Stewart Island / Rakiura
Community & Environment Trust

for people for environment

Scoping the Potential to Eradicate Rats, Wild Cats and Possums from Stewart Island/Rakiura

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Quotes of note

Southland mayor Frana Cardno on visiting Sirocco the kakapo on Ulva Island (Southland Times, 2 Sept 2006).
"It was a truly magical experience walking through the bush on Ulva Island. The lush undergrowth, the sounds of kiwi and kaka's call and you can't help reflect and say a quiet thankyou to the Ulva Island Trust in partnership with DOC, who have eradicated all pests from this beautiful island. The birds and bush are being restored to what we had in the past, what an investment for the future."

Andy Roberts, Southern Islands Area Manager (Campbell Island Eradication Scoping Paper 2000).
"We only got to this position by doing what others believed was impossible!"

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June 2008

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Summary

What is proposed?

Stewart Island / Rakiura has exceptionally high conservation values; in part due to the absence of certain pests that are present on mainland New Zealand (notably stoats and mice). However, Norway rats (*Rattus norvegicus*), ship rats (*Rattus rattus*), kiore / Pacific rats (*Rattus exulans*), wild cats (*Felis catus*) and possums (*Trichosurus vulpecula*) are established on Stewart Island / Rakiura and these species are causing a steady decline in the Island's indigenous flora and fauna.

It has been proposed that rats, wild cats and possums could be eradicated from Stewart Island / Rakiura. This is not a new idea, with the prospect of eradicating rats from Stewart Island / Rakiura having been discussed for at least the last nine years. It is now timely to undertake a systematic study of the feasibility of this proposal.

This document identifies critical issues and undertakes an initial evaluation of the feasibility of eradicating rats, wild cats and possums from the whole of Stewart Island / Rakiura. It aims to evaluate whether this is possible by identifying and examining the key issues (technical as well as social issues). It also considers how a firm proposal to eradicate these pests can be advanced. The Department of Conservation has prepared this document on contract to the Stewart Island / Rakiura Community and Environment Trust (SIRCET), with funding from the Tindall Foundation.

The eradication of other introduced mammals from Stewart Island / Rakiura (hedgehogs, red deer and white-tailed deer) is not considered in this study. It is recommended that hedgehogs be included in any further discussion on eradication. Deer are not being targeted for eradication as: (i) the community places value on the deer herd and has requested that they not be considered for eradication; and (ii) to target deer would substantially alter the structure of a future eradication programme, and significantly increase costs. It is not known whether mice have established on the Island. Confirming the presence or absence of mice, as well as establishing systems to minimise the risk of mouse invasion, should be given priority.

This feasibility study has set no timeframe for any proposed eradication. Such a programme can only succeed with full community and landowner support. Thus it would only occur when the community wants it to, be that five or fifty years.

Why eradicate these pests?

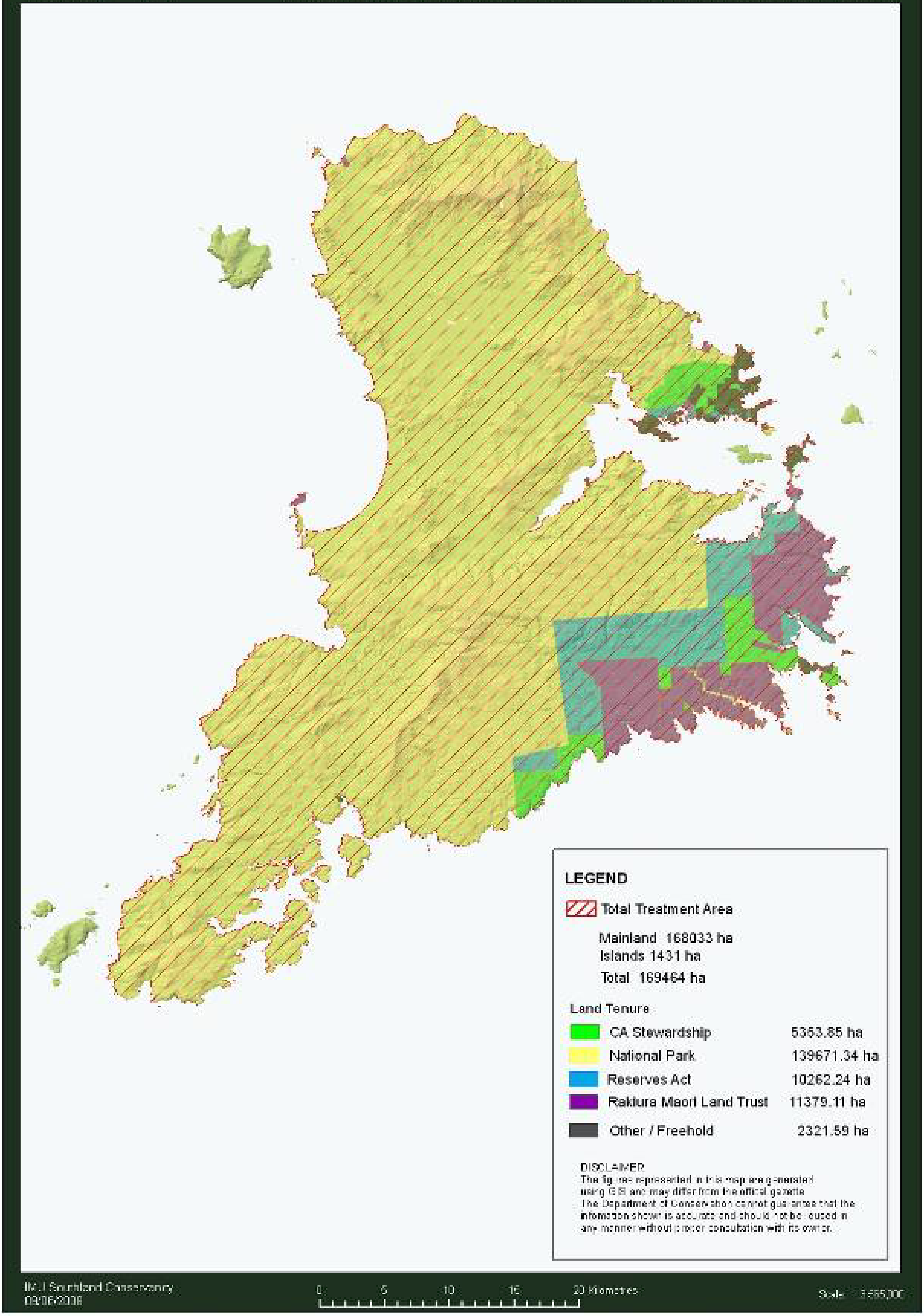
Rats, wild cats and possums are without doubt, having a major detrimental impact on the native flora and fauna of Stewart Island / Rakiura, driving many to extinction. The impact of these pests is obvious when one compares the flora and fauna of pest free islands, such as Ulva Island, and the rest of Stewart Island. Not only have the resident birds increased in number on Ulva Island since rats were removed, but birds that can not co-exist with rats (e.g. saddleback and mohua) are thriving since being transferred to the Island.

Without eradication, many of the important native species that remain on Stewart Island / Rakiura will continue to decline until they only exist on offshore islands or at sites where ongoing intensive pest control is occurring. With eradication, not only will these declines be reversed, but other species could be moved to Stewart Island / Rakiura, helping to secure them from extinction. To achieve similar gains with a "control" technique is not possible across the whole of Stewart Island / Rakiura.

Potential treatment area

For an eradication to be effective, the main Island and all islands within 1km of its coast, that contain rats, would need to be targeted (Norway rats can swim 1km). Therefore, the area that would require treatment is 169 464ha. Approximately 90% of this area is owned by the Crown; Rakiura Maori Land Trust manages about 8% with the remainder in private title.

FIGURE - 1.4.1 RAKIURA / STEWART ISLAND - TOTAL TREATMENT AREA



Can it be done?

Five conditions must be met to achieve eradication. These conditions are examined below, in relation to the potential eradication of rats, wild cats and possums from Stewart Island / Rakiura.

CAN ALL INDIVIDUALS BE PUT AT RISK BY THE ERADICATION TECHNIQUE? CAN THEY BE KILLED AT A RATE EXCEEDING THEIR RATE OF INCREASE AT ALL DENSITIES?

There have been many successful rodent eradication projects worldwide. A smaller number of cat and possum eradications have also occurred. Eradication operations targeting multiple species are becoming more common in New Zealand. Such operations have occurred in conjunction with pest-proof fenced "mainland islands". New Zealand is a world leader in eradication technologies.

A range of methods were considered in this feasibility study. Biocontrol options were not considered feasible as: (i) they do not remove all of a population; (ii) the technology has not been developed for possums, rats and wild cats; and (iii) approval for use would be difficult to obtain, especially considering New Zealand's proximity to Australia, where possums are endemic. Ground based techniques were discounted as the primary eradication tool due to the size of Stewart Island / Rakiura. For example, to establish bait stations across the Island would require over 400 000 bait stations, with over 20 000km of tracks and would require over 2000 person days for each fill.

The use of a second generation anticoagulant in a cereal pellet bait and aerial bait distribution is proposed as the only feasible and logistically practicable way of eradicating rodents from an area the size of Stewart Island / Rakiura. An aerial application is feasible when considering application times and weather windows. Nevertheless, any innovations that could speed up bait distribution (e.g. improving fixed wing aircraft bait distribution consistency) would further improve the chance of success and reduce the cost of the operation.

An aerial application of bait is not suitable for the township area. Ground based techniques would need to be employed in the township. However, as the time required for this would be substantially greater than an aerial operation, a measure would be required to inhibit the crossing of pest individuals between the ground-treated and aerially treated sites. This could be achieved through the construction of a low (1m high) predator-proof fence or through a substantial ground-based overlap being carried out into the aerially-treated area. Eradicating the target pests within the township will require building community support through early involvement.

While there is a possibility that an aerial application of brodifacoum bait would put all possums and wild cats at risk, there is also a chance that a small number of possums and wild cats will survive. Follow-up work will be required for these two species. It is proposed that this be in the form of traps and hunting with registered predator dogs.

Such operations could not be conducted across all of Stewart Island / Rakiura. Work will be required on the distribution and habitat use of these animals to ensure follow-up operations can be targeted to specific areas (e.g. podocarp forest). If there is habitat specificity, then follow-up work is likely to be feasible.

Production of large amounts of bait will be required (4250 tonnes). This quantity exceeds the current production capability of the manufacturer. It would take at least 10 months to produce the bait, which has a recommended storage life of four months. These production issues could be overcome by purchasing two new machines and temporarily setting up a production facility in Bluff or Invercargill.

There are a number of research requirements and gaps in knowledge that need to be addressed before eradication could be declared feasible. Future work may reveal the potential for cost efficiencies (e.g. fixed wing aircraft might be used rather than helicopters to distribute baits). Further research will be needed to address fundamental questions (e.g. habitat selection by cats and possums).

Deer present a significant risk to the success of the operation as they may create bait gaps. Deer repellant may significantly reduce this risk, as well as the impact of the operation on deer hunting opportunities. The efficacy of deer repellant on white tailed deer and its palatability to the target species should be investigated.

For rodents, it appears that only a small amount of research is required to establish whether or not all individuals can be put at risk by the eradication techniques; and whether they can be killed at a rate exceeding their rate of increase at all densities. There is more uncertainty surrounding cats and possums, particularly in relation to the efficacy of follow-up work. Significant new research may be required.

CAN THE PROBABILITY OF THE PEST RE-ESTABLISHING BE MANAGED TO NEAR ZERO?

Re-invasion incidents are reasonably common throughout New Zealand. The re-invasion risk for Stewart Island / Rakiura is high due to the type and frequency of transport activities associated with the permanent settlement, recreational opportunities and commercial activities carried out around the island. Rats and mice are most likely to re-invade.

If an eradication operation were to proceed, then both a biosecurity and a contingency plan will need to be developed in conjunction with the community as part of the operational planning. This plan will need to identify the key pathways that pests could use to get to Stewart Island / Rakiura and design ways of preventing this.

The use of rodent detecting dogs at departure points could provide a relatively quick and unobtrusive method of intercepting rodents. Other tools that could be employed include traps and bait stations and detection devices such as ink pads or hair traps. Biosecurity requirements should not unduly inconvenience people travelling to Stewart Island / Rakiura, but may require that people departing for Stewart Island / Rakiura do so from designated points.

It would be vital to establish quarantine and contingency measures prior to any eradication being undertaken. In this way, procedures can be refined, leading to greater confidence that quarantine and contingency measures are effective and sustainable.

With appropriate quarantine and contingency measures consistently applied on Stewart Island / Rakiura, it is likely that the probability of a pest re-establishing is manageable to near zero.

Regardless of progress towards developing an eradication plan, it is recommended that a high priority is given to establishing biosecurity measures for preventing any more organisms, especially mice, from establishing on Stewart Island / Rakiura.

IS THE PROJECT SOCIALLY ACCEPTABLE TO THE COMMUNITY INVOLVED?

While there has been strong support for the completion of this scoping exercise, it would be premature to anticipate future support for an eradication project. The level of community support will change as new information becomes available and societal attitudes change over time. It is not appropriate to 'tick a box' saying the community supports this proposal, but rather to build and maintain that support by facilitating community involvement at all stages of the project.

There are a large number of landowners, agencies and stakeholders with an interest in this eradication proposal. This study has identified key groups of people that will need to be involved if any development toward an eradication process is to proceed (e.g. the resident community, iwi, Rakiura Maori Land Trust, deerstalkers, fishermen, tourist operators, mussel farmers, etc.).

A number of concerns regarding this proposal have been raised by the community and are discussed in the main document. These include: cost; changes to lifestyle; effects on health; pet ownership; the cultural value of kiore and; the impacts on deer hunting opportunities.

The impact on deer hunting and subsistence living has the potential to be large. Deerstalkers need to be fully engaged in assessing the viability of any eradication project as a key stakeholder.

A governance group of representative stakeholders is proposed to assess this feasibility study and guide the development of a pest eradication strategy for Stewart Island / Rakiura, should this be the direction adopted. The structure of a governance group needs careful consideration to ensure that the resident community's interests are well represented and that they do not feel overwhelmed by outside interests.

DO THE BENEFITS OF THE PROJECT OUTWEIGH THE COSTS?

This study looked at the ecological, social and economic benefits and costs of the proposed eradication. There is currently significant uncertainty surrounding the social and economic costs and benefits.

Ecological benefits appear to outweigh ecological costs, based on the experience of many other eradication operations conducted in New Zealand. Many native plant and animal species will benefit from the removal of rats, wild cats and possums. This includes those that could be (re)introduced to the Island. There are non-target risks associated with an aerial baiting campaign of the nature described. Any future eradication programme will need to be carefully developed to mitigate the risk of the operation to non-target native animals.

Socially, it is difficult to determine if the benefits outweigh the costs as it is dependant on an individual's

personal values. A full social impact study is recommended as well as involvement of the community in all aspects of planning and decision making.

Economically, it is likely that there will be high returns; mainly from increases in opportunities for tourism. This study has been unable to quantify the change in tourism in response to a rat, wild cat and possum eradication, but it is likely to provide a reasonable return on the operational cost. The development of a new tourism strategy that takes into account social, environmental and cultural impacts, as well as growth and development, is recommended for Stewart Island / Rakiura.

Good planning and strategies, developed with the involvement of the community and other affected parties, will help minimise costs and maximise benefits, to the point where the benefits of the project will outweigh the costs.

Cost

The financial cost to eradicate rats, wild cats and possums from Stewart Island / Rakiura is estimated to be in the order of $35 million to $55 million.

Key steps should any proposal be taken further

Eradicating rats, wild cats and possums from Stewart Island / Rakiura, using an aerial drop of brodifacoum poison bait, appears to be feasible. Follow-up ground hunting would be required for possums and wild cats. There are significant logistical issues that need to be addressed, but there is a good chance these can be overcome with targeted research and careful operational planning. There are many issues (especially social), for which solutions need to be found before an eradication operation is seriously considered. While this section does not cover funding or costs for each step (see Section 5), should the trust choose to progress the eradication proposal, it is recommended that they seek funding to develop a process to work through some of the key issues that have been identified. Regardless of how an eradication plan may develop, there are some key parts to the process that would be of substantial benefit to the community and thus there is little to lose in embarking on this path.

It is imperative that the resident community are involved in all aspects of planning for the eradication of rats, wild cats and possums on Stewart Island / Rakiura. Other key stakeholders have also been identified in these studies (e.g. RMLT). These stakeholders must also be fully involved in planning and decision making. This section does not nominate responsibility for each step. It simply tries to list required steps in a sequential order.

Key steps towards a pest eradication project for Stewart Island / Rakiura. The coloured panels are potential "show stoppers" that have to be resolved before going further.

Increasing timeframe

Social requirements	Research and knowledge gaps	Operational planning requirements
A governance group should be created to oversee the development of a firm proposal. This group should include key stakeholders and some independent science advisors. A round table approach should be adopted.		
Develop a tourism strategy for Stewart Island to guide tourism growth and protect lifestyle values.	Fund innovation for aerial application - i.e. fixed wing aircraft, adjustments to buckets leading to larger swath widths or faster flying times, etc.	
	Further national knowledge and develop tool kit on multi-species eradications; Including, research into pest interactions around baits and potential for competitive exclusion.	
Contribute / submit to any district or regional plans to create a regulatory framework for an eradication operation.	Determine the distribution and density of hedgehogs on Stewart Island.	Develop an eradication plan for hedgehogs; if their distribution is limited, eradication may be achievable as a stand alone project. Hedgehogs should be included as a target animal henceforth.
Work with deerstalking interests to determine acceptable impacts of a pest eradication programme on deer, deer hunting and subsistence living.	**Investigate the effectiveness of deer repellent on white-tailed deer and its effect on bait palatability to rats, cats and possums. Investigate legislative limits.**	Leave deer off the target animal list for eradication; Encourage DOC and Liaison Group to continue monitoring programme investigating impacts of deer on forest health.
	Determine if mice have established on Stewart Island. If so, to what extent and could they be eradicated?	
	Develop and refine tools and methods for detecting target animals at low densities and/or determine probabilities of detection.	
	Investigate habitat specificity in cats and possums. Can follow-up operations be targeted to specific areas of Stewart Island?	
	Continue to investigate alternative toxins for wild cats (e.g. Australian 1080 sausage and PAP toxin) and test on Stewart Island.	Seek registration for PAPP and 1080 sausage for use on cats on Stewart Island / Rakiura.
Review old / develop new national kiore / Pacific rat management plan in partnership with iwi.	Review of label of brodifacoum and identify actions required for relicensing for this operation.	**Seek registration for brodifacoum use on the mainland; which may include registering with a deer repellant.**
Work with marine farmers (salmon and mussels) to develop suitable mitigation measures.	Investigate the effect that pest removal would have on carbon sequestration.	
Start working with community to develop acceptable and practicable methods for biosecurity. Run trial period so that community can see what is involved.	**Test the efficacy of biosecurity plans.**	Develop result and outcome monitoring plans and biosecurity and contingency plans.
	Establish weather monitoring across potential eradication units to determine likelihood of "weather windows".	**Develop a ground baiting plan for Oban township, including further investigation of the costs and benefits of a predator proof fence.**
Commission a social impact study, or something similar, to clarify the effects that an eradication would have on the community.		Develop dog team and staff capacity for biosecurity, contingency, result monitoring and eradication work.
Residents fully support a pest eradication operation and accept the on-going implications of the operation, in relaton to quarantine and all aspects of their lives and work (eyes wide open).	**Investigate and finalise methods of bait production, transport and storage.**	Undertake trial eradication operations.
	Investigate the ideal baiting rate for Stewart Island. A reduction from 25kg/ha has potential for major savings, especially in regard to bait production times and cost.	Develop operational plan.
		Operational planning needs to identify and work toward mitigating non-target risk.
	Is there toxin resistance? Test rats, possums and wild cats for brodifacoum resistance in areas of historical use.	Cease use of second generation anti-coagulants on Stewart Island at least three years prior to any eradication operation.
		Develop ecological restoration / management plan, including potential transfers, for post-eradication environment.

Implement eradication programme.

Contents

Photo credits

Photos have mainly been supplied by the author and the Department of Conservation.

Other contributors are: Kari Beaven (p4, 37, 71), Eamonn Ganley (p17, 23), David Mudge (p30), Colin Bishop (p3) and Phred Dobbins (81).

1. What is being considered?

It has been proposed that rats, wild cats and possums could be eradicated from Stewart Island / Rakiura. Eradication is the permanent removal of every individual of a target pest from a defined area that is surrounded by some type of barrier that prevents reinvasion. This document examines the feasibility of the proposal to eradicate rats, wild cats and possums from the whole of Stewart Island / Rakiura. It aims to evaluate whether this is possible by identifying and examining the key issues (technical as well as social). It also considers how a firm proposal to eradicate these pests can be advanced.

The Department of Conservation (DOC, the Department) has prepared this document on contract to the Stewart Island / Rakiura Community and Environment Trust (SIRCET) with funding from the Tindall Foundation.

The document has three main parts. The first is introductory, describing the background to this feasibility study, what makes Stewart Island / Rakiura special, as well as the target pests. The second part examines the feasibility of eradication and discusses the issues that have been identified to date. The third section presents a preliminary analysis of costs.

1.1 The path to now

There currently exists a productive, collaborative working relationship between the various land managers on Stewart Island / Rakiura, including DOC and the Stewart Island / Rakiura community. A key step in this has been the formation of a Liaison Group (comprised of community members, iwi, deerstalkers and Forest and Bird) to advise and work with the Department to find solutions to managing pest animal species on Stewart Island / Rakiura.

Key outcomes of the liaison group process have been:

1. An approach to the Minister of Conservation from the Liaison Group for money for possum management to be expanded across the whole Island.
2. The Southland branch of the New Zealand Deerstalkers Association (NZDA) has adopted 300ha of coastal forest at Mason Bay for ongoing rat and cat control to complement DOC's possum control operations.
3. The Liaison Group and SIRCET have requested that the possibility of eradicating rats and wild cats from Stewart Island / Rakiura be examined.

Conservation management outside Rakiura National Park and other DOC reserves has been given further impetus by the formation of the Halfmoon Bay Habitat Restoration Project (see www.sircet.org.nz). This project involves community volunteers trapping rats, possums and wild cats on private land extending from Golden Bay to Ackers Point. Native bird numbers in the project area have undergone a significant increase. For example, tui and bellbird numbers have increased 230% over three years (Beaven 2007). The reduction in pest numbers has also enabled Stewart Island weka to be successfully introduced to the township area. The project has effectively motivated members of the community to engage in the active management of pests. This has been achieved by a local trust (SIRCET) with a band of dedicated volunteers.

The community (via a range of formal and informal forums) was canvassed to get their ideas on where the Tindall Foundation could “make a difference” on Stewart Island / Rakiura, following a visit from Trevor Gray (CEO of the Tindall Foundation). The idea of investigating the potential to remove rats, possums and wild cats from Stewart Island / Rakiura met with unequivocal support. A proposal was put to the Tindall Foundation and funding was forthcoming for investigating the potential to make Stewart Island / Rakiura rat, wild cat and possum free.

Key steps in this process involve identifying the barriers to eradicating these pests (e.g. lack of knowledge), fostering community involvement, and determining how much an eradication project might cost. This document intends to identify critical issues and undertake an initial evaluation of the feasibility of eradication.

This is not a new idea. In 1985, Andy Roberts (Area Manager, Southern Islands, DOC Southland) investigated the potential to fence and remove cats from the southern half of the Island to protect kakapo. The prospect of eradicating rats from Stewart Island / Rakiura has been discussed for at least the last nine years. It is now timely to undertake a systematic study of the feasibility of this proposal.

That said, this feasibility study has no set timeframe for eradication; it can’t succeed without full community and especially landowner support. Thus it would only occur when the community wants it to, be that five or fifty years. Nevertheless, the process of working through some of the issues associated with the proposal could certainly progress much more quickly.

1.2 Stewart Island / Rakiura

Stewart Island / Rakiura is the third largest of New Zealand’s islands, located approximately 30km to the south of the South Island (Lat. 46º 39’ S to 47º 16’ S and Long. 167º 20’ E to 168º 14’ E.) (Figure 1.2.1). It is a large island, measuring 64km by 40km, surrounded by over 95 small islands and large rock stacks, including several that have been cleared of pests in recent years (e.g. Whenua Hou, Taukihepa, Bench and Ulva Islands). The total land area of all of these islands is 174 600ha.

Stewart Island / Rakiura is composed of igneous rocks that form the large granite formations of Mt Anglem / Hananui (the Island’s highest point at 979m), the Ruggedy Mountains in the north of the Island and the Tin Range and peaks of the south, including the exfoliating granite domes of Gog and Magog. Other significant features include Paterson Inlet, with the Freshwater and Rakeahua Rivers at its head. The Freshwater River drains from a large, significant wetland systems. The eastern coast is characterised by bays and inlets such as Paterson Inlet / Whaka a te wera, Port Adventure and Port Pegasus / Pikihatiti in the south eastern corner. The rugged western coastline features Mason Bay, a 12km stretch of sandy beach and dune system.

Compared to most lowland areas of New Zealand, there has been relatively little human settlement or development on Rakiura. As a result, Stewart Island / Rakiura still has large areas of forest cover and a diverse range of rare plant and animal species. Nevertheless, the forests have been significantly affected by browsers (Ross 1977; Veblen and Stewart 1980; Stewart and Burrows 1988; Stewart and Burrows 1988; Coleman and Pekelharing 1989; Graeme 1996; Bellingham and Allan 2003; Lough 2003; Clayton 2005). Many of the alien species that are having significant impacts elsewhere in the country (e.g. stoats, ferrets, weasels, pigs, goats, mice, etc), have not been introduced to, or have not established on Rakiura. However, rats, wild cats, possums, deer and a small isolated population of hedgehogs are present.

Rimu (*Dacrydium cupressinum*) is common, along with kamahi (*Weinmannia racemosa*), southern rata (*Meterosideros umbellata*), miro (*Prumnopitys ferruginea*) and totara (*Podocarpus hallii*), in what are the southernmost podocarp forests in New Zealand. Rimu and kamahi-dominated forest covers about 60% of the land area. Manuka (*Leptospermum scoparium*), leatherwood (*Olearia colensoi*), inaka (*Dracophyllum longifolium*) scrublands make up a further quarter, with the remainder composed of grasslands, alpine turf, wetlands, sand dunes or bare rock (Figure 1.2.2).

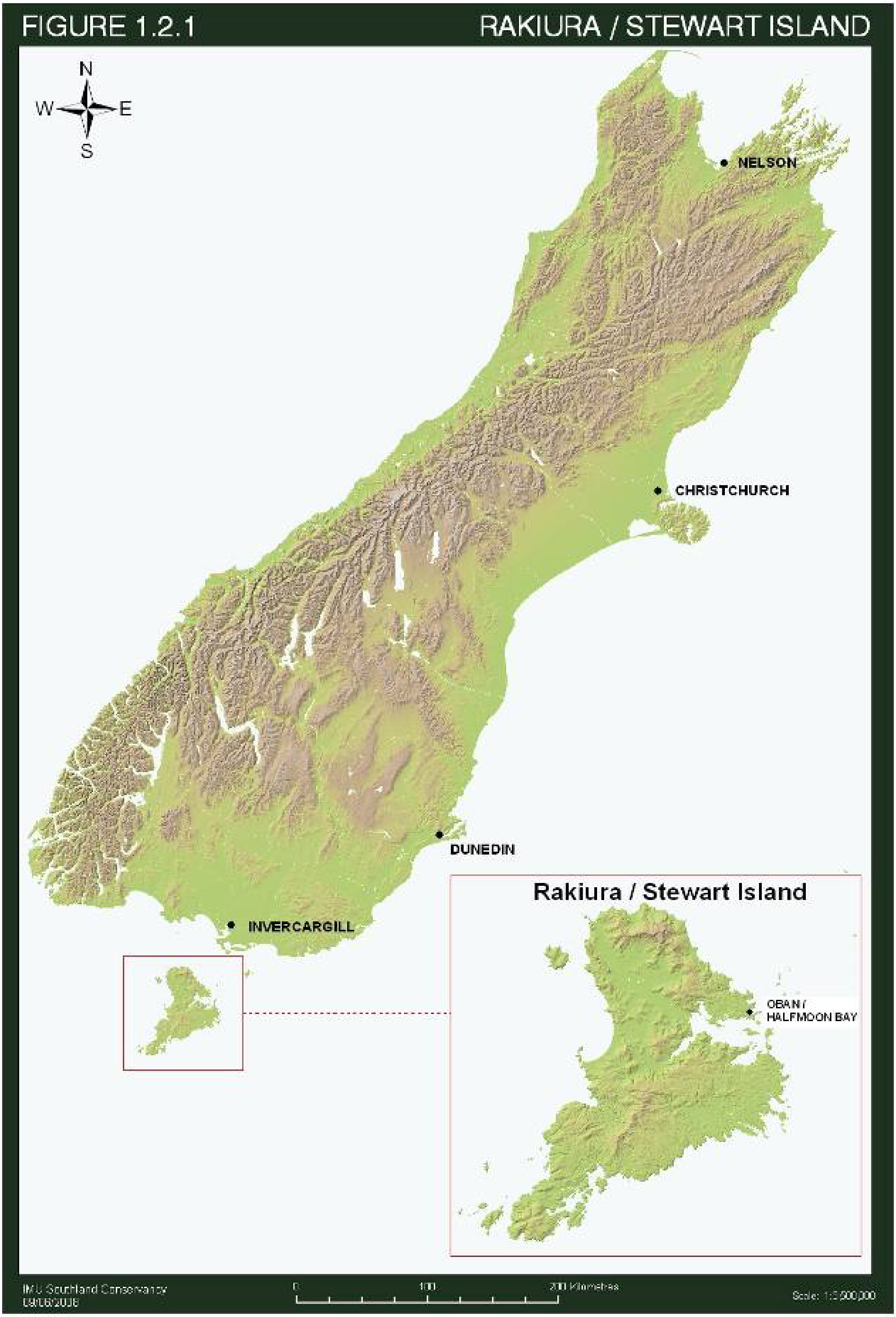
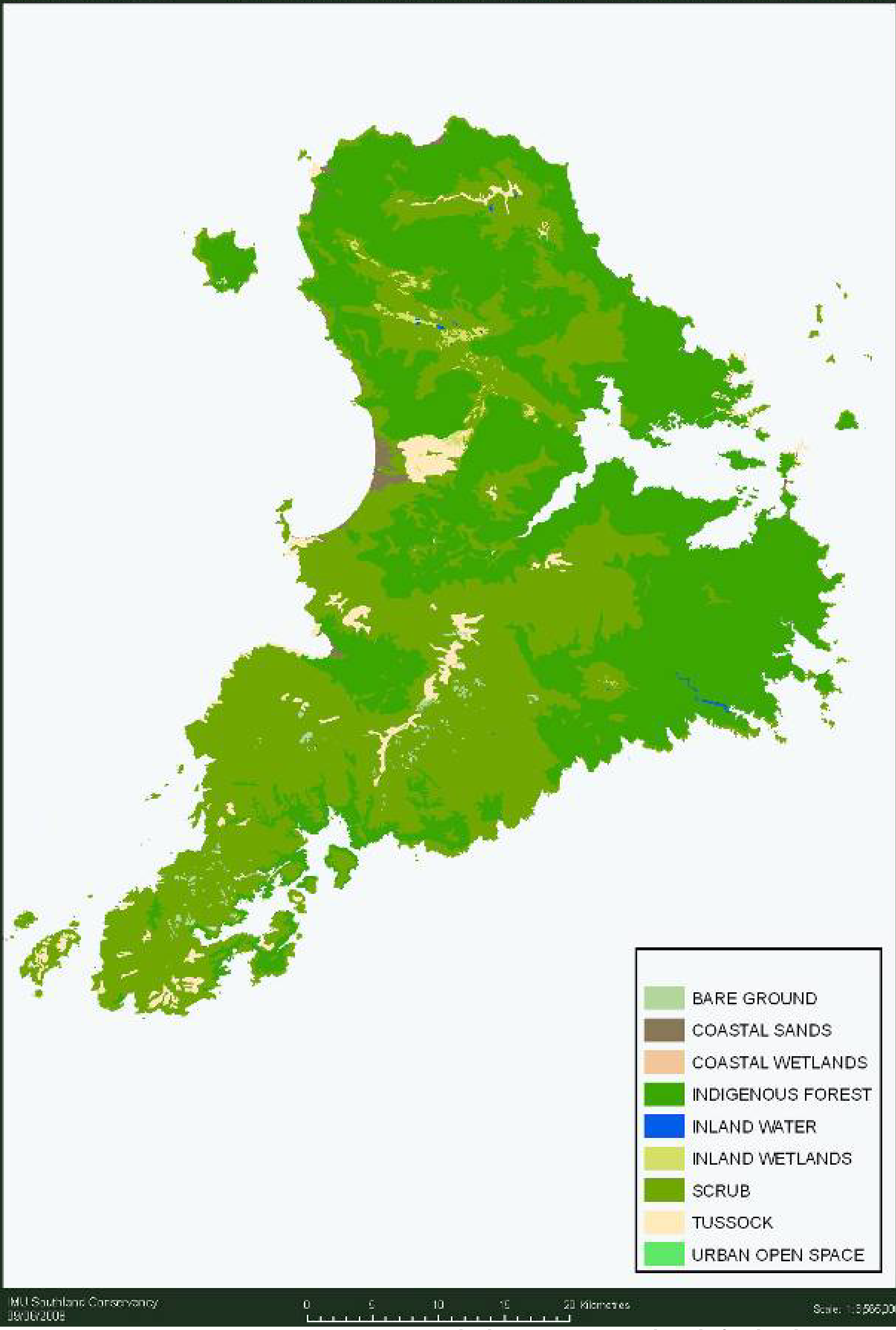


FIGURE 1.2.1
RAKIURA / STEWART ISLAND
N
W
E
S
NELSON
CHRISTCHURCH
DUNEDIN
INVERCARGILL
Rakiura / Stewart Island
OBAN / HALFMOON BAY
IMU Southland Conservancy
0
100
200 Kilometres

FIGURE 1.2.2 RAKIURA / STEWART ISLAND VEGETATION CLASSES

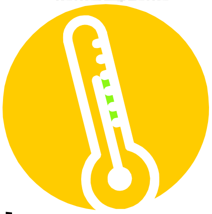


1.3 Climate of Stewart Island / Rakiura

Stewart Island / Rakiura has a cool temperate climate that is highly oceanic - high humidity, windy and lacking extremes of temperature or seasonal change (McGlone and Wilson 1996). Winters are reasonably mild and calm with the average rainfall less than that of Auckland. The rainfall does vary across the year with seasonal maximums in June and November; minimum in February (see also Section 3.1.5). Summers are also mild with temperatures up to the high-20's and sunshine hours equal to the national average (Anon 1997). There can be a marked contrast in weather across the Island, due to its size and topography, with rainfall and wind typically higher in the hillier areas and to the west and south.

Rainfall	1580mm
Rain days per year	290

Sunshine hours	1700hrs



Average summer max	16.6
Average winter max	9.9

Prevailing wind direction	West
Average wind strength	10 km/hr
Calm days	73

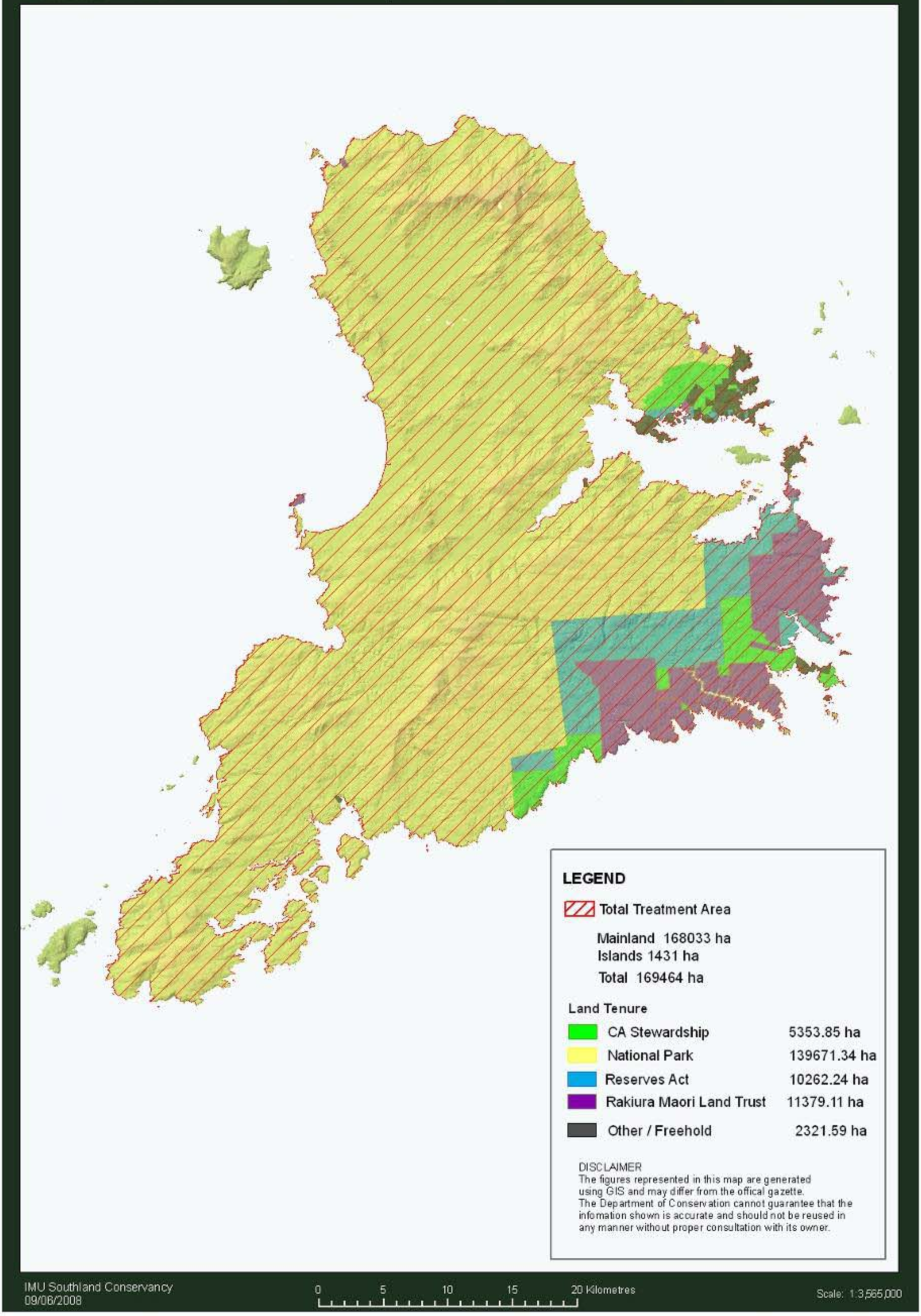
1.4 The potential treatment area

Eradicating possums, rats and wild cats from Stewart Island / Rakiura would involve treating everywhere these pests reside on the Island, as well as on adjacent islands that are within swimming distance. There are over 61 small islands and rock stacks within 1km of the coast of Stewart Island / Rakiura. A number of these are Titi (muttonbird) Islands and are owned and birded by descendants of the original owners of Stewart Island / Rakiura, often known or referred to as Rakiura Maori.

The area that would require treatment is 169 464ha (Figure 1.4.1). There are a range of land owners and managers. Approximately 90% of the Island is public conservation land, administered by Southland Conservancy of DOC. Of this, 139 960ha (about 80% of total land area) is National Park. There is also a small amount of unallocated crown land that is administered by Land Information New Zealand (LINZ).

Of the 10% of the Island not managed by the Crown, the Rakiura Maori Land Trust (RMLT) is responsible for about 8% and the remaining 2% mainly comprises one small township (approx 400 people), located on the the northern side of Paterson Inlet, extending around to Halfmoon and Horseshoe Bays. The township is comprised of a range of land managers and owners including DOC, RMLT, Southland District Council and freehold owners. There are a couple of relatively small sections of freehold land scattered around the Island.

FIGURE - 1.4.1 RAKIURA / STEWART ISLAND - TOTAL TREATMENT AREA



2. Why eradicate these pests?

This section covers the "why" questions, setting a context for why we might pursue the goal of eradicating possums, rats and wild cats from Rakiura.

2.1 Why consider eradication on Stewart Island / Rakiura?

Stewart Island / Rakiura has high natural heritage value. This was reflected in its inclusion in the tentative list for World Heritage Sites (Anon 2006). In their report, the World Heritage Advisory Group described Stewart Island / Rakiura in the following way:

"*Stewart Island / Rakiura is the most accessible remnant of wild, pre-human New Zealand. It still retains a natural landscape, with many areas of exceptional natural beauty. The intact sequence of the island's indigenous vegetation is the outstanding ecological feature on land, an unbroken green mantle from subalpine shrublands down to thick coastal forest. The Mason Bay duneland, 12 km long in one magnificent*

sweep, is of national conservation importance because of its range of threatened plants. These include the sand tussock Austrofestuca littoralis, a rare creeping herb Gunnera hamiltonii, and the shore spurge Euphorbia glauca. Many of the northern beaches (e.g. Smoky and Hellfire beaches) are outstanding examples of natural dune systems free of major weed species and human development.

The freshwater ecosystems of Stewart Island / Rakiura are significant habitats for indigenous freshwater communities because of the absence of human-induced modifications and alien species. Indeed, of all the groups of indigenous species on Stewart Island / Rakiura, the freshwater communities are arguably the most intact. The Freshwater and Rakeahua Rivers, the main rivers feeding into Paterson Inlet/ Whaka a Te Wera, are of outstanding scientific value as two of the last remaining large, floodplain river systems in New Zealand that have remained essentially free of human induced impacts throughout their catchments. They also contain abundant populations of giant kokopu, a nationally threatened fish species. [This is mainly a result of the absence of salmon and trout from these river systems]. *In their entirety, the island's freshwater communities are of great importance as the largest, most diverse examples of intact freshwater ecosystems that are probably representative of those which occurred in mainland New Zealand prior to the impact of European settlement.*"

Stewart Island / Rakiura is also notable for its large population of southern tokoeka (a distinct variety of kiwi), as well as its high level of endemism (plants and animals that are only found in the Stewart Island / Rakiura area), including two skink species, two geckos, weka, robin and fernbird (Table 2.1.1) as well as many invertebrates (E. Edwards, pers. comm.). It is also the only breeding site of the nationally critical southern NZ dotterel (Hitchmough et al. 2005).

Stewart Island / Rakiura is a nationally important centre of plant endemism. There are 21 endemic species plus another 18 that are only shared with Southland and/or the sub-Antarctic islands. Some sites within Stewart Island / Rakiura are nationally (possibly internationally) important for plant conservation. These include Mason Bay, the Rakeahua Valley, Mt Anglem and Table Hill / Tin Range (B. Rance, pers. comm.).

The Island is fortunately still free of many alien animal pests (e.g. stoats, ferrets, weasels, mice, goats, pigs, wallabies, hares and rabbits), which have caused so much ecological damage elsewhere in the country (Innes and Hay 1991; King 1998; Holdaway 1999). The ecological significance of the absence of these animals, and subsequent lack of impact on the forests and animals within, should not be underestimated. As early as 1936, the absence of stoats and weasels from the Island was noted as making the Island "a sanctuary for native birds" (Williams 1936). Stoats have been implicated as the main cause of decline in kiwi throughout New Zealand and their absence from Stewart Island / Rakiura is the key contributor to the Islands relatively healthy kiwi population (Robertson 2003).

The absence of mice from Stewart Island / Rakiura is notable. Stewart Island / Rakiura is the largest mouse free area in New Zealand (if not one of the largest in the world). Mice are known to have significant impacts on lizards, invertebrates and seeds (Newman 1994). Recently they have even been recorded attacking and eating albatross and petrel chicks (Cuthbert and Hilton 2004). Keeping Stewart Island / Rakiura mouse free will be a large and important challenge in itself (this is discussed further in Section 3.2).

The forest cover on Stewart Island / Rakiura is close to pristine compared with mainland New Zealand. Nevertheless, the Island is subject to degradation caused by the presence of possums, rats, wild cats and deer (Ross 1977; Veblen and Stewart 1980; Stewart and Burrows 1988; Stewart and Burrows 1988; Coleman and Pekelharing 1989; Graeme 1996; Harper 2002; Bellingham and Allan 2003; Lough 2003; Clayton 2005). Despite the absence of a number of pest species, the Island's systems will continue to change under the pressure exerted by the existing alien species. The removal of rats, wild cats and possums is probably a necessary step if the indigenous flora and fauna of Stewart Island / Rakiura is to be sustained.

Table 2.1.1: *Estimate of threatened species on Stewart Island / Rakiura, based on the New Zealand threat classification system (Molloy et al. 2002). This is an underestimate as the data on invertebrates is limited and fish and marine mammals have been excluded.*

Threat status	Number of species on Stewart Island / Rakiura	Number of endemics	Examples - animals	Examples - plants
Nationally Critical	8	2	Southern NZ dotterel; *Meterana "Foveaux Strait"; Notoreas "Mason Bay"; Quadraceps dominella; Quadraceps novaeseelandiae; Saemundssonia chathamensis.*	*Gunnera hamiltonii; Puccinella rarofloreens*
Nationally Endangered	16	3	Short tailed bats; long tailed bats; tawaki / Fiordland crested penguins; Australasian Bittern; mohua; mätä / Stewart Island fernbird; Stewart Island weka; South Island käkä; toutouwai / Stewart Island robin; tïeke / South Island saddleback; *Brueelia sp.; Neopsittaconirmus kea.*	*Crassula peduncularis; Lepidium oleraceum; Uncinia strictissima*
Nationally Vulnerable	3	0	Stewart Island shag; hoiho / yellow-eyed penguin	*Ranunculus ternatifolius*
Serious Decline	7	0	-	*Carex littorosa; Drymoanthus flavus; Euphorbia glauca; Luzula celata; Myosotis pygmea; Pterostylis palidosa; tetrachondra hamiltonii*
Gradual Decline	28	3	Southern tokoeka / kiwi; yellow-crowned kakariki; koekoeä / long-tailed cuckoo; kererü; tïtï / sooty shearwater; tïtipounamu / riflemen; banded dotterel; kororä / little blue penguin; harlequin gecko; jewelled gecko; green skink.	*Austrofestuca littoralis; Coprosma wallii; Crassula kirkii; Deschampsia spiralis; Epilobium chionanthum; Gunnera arenaria; Leptinella serrulata; Libertia peregrinans; Mazus arenarius; Melicytus flexuosus; Ourisia modesta; Pimelia lyallii; Rununculus recens; Raoulia aff. Hookerii; Raukaua edgerleyii; Sonchus kirkii.*

2.2 The target pest species

This plan is focussed on the potential eradication of all three rat species, wild cats and possums. The following section describes each of these species.

2.2.1 NORWAY RATS (*Rattus norvegicus*) [1]

This is the largest rat in New Zealand. Most weigh in the range of 150-300g (max 400g). The combined length of body and tail averages about 335mm. They have a stout body, heavy tail and relatively short ears. They swim readily and well, hence "water rat" is a common alternative name. This skill enables them to reach new islands unaided - depending on water temperature and sea conditions, up to 1km of water can be crossed (Russell et al. 2008). Therefore, any island within 1km of the coast of Stewart Island / Rakiura would need to be included in the treatment area. Norway rats can climb with agility when necessary, but do so more rarely than ship rats. Where they co-exist, Norway rats usually remain on the ground, whilst ship rats occupy the trees. Norway rats regularly stow away on boats, and this remains a potential source of new island invasions.

The extensive world distribution of the Norway rat is almost entirely the result of accidental dispersal by man. The species is thought to have originated in north-eastern China. It is now found across Europe, Asia Minor and southern Siberia to the Pacific coast, in China, Korea, Japan, temperate North and coastal South America, and locally in Africa and southern Australia. It has also become established on many oceanic islands, from the tropics to polar regions.

Norway rats were the first of the European rodents to become established in New Zealand. Almost certainly they got ashore in the late 18th century from visiting European or North American sailing ships, especially the many sealing and whaling vessels which began calling from 1792 onward. Today, Norway rats have a wide but patchy distribution in New Zealand. The most extensive populations occur in virtually all towns and cities, around farms and in cropland. They are much less common away from habitation, forming isolated populations in wetlands, watercourses and coastal areas.

On Stewart Island / Rakiura, Norway rats dominate in subalpine shrubland (Harper 2002). Their abundance fluctuates across the year, but is lower in the late summer. Pregnancy occurs mainly in early autumn with juveniles present in winter (Harper 2002).

[1] Description taken mainly from Innes, J. (2005). Norway rat. The handbook of New Zealand mammals. C. M. King. Auckland, Oxford University Press.

2.2.2 SHIP RATS (*Rattus rattus*)[2]

Ship rats are smaller than Norway rats at about 130g and about 340mm long. They are found throughout the world, from Sweden at 63^{o}N to Macquarie Island at 55^{o}S Lat. Ship rats have been spread with human trading activities throughout the world from its evolutionary homeland in India (Oceanian form). Ship rats arrived in New Zealand later than Norway rats, probably in the early 19th century, but did not spread until after 1890. They are now, by far, the most uniformly distributed of the three rat species on the mainland. On Stewart Island / Rakiura they are found in all forest types, but dominate in podocarp–broadleaf forest (Harper 2002). They have a similar seasonal variation in numbers to Norway rats.

Ship rats are among the most widespread mammals on the New Zealand mainland, yet are seldom seen and little known, largely because they are nocturnal, often aboreal and shy. Ship rats are skilful climbers in forest and can scale rough vertical surfaces, traverse fine wires and run through lattices of fine branches. Ship rats are capable of swimming at least 500m (Russell et al. 2008).

2.2.3 KIORE / PACIFIC RAT (*Rattus exulans*)[3]

The kiore, or Pacific rat, is the smallest of the three species of rats in New Zealand at about 260mm in total length and about 70g in weight. They can swim a maximum of 130m, but not willingly or well.

Kiore / Pacific rats range through the tropical zone from continental and insular south-east Asia eastward, across numerous islands in the western and central Pacific, as far as Easter Island, north to Myanmar / Burma and to Kure Atoll in the Hawaiian group and south to Stewart Island / Rakiura.

Kiore / Pacific rats were brought to New Zealand, probably accidentally, by the Polynesians. They may have arrived in New Zealand as early as 1250-1300AD. They were used for food by Maori and the care taken in trapping and preparing kiore / Pacific rat suggests that they were much esteemed as food, even though they did not comprise a major part of the diet.

Kiore / Pacific rat disappeared from most of the North Island by about 1850-60 and from the northern part of the South Island by the 1890s. This may have been due to the invasion of the other two European rat species (Russell and Clout 2004). They are now restricted to a number of offshore islands around the top of the North Island, islands in Cook Strait and on the mainland in Fiordland, South Westland and on

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[2] Description taken mainly from Innes, J. (2005). Ship rat. The handbook of New Zealand Mammals. C. M. King. Auckland, Oxford University Press.

[3] Description taken mainly from Atkinson, I. A. E. and D. R. Towns (2005). Kiore. The Handbook of New Zealand Mammals. C. M. King. Auckland, Oxford University Press.

Stewart Island / Rakiura. On Stewart Island / Rakiura, kiore / Pacific rat are at their highest densities in manuka shrublands (Harper 2002) and grasslands (pers. obs.). They have a similar seasonal variation in numbers to Norway rats.

2.2.4 WILD CATS (*Felis catus*)[4]

The house cat was domesticated in the eastern Mediterranean at least 3000 years ago, from the North African wild cat. House cats have been taken to many parts of the world as pets and for rodent control. They are now present in most human settlements from the equator to high latitudes. From these settlements, wild populations have frequently become established.

Cats were brought to New Zealand in the ships of the early European explorers, from 1769 onward. Ships of the period were infested with rats and carried a large number of cats to control them. Wild cats probably became established in New Zealand by the 1830s to 1850s. They were introduced to many offshore and outlying islands by sealers and whalers, settlers, farmers, muttonbirders and lighthouse keepers. Wild cats are now widely distributed throughout all three main islands of New Zealand. Wild cats are not good swimmers, but have been known to cross water gaps of 50m (K. Broome, pers. comm.).

2.2.5 POSSUMS (*Trichosurus vulpecula*)[5]

The brushtail possum is endemic to mainland Australia, Tasmania and some offshore islands. It has the widest distribution of any marsupial in Australia.

Possums were introduced to New Zealand to establish a fur trade similar to that which had flourished in Australia since the early 1800s. The first successful liberation was made in the forest behind Riverton in 1858. Most importations were made by the regional acclimatization societies. The total imports numbered only about 200-300, with over half of these coming from Tasmania. The consequent spread of possums was accelerated by additional liberations of New Zealand bred progeny of the original introductions. Legal liberations continued until the 1920s and possums were protected, off and on, to some degree until 1947. There is no protection now.

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[4] Description taken mainly from Gilles, C. and B. M. Fitzgerald Ibid.Feral cat.

[5] Description taken mainly from Cowan, P. E. Ibid.Brushtail possum.

Possums are now found throughout all three of the main islands of New Zealand, as well as a small number of offshore islands. In the Stewart Island / Rakiura area, they are restricted to the main island, Native Island and Bravo Island.

2.3 Why is getting rid of rats, wild cats and possums important?

New Zealand ecosystems developed without terrestrial mammalian predators, the only land mammals being native bats. These systems, and the species within them, are ill equipped to deal with the hunting strategies of rats, wild cats and possums.

Rats, wild cats and possums are, without doubt, having a detrimental impact on our native flora and fauna, driving many to extinction (Harper 2002). You need only look at the difference between pest free islands, such as Ulva Island, and areas where these pests occur to see the impact. Not only have the resident birds increased in number on Ulva Island since rats were removed, but birds that can't co-exist with rats (e.g. saddleback and mohua) have been transferred there and are thriving (Jamieson 2008).

Clayton (2005) found significant increases in seedling and sapling density of a number of woody plants and treeferns on Ulva Island after rats were removed. On other Paterson Inlet islands, where rats are still present, six of ten plant species common to all of the islands showed depressed recruitment (Clayton 2005).

Worldwide, rats have negatively affected at least 170 taxa of plants and animals on over 40 islands or archipelagos and have caused at least 50 extinctions (Howald et al. 2007).

At a local level, reports from the community members of Stewart Island / Rakiura reflect community observations on the noticeably significant, negative impact rats have had on bird diversity and population density, as well as damage to food stores, gardens, water pipes, electrical wiring and the odd dead rat in a water tank.

The Halfmoon Bay Habitat Restoration project has been trapping rats, wild cats and possums from the Ackers Point peninsula for over three years. Even this level of control has resulted in significant increases in bird numbers, especially tui, bellbirds and tomtits (Beaven 2007). Kakariki showed a significant increase in numbers within two years of possum, wild cat and rat

control at Bobs Point, Stewart Island / Rakiura. Similarly, there was a significant increase in the number of seedlings at the site (Harper 2007).

Although the bird life on Stewart Island / Rakiura is often touted as being more abundant and diverse than elsewhere in New Zealand, the reality is that it is in poor health, with some species only having hung on this long due to the absence of mustelids. Kereru and kaka are in very low numbers on the main island, with numbers being supported by strongholds on pest free islands (G. Harper, pers. comm.). In the absence of pest control, the rats, possums and wild cats are still slowly driving them down in number, toward extinction (Beaven 2007). Of note are Stewart Island weka which disappeared from the main island as recently as the turn of the century and riflemen that went extinct on the main island in the early 1990's (P. Shaw, pers. comm.). Other birds that have already gone extinct from Stewart Island / Rakiura since 1900 include: brown teal / pateke, Stewart Island snipe, kakapo, mohua, South Island saddleback and South Island kokako (Harper 2002). The individual contribution of each of these animal pests to these extinctions is unknown, but the combined impact is clear.

The benefits of removing possums, rats and wild cats are further explored in Section 3.4. The following sections outline the impact of each individual pest species.

2.3.1 NORWAY RATS

The Norway rat is omnivorous and has an opportunistic attitude to potential food. Dietry studies of wild rats in New Zealand have identified seeds, fruits, leaves, fern rhizomes, insects, molluscs, crustaceans and annelids. In coastal areas, they rely to a considerable extent on shoreline foods collected at low tide or by diving. Vertebrate items such as eggs, birds and lizards are sometimes taken. Carcasses of dead animals are readily scavenged, including other rats caught in traps. Food may be hoarded in burrows and sheltered places (Innes 2005).

The terrestrial habits of Norway rats make native animals which live, roost or nest on the ground particularly vulnerable (e.g. seabirds). The rats take eggs and nestlings, and are also large enough to kill adults of most bird species. On Langara Island, British Columbia, Norway rats had exterminated five seabird species and reduced the other from 200 000 to 14 600 breeding pairs (Harfenist 1994). Many invertebrates, usually the larger ground-dwelling species (such as weta and carabid beetles), have suffered from the introduction of these rats (Innes 2005). The impact of Norway rats on native reptiles and plants has been given little attention, but is likely to be high. The understorey and seedling vegetation on Ulva Island has changed dramatically since Norway rats were removed (Clayton 2005).

2.3.2 SHIP RATS

Ship rats are omnivorous generalists, but capable of being selective feeders. They eat both plant and animal foods all year round. The main animal food are arthropods, especially wetas, but also beetles, spiders, moths, and stick insects. Important fruits include coprosma, rimu, miro and supplejack, amongst many others. They also eat lizards and are known relentless predators of birds, their eggs and their young, especially of forest passerines (Innes 2005). Their excellent climbing ability is thought to have restricted Stewart Island robin distribution to areas where ship rats are in low abundance, such as manuka shrublands (Greer 2000; Harper 2002).

On Big South Cape Island / Taukihepa in 1964, ship rats at high density browsed punui (*Stilbocarpa lyalli*) to ground level and defoliated five-finger (*Pseudopanax arboreus*); they also quickly eliminated five endemic bird species, the greater short tailed bat and a large flightless weevil (Innes 2005).

Ship rats in the Orongorongo Valley were identified as the most pervasive and devastating agents of change (Innes 2005). The Asian version of the ship rat was implicated in a 40% decline in seabird species diversity, including the total loss of several species, on McKean Island in the Phoenix Islands group (Pierce et al. 2006). Ship rat predation is causing decline in kereru, mohua, robins and tomtits (Innes 2005).

2.3.3 KIORE / PACIFIC RATS

Kiore / Pacific rats eat a wide range of animal foods, including lepidopteran larvae, weta, centipedes, spiders, earthworms, ants, beetles, weevils, snails as well as lizards and birds. They also eat the flowers, fruits, stems, leaves and roots of many forest plants, significantly reducing recruitment. Their impact on New Zealand's biota is large and indisputable (Atkinson and Towns 2005).

After removal of kiore from Korapuki Island, nine previously unreported species of large, conspicuous invertebrates appeared and then became widespread and abundant. Similar significant increases in invertebrates were also seen on other islands once kiore were eradicated (e.g. Tiritiri Matangi Island, Lady Alice Island) (Atkinson and Towns 2005). This was also true for lizards either due to predation by kiore or, in the case of tuatara, competition for food. For example, on Korapuki Island capture frequencies of shore skinks increased 50-fold over the five years after kiore were removed (Atkinson and Towns 2005).

2.3.4 WILD CATS

Wild cats are directly responsible for a large percentage of global extinctions, particularly on islands (Nogales et al. 2004). On Stewart Island / Rakiura, wild cats feed mainly on rats (over 81% of diet), but birds are also a significant dietry item (13.2% by weight); Lizards and insects (especially weta) are also eaten (Dowding et al. 1999; Gilles 2001; Harper 2002). They will readily eat carrion and often forage in coastal areas along high tide lines. Seabirds, if present, can make up a large proportion of a wild cat's diet. Wild cats have caused the local extinction of kakapo and brown teal and the decline of NZ dotterel on Stewart Island / Rakiura (Harper 2002; Dowding and Davis 2007). A cat killed at Mason Bay in 2000 was found to have 11 skinks in its stomach (P Dobbins, pers. comm.).

Species have disappeared from many islands after cats were introduced (Stephens Island wren, saddleback, and a range of small to medium seabird species). Cats introduced onto Herekopare Island in about 1925 eradicated at least six species of land birds – yellow-crowned kakariki, robin, fernbird, brown creeper, snipe and banded rail as well as large breeding populations of diving petrels and broad-billed prions (Gilles and Fitzgerald 2005).

On Little Barrier Island, cats contributed to the extinction of the Little Barrier snipe, the local extinction of North Island saddleback and the severe reduction in numbers of grey-faced petrel, Cook's petrel and black petrel, plus the decline of lizard and tuatara species (Veitch 2001). Seabirds and other ground nesting birds are particularly at risk from cat predation (Gilles 2001; Thomas and Taylor 2002; Keitt and Tershy 2003; Rodriguez et al. 2006).

Cats may be a significant cause of mortality to both short-tailed and long-tailed bats, especially at the more accessible roosts. There have been reports of wild cats killing kiwi on Stewart Island / Rakiura. There is a strong body of evidence that wild cats have, and continue to have, a major effect on native fauna (Karl and Best 1982; Harper 2002).

2.3.5 POSSUMS

Possums are best described as opportunistic feeders, eating mainly leaves. They also take buds, flowers, fruits, ferns, bark, fungi, invertebrates, and have been observed eating birds and eggs, as well as carrion. Selective browsing of preferred plant species intensifies the impact of possums on New Zealand forests. The effects are unquestionable; extensive canopy defoliation and mortality attributable to possums has been described in many areas. Selective browsing on particular species and individual trees eliminates some species and favours others less palatable to possums, resulting in a gradual change in forest composition (Cowan 2005). On Stewart Island / Rakiura, this has been evidenced in the decline of fuchsia in coastal gullies (Ross 1977). Possums have not reached a natural balance with native vegetation on Stewart Island / Rakiura and evidence suggests that this is unlikely to occur until drastic and unacceptable change to the forest structure has occurred.

Secondary effects of possum browsing may be less obvious. Canopies weakened by browsing are more susceptible to wind-throw, salt damage, pathogens, insects or climatic extremes (Coleman and Pekelharing 1989). Possums compete with native birds for resources. Possum browsing reduces the production of flowers and fruit, with consequent effects on native animals. Possums compete for nest sites with hole nesting birds (e.g. kiwi), and are significant predators of the eggs and nestlings of a variety of forest bird species (Innes et al. 2004). Possums have also proven to be significant predators of kaka eggs, chicks, fledglings and adults (Powlesland et al. 2003). Powlesland et al (2003) went so far as to describe possums, in some forest types, as the critical threat to kaka conservation.

2.4 Why are deer, hedgehogs and mice excluded from consideration?

With the removal of rats, possums and wild cats from the Island, the only alien species remaining would be a small localised population of hedgehogs and red and white-tailed deer. It is worth discussing why these should not be included as target animals.

Mice have also been recorded in Halfmoon Bay on Stewart Island / Rakiura and occasionally reported on the salmon farm at Big Glory Bay. This leads to the potential that mice have established on Stewart Island / Rakiura and thus warrants further discussion.

2.4.1 HEDGEHOGS (*Erinaceus europaeus*)

Hedgehogs are known predators of invertebrates, lizards and ground nesting birds' eggs and chicks (Jones et al. 2005; Jones and Sanders 2005). They were found to be responsible for two out of three dotterel nest failures at Tawharanui Regional Park (Dowding 1998). In the Mackenzie Basin, they were responsible for 20% of predation events on nests of banded dotterel, black stilt and black fronted terns (Sanders and Maloney 2002). They also compete with native insectivores (e.g. kiwi) for food (Jones and Sanders 2005).

There is thought to be only a small population of hedgehogs that are localised to the township area, especially Ringaringa. The exact distribution and density of hedgehogs on the Island is unknown and should be investigated. There is no particular reason that hedgehogs were excluded from this feasibility study. It is recommended that hedgehogs be included in the target animal list for any further discussion on Island wide eradication.

An eradication plan for hedgehogs should be developed, including a survey of distribution and density. If the population is as small and localised as suspected, then eradication may be achievable as a stand-alone project. This is likely to involve ground hunting techniques including the use of poison, traps and dogs.

2.4.2 RED (*Cervus elaphus*) AND WHITE-TAILED (*Odocoileus virginianus*) DEER

Deer have not been included in this feasibility study for a number of reasons, not least of which is that the community group that contracted the feasibility study asked for deer not to be included in eradication plans.

There is strong support from within the local community and hunting interests for deer to be retained on Stewart Island / Rakiura. The support of the general community and hunters is vital to the success of any proposed rat, wild cat and possum eradication and will only be gained if deer are not targeted for eradication.

There are also operational reasons for excluding deer. To target deer would substantially alter the structure of the proposed eradication techniques. A deer targeted operation is likely to be so different that it would significantly increase the costs.

In a separate project, DOC and the community, through the medium of the Liaison Group, are monitoring the impacts of deer on forest regeneration and health. Should this monitoring demonstrate that the impacts of current deer densities are ecologically unsustainable, DOC has indicated that it would look to manage deer, in conjunction with the Pest Liaison Group, to mitigate adverse effects on the environment.

Further discussion on deer is included in Sections 3.3 and 3.4.

2.4.3 MICE (*Mus musculus*)

Mice are not believed to have established on Stewart Island / Rakiura. An unknown number appear to regularly hitch rides to Halfmoon Bay, probably in the large volume of supplies that are shipped to Stewart Island / Rakiura. Some have also been reported to come across with salmon feed and are occasionally observed on the salmon farm (moored in Big Glory Bay). Therefore, if mice haven't already established on Stewart Island / Rakiura, then a continual threat of establishment is present. The lack of mice is due to good luck rather than good management. It is likely assisted by cats and the three rat species preying on any invading animals and occupying available niche preventing establishment. It appears that mice and kiore / Pacific rat have similar niches to each other and distinct from those of the two larger rats. This, combined with predation, may explain why mice do not appear to have established on Stewart Island / Rakiura.

This raises some issues for any proposed eradication of rats that need to be addressed. If mice are resident, they may not be eradicated with an operation targeting rats and their population may irrupt in the absence of rats (Innes et al. 1995; Murphy et al. 1999). If mice are not resident, careful biosecurity measures will need to be developed to ensure that they don't invade (see Section 3.2).

Regardless of the future nature of pest management on Stewart Island / Rakiura, it would be sensible to determine if mice have established on Stewart Island / Rakiura (critical if an eradication operation is going to progress). Due to the importance of Stewart Island / Rakiura as a mouse-free area, a system for keeping mice and other pests that are absent from Stewart Island / Rakiura from invading the Island should be investigated. The eradication of mice from the salmon farm in Big Glory Bay should also be investigated. Discussion should be had with the salmon farm company regarding biosecurity practices to prevent further mouse invasions. The eradication of rats on Stewart Island / Rakiura should only proceed if any confirmed mouse populations are eradicated and systems put in place to prevent their re-establishment.

2.5 Why is 'eradication' proposed instead of 'control'?

Eradication, as opposed to control, is proposed as the best long-term solution for the ecosystems of Stewart Island / Rakiura. This is mainly because eradication provides opportunities that control does not in regard to species recovery and management. Eradication has become a powerful tool to prevent extinctions and restore ecosystems (Donlan et al. 2003; Towns and Broome 2003). Many of our native species exhibit extreme sensitivity to predation by even low levels of these alien species, making control an unsuitable option. As an example, saddleback struggle to survive where rats are present. Almost all successful re-introductions have been to areas where rats have been eradicated. For saddleback to survive in a 'controlled' area, rat numbers would have to be consistently suppressed to extremely low levels, creating an environment equivalent to that produced by eradication. This effort would be intense and ongoing.

While control has proven achievable on a small scale (Beaven 2007), to get equivalent benefits to an Island wide eradication would require large scale control operations. This is simply not logistically feasible using a ground based approach such as trapping or bait stations (see Section 3.1.5).

The key differences between control and eradication are summarised in Table 2.5.1.

Table 2.5.1: *Differences between control and eradication (Saunders and Brown 2001). Control, in this instance, is to a level that produces an ecologically meaningful result similar to those produced by eradication.*

ERADICATION	**CONTROL**
Essentially only feasible on islands or behind pest-proof fences where the risks of re-invasion by terrestrial pests is relatively low or can be managed. Nevertheless, the scale of Stewart Island / Rakiura is challenging even for this method.	Potentially feasible at any defined site, but generally limited in size, especially for rats. Control across an area the size of Stewart Island / Rakiura is impossible for rats. Continual reinvasion is an issue
Permanently removes the impacts of invasive animal species by eliminating the entire population.	The impacts of invasive alien animal species are managed by sustained harvesting of the invasive species populations. Not concerned with removing the 'last animal'.
The total treatment area must be comprehensively treated	Population can be targeted in specific areas only, and these can vary according to need
A one-off operation – with on-going surveillance and management of reinvasion risks.	On-going management and monitoring.
On-going quarantine and contingency measures required to prevent re-colonisation.	On-going quarantine and contingency measures (for targeted species) not necessary.
High initial investment, followed by relatively low on-going inputs (depending on the scale of ongoing biosecurity requirements).	Generally low-medium, on-going investment. Potentially high long term cost
Significant potential benefits which improve over time.	Variable benefits dependent on effectiveness of control regimes.
Short term pulse of toxin or trapping restricting period of non-target effects.	Multiple long term toxin or trap availability. Increases potential for non-target effects due to time available. Continuous control means non-target effects need to be carefully managed which can constrain control tools used.
Short term pulse seldom leads to aversion or resistance.	Long term toxin or trap use can lead to aversion or resistance.
Benefits continue indefinitely if quarantine maintained.	Benefits are lost as pest populations rebuild after control stopped.

2.6 Section Summary

Stewart Island / Rakiura has high natural heritage values, in part due to the absence of a number of pests that are present on the rest of mainland New Zealand (notably stoats and mice are absent). The pest species that are on the Island are having a negative impact on the Island's natural heritage values. Therefore the eradication of Norway rats, ship rats, kiore / Pacific rats, wild cats and possums should be considered.

For a variety or reasons, the other introduced mammals present on Stewart Island / Rakiura (hedgehogs, red deer and white-tailed deer) are not included as target animals in this feasibility study. It is unknown if mice have established on the Island and determining this, as well as establishing systems to minimise the risk of mouse invasion, should be given priority.

3. Can it be done?

Five principles have been identified which must be met in every case, for all target species, to achieve eradication (Parkes 1990; Bomford and O'Brien 1995; Cromarty et al. 2002; Broome et al. 2005):

1. All individuals are put at risk by the eradication technique(s);
2. They can be killed at a rate exceeding their rate of increase at all densities;
3. The probability of the pest re-establishing is manageable to near zero;
4. The project is socially acceptable to the community involved;
5. Benefits of the project outweigh the costs.

These principles are addressed individually in this chapter.

3.1 All individuals can be put at risk by the eradication technique(s) & they can be killed at a rate exceeding their rate of increase at all densities.

3.1.1 WHAT HAS WORKED BEFORE?

Nationally and internationally, rat eradications have moved from experimental to standard practice for small to medium sized eradication areas (<3000ha). New Zealand is recognised as a world leader in rat eradications.

From 1960 to the mid 1980’s most eradications were of rats and were done by ground based techniques (Thomas and Taylor 2002). From the 1990’s, aerial spreading of bait by helicopters eventually led to the removal of rodents from subantarctic Campbell Island (11 300 ha) in 2001 (Clout and Russell 2006).

The most significant technical advance recently was not in the baits nor the means of spreading them, but the availability of satellite navigational guidance systems, especially Differential Global Positioning System (DGPS) (Howald et al. 2007). The capacity to precisely identify helicopter flight paths has enabled the elimination of refuge (unbaited) areas in which a few target animals could survive, as well as allowing coordinated approaches to the rapid spreading of baits over very large areas (Towns and Broome 2003).

Further refinements, such as the ability to download flying path lines on the day of the drops, has further increased the confidence in the success of this methodology.

By 2007, there had been 332 successful rodent eradications worldwide (Howald et al. 2007). The following table summarises eradication attempts for our target species.

Table 3.1.1: *Summary of known completed eradications between 1951 and 2007 (Nogales et al. 2004; Clout and Russell 2006; Howald et al. 2007; Ritchie 2007).*

	Successful Operations (Worldwide)	Failures (World wide)[6]	Largest Successful Area (NZ)	Largest Successful area (Worldwide)
Norway rat	104	5	Campbell (11 300 ha)	Campbell (11 300 ha)
Ship rat	159	15	Maungatautari (3500 ha)[7]	Maungatautari (3500 ha)
Kiore / Pacific rat	55	6	Hauturu / Little Barrier Island (3083 ha)	Hauturu / Little Barrier Island (3083 ha)
Possum	16	1	Maungatautari (3500 ha)	Maungatautari (3500 ha)
Wild Cat	55	?	Maungatautari (3500 ha)	Marion Island (29 000 ha)

Multi-species eradications

In New Zealand, eradications have historically been the domain of DOC and limited to offshore islands. However, the 1990's saw rapid growth in the uptake of DOC's "Mainland Island" concept by community groups, as well as the development of predator-proof fencing technology. A new era of eradications on mainland sites was born, with the fence creating the 'island'. Naturally this led to an increase in multi-species eradications, primarily on the mainland.

These Mainland Island eradications have ranged from 16ha to 3500ha. All have targeted multiple pest species – usually successfully (see Table 3.1.2). In this table a species was not considered eradicated if that target species re-established from survivors or from re-invasion.

[6] Failures are likely to be underreported in the literature
[7] Note that Maungatautari is a fenced site on the mainland in the North Island

Table 3.1.2: *Mainland multi species eradication programmes. Adapted from Ritchie (2007).*

Location	**Size**	**Pest species targeted**	**Eradication techniques and success rate**	**Success for rats, wild cats and possums?**
Warrenheip	16ha	Ship rats Norway rats Mice Mustelids[8] Cats Possums Hedgehogs Rabbits	Ground based baiting, shooting and trapping programme in 2000. All species eradicated.	Yes
Macraes Flat	19ha	Ship rats Norway rats Mice Mustelids Cats Possums Hedgehogs Rabbits Hares Pigs	Ground based bait station, shooting and trapping programme in 2005. Most species appear to have been eradicated. Last mouse seen August 2006. Rabbit eradication ongoing.	Yes
Maungatautari Ecological Island Enclosures	35ha northern enclosure & 65ha southern enclosure	Ship rats Norway rats Mice Mustelids Cats Possums Hedgehogs Rabbits	Aerial baiting using Pestoff 20R at 15kg/ha and then 8kg/ha with ground based follow up in 2004. Eradication successful all species.	Yes
Bushy Park	98ha	Ship rats Norway rats Mice Mustelids Cats Possums Hedgehogs Rabbits	Two aerial drops, each using Pestoff 20R at 10kg/ha in 2005. Eradication successful for all species except mice.	Yes
Ecological Preserve Stewart Island / Rakiura	160ha	Ship rats Norway rats Kiore / Pacific rat Cats Possums White-tailed deer	Ground based techniques – bait stations (100 x 50m), feratox and dogs for possums, dogs and live traps for deer. Operation still underway December 2007.	Possums and cats only as at Dec 07.

[8] Mustelids is a collective term for ferrets, stoats and weasels

Karori Wildlife Sanctuary	225ha	Ship rats Norway rats Mice Mustelids Cats Possums Hedgehogs Rabbits Hares Pigs Goats Deer	Two aerial drops using Pestoff 20R at 8kg/ha and then 7kg/ha in 1999. Ground based follow-up with hand broadcasting, trapping and bait stations. All species eradicated, but mice now present.	Yes
Tawharanui Open Sanctuary	550ha	Ship rats Norway rats Mice Mustelids Cats Possums Hedgehogs Rabbits	Two aerial drops using Pestoff 20R at 8kg/ha and then 7kg/ha in 2004. Ground based follow-up with hand broadcasting, trapping and bait stations. Mice, and rabbits still present. Tawharanui is fenced to the coast and is subject to periodic re-invasions of pests.	Yes
Maungatautari Ecological Island	3500ha	Ship rats Norway rats Mice Mustelids Cats Possums Hedgehogs Rabbits Pigs Goats Deer	Three aerial bait applications at 15kg/ha, then 8kg/ha, and 8kg/ha completed in 2007. Hunters used for pigs, deer and goats. Follow-up required for cats, with two cats cage trapped (feeding on non-poisoned rabbits). Eradication successful for all species except mice, rabbits and hares.	Yes

3.1.2 PREVIOUS ERADICATION SUCCESS BY SPECIES

Rodents

With good planning and preparation a relatively high level of success has been achieved for rat eradications using aerial techniques (Clout and Russell 2006). With the successful completion of Campbell Island, island size, in most cases, seems to be less of a limiting factor; rather, social acceptance and funding are likely to be the main challenges (Saunders and Brown 2001; Howald et al. 2007). Nevertheless, when considering an island the size of Stewart Island / Rakiura, size is still a limiting factor, presenting logistical challenges that should not be underestimated or understated.

While most eradications have been successful (see Table 3.1.1), a small number have failed or partly failed to achieve their objectives (Clout and Russell 2006). In most, if not all of these operations, failure was both predictable and avoidable. In one instance the island was found to be within the natural swimming range of the rats and was subsequently re-colonised. In another, Norway rats may have dominated bait stations and prevented access to some by mice which subsequently survived the operation (this could also be an issue for kiore / Pacific rat). Inexperienced operators and/or a failure to make toxic baits available to every individual rodent were the likely causes of failure in at least two other operations (Howald et al. 2007).

Eradication attempts where more than one rodent species have been targeted have been proportionately less successful in achieving total eradication than have single-species eradications. This is particularly so when the combination has involved a rat species as well as mice. Several projects which were successful in removing rats have failed to achieve mouse eradication as part of the same operation. Mice are thought to be absent from Stewart Island / Rakiura (see Section 2.4). Where mice are absent, eradicating multiple species of rat presents few failures. An eradication campaign, using the DOC standard aerial baiting techniques, successfully removed all three rat species from Pearl Island (Port Pegasus / Pikihatiti, Stewart Island / Rakiura).

The Department of Conservation has established peer review systems and a national Island Eradication Advisory Group (IEAG). Their purpose is to review operational plans and project activities so that what is learnt from one operation, be it a success or failure, can be carried on to the next one in order to minimize the risks of any further avoidable failures. The IEAG has advised on several international projects.

We have most experience with rat eradication. The techniques and constraints are well known. Further research is likely to be required in certain areas, including the eradication of rats in the presence of a number of other species (e.g. the interactions of all three rat species with each other and with possums around baits and the potential for competitive exclusion).

Possums

Possums have been eradicated from 10 islands in New Zealand, ranging in size from 1ha to 2321ha (Clout and Russell 2006). Both aerial baiting and use of bait stations, combined with follow-up hunting, especially using dogs, or trapping appear to be effective at eradicating possums (Brown and Sherley 2002).

At Tawharanui, two possums (a female and a juvenile) were caught in traps in the same location seven months after the second drop. No possums have been detected at Tawharanui since. Small numbers of possums (1-4) also survived baiting operations on Stewart Island / Rakiura and at Karori. In all cases, these individuals were finished off by ground based follow-up. But, at Maungatautari, it appears that all of the possums were eradicated by the aerial bait drop, with no follow-up being required.

Experience suggests that a very small number of possums will survive an initial aerial baiting operation. Follow-up work will need to be incorporated into planning and budgeting. Detecting surviving possums on Stewart Island / Rakiura will be logistically challenging, not only because of the size, but also due to areas of almost impenetrable vegetation. Lessons learnt from the Kapiti Island possum eradication suggest that a knockdown in possum numbers with a toxin, followed up by hunting with dogs would be an effective eradication strategy (Brown and Sherley 2002) (see also Section 3.1.7).

Wild cats

Internationally, the most common methods in successful wild cat eradication programmes were trapping and hunting (often with dogs) (Nogales et al. 2004). In New Zealand, wild cats appear to have been eradicated from all sites by a knockdown in numbers after aerial application of bait, via secondary poisoning and direct poisoning (R. Griffiths, pers. comm.), followed-up by hunting / trapping. However, wild cats can avoid secondary poisoning if too few rodents (or rabbits) are poisoned, or if the wild cats are not hungry enough to eat the liver, stomach and intestines of prey containing lethal concentrations of brodifacoum (Dowding et al. 1999; Gilles 2001).

Two wild cats were detected on the main mountain at Maungatautari in January 2007, after bait drops. Both animals were easily live trapped and were found to be male. It seems that these animals survived as they were feeding on rabbits. This was also the case on Motuihe Island, where cat mortality was low as the cats were eating rabbit muscle tissue in preference to internal organs or rats (Dowding et al. 1999). Rabbits appear to be a poorer vector than rodents for secondary poisoning of wild cats.

On 1283ha Tuhua / Mayor Island (where rabbits are absent), all cats were eradicated with an aerial application of 12kg/ha (8kg/ha, then 4kg/ha) brodifacoum bait targeting kiore and Norway rats. No follow-up work was required (Jones 2003). But, on Raoul Island in the Kermadec group, a similar aerial bait application only killed about 90% of the cats, with ground baiting and trapping required to eradicate the survivors (M. Ambrose, pers. comm.). It is unknown why, in the absence of rabbits, the initial bait application didn't kill all of the cats on Raoul Island but its semi-tropical nature may have contributed in some way.

Harper (2002) found that wild cats on Stewart Island / Rakiura appeared to be under nutritional stress from late spring to early autumn. Rats formed 81% of the wild cat's diet by weight and seasonal depressions in rat abundance every year were limiting cat numbers. When rat abundance was reduced wild cats were more likely to leave established home ranges and die, probably through starvation. They did not apparently prey-switch to birds as secondary prey. Harper went on to suggest that the removal of rats is likely to substantially reduce cat numbers, possibly to the point where they will die out naturally (Harper 2002; Harper 2005).

Nine out of ten radio collared wild cats were killed by a ground based 1080 possum control operation on the north coast of Stewart Island / Rakiura. These wild cats were found to be scavenging poisoned possum carcasses. The one cat that didn't die was living on the edge of the treatment area and may not have encountered poisoned prey.

Due to the absence of rabbits, the nutritional stress and dependence on rats displayed by wild cats on Stewart Island / Rakiura, there is a good chance that most, if not all, wild cats could be killed by an aerial bait application on Stewart Island / Rakiura. Nevertheless, as for possums, follow-up work needs to be planned and budgeted for (see Section 3.1.7).

A new cat bait has been developed and trialed with some success in Australia. This involves a meat sausage type bait that contains 1080 and is distributed via aircraft. It has been used successfully in eradicating wild cats from 1020ha Hermite Island (Algar et al. 2002). This toxin and bait combination has not been registered for use in New Zealand and the whole process of registration, including field trials, would need to be conducted (A. Fairweather, pers. comm.). There has also been some work in New Zealand on developing new baits for stoats and cats. A toxin called PAPP is currently undergoing registration for use in New Zealand but may not be approved for cats for some time (A. Fairweather, pers. comm.). Both of these options should be investigated further as they may prove to be effective tools for removing any wild cats not killed via the aerial baiting operation. Alternatively, it may be worth considering Stewart Island / Rakiura as a trial site for any new cat eradication technology such as the Australian sausage. Nogales et al. (2004) suggest that new and more efficient techniques, used in combination with current techniques, will likely be needed for success on larger islands.

3.1.3 WHICH METHODS COULD BE USED?

While other eradication options have been investigated, including genetic engineering, viral agents and immuno-sterilants, none of these have been used successfully to eradicate rodents or possums or wild cats. Given the rate of progress in such fields, it is possible new approaches to eradication may become available in the next 10-20 years. But, even if a new approach did emerge, it would need to be tested and refined before it could be seen as a viable alternative to eradication using toxins (Montague 2000).

On Marion Island, in the sub-Antarctic Indian Ocean, a cat disease (*Feline panleucopenia*) was used to reduce cat numbers by about 80%, before eradication was conducted using hunting and trapping. But, the experience with rabbits and RCD calicivirus has shown how difficult it can be to gain consensus and approval for the use of a biocontrol agent for mammals. While immunocontraception is being worked on for possums, this is still many years from even being at field trial stage, let alone application to an area as ambitious in size as Stewart Island / Rakiura (Montague 2000). Also, it is unlikely to be a suitable tool for eradication as generally diseases do not remove an entire population. Any potential disease controls would need to be subject to extensive testing on non-target species, following extensive public consultation. A lot of work will be required to ensure target specificity. The use of a biocontrol agent for possums so close to Australia where there are 24 endemic species of possum is an obvious concern. There are few examples of vertebrate biological control that instill confidence about the use of the techniques (Montague 2000).

The use of traps alone to eradicate rodents or possums or wild cats is not considered feasible because of the size of Stewart Island / Rakiura (similar problems to bait stations; see Section 3.1.5). However, the use of a mix of a) toxins to knockdown possums and cat numbers, and b) traps as one of the follow-up techniques for possums and cats, is thought to be both feasible and desirable. Therefore, the choice of toxin and method of delivery seem to be the key questions.

3.1.4 WHICH TOXINS AND BAITS SHOULD BE USED?

Given the particular challenges associated with eradicating rodents, possums and wild cats from Stewart Island / Rakiura – especially its size, the three species of rodent present, possums and deer which may also take some of the bait, and the fact that it is inhabited by people - using an untried technique or an unproven toxin would add significant additional risks to any eradication operation.

Most rodent eradication campaigns in New Zealand have involved the use of one of the ‘second-generation’ anticoagulants, principally brodifacoum but also, in a few cases, floucomafen and bromodialone. Second generation anticoagulants act by inhibiting the synthesis of vitamin-K dependent clotting factors in the liver, which ultimately results in death by internal haemorrhaging, typically within 3-10 days (Hadler and Sahdbolt 1975).

First generation anticoagulants have been used in only 29 eradication campaigns (c.f. 226 for second generation anticoagulants)(Howald et al. 2007; Witmer et al. 2007). Broadcast baiting of diphacinone (a first generation anticoagulant) is currently under investigation in Hawaii. There does not appear to have been other toxins or techniques successfully employed in eradication operations in New Zealand in recent years.

Toxin options

Table 3.1.3 outlines the various toxins which might be considered for use in eradication operations. More detailed information about these toxins, their mode of action and environmental consequences may be obtained from the cited references.

Initial public feedback on the draft asked why 1080 wasn’t considered suitable. 1080 is an acute poison whereas brodifacoum is termed a chronic poison. This relates to how quickly they act. Due to 1080’s fast action, any animals that only eat a non-lethal amount get sick and are put off eating any more of the toxin (a bit like eating bad chicken and not being able to go near it for years after). Brodifacoum takes days to cause illness (Morriss et al. 2008), therefore the animals don’t associate their sickness with the meal, making it ideal for eradication purposes. On top of this, 1080 has not been successfully used in any eradication project. It can be detected by some rats (meaning they won’t eat it) and is thus likely to lead to a failed eradication. For eradication purposes, brodifacoum is clearly the better toxin.

Table 3.1.3*: Summary information for toxins available in New Zealand and their pros and cons in relation to eradications (Eason and Wickstrom 2001; Broome et al. 2006; Broome et al. 2006; Fisher and Broome 2006; Fisher and Fairweather 2006; Fisher and Fairweather 2006)*

TOXIN	PROS	CONS
Warfarin, Diphacinone, Pindone, Coumatetralyl (1st generation anticoagulants) *Trade names: Ditrac, RatAbate, Pest-Gone, No Rats, Racumin.*	Diphacinone has successfully eradicated ship rats on some small islands. Readily metabolised.	Generally require rodents to feed on them multiple times on successive nights to be effective. This would be extremely difficult to achieve. Only Pindone is currently registered for aerial application. Significant non-target risks to wildlife and pets
Floucomafen, Bromodialone *Trade names: Bromard, Rid Rat Super, Storm Secure, Stratagem.*	Second generation anticoagulants are slow acting allowing secondary poisoning of cats and not incurring bait shyness.	The effectiveness of brodifacoum in rodent control and eradication operations is better known than for fluocomafen or bromodialone. (There is no advantage in using either of these otherwise apparently suitable alternatives). Lack of information of the environmental effects of bromodialone and floucomafen. Not registered for aerial application Significant non-target risks to wildlife and pets
Brodifacoum *Trade names: Talon, Final, Entrap, Pestoff.*	Proven successful in many eradication campaigns. Well-known effects means clearer idea of the mitigation actions necessary to minimize non-target risks. Antidote available (pets & humans). Slow acting allowing secondary poisoning of cats. Registered for aerial application.	Significant non-target risks to wildlife and pets (see Section 3.4). Can remain in liver of sub lethally poisoned animals for months.
1080 (sodium monofluoroacetate) *Trade names: No Possums, Pestoff Professional.*	Less risk to non-targets and people as it degrades quickly and is metabolized rapidly. Registered for aerial application. Registered for use on rats, cats and possums. Highly toxic to rats, cats and possums. Very well studied with large knowledge base developed. Well known effects means clearer idea of mitigation actions necessary to minimize non-target risks.	As with other acute (fast acting) toxins bait shyness is more likely. Can be detected and avoided by some individual rodents making it unsuitable for eradications. Significant non-target risks to wildlife and pets.
Cholecalciferol	Lower risk to birdlife than	Still potentially lethal to non-

Trade names: Pestoff Decal, No Possums.	brodifacoum. Highly toxic to mammals. Naturally occurring product (Vitamin D). Effective treatment for toxicosis available.	targets and likely to cause some deaths. Unproven in eradications; success in possum control operations has ranged from 63.1-93.7% reduction. Not registered for aerial application. Risk of secondary poisoning to cats considered low. As with other acute (fast acting) toxins bait shyness is more likely, making it unsuitable for eradications. Not registered for use on rats.

Recommended Toxin

If rodents, wild cats and possums are to be eradicated from Stewart Island / Rakiura, the only toxins currently available which would provide a realistic prospect of success are the second-generation anticoagulants. Of these, brodifacoum clearly stands out as the preferred choice. Considerable research has been conducted into this toxin and its successful use to achieve rodent eradication objectives has been demonstrated many times globally. Of the 284 islands (47 628ha) that have had rats eradicated, brodifacoum has been used in 71% of campaigns and 91% of the total area treated (Howald et al. 2007). Locally, brodifacoum has been used to successfully eradicate rats from Ulva Island, Bench Island, Pearl Island, Rarotoka / Centre Island, Putauhina, Poutama, Codfish Island / Whenua Hou, Campbell Island, Pukeweka, Rerewhakaupoko / Solomon Island, Horomamae / Owen Island, Mokinui and Taukihepa.

Brodifacoum is currently the most common poison used to control rodents in households. It is sold "over the counter" as "Talon" and "Pest-Off". Brodifacoum is the most commonly used rodenticide in the United States and is widely available for household consumers, although the Environmental Protection Agency is currently considering restricting its use to professional pest control operations (Buckelew 2008).

Of major concern with brodifacoum, as for most other toxins, is the potential for unacceptable non-target effects. However, as a result of previous research and experience in eradication projects, including those local projects listed above, these effects can often be predicted. With such information, mitigation of effects can, in most situations, be undertaken where necessary to reduce the risks. The high risk period during eradications is relatively short (a matter of a few weeks to a few months), until bait decomposition and animal tissue containing toxin breaks down. Bait breakdown is influenced by moisture, temperature (leading to mould growth) and insect activity (O'Connor and Eason 2000). The risk level then drops off, although toxin may remain in the environment for a number of months, biodegrading over time. Further information on the affect of brodifacoum on non-target species is in Appendix 1.

Brodifacoum acts by interfering with the synthesis of vitamin-K dependent clotting factors. This increases the clotting time of blood and leads to death by internal haemorrhaging. Brodifacoum is not readily metabolized and a portion of an ingested dose is bound in the liver, kidney or pancreas where it remains in a stable form for some time and is only very slowly excreted (Fisher and Fairweather 2006).

While these qualities (persistence in animal tissue, cumulative effect and ability to pass through the food chain) make brodifacoum unsuitable for ongoing control operations, they are the very qualities that make it suitable for "one-off" operations such as eradications. Brodificoum is considered the best toxin for eradications as:
1. It is slow acting, so no bait shyness is incurred;
2. It is cumulative so that every feed builds toward a lethal dose;
3. It is well tested and proven effective in eradications; and
4. It has the ability to kill rats, wild cats and possums from direct feeding on bait as well as from feeding on poisoned prey (termed secondary poisoning).

Toxin use - past and present

The use of toxins, especially long term, can lead to animals developing a resistance or tolerance to that toxin. For example, brodifacoum had been used to control rats on Ulva Island for the ten years prior to eradication. During the eradication attempt, some trapped rats were found to have ingested a very high dose of brodifacoum with no apparent ill effects (Thomas and Taylor 2002). Thus, it is important to identify areas where toxin use has occurred in the past, so that the potential of bait or poison tolerance or resistance can be investigated.

While the toxin 1080 has been used for cat control in the New Zealand dotterel breeding areas and for control of possums over large sections of the Island, this section will focus on brodifacoum (and similar anti-coagulants) as the proposed toxin for this eradication.

Since 1998, bromidiolone has been used in bait stations in the dotterel breeding areas to stop rats taking 1080 baits intended for wild cats (P. Dobbins, pers. comm.). The areas of control are shown in Figure 3.1.1. Annually, only about 70kg of bait is being applied across all of the dotterel breeding areas (40g per bait station per month from August to February).

All public huts on Stewart Island / Rakiura have had diphacinone bait supplied, as required to prevent rat damage, since about 2001. It is also likely that some titi islands with rats still present have intermittent rat control occurring around buildings, as well as more widespread use in attempts to control or eradicate rats.

If bait shy or bait resistant animals are likely to occur anywhere, it will be around the township. There has been a long history of poison, principally brodifacoum in recent years, being liberally applied around houses to control rats. This has occurred throughout the township and for at least 40 years (A. Pullen, pers. comm.). These applications have typically been intermittent, uncontrolled and unstructured.

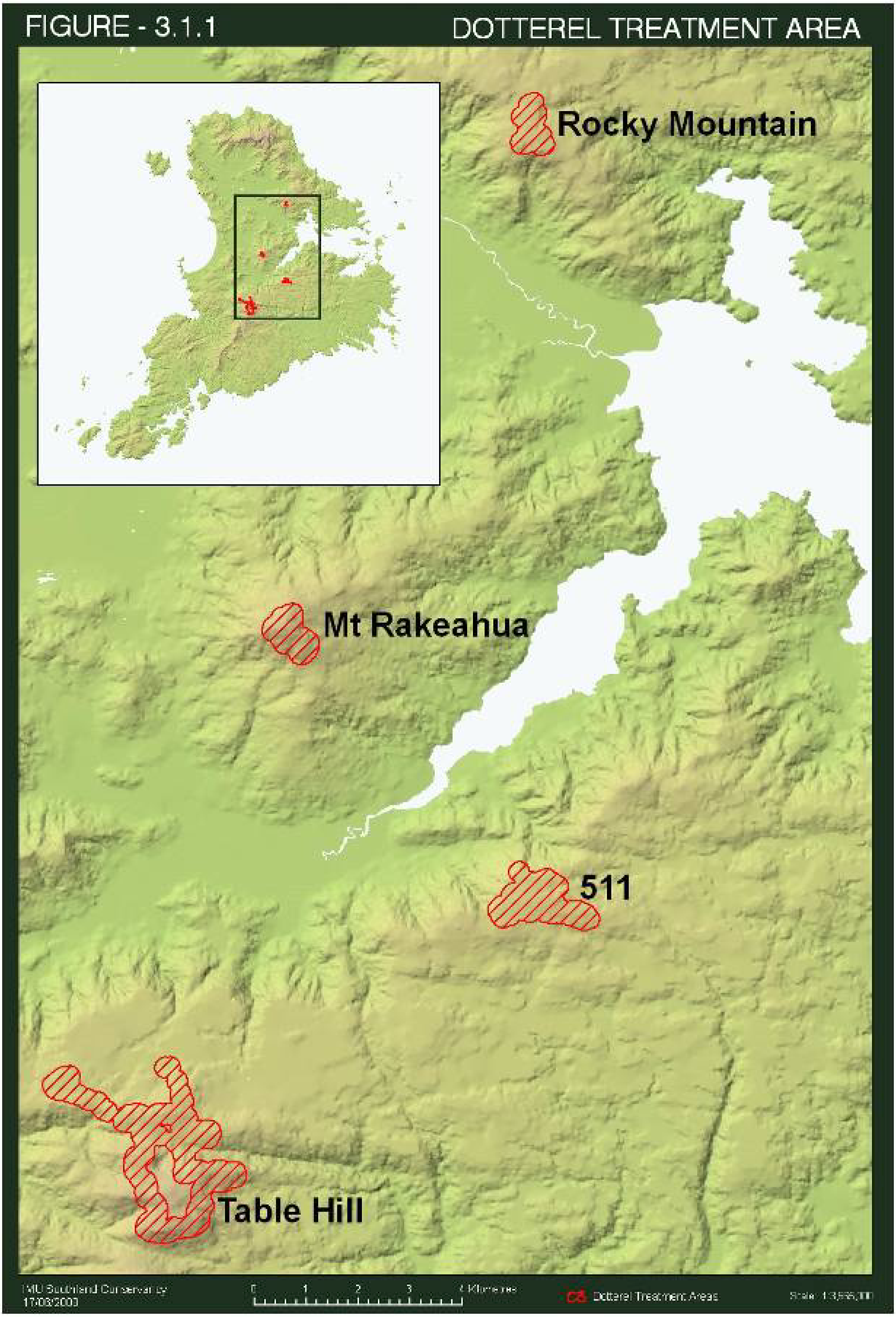


FIGURE - 3.1.1
DOTTEREL TREATMENT AREA
Rocky Mountain
Mt Rakeahua
511
Table Hill
17/03/2003
0
1
2
3
Dotterel Treatment Areas

On top of this, Golden Bay Wharf, Thule Wharf and the main Halfmoon Bay Wharf have been baited with brodifacoum (1996 – 2000) and diphacinone (2000 – present). The bait station regime has been maintained to reduce the likelihood of rats invading Ulva Island.

The Dancing Star Foundation has used brodifacoum behind its predator proof fence since 2006 in an attempt to eradicate all pests from within the fenced area.

If an eradication programme is implemented in the future, then the application of brodifacoum toxin for all target species should cease at least three years prior to the operation. This will minimise the chance of any toxin tolerance or resistance being present and compromising the success of the operation. Other toxins can be used and in suitable cases alternative toxins or traps could be supplied to the users at no cost and its use monitored.

The areas identified above should have rats, possums and wild cats caught and tested for resistance to brodifacoum.

Bait Matrix

Baits are a food package designed to be attractive for the target animal to eat. They are not in themselves toxic, but have the toxin added to them as a way of getting the toxin into the target animal. For example, the bait Pestoff 20R is composed of cereals, sugars, waxes and binders.[9]

The ideal bait and toxin combination is: i) palatable and lethal to target species after a single feeding; (ii) persistent in the environment long enough for target species to be exposed; (iii) short enough to minimize non-target exposures; (iv) low probability of engendering bait shyness and (v) non-toxic or non-palatable to non-target species (Howald et al. 2007).

Choosing a bait which is attractive to all target species and which will remain palatable long enough for all target species to consume a lethal dose of toxin is a critical element in successful eradications. The bait in which the toxin is held must be extremely palatable to the target species and must be in a form suited to the method of distribution and presentation. There are several commercially available baits to choose from. Compressed grain pelleted baits have proven to be particularly palatable to rodents in eradication operations worldwide. The advantage is that an adequate dose of toxin is delivered when compared with loose grain, or waxy blocks, which may not result in rodents receiving a lethal dose of toxin. Also, the bait has to be able to go through the machinery (e.g. spinner bucket) and be spread effectively with minimal fragmentation.

Currently, Pest-off 20R, RS5 and Agtech baits are the only effective products available for aerial spread in New Zealand. Pestoff 20R is highly palatable (Morriss

[9] Ingredient list taken from Material Safety Data Sheet for Pestoff 20R.

et al. 2008) and well proven, having been used in most island eradication operations. Morriss et al (2008) found that weathered bait was less palatable for Norway rats. Therefore, there may be advantages in investigating a harder bait that will resist weathering (see also Section 3.1.5) and will also store for longer periods (see Section 3.1.6). Bell Laboratories (USA) has developed a harder bait named Brodifacoum 25 Conservation. This bait has been field tested, with good results, for effectiveness on rats and ability to withstand harsh environmental conditions in the Aleutian Islands (Buckelew et al. 2007). This increased time in the environment could also lead to increased potential for non-target effects.

Alternatives could be considered if they met the following criteria;

- Bait has proven palatability to all rodent species targeted as well as possums and ideally wild cats.
- Manufacturer has a proven track record of quality control at all steps in the manufacturing process.
- Bait has proven storage life and has been used in conditions likely to be encountered on Stewart Island / Rakiura.
- There is sufficient information about palatability to non-target species to enable those species at risk to be predicted and the risks managed to acceptable levels.
- The bait is logistically and financially feasible to produce.

3.1.5 BAIT DISTRIBUTION OPTIONS

Bait spreading is a critical aspect of any rodent eradication. Bait needs to be spread so that every target animal on the Island has access to a lethal amount of toxin. Failure to achieve this will lead to failure of the operation. The treatment area for Stewart Island / Rakiura is 169 464ha (see Section 1.4). This large area presents significant logistical challenges in relation to the bait distribution method.

Helicopter broadcast poison bait

Aerial broadcasting is the most common / primary technique used for applying bait across large areas. It involves the use of helicopters with purpose-built, underslung bait buckets. A power-operated spinner at the base of the bucket assists to evenly spread the bait, typically to a distance of 40m from the bucket, generating an 80m wide swath as the helicopter flies along set lines at set speeds. More recent operations have employed differential global positioning (DGPS) navigational systems, which enable more precise positioning and for the true flight path of the helicopter to be accurately recorded. Analysis of this flight information during the operation assists in ensuring complete coverage of the treatment area.

Currently the Best Practice for aerial applications of bait for rodents is a double bait application event, usually 10-14 days apart, with the second application flight direction at 90 degrees to the first and with a reduced baiting rate. Some mainland multi species eradications are trialling third applications to target mice. These applications use overlapping swaths, whereby each swath of baits overlaps with the previous one by 50%. This means all areas are covered twice. In practice this approach substantially reduces the risks of significant "bait gaps"- especially over steep terrain.

Pestoff 20R is only registered for stock-free islands and within predator proof fences according to the Code of Practice (Anon 2006). Although it could possibly be argued that Stewart Island / Rakiura falls within the Code of Practice's definition of an 'island', unless this is verified, it would be prudent to presume that it would be illegal to spread brodifacoum bait in this manner on Stewart Island / Rakiura. For an operation of this nature to be legal, the registration would need to be changed. This is what happened for treating mainland sites behind predator-proof fences, when the earlier registration only allowed use on stock-free islands.

Aerial baiting, possibly in combination with other methods, will be the key way that baits could be delivered to every rodent, wild cat and possum on Stewart Island / Rakiura. There is no way that baits could be spread on the cliffs or other steep areas or in some vegetation types by people on foot. Aerial baiting is also much faster than ground-based approaches, putting all individuals at risk within a much shorter time frame and minimizing the risk of individuals moving from baited to unbaited areas, with consequently lower risks of target animals not encountering toxic baits and lower costs per hectare. With modern navigational equipment, aerial baiting is also more accurate than ground-based operations, with consequently less risk of failure due to bait gaps.

Other operations suggest that helicopters, regardless of size, could distribute bait over 2000 – 3000ha per day (P. de Monchy and K. Broome, pers. comm.). If we base Stewart Island / Rakiura's treatment area as 169 464ha, then bait distribution would take between 56 and 85 machine days for each of two applications. If ten helicopters were used, then bait distribution would take six to nine days per application. Any innovation that increased bait application speed (e.g. bigger spinners resulting in larger swath widths, or adjustments to buckets allowing increased application flight speeds), would subsequently reduce the time and cost required for application.

The best practice for aerial bait spread requires fine days for spreading; with a further three fine nights to ensure bait integrity. An operation as described above would require 9-12 days of fine weather for each application during the months of July to October (considered the best time of year for eradicating rats due to food availability and breeding cycles). These fine days would not have to be consecutive. Bait spread could be completed in sections, providing for several "weather windows", as long as re-baiting buffers or overlaps are employed for any breaks in application. Ideally, these periods of spread would be close together.

Landcare Research has initiated some research using DNA variability in the target animal to see if topographical features are presenting barriers to movement, creating isolated populations (G. Nugent, pers. comm.). This would be worth investigating further on Stewart Island / Rakiura as it may allow the Island to be divided into “eradication units”. This in turn would allow more flexibility in weather windows, as well as for bait production (see Section 3.1.6) and follow-up hunting for cats and possums (Section 3.1.7).

Analysis of weather data suggests that the July to October timeframe contains some of the driest months of the year, with on average at least 14 fine days per month (Figure 3.1.2). It therefore appears feasible for two applications to occur over these months, but further data on weather windows and variability across the Island would be warranted.

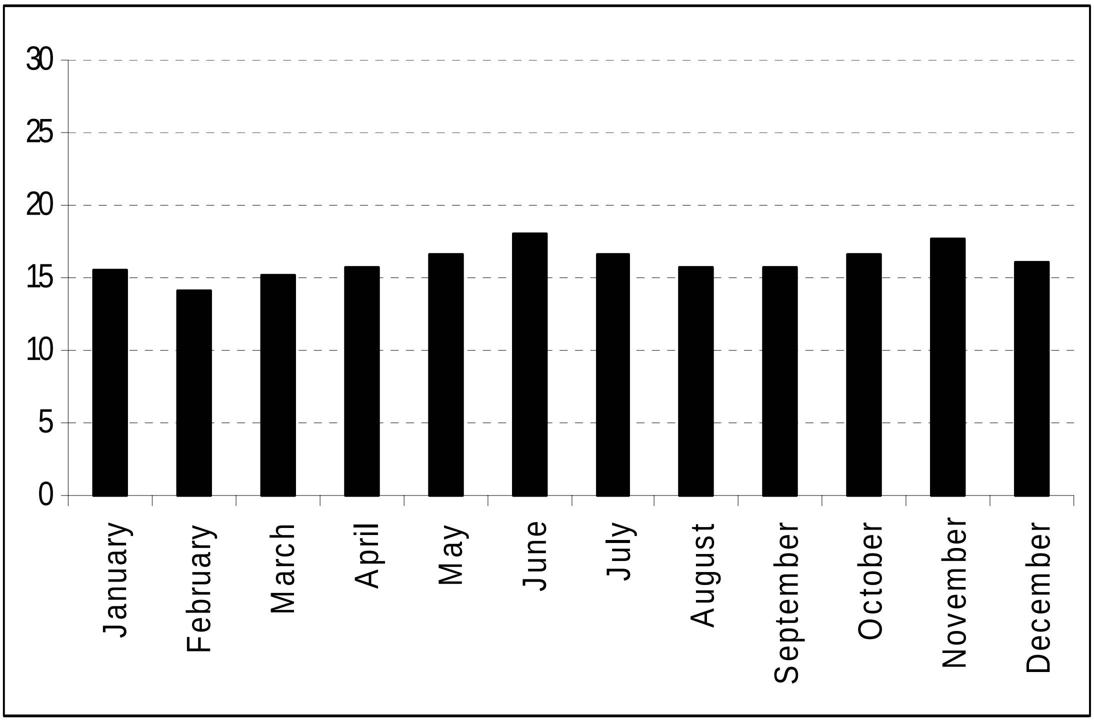


Figure 3.1.2: *Average number of wet days (1mm+ of rain) per month. Oban weather station 1915-1957. Data from the NIWA National Climate Database.*

Provided suitably ‘eradication experienced’ operators were employed, with tried and proven equipment, there is a very high probability that baits could be delivered to every rodent on Stewart Island / Rakiura using this method. It is questionable if there are enough suitably experienced “eradication” pilots within New Zealand. Further work is required to identify the number of suitable machines and pilots available. It may he necessary to train additional pilots.

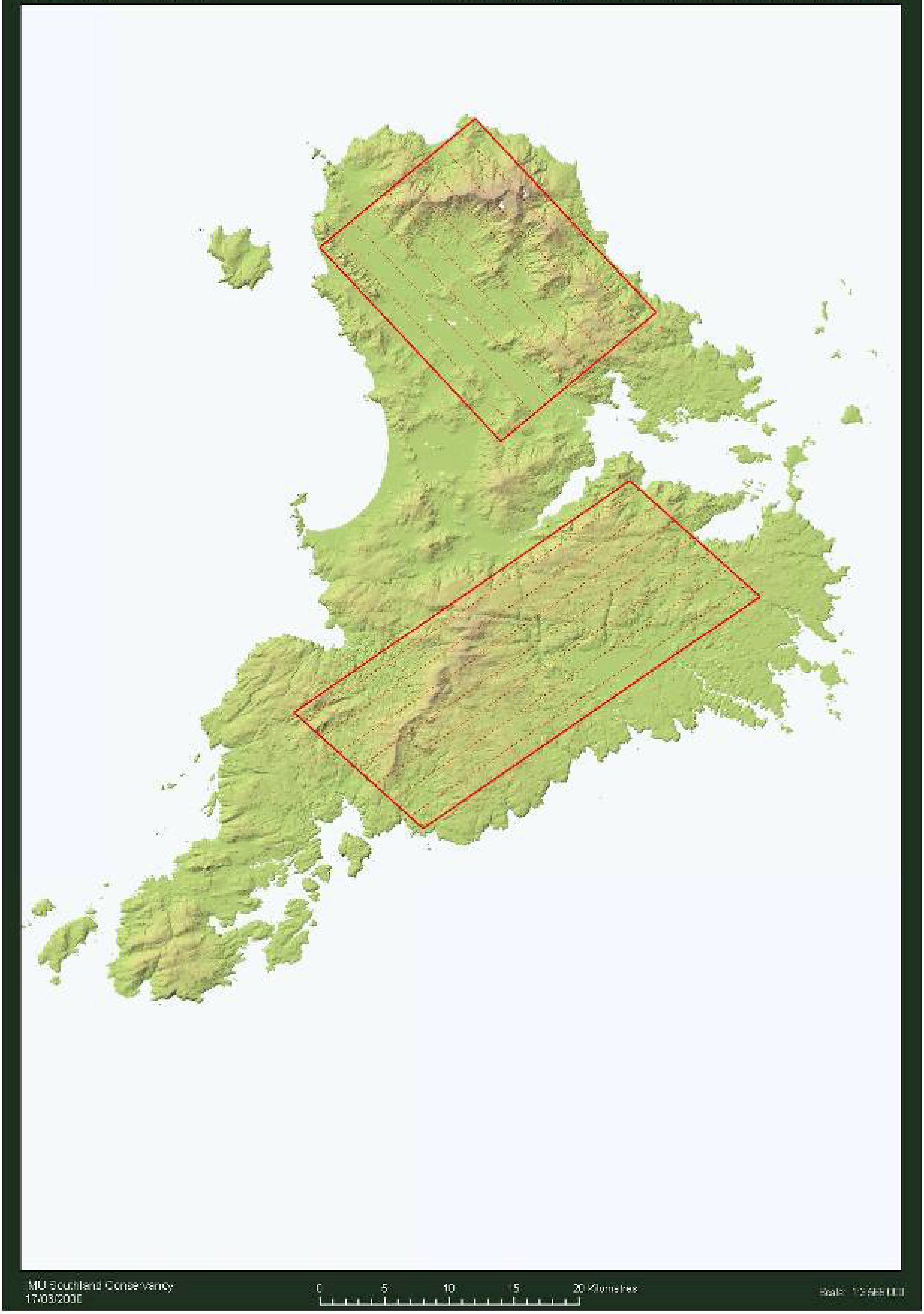
Fixed wing broadcast operation

Fixed wing aircraft have been used for many years for fertiliser distribution and, like helicopters, have access to differential GPS technology. They have not been used for island eradications in the past due to their lack of manoeuvrability in small areas. Nevertheless, fixed wing use tends to be considerably cheaper than helicopter and they have potential for a large load capacity.

Large "squared off" areas of Stewart Island / Rakiura could be effectively and relatively cheaply treated by fixed wing application. Helicopters could then be used to fill in all of the coastal or non-linear areas (Figure 3.1.3).

For this to be used with confidence further work would be required, including field trials on refining distribution techniques from fixed wing to ensure even bait coverage.

FIGURE - 3.1.3 POTENTIAL FIXED WING SPREAD



Poison baiting using bait stations

Bait station operations involve the establishment of a grid system of stations across the entire area to be treated. Often bait stations are left in position un-baited to allow rodents to become accustomed to them, thereby reducing any initial neophobia before bait is made available. Bait stations are normally loaded simultaneously (i.e. on the same day) with toxic baits and initially replenished daily, always ensuring that bait will be available every night at each station. Some rats and possums may occupy areas around particular bait stations, thus preventing subordinate rats and possums reaching bait. For example, on Kapiti Island, dominant Norway rats prevented sub-ordinate Norway rats or kiore / Pacific rats from accessing bait stations (Bramley 1999). Trials revealed that kiore / Pacific rats would not even use bait stations that Norway rats had used (Cromarty et al. 2002). As a result, bait take may persist for some time after the initial fill. However, once the dominant animals have died the baits become more accessible to others. Bait take may occur over several weeks, even months, before all individuals succumb.

The duration of a bait station campaign depends on various factors, including the density of bait stations and of rodent and possum populations (basically, the more bait stations there are the quicker the operation will be). The correct spacing of bait stations is critical – for rats in New Zealand it appears that grid systems varying between 50 x 50m , 50 x 100m and 100 x 100m are appropriate, depending on the species present (Thomas and Taylor 2002).

Bait stations require intense effort, not only in establishing a track network and putting the bait stations in place, but then regular filling for extended periods. If a 50 x 100m grid was used, at least 400 000 bait stations would be required to cover Stewart Island / Rakiura, with over 20 000km of track network to service them. This number of bait stations would take over 2000 person days for one fill (A. Gutsell, pers. comm.), making it impossible to replenish all stations on a daily basis. The required track network, aside form the logistics of installation, would cause extensive environmental damage. Due to the size of Stewart Island / Rakiura, it is not practicable to use bait stations over the whole Island, but this technique could be employed in localized areas such as the township.

Hand broadcast poison bait

Hand-spreading theoretically simulates the effect of aerial distribution. It is difficult to guarantee the same consistency of coverage as aerial application due to human error and physical barriers. It involves people carrying bait and dispersing a pre-determined quantity per set distance traveled at set bait intervals. It is useful for treatment of small areas where bait stations cannot be safely established or to supplement bait station work (i.e. work on a small Stewart Island / Rakiura area has demonstrated that hand spreading was required on top of a 50m x 100m bait station grid to eradicate all three species of rat). It has, along with all broadcast techniques, the added benefit over bait stations of making bait available to all individuals at once, which is vital for a multi species project such as is being investigated for Stewart

Island / Rakiura, especially with the potential for competitive exclusion. This technique is limited to small areas and is not appropriate for the whole of Stewart Island / Rakiura due to the time required as well as the potential for gaps to occur.

Consideration should be given to hand-spreading bait in buffer areas between the boundaries of aerial and ground-based operational zones, as well as in areas with bait stations (e.g. the township) where this is acceptable.

3.1.6 BAITING RATES

Early aerial baiting operations in New Zealand involved sowing rates up to 30kg/ha. For rat eradications, this has gradually been reduced to as low as 12kg/ha. But for sites where multiple pests are present (e.g. Maungatautari), the baiting rates are still in the order of 20-30kg/ha.

Most eradications involve two drops of bait timed far enough apart for dominant animals to be killed, thereby allowing subordinate animals (both inter- and intra-species dominance) access to bait pellets and ensuring there are no bait gaps (due to flying or weather). The volume of bait used per drop is also a function of the type of habitats and terrain as well as the range and density of species being targeted.

For the purposes of this document and trying to estimate logistical issues and an approximate cost, a baiting rate of 25kg/ha has been used (split across two applications and following best practice techniques). Based on this rate, a 169 464ha treatment area would require 4250 tonnes of bait. This would contain 85kg of toxin, or 0.5g of toxin per hectare.

Since bait constitutes a significant part of overall eradication costs, reduced sowing rates can lead to significant cost savings. Nevertheless, operations targeting multiple species are not nearly as well proven and it would pay to err on the side of caution in regard to baiting rates, especially as deer and possums have the capacity to eat large amounts of bait. If deer repellant was used in baits, this would potentially reduce the amount of bait required, but extra trials would be required (see Section 3.3.5).

Landcare Research has been conducting research into multi species eradications and ways of reducing baiting rates for control operations (G. Nugent, pers. comm.). The findings of this research may contribute to our understanding of minimum required baiting rates. To put this in context, a reduction to a 20 kg/ha application rate would require 849 tonnes less bait, with a saving of $3.2 million in bait costs alone. Determining the ideal baiting rate for Stewart Island / Rakiura will require further work and trials.

Production and transport

Producing 4250 tonnes of bait would seriously test the country’s production facility. The facility can currently produce around 10 tonnes of brodifacoum baits (Pestoff 20R) per 10 hour day from its largest machine. If a day and a night shift were operating, then 20-22 tonnes could be produced per day, allowing some time for repairs, maintenance and cleaning. The facility managers are unsure on how productive or problematic night shifts may be, as they haven't done them for many years (B. Simmons, pers. comm.).

If all went well, with one machine dedicated to this production, 400-500 tonnes per month could be produced (B. Simmons, pers. comm.). It would take over 10 months to produce the required amount of bait. This timeframe produces serious issues for long term storage of that quantity of bait (approximately 8000m^2 of storage capacity near Bluff or Invercargill would be required) and for ensuring bait integrity during storage (palatability as opposed to toxicity which remains relatively stable for 12 months).

The storage life of bait is about three months, definitely no more than four (B. Simmons, pers. comm.). Therefore, for the operation to be successful, bait production time frames need to be reduced to within the four month maximum storage life of the bait. This could be achieved by purchasing more bait production machines ($500 000 each; B. Simmons, pers. comm.). Three machines producing bait would reduce production time to less than four months. Any reduction in baiting rate would also subsequently reduce production time.

Transport from Wanganui (the site of the factory) would involve a truck and trailer leaving the factory every day that the plant was operating (20-22 tonnes) at a cost of about $1.5 million. Given the total volume and subsequent value of bait, it may be viable to establish a temporary production facility near Bluff and have all of the raw materials shipped to Port Chalmers or Bluff (B. Simmons, pers. comm.).

Although such an outcome is potentially possible, it is unknown if this is possible in reality as the factory has never tried producing bait at such a rate, and they have never tested their suppliers' capacity to supply raw materials to such an extent (B. Simmons, pers. comm.). All of these factors and storage capacity will need to be tested before this eradication could be declared feasible.

3.1.7 WHAT MIGHT WORK ON STEWART ISLAND / RAKIURA?

Eradicating pests from Stewart Island / Rakiura is more complex than many earlier eradication projects because of the presence of a permanent human settlement and because of the size of the Island. It is likely that a range of methods would need to be employed to eradicate rats, wild cats and possums.

An aerial application of a suitable toxin, combined with an intensive ground based approach around inhabited areas, seems to be the only practicable method available that would achieve the total eradication of rats from Stewart Island / Rakiura.

Follow-up work for possum and wild cat eradication

An aerial application of toxic baits is also likely to reduce possum and wild cat numbers to very low levels. Possums and wild cats (R. Griffiths, pers. comm.) would die as a result of the direct consumption of baits, as well as from eating rats and possums that contained poison (called secondary poisoning). Wild cats would likely starve following removal of their prime food item (Harper 2002). While Harper (2002) has suggested that the removal of rats may be enough to cause the death of all wild cats on the Island, follow up operations, probably using detection dogs and a combination of traps and poison, should be planned for to achieve total eradication of both wild cats and possums.

It is hard to imagine how this follow-up hunting over the entire Island could be completed without the use of dogs. To get an idea of what is required, the following assumptions are made: (i) that follow-up work would continue for three years; (ii) that dogs would be trained to detect both possums and cats or each handler will have a team of dogs; and (iii) that the maximum area that one dog team could hunt effectively is about 3000 - 5000ha (S. Theobald, pers. comm.). Given the area of Stewart Island / Rakiura, between 33 and 56 dog teams would be needed. There is some evidence that cats and possums are restricted in distribution on Stewart Island / Rakiura (Harper 2002). If this proves accurate, then follow-up work could target these preferred areas, potentially reducing the number of dog teams required to about twenty.

The actual shape of follow-up work would require further and careful planning. The successful eradication of wild cats and possums from Stewart Island / Rakiura will depend on follow-up operations being well planned and well implemented. It will undoubtedly be a large and expensive part of the total eradication operation. Unless searching is targeted to key cat and possum habitat (e.g. podocarp forest), it is unlikely that this follow-up work would be feasible. Further work is recommended on the distribution and habitat use of both possums and cats on Stewart Island / Rakiura to determine if this follow-up work can be targeted to specific areas.

The Township

This section discusses the technical issues related to the eradication of rats, wild cats and possums from around the township. Social impacts, including issues related to human health, are discussed in Section 3.3.

Oban is the only settlement on Stewart Island / Rakiura. The settlement covers approximately 700ha, but a further 1600ha of private land surrounds the township. Private land is situated on the northeastern shore of Paterson Inlet, extending around the coastal area to Horseshoe Bay (Figure 3.1.4). There are 402 residents and 186 dwellings, as well as a number of commercial and non-commercial buildings (Statistic New Zealand Census 2006). These include the hotel, two fish processing sheds, a restaurant, the fire station, a general store, primary school and the DOC office.


FIGURE 3.1.4
OBAN / HALFMOON BAY TOWNSHIP
N
W
E
S
Horseshoe Bay
Horseshoe Point
Halfmoon Bay
Halfmoon Bay
Oban
Ackers Point
0
5
10
15
20 Kilometres

The eradication of alien pests from permanently inhabited islands is a relatively new development in eradications, involving additional operational challenges compared to uninhabited islands.

While there have been some successful eradications on inhabited islands (e.g. Ascension, Viwa and Falklands), there is nothing approaching the scale of occupancy of Stewart Island / Rakiura. Other inhabited islands being considered or suggested for rodent eradication include Lord Howe, Galapagos, Tristan de Cunha and Great Barrier Island.

Because of risks to pets, as well as public health, safety reasons and community concerns regarding aerial bait application, the township and immediate surrounds should not be considered for aerial baiting. In these areas, the same bait being used in the aerial operation could be applied in bait stations, perhaps in association with hand-spreading in appropriate areas.

For an eradication to succeed, bait stations and other eradication methods (e.g. hand-laying of baits and traps) must be employed in every house and every other structure on the Island (e.g. offices, sheds, shops, guest rooms, public buildings, school, restaurants, etc). Baits would need to be placed in all ceiling cavities and attics, and all other locations where rodents might possibly occur. Ensuring effective coverage would be a major challenge and present significant risks to an Island-wide operation. Such an operation would require virtually universal community support (or, at least, compliance).

While it is recommended that a future eradication operation should aim for 100% community support, it should be noted that gaining 100% support will be a difficult task to achieve. Therefore, is it recommended that careful consideration be put into planning how to achieve this support, as well as actions and direction should opposition occur.

Would a pest proof fence be useful?

Integrating general aerial and ground-based eradication operations in the vicinity of the town would pose logistical challenges, especially if animals can move freely between the areas. To overcome these issues, the two treatment areas need to be separated either by large overlapping buffers in treatment, or by a physical barrier such as a pest-proof fence. The fence could be constructed just for the term of the eradication and then dismantled, or retained as a long-term biosecurity tool. This option has received both strong support and strong opposition.

A predator-proof fence could be built from Paterson Inlet through to Lee Bay – a distance of about 5km. This fence would be double hooded to create a barrier to movement both into and out of the township area. Consultation to determine the number, placement and design of gates would ensure that people have relatively unimpeded access through the fence. The fence itself could provide a new walking track. As well as creating two independent operational zones, the fence may contribute a sense of security to local residents in regard to the aerial baiting – a physical barrier that the aerial baiting will not cross. The fence need not be high. The Oban community is familiar with the 2m high predator fence at Lee Bay. A rat-proof fence need only be 1m high.

A permanent fence would have the added advantage of creating a containment area, should an alien species re-invade Stewart Island / Rakiura. For example, if a rat managed to get to the wharf, we could be reasonably confident that it would be contained around the township. If bait stations and traps were maintained in this zone, there would be an excellent chance of killing the individual(s) before they could breed.

There are, however, significant issues associated with a predator-proof fence. A fence would be expensive (over $200 per metre) and require regular and ongoing maintenance (with associated costs). A peninsula fence has open ends that will require intensive management to prevent animals swimming around; although there is ongoing research and refinement that is reducing the susceptibility of fence ends to reinvasion. There is also some strong social opposition to the fence with some saying it would feel “like a prison”, or they would simply find it “an eyesore”. There may also be legal obstacles to restricting access to a national park (regardless of how many gates are installed).

The costs and benefits of a fence are worthy of close investigation, however, the legal and social implications may be difficult to resolve. A careful analysis will need to be completed looking at the cost and benefit of a fence versus non-fence management options such as overlapping treatment buffers.

3.1.8 CONCLUSION: CAN ALL INDIVIDUALS BE PUT AT RISK BY THE ERADICATION TECHNIQUES AND CAN THEY BE KILLED AT A RATE EXCEEDING THEIR RATE OF INCREASE AT ALL DENSITIES?

There have been many successful rodent eradications worldwide and multi-species eradications are becoming more common in New Zealand with the advent of pest-proof fenced “mainland islands”. New Zealand has considerable experience with eradication technologies.

The use of second generation anticoagulant baits (e.g. Pestoff) and aerial bait distribution is probably the only feasible way of eradicating rodents from an area the size of Stewart Island / Rakiura. Aerial application of bait is not suitable for the township area. Ground based techniques would need to be applied in this specific area and this may be assisted by a predator-proof fence. Community support is necessary to achieving eradication around the township.

Aerial application of brodifacoum bait would put all possums and cats at risk, however, there is also a good chance that some possums and wild cats would survive. Therefore, follow-up work will be required for these two species. It is proposed that this be in the form of traps and hunting with dogs. Conducting such operations across the whole of Stewart Island / Rakiura would probably not be feasible. Work will be required on the distribution and habitat use of these animals to determine whether follow-up can be targeted to specific areas (e.g. podocarp forest). If there is habitat specificity, then follow-up work is likely to be feasible.

There are a number of research requirements and gaps in knowledge that need to be addressed. Some of these gaps relate to the efficiency of the eradication methods (e.g. fixed wing aircraft bait distribution), others to capacity (e.g. bait production and storage capacity, number of suitably experienced pilots, and habitat selection by cats and possums).

For rodents, it appears that all individuals can be put at risk by existing eradication techniques and rodents can be killed at a rate exceeding their rate of increase at all densities. There is more uncertainty for cats and possums, primarily in relation to follow-up work.

3.2 The probability of the pest re-establishing is manageable to near zero

Eradicating rats, wild cats and possums from Stewart Island / Rakiura presents a set of specific challenges and risks. Maintaining the Island as pest free involves an additional suite of challenges and risks. Despite its size, Stewart Island / Rakiura is still an island surrounded by water, with limited points of access. This section explores the feasibility of keeping the Island pest free.

3.2.1 HOW COULD SOMETHING GET BACK?

Because of the high visitation rates (vessels, aircraft) to Stewart Island / Rakiura, it can be assumed that the risk of rodents reaching here is higher than for islands where visitation rates are lower. This risk is compounded by the number of people living in Oban, meaning more and riskier cargo is imported to the Island (e.g. bulk food, building materials, etc). It can be assumed that there are risks associated with every vessel or aircraft which comes to the Island, although the level of risk will vary according to the type and size of the vessel, cargo and the standard of checking applied at departure points. Biosecurity procedures will need to be consistently applied in order to keep these risks within acceptable limits.

Modern vessels are less likely to carry vermin compared with older cargo vessels (e.g. during the 1900s), however, some risk remains (see Table 3.2.1).

Table 3.2.1: *Potential pathways for terrestrial pest invasion.*

Vector of re-invasion	**Species**	**How**	**Known history on Stewart Island / Rakiura**
Planes and helicopters	Rodents and invertebrates	Hide within aircraft or gear being transported by aircraft.	• A rat was seen to jump out of a Stewart Island Flights plane when bags were being offloaded on Stewart Island / Rakiura

Ferry service and freight boats.	Rodents and invertebrates especially, but also cats, possums and mustelids.	Hop-on vessel at departure port and off again at destination. Transported inadvertently within peoples luggage. Transported inadvertently within freight, especially food supplies for shop and building materials.	• Unconfirmed reports of mice turning up in Halfmoon Bay. • Visitors have brought unneutered cats to the Island, occasionally leaving them behind when haven't turned up in time to go home.
Salmon service vessel	Rodents and invertebrates	Hop-on vessel at departure port and off again at destination. Transported inadvertently with salmon food supplies.	• Reports of mice regularly arriving at salmon barge with salmon food supplies.
Recreational boats	Rodents and invertebrates.	Hop-on vessel at departure port and off again at destination. Transported inadvertently within peoples luggage.	• On average one rat per year invades Ulva Island presumably off recreational boats
Fishing type boats	Rodents and invertebrates	Hop-on vessel at departure port and off again at destination.	• Rats invaded Taukihepa presumably off a fishing boat in the early 1960's. • Fishermen often report rats stowing away on boats in years when rat numbers are very high.
Bio-terrorism	All	Someone deliberately releasing a new organism onto Stewart Island / Rakiura.	• Pigs were released at Mason Bay approx 18 years ago. • Hunters threatened to release stoats onto Stewart Island / Rakiura when possum control was being debated in 2000.
Shipwrecks	Rodents	Swim off wrecked boat	• There have been at least four boats wrecked on Stewart Island / Rakiura in the previous 15 years (e.g. the Dong Won, Marine Maid, etc)

3.2.2 KEY INVASION THREATS

Rats, wild cats, possums

The likelihood of possums or wild cats reinvading Stewart Island / Rakiura is considered low unless they are deliberately re-introduced. That said, a possum was caught hiding in building material bound for Great Barrier Island (Keith Broome, pers. comm.) and un-neutered cats are regularly brought over to Stewart Island / Rakiura on "holiday". Environment Southland's Regional Pest Management Strategy (RPMS) (Anon 2007) requires all cats being brought to Stewart Island / Rakiura, as well as those that are already resident, to be neutered and micro-chipped. Unless the enforcement of this can be guaranteed, it poses a real risk of a wild population re-establishing. This risk could be alleviated by simply banning cats from coming over on 'holiday' and neutering resident pet cats as per RPMS requirements.

There would be an on-going risk that rodents (both rats and mice) will re-colonize Stewart Island / Rakiura following any eradication – they are very effective dispersers and are commensal travelers with humans. The consistent application of rigorous quarantine measures to minimize re-invasion risks, combined with contingency actions to detect and remove any re-invaders, will be critical to maintaining the rodent-free status.

Mice

Mice deserve specific mention as the likelihood of mice invading Stewart Island / Rakiura would be significantly increased once rats are removed. Not only are they commensal with humans, but their small size makes them difficult to detect. It appears that they have been regularly arriving on Stewart Island / Rakiura, but the three rat species present on Stewart Island / Rakiura have prevented their establishment (see Section 2.4.3). Mice will probably establish on Stewart Island / Rakiura once rats are removed, unless targeted biosecurity and contingency measures are implemented.

As discussed in Section 2.4.3, mice may already be present at low numbers on Stewart Island / Rakiura. Further research to confirm their presence and distribution is required. If they are present, then attempts must be made to remove them as part of any future pest eradication programme.

Regardless of whether rats are eradicated, the potential remains for mice to establish on Stewart Island / Rakiura. This establishment may be a result of changes in freight or visitor numbers, localised rat control or even a changing climate. Recognising the importance of the absence of these pests from Stewart Island / Rakiura, it is recommended that biosecurity and contingency measures are instigated to minimise the risk of the establishment of mice.

Other organisms

Stewart Island / Rakiura is special in lacking a large number of pests that are present on the rest of New Zealand – both terrestrial and marine – not to mention organisms that haven't yet invaded New Zealand. As for mice, it would be worthwhile to invest in biosecurity measures to minimise the risk of establishment of any new pest organism on Stewart Island / Rakiura.

3.2.3 HOW DO WE STOP INVASIONS?

It is better to keep pests out, rather than to try to deal with them once they arrive. With rats, there is only a brief opportunity (usually days) to catch the animals before they disperse, often over large distances (Russell et al. 2008).

Many rodent-free islands in New Zealand have some level of control on public access for biosecurity reasons. Several islands where rodents have been eradicated have an open-access policy with few restrictions on entry (e.g. Ulva Island, Matiu / Somes Island, Tiritiri Matangi and Motuora Island). Others are occasionally or regularly visited and, in some cases, permanently occupied (e.g. Maud Island and Codfish Island / Whenua Hou; both permanently occupied island reserves). On these islands, incursions by rodents were reasonably common (36 incursions on 25 islands in the last 100 years)(Russell et al. 2008). However, no rat-free New Zealand islands contain a permanent settlement containing hundreds of people or over a thousand vessel visitations each year, as is the case on Stewart Island / Rakiura.

To maintain a rat, possum and wild cat free Island and to prevent the establishment of other organisms (e.g. mice), a rigorous biosecurity system will need to be implemented. This system will need to be at a level that reduces the risks of unwanted organisms being transported to the Island, but it cannot be too arduous. A difficult or laborious biosecurity system will compromise compliance.

The risk of rodent invasion after an eradication programme can probably be minimised with modern biosecurity and contingency procedures, appropriate public awareness and support, in conjunction with modern transport and storage facilities (Russell et al. 2008). There will be costs associated with maintaining on-going quarantine and contingency programs (see Section 5). A biosecurity plan will need to be prepared and measures put in place prior to an eradication operation. Any future plan will need to be developed in partnership with the community.

Some suggested biosecurity measures that could be considered for inclusion in a plan are:

- Traps and bait stations at departure wharfs.
- Signage and education for voluntary checks.
- Compulsory checks – either visually and/or with teams of rodent detecting dogs.
- Pest proof containers and storage sheds.

- Restricting the number of departure points to Stewart Island / Rakiura to facilitate checks (i.e. a boat coming down from Dunedin may have to call into Bluff for a check prior to leaving for the Island).
- Developing a certification system for boaties (i.e. developing a standard for boaties to achieve, similar to Qualmark, etc).

Rodent dogs

Teams of rodent-detecting dogs could be deployed at departure and arrival points. There is a history of dogs being used to detect and catch rats and cats in New Zealand. A "Predator Dog" program has been long established by the Department of Conservation. Terriers have been trained to detect various pests – including rats and mice, whilst posing no threat to other non-target species. This program is already proving to be very successful, and is being expanded to incorporate a growing range of quarantine and contingency scenarios. Dogs have proven their effectiveness for both surveillance of rat free islands and as part of a contingency response to incursions, often detecting rodents where other methods failed (Russell et al. 2008).

Dogs could be used to check-over vessels and aircraft prior to departure to Stewart Island / Rakiura. This would be a quick and effective technique for ensuring that the risk of pest animals being unknowingly carried on vessels is minimized.

Who might pay is a subject of debate, with charges likely to put some people off and reducing compliance. That said, vessel operators might be willing to contribute to the cost of maintaining biosecurity measures if they see benefit to their businesses or to the community.

3.2.4 WHAT DO WE DO IF A PEST GETS HERE?

Well maintained contingency / detection devices can be effective, but on large islands surveillance devices must also be strategically placed (e.g. at points of known arrival) (Russell et al. 2008).

A range of surveillance and contingency techniques could be applied at key sites on the Island. These will need to be identified, but may include high visitation sites like Port Pegasus / Pikihatiti, Mason Bay, Port William, Freshwater and Lords River. Contingency actions may include the maintenance of poison bait stations and traps at key sites, proper inspection of "at risk" cargo prior to unloading and the maintenance of detection devices (e.g. tracking tunnels, wax tags, etc). Dogs could also be used to periodically check high risk areas on the Island.

A full contingency plan needs to be developed, including "ready response" provisions should rodents, possums or wild cats be detected, as part of the operational planning for the eradication. The plan needs to be able to state what exactly would be done if an invasion was detected, outlining responsibilities, actions and resource requirements.

While the permanent community on Stewart Island / Rakiura increases the risk of re-invasion, it also presents important opportunities. Provided most residents remain committed to maintaining a rodent-free status for the Island, and they have been provided with the appropriate plans, standard procedures, skills and equipment, local residents could take responsibility for maintaining surveillance programs and for implementing quarantine procedures. They could also be the "first response force" in any contingency operation when unwanted organisms are detected.

3.2.5 CONCLUSION: CAN THE PROBABILITY OF THE PEST RE-ESTABLISHING BE MANAGED TO NEAR ZERO?

Re-invasion incidents are reasonably common throughout New Zealand and on Stewart Island / Rakiura. The risks for Stewart Island / Rakiura are high due to the type and frequency of transport activities associated with the permanent settlement. Rats and mice are thought to be the species most likely to invade.

If an eradication operation were to proceed, then both a biosecurity and a contingency plan will need to be developed in conjunction with the community as part of the operational planning. Biosecurity requirements should not unduly inconvenience people travelling to Stewart Island / Rakiura, but may require approved departure points. The use of rodent detecting dogs at departure points could provide a relatively quick and unobtrusive method for intercepting rodents.

It would be vital to establish quarantine and contingency measures and have them in place prior to any eradication being undertaken. In this way, procedures may be refined, leading to greater confidence that quarantine and contingency measures are effective and sustainable.

With appropriate quarantine and contingency measures consistently applied on Stewart Island / Rakiura, it is likely that the probability of a pest re-establishing is manageable to near zero.

Regardless of the progress made toward developing an eradication plan, it is recommended that a high priority is given to establishing biosecurity measures for preventing any more organisms, especially mice, from establishing on Stewart Island / Rakiura.

3.3 Is the project socially acceptable to the community?

3.3.1 LAND OWNERSHIP AND MANAGEMENT

The idea of eradicating rats, wild cats and possums from Stewart Island / Rakiura is exceedingly complex, not only because of the sheer size of the Island, but also because of the number of landowners and groups involved. Most eradication operations to date have been on single land owner parcels (e.g. DOC reserves). While DOC manages a large portion of Stewart Island / Rakiura, there are many private landowners and interest groups.

Rakiura Maori Land Trust manage approximately 8% of Stewart Island / Rakiura. The Tutai-Ka-Wetoweto section of this land (around Lord's River) is managed for conservation values under an agreement with the Crown (Lough 2003). Rakiura Maori Land Trust will be a key partner in any future development of this feasibility study. An eradication operation simply could not proceed without their support and involvement. RMLT have indicated their support of the feasibility study on the basis that it will provide the information needed to form a decision on their level of support for the outcomes or recommendations of the study (S. Harteveld, pers. comm.).

There are also a large number of private landowners. How to involve all of these stakeholders and the diverse and often opposing range of interest groups (e.g. Southland District Council, fishermen, Forest and Bird, trampers, etc) will present a challenge.

Regulatory issues

As well as requiring support of all landowners, there are a number of organisations with a statutory interest in the Island and any future pest eradication operation. These include the Department of Conservation, the Medical Officer of Health, the Environmental Risk Management Authority (ERMA), Environment Southland and the Southland District Council.

Each of these organisations has their own regulatory requirements that will need to be identified and met as part of the operational planning of any eradication operation. This also makes these organisations key stakeholders for consultation as part of any eradication process.

In the meantime, it would be worthwhile for the trust (SIRCET) to engage in any plans and public process to build in the potential to eradicate rats, wild cats and possums from Stewart Island / Rakiura (e.g. Environment Southland's Regional Pest Management Strategy and Coastal Plan, Southland District Council's District Plan and Long Term Council Community Plan, Department of Conservation's Rakiura National Park Management Plan, etc.).

3.3.2 COMMUNITY ENGAGEMENT

The needs, concerns and aspirations of the resident community must be incorporated in any future eradication plan. Those living, or owning land on the Island (the resident community, or community of place) will be the most directly influenced by an eradication programme. However, there are also a range of other people with a stake in Stewart Island / Rakiura (community of interest) who also need to be involved.

In a study preceding the formation of Rakiura National Park, Booth and Leppens (2002) found that Stewart Islanders held nature, the land and sea and peace and quiet in high regard.

It will be a challenge to develop a process where the local community does not feel that it is being overwhelmed by the rest of New Zealand, but which also takes into account the views of those groups not living on the Island. One potential solution is to allow provision for local representation on any organising or governance group, as well as agreeing to some principles to protect certain elements of the "Stewart Island lifestyle". This type of approach is similar to that advocated by Moore in her doctorate study into sustainable tourism planning (Moore 1998).

The development of this feasibility study has been assisted to a considerable degree by valuable public comment and feedback. Key groups have been targeted for comment, including iwi, Rakiura Maori Land Trust, the local community and deerstalkers (see Appendix 3 for an account of discussions and consultation conducted to date and key stakeholder groups). A community meeting held on 3rd April 2008, identified a range of issues for the community (see Appendix 2). The key issues identified are listed in Table 3.3.1.

Table 3.3.1: *Key issues identified by the community and location of relevant discussion in this document.*

Issue	Relevant sections
The potential of a predator proof fence – efficacy, restriction of access, prison-like.	3.1.7 3.2.4
Who will cover costs of eradication and maintenance? Islanders shouldn't be disadvantaged.	5
Effects on pets and pet ownership	3.3.3 3.4
Unrestricted tourism development destroying lifestyle.	3.3.2 3.4
Kiore / Pacific rat have cultural value to some iwi.	3.3.8
Difficulty in maintaining biosecurity and cost in time and dollars to Islanders.	3.2 5
Toxin effects on waterways, fishing, marine farms	3.3.6 3.4
Potential effects on human health	3.3.7
Effects on deer hunting	2.4.2 3.3.2 3.3.5
Poisoning of native species	3.4.1 Appendix 1

This section aims to identify and explore issues that were identified by the community and key interest groups that need to be addressed before a firm proposal can be developed. This section does not attempt to solve the issues; rather it identifies and suggests a process for addressing each one.

Governance Group

The involvement of the local and wider community in the development of an eradication proposal will be vital to its success. Following a shared knowledge, collaborative approach, where the community is empowered to make its own choices, will help maintain community ownership of the eradication proposal should it be taken further (see Courtney 2006 & www.skillfulmeans.org). This is a community owned project and can only proceed and succeed if it is run as a community led process. That said, there is no single organisation or individual that has the right to dictate what should happen across the whole of Stewart Island / Rakiura. Recognising this, it is proposed that a governance group be formed if this proposal is to be taken any further.

It is suggested that the Governance Group be comprised of representatives of the key stakeholders and landowners on Stewart Island / Rakiura and includes independent technical members. A "round table" approach to management is recommended. The exact structure of this group needs careful thought to ensure that the local community has a strong say in decisions and is not "swamped" by outside interests.

This Governance Group could form its own trust, or other legal entity, to manage any eradication funding or report to SIRCET as a sub-committee. The structure of this group will require careful thought with reporting and decision making lines clearly defined. The level of decision making will likely need to be kept high to give those doing the work enough management autonomy to get things done.

3.3.3 EFFECT ON CATS AND DOGS

A range of opinions on local pets have been voiced during public consultation on this document. These range from all exotic pets being banned through to the championing of the rights to have a pet. It is beyond the scope of this document to discuss the rights of Islanders to have pets, the levels of control that should be exerted on dog ownership or if visitors should be allowed to bring dogs. The document does cover the potential impacts of a poison operation on dogs and cats and the potential for a wild cat population to re-establish from the pet population.

There are suitable provisions in Environment Southland's RPMS (Anon 2007) to prevent wild cats re-establishing from pet cats on Stewart Island / Rakiura. The provisions require all pet cats on Stewart Island / Rakiura to be neutered and micro-chipped. Ensuring compliance with these provisions will be essential to maintain Stewart Island / Rakiura free of wild cats after eradication. These provisions also apply to cats being brought on holiday, but consideration might be given to banning the bringing of non-resident cats to Stewart Island / Rakiura (see also Section 3.2).

There is some risk of cats and dogs being poisoned through eating cereal baits directly, or of secondary poisoning due to the persistence of brodifacoum in body tissues which may be consumed by these animals. Anticoagulant poisons are slow acting and there is a reliable antidote that is readily available. Although treatment is often complicated, the prognosis for successful recovery is generally good if toxicosis is detected early. Pets would need to be confined or otherwise prevented from accessing bait or rodent carcasses, should an eradication be undertaken. Primary poisoning is probably a greater concern if pets are in an area aerially treated. Secondary poisoning will only be an issue if pets are allowed to roam and scavenge.

Rodent control operations, using similar anticoagulant baits sold "over the counter" have been in place on private land and around houses for over 30 years, apparently with few pet mortality issues. Dog control regulations may serve to limit any potential negative effects of an eradication operation. Nevertheless, the key to eliminating any negative effects for dogs will be adequate education of owners as to the degree and possible mechanisms for risk and treatment coupled with local veterinarians holding stocks of Vitamin K. Temporary additional dog control regulations during and immediately following any eradication will also be useful.

3.3.4 EFFECT ON STOCK

There is potential for cattle, sheep or goats to eat bait and a potential human health risk from subsequently eating any of these animals. Stock would need to be prevented from accessing bait on the Island. Stock may have to be temporarily removed from the Island to secure grazing on the mainland.

3.3.5 DEER HUNTING

Deerstalkers have frequently expressed their passion for white-tailed deer on Stewart Island / Rakiura. These are considered, by the deerstalkers, to be an iconic and highly valued species. Some sectors of the deerstalking community have also been vociferously anti toxin use. This presents challenges for an aerial baiting operation of the nature described. Without the support of the deerstalkers, both locally and nationally, it is unlikely that the eradication proposal could proceed.

It should be noted that any future operation would not target deer (see Section 2.4). Aerial operations, while likely to kill some deer, will not result in eradication. Eradication of deer would require a completely different type of operation to the eradication of rats, wild cats and possums. Regardless of the technical differences, the resident community places a high value on deer and wishes to see them retained.

Deer in themselves present another issue in regard to the eradication of rats, wild cats and possums. Deer have the potential to compromise the success of an operation by eating large amounts of bait, which could result in bait gaps (i.e. bait will not be available for some rats or possums).

To prevent bait gaps, it is suggested that the potential for a deer repellent be investigated. Deer repellent is a chemical compound that can be added to bait that makes it unattractive to deer. Trials so far for 1080 cereal pelleted bait suggest that the repellent works effectively on red and sika deer, reducing deer killed from up to 65% to less than 15% (Morriss et al. 2004). Although trials so far indicate that the repellent has no effect on the attractiveness of 1080 bait to possums (Morriss et al. 2004; Morriss 2007), trials or research will need to be conducted to ensure that it does not negatively affect bait palatability for rodents, cats or possums on Stewart Island / Rakiura as well as to determine its effectiveness on white-tailed deer.

Impact on hunting

Brodifacoum is a broad-spectrum toxin and is toxic to all vertebrates. It is not known how many deer will eat baits (or the potential reduction in bait consumption if deer repellent is used) and of these, how many would die.

Deer that consume a sub-lethal amount of bait may also be affected by the toxin. Sub-lethal effects reported in animals include increased blood clotting times, lassitude and anorexia, although most animals appear to fully recover within a month of poisoning. The first year of breeding after an operation may also be disrupted as high, but non-lethal, doses of brodifacoum can cause increased rates of abortion. In sub-lethally poisoned pregnant ewes there was an increase in the number of foetuses aborted and lambing rates declined (Fisher and Fairweather 2006).

The caution period is the timeframe after bait application finishes, when it is expected that the risk of pesticide residues to the public has passed (i.e. residues will no longer be present in baits, carcasses, or living animals). Currently, the DOC withholding or caution period for a brodifacoum operation is 12 months for an aerial or 18 months for a bait station operation. Brodifacoum residues will probably be in the liver and possibly kidneys and lungs of survivors for at least a year, possibly for life. Much lower levels have also been recorded in muscle tissue (Fisher and Fairweather 2006). This provides a health risk for hunters who may consume meat over this period (see also Section 3.3.7) and will subsequently impact on those Islanders who rely on deer for their meat supply. Brodifacoum is not passed across from mother to fawn, so the next generation of deer after an operation should be clear and healthy.

Without doubt, there would be an impact on hunting opportunities on Stewart Island / Rakiura. These impacts may last from a few months to up to five years depending on the mitigation measures that could be developed. There is a need for more science-based examination of the potential effects of an operation on white-tailed deer.

Due to the high value placed on the Stewart Island / Rakiura deer herd by deerstalkers, and the complexity of the problems, it is recommended that deer stalkers (via NZDA?) are included in all aspects of operational planning and any governance group (see Section 3.3.2). Deerstalkers will be key to finding a potential acceptable path through the issues associated with a potential rat, wild cat and possum eradication operation.

3.3.6 WATER QUALITY

Any impacts on water quality are generally considered to be negligible. Brodifacoum is not readily soluble; it binds strongly to soil and is slowly degraded. It is unlikely to contaminate waterways unless tonnes of bait are deposited at one point.

To ensure that all the Island is covered during the bait drop, it is inevitable that some baits will go into the tidal area and into streams – this can be minimised using experienced pilots and the latest technology. The rest of this section outlines knowledge of the effects and fate of brodifacoum in water. It is adapted from Fisher and Fairweather (2006).

Freshwater

Brodifacoum degrades slowly (weeks to months) in natural water. During a laboratory study the stability of radio-labelled brodifacoum in sterile buffered water showed that the half-life of brodifacoum at pH 7 and 9 was much longer than 30 days. A precise calculation of the half-life was not possible because the degradation seen after one day did not continue (World Health Organisation 1995).

That said, no residues of brodifacoum have been detected in water bodies following pest control operations in New Zealand. No residues of brodifacoum were detected in four water samples taken one month after an aerial application of Talon®20P cereal pellets at 15 kg/ha on Red Mercury Island, October 1992 (Morgan and Wright 1996). Water samples were also taken from streams on Lady Alice Island before and 2, 12 and 34 days after an aerial poisoning operation using Talon®20P cereal pellets at 12 kg/ha. No residues of brodifacoum were detected (Ogilvie et al. 1997).

During the 2004 Hauturu rat eradication, eight water samples were taken directly down stream from baits lying in stream beds within 24 hours of the aerial drop. Brodifacoum was not detected in any of the samples taken (Griffiths 2004). Samples tested from bore water on the island did not detect any brodifacoum.

Two fenced 'cells' on Mt Maungatautari (35ha and 65ha) each received two bait drops of Pestoff 20R brodifacoum cereal bait in September and October 2004. 15kg/ha was applied on the first drop and 8kg/ha in the second. The area (c.8ha) immediately around the inside of both cell fences was hand spread. A total 183 stream water samples were taken from four streams flowing out of the poison area. In each stream, samples were taken at the fence boundary and again 800 metres downstream. Time intervals post each drop for taking samples were 1hr, 2hrs, 3hrs, 6hrs, 9hrs, 12 hrs, 24hrs, 48hrs, 72hrs, 2 weeks, 3 months. No sample analysed detected brodifacoum. The minimum detection level for these samples was 0.02 µg/l**.**

The presence and type of sediment layers in a waterway will affect the degradation of brodifacoum in aquatic environments. Erosion of soil containing bound brodifacoum may result in the toxin reaching water, but brodifacoum is likely to remain bound to organic material and settle out in the sediment (Eason and Wickstrom 2001). The flow and volume of the waterway will also affect the distribution of any bait- or soil-bound brodifacoum entering natural waterways.

Marine

In 2001 a truck crashed into the sea at Kaikoura spilling 18 tonne of Pestoff 20R (20 mg/kg brodifacoum) cereal pellets into the water. Measurable concentrations of brodifacoum were detected in water samples from the immediate location of the spill within 36 hours but after 3 days the concentrations were below the level of detection (0.02 µg/l) (Primus et al. 2005). For comparison, an aerial operation would only be applying in the order of 25kg/ha (0.14% of the amount spilt at Kaikoura).

The potential effects of a brodifacoum baiting operation on aquaculture, is discussed in Section 3.4.3.

3.3.7 PUBLIC SAFETY

An aerial eradication operation will, for a short period, place baits in close proximity to people. People are not particularly vulnerable to brodifacoum poisoning, which is why products containing it are available 'over the counter' in New Zealand (and most other countries) for household rodent control (Holm et al. 2006). There have been no reported cases of humans being poisoned by brodifacoum in New Zealand, despite its widespread use both in eradications and for household rat control. However, any future project would require specific measures to ensure the safety of people.

Human toxicology (Fisher and Fairweather 2006)

There is no clearly defined LD_{50} dose for humans. As little as 1-2 mg of brodifacoum can produce clinical coagulopathy (defect in the body's mechanism for blood clotting) in adult humans. However, there is a wide variation in susceptibility to brodifacoum among individuals. People suffering from anaemia or liver disease, or who are taking prescription anticoagulants are more susceptible to brodifacoum poisoning. The most common exposure route is orally, followed by inhalation.

The onset of toxicity takes days in acute cases. In minor poisoning cases there may be no obvious signs of poisoning, while in moderate cases symptoms include haematomata, haematuria, blood in faeces, bleeding gums and excessive bleeding from minor cuts or abrasions. Signs of acute poisoning are severe gastrointestinal bleeding, cerebrovascular accidents, and massive haemorrhage (internal bleeding) resulting in shock. Nevertheless, a person would need to eat an exceedingly large number of baits to cause death (see Table 3.3.2).

Table 3.3.2: *Amount of brodifacoum bait needed to be ingested by a human to result in death based on the* ld_{50} *(Fisher and Fairweather 2006). These figures represent the amount of bait that would have to be consumed in one sitting for a 50% chance of death. These are straightforward acute toxicology calculations and are only for indicative purposes.*

	LD_{50} (mg/kg)	Average weight (kg)	Amount (grams) of 0.02 g/kg brodifacoum bait for LD50	Number of bait pellets required to be eaten.
Child	0.25	15	187.5	93
Adolescent	0.25	30	375	187
Small adult	0.25	60	750	375
Large adult	0.25	90	1125	562

Effects of sub lethal poisoning (Fisher and Fairweather 2006)

Brodifacoum, a second generation anticoagulant, is highly persistent in living tissue (especially liver), but biodegradable (to CO^2 and H^2O) in the environment, with no toxic metabolites. The long term effect of sub lethal poisoning is uncertain. The persistence of brodifacoum means repeated sub lethal doses could accumulate - a situation unlikely to arise if eradication is successful and biosecurity managed.

Brodifacoum is a slight skin irritant and a mild eye irritant. It is classified as non-mutagenic (World Health Organisation 1995) and unlikely to be carcinogenic. There is no evidence that brodifacoum has sub-lethal effects on reproduction or lactation. However, high maternal mortality and abortions have been observed in higher dose groups of available relevant studies.

When female rats were given brodifacoum at various doses between 0.001 and 0.02 mg/kg daily during days 6-15 of pregnancy there was no evidence of effects on the foetus at termination. At higher daily doses to female rats (above 0.05 mg/kg) during pregnancy there were 'anticoagulant effects in the dams which resulted in a high incidence of abortion' (World Health Organisation 1995).

Female rabbits were given daily brodifacoum doses of between 0.001 and 0.005 mg/kg from days 6-18 of pregnancy. At the highest dose there were a high proportion of maternal deaths. No effects were observed in foetuses of surviving mothers, or in the lower dose groups (World Health Organisation 1995).

Vitamin K1 is recognised as an effective antidote. However, it has to be maintained for a relatively long treatment period because of the persistence of brodifacoum in living bodies (Eason and Wickstrom 2001).

Risk management

While there is some risk to human health from both primary (e.g. children consuming baits) and secondary poisoning (e.g. people eating carcasses containing toxin), this risk is considered minimal due to both the packaging of the toxin (green cereal based bait), its distribution (about 1 pellet per $2m^2$) and the volume that would need to be consumed (over 300 pellets for an adult).

Regardless, as part of operational planning, comprehensive mitigation measures will need to be developed that eliminate the poisoning risk to people. These may include temporarily closing areas of the park, providing education, publicity material, signage, etc. The primary method of risk mitigation is likely to be effective communication with all residents and visitors to ensure they understand the hazard and how to keep themselves safe from exposure.

It is worth noting that despite extensive use of brodifacoum over the last four decades within New Zealand for rodent control and eradication, there have been no incidents of accidental poisoning recorded. Similarly, no cases of 1080 poisoning have been recorded despite its widespread use for controlling possums and rodents (Griffiths 2007).

3.3.8 CULTURAL VALUE OF KIORE / PACIFIC RAT

A number of iwi are concerned with the eradication of kiore / Pacific rat, as they are seen to have cultural significance (see also Section 2.2.3).

Kaitiaki Roopu (the DOC - Ngai Tahu consultative group), suggested that a kiore / Pacific rat management plan could be developed. They felt that this would go some way toward alleviating fears of the total extermination of kiore / Pacific rat from New Zealand. This concept had the underpinning presumption that such a plan would recommend a number of sites within New Zealand where kiore / Pacific rat will be retained.

A management plan for kiore / Pacific rat has been developed previously (A. Roberts, pers. comm.). This is likely to need re-development to take into account the potential of removing kiore form Stewart Island / Rakiura.

3.3.9 CONCLUSION: IS THE PROJECT SOCIALLY ACCEPTABLE TO THE COMMUNITY?

While there has been strong support for the completion of this scoping exercise, it would be premature to predict the level of support that a firm eradication proposal may receive. The level of community support will continuously change as new information becomes available and societal attitudes change over time. It is not appropriate to tick a box saying the community supports the eradication of these target pests, but rather to build and maintain that support through involvement and input.

There are a large number of landowners, agencies and stakeholders with an interest in any proposed eradication of rats, wild cats and possums. This section has identified key groups of people with a stake in the Island that will need to be involved in the development of an eradication process (e.g. resident community, iwi, RMLT, deerstalkers, DOC, Environment Southland, etc).

A number of concerns regarding eradicating rats, wild cats and possums, have been raised by the community. These include: cost; changes to lifestyle; effects on health; pet ownership; the cultural value of kiore and; the impacts on deer hunting opportunities. Deerstalking is potentially one of the most significant conflict areas. Deerstalkers need to be engaged at an early stage if it is decided to proceed with the development of a pest eradication programme. It will be necessary to proceed in such a way as to satisfy stakeholder concerns and aspirations.

Should the trust choose to take this feasibility study further, a governance group of representative stakeholders is proposed to guide the next stages in the scoping and development process, including measures to address all of the community's concerns. The structure of a governance group needs careful consideration to ensure that the resident community's interests are well represented.

3.4 The benefits and costs of a pest eradication programme

It is expected that there will be both costs (social, financial and ecological) and benefits associated with any future eradication programme. There will, of course, be some unanticipated costs and benefits. However, this section attempts to describe some of the potential effects, both positive and negative, in the ecological, social and economic sectors.

3.4.1 ECOLOGICAL

Ecological Benefits

The eradication of rats, possums and wild cats from Stewart Island / Rakiura would secure extraordinary conservation outcomes. It would probably be the single most important conservation intervention New Zealand could make in the foreseeable future. The ecological benefits of the eradication will be indubitable and profound. One only needs to look at the existing pest free islands, such as Tiritiri Matangi Island, Kapiti Island, or closer to home, Ulva Island, Putauhinu and Codfish Island / Whenua Hou to realise the potential ecological benefits.

Some examples of measured ecological responses to rodent eradication are listed in Table 3.4.1. It should be noted that these eradications have removed all introduced animals from a site and have not retained deer. The impact of deer in the absence of possums, rats and wild cats is unknown. Nevertheless, there are some examples where only certain predators have been controlled, leaving deer present, that have resulted in significant increases in biodiversity.

The Stewart Island / Rakiura Community and Environment Trust has been targeting possums, rats and wild cats for control and haven't yet implemented any deer control. Nevertheless, monitoring results have shown substantial improvements in tui, bellbird, fantail and tomtit numbers as well as an increase in size of mistletoe (Beaven 2007). In the initial years of the Otamatuna Mainland Island, in Te Urewera National Park, possums, rats and stoats were targeted, but deer and pigs were still present in reasonable numbers. Despite this, significant increases in forest bird numbers and canopy cover were recorded (Beaven et al. 2000).

Table 3.4.1: *Examples of ecological response to rodent eradication. Adapted from Saunders and Brown (2001).*

Location	**Size (Ha)**	**Species**	**Response**	**Reference**
Korapuki Island	18	Kiore / Pacific rat	30x increase in Shore skink numbers 6 years after rat eradication.	(Towns 1996)
Mana Island	210	Mice	The gold-striped gecko was rediscovered after mouse eradication, almost 25 years after the last recorded sighting. These geckos were eventually found in significant numbers and persisted in several colonies. Other species e.g. flightless heavy invertebrates such as giant weta also flourished after the mice were eradicated. Since then, other endangered endemic species have been transferred to the island e.g. takahe and the flightless flax weevil. McGregor's skink has increased and they have became more widespread over the island	(Newman 1994)
Nukuwai ata Island	242	Kiore / Pacific rat	20x increase in seedling numbers and 7x increase in diversity in six years. 80% increase in tree weta population in two years.	(Aviss 1997; Brown 1997)
Kapiti Island	1970	Norway rats & kiore / Pacific rat	Parakeet numbers increased by 152%, robins by 103% and bellbirds by 53% three years after rodents were eradicated.	(Empson and Miskelly 1999)
Red Mercury Island	225	Kiore / Pacific rat	Increased abundance of saddlebacks.	(Robertson et al. 1993)
Campbell Island	11000	Norway rats	Snipe self reintroduced from Dent Island. Campbell Island teal re-introduced and expanding in number.	McClelland, pers obs.
Ulva Island	259	Norway rats	Four bird species and one skink species successfully re-established. Saddleback increased from 30 to over 250 in 8 years. Robin increased from less than 30 to	(Clayton 2005; Jamieson 2008)

			over 300 within 8 years. Seedling and sapling densities significantly increased over 10 years.	
Hauturu / Little Barrier Island	3083	Kiore / Pacific rat	Cooks petrel breeding success increased from 10% to 70%. Three species of reptile increased in number and two species were rediscovered. Weta increased in number.	R. Griffith, pers. comm.

If eradication was to proceed, a full Island ecological restoration / management plan should be developed. The development of this plan should include discussions with recovery groups and conservation managers. The following species are amongst those that could benefit from a pest eradication: Stewart Island fernbird / mätä, Stewart Island robin / toutouwai, kaka, kereru, kakariki, riflemen / titipounamu, kiwi, brown creeper, harlequin gecko, southern skink, southern NZ dotterel, long tailed and short tailed bats and Stewart Island weka. This list does not even mention the many other species of birds, reptiles, invertebrates and plants that are likely to increase in number. It is not simply a case of increasing the numbers of individuals of certain species, but of reversing current trends of decline. Some species will be lost without some intervention.

Potential translocations

Not only would the species and forest already on Stewart Island / Rakiura benefit, but other species that have been missing for some time could be (re)introduced. Potential forest bird introductions to the main island could include: käkäpö, saddleback / tïeke, mohua and North Island kökäkö. Again, a full list of possible re-introductions would be incorporated into an Island ecological restoration / management plan.

For some species, translocation to an introduced predator free Stewart Island / Rakiura would set-up a large "back-up" population, helping to prevent their extinction. For example, yellow-head / mohua are struggling to survive on the mainland of New Zealand. Rat plagues in beech mast years are decimating populations. In 2000, a rat plague extirpated the whole population at Mt Stokes and reduced the Eglington Valley population from over 200 birds, to less than ten. Stewart Island / Rakiura could support a safe and secure mohua population numbering in the thousands.

NZ Biodiversity Strategy outcomes

The New Zealand biodiversity strategy has taken a bold stand on New Zealand's biodiversity health by 2020 (Anon 2000).

For example, the desired outcome for biodiversity on land is: *A net gain has been made in the extent and condition of natural habitats and ecosystems important for indigenous biodiversity. Scarce and fragmented habitats (such as lowland forests and grasslands, wetlands and dunelands) have increased in area and are in better ecological health due to improved connections and the sustainable management of surrounding areas. Some modified habitats are restored…………No further extinctions have occurred. Populations of all indigenous species and subspecies are sustained in natural or semi-natural habitats and their genetic diversity is maintained. Fewer threatened species require active recovery programmes and ex situ management.*

It is unlikely that all of our efforts combined will be able to achieve the goals we have set ourselves as a nation unless we start taking bold action. A 174 600ha (total area of the Stewart Island / Rakiura archipelago) predator free area would contribute significantly toward reversing the decline of New Zealand's biodiversity.

Ecological Costs

Three ecological costs can be envisaged at this early stage: non-target poisoning effects; the effects of failure and; mice establishing across the Island. Mice are covered in Sections 2.4 and 3.2, therefore this section will focus on the unintentional poisoning of native species from the eradication operation and the potential consequences of failure. While non-target impacts are explored in further detail in Appendix 1, a summary discussion is presented below.

Failure

If this eradication was unsuccessful, the conservation costs are unlikely to be huge for the Island, but the implications of failure would be nationally and internationally significant. Failure would likely lead to a reluctance to fund other large scale proposals both here and worldwide. This reinforces the need for careful planning and consideration through every step of the proposed operation.

Non-target risks

All conservation management activities involve costs and risks, as well as benefits. There is a dynamic equation involving costs, risks and benefits which must be carefully assessed as part of any project planning process. The risk to non-target species in an eradication campaign is a function of the species present and their behaviour; toxicological properties; composition and delivery method of bait; the susceptibility of those species to the toxin; and the probability of exposure to the toxin either directly or indirectly (Howald et al. 2007).

Experience in New Zealand has shown that some native animals will ingest toxin, either directly through eating baits (primary poisoning), or indirectly, through eating animals which have consumed and stored bait in organs or tissues (secondary poisoning) (Murphy et al. 1998; Fisher and Fairweather 2006). The challenge in planning eradication operations where brodifacoum is to be employed is to identify non-target species which may be at risk and to find ways by which these risks may be reduced to acceptable levels either at the individual or population level. A variety of methods have been developed to mitigate non-target impacts, and applied research can further aid in minimising impacts (Howald et al. 2007).

The scale of undesired effects is also an important consideration. As a principle, the loss of a few individuals of a native species as part of an operation to remove threats to the remaining individuals of that species, as well as many other species, may be seen as acceptable. Alternatively, population-level impacts on important native species would probably be unacceptable. In New Zealand, no rodent eradication proposal has been abandoned to date because of concerns about unacceptable risks to non-target species (Saunders and Brown 2001). This is not to say that native species have not been identified as being at risk from a poisoning operation. Rather, a range of measures have been employed to minimize these risks to acceptable levels in the context of the anticipated benefits following the removal of rodents. No populations of any non-target species have been extirpated as a result of eradication operations. Even in cases where most of the individuals of a non-target population are known to have consumed bait and died (e.g. weka on Ulva Island, fernbird on Codfish Island / Whenua Hou), these populations have quickly recovered to pre-eradication population levels or higher (Howald et al. 2007). In other cases, potentially susceptible or particularly important species have been temporarily moved, or held in captivity, and in all cases have been successfully re-established (e.g. kakapo, short-tailed bats, fernbirds on Codfish Island / Whenua Hou, and weka on Kapiti Island).

The identification of native species on Stewart Island / Rakiura which may be at risk from an Island-wide poisoning operation and development of measures by which these risks may be reduced to acceptable levels, will be an important task to undertake in the planning phase of the eradication. Such a process will require inputs from people with specialist knowledge of the behaviour of sensitive species. Appendix 1 presents the full current state of knowledge regarding the impacts of brodifacoum on non-target animals. While there is a large and mounting knowledge of the effects of brodifacoum on non-target animals, there are still gaps in our knowledge. Further research will be required to address specific concerns. Specialist science advice should be sought to develop trials that will answer identified gaps in knowledge.

As an example, in order to gain a better impression of the risk to non-target species from aerially-sown baits, a non-toxic bait trial may be considered. This could involve a bait-drop using exactly the same bait proposed for use in the eradication operation, but without any toxin. Instead, a bio-marker could be used such as Rhodamine B, which is easily detectable as colouration on any animal which has fed on the baits, or in its droppings. If a reasonably large area is treated with non-toxic bio-marked bait, some assessment can be obtained of the range of species taking baits and their proportions. Unfortunately this technique cannot be used to assess whether animals might ingest enough bait to receive lethal doses of toxin. However, a worst-case scenario could be assumed for planning purposes.

It should be noted that the environmental risks (including non-target impacts) of a "one-off" application of toxin in order to achieve eradication, are likely to be significantly less than those associated with the on-going use of toxins in a control program. In New Zealand, the Department of Conservation continues to use brodifacoum as the toxin of choice for rodent eradications, but has restricted its use for on-going control operations.

3.4.2 SOCIAL

This study has found it difficult to identify the social benefits and costs associated with the proposed eradication operation. There are few studies within New Zealand that explore this issue. The few that have been conducted focus on the economic costs and benefits (Booth and Leppens 2002; Buchan 2007). A public meeting was held on the 3rd April 2008, where the resident community raised a number of social costs and benefits. These are discussed further in Sections 3.3 and Appendix 2. It is recommended that a full cost/benefit analysis or social impact study be conducted to provide further information to assist in determining if the benefits outweigh the costs.

Social Benefits

The Stewart Island / Rakiura economy is no longer based on fishing (Booth and Leppens 2002). Until another major industry is developed, the community and some key social services will continue to struggle to survive. For example, the school roll has dropped from approximately 70 to 14 within one generation (B. Hamilton, pers. comm.). These problems are exacerbated by the small rating base of Stewart Island / Rakiura, making it unrealistic for the community to fund these services themselves. Tourism is still in the early stages of development and future growth is dependant on the quality of products. It is currently hindered by perceptions of weather and access across Foveaux Strait.

Having the largest pest free island in New Zealand is highly likely to cause a positive growth in tourism that should result in a self sustaining industry, with financial flow-on to the community. The effects of tourism are more fully covered in Section 3.4.3.

While it is hard to predict what the actual benefits would be, benefits are likely to arise from a strengthened economy. Having a sound, community-led strategy for tourism on the Island will ensure that more tourism dollars flowing into the community will strengthen the local economy, resulting in more jobs and potentially more families. Such a strategy, in conjunction with RMA plans and policy statements, can also help avoid, remedy or mitigate any adverse environmental effects associated with increased tourism.

Some potential benefits from a pest eradication highlighted during the course of this study include:

- A reduction in property damage done by rats (e.g. a recent house fire was thought to be a result of rats chewing through wires; in 2000 numerous boats suffered electrical damage from rats chewing on wires).
- Local gardens will have increased productivity without rats and possums consuming vegetables, seedlings and flowers.
- A process will have been developed that involves the resident community in decision making for the proposed eradication, thus giving the community input into the direction of tourism and other key concerns.
- A reduction in human health issues associated with rodents acting as disease vectors.
- Having more native wildlife around will make the Island a more pleasant place to live
- Provided growth is guided by a community minded strategy, more jobs available will result in more families, leading to more children at the school
- Community pride may increase as a result of living in the "best environment in the country".
- An increase in the number and diversity of jobs available on the Island.

Social Costs

There will be some social costs associated with a pest free Stewart Island / Rakiura. The extent to which these can be managed to reduce their impacts is difficult to guess. Nevertheless, careful planning, strategizing and input into district plans would go some way toward minimizing the impacts of an eradication operation.

Some potential costs highlighted during the course of this study include:

- The cost of living may increase.
- An increase in property prices would make it economically difficult for working families.
- A loss of control by the community over their lifestyle and community direction (Section 3.3.2 and 3.4.3 discuss a process for retaining local input into decision making).
- The resident community may feel overrun by tourists (Section 3.3.2 discusses a community driven approach to guide tourism change).
- Hunting opportunities may be lost or impaired (Section 3.3.5 discusses the potential impacts on hunting opportunities).

- A tourist culture may replace local traditions and culture (the potential impact of tourism is discussed in Section 3.4).

A baseline study was conducted by Booth and Leppens (Booth and Leppens 2002) to facilitate future monitoring and assessments of the long term effects of tourism on the Island and on the Island's residents. The issues identified as part of this study are similar to those identified by Booth and Leppens when they looked at the creation of Rakiura National Park. This suggests that it is not the eradication proposal itself that is the reason for these concerns, but the potential impacts of associated social change.

Ensuring that the resident community's interests are well represented on any consultative or governing group could go some way toward mitigating these concerns (see Section 3.3.2). The community is best placed to contribute to the answers and strategies for managing some of the costs so that they can maximize benefits, but manage or mitigate negative impacts (Moore 1998).

3.4.3 ECONOMIC

Any future pest eradication programme will impact tourism. It is expected that a pest-free Stewart Island / Rakiura would substantially increase the desirability of the Island as a tourism destination. This has subsequent benefits and costs that would need to be carefully managed.

Research into five New Zealand case study areas found that even with high visitor densities, an overwhelming majority of residents indicated a desire for the continued presence of tourism in their communities and over 50% wanted to see more. This research concluded that with appropriate planning and local government engagement, tourism generates a social and economic benefit for communities (Anon 2007).

Economic Benefits

While the potential growth in tourism is hard to quantify, it is not hard to imagine the potential draw card of being able to see kiwi foraging on the front lawn of your accommodation or a saddleback sitting on your balcony. A pest free environment will lead to a natural growth in the tourism sector (e.g. travel, accommodation, guides, meals, facilities, etc). At the 2006 New Zealand Tourism Conference, Geoff Burns (Chair of the Tourism Association), described Stewart Island / Rakiura as "one of the undiscovered jewels of the world".

Nationally, tourism is a large and growing part of New Zealand's economy. With total tourism expenditure of $17.5 billion, it is our biggest export sector accounting for 18.7% of all exports or 9% of national GDP (Anon 2007). Directly or indirectly tourism supported 173 000 jobs (Anon 2007). Tourism is a net financial contributor to central government with tax revenues from tourism exceeding expenditure by $429 million in 2003/2004 (Anon 2007). It is generally cost neutral for local government, but has considerable flow-on economic benefits to the wider regional communities (Anon 2007).

The New Zealand Tourism Strategy (NZTS)(Anon 2007) envisages "*a sustainable tourism sector by 2015, requiring a balance to be achieved between ensuring the financial success of our business and the satisfaction of our customers, protecting our physical environment and supporting our communities. A sustainable tourism sector means that the natural environment will be protected and enhanced, and the environmental footprint of the tourism sector will continue to shrink. Our communities will benefit from tourism and value its contribution. Our natural attractions are treasured by New Zealanders and renowned throughout the world. New Zealand's network of national parks and world heritage areas have international standing.*"

A "predator free" Stewart Island / Rakiura is strongly aligned with this vision. Any future pest eradication is also consistent with and would contribute to the national tourism strategy in the following ways:

1. Enhances and naturally markets the "100% Pure New Zealand" brand.
2. Demonstrates Kaitiakitanga. The New Zealand Tourism Strategy defines this as the guardianship and sustainable management of natural, built and cultural resources for the collective benefit of current and future generations.

It is recognized that New Zealand's natural environment is the primary motivation for travel by our international visitors and plays a major part in domestic leisure travel. It is the cornerstone of the New Zealand experience and the basis for thousands of tourism businesses (Anon 2007). The idea that enhancing this natural asset will benefit tourism is not in question, the question is by how much.

Tourism has been a significant driver of regional economic growth supporting the revitalization of towns and communities. The development of local visitor products and experiences has helped build regional pride and resulted in the beautification of towns. People have been attracted back by employment opportunities in areas where traditional industries have experienced decline (e.g. Kaikoura, Otago Rail Trail, etc).

The financial return from tourism to Stewart Island / Rakiura, was estimated as $8.1 million in 1997 (Anon 1997). When the Rakiura National Park was created, 61% of Stewart Island / Rakiura residents believed that tourism had been of benefit to them personally and 73% believed tourism to be of benefit to the community (Booth and Leppens 2002). At this time, tourism was the main form of employment on the Island, accounting for 24% of all jobs (Booth and Leppens 2002). The community and local government receive considerable benefit from tourism, but this is often not 'visible' and therefore not clearly understood. Examples include:

- Visitor spending (e.g. meals, accommodation, souvenirs, services, etc.) providing economic benefit;
- Employment, supporting jobs and lifestyles;
- Facilities, retail outlets and services that the resident population alone could not sustain e.g. transport and eateries;
- A vibrant, active community – tourism can drive the revitalization of small towns engendering local pride and ownership;
- Events establishing communities as desirable destinations with iconic characteristics, such as the Hokitika Wild Foods Festival.

This study has been unable to obtain a prediction of increased value in tourism dollars from Tourism New Zealand or Venture Southland. Nevertheless, a 10-15% return on investment does not seem an unrealistic goal (see Section 5).

Case Study: Ulva Island

Ulva Island (267ha) is located in the middle of Paterson Inlet, Stewart Island / Rakiura. The island has been pest free for over ten years following successful rat eradication and has had four bird species successfully reintroduced. It is an Open Sanctuary, with almost unrestricted public access. Of the approximately 34 800[10] visitors who travel to Stewart Island / Rakiura each year, about 26 000 visit Ulva Island. In 2006, the Ulva Island Trust held a käkäpö viewing opportunity for 10 weeks that had an estimated community economic benefit of between $300 000 and $700 000. A number of businesses derive income from Ulva Island, with about 15 holding concessions for guided walking and four water taxi operators deriving a substantial portion of their business from transporting people to and from the island. Overall, Ulva Island is of significant benefit to the Stewart Island / Rakiura community.

Carbon Credits

Stewart Island / Rakiura's forests are not yet eligible for the government's carbon trading initiative; eligible forests are those planted after 1990 (www.maf.govt.nz/forestry). While not covered by the current government system, it is likely that pest removal will result in increased carbon sequestration. It would be worthwhile investigating the potential contribution of pest removal to increased carbon storage, to fully understand the associated benefits.

Economic Costs

As well as all of the benefits, increases in tourism potentially threaten the "Island lifestyle". This has been a recurring concern regarding perceived change since the 1980's (Booth and Leppens 2002). Costs may also include increased costs of living, increased property values and rental costs.

During the creation of the Rakiura National Park, residents' concerns regarding tourism were mainly associated with uncontrolled growth (57%). Other concerns raised were existing infrastructure not coping (13%) and change to lifestyle (6%). It was also evident that the perception of a changing lifestyle was stronger when residents perceived tourism in a negative light (Booth and Leppens 2002).

Infrastructural impacts are regularly raised as a potential cost. Recent infrastructural upgrades by the Southland District Council seem to have addressed this issue with

[10] Figure obtained from 2007 data supplied by Stewart Island Flights and Stewart Island Experience

new public toilets, an expansion to the sewerage scheme, foreshore upgrade and work underway on upgrading the power scheme and road network. As long as increased tourism doesn't result in substantially more vehicles, then the new infrastructure, aside from the sewerage scheme, will easily handle twice the current tourism numbers (I. Harvey, pers. comm.). The sewerage scheme may require further expansion to the settling ponds and disposal fields to accommodate increased use (B. McKenzie, pers. comm.).

It is essential that the resident community takes an active role in planning and development to create the type of tourism sector that they want, to meet their economic, social, environmental and cultural needs (Moore 1998). Communities that take an active role in planning for and managing tourism stand to gain substantial benefits, and are more likely to satisfy visitors and deliver on the vision (Anon 2007). Maximum volume does not necessarily equate to maximum value nor does it necessarily lead to sustainable businesses (Anon 2007). As for social costs, many of the economic costs could be mitigated or managed with careful planning.

The Stewart Island / Rakiura Tourism Strategy (Anon 1997) is out of date and ill-equipped to manage current tourism growth, let alone the potential tourism growth in a post-eradication environment. This strategy should be redrafted to guide sensible and sustainable tourism that suits Stewart Island / Rakiura's unique setting and lifestyle. This process needs to address the management of social impacts and concerns as well as environmental impacts.

Aquaculture

There has been some concern raised about the effect of a toxin operation on the aquaculture industry. Negative economic effects on these companies could occur if any toxin was detected in mussels or farmed salmon, or the operation resulted in elevated faecal coliform levels (a potential combination of a large number of dead animals and heavy rain).

It is unlikely that any bait will be ingested by mussels or farmed salmon as bait spreading will follow the coast and not go more than 40m into the tidal area (below MHWS). This can be further reduced by agreed strategies in areas surrounding mussel farms (e.g. by the use of deflectors on spreading buckets, etc.). Also, the toxin is not water soluble (see Section 3.3.6).

At Great Barrier Island, where an aerial brodifacoum application is planned to eradicate rats from Kaikoura Island, neighbouring mussel farmers agreed to the operation contingent upon the timing being after July (after harvesting finished and spawning has started) and completed before harvesting begins again in Oct. They have also developed plans to minimise bait drop into the sea (Ritchie 2008).

Regardless of the current perceived level of risk, mussel and salmon farmers should be involved in planning to develop acceptable mitigation measures if eradication plans develop.

3.4.4 CONCLUSION: DO THE BENEFITS OF THE PROJECT OUTWEIGH THE COSTS?

This section looked at the ecological, social and economic benefits and costs of the proposed eradication. There is currently significant uncertainty surrounding the social and economic costs and benefits.

Ecological benefits appear to outweigh ecological costs, based on the experience of many other eradication operations conducted in New Zealand. A future eradication programme will need to be carefully developed to mitigate the risk of the operation to non-target native animals.

Socially, it is difficult to determine if the benefits outweigh the costs as it is dependant on an individual's personal values. A full social impact study is recommended as well as involvement of the community in all aspects of planning and decision making.

Economically, it is likely that there will be high returns; mainly from increases in opportunities for tourism. This study has been unable to quantify what the growth in tourism might be in response to a rat, wild cat and possum eradication, but it is likely to provide a reasonable return on the operational cost. The development of a new tourism strategy that takes into account social and environmental impacts, as well as growth and development, is recommended for Stewart Island / Rakiura.

Good planning and strategies, developed with the involvement of the community and other affected parties, is likely to contribute to minimising costs and maximising benefits, to the point where the benefits of an eradication operation are likely to outweigh the costs.

4. How will we know if an eradication programme has worked?

Monitoring programmes will need to be developed that give us information on the effectiveness of the operation (result monitoring), as well as the subsequent change in system health (outcome monitoring).

4.1 RESULT MONITORING

Result monitoring is aimed at telling us if we have killed all of the target animals or any non-target animals in a pest eradication programme. Detecting pests at low levels, over a large area will be difficult, if not exceedingly difficult should such a programme be undertaken on Stewart Island (Russell et al. 2005; Russell et al. 2008). Currently, managers tend to wait two years after attempting to eradicate rodents, so that they can get to detectable levels, before declaring the operation a success or failure. Further research into improving detection rates would be useful, as this opens the potential of dealing with residual pockets of rats, wild cats or possums before they can re-establish across the Island.

Development of a result monitoring plan would be a key requirement of operational planning. Some current detection devices are: wax tags; chew cards; traps; run through tunnels to capture footprints or hair; and dogs. It is unlikely that any one method would be used; more likely a combination of methods would be employed.

Dogs are likely to be a key element of any monitoring plan. Not only can they find animals, but they can also indicate any scent tracks left behind by an animal, assisting trap placement, etc (Russell et al. 2008). The use of dog teams should be tied in with biosecuirty and contingency requirements (Section 3.2) as well as planned follow-up work for wild cats and possums (Section 3.1.7).

4.2 OUTCOME MONITORING

Outcome monitoring gives information on the change effected by an operation. For example, have bird numbers increased or decreased and by how much? Has the forest's health improved? Has the lifestyle of community members been negatively affected?

Monitoring is generally an expensive component of any operation. Somewhere between 50 and 70% of the overall costs of on-going intensive pest control programs at 'Mainland Islands' in New Zealand were associated with monitoring, rather than pest control *per se* (Saunders and Brown 2001). It is very important, therefore, to determine the important questions which need answering at the outset and to tailor monitoring (sampling) programs so that they address declared hypotheses.

As for result monitoring, the key elements that would indicate the effect of the eradication operation on Stewart Island / Rakiura's environmental, social and economic health should be determined as part of the operational planning. Luckily, Stewart Island / Rakiura already has a good baseline of information to demonstrate response to rat, wild cat and possum removal (e.g. invertebrate monitoring, seedling data, 20x20 vegetation monitoring plots, etc.).

5. Monetary cost

This section aims to give an indication of the costs involved with an Island-wide pest eradication programme. A full detailed operational budget would need to be developed if eradication plans progress, but at least an approximated figure will assist in determining if the proposed eradication of rats, wild cats and possums from Stewart Island is financially feasible.

5.1 OTHER OPERATIONS

Some indication of likely costs can be gained from reported costs from other eradication operations undertaken in New Zealand (Table 5.1).

Table 5.1: *Indicative operational costs for some rodent eradications undertaken in New Zealand. Adapted from Saunders and Brown (2001). Prices per hectare are inflation adjusted to 2008 values using the Reserve Bank of New Zealand's online inflation calculator (www.rbnz.govt.nz/inflationcalculator).*

Island	Size	Date	Technique	NZD / hectare
Breaksea	170	1988	Bait station	797
Double (part)	32	1989	Bait station	685
Double (part)	32	1989	Hand-broadcast	492
Stanley	100	1991	Aerial	161
Nukuwaiata	195	1993	Aerial	97
Kapiti	1970	1996	Aerial	90
Long	140	1997	Aerial	89
Codfish Island / Whenua Hou	1396	1998	Aerial	276
Tuhua / Mayor Island	1283	2000	Aerial	141
Campbell	11,300	2001	Aerial	259
Raoul	2978	2002	Aerial and hand laying and trapping for cats	295
Pearl	512	2005	Aerial	178
Bench	176	2005	Aerial	246
Taukihepa	939	2006	Aerial	266-319
Mangatautari	3000	2007	Aerial	176*

*Cost for two bait drops on Maungatautari only, the third was not included to enable comparability with other operations.

Most indicative costs presented here are for the eradication operation itself and do not generally include costs associated with planning, research, monitoring or biosecurity. They are also, excepting Maungatautari, Raoul, Taukehepa, Pearl and Tuhua, only for the eradication of a single species of rat and may have dubious applicability to multi-species eradication operations.

The Codfish Island / Whenua Hou operation cost approximately $402,000 (CPI adjusted). This included the operation and non-target mitigation (including captive management and translocations) (Pete McClelland, pers. comm.). Prior feasibility studies, planning and research were not included and, as for most operations, probably contributed substantially to the overall cost. That said, there are economies of scale to be gained from larger areas (i.e. while the operational cost will increase proportionally, the planning cost will not).

This is reflected at Maungatautari, where 23kg/ha of bait was dropped in two applications, at an overall operational cost of about $620 000 (CPI adjusted) (Pim de Monchy, pers. comm.), close to $100 per hectare cheaper than the Codfish Island / Whenua Hou operation.

If we based an operational cost on $280 per ha (slightly higher than the Codfish Island / Whenua Hou operation), then as an approximate figure, the operational costs for Stewart Island / Rakiura would be about $47.5 million dollars. This would not include any consultation, trials, planning consent requirements or follow-up work that would be required for cats and possums. These costs could be in the order of $8 million (see Section 5.2).

5.2 A BREAKDOWN COSTING APPROACH

If the individual components of an eradication operation are combined, then an overall eradication cost of just over $36 million is estimated (see tables below). Only $26.2 million of this is the cost of the toxin operation, with a further $10.3 million in planning and follow-up. There are opportunities for cost reductions through innovation, especially in regard to bait spreading. Fixed wing aircraft use could substantially reduce costs, as can adjustments that increase bait sowing speed. As an example, increasing the bucket capacity from 500kg to 800kg, the sowing speed from 50knots to 70knots and the swath width from 60m to 100m, would result in a saving of almost $3million.

Ongoing biosecurity costs are in the ballpark of $400k per annum. Currently, between DOC and SIRCET, over $400k per year is spent on possum, rat and cat control on Stewart Island / Rakiura.

It is estimated that $160k would be required to form a governance group and develop a tourism strategy, with ongoing annual costs of about $60k.

As discussed at the start of this section, these are approximated estimates that indicate the likely financial commitment required.

Planning estimates

Item	Composition	Cost $
Administration costs		30 000 per year
Governance Group		30 000 per year
Tourism Strategy Development		100 000
TOTAL		160 000

Pre-operational estimates

Item	Composition	Cost $
Permits and consents		100 000
Bait application trials		200 000
Deer repellent trial		500 000
Bait registration costs		150 000
Other trials		120 000
Community and public consultation		60 000
Project Manager	$90k per year over five years	450 000
Project Manager travel costs	$5000 x 5 years	25 000
Admin costs		20 000
TOTAL		1 625 000

Bait application operational estimates

Item	Composition	Cost $
Helicopter hire		6 417 000
Bait acquisition		14 828 000
Staff costs	Wages, accommodation and travel; 20 people for 1 month.	190 000
Field equipment	Safety equipment	4000
Non target mitigation studies, measures, etc		1 000 000
Brodifacoum testing		30 000
Contingencies		1 000 000
Compensation for loss of income, etc		250 000
Bait storage		250 000
Bait production machines	2 x $500 000	1 000 000
Predator fence (if used)	5km at $240 per metre	1 200 000
TOTAL		26 169 000

Post operational and follow-up estimates

Covers follow-up costs for possums and cat eradication.

Item	Composition	Cost $
Monitoring		500 000
Dog teams for follow-up work	20 dogs and handlers at $90k each for three years	5 400 000
Detection devices, traps, etc		175 000
Food		325 000
Travel, accom, etc		300 000
Field equipment		300 000
Helicopter, plane, boat transport		430 000
Bivvies	$30k x 20	600 000
Fence maintenance	$30k x 3 years	90 000
Biosecurity costs (ongoing)		400 000
TOTAL		8 520 000

5.3 COMPARABLE COSTS – JUST FOR INTEREST

Although the cost of this operation is high, it is worth looking at other areas of national expenditure to give it a context. A small sample of recent expenditure is listed below for comparison.

- The Maungatautari Ecological Area, a 3500ha predator fenced reserve in the Waikato, cost about $11m to establish. This included the cost of the fence and the capital cost of pest eradication. This does not include the cost of project management, fence maintenance or monitoring. (Pim de Monchy, pers. comm.).
- In July 2007, the government committed $34m to the America's Cup campaign.
- New Zealander's spent $258m on racing and other sports gambling, $493m at casinos and $321m on lotto and instant kiwi in 2006 (Department of Internal Affairs figures).
- Tourism NZ predicts that by 2012, tourism spending in Southland will be $226.8m per annum.
- The government committed $240m in 2008 to the upgrade of Eden Park so that it can host the rugby world cup.
- It cost $317m to build Te Papa 10 years ago.
- $216.3m was dedicated in the 2008 government budget for the replacement of Mt Eden Prison.
- $91.7 m was budgeted for in 2008 to recruit additional probation officers.

5.4 SUMMARY

The financial cost to eradicate rats, wild cats and possums from Stewart Island / Rakiura is estimated to be in the order of $35 million to $55 million. These are approximate figures only and should be used with the appropriate level of caution.

Appendix 1: The risk brodifacoum poses to non-target native animals (Fisher and Fairweather 2006).

This appendix presents <u>all</u> knowledge relating to brodifacoum risks to non-target native animals. It is recognised that some of this knowledge is not relevant to Stewart Island / Rakiura, but it does display the full depth of knowledge as well as where gaps occur.

WHAT IS THE LETHAL DOSE (LD50) RANGE FOR EACH TAXON?

With brodifacoum only a single dose is required to induce death if a sufficient quantity is ingested. Acute oral LD_{50} values for native taxa are given in Table A1.1.

Table A1.1: *Acute oral toxicity (ld_{50} mg/kg) of brodifacoum for native taxa*.

SPECIES	LD_{50} mg/kg	REFERENCES
Birds	< 0.75 to > 20.0	
Australasian harrier	10.0	Godfrey (1985)
Duck (Paradise shelduck)	> 20.0.	Godfrey (1985)
Gull (Southern black-backed)	< 0.75	Godfrey (1985)
Gull (Black-billed) (*Larus bulleri*)	< 5.0	Godfrey (1985)
Pukeko	1.0	Godfrey (1985)
Silvereye	> 6.0	Godfrey (1985)
Mammals	No published data available	
Reptiles / amphibians	No published data available	
Fish	No published data available	
Invertebrates	> 62.5	
Large-headed tree weta	> 62.5	Booth et al. (2001)

Reptiles/amphibians

While a literature search failed to find published or verified unpublished LD_{50} data on the direct acute toxicity of brodifacoum to New Zealand reptiles, reptiles are known to be susceptible. Following the deaths of four tuatara (*Sphenodon* sp.) at the Auckland Zoo in 2003, one was determined to have died as a result of brodifacoum poisoning (Griffiths 2004). Telfair's skinks (*Leiolopsima telfarii*) were found dead after eating rain-softened Talon® 20P used on Round Island, Mauritius, with residues detected in their livers (Eason and Wickstrom 2001). There was a 15 % mortality of the Caribbean gecko species *Sphaerodactylus macrolepis* when exposed to Talon-G (cereal pellets containing 0.02 g/kg brodifacoum) during pen trials (Garcia et al. 2002).

Despite this, no populations have been extirpated by an operation nor do reptiles appear to be hypersensitive to brodifacoum (J. Reardon, pers. comm.). Populations have generally increased in number following rodent removal (Newman 1994; Towns 1996).

Invertebrates

Molluscs

Booth et al. (2003) used introduced common garden snails (*Helix aspersa*) as a model for **native snails**. In pen trials, snails were exposed to soil contaminated with brodifacoum at 0.02 to 2 mg ai/kg, and to contaminated soil (100 to 1000 mg ai/kg) and Talon® 20P pellets. No snail mortality was observed in either trial. Primary poisoning of native *Powelliphanta* snails from cereal pellets containing brodifacoum is unlikely, however the potential for secondary poisoning through the consumption of invertebrates containing brodifacoum residues requires further investigation.

Bowie and Ross (2006) allowed introduced **slugs** (*Deroceras spp*) held in captivity, to feed freely for 40 days on Talon 50WB® wax baits containing 0.05 mg/kg brodifacoum. No mortality was observed.

There are indications that molluscs outside of New Zealand may be susceptible to brodifacoum. Gerlach & Florens (2000) reported 100% mortality of two Seychelles Islands snails (*Pachnodus silhouettanus* and *Achatina fulica*) after they consumed brodifacoum baits. Lethal doses varied with snail size, with 15-20mm *P. silhouettanus* being killed by a dose of 0.01 to 0.2 mg/snail within 72 hours. This is equivalent to a *P. silhouettanus* eating between 0.5 and 10 g of 0.02 g/kg brodifacoum bait or between 0.2 and 4g of 0.05 g/kg brodifacoum bait. *A. fulica* were killed by a dose of 0.04 mg/kg in 72 hours (Booth et al. 2003). This is equivalent to a *A. fulica* eating approximately 0.2 g of 0.02 g/kg brodifacoum bait or 0.8 g of 0.05 g/kg brodifacoum bait.

Gerlach & Florens (2000) also reported observing *Pachystyla bicolor* eating baits and finding significant numbers of recently dead snails following a brodifacoum operation to control rats in Mauritius.

Annelids

Booth et al. (2003) used introduced pasture earthworms as a model for **native earthworms** in pen trials. Brodifacoum was toxic to the worms at 500 and 1000 mg a.i./kg soil. These concentrations are equivalent to 25 or 50 kg of 0.02 g/kg brodifacoum bait being distributed into 1 kg of soil. It is unlikely these concentrations would occur in the field.

Arthropods

Craddock (2003) used locusts (*Locusta migratoria*) to model **weta** in pen trials. No toxic effects could be determined following exposure to Pestoff possum baits containing 0.02 g/kg brodifacoum for six weeks. An undescribed species of **weevil** colonised a bag of toxic bait during this experiment and were able to reproduce from an estimated population of 20 to about 1500 individuals over a period of 2 months living solely on brodifacoum bait.

Booth et al. (2001) orally dosed **tree weta** (*Hemideina crassidens*) with up to 62.5 ug/g brodifacoum. No mortality was observed over 3 weeks. Bowie and Ross (2006) allowed three adult **cave weta** (*Pleioplectron simplex*) and five **ground weta** (*Hemiandrus spp*) held in captivity, to feed freely for 60 days on Talon 50WB® wax baits containing 0.05 mg/kg brodifacoum. Mortality observed over the study period was not significantly different between treatment and non-treatment groups, 4 of 8 died in the treatment group and 2 of 7 in the non-treatment group fed non-toxic cereal baits.

Bowie and Ross (2006) compared the mortality of **carabid beetles** (*Laemostenus companatus*) held in captivity and allowed to feed freely for 40 days on Talon 50WB® wax baits containing 0.05 mg/kg brodifacoum. No mortality was observed over the study period in treatment or non-treatment groups.

HOW MUCH BAIT NEEDS TO BE INGESTED FOR POISONING, BASED ON PEN TRIALS WITH NATIVE SPECIES?

The amount of bait need to be ingested by native species to result in death is given in Table A1.2.

Table A1.2: *Amount of bait needed to be ingested to result in death based on ld_{50} mg/kg for native species.*

Species	Ld_{50} (mg/kg)	Average weight female (g)	Amount (g) of 0.02 g/kg brodifacoum bait for ld_{50}	Amount (g) of 0.05 g/kg brodifacoum bait for ld_{50}
Birds				
Southern black-backed gull	<0.75	850	31.9	12.8
Pukeko	1.0	850	40.4	16.2
Black-billed gull	<5.0	250	62.5	25.0
Silvereye	>6.0	13	3.9	1.6
Australasian harrier	10.0	850	425.0	170.0
Paradise shelduck	>20.0	1400	1400.0	560.0
Invertebrates				
Weta	62.5	1	3.13	1.25

BASED ON THE MODE OF ACTION, ARE THERE ANY TAXA THAT ARE UNLIKELY TO BE AFFECTED BY BRODIFACOUM?

Brodifacoum is perceived as lacking insecticidal properties because invertebrates do not possess the same blood clotting systems as vertebrates (Shirer 1992). However, Walker et al. (2001) reported that carboxylase enzyme systems, the enzymes brodifacoum binds to, are present in molluscs (i.e. *Conus*) and arthropods (i.e. *Drosophilla*), suggesting invertebrate physiology may be affected by brodifacoum. Earthworms have been killed by excessively high brodifacoum doses during laboratory trials (Booth et al. 2003), and there is evidence of snails dying from brodifacoum poisoning overseas (Gerlach and Florens 2000), but all trials done in NZ so far have failed to show an effect from invertebrates feeding on brodifacoum baits (Booth et al. 2001; Booth et al. 2003; Craddock 2003; Bowie and Ross 2006).

HAVE SUB-LETHAL EFFECTS ON BIRDS, MAMMALS, REPTILES/AMPHIBIANS, FISH, ARTHROPODS, OR MOLLUSCS BEEN DESCRIBED FOR BRODIFACOUM?

A literature search failed to find published or verified unpublished data on the potential long-term effects of sub-lethal brodifacoum exposure in native birds, bats, reptiles, or molluscs.

No effect was found on **ground weta** (*Hemiandrus spp*) and **cave weta** (*Pleioplectron simplex*) held in captivity and allowed to feed freely for 47 days on Talon 50WB®

wax baits containing 0.05 mg/kg brodifacoum. Mortality observed over the study period was not significantly different between treatment and non-treatment groups. The mean weight of surviving weta in both groups declined over the period but the difference in weight loss between groups was not significant (Bowie and Ross 2006).

WHAT SPECIES (INDIVIDUAL ANIMALS) HAVE BEEN REPORTED AS NON-TARGET DEATHS IN FIELD OPERATIONS WITH BRODIFACOUM USE?

Birds

A number of non-target native bird species have been found dead following the use of brodifacoum during pest control operations (Table A1.3 & A1.4).

Table A1.3: *Non-target native species deaths reported during bait station operations using brodifacoum.*

Species	No. of operations	Total found dead	No. Tested for residues	No. of positive residues	Reference
Cereal Pellets					
Kaka	1	1	1	1/1	(G Taylor pers. comm. 2001)
Robin (N.I.)	1	1	1	1/1	Beaven (1998)
Silvereye	1	1	0		Brown (1997)
Weka	1	1	1	1/1	A. Glaser pers. comms., VPRD:T1183
Blocks					
Robin (S. I.)	2	7	0		Taylor and Thomas (1993); Cash & Gaze (2000)
Kereru	1	1	0		Cash & Gaze (2000); B Cash pers. comm. 2005)
Kingfisher	1	1	0		Cash & Gaze (2000)
Weka	1	4	4	4/4	L. Chadderton pers. comms.

Table A1.4: *Non-target native species deaths reported during aerial and handlaying operations using brodifacoum.*

Species	No. of operations	Total found dead	No. tested for residues	No. of positive residues	Reference
Cereal aerially sown					
Australasian Harrier	4	8	2	2	Dowding et al. (1999); Griffiths (2004); Lovegrove & Richie (2005); Pestlink: 0203GRB03
Dotterel (NZ)	2	4	1	1	Lovegrove & Richie (2005); Dowding et al. (1999); Dowding et al (2006)
Duck (Auckland Is. teal) (*Anas aucklandica*)	1	7	0		Torr (2002)
Duck (brown teal) (*Anas aucklandica*)	1	3	2	2	Veitch (2002)
Duck (grey)	3	4	1	1	Dowding et al. (1999); Griffiths (2004); Lovegrove & Richie (2005)
Duck (paradise shelduck)	3	64	4	4	Dowding et al. (1999); Veitch (2002); Lovegrove & Richie (2005)
Fernbird	1	3	3	2	Ranum et al. (1994)
Gull (Southern black-back)	2	9	9	9	Dowding et al. (1999); McClelland (2001); VPRD
Gull (red-billed)	2	2	1	1	McClelland (2001); Lovegrove & Richie (2005); VPRD:T1535
Kaka	1	4	3	3	Empson & Miskelly (1999)
Kakariki	4	7	5	2	Ogilvie et al. (1997); McClelland (2002); Veitch (2002); Griffiths (2004); VPRD: T0314, I014
Kingfisher	1	2			Lovegrove & Richie

					(2005)
Kiwi (Brown)	1	2	0		Griffiths (2004)
Kiwi (Little spotted)	2	3	1	1	Robertson & Colbourne (2001); Griffiths (2004)
Morepork	8	22	7	7	Ogilvie et al. (1997); Walker & Elliot (1997); Empson & Miskelly (1999); Stephenson et al. (1999); McClelland (2002); Williams & Jones (2002); Towns & Broome (2003); Griffiths (2004); VPRD
Pied stilt	1	3	1	1	Lovegrove & Richie (2005); Dowding et al (2006)
Plover (Spur-winged)	1	1			Lovegrove & Richie (2005); Dowding et al (2006)
Pukeko	5	138	9	9	Ranum et al. (1994); Dowding et al. (1999); Veitch (2002); Griffiths (2004); Lovegrove & Richie (2005)
Robin (N.I.)	1	1	0		Stephenson et al. (1999)
Saddleback	4	10	2	2	Stephenson et al. (1999); Veitch (2002) ; Towns & Broome (2003)
Shag (little)	1	1	1	1	Williams & Jones (2002)
Skua (Brown) (*Catharacta skua*)	1	40	0		Torr (2002)
Spotless crake	1	1	1	1	Veitch (2002)
Tui	1	2	2	1	McClelland (2002)
Weka	1	1	0		Stephenson et al. (1999)
Cereal hand laid					
Australasian harrier	1	2	2	2	Rammell et al. (1984)
Duck (paradise shelduck)	1	1	1	1	Rammell et al. (1984)
Gull (Southern black back)	1	2	2	2	Rammell et al. (1984)

Fish

Prior to the eradication of rats from Kapiti Island in 1996, several trials were carried out to examine the likely impact of brodifacoum on fish. Empson and Miskelly (1999) reported on aquarium trials where **Blue cod** (*Parapercis colias*), **spotty** (*Notolabrus celidotus*) and **variable triple fin** (*Forsterygion varium*) were fasted for 24 hours before being exposed to brodifacoum cereal pellets for 1 hour. The fish were moved to a clean tank and held for 23-31 days, then killed and analysed. Six of 24 **triple fins** exposed to bait died although none were observed eating bait and no residue was detected in their livers. Of 30 **spotties**, six ate toxic bait and one died of brodifacoum poisoning. Two other **spotties** which died were not observed eating bait but showed clinical signs of poisoning. It is thought the poison was absorbed through gills or skin. This is unlikely to happen in the sea given wave action and dilution.

A field trial was also conducted to examine the fate of Talon® 20P cereal pellets dropped into the sea at Kapiti Island and any consumption by fish. Non-toxic baits disintegrated within 15 minutes and **spotties**, **banded wrasse** (*Notolabrus fucicola*) and **triple fins** were observed eating the bait (Empson and Miskelly 1999).

IN WHICH SPECIES HAVE RESIDUES OF BRODIFACOUM BEEN DETECTED FOLLOWING OPERATIONS?

Sub-lethal brodifacoum residues have been detected in a number of native birds and invertebrates following pest control operations. The monitoring has occurred in two ways. Live animals have been sampled for brodifacoum residues during and post-aerial and bait station operations. Alternatively, brodifacoum residue samples have been taken from native birds that died as a result of causes other than poisoning (e.g. natural cases, predation) following pest control operations.

Birds

Native birds have been sampled on two occasions following the use of brodifacoum during pest control operations. In 1995, four months after brodifacoum was used in bait stations at Mapara Wildlife Management Reserve, King Country, 14 native birds (five tomtits, five whiteheads, one bellbird, one fantail, one Australasian harrier and one morepork) were sampled for brodifacoum residues. Only the morepork contained residue. Four robins were sampled for brodifacoum residues in Waipapa, Pureora Forest Park, two months after brodifacoum was used in bait stations in 1997. None of the birds had brodifacoum residues (Murphy et al. 1998).

The results of the residue tests on the sampled birds and birds that died from causes other than poisoning in areas where brodifacoum has been used are presented in Tables A1.5 & A1.6.

Table A1.5: *Residues detected in sub-lethally exposed non-target native birds following aerial operations using brodifacoum.*

Species	No. of postive samples	Residue range (mg/kg)	Reference
Cereal pellets			
Kiwi (little spotted)	1/1	0.01	Colbourne & Robertson (1997)

Table A1.6: *Residues detected in sub-lethally exposed non-target native birds following bait station operations using brodifacoum.*

Species	No. of postive samples	Residue range (mg/kg)	Reference
Cereal pellets			
Australasian harrier	0/1		Murphy et al. (1998)
Bellbird	0/1		Murphy et al. (1998)
Fantail	0/1		Murphy et al. (1998)
Morepork	1/1	0.61	Murphy et al. (1998)
Kaka	2/3	0.01 – 0.09	G Taylor (pers. comm. 2001)
Kereru	0/5		Eason et al. (2002)
Kiwi (brown)	14/29	0.01 – 0.69	Eason et al. (2002)
Robin (N.I.)	0/4		Murphy et al. (1998)
Silvereye	0/1		VPRD: T0758
Tomtit	0/5		Murphy et al. (1998)
Tui	0/1		VPRD: T0755
Weka	26/48	0.01 -0.95	VPRD: T0911, T1103, T1252B, T0912, T1183, 265
Whitehead	0/5		Murphy et al. (1998)

Invertebrates

Sampling of living invertebrates on or near bait stations and pellets has been conducted on several occasions. The results of these surveys are presented in Tables A1.7 and A1.8.

Table A1.7: *Residues detected in sub-lethally exposed non-target native invertebrates following bait station operations using brodifacoum.*

Species	No. of postive samples	Residue range (mg/kg)	Reference
Cereal pellets			
Beetles	21/58	0.02 – 3.09	Craddock (2003)
Cockroaches	24/24	0.0.065 - 2.34	Craddock (2003)
Weta	28/63	0.06 – 7.47	Craddock (2003)
Misc invertebrates	18/62	0.03 – 3.61	Craddock (2003)
Blocks			
Beetles	7/38	0.02 – 3.3	Wright & Eason (1991); Morgan et al. (1996)
Centipede	0/18		Morgan et al. (1996)
Cockroach	0/21		Morgan et al. (1996)
Insect larvae (unidentified)	0/8		Morgan et al. (1996)
Millipede	0/25		Morgan et al. (1996)
Slater	0/12		Morgan et al. (1996)
Snail	0/4		Morgan et al. (1996)
Spider	0/17		Morgan et al. (1996)
Wasp	0/1		Morgan et al. (1996)
Weta (ground)	0/20		Morgan et al. (1996)
Weta (cave)	0/10		Morgan et al. (1996)
Worm	0/23		Morgan et al. (1996)

Table A1.8: *Residues detected in sub-lethally exposed non-target native invertebrates following aerial operations using brodifacoum.*

Species	No. of postive samples	Residue range (mg/kg)	Reference
Ant	0/2		Morgan et al. (1996)
Beetle	0/5		Ogilvie et al. (1997); Morgan et al. (1996); VPRD
Cockroaches	2/25	0.03 – 0.04	Booth et al. (2001); Morgan et al. (1996); Ogilvie et al. (1997)
Insect larvae (unidentified)	0/6		Morgan et al. (1996)
Millipede	0/10		Morgan et al. (1996)
Misc invertebrates	0/1		VPRD:T0641
Slater	0/14		Morgan et al. (1996)
Slugs	1/6	0.12	Morgan et al. (1996)
Snail	0/5		Morgan et al. (1996)
Spider	0/17		Morgan et al. (1996)
Worm	0/20		Morgan et al. (1996)
Weta (cave)	1/8	4.3	Morgan et al. (1996); Ogilvie et al. (1997)
Weta (tree)	0/20		Ogilvie et al. (1997)

WHAT EVIDENCE IS THERE TO SUGGEST THAT BRODIFACOUM USE CAUSES OR DOESN'T CAUSE A POPULATION DECLINE OF NATIVE SPECIES AT SITES WHERE IT IS USED?

Birds

Australasian Harrier

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated no change in the harrier population post eradication (Robertson et al. 1993).

New Zealand falcon

There was no evidence of New Zealand falcons being killed by use of Talon® 50WB blocks in Novacoil bait stations on either Hawea Island (40 x 40 m bait station grid) (Taylor and Thomas 1989) or Breaksea Island (50 x 100 m bait station grid (Taylor and Thomas 1993).

Bellbird

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated a decline in the bellbird numbers on the island (Robertson et al. 1993).

Cuckoo (Shining) (Chrysococcyx lucidus)

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated an increase in the shining cuckoo population after the aerial drop (Robertson et al. 1993).

Dotterel (New Zealand) (Charadrius obscurus)

All 4 pairs of NZ dotterel on Motuihe Island survived an aerial distribution of Talon® 7-20 at 8 kg/ha followed by 3.5 kg/ha 10 days later (Dowding et al. 1999). There was a higher than expected mortality among NZ dotterel at Tawharanui Regional Park Open Sanctuary following the aerial application of Pestoff® 20R cereal baits at 8kg/ha followed a month later by 7 kg/ha. Six of 12 NZ Dotterels known from the area probably died from brodifacoum poisoning, possibly from eating contaminated sand hoppers (Dowding et al. 2006).

Duck (Paradise Shelduck)

Dowding et al. (1999) reported a 60% (31/52) mortality of paradise shelduck on Motuihe Island after Talon® 7-20 was aerially distributed at 8 kg/ha followed 10 days later by 3.5 kg/ha.

Despite 32 paradise shelducks being found dead and significant declines in numbers at two of three monitoring sites following the Pestoff 20R aerial drop at Tawharanui Regional Park Open Sanctuary, the overall numbers of paradise shelducks increased. Lovegrove & Richie (2005) attributed this to immigration from areas outside the park.

Fantail

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated no change in the fantail population (Robertson et al. 1993).

Fantail numbers did not change between five-minute bird counts undertaken before and after the two Pestoff 20R aerial drops at Tawharanui Regional Park Open Sanctuary in September and October 2004 (Lovegrove and Ritchie 2005).

Fernbirds

Fernbird were monitored by territory mapping and banding during an aerial operation in the Waituna Wetlands when Talon® 20P was sown at a rate of 37.5 kg/ha. 86% of the banded birds disappeared after the operation. Overall, bird numbers declined by only 50% because some birds immigrated into the treatment area following the death of the residents (Ranum et al. 1994).

Most of the fernbirds present on Codfish Island / Whenua Hou were killed during the eradication of rats from the island in 1997. In the operation, Pestoff® 20R pellets were aerially sown at 9.7 kg/ha followed, nine days later by 9.3 kg/ha over most of the island except in the prime fernbird habitat where Pestoff® 20R pellets were placed in Novacoil bait stations on a 25 x 50m grid. Very few fernbirds were recorded for the first two years after the poison operation, but by 2002 the population had built up and expanded into most of its former range (McClelland 2002).

Grey warbler (Gerygone igata)

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated a small decline in the grey warbler population following the poison drop (Robertson et al. 1993).

Grey warbler numbers did not change during five-minute bird counts undertaken before and after the two Pestoff 20R aerial drops at Tawharanui Regional Park Open Sanctuary in September and October 2004 (Lovegrove and Ritchie 2005).

Hihi (Stitchbirds) (Notiomystis cincta)

Hihi survival was monitored during the Mokoia (Armstrong et al. 2001) and Kapiti (Empson and Miskelly 1999) Island rat eradications. On Mokoia Island, mark-recapture data analysis showed that the poison drop (Talon® 7-20 at 10 kg/ha) had no or negligible effect on hihi survival (Armstrong et al. 2001). Empson & Miskelly (1999) reported there was no evidence of hihi being killed during the Kapiti Island operation (Talon® 7-20 at 9.0 kg/ha and 5.1 kg/ha), and survival rates increased after the poison drop, possibly due to the removal of the Norway rats.

Kaka

4 out of 20 (20%) of radio-tagged kaka died during the rat eradication (Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha 25 days later) on Kapiti Island (Empson and Miskelly 1999).

All 5 kaka monitored by radio telemetry on Whatupuke Island survived an aerial poison drop of Talon® 20P at 12 kg/ha with some follow up hand laying. Additionally, no reduction in kaka numbers was detected during five-minute bird counts one month after the operation compared with counts one month before the operation (Pierce and Moorhouse 1994).

No obvious change in the number of kaka present (6 birds including one with a radio-transmitter) on Nukuwaiata Island occurred when Talon® 7-20 was sown at 11 kg/ha (Brown 1997).

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated no change in the kaka population on the island (Robertson et al. 1993).

Kakariki

Five-minute bird counts conducted prior to and post the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) and Kapiti Island (aerial application of Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha, 25 days later) indicated that kakariki were not affected by the operation (Robertson et al. 1993; Empson and Miskelly 1999).

Kereru

Five-minute bird counts conducted prior to and post the rat eradications on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) and Kapiti Island (Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha 25 days later) suggested that kereru were not affected by the aerial application (Robertson et al. 1993; Empson and Miskelly 1999).

Kereru numbers increased significantly in the five-minute bird counts undertaken after the two Pestoff 20R aerial drops at Tawharanui Regional Park Open Sanctuary in September and October 2004 (Lovegrove and Ritchie 2005).

Following rat control using Talon® 50WB blocks in Novacoil bait stations on a 50 x 100m grid in Wenderholm Regional Park in 1992, kereru breeding success was significantly higher (5 fledglings from 11 nests) than over the preceding 5 years (no fledglings from 27 nests) (Clout et al. 1995)

Kingfisher (Halcyon sancta)

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated an increase in the kingfisher population on the island (Robertson et al. 1993).

Five-minute bird counts undertaken before and after the rat eradication at Tawharanui Regional Park open sanctuary (Pestoff 20R aerially sown) indicated a significant decline in kingfisher numbers (Lovegrove and Ritchie 2005).

Kiwi (brown)

At Rarewarewa and Riponui, Northland, none of 55 radio transmittered brown kiwi died from brodifacoum poisoning after Talon® 20P and wax-coated Pestoff® pellets were used in Philproof bait stations on 150 x 150 m grids for up to 32 months (Robertson et al. 1999). The survival of chicks in these poisoned areas was significantly higher than for chicks in nearby un-poisoned blocks, and was sufficient to replace adult losses.

Kiwi (Little spotted)

Robertson et al. (1993) reported that on Red Mercury Island all nine Little Spotted kiwi with radio transmitters were still alive 1 month after the 1992 rat eradication operation (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB). The authors expected the Little Spotted kiwi population to continue growing from the 11 pairs estimated in September 1992, as the absence of rats should improve the availability of invertebrate prey

The Little Spotted kiwi population on Tiritiri Matangi Island was not seriously affected by the aerial application of Talon® 20P at 10 kg/ha (Eason et al. 2002).

Little Spotted kiwi were monitored through the Kapiti Island rat eradication (Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha 25 days later) using 50 banded birds, 10 of which also had radio-transmitters (Robertson and Colbourne 2001). Two of the 10 birds with radio-transmitters died (a mortality rate of 20%) within a month of the poison drops, One of these birds tested positive for brodifacoum residues. Six months after the eradication, 46 of the banded birds were still alive. Robertson & Colbourne (2001) estimated that in the worst-case, poison induced mortality was 8% (3-19%). They concluded that the short term effect of operation on little spotted kiwi was small and the removal of the rats would increase long term survival rates.

Kokako (Callaeas cinerea)

There was an 85% (11/13, including 3 with radio-transmitters) survival rate among the kokako monitored during the rat eradication (Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha 25 days later) on Kapiti Island (Empson and Miskelly 1999).

Morepork

Morepork mortality has been monitored using radio tagged birds or call counts during six aerial operations.

Three of 14 (21%) radio tagged morepork died in the 51 days after Talon® 7-20 was aerially applied at 10 kg/ha over Mokoia Island (Stephenson et al. 1999). On Kapiti Island, morepork call rates dropped from 15.6 calls/hr pre- to 11.9 calls/hr post- rat eradication (Talon® 7-20 at 9.0 kg/ha and 5.1 kg/ha). This change was not statistically significant (Empson and Miskelly 1999). Moreporks decreased after the aerial distribution of Talon® 20P at 10 kg/ha on Tiritiri Matangi Island, 1993, but it is not known whether this was induced by poisoning or the removal of their major food item, rats (Eason et al. 2002). There was no evidence of a detrimental effect on the morepork population Red Mercury Island (Robertson et al. 1993) after aerial distribution of Talon® 20P to eradicate kiore / Pacific rat. Morepork call counts did not change significantly after the Pestoff 20R aerial drops at Tawharanui Regional Park Open Sanctuary in September/October 2004 (Lovegrove and Ritchie 2005).

Taylor & Thomas(1993) reported there was no evidence of morepork being killed by use of Talon® 50WB blocks in Novacoil bait stations on Breaksea Island (50 x 100 m bait station grid.

Oystercatcher (Variable) (Haematopus unicolor)

Dowding et al. (1999) reported no mortality in 7 pairs of variable oystercatcher on Motuihe Island when Talon® 7-20 was spread aerially at 8 kg/ha and then 3.5 kg/ha in 1997. All nine colour banded variable oystercatchers resident at Tawharunui at the time Pestoff® 20R cereal baits were spread in two aerial applications of 8kg/ha and 7 kg/ha, survived (Dowding et al. 2006).

Pukeko

Over 90% of pukeko on Tiritiri Matangi Island were killed following the aerial distribution of Talon® 20P at 10 kg/ha (Veitch 2002), and Dowding et al. (1999) reported that on Motuihe Island, 49% (48/98) of pukeko died following the aerial sowing of Talon® 7-20 (8 kg/ha followed 10 days later by 3.5 kg/ha). Lovegrove & Richie (2005) estimated pukeko numbers declined by 80% after Pestoff 20R was aerial sown in Tawharanui Regional Park open sanctuary.

Robins

Robins have been monitored during three aerial (Walker and Elliott 1997; Empson and Miskelly 1999; Armstrong and Ewen 2001) and one handlaid (Brown 1997) brodifacoum operations, with reported survival rates of between 35 – 90%.

On Nukuwaiata Island, 14/20 (70%) banded South Island robins survived Talon® 7-20 sown at 11 kg/ha (Walker and Elliott 1997).

Based on mark-recapture data analysis, Armstrong & Ewen (2001) estimated there was 10 -12.5 % mortality of North Island robins on Tiritiri Matangi Island following the use of Talon® 20P at 10 kg/ha. It was estimated that this mortality resulted in a one year lag in the robin population's growth but had no long-term effect on the viability of the population.

On Kapiti Island, banded North Island robins were monitored at two study sites during the 1996 rat eradication (Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha 25 days later) (Empson and Miskelly 1999). Survival rates of 35% and 74% were recorded. However, these survival rates are likely to be an underestimate of overall robin survival because the study sites were adjacent to public tracks where the birds were habituated to sampling novel foods. Analysis of data from one site showed that 60% of the robins adjacent to tracks survived compared to 100% of those away from tracks. In the year following the operation there was improved robin nesting success.

Brown (1997) monitored radio-tagged and banded South Island Robins in a 20 ha study site at Station Creek, Maruia. Where Talon® 20P was hand broadcast at 3 kg/ha, in October 1996, the minimum estimate of the robin's survival was 52.2% (95% CI = 31 - 75%). Where Talon® 20P pellets were placed in Philproof bait stations on a 100 x 100m grid in September 1996, the minimum estimate of the robin's survival was 96.7% (95% CI = 83 - 100%).

On Breaksea Island, Taylor and Thomas (1993) counted all South Island robins seen and heard at 100m intervals along representative tracks before and after the application of Talon® 50WB blocks in 400 mm Novacoil stations on a 50 x 100 m grid. No change in robin counts were observed. Several robins were seen entering bait stations and/or eating crumbs of bait scattered by rats and two robins were found dead.

Saddleback

Population changes of saddlebacks were monitored for 8 months post rat and rabbit eradication on Stanley Island (Talon® 20P aerially distributed at 17kg/ha and Talon® 50 WB hand-laying at 1 kg/ha), by following banded birds during and after application, and with 5 minute bird counts. 41 of 43 banded birds were located post rat eradication. Saddleback mortality due to poisoning was <5% and may have been as low as 1%. This mortality was not sufficient to result in an increase in the annual overall mortality (Towns et al. 1993).

At a study site on Tiritiri Matangi, about 21% of the banded North Island saddlebacks died following the rat eradication using Talon® 20P at 10 kg/ha. Post rat eradication counts showed that this mortality was not detrimental to the saddleback population in the medium term (Veitch 2002).

Davidson & Armstrong (2002) estimated that saddleback mortality immediately after the aerial application of Talon® 7-20 at 10 kg/ha on Mokoia Island was 45% for adults and 35% for juveniles. This mortality probably set population growth back by 1-2 years, but fecundity appeared to be unaffected when density effects were considered.

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated saddleback population was unaffected by the poison drop (Robertson et al. 1993).

While saddleback were not monitored during the rat eradication on Kapiti Island (Talon® 7-20 at 9.0 kg/ha and 5.1 kg/ha), they had highly successful breeding season after the rat eradication, with the number of pairs increasing by 120% (Empson and Miskelly 1999).

Silvereye

Five-minute bird counts undertaken before and after the rat eradication on Red Mercury Island (Talon® 20P pellet aerially sown at 15.5 kg/ha and some hand laying of Talon® 50WB) indicated the silvereye population increased post eradication (Robertson et al. 1993).

Silvereye numbers did not change between five-minute bird counts undertaken before and after the two Pestoff 20R aerial drops at Tawharanui Regional Park Open Sanctuary in September and October 2004 (Lovegrove and Ritchie 2005).

Skua (brown)

Approximately two thirds of the Enderby and Rose Island skua population died when two applications (18 days apart) of Wanganui #7 pellets were aerially sown at 5 kg/ha (10kg/ha in areas with high rabbit numbers), in 1993. One year later the population had not recovered, but by 2001 the population had recovered to near pre-poisoning levels (Torr 2002).

There was no evidence of brown skua being killed by use of Talon® 50WB blocks in Novacoil bait stations on Hawea Island (40 x 40 m bait station grid) (Taylor and Thomas 1989).

Tomtit

Five-minute bird counts conducted prior to and post the rat eradication on Kapiti Island suggested that tomtit were not affected by the aerial application of Talon® 7-20 at 9.0 kg/ha followed, 25 days later, by 5.1 kg/ha (Empson and Miskelly 1999).

Tui

Tui increased significantly in the five-minute bird counts undertaken after the two Pestoff 20R aerial drops at Tawharanui Regional Park Open Sanctuary in September and October 2004 (Lovegrove and Ritchie 2005).

Weka

All 15 banded western weka and more than 98% of the unbanded weka were killed on Nukuwaiata Island, following the use of Talon® 7-20 at 11 kg/ha in 1993 (Brown 1997).

Empson & Miskelly (1999) reported that following the aerial distribution of Talon® 7-20 on Kapiti Island (9.0 kg/ha followed by 5.1 kg/ha 25 days later), mean weka call rates dropped significantly. Three months after the operation, weka were still less conspicuous than prior to the operation.

Prior to eradication of rats on Tawhitanui Island, Marlborough Sounds, using Talon® 50WB blocks in Novacoil bait stations Western Weka were observed to be ‘very common’. Ninteen months after the operation, there were no definite sightings of weka on the island (Taylor 1984). 80-90% of Stewart Island weka on Ulva Island died following the eradication of Norway rats using Talon® 50WB blocks in bait stations (Eason et al. 2002).

Whiteheads

Five-minute bird counts conducted prior to and post the rat eradication on Kapiti Island suggested that whiteheads were less conspicuous following the aerial application of Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha 25 days later (Empson and Miskelly 1999).

Mammals

Short-tailed Bats (Mystacina tuberculata)

During the 1998 Codfish Island / Whenua Hou rat eradication (Pestoff® 20R aerially sown at 9.7 kg/ha followed, nine days later by 9.3 kg/ha and Pestoff® 20R in Novacoil bait stations on a 25 x 50m grid in key fernbird habitat), the wild bat population was monitored using radio tracking and video monitoring of roosts. Bats were also held in captivity on the island during the poison drop. There were no observable losses in either the wild population or the released captive bats, and the poison drop had no effect at a population level (McClelland 2002).

Lizards

Two months after Talon® 20P was aerially sown at 17.5 kg/ and Talon® 50 WB hand-laying at 1 kg/ha on Stanley Island, lizard pitfall capture rates were 29% higher than the previous best (Towns et al. 1993).

Brown (1997) reported that the *Oligosoma lineoocellatum* population on Nukuwaiata Island increased by 67% over the two years following the aerial application of Aerial Talon® 7-20 at 11 kg/ha to remove rat and weka.

Fish

Spotties

There was no evidence of a population decline in spotties as a result of the aerial application of Talon® 7-20 at 9.0 kg/ha followed by 5.1 kg/ha on Kapiti Island, based on surveys conducted before and after the poison drops (Empson and Miskelly 1999)

Invertebrates

Large-headed tree weta numbers on Nukuwaiata Island increased by 50% in the first year after the aerial application of Aerial Talon® 7-20 at 11 kg/ha. By the second year the weta numbers had increased 80% (Booth et al. 2001)

Spurr (1993) monitored invertebrates through a simulated aerial application in a scenic reserve near Pelorus Bridge, Marlborough. Talon® 20P was handlaid at 10 kg/ha and ground-dwelling invertebrates monitored by pitfall trapping. The relative numbers of invertebrates caught in the treatment and non-treatment areas one year after the poisoning were similar to those before poisoning. The author noted there was rapid reinvasion of the site by rodents which may have influenced the result.

Spurr (1993) monitored invertebrates through a simulated bait station operation in a scenic reserve near Pelorus Bridge, Marlborough. Talon® 50WB blocks were placed in Novacoil bait stations on a 50 x 50 m grid and ground-dwelling invertebrates monitored by pitfall trapping. The relative numbers of invertebrates caught in the treatment and a non-treatment areas one year after the poisoning were similar to those before poisoning.

Appendix 2: Rat Eradication Scoping Document, Public meeting held 3rd April 2008 at Stewart Island / Rakiura

Attendance:
SIRCET Trustees – Margaret Hopkins, Jo Learmonth, Margaret Fairhall
DOC – Andy Roberts, Brent Beaven
58 members of the public
2 x TV1 news crew
Apologies: Jim Barrett, Eric Roy

Introduction

The meeting was held to discuss the draft discussion document that had been distributed in December 2007. The aim of the meeting was to identify any issues or concerns that the community may have had with the proposed eradication, so that these could be written into the feasibility study. A key part of the feasibility study is to identify issues that would be associated with an eradication proposal so that we can clearly see if an eradication is feasible.

After a brief introduction by Margaret and Brent, we started to explore issues. Discussion was focussed around key issues, with all thoughts on one issue being discussed and listed before moving onto the next issue. As ideas were raised, these were written onto a white board for everyone to see.

The following is a record of issues identified.

Issues identified.

<u>Predator Proof Fence (discussed in Sections 3.1 and 3.2)</u>

- Legal access issue; access to National Park restricted
- Cost / benefit analysis needed. Some thought that it was a waste of money.
- Who would bear the cost of ongoing maintenance
- Comparison with other methods. Could other methods achieve the same thing?
- Analysis of success of other fenced projects
- Could use fence to trial pest removal around township
- High level of certainty needed before proceeding. Some worry about long term effectiveness of fences (i.e. 20yr plus)
- Cultural / social implications – cultural engineering; not everyone into conservation; worried about lifestyle; disenfranchising elements of the community.
- Some suggestion that could be a temporary structure just for eradication.
- Pests going around ends raised as issue – fence effectiveness.
- Had potential to contain any invading animals after eradication achieved
- Aesthetics; visual pollution
- Fence only one tool in big picture

- Cautious approach needed

Post Eradication Implications (discussed in Sections 3.2, 3.3, 3.4 and 5)

- Cost of maintenance – who will cover this?
- Definition of community needs refining (p32 in draft document)
- Restrictions on peoples' movements to, from and around the island; adding another level of bureaucracy into access.
- Effect on domestic cats; peoples ability to have pets.
- Unrestricted tourist development; impact on environment; change of lifestyle for residents; costs of/on infrastructure (who pays?)
- Cap on tourist numbers might be required – Tourism Strategy Review/rewrite.
- Fear of uncontrolled growth
- Subservience to tourism; danger that will end up doing what tourists want as opposed to community.
- Is there an impact on other activities e.g. aquaculture?
- Possible negative media implications on aquaculture industry if toxins used.
- Entry & exit ports may require effort and infrastructure. Are they included in eradication?
- Biosecurity problems
- Prioritisation of pests for eradication – do they change / is there a balance?
- Kiore / Pacific rat – cultural implications.

Biosecurity (discussed in Sections 3.2)

- Control difficulties – small private boats
- Heaps of foreign fishing vessels / large ships / domestic vessels / fishing vessels
- Shipwrecks
- Need to guarantee we can prevent reinvasion
- Examples of similar exercises that have succeeded / failed
- Movement of domestic cats & dogs between mainland & Stewart Is. – tougher control?
- Risk assessment of Biosecurity implications needed
- Border control – cost to community & traveller / intrusive / time factor
- Increased risk of mice invading & establishing in absence of rats
- Risk of eco-terrorism
- Education required – national & international

Toxins / aerial application (discussed in Sections 2, 3.1, 3.3 and 3.4)

- Suggested that remove people temporarily & 'nuke it'
- Aerial poisoning unacceptable – effects on waterways / fishing / marine farms
- Brodifacoum v 1080 – worst of two evils? Bargaining point?
- Cumulative effects of poison, especially in food chain and potential to effect marine farms?; sublethal poisoning of deer and people eating?
- More info needed on effects on places where people live / work / recreate; effect on human health?

- Persistence of toxic residues and withholding periods?; Stand down time for deer consumption – costs to families & community; Notification periods differ for various agencies
- Safety based on current information. In 5yrs, will we find it is worse?
- Clean / green image tarnished by use of poisons
- Non-target species effects
- Pets affected & by-kill
- Cultural implications regarding toxins in waterways
- Poison pellet coverage problems? Will the method proposed actually work in Stewart Island / Rakiura's forest type?
- Method appropriate for target animals and terrain; wild cats will need follow-up, probably won't be killed by eating poisoned rats.
- Logistics need more detail; Time / effort for bait spread & methodology
- Is there other options that would work? E.g. cat flue, biocontrol, sterilisation
- Poison itself is an issue
- Is control as or more effective than eradication?? Explore all options.

<u>Deer / recreational hunting (discussed in Sections 2.4 and 3.3)</u>

- Deer repellent in baits – other examples of use? Good if works. Assumes that deer will eat bait.
- Repellent only tested on sika deer to date. Need tests on white tail.
- Is there any possibility of a sheep, cattle and bird repellent?
- Effect of deer repellent on target species
- Would reduction in deer numbers be positive? Increased herd health?
- Traditional hunting a valued recreational & commercial activity
- Ground based operations may be safer for deer
- Would deer be next on the list – needs to be addressed
- Compensation for transport operators if deer affected
- Evaluation needed on deer numbers per hectare / thresholds; are they the pests that it is claimed?
- Tensions between sectors of community with regard to deer
- Are hunters providing enough control on deer numbers?
- Hunters contributions to Island economy and lifestyle
- Islanders reliance on deer for food
- Apply science / quantitative methodology to process.

<u>Benefits for the Community (discussed in Sections 3.3 and 3.4)</u>

- Economics – who will pay? Islanders shouldn't be financially disadvantaged
- Examples of other inhabited Islands needed
- Opinions of people who live here should have priority consideration
- Identify benefits to the community – employment, economic – quantify
- Community definition should be based around those who live here, rate payers, people of Southland; community of interest versus community of place.

Miscellaneous (discussed in Sections 3.1, 3.2 and 3.3)

- Private land rights. Should look at compulsion mechanisms if not everyone agrees
- Plan against further bioinvasion regardless of where this operation/study gets to
- Impediments to success
- Bush is suffering enough now
- What happens if we do nothing as an option?

Cost (discussed in Sections 3.2, 3.3, 3.4 and 5)

- Where is the money going to come from?
- Ongoing costs – who is covering them?
- Personal costs to community members e.g. food going up as needs biosecurity
- Not just $ cost
- Will cost of living increae i.e. biosecurity
- Impact on visitor 'rating'?

Appendix 3: Identified stakeholders and consultation

Table A3.1: *Key consultation conducted as part of the development of this feasibility study.*

Workshop Kaitiaki Roopu	14-Aug-07
Meet some RMLT trustees	10-Aug-07
SIN update	10-Aug-07
Meet venture Southland	23-Aug-07
Drop in public workshop	3-Sep-07
Workshop Stewart Island / Rakiura DOC staff	7-Sep-07
Brainstorm sessions – Invercargill DOC staff	14-Sep-07
Discussion document released publicly	24-Dec-07
SIN update	15-Feb-08
ODT, NZ Herald articles appeared	7-Mar-08
Meet Southland Branch NZDA.	19-Mar-08
Public meeting on Stewart Island / Rakiura	3-Apr-08
Meet some RMLT trustees	4-Apr-08
Island Eradications Advisory Group review meeting	27-Apr-08
Internal DOC review meeting	9-May-08
IEAG review meeting	15-May-08

Table A3.2: *Initial list of identified stakeholders listed in alphabetical order. This is far from complete and can be added to as others are identified.*

Name of stakeholders	**Contact**
Charter boat operators	
Commercial Fishermen	
Community Board	Barry Rhodes (Chair)
Crayfish quota holders	
Dancing Star Foundation	Michael Tobias
Department of Conservation	Andy Roberts
Diving groups	
Environment Southland	Richard Bowman
Forest and Bird	Sue Maturin
Freight Boat	Ian and Sue Munro
Great Barrier Island Trust	Jude Gilbert
Hunter Hut Trust	John DeLury
Kaitiaki Roopu	via DOC
Local hunters	Marty Pepers, Greg Northe, Kyle Learmonth, etc
Mussel farmers	
Muttonbirders	Tane Davis, Robert Crote

NZDA National	Dianne Brown
NZDA Southern Branch	Ray Phillips
NZDA Sthn Otago Branch	
Paua quota holders	
Rakiura Maori Land Trust	Stephen Harteveld
Port Authority	
Rakiura Runaka	Phillip Smith and Jan West
Recreational boaties	
Recreational fishermen	
Salmon farm	
Southland aeroclub	
Southland District Council	David Adamson
Stewart Island / Rakiura Community and Environment Trust	Margaret Hopkins
Stewart Island / Rakiura Animal Pest Liaison Group	via DOC
Stewart Island Experience	Matt Sillers
Stewart Island Fisherman's Association	Colin Hopkins
Stewart Island Flights	Raymond Hector
Stewart Island resident community	
Tindall Foundation	Evelyn Gauntlett
Tourism NZ	Simon Douglas
Tourism Operators	
Venture Southland	Kathryn MacDonnell

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