications (Howald et al., 2007). In addition, aerial broadcast brodifacoum has been used for removing predators from many predator-proof fenced sanctuaries (Burns et al., 2012). The average cost for aerial broadcast brodifacoum predator removal on uninhabited islands is $345 ha⁻¹ including GST, but it can cost $920-$8,000 ha⁻¹ including GST if the operations involve working around livestock and/or people (Parkes et al., in prep.).

Brodifacoum is the only alternative to sodium fluoroacetate (1080) that is effective against both rodents and possums (Eason et al., 2010). Aerial broadcast Brodifacoum is particularly effective against rats, with the capability to reliably eradicate 100% in a single application over large scales.
(Parkes et al., 2016). Brodifacoum is effective against stoats through secondary poisoning (PCE, 2011). Secondary poisoning occurs when one organism consumes another organism that has been exposed to a toxin. Both stoats and ferrets prey on rats and are therefore vulnerable to such poisoning. However, brodifacoum is not reliably effective against ferrets (Tim Sjoberg, personal communication, November 28, 2016).

The use of aerial broadcast brodifacoum comes with many risks, including very high persistence in the environment and food chain, which increases the risk of by-kill, including native birds, relative to less persistent toxins, such as sodium fluoroacetate (Green, 2004; PCE, 2011; Eason et al., 2002; Hoare & Hare, 2006). Brodifacoum persistence may also expose domestic and game animals to dangerous levels of the toxin. Brodifacoum is also considered to be a particularly inhumane method of killing (PCE, 2011).

Because of its potential negative impacts, the Department of Conservation permits aerially broadcast brodifacoum only on un-stocked off shore islands or within fenced ecosanctuaries (Ewans, 2014). Considering its potential negative impacts, particularly its persistence in the environment, aerially broadcast brodifacoum is unlikely to be appropriate for widespread use on Banks Peninsula, but it is capable of removing rats and stoats from the Peninsula. If it were used, aerial brodifacoum would not remove many, but not all, stoats and ferrets, so would need to be supplemented with DOC 250 traps.

The following configuration is recommended for aerially broadcast brodifacoum:

- Aerial broadcast of brodifacoum
- DOC 250 (targeting stoats and ferrets: 0.10 ha⁻¹)

**Aerially broadcast sodium fluoroacetate**

Sodium fluoroacetate is the aerially broadcast toxin most frequently used by DOC and OSPRI (Operational Solutions for Primary Industries) on the New Zealand mainland. Sodium fluoroacetate is often used at large scales (over 10,000 ha) to target rats, possums, and stoats (Brown et al., 2015). Unlike brodifacoum and pindone, public health permission is required from the Ministry of Health for the use of sodium fluoroacetate (Ministry of Health, 2013).

Unlike pindone and brodifacoum, sodium fluoroacetate is water-soluble and does not persist in the environment for long periods (Eason et al., 2011). Despite biodegrading quickly, sodium fluoroacetate still poses risks to non-target species such as dogs, some native birds and game animals (Eason et al., 2010; Beaven, 2008; Parkes et al., 2016). Such risks often lead to opposition to the use of sodium fluoroacetate, particularly from hunters (Brown et al., 2015). For such reasons, the aerial broadcast of sodium fluoroacetate on Banks Peninsula is likely to face community opposition.

Control using aerial broadcast sodium fluoroacetate is very cheap in comparison to all other tools considered, and can cost as little as $12 ha⁻¹ (PCE, 2011). A recent sodium fluoroacetate operation targeting stoats, rats, and possums over 11,592 ha cost $31 ha⁻¹ (including GST and all administrative costs) (Brown et al., 2015). Golding (Chris Golding, DOC Biodiversity Operations Manager, pers. comm. March 3 2017) notes there may be efficiencies over larger areas, but that these are unlikely to apply to Banks Peninsula because of the specific operational requirements arising from the mixed land uses there.

Sodium fluoroacetate has proven very effective at controlling rats and possums at low densities (Parkes et al., 2016; PCE, 2011). Sodium fluoroacetate also controls ferrets and stoats to some extent through secondary poisoning (PCE, 2011). However, the aerial broadcast of sodium fluoroacetate does not eradicate all predators (Beaven, 2008).

The sodium fluoroacetate application rate is normally less than 2 kg ha⁻¹ (PCE, 2011). Trials are currently underway with higher loading rates to investigate whether eradication of rats is possible near Mt Taranaki (Tim Sjoberg, personal communication, November 28, 2016).
Aerial broadcast sodium fluoroacetate could potentially supplement other methods of predator control on Banks Peninsula. However, current sodium fluoroacetate aerial broadcast methods will not, by themselves, remove 100% of any of the predator species from Banks Peninsula. Where eradication is not the goal sodium fluoroacetate is likely to be the most cost effective method of controlling predators at low densities.

**Aerially broadcast pindone**

Pindone is a first generation anticoagulant with similar negative effects to brodifacoum, however it is much less effective than either brodifacoum or sodium fluoroacetate (Green, 2004; PCE, 2011). Therefore, aerially broadcast pindone is not a suitable or effective method for removing predators from Banks Peninsula and is registered only for the control of rabbits.

### 3.4.3 Hand broadcast toxins

Hand broadcast of toxins (or ground baiting, in which baits are distributed by people on foot) has comparable effectiveness as aerial baiting (Ewans, 2014). One advantage is that waterways are avoided, which may mitigate some community concerns. Hand broadcasting is only suitable for small areas and is not a feasible tool for removing predators from Stewart Island; due to both the time it would take and the unacceptable bait coverage compared to aerial broadcast (Beaven, 2008).

Fifteen toxins are registered for use in New Zealand. The predator free Stewart Island assessment (PFR, 2013) identified ten potentially useful hand broadcast toxins. Evaluating all of these toxins is beyond the scope of this report. Brodifacoum is the most effective hand broadcast toxin for targeting rats (Broome et al., 2014). As with aerial broadcast brodifacoum, hand broadcast brodifacoum is effective against rodents and possums through primary poisoning (Eason et al., 2010), is effective against stoats through secondary poisoning (PCE, 2011), and is not reliably effective against ferrets (Tim Sjoberg, personal communication, November 28, 2016).

Considering the fact that hand broadcast toxins have similar risks as aerial broadcast toxins and are suitable only for small areas because of expense and labour requirements, hand broadcast toxins are not suitable for wide-scale use on Banks Peninsula. However, hand broadcast toxins may be appropriate for limited use in challenging areas such as caves and cliffs, or if landholders do not consent to the use of other methods.

### 3.4.4 Poisons in bait stations

Bait stations are toxic bait containers that come in many configurations, often with internal spikes to hold bait in place. Bait bags are an alternative to bait stations, with a wide variety of toxins registered for use in bait stations in New Zealand (PCE, 2011). We do not consider bait bags because bait bags are intended for a single use only (MPI, undated) and are not well protected from weather (MPI, undated).

**Advantages of toxic bait stations**

Containing toxins in bait stations can mitigate many of the negative environmental effects of aerial and hand broadcast toxins. Bait stations can exclude some non-target species, avoiding their exposure to primary poisoning, and bait stations reduce the volume of toxins directly entering the environment. For these reasons, toxic bait stations are more likely to receive community support over aerially or hand broadcast toxin methods. Another advantage of bait stations is they require considerably less labour than conventional trapping (Ewans, 2014).

**Disadvantages of toxic bait stations**

The labour requirements and cost are still likely to exceed those of aerially broadcast toxins when used at a large scale.
Bait stations containing brodifacoum

Brodifacoum is considered the best practice bait station toxin for eradicating rodents (Broome et al., 2014), having been used successfully in many island eradications of rodents (Howald et al., 2007). The largest successful eradication of rodents from an island using bait stations containing brodifacoum is 3,105 ha Langara Island in British Columbia (Taylor et al., 2000). This is substantially larger than any successful island eradication using conventional trapping (<15 ha), but still far smaller than the largest successful eradication using aerially broadcast toxin (108,423 ha) (Howald et al., 2007; South Georgia Heritage Trust, 2014).

As with other application methods, brodifacoum bait stations are effective against rodents and possums through primary poisoning (Eason et al., 2010), are effective against stoats through secondary poisoning (PCE, 2011), and are not reliably effective against ferrets (Tim Sjoberg, personal communication, November 28, 2016).

Bait stations containing PAPP

PAPP is an effective and humane toxin for targeting stoats through primary poisoning (Eason et al., 2010). PAPP may supplement brodifacoum where there is insufficient rat abundance to kill stoats through secondary poisoning. PAPP is effective only against stoats and cats, and is not registered for aerial broadcast (Brown et al., 2015).

OSKA bait stations

Inter species competition for bait can lead to some species avoiding bait stations (Broome et al., 2014). However, the OSKA (One Station Kills All) bait station has a spring loaded treadle that possums push down to access possum bait, while having a tunnel with bait that only rats or stoats can access (Pest Control Research, undated b). This separation of bait can mitigate the impact of Inter species competition for bait between rats and possums. The cost of a single OSKA bait station is $28.20 including GST (Pest Control Research, undated b).

We recommend the OSKA bait station containing both brodifacoum and PAPP for removing rats and possums (through brodifacoum primary poisoning), and stoats (through PAPP primary poisoning and brodifacoum secondary poisoning). OSKA bait stations would have to be supplemented with DOC 250 traps to remove ferrets. The cost of a single stainless steel DOC 250 and box is $149.50 including GST (Predator Traps, 2014).

The following configuration is recommended if primarily bait stations are utilised:

- OSKA Bait stations (targeting rats, stoats and possums: 4 ha⁻¹)
- DOC 250 (targeting ferrets, but also likely to kill rats and stoats: 0.10 ha⁻¹)

3.5 Broad scale strategies

Winter to early spring is the preferred season in NZ to apply the bait. We base this timing on past successes and it tends to coincide with times of natural food scarcity, lower numbers of rats and low breeding. It can also coincide with times of low non-target activity”.

3.5.1 Defendable area

An important issue in pest management is deciding where to draw boundaries for control activities. In this case, the difficult decisions relate to the western boundary. Selection of this boundary has important implications for both project feasibility and project cost. One option we considered was to use the boundary of the former Banks Peninsula District, which covered 115,600 ha (Christchurch City Council, 1999). The Summit Road Society, amongst others, undertakes significant voluntary pest management near this boundary. The western boundary of the former district presents significant challenges for pest management, including the requirement for an extremely long predator-proof

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24 We understand there is research underway to evaluate meat bait for aerial broadcast.
fence or buffer zone, including significant urban areas. The area west of Gebbies Pass has a high level of human habitation and road networks, which would make predator control and biosecurity complex. Inclusion of Lyttelton with a population of 2,859 (Statistics New Zealand, 2013a) and its major port would present a particularly significant biosecurity challenge. The likely failure to achieve zero predator densities in these areas, and the very high potential for ongoing reinvasions into those areas, suggests high predator removal and ongoing management costs within this boundary zone. It would be significantly easier and less expensive to control predators at zero densities and prevent reinvasion by excluding the Port Hills area and the area west of Gebbies Pass, at least initially. However, we note that ongoing pest management in the excluded areas would be extremely beneficial to maintenance of predator free Banks Peninsula by significantly reducing reinvasion risks. While acknowledging the benefits of including a broader western boundary encompassing all of the former Banks Peninsula District, and the benefits of more people assisting with voluntary pest management, we scope the feasibility for achieving predator free status in a smaller eastern area.

The area evaluated includes only the area east of Gebbies Pass, (approximately 93,205 ha - Figure 2). If predator eradication is unachievable over this 93,205 ha area, then attaining the larger 115,600 ha predator free area would also be unfeasible. This proposed predator free area would require approximately 20 km of predator-proof fence or buffer zone to isolate the Peninsula from the mainland (see Figure 4), with 4.58 ha protected for every metre of predator-proof fence or buffer zone. Placing the predator free boundary further east of Gebbies Pass, would require considerably more predator proof-fence or buffer zone at the expense of less total area protected, offset (at least partially) by the lower cost of removing predators from the smaller area. Of course, this smaller area would reduce benefits too. We do not evaluate potential boundaries to the east of Gebbies Pass.

**Figure 2**

Extent of proposed predator free Banks Peninsula

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25 This spatial estimate does not account for elevation changes, so the actual area requiring predator control will be slightly larger.
3.5.2 Rolling front

A rolling front works by removing predators from one area before removing predators from an adjacent area. A rolling front can allow limited resources to be used for maximum effect (Cox & Haley, 2015). Russell et al. (2015) have suggested that the removal of predators at scales of over 100,000 ha is unachievable with current technology without the use of a rolling front. At 93,205 ha, the proposed Banks Peninsula predator free area approaches this scale.

The rolling front strategy successfully eradicated rats from the 108,423 ha South Georgia Island (South Georgia Heritage Trust, 2014). The South Georgia rolling front was repositioned daily and allowed for systematic sowing of aerially broadcast bait, avoiding the target species entering previously treated zones (South Georgia Heritage Trust, 2014).

Whilst the South Georgia operation was a similar scale to Banks Peninsula, it had several advantages over Banks Peninsula, including glaciers isolating the treatment areas and a lack of human habitation, which allowed widespread use of aerially broadcast brodifacoum (South Georgia Heritage Trust, 2014).

Based on experiences elsewhere, using aerial broadcast toxin on Banks Peninsula in a rolling front strategy may allow for resources to be used more effectively by preventing predators from reinvading treated areas. However, there have been no demonstrations of the rolling front strategy using traps or bait stations at a large scale. However, the large labour requirements for traps and bait stations mean that simultaneous treatment of the whole Peninsula is almost certainly infeasible, requiring some type of staged operation. We return to this point in a later chapter.

A simplified example of a rolling front applied to Banks Peninsula is illustrated in Figure 3. Application of the rolling front at the property level would probably be necessary because of requirements for landholder permissions and the synchronised movement of livestock. Therefore, such an operation would entail much finer blocks than those depicted in concept in Figure 3.

A potentially good starting location for a rolling front is Wildside project area in the south-eastern corner of Banks Peninsula. The Wildside project already has considerable predator control infrastructure (700 traps; Haley, 2015), and project personnel have years of experience in local predator control. Alternatively, a rolling front could start at Gebbies Pass and progress east.

The time scale for removing predators from Banks Peninsula using a rolling front strategy will be dependent on the methods used, resources available, and how long it takes to get permissions. The South Georgia rolling front rat eradication completed in 2015 took approximately four years (South Georgia Heritage Trust, undated). Considering that Banks Peninsula has a large number of human inhabitants and would require removal of multiple predator species, the timeline there would likely be much longer. Whilst we do not calculate timelines specifically for a rolling front, we later estimate total time requirements.
3.5.3 Blended approach

A predator free Banks Peninsula will require the application of an array of predator control methods. No single method of predator control is suitable for every land use, no single method is effective against every predator, and no single method is acceptable to every landholder or resident. Identifying methods that are appropriate, socially acceptable and effective against all the targeted predators will require working closely with the local community and individual landholders.

Multiple control methods should also be applied to each individual species where possible. This is because any long term method of control is likely to place selective pressure on a species, leading to the survivors of that species being less affected through either learned or innate behaviour (Cox & Haley, 2015). Therefore, multiple control methods for each targeted species are more likely to be successful.

3.6 Barriers

Banks Peninsula would not remain pest free unless reinvasion is prevented. Effective methods of mitigating the risk of reinvasion include either a predator-proof fence or a buffer zone.

3.6.1 Predator-proof fence

A predator-proof fence is the most common method of preventing reinvasion of predators into mainland ecosanctuaries. Overall, a predator-proof fence provides very good protection from mammalian predators, with proven effectiveness at ecosanctuaries such as Zealandia. The public often considers a predator-proof fence an attractive and inspiring proposition (Burns et al., 2012; Norbury et al., 2014). However, a 2014 inventory found that seven out of eight fenced sanctuaries studied had some level of incursion by targeted species (Ewans, 2014). Predator-proof fences do not prevent 100% of incursions.

A predator-proof fence requires relatively large capital investment. Recent New Zealand predator-proof fence construction costs range from $253 to $461 per metre, including GST (see Table 3). The predator-proof fences in Table 3 targeted all mammalian predators, including cats. A slightly shorter (and potentially cheaper) fence that would not exclude cats could be constructed for preventing reinvasion into Banks Peninsula. The lifespan of a predator-proof fence is 25 years, after which further investment will be required (Scofield et al., 2011).
Table 3
Costs of constructed and proposed predator proof fences in New Zealand

<table>
<thead>
<tr>
<th>Location</th>
<th>Area protected (ha)</th>
<th>Fence length (m)</th>
<th>Fence capital cost Including GST</th>
<th>$/metre Including GST</th>
<th>$/ha Including GST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orokonui</td>
<td>307</td>
<td>8,700</td>
<td>$2,200,000</td>
<td>$253</td>
<td>$7,166</td>
</tr>
<tr>
<td>Tawharanui</td>
<td>550</td>
<td>2,500</td>
<td>$770,500</td>
<td>$308</td>
<td>$1,401</td>
</tr>
<tr>
<td>Shakespear</td>
<td>500</td>
<td>1,700</td>
<td>$1,058,000</td>
<td>$622</td>
<td>$2,116</td>
</tr>
<tr>
<td>Halfmoon Bay (proposed)</td>
<td>4,800</td>
<td>8,800</td>
<td>$4,057,200</td>
<td>$461</td>
<td>$845</td>
</tr>
</tbody>
</table>

Sources: Bell (2014), Matt Maitland, Senior ranger, Auckland Council (pers. comm.), Elton Smith, Manager of Orokonui Ecosanctuary (pers. comm.).

There are many ongoing operational costs for a predator-proof fence to be truly effective, including clearance of vegetation on both sides of the fence to prevent predators climbing vegetation (Burns et al., 2012), and monitoring and repairing damage (Maitland, 2011; Orokonui Ecosanctuary, 2016). The Tawharanui Open Sanctuary, for example, allocates 5% of fence construction cost towards annual maintenance (MacGibbon, 2010).

Predator-proof fenced mainland ecosanctuary incursions have been more frequent on peninsulas, which are vulnerable between the ends of the fence and the ocean (Ewans, 2014). Attempts to counter this vulnerability have included intensive predator control immediately outside the fence and at the ends of the fence (Burns et al., 2012). Tawharanui open sanctuary attempted to counter this vulnerability by using koru shaped fence ends (Maitland, 2011). This koru design endeavoured to channel targeted species towards strategically placed traps. The integration of such features into a Banks Peninsula predator-proof fence would likely increase its effectiveness, but also its cost.

Zero Invasive Predators are developing a low predator proof fence (Tim Sjoberg, personal communication, November 28, 2016), which would not exclude cats but could still exclude the targeted predators. This lower fence may provide a significantly cheaper predator-proof fence solution in the future.

A potential Banks Peninsula predator-proof fence location on is illustrated in Figure 4. A priority consideration for this fence location was to cross as few property boundaries as possible to simplify consent processes.
3.6.2 Buffer zones

Buffer zones consist of an area of high intensity trapping composing either traps or bait stations. A buffer zone can be an alternative to a predator-proof fence or can supplement a fence.
Norbury et al. (2014) determined that the most cost effective buffer zone, without a fence, targeting multiple species had a depth of 500m with traps placed in a 100m randomized block spacing (i.e. 1.0 traps ha\(^{-1}\), or 50 traps per km of fence). However, buffer zones are unable to match the near zero intrusions that predator-proof fences provide (Burns et al., 2012). Norbury et al. (2014) concluded that only a predator proof fence provides sufficient protection on the mainland for native species highly vulnerable to predation. The inability of buffer zones to provide sufficient protection is evident by the fact that all New Zealand ecosanctuaries of meaningful size rely on predator-proof fences to mitigate reinvasion. Therefore, we assume a predator-proof fence would be required to prevent reinvasion into Banks Peninsula. However, it is impractical to fence all potential reinvasion points, so use of some buffer zones is inevitable. Based on our earlier analysis, these would require a grid density of at least 4 traps ha\(^{-1}\), which is higher than recommended by Norbury et al. (2014) because the goal is not cost effective control, but prevention of 100% of reinvasions.

Buffer zones on one or both sides of the fence could supplement a Banks Peninsula predator-proof fence. This would provide additional layers of defence either by preventing invaders reaching the fence, or by killing them in the event that they pass the fence. Buffer zones could also be established where roads pass through the predator-proof fence. Having buffer zones instead of gates could prove a more appropriate solution, considering the disruption to traffic a gate would likely cause.

Buffer zones could also mitigate the risk of incursions from swimming predators by extending buffer zones from the ends of the predator proof fence at least 3km along the coast (the maximum swimming range of stoats). Buffer zones could also prevent reinvasion along the coast anywhere within 3km of an untreated land mass, such as the eastern side of Lyttelton Harbour and the southern end of Kaitorete Spit.

Buffer zones could also be valuable around townships and areas with significant human activity because townships are high-risk sources for reinvasion (Clayton, 2015). A buffer zone is likely to be far more suitable than fencing a community because it does not restrict human movement or have the undesirable visual impacts of a fence.

### 3.7 Biosecurity

In addition to a predator proof-fence and buffer zones, other ongoing biosecurity measures will be required to maintain Banks Peninsula's predator free status. Such measures could include quarantine facilities, monitoring and rapid response.

The intrusion of some predators back onto Banks Peninsula is inevitable. Some of the potential incursion pathways are:

- Swimming or rafting
- Abandoned domestic predators
- Intentional release of predators
- Predator-proof fence failure
- Buffer zone failure
- Freight/cargo
- Motor vehicles
- Ships (both private and commercial)
- Culverts and streams
- Personal luggage

Preventing predator populations from becoming re-established (creating a self-sustaining population) is of critical importance. Quarantine, early detection and rapid response can reduce the risk of a population becoming re-established (Clayton, 2015).
3.7.1 Monitoring and early detection

Detection of predators at low densities is critical for controlling reinvasions. The most common method of detecting predators is through tracking tunnels and chew cards. DOC recommends tracking tunnels containing inks pads for monitoring populations of rats, stoats and ferrets (Parkes, 2009). The cost of a single tracking tunnel with an inkpad is $9.78 including GST (Pest Control Research, undated g). Additionally, chew cards can monitor possum and rat numbers. The cost of a single chew card is $0.40 including GST (Pest Control Research, undated h). The advantage of chew cards for monitoring rats is that they are more sensitive for detecting rats at low densities (Clayton, 2015). However, chew cards are not effective for monitoring stoats or ferrets.

James Ross, senior ecology lecturer at Lincoln University, suggests a monitoring grid of 50m x 50m (4 ha$^{-1}$) stretching at least 1km out from areas vulnerable to reinvasion (personal communication, January 26, 2017). Such a grid with chew cards would likely be effective at monitoring rat and possum incursions. A tracking tunnel grid at a density of 0.10 ha$^{-1}$ would likely provide sufficient monitoring for stoats and ferrets, considering their home ranges and their recommended trapping grids. We estimate areas vulnerable to reinvasion cover at least 10% of Banks Peninsula.

Predator detection dogs are another monitoring method. However, dog training is expensive and dogs can be trained to detect only one species (Clayton, 2015). Trail cameras can be used for monitoring, but are expensive (Clayton, 2015). New electronic detection devices that can send incursion alerts to phones are being developed by Zero Invasive Predators (Tim Sjoberg, personal communication, November 28, 2016), and in the future may provide a more effective monitoring system.

A predator-proof fence will also require continual monitoring for breaches and damage to ensure consistent effectiveness.

3.7.2 Quarantine

Quarantine facilities with ongoing gear checking could help to intercept predators at high-risk incursion pathways. These pathways include docks, such as those in Akaroa$^{26}$, and roads that bisect the predator-proof fence, such as the Christchurch to Akaroa Highway and the Teddington to Diamond Harbour road. The use of dogs for detecting predators in high-risk cargo and freight is particularly effective (Clayton, 2015). The use of detector dogs, along with staff to conduct biosecurity checks could be helpful for preventing predator access to Banks Peninsula; however, this would impose significant disruption and delay to travellers. In addition, stopping and/or searching people going about their business within national borders would require special legal provisions. Hence, we consider the imposition of internal quarantine is unlikely and we have not attempted to estimate quarantine costs.

3.7.3 Response

Upon detection of a predator incursion, a rapid response to kill the intruders is critical. The response must eliminate the predator incursion before a self-sustaining population establishes. To insure response is prompt and sufficient, there should be a response plan in place. The Tawharanui Open Sanctuary response plan includes increased trapping and monitoring intensity (Maitland, 2011). A Banks Peninsula response plan should include similar protocols and have staff on standby ready to respond at short notice to carry out such measures.

$^{26}$ The risk of reinvasion from the Port of Lyttelton, which is within swimming distance of the proposed predator free area, is also a very important consideration.
Chapter 4
Economic

4.1 Predator removal scenarios

Estimated costs and timelines are provided for five scenarios.

- Scenario One: bait stations
- Scenario Two: single use traps
- Scenario Three: self-resetting traps
- Scenario Four: aerial broadcast brodifacoum
- Scenario Five: aerial broadcast sodium fluoroacetate

Scenarios Four and Five are included for comparative purposes. Scenario Four (aerial broadcast of brodifacoum) comes with significant environmental risks and so is extremely likely to be unacceptable. Scenario Five (aerial broadcast of sodium fluoroacetate) will not remove 100% of predators from Banks Peninsula, but does allow ongoing control at low densities. There is no guarantee that the other scenarios will remove 100% of predators. However, traps, bait stations and aerial brodifacoum have proven effective at least in small scale eradications. Banks Peninsula predator removal should incorporate a blend of these scenarios. Consistent with our overall research objective of a broad scale scoping analysis, we have not estimated costs or timelines for the many possible blended scenarios.

4.1.1 Assumptions

A rolling front may allow for some cost savings through the redeployment of resources. However, every section of the control area will still require the same level effort to treat. Therefore, the overall savings are likely be insignificant relative to other costs. Rolling front efficiencies are not estimated.

Evaluation necessitates assumptions about methods, costs, labour requirements, and effectiveness. We rely on two main sources, Halfmoon Bay and our own assumptions based on preceding analysis and discussions with experts. Although never actuated, the proposed predator free Halfmoon Bay project has many similarities to a predator free Banks Peninsula project (see Table 4). Due to these similarities, we use some of the estimates from the Half Moon Bay project as proxies.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Comparison of the proposed Half Moon Bay project and a potential Banks Peninsula project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proposed Half Moon Bay Project</td>
</tr>
<tr>
<td>Area (ha)</td>
<td>4,800</td>
</tr>
<tr>
<td>Population</td>
<td>378</td>
</tr>
<tr>
<td>Geography</td>
<td>Peninsula, mostly forested</td>
</tr>
<tr>
<td>Target species</td>
<td>Norway rats, ship rats, kiore, possums, feral cats and hedgehogs</td>
</tr>
</tbody>
</table>

Source: PFR Governance Group, 2015; Statistics New Zealand, 2013b; Statistics New Zealand, 2013a; Christchurch City Council, 2016
Assumptions adapted from the proposed predator free Halfmoon Bay project (Ewans, 2014):

- Twenty rounds of bait station checks/refill will be required for both single-kill traps and bait stations to remove the targeted predators.
- The cost of all labour and logistics to check and/or refill is $8.63 including GST per trap, bait station or monitoring device.
- Field personnel can each make 50 checks or refills per day.

Other assumptions:

- The predator removal area is 93,205 ha.
- One hundred full time field staff will conduct predator removal operations and monitoring. This allows for a maximum of 5,000 trap checks per day.
- Each full-time-equivalent field staff member is in the field for 230 days per year (46 weeks).
- The initial cost of placing each bait station or trap is three trap or bait station checks ($25.88). This accounts for the logistical challenge of carrying devices into place and marking and cutting tracks.
- To account for the greater weight and size of DOC 150 and DOC 250 traps, the initial cost of setting these up is five trap or bait station checks ($43.13).
- Good nature A12 and A24 self-resetting traps require only 10 check/refills (50% that of other methods). Bait replacement is still required for self-resetting traps.
- All costs are inclusive of GST. Divide by 1.15 to obtain costs exclusive of GST.

4.1.2 Scenario One: bait stations

- OSKA bait stations containing both brodifacoum and PAPP (targeting rats, stoats and possums: 4 ha\(^1\))
- DOC 250 (primarily targeting ferrets but also likely to kill rats and stoats: 0.10 ha\(^1\))
- The cost of each OSKA bait station is $28.20 including GST (Pest Control Research, undated b).
- The cost of each stainless steel DOC 250 and box is $149.50 including GST (Predator Traps, 2014).

The estimated total cost of removing predators from Banks Peninsula under this scenario is approximately $88 million (Table 5). The minimum estimated time for removing predators from Banks Peninsula under this scenario is approximately 7.7 years (Table 6). Trap deployment alone with 100 full time staff would take about one year.

Table 5

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Cost Including GST</th>
<th>Sub-totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSKA purchase</td>
<td>93,205 ha x 4 traps/ha x $28.20/trap</td>
<td>$10,513,524</td>
<td></td>
</tr>
<tr>
<td>OSKA setup</td>
<td>93,205 ha x 4 traps/ha x ($8.63 x 3)/trap</td>
<td>$9,652,310</td>
<td></td>
</tr>
<tr>
<td>OSKA check/refill</td>
<td>93,205 ha x 4 traps/ha x ($8.63 x 20)/trap</td>
<td>$64,318,732</td>
<td>$84,514,566</td>
</tr>
<tr>
<td>DOC 250 purchase</td>
<td>93,205 ha x 0.1 traps/ha x $149.50/trap</td>
<td>$1,393,415</td>
<td></td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 5)/trap</td>
<td>$402,180</td>
<td></td>
</tr>
<tr>
<td>DOC 250 check/refill</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 20)/trap</td>
<td>$1,608,718</td>
<td>$3,404,313</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>$87,918,878</td>
</tr>
</tbody>
</table>
### Table 6
**Time for predator removal: Scenario One**

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSKA bait station setup</td>
<td>93,205 ha x 4 traps/ha x 3 CE</td>
<td>1,118,460 CE</td>
</tr>
<tr>
<td>OSKA bait station checks</td>
<td>93,205 ha x 4 traps/ha x 20 CE</td>
<td>7,456,400 CE</td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x 5 CE</td>
<td>46,603 CE</td>
</tr>
<tr>
<td>DOC 250 checks</td>
<td>93,205 ha x 0.1 traps/ha x 20 CE</td>
<td>186,410 CE</td>
</tr>
<tr>
<td>Total check equivalents</td>
<td></td>
<td>8,807,873 CE</td>
</tr>
<tr>
<td>Total days</td>
<td>100 staff, 5000 CE per day</td>
<td>1,762 days</td>
</tr>
<tr>
<td>Total years</td>
<td>230 work days per staff member per year</td>
<td>7.7 years</td>
</tr>
</tbody>
</table>

#### 4.1.3 Scenario Two: single use traps
- DOC 150 (targeting rats and stoats: 4 ha⁻¹)
- DOC 250 (primarily targeting ferrets but also likely to kill rats and stoats: 0.10 ha⁻¹)
- Trapinator trap (targeting possums: 1 ha⁻¹)
- The cost of each DOC 150 and box is $72.45 including GST (Predator Traps, 2014).
- The cost of each DOC 250 and box is $149.50 including GST (Predator Traps, 2014).
- The cost of each Trapinator trap is $51.75 including GST (Pest Control Research, undated a).

The estimated total cost of removing predators from Banks Peninsula under this scenario is approximately $134 million (Table 7). The minimum estimated timeline for Banks Peninsula predator removal under this scenario is approximately 10.2 years (Table 8).

### Table 7
**Cost of predator removal: Scenario Two**

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Cost Including GST</th>
<th>Sub-totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC 150 purchase</td>
<td>93,205 ha x 4 traps/ha x $72.45/trap</td>
<td>$27,010,809</td>
<td></td>
</tr>
<tr>
<td>DOC 150 setup</td>
<td>93,205 ha x 4 traps/ha x ($8.63 x 5)/trap</td>
<td>$16,087,183</td>
<td></td>
</tr>
<tr>
<td>DOC 150 check/refill</td>
<td>93,205 ha x 4 traps/ha x ($8.63 x 20)/trap</td>
<td>$64,348,732</td>
<td>$107,446,724</td>
</tr>
<tr>
<td>DOC 250 purchase</td>
<td>93,205 ha x 0.1 traps/ha x $149.50/trap</td>
<td>$1,393,415</td>
<td></td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 5)/trap</td>
<td>$402,180</td>
<td></td>
</tr>
<tr>
<td>DOC 250 check/refill</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 20)/trap</td>
<td>$1,608,718</td>
<td>$3,404,313</td>
</tr>
<tr>
<td>Trapinator purchase</td>
<td>93,205 ha x 1 trap/ha x $51.75/trap</td>
<td>$4,823,359</td>
<td></td>
</tr>
<tr>
<td>Trapinator setup</td>
<td>93,205 ha x 1 trap/ha x ($8.63 x 3)/trap</td>
<td>$2,413,077</td>
<td></td>
</tr>
<tr>
<td>Trapinator check/refill</td>
<td>93,205 ha x 1 trap/ha x ($8.63 x 20)/trap</td>
<td>$16,087,183</td>
<td>$23,323,619</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>$134,174,656</td>
<td></td>
</tr>
</tbody>
</table>
Table 8
Time for predator removal: Scenario Two
CE= Check-equivalent

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC 150 setup</td>
<td>93,205 ha x 4 traps/ha x 5 CE</td>
<td>1,864,100 CE</td>
</tr>
<tr>
<td>DOC 150 checks</td>
<td>93,205 ha x 4 traps/ha x 20 CE</td>
<td>7,456,400 CE</td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x 5 CE</td>
<td>46,603 CE</td>
</tr>
<tr>
<td>DOC 250 checks</td>
<td>93,205 ha x 0.1 traps/ha x 20 CE</td>
<td>186,410 CE</td>
</tr>
<tr>
<td>Trapinator setup</td>
<td>93,205 ha x 1 trap/ha x 3 CE</td>
<td>279,615 CE</td>
</tr>
<tr>
<td>Trapinator check</td>
<td>93,205 ha x 1 trap/ha x 20 CE</td>
<td>1,864,100 CE</td>
</tr>
<tr>
<td>Total check equivalents</td>
<td></td>
<td>11,697,228 CE</td>
</tr>
<tr>
<td>Total days</td>
<td>100 staff, 5000 CE per day</td>
<td>2,339 days</td>
</tr>
<tr>
<td>Total years</td>
<td>230 work days per staff member per year</td>
<td>10.2 years</td>
</tr>
</tbody>
</table>

4.1.4 Scenario Three: self-resetting traps

- Goodnature A24 (targeting rats and stoats: 4 ha⁻¹)
- Goodnature A12 (targeting possums: 1 ha⁻¹)
- DOC 250 (primarily targeting ferrets but also likely to kill rats and stoats: 0.10 ha⁻¹)
- The cost of each Goodnature A24 is $171.93 including GST (Goodnature, undated)
- The cost of each Goodnature A12 is $171.93 including GST (Goodnature, undated)
- The cost of each DOC 250 and box is $149.50 including GST (Predator Traps, 2014).

The estimated total cost of removing predators from Banks Peninsula under Scenario Three is approximately $132 million (Table 9). The minimum estimated time for predator removal is approximately 5.5 years (Table 10).

Table 9
Cost of predator removal: Scenario Three

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Cost Including GST</th>
<th>Sub-totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodnature A24 purchase</td>
<td>93,205 ha x 4 traps/ha x $171.93/trap</td>
<td>$64,098,943</td>
<td></td>
</tr>
<tr>
<td>Goodnature A24 setup</td>
<td>93,205 ha x 4 traps/ha x ($8.63 x 3)/trap</td>
<td>$9,652,310</td>
<td></td>
</tr>
<tr>
<td>Goodnature A24 check</td>
<td>93,205 ha x 4 traps/ha x ($8.63 x 10)/trap</td>
<td>$32,174,366</td>
<td>$105,925,618</td>
</tr>
<tr>
<td>DOC 250 purchase</td>
<td>93,205 ha x 0.1 traps/ha x $149.50/trap</td>
<td>$1,393,415</td>
<td></td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 5)/trap</td>
<td>$402,180</td>
<td></td>
</tr>
<tr>
<td>DOC 250 check</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 20)/trap</td>
<td>$1,608,718</td>
<td>$3,404,313</td>
</tr>
<tr>
<td>Goodnature A12 purchase</td>
<td>93,205 ha x 1 trap/ha x $171.93/trap</td>
<td>$16,024,736</td>
<td></td>
</tr>
<tr>
<td>Goodnature A12 setup</td>
<td>93,205 ha x 1 trap/ha x ($8.63 x 3)/trap</td>
<td>$2,413,077</td>
<td></td>
</tr>
<tr>
<td>Goodnature A12 check</td>
<td>93,205 ha x 1 trap/ha x ($8.63 x 10)/trap</td>
<td>$8,043,592</td>
<td>$26,481,405</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>$132,407,023</td>
</tr>
</tbody>
</table>
Table 10
Time for predator removal: Scenario Three
CE= Check-equivalent

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodnature A24 setup</td>
<td>93,205 ha x 4 traps/ha x 3 CE</td>
<td>1,118,460 CE</td>
</tr>
<tr>
<td>Goodnature A24 checks</td>
<td>93,205 ha x 4 traps/ha x 10 CE</td>
<td>3,728,200 CE</td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x 5 CE</td>
<td>46,603 CE</td>
</tr>
<tr>
<td>DOC 250 checks</td>
<td>93,205 ha x 0.1 traps/ha x 20 CE</td>
<td>186,410 CE</td>
</tr>
<tr>
<td>Goodnature A12 setup</td>
<td>93,205 ha x 1 traps/ha x 3 CE</td>
<td>279,615 CE</td>
</tr>
<tr>
<td>Goodnature A12 check</td>
<td>93,205 ha x 1 traps/ha x 10 CE</td>
<td>932,050 CE</td>
</tr>
<tr>
<td></td>
<td>Total check equivalents</td>
<td>6,291,338 CE</td>
</tr>
<tr>
<td></td>
<td>Total days</td>
<td>100 staff, 5000 CE per day</td>
</tr>
<tr>
<td></td>
<td>Total years</td>
<td>230 work days per staff member per year</td>
</tr>
</tbody>
</table>

4.1.5 Scenario Four: aerial broadcast brodifacoum

- Aerial broadcast of brodifacoum (targeting possums and rats primarily through poisoning, and some stoats through secondary poisoning)
- DOC 250 (targeting stoats and ferrets: 0.10 ha⁻¹)
- Aerial broadcast of brodifacoum costs $920 ha⁻¹ including GST. This is the low estimate for conducting brodifacoum eradications around people and livestock (Parkes et al., in prep).
- The cost of each DOC 250 and box is $149.50 including GST (Predator Traps, 2014).

The estimated total cost of removing predators from Banks Peninsula under this scenario is approximately $89 million (Table 11). One advantage of this approach is the significant labour saving and hence reduced time to complete predator elimination (Table 12). In this case the time to completion is unrealistic because it would not be feasible to deploy traps and check them twenty times in 47 days. It is likely that this scenario would entail a significantly smaller workforce, extending the time to completion.

Table 11
Cost of predator removal: Scenario Four

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Cost Including GST</th>
<th>Sub-totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerial brodifacoum</td>
<td>93,205 ha x $920/ha</td>
<td>$85,748,600</td>
<td></td>
</tr>
<tr>
<td>DOC 250 purchase</td>
<td>93,205 ha x 0.1 traps/ha x $149.50/trap</td>
<td>$1,393,415</td>
<td></td>
</tr>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 5)/trap</td>
<td>$402,180</td>
<td></td>
</tr>
<tr>
<td>DOC 250 check</td>
<td>93,205 ha x 0.1 traps/ha x ($8.63 x 20)/trap</td>
<td>$1,608,718</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>$89,152,913</td>
</tr>
</tbody>
</table>
Table 12
Time for predator removal: Scenario Four
CE= Check-equivalent

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC 250 setup</td>
<td>93,205 ha x 0.1 traps/ha x 5 CE</td>
<td>46,603 CE</td>
</tr>
<tr>
<td>DOC 250 checks</td>
<td>93,205 ha x 0.1 traps/ha x 20 CE</td>
<td>186,410 CE</td>
</tr>
<tr>
<td>Total check equivalents</td>
<td></td>
<td>233,013 CE</td>
</tr>
<tr>
<td>Total days</td>
<td>100 staff, 5000 CE per day</td>
<td>47 days</td>
</tr>
<tr>
<td>Total years</td>
<td>230 days per staff per year</td>
<td>0.2 years</td>
</tr>
</tbody>
</table>

4.1.6 Scenario Five: Aerial broadcast sodium fluoroacetate

Aerial broadcast of sodium fluoroacetate will not remove 100% of predators from Banks Peninsula (see Aerial broadcast section). However, sodium fluoroacetate can control stoats, rats, and possums at low densities. Ferrets are uncontrolled under this scenario and sodium fluoroacetate would require ongoing operations to maintain stoats, rats, and possums at low densities.

- Estimated cost of each application of aerial broadcast sodium fluoroacetate is $31 ha\(^{-1}\) including GST based on the cost of a recent 11,592 ha operation targeting stoats, rats, and possums (Brown et al., 2015).

The initial total cost of controlling stoats, rats, and possums on Banks Peninsula under this scenario is approximately $2.9 million. Note, however, that there would be a need for ongoing applications to maintain these species at low densities, and this scenario does not include costs to control or eliminate ferrets.

4.2 Predator-proof fence

We use a low-end estimate of the cost of constructing the predator-proof fence ($320 per metre including GST (Table 3). Based on this mean, the estimated cost of construction for a 20,363m predator proof-fence on Banks Peninsula is $6.52 million. Based on the operating budget for Tawharanui Open Sanctuary (MacGibbon, 2010), 5% of the fence construction cost is allocated to annual maintenance ($326,000 per year).

4.3 Biosecurity

4.3.1 Monitoring

The following monitoring setup is proposed:

- Chew cards (4 ha\(^{-1}\)) for monitoring rats and possums
- Tracking tunnels (0.10 ha\(^{-1}\)) for monitoring stoats and ferrets

Assumptions relating to monitoring are:

- The area requiring monitoring is 10% of Banks Peninsula (9,320 ha).
- The cost of checking and replacing either a chew card or tracking tunnel inkpads is $8.63.
- The setup cost is the same as the cost of checking and replacing one chew card or tracking tunnel (Monitoring devices are relatively simple to setup and tracks would already have been made for the predator removal operation).
- Four checks of every monitoring device will be required per year.
- The cost of each tracking tunnel with an inkpad is $9.78 including GST (Pest Control Research, undated g).
- The cost of each chew card is $0.40 including GST (Pest Control Research, undated h).

The total estimated setup cost of the monitoring grid is $0.35 million, and the total estimated annual cost of the monitoring grid is $1.3 million (Table 13).

<table>
<thead>
<tr>
<th>Component</th>
<th>Workings</th>
<th>Cost Including GST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chew card purchase</td>
<td>9,320 ha x 4 cards/ha x $0.40/card</td>
<td>$14,912</td>
</tr>
<tr>
<td>Chew card setup</td>
<td>9,320 ha x 4 cards/ha x $8.63/card</td>
<td>$321,726</td>
</tr>
<tr>
<td>Tracking tunnel purchase</td>
<td>9,320 ha x 0.1 tunnels/ha x $9.78/tunnel</td>
<td>$9,115</td>
</tr>
<tr>
<td>Tracking tunnel setup</td>
<td>9,320 ha x 0.1 tunnels/ha x $8.63/tunnel</td>
<td>$8,043</td>
</tr>
<tr>
<td>Total setup cost</td>
<td></td>
<td>$353,797</td>
</tr>
<tr>
<td>Chew card check</td>
<td>9,320 ha x 4 cards/ha x $8.63/check x 4 checks/year</td>
<td>$1,286,906</td>
</tr>
<tr>
<td>Tracking tunnel check</td>
<td>9,320 ha x 0.1 tunnels/ha x $8.63/check x 4 checks/year</td>
<td>$32,173</td>
</tr>
<tr>
<td>Total annual cost</td>
<td></td>
<td>$1,319,078</td>
</tr>
</tbody>
</table>

4.3.2 Quarantine and response

We have not estimated the cost or responding to predator incursions. Response to a predator incursion can be very expensive. For example, the reported cost of removal of three stoats that invaded Kapiti Island was over $600,000 (Radio New Zealand, 2012). Banks Peninsula predator incursion responses may require similar or greater levels of resources, but these costs are unknown.

We have not estimated the initial and ongoing costs of quarantine facilities. The construction and staffing of quarantine facilities would require additional, probably highly significant, resources. However, it is not clear whether quarantine facilities would be established, or their nature.

4.4 Total cost and timeframes

Based on existing technology, we estimate the initial cost of achieving a predator free Banks Peninsula, excluding administrative and consenting costs, at $95-$140 million including GST (Table 14), which is $1,016-$1,513 ha\(^{-1}\). These estimates are consistent with the estimate of $1,373 ha\(^{-1}\) for eradicating ship rats, mice, stoats, and possums from New Zealand’s three main Islands (Parkes et al., 2016). The estimated ongoing annual cost of maintaining Banks Peninsula’s predator free status is $1.65 million (see Table 14), excluding buffer zones and quarantine facilities, which may be required at roads, rivers, the coast, and at ports.

Because the different scenarios have different times to completion and cost structures it is helpful to assess the present value of cost for each scenario (Table 14). Doing so requires some assumptions about timing of costs. We assume initial costs spread evenly over the predator removal period, and employ Treasury’s recommended discount rate (6%).

31
Control of rats, possums and stoats at low densities using aerial broadcast of sodium fluoroacetate would cost in the order $2.9 million per application (Table 14), but under this scenario, Banks Peninsula will not attain predator free status. Ongoing applications of sodium fluoroacetate would be necessary to maintain control – we assume a five-year return period for illustrative purposes.

To put cost of removing predator free Banks Peninsula in context, Table 15 compares these estimates with other large-scale predator removal operations. Note that all of these projects apply different methods and target different predators. Predator removal under Scenarios One, Two and Three would take a minimum of five to ten years. Estimates exclude the cost and time for planning and cost of establishing and operating buffer zones supplementing the predator-proof fence. Planning an operation of this scale, including getting the rights to access private land, resource consents and gaining community support may take years. Aerial broadcast toxins dramatically decrease the time required for complete predator removal.
<table>
<thead>
<tr>
<th></th>
<th>Scenario One: bait stations</th>
<th>Scenario Two: single use traps</th>
<th>Scenario Three: self-resetting traps</th>
<th>Scenario Four: aerial brodifacoum</th>
<th>Scenario Five: aerial sodium fluoroacetate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$ millions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predator removal</td>
<td>$87.92</td>
<td>$134.17</td>
<td>$132.41</td>
<td>$89.15</td>
<td>$2.89</td>
</tr>
<tr>
<td>Predator-proof fence construction</td>
<td>$6.52</td>
<td>$6.52</td>
<td>$6.52</td>
<td>$6.52</td>
<td>$2.89</td>
</tr>
<tr>
<td>Monitoring grid setup</td>
<td>$0.35</td>
<td>$0.35</td>
<td>$0.35</td>
<td>$0.35</td>
<td>$0.35</td>
</tr>
<tr>
<td><strong>Total initial cost</strong></td>
<td>$94.74</td>
<td>$140.99</td>
<td>$139.25</td>
<td>$96.02</td>
<td>$2.89</td>
</tr>
<tr>
<td>Predator-proof fence maintenance (annual)</td>
<td>$0.33</td>
<td>$0.33</td>
<td>$0.33</td>
<td>$0.33</td>
<td>$0.33</td>
</tr>
<tr>
<td>Monitoring (annual)</td>
<td>$1.32</td>
<td>$1.32</td>
<td>$1.32</td>
<td>$1.32</td>
<td>$1.32</td>
</tr>
<tr>
<td>Additional control (5 yearly)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$2.89</td>
</tr>
<tr>
<td><strong>Total ongoing cost (annual)</strong></td>
<td>$1.65</td>
<td>$1.65</td>
<td>$1.65</td>
<td>$1.65</td>
<td>$0.60</td>
</tr>
<tr>
<td>Estimated removal operation time</td>
<td>7.7 years</td>
<td>10.2 years</td>
<td>5.5 years</td>
<td>Unknown</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Present value of costs</td>
<td>$91.2</td>
<td>$121.2</td>
<td>$136.4</td>
<td>$118.4</td>
<td>$9.5</td>
</tr>
</tbody>
</table>
Table 15
Comparison of total initial costs of predator removal

<table>
<thead>
<tr>
<th>Operation</th>
<th>Predator removal cost Including GST (where applicable)</th>
<th>Area (ha)</th>
<th>Cost ha⁻¹ Including GST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario One: bait stations</td>
<td>$87.9 m</td>
<td>93,205</td>
<td>$943</td>
</tr>
<tr>
<td>Scenario Two: single use traps</td>
<td>$134.2 m</td>
<td>93,205</td>
<td>$1,440</td>
</tr>
<tr>
<td>Scenario Three: self-resetting traps</td>
<td>$132.4 m</td>
<td>93,205</td>
<td>$1,421</td>
</tr>
<tr>
<td>Scenario Four: aerial brodifacoum</td>
<td>$78.0 m</td>
<td>93,205</td>
<td>$837</td>
</tr>
<tr>
<td>South Georgia Island²⁷</td>
<td>$15.4 m</td>
<td>108,423</td>
<td>$142</td>
</tr>
<tr>
<td>Zealandia³⁸</td>
<td>Unknown</td>
<td>225</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maungatautari³⁹</td>
<td>$23,000,000</td>
<td>3,400</td>
<td>$6,765</td>
</tr>
<tr>
<td>Half Moon Bay: bait stations (estimate)³⁰</td>
<td>$10,809,425</td>
<td>4,800</td>
<td>$2,252</td>
</tr>
<tr>
<td>Half Moon Bay: traps (estimate)³¹</td>
<td>$14,366,203</td>
<td>4,800</td>
<td>$2,993</td>
</tr>
<tr>
<td>All of New Zealand (estimate)³²</td>
<td>$36,800,000,000</td>
<td>26,802,100</td>
<td>$1,373</td>
</tr>
</tbody>
</table>

²⁷ $11 million USD for entire operation over five years (Bell Laboratories Inc, 2015).
²⁸ $10m for fence construction and aerial poison operation (Clayton, 2015). GST status of this cost is unknown.
³⁰ 50m x 50m grid (4 ha⁻¹) brodifacoum baits in bait stations (PFR Governance Group, 2015).
³¹ 50m x 50m grid (4 ha⁻¹) traps only (PFR Governance Group, 2015).
³² Estimated minimum cost for eradication of mice, ship rats, stoats and possums from New Zealand’s three main islands (Parkes et al., 2016).
Chapter 5
Summary and Conclusions

This scoping analysis has drawn from a wide range of predator extermination experiences to understand the broad scale parameters involved in managing rats, possums, stoats, and ferrets at zero density on Banks Peninsula. Inevitable reinvasions mean it is not possible to eradicate each of these species once and then for Banks Peninsula to remain predator free without further action. Ongoing border protection and interior monitoring would be essential for sustained control at zero density.

Existing predator eradication technology includes distribution of toxins on the ground and from the air, and trapping. Research is seeking to broaden this suite of tools, but for now that is what is available, and what we have evaluated here. Extermination requires exposure of all target animals to the control method, so home ranges determine how closely control points must be spaced. This varies, by species, as does the type of control apparatus required. We used that information to identify three main predator removal scenarios, for which we derived order of magnitude costs and time required for removal. Our primary purpose was to evaluate methods that did not entail aerial poisoning, but we evaluated aerial brodifacoum, as well as aerial sodium fluoroacetate for comparative purposes. We do not believe these aerial poisoning methods are suitable for Banks Peninsula. Aerial brodifacoum has significant adverse environmental consequences and the present value of costs for Scenario Four exceeds that for Scenario One and is similar to Scenario Two. Aerial sodium fluoroacetate has some potential cost advantages, but on its own is least likely to obtain zero density and is not suitable for Peninsula-wide application.

Regardless of the method of predator removal used, ongoing biosecurity measures (and ongoing costs) will be required to maintain predators at zero densities. Without ongoing biosecurity measures predator numbers on Banks Peninsula would likely return to similar levels to now.

Non-aerial predator removal is an extremely labour intensive and expensive business, so application at the Banks Peninsula scale is unprecedented. Our estimates are that predator removal operation costs (i.e. exclusive of planning, consent, administration, and ongoing predator management costs) would be in the range of $88m to $134m. However, ongoing costs are also significant - our estimate is in the order of $1.65m per annum without buffer, quarantine, or other biosecurity measures. In comparison, the national strategy to eliminate predators from the whole of New Zealand by 2050 has a budget of $84m ($28m from central government on a one-for-two top-up basis for others’ contributions) and the Department of Conservation’s 2016 Battle for our Birds budget was $20.7m for one-off predator reduction operations on 800,000 ha of Conservation land.

Even with a significant workforce of 100 full-time equivalent field staff, attaining zero predator densities across Banks Peninsula would take a considerable number of years. Acknowledging that is important to ensure that sufficient long-term funding is available on commencement to take the project to completion – or risk its complete failure in the long run. It is also important to understand the quantum of labour required, and for how long, where volunteer labour is a significant contributor. Loss of volunteers runs exactly the risks as loss of funding – previous investments can be undermined totally.

Options to reduce costs and/or labour requirements are to change the programme target to either controlling fewer species, to maintaining low (but not zero) predator densities, improving community engagement, including provision of voluntary labour, or some combination of these. In the future, new technology may provide the answers, but for now is unavailable.
Removing rats and/or ferrets could also have significant implications. Rats have the smallest home ranges of the species assessed and so the required grid pattern is much denser than for other species, with rats requiring control features at the rate of 4 ha\(^{-1}\), whereas the next most dense control is for possums at 1 ha\(^{-1}\) (ferrets are 0.1 ha\(^{-1}\)). Removing rats from the programme would reduce both removal and monitoring costs. For example, under Scenario One removal costs associated with the OSKA traps would decrease from $84.5m to $21.1m because the required grid density is only one fourth that required for rats. Time to removal would fall by a commensurate amount. Of course, the rats would remain. It was beyond our remit to estimate the suppression effect that would have on protected species recovery, or the associated reduction in benefits.

Savings from removing ferrets from the programme are far less than from removing rats. Looking again at Scenario One, DOC250 traps would no longer be required, saving $3.4m in removal costs. Again, there is likely to be an adverse effect on protected species, but we have not investigated that.

The aerial sodium fluoroacetate example (Scenario Five) is an example of the implications of changing the programme target to control at low densities, which would result in an order of magnitude reduction in present value of costs, despite the requirement of ongoing aerial toxin applications.

Community residents can affect project viability in two main ways, as a source of volunteer labour and by their decisions about predator control activities undertaken by them or others on the land they manage. The draft community survey in Appendix 3 sheds light on these matters.

There are significant logistical, legal, and financial challenges to achieving a predator free Banks Peninsula. These potential barriers are sensitive to the species targeted and the methods used. We recommend further investigation of the effects of a restricted programme, particularly the exclusion of rats, on conservation outcomes and community support to assess whether a more affordable scheme that could be completed in a much shorter time has merit relative to the proposal we assessed (controlling all five of the target species at zero density).
References


Appendix 1
Current Banks Peninsula mammalian pest control programs

Wildside predator control programme
The most concentrated predator control programme currently underway is the Wildside project. The Banks Peninsula Conservation Trust (BPCT) in collaboration with the Christchurch City Council, DOC, Environment Canterbury, and private landowners manages this project. The area of the Wildside programme consists of 13,500 ha of mixed land uses located in south eastern Banks Peninsula (Haley, 2015). The land uses consist of 75% private rural farmland and 25% conservation reserves (Haley, 2015). Predator control currently consists of 700 traps (of a variety of types) laid out across 7,500 ha of the Wildside area (Haley, 2015). Species targeted under this programme are feral cats, ferrets, stoats, weasels, and possums.

Other programs targeting predators such as rats, feral cats, ferrets, stoats, weasels, and possums are located throughout the Peninsula. However, these programs are of much smaller scale than Wildside.

Little River Trap Library
Volunteers run the Little River Trap Library, which is open to the public every Sunday. The Library lends bait stations and traps free of charge for up to three months, with the option to extend the loan to six months (Little River-Wairewa Community Trust, undated). The Library offers training in the correct use of traps and bait stations.

Feral Goat Programme
Banks Peninsula Feral Goats is an ongoing programme to control feral goats over the entire peninsula. A partnership between BPCT, DOC, Christchurch City Council, and Environment Canterbury manages this programme. The primary contractor for this programme is Excell Pest Control. As of 2015 the programme had 4,971 confirmed kills. However, a major obstacle to eradicating goats from the Peninsula is private landholders prohibiting control on their properties, which has allowed goats to re-establish themselves in previously cleared areas.

Rabbit Management
Under the current Canterbury Regional Pest Management Strategy (CRPMS) rabbits should be kept at densities of level three or less on the modified McNean scale (ECan, 2011). Banks Peninsula landholders are rated for rabbit control. This is unique to the Canterbury region and facilitates rabbit control by experienced contractors (ECan, 2014b).

Community Initiated Possum Programme
Environment Canterbury manages the Banks Peninsula Community Initiated Possum Programme, which began in 2006. The programme encompasses the majority of Banks Peninsula (93,000 ha) and has been responsible for killing at least 21,997 possums (ECan, 2014b). Landholders often conduct their own additional possum control, which is supported by the Banks Peninsula Pest Liaison Committee (ECan, 2012).
## Appendix 2
### Inventory of ongoing and completed predator control projects

<table>
<thead>
<tr>
<th>Islands</th>
<th>South Georgia Island</th>
<th>Campbell Island</th>
<th>Langara Island</th>
<th>Tiritiri Matangi Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Name:</td>
<td>Completed eradication project with complete eradication yet to be confirmed.</td>
<td>Completed eradication project.</td>
<td>Completed eradication project.</td>
<td>Completed eradication project.</td>
</tr>
<tr>
<td>Project Type:</td>
<td>Subantarctic island and overseas territory of the United Kingdom, 1,750km east of the southern tip of South America. The island is partly covered by glaciers that restrict the areas habitable by rats.</td>
<td>Uninhabited New Zealand subantarctic island, 700km south of Bluff.</td>
<td>At the northwest tip of the Queen Charlotte Islands in British Columbia, Canada.</td>
<td>30km north-east of central Auckland, New Zealand.</td>
</tr>
<tr>
<td>Geography:</td>
<td></td>
<td>Department of Conservation (DOC). DOC received assistance form from the RNZ Navy, RNZ Airforce, and Meteorological Service.</td>
<td>Part of the Langara Island Seabird Habitat Recovery Project, involving the Canadian Wildlife Service, Pacific Yukon Region, Environment Canada and the Nestucca Environmental Recovery Trust.</td>
<td>Tiritiri Matangi Island Open Ecosanctuary is co-managed by the Supporters of Tiritiri Matangi (a non-profit community organisation) and the Department of Conservation. There are Supporters of Tiritiri Matangi and DOC staff permanently based on the island.</td>
</tr>
<tr>
<td>Management:</td>
<td>South Georgia Heritage Trust. With assistance from Friends of South Georgia Island, South Georgia Government and the British Antarctic Survey.</td>
<td></td>
<td>Part of the Langara Island Seabird Habitat Recovery Project, involving the Canadian Wildlife Service, Pacific Yukon Region, Environment Canada and the Nestucca Environmental Recovery Trust.</td>
<td></td>
</tr>
<tr>
<td>Targeted Species:</td>
<td>Norway rat (Rattus norvegicus).</td>
<td>Norway rat. No other species of mammalian predator was present on the island.</td>
<td>Norway Rat.</td>
<td>Kore (Polynesian rat). No other mammals were present on the island.</td>
</tr>
<tr>
<td>Protected Species:</td>
<td>Many seabird species, but particularly the South Georgia Pipit, which was at risk of extinction due to predation from rats.</td>
<td>Many native bird species, including the New Zealand pipit and the Campbell Island snipe.</td>
<td>Many native Canadian bird species are present on the island, including the ancient murrelet, raven, and others. Non-target species include the shrew, a mammal native to the island. The presence of non-target land mammals is notably different to New Zealand, which has no native land mammals other than bats.</td>
<td>Many native bird species live on the island, including pukeko, little spotted kiwi, North Island saddleback, and North Island robin.</td>
</tr>
<tr>
<td>Area Protected:</td>
<td>108,423 ha were treated to protect an area of 390,300 ha.</td>
<td>11,330 ha.</td>
<td>3,105 ha (the entire island).</td>
<td>224 ha (the entire island).</td>
</tr>
<tr>
<td>Methods:</td>
<td>Aerial broadcast brodifacoum toxic baits. Application rate ranged from 1.5kg/ha to 3.5kg/ha for areas of denser vegetation. The operation took four years until March 2015. The operation maintained a single rolling front, repositioned daily, allowing systematic bait sowing and avoidance of the target species entering previously treated zones.</td>
<td>Applied 120 tonnes of brodifacoum by four helicopters over a month. The operation consisted of two bait drops, both of which covered the entire island, the first at a rate of 6kg/ha and the second at a rate of 3kg/ha. There was a trial of nontoxic baits at these application rates before the main operation to determine the chance of the operation succeeding. Bait was applied with a 50% overlap to minimise the chance of application gaps. The island was split into sections which allowed baits to be dropped systematically during the winter when low food availability was expected to increase bait uptake.</td>
<td>Bait stations containing brodifacoum were placed in 75m x 75m and 100m x 100m grids over the entirety of the island. 3,905 bait stations at a rate of over 1 ha⁻¹. The bait station method used in this project was adapted and scaled up from smaller operations used in New Zealand. Rats consumed 90g/ha of bait compared to 1,185g/ha in a similar baiting setup on Breaksea Island, New Zealand. One interpretation is that Langara Island had rat density only 7.6% of that on Breaksea Island.</td>
<td>Aerially broadcast Brodifacoum (unknown application rate).</td>
</tr>
</tbody>
</table>
Challenges:
The severe and erratic weather conditions proved challenging for helicopters. The remote location also provided significant logistical challenges. A significant challenge to the operation was the substantial size of Campbell Island (11,330 ha), which required significant resources, including four helicopters and 120 tons of brodifacoum baits. Further complicating the operation was the inhospitable climate and the distance from the mainland (700km), which made logistics difficult. For example, the helicopters had to be fitted with long range fuel tanks and had to stop at several pre-prepared fuel depots en route to Campbell Island. Campbell Island terrain includes cliffs of up to 400m in height, which required special helicopter manoeuvres to apply adequate bait in these areas. Some non-target species, such as raven and shrews, were particularly vulnerable to brodifacoum poisoning. Another challenge was the severe weather that often occurs on the Island during the winter period, preventing winter operations. This lowered the chances of success because low food availability in winter increases uptake of bait by target species. The many fishing lodges on Langara Island presented a reinvasion risk. During the eradication phase there was debate in the media surrounding the use of aerially applied toxins. Increased visitor numbers since eradication have increased the probability of reinvasion. Specific high-risk reinvasion pathways include stowaways in boats and shipping containers.

<table>
<thead>
<tr>
<th>Cost</th>
<th>$NZ15m</th>
<th>Unspecified</th>
<th>Unspecified</th>
<th>Unspecified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of Community Involvement:</td>
<td>There are no permanent residents on South Georgia, which limited community involvement. However, there is a ‘sponsor a ha programme’ which allows the wider community to give financial support.</td>
<td>Uninhabited.</td>
<td>Fishing lodges on Langara voluntarily treated their facilities and barges to mitigate the risk of reinvasion.</td>
<td>The Supporters of Tiritiri Matangi has over 1,600 members.</td>
</tr>
<tr>
<td>Effectiveness:</td>
<td>No rats have been seen since 2015. However, an additional two years of monitoring is required before it official confirmation of rat eradication.</td>
<td>Campbell Island was declared officially free of rats in 2005. The abundance of flightless invertebrate and many native bird species has greatly increased since the eradication was completed.</td>
<td>Eradicated Norway rats. Small pockets of rats survived the initial operation in areas inhabited by humans. However, these populations were quickly eliminated. No signs of rats since January 1996. Langara Island is the largest successful ground-based rat eradication (no aerial broadcasting of toxins) in the world.</td>
<td>Kiore were eradicated from the island by 1993. There was significant by-kill of native bird species, but their populations quickly recovered in the absence of Kiore predation.</td>
</tr>
</tbody>
</table>
## New Zealand Mainland Islands

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Zealndia Ecosanctuary</th>
<th>Maungatautari Ecosanctuary</th>
<th>Orokonui Ecosanctuary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Type:</strong></td>
<td>Completed project with ongoing biosecurity challenges and control of some species.</td>
<td>Completed project with ongoing biosecurity challenges.</td>
<td>Completed project with ongoing biosecurity challenges.</td>
</tr>
<tr>
<td><strong>Geography:</strong></td>
<td>Urban ecosanctuary/mainland island located 3km from the Wellington central business district.</td>
<td>A mainland island/ecosanctuary in the Waikato region of the central North Island.</td>
<td>A coastal Otago forest mainland island/ecosanctuary 20km north of the Dunedin central business district.</td>
</tr>
<tr>
<td><strong>Management:</strong></td>
<td>Karori Sanctuary Trust, a not-for-profit community-led organisation. Funding from many sources, including the Wellington City Council, Victoria University, Department of Conservation, Forest and Bird, Wellington Tentsh Trust, and others.</td>
<td>Part of the Maungatautari Restoration Project, which is managed by the Maungatautari Ecological Island Trust. The Maungatautari Ecological Island Trust is a community organisation that receives funding and support from DOC, Waikato Regional Council, Waipa District Council, and many other groups.</td>
<td>Otago Natural History Trust, a community based organisation that receives technical and financial support from many government and non-government groups including DOC, the University of Otago, and the Ministry of Education.</td>
</tr>
<tr>
<td><strong>Targeted Species:</strong></td>
<td>10 mammalian pest species, including stoats, rats, possums and mice.</td>
<td>Deer, possums, goats, pigs, cats, hedgehogs, ferrets, stoats, weasels, Norway rats, ship rats, mice, rabbits and hares.</td>
<td>12 species, including rats, weasels, stoats, and rabbits.</td>
</tr>
<tr>
<td><strong>Protected Species:</strong></td>
<td>Currently contains more than 40 different species of native birds, including the little spotted kiwi and New Zealand falcon. Also contains many native reptiles, invertebrates and frogs. Most of these species are vulnerable to mammalian predators.</td>
<td>Many native New Zealand species, including reintroduced kiwi, kaka, Takahe, and others vulnerable to predation by mammalian predators.</td>
<td>Many native species, including the Haast tokoeka kiwi, and jewelled gecko.</td>
</tr>
<tr>
<td><strong>Area Protected:</strong></td>
<td>22.5 ha.</td>
<td>3,400 ha.</td>
<td>307 ha.</td>
</tr>
<tr>
<td><strong>Date eradication or removal of species began:</strong></td>
<td>September 1999.</td>
<td>November 2006.</td>
<td>August 2007.</td>
</tr>
<tr>
<td><strong>Methods:</strong></td>
<td>An 8.6km long predator-proof fence to prevent reinvasion. Helicopter broadcast toxin was used for initial target species removal, followed up with ground baiting operations. Ground based control by trapping and bait stations continues to mitigate the risk of reinvasion.</td>
<td>A 4.7km long predator-proof fence with pest proof access gates and specially designed water gates was constructed to create the mainland island. Two trial fences protecting 35 and 65 ha were constructed prior to the main fence to test the viability of the main 3,400 ha project. The main pest removal method involved three applications of brodifacoum bait using helicopters at a rate of 10 kg/ha for each application. Other ongoing methods of predator control include trapping, ground baiting and bait stations. 270km of tracking lines encompassing 2,700 monitoring tunnels are used to check for reinvasion and the status of predators.</td>
<td>An 8.7km long predator-proof fence. The initial removal of pests was conducted using aerial baiting (unspecified toxin), trapping, hand broadcast baiting and bait stations.</td>
</tr>
<tr>
<td><strong>Challenges:</strong></td>
<td>Zealandia is located in a very populous area and has a very high number of visitors per year (126,000 for the 2015/16 financial year), which increases the risk of reinvasion and the biosecurity challenge.</td>
<td>Particular challenges for this project included getting the rights to access private land for fence maintenance. Some landowners with land within the enclosure also felt entitled to a portion of the revenue received by the sanctuary. After the initial predator removal operation some rats remained undetected for up to 18 months before being tracked and then trapped. Furthermore, the home ranges of rats increased up to 20 ha after the initial removal operation.</td>
<td>Ongoing prevention of reinventing pests and generating enough funds to continue operating the sanctuary, including funds for pest control.</td>
</tr>
<tr>
<td><strong>Cost:</strong></td>
<td>Unknown</td>
<td>The cost of the predator-proof fence and pest removal operations up until 2011 was $20m. GST status is unknown – we presume exclusive of GST. This equates to $5,882 ha⁻¹ protected. The ongoing cost of maintaining the project is $1.6 million per year. This is an ongoing cost of $470 ha⁻¹ per year.</td>
<td>Constructing the 8.7km predator proof fence was $2.2m including GST ($253 m⁻¹).</td>
</tr>
<tr>
<td><strong>Degree of Community involvement:</strong></td>
<td>Zealandia encourages the community to help with conservation initiatives and to look after the infrastructure within the sanctuary. Currently Zealandia has over 400 volunteers (&gt;35 full-time staff equivalents) and 70 full-time paid staff. 24 volunteers help with biosecurity such as checking visitor bags for unwanted pests. Close proximity to Wellington probably provides a larger pool of potential volunteers compared to other projects.</td>
<td>The project has 500 volunteers contributing the equivalent of 14 staff working 40 hours per week. This is in addition to the 37 paid full time equivalent staff working on the project.</td>
<td>The sanctuary employs 10 full time equivalent staff, including educators, café staff, guides and others. More than 100 Volunteers contribute around 13,000 hours per year (= 6.5 full time equivalents or 39% of the sanctuary’s total labour force). Volunteers monitor the fence and pest numbers, and undertake track maintenance and weed control, amongst other activities.</td>
</tr>
<tr>
<td><strong>Effectiveness:</strong></td>
<td>Removed target species within a few months. However, mice have successfully reinvaded and now have an established population. There is ongoing mouse population control (but not eradication) by bait stations. Weasels and rats occasionally reinvaide, but are currently not present in the sanctuary. Common reinvasion routes include windfall tree bridges and partially blocked culverts.</td>
<td>Rats were detected at 48% and mice at 18% of tracking tunnels prior to the pest removal attempt. All target species have been removed from the Maungatautari Ecosanctuary except for mice, rabbits and hares. Mice have a particularly entrenched population.</td>
<td>All targeted species were successfully removed from the sanctuary. An average of one to two predator incursions annually. Storm damage to the fence is one known reason for incursions.</td>
</tr>
</tbody>
</table>
Sources:
- Bell (2014)
- Innes et al. (2012)
- Karori Sanctuary Trust (2016)
- Zealandia (undated)
- Innes et al. (2012)
- Maungatautari Ecological Island Trust (undated a)
- Maungatautari Ecological Island Trust (undated b)
- Speedy et al. (2007)
- Bell (2014)
- Orokonui Ecosanctuary (undated)
- DOC (2015c)
### New Zealand Peninsulas

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Tawharanui Open Sanctuary</th>
<th>Shakespeare Open Sanctuary</th>
<th>Otago Peninsula</th>
<th>Cape Sanctuary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Type:</td>
<td>Completed project with ongoing biosecurity challenges.</td>
<td>Completed project with ongoing biosecurity challenges.</td>
<td>Ongoing project.</td>
<td>Completed project with ongoing biosecurity challenges.</td>
</tr>
<tr>
<td>Geography:</td>
<td>The end of the Tawharanui Peninsula, Auckland.</td>
<td>Shakespeare Open Sanctuary is located in the Auckland region at the end of the Whangaparaoa Peninsula.</td>
<td>East of Dunedin. The Peninsula is approximately 20 km long with maximum width of approximately 15 km.</td>
<td>Cape Kidnappers Peninsula, Hawkes Bay. Multiple land uses, including tourism, forestry, and 650 ha of farmland.</td>
</tr>
<tr>
<td>Management:</td>
<td>Tawharanui Open Sanctuary Society, a community based organisation that operates in a partnership with the Auckland Council and receives support from many sources.</td>
<td>Shakespeare Open Sanctuary is managed by the Shakespeare Open Sanctuary Society, a community based organisation that receives support from the Auckland City Council and sponsors such as MAXLIFE batteries.</td>
<td>This initiative to remove possums from the peninsula is managed by the Otago Peninsula Biodiversity Group, which is a community based organisation with a part time Project Manager and a part time Operations Manager. Financial support is received from DOC, Otago Community Trust, Dunedin City Council and other sponsors.</td>
<td>Privately owned by three families. Two full time staff manage traps and bait stations with assistance from volunteers. Sponsors, including Victoria University, DOC, and others.</td>
</tr>
<tr>
<td>Targeted Species:</td>
<td>At least 10 species were targeted for removal. These species include mice, ship rats, Norway rats, weasels, stoats, ferrets, possums, cats, rabbits and hedgehogs.</td>
<td>At least 10 species were targeted for removal. These species include mice, ship rats, Norway rats, weasels, stoats, ferrets, possums, cats, rabbits and hedgehogs.</td>
<td>Possums. The goal is to lower residual trap catch to 1% by 2018, therefore not control at zero densities or eradication.</td>
<td>Mammals targeted include rodents, ferrets, stoats, cats, goats, possums and hedgehogs.</td>
</tr>
<tr>
<td>Protected Species:</td>
<td>Many native species, including takahē, kiwi, pateke, kakariki, bellbirds, robins, kaka, whiteheads, and saddlebacks.</td>
<td>Many native bird species. Seeking to reintroduce the small spotted kiwi.</td>
<td>Stock vulnerable to bovine tuberculosis spread by TB-infected possums.</td>
<td>The sanctuary had relatively sparse of native species. Species have since returned or been translocated into the sanctuary, including kiwi, robin, and rifleman.</td>
</tr>
<tr>
<td>Area Protected:</td>
<td>$550 ha.</td>
<td>500 ha.</td>
<td>9,500 ha.</td>
<td>2,500 ha.</td>
</tr>
<tr>
<td>Methods:</td>
<td>A 2.5km predator-proof fence isolates Tawharanui Open Sanctuary from the rest of the Peninsula. This fence has a unique koura shape design at the ends to help prevent intrusion near the coast. Initial pest removal was by two aerial brodifacoum applications in conjunction with hand broadcast toxins, bait stations, conventional trapping, and shooting. A network of traps is still maintained within the sanctuary, including a buffer zone at high risk areas to decrease risk of reinvasion. A response plan is also in place for when intruders are detected, including increased intensity of trapping and monitoring.</td>
<td>A 1.7km long predator-proof fence was constructed to isolate Shakespeare Open Sanctuary from the rest of the Whangaparaoa Peninsula. The predator-proof fence incorporates an automatic gate for vehicle access and three gates for walking access. The initial method of removing the targeted pests is not stated. There are trap lines and monitoring tunnels throughout the sanctuary to minimise reinvasion, more intensively placed close to the fence to act as a type of buffer zone. The traps are conventional kill traps, including DOC 200s and smaller mouse traps. Fence monitoring by trail cameras and foot patrols.</td>
<td>Systematic possum removal in two stages across five sectors. The two stages include an initial knockdown phase and a mop up phase. One 400 ha sector at the southern base of the Peninsula is more intensively managed as a buffer zone. The knockdown phase is uses bait bags, conventional traps, and night shooting. The mop up phase only occurs in areas identified as having particularly high possum densities. Mop up methods include indicator dogs and GPS positioned conventional traps and bait stations. No use of aerial broadcast toxins.</td>
<td>Isolated by a 10.6 km length, 1.9m high predator-proof fence. 1,400 traps control mustelids and 2,200 bait stations control rodents, generally spaced at 100m along ridge lines.</td>
</tr>
<tr>
<td>Challenges:</td>
<td>Tawharanui is an open sanctuary where visitors can come and go as they please (~ 160,000 visits in 2011). This presents a large biosecurity risk from both the visitors and their vehicles (including boats). Despite the special koura design, the ends of the predator-proof fence are still particularly vulnerable to reinvasion because of a 60m gap between the fence and the ocean at low tide. The single, automated vehicle gate is a high risk intrusion pathway, due to lack of a quarantine containment &quot;cell&quot;.</td>
<td>The ends of the fence are particularly vulnerable to intruders at low tide. 550,000 people visit the Shakespeare Open Sanctuary annually. Human and vehicle traffic greatly increases the risk of reinvasion.</td>
<td>The Peninsula has many private land owners and the buffer zone is in close proximity to dense residential housing. Neighbouring residential gardens contain &quot;reservoirs&quot; of possums. 200,000 people visit the Otago Peninsula annually and there is no predator-proof fence. All these factors greatly increase the risk of reinvasion by possums from uncontrolled areas. Other identified barriers to removing possums from the peninsula include pest control in close proximity to inhabited areas constraining the methods used to those considered safe to both humans and domestic animals. Some physically inaccessible areas, such as steep terrain, also limit pest control methods.</td>
<td>Predator proof fence ends are at high risk of reinvasion.</td>
</tr>
<tr>
<td>Cost:</td>
<td>Predator-proof fence construction $770,500 including GST (2.5 km, $308 m²). Predator removal cost is unknown.</td>
<td>Predator-proof fence construction $1,058,000 including GST (1.7 km, $622 m²).</td>
<td>Initial public consultation $56,000. Initial planning $175,000. Pest control operation and monitoring (2010 – 2013) $396,558. Total so far $627,000 ($66 ha⁻¹). GST status unknown. The project is incomplete.</td>
<td>Unspecified.</td>
</tr>
<tr>
<td>Degree of Community Involvement:</td>
<td>Volunteers regularly check the predator-proof fence for possible breaches and damage. The traps within the sanctuary are checked by a combination of volunteers and Auckland City Council Staff.</td>
<td>Volunteers conduct fence inspections every week and check traps every second month.</td>
<td>The Otago Peninsula Biodiversity Group has 73 volunteers who contributed 5,500 hours to the project between 2010 and 2013. However, contractors are the primary means of conducting pest control operations.</td>
<td>Volunteers checks traps and bait stations on a regular basis.</td>
</tr>
</tbody>
</table>
### Effectiveness:

All the targeted species have been removed except for mice, rabbits, and hedgehogs. Rats, cats, possums, weasels and stoats occasionally rein invade, but have successfully been contained. Reinvasion occurs more frequently during late summer when there is less food availability.

All targeted species except mice have been removed. Reinvasions have occurred by rats, possums, cats, weasels and rabbits, but all have been successfully contained. There is limited control of mouse populations by conventional kill traps.

Almost 10,000 possums had been removed by 2016 - a 75%-98% reduction in possum numbers in the first three sectors. Information is not yet available on sectors four and five as operations in these areas are still underway.

Hedgehogs, possums, goats and mustelids have all been eradicated and rats were at very low levels by 2007. Over 750 cats have been trapped, but they are still a problem for the sanctuary. Mice can penetrate the fence. Traps and bait stations keep predators at low levels.

### Sources:

- Maitland (2011)
- TOSSI (undated)
- Bell (2014)
- Maitland (2011)
- Shakespeare Open Sanctuary Society Incorporated (undated)
- Otago Peninsula Biodiversity Group (2009)
- Haumoana (undated)
- Nature Space (undated)
- Poutiri (undated)
### Other New Zealand projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Cape to City</th>
<th>Zealandia and Orokonui Halos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Type:</td>
<td>Proposed project.</td>
<td>Ongoing project to control predators.</td>
</tr>
<tr>
<td>Geography:</td>
<td>Halfmoon Bay, east coast of Stewart Island.</td>
<td>This is a mainland project located in the Hawkes Bay region between Hastings and Cape Kidnappers.</td>
</tr>
<tr>
<td>Management:</td>
<td>The feasibility assessment for a predator free Halfmoon Bay was conducted by the Predator Free Rakiura Governance Group, a community based organisation that receives technical assistance and support from many organisations, including DOC.</td>
<td>The project is managed by the Hawke’s Bay Regional Council in collaboration with DOC, Landcare Research and others.</td>
</tr>
<tr>
<td>Targeted Species:</td>
<td>Norway rats, ship rats, kiore, feral cats, possums and hedgehogs. Mice and mustelids (stoats, ferrets and weasels) are not present on Stewart Island.</td>
<td>Include stoats, possums, hedgehogs, mustelids, and feral cats.</td>
</tr>
<tr>
<td>Protected Species:</td>
<td>Many native species, including Stewart Island kīwi and yellow-eyed penguin.</td>
<td>Unspecified.</td>
</tr>
<tr>
<td>Area Protected:</td>
<td>Two different scenarios were considered. The most ambitious scenario considered the construction of an 8.8km long predator proof fence and the protection of 4,800 ha. This is the scenario considered here.</td>
<td>26,000 ha.</td>
</tr>
<tr>
<td>Date eradication or removal of species began:</td>
<td>This project has not been initiated.</td>
<td>May 2015.</td>
</tr>
<tr>
<td>Methods:</td>
<td>Construction of an 8.8km long predator proof fence would be the first stage. The governance group considered four different predator removal methods at two different grid sizes. They considered the most likely method to achieve success is Brodifacoum baits in bait stations having ruled out aerial toxin application because of opposition from the public, identified in a 2014 survey.</td>
<td>The goal is to drive targeted species to very low densities, not complete eradication.</td>
</tr>
<tr>
<td>Challenges:</td>
<td>Difficulty of predator control in an area permanently inhabited by humans and their domestic pets. Large biosecurity challenges due to the high volume of people, luggage and freight entering the controlled area. During the predator removal stage every building, structure, vessel and vehicle in the area would require treatment.</td>
<td>Many different land uses and owners.</td>
</tr>
<tr>
<td>Cost:</td>
<td>Predator-proof fence construction $4.06 m (8.7km, $461 m$). Annual maintenance of $170,000 ($20 m$ year$^{-1}$). Initial predator control cost is $10.8 m to $29.2 m, depending on method and grid size. The estimated cost of biosecurity is $1.41 m, with an ongoing annual cost of $2.15 m. All costs include GST.</td>
<td>$6 m has been invested into the project from various groups, including government and NGOs. GST status is unknown.</td>
</tr>
<tr>
<td>Degree of Community Involvement:</td>
<td>The assessment states that a fundamental component of successful biosecurity will involve working closely with the local community.</td>
<td>The project managers suggest that community participation is required for the project to be successful. The project is in its early stages, so the actual level of community involvement is yet to be demonstrated.</td>
</tr>
<tr>
<td>Effectiveness:</td>
<td>The assessment suggests that periodic reinvasion of predators into the protected area would be inevitable.</td>
<td>This is a relatively new project and therefore the effectiveness is yet to be determined.</td>
</tr>
</tbody>
</table>
Appendix 3
Predator Free Banks Peninsula Survey

This survey is for Banks Peninsula landholders and land managers. Results will help ascertain the feasibility of making Banks Peninsula predator free.

1. What is the approximate total area of your Banks Peninsula property?
   (One ha = 10,000m² = 2.47 acres)
   Ha: ________________

2. If the costs and methods were acceptable to you, would you support making Banks Peninsula predator free?
   (Under this scenario, predators are defined as rats, possums, ferrets and stoats)
   a) Yes (go to question 3)
   b) No (go to question 6)

3. Why do you support making Banks Peninsula predator free?
   (Circle all that apply)
   a) I want to increase tourism on Banks Peninsula
   b) I want to increase the abundance of native animals on Banks Peninsula
   c) I want to prevent the spread of disease from predators to livestock on Banks Peninsula
   d) I support making Banks Peninsula predator free for other reasons
   e) Other (please specify):________________________________________

4. Would you be willing to volunteer your own time to help achieve the goal of predator free Banks Peninsula?
   a) Yes (go to question 5)
   b) No (go to question 6)
5. **How much of your own time are you willing to volunteer per year to help make Banks Peninsula predator free?**

   Days per year: ____________

6. **Do you currently do predator control on your property?**

   a) Yes *(go to question 7)*
   b) No *(go to question 9)*

7. **Which of the following species are currently subject to control on your property?** *(Circle all that apply)*

   f) Rats
   g) Possums
   h) Stoats
   i) Ferrets
   j) Weasels
   k) Feral cats
   l) Hedgehogs
   m) None of these

8. **Which of the following methods of predator control are used currently on your property?** *(Circle all that apply)*

   a) Conventional kill traps
   b) Self-resetting kill traps
   c) Toxic bait stations/bags
   d) Hand broadcast toxic baits
   e) Shooting
   f) Other (please specify): __________________________________________
9. **How desirable to you is removal of each of the following species from Banks Peninsula?**

<table>
<thead>
<tr>
<th>Species</th>
<th>Very desirable</th>
<th>Moderately desirable</th>
<th>Slightly desirable</th>
<th>Not desirable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possums</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stoats</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Ferrets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weasels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feral cats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hedgehogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. **How acceptable to you is the use of each of the following predator control methods on Banks Peninsula?**

<table>
<thead>
<tr>
<th>Method</th>
<th>Very acceptable</th>
<th>Acceptable</th>
<th>Neutral</th>
<th>Unacceptable</th>
<th>Very unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional kill traps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-resetting kill traps</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Poison bait stations/bags</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerial broadcast poison</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand broadcast poison</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predator-proof fences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetic engineering</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Shooting</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
11. **Which of the following methods of predator control (if any) would you permit on your property?**

   *(Circle all that apply)*

   a) Conventional kill traps  
   b) Self-resetting kill traps  
   c) Toxic bait stations/bags  
   d) Aerial broadcast toxic baits  
   e) Hand broadcast toxic baits  
   f) Shooting  
   g) None of these

12. **Do you think aerial broadcast of 1080 (sodium fluoroacetate) should be used on Banks Peninsula?**

   a) Yes  
   b) No  
   c) I don’t know

13. **In relation to the use of aerial broadcast 1080 on Banks Peninsula, which of the following statements concerns you the most?**

   *(Circle ONE)*

   a) Contamination of waterways  
   b) Risk to native animals  
   c) Risk to domestic pets  
   d) Risk to game animals  
   e) Risk of toxin persisting in the environment for long periods  
   f) The inhumane manner in which the toxin kills  
   g) The indiscriminate manner in which aerial broadcast 1080 is applied  
   h) None of these statements concerns me
14. Do you think poison bait stations containing brodifacoum should be used on Banks Peninsula?

a) Yes
b) No
c) I don’t know

15. In relation to the use of toxic bait stations containing brodifacoum on Banks Peninsula, which of the following statements concerns you the most?
(Circle ONE)

a) Contamination of waterways
b) Risk to native animals
c) Risk to domestic pets
d) Risk to game animals
e) Risk of toxin persisting in the environment for long periods
f) The inhumane manner in which the toxin kills
g) None of these statements concerns me

16. Comments:
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________