Eliminating Predators from Stewart Island

Scoping report to investigate issues of technical feasibility

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Te Papa Atawhai

Cover image: Sculpture at the entrance to Rakiura National Park, Stewart Island
Photo: Sue Wilkins (2008)

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EXECUTIVE SUMMARY

Stewart Island represents a significantly larger biodiversity restoration project than we have ever attempted. At over 169,000 ha any attempt to remove rats, feral cats, and possums would be 15 times larger than the largest successful island eradication conducted in New Zealand (Norway rats from Campbell Island).

Using our current suite of tools and best practice for island eradications, we do not consider that it is technically feasible to eradicate rats, cats, and possums from Stewart Island at this time.

Pivotal to the success of this project is the ownership of it *by the Stewart Island community*. Through seeing and understanding what can be achieved, the community will become project champions and the guardians of the natural capital that is restored. By significantly enhancing the biodiversity around the Halfmoon Bay area that understanding will occur, and the aspirations of the local community will include capturing the environmental AND economic benefits that a predator-free Stewart Island can bring. To achieve this, we propose starting with a project to eliminate predators from an area encompassing the township (somewhere between 1000ha and 5000ha). The final extent and methods used to eliminate the predators would be for the community to decide. We recommend that, to the extent it is financially possible, the community be allowed to make the biodiversity gains 'on their terms'.

We have also identified the critical technical innovations that would 'change the game' for this project (and most large scale predator control projects in New Zealand). If these innovation challenges were overcome, they would go a long way towards making a project of this magnitude feasible.

The critical technical innovations are:

- large scale detection of key predators
- targeted application of toxin *[this innovation would flow on from the detection innovation]*
- improved efficiency of bait spreading
- lure development
- deer repellent

In addition to the critical technical innovations, a number of important knowledge gaps have been identified during this analysis. These gaps need to be better understood before we can determine the feasibility of this project. They are:

- predator interactions e.g. will cats be driven towards local extinction if rats are removed?
- will mice establish and erupt if rats and/or cats are removed?
- refine technologies for predator-proof fencing
- new toxin application methods
- ongoing biosecurity, especially against rats and mice
- invasion behaviour

In order to drive these innovations forward, a minimum investment of $1 million per annum is required for the next 5 years.

SETTING THE SCENE

Dr Gareth Morgan (of the Morgan Foundation) has approached the Department of Conservation proposing a partnership approach to investigating the elimination of rats, possums, and feral cats from Stewart Island. This report scopes the main issues and areas for consideration before such a venture can be undertaken[1].

Target area

Stewart Island/Rakiura is the third largest island of New Zealand. It is located approximately 30km south of the South Island. It is a large island surrounded by a number of smaller islands and rock stacks (some of which are already predator free, such as Codfish Island (Whenua Hou) and Big South Cape Island (Taukihepa)). The total land area that would need to be targeted in an elimination attempt would be 169,464 ha. This represents a project that is 15 times larger than the largest successful rodent eradication (Norway rats off Campbell Island); and 6 times larger than the largest successful cat eradication (29,000ha Marion Island).

Approximately 90% of the island is public conservation land managed by the Department of Conservation, of which 80% is the Rakiura National Park. The remaining 10% of the island is managed by the Rakiura Maori Land Trust (approx. 8%); or in freehold title (2%) centred on the town. The population on the island is approx. 380 people, the majority of which are concentrated in the township area on the northern side of Paterson Inlet.

Conservation priorities

Within DOC's ecosystem prioritisation system of Public Conservation Land, Stewart Island has twelve ecosystem management units present in the top 700 ranked units. The highest ranked ecosystem management unit is the Rakeahua River wetlands (664ha), ranked at 147. The other ecosystem management units (and associated ranks) are:

- Freshwater River (10,748ha) - 251
- Tin Range (7482ha) - 257
- Toitoi flat wetland (948ha) - 337
- Ruggedy dunes/saline (118ha) - 352
- Port Pegasus (14,521ha) - 380
- Mason Bay dunes (1,193ha) - 386
- Smokey beach dunes (65ha) - 498
- Mount Anglem (14,583ha) - 550
- Rakeahua (7,068ha) - 619
- Doughboy Bay dunes (84ha) - 673
- Three Legged Woodhen (2ha) – 693

While it is clear that Stewart Island contains some very important conservation sites, only the top 400 ecosystem management units across the country have been funded for management from within DOC's current budget. Therefore, the restoration of further sites will not happen without the help of the community. Accordingly, the Department has embarked on a new operating model, whereby we seek to achieve more conservation across the country by engaging with others in our work. Our engagement with Dr Gareth Morgan and our serious consideration of the proposal to eliminate predators from Stewart Island is an example of this new operating model in practice.

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1 This report draws heavily from the work done in 2008 by Brent Beaven for the Stewart Island Rakiura Community and Environment Trust (SIRCET).

Target species

Stewart Island is fortunately free from mustelids, rabbits, feral pigs, and feral goats – all of which have caused significant environmental damage across New Zealand.

This investigation is centred on the following target species present on Stewart Island:

- Norway rat (*Rattus norvegicus*)
- Ship rat (*Rattus rattus*)
- Kiore/Pacific rat (*Rattus exulans*)
- Possum (*Trichosurus vulpecula*)
- Feral cat (*Felis catus*)

However, we also consider that any future work should include hedgehogs (*Erinaceus europaeus*), which are known to be present in small numbers near the township of Oban.

Deer (red deer – *Cervus elaphus*; and white-tailed deer – *Odocoileus virginianus*) have been excluded from this project; largely due to the high value placed on these animals by the local and extended community, and the expectation that inclusion of deer will result in significant public opposition to any proposal to undertake this predator elimination project.

It is necessary to mention that the retention of deer on the island will have serious ecological consequences, namely through the inhibition of forest regeneration. This level of impact will need to be monitored, and the exclusion of deer from this project does not remove the Department of Conservation's responsibility to control deer if the necessity arises in the future.

Current approach to eradications

The current agreed best practice for island eradications of rodents[2] in New Zealand is the aerial application from a spreader bucket beneath a GPS-guided helicopter of brodifacoum (second generation anti-coagulant toxin) cereal baits. The bait is spread in two complete applications over an entire island (first being 8kg/ha; and second being 4.5kg/ha) 7-10 days apart. Projects targeting multiple species at the same time (e.g. the Rangitoto-Motutapu Islands multi-species eradication) have used larger application rates and/or a third application to ensure that the target animals gain access to the necessary volume of toxin.

Given the large scale of this project and the number of target species involved, if the project were to proceed in the short term in accordance with current best practice, a higher total bait application rate of 25kg/ha (likely spread over 2 or 3 applications) would likely be required. As such, a minimum of 4240 tonnes of bait would be needed. Animal Control Products (the company that produces brodifacoum bait in New Zealand) can currently produce approx. 10 tonnes of bait per day. Therefore to produce the amount of bait being suggested, Animal Control Products would take 424 days or over 14 months. In addition, the bait currently has a recommended storage life of 3 to 4 months.

Success in a multi species eradication project relies heavily on possums eating the bait directly, and cats succumbing to secondary poisoning through scavenging and eating poisoned rats and possums. However, it is unlikely that all individuals will be killed as a

[2] Broome, K.G.; Brown, D; Cox, A.; Cromarty, P.; McClelland, P.; Golding, C.; Griffiths, R.; Bell, P. 2011: Current Agreed Best Practice for Rodent Eradication-Aerial broadcasting poison bait (Version 2.2). New Zealand Department of Conservation internal document. Department of Conservation, Wellington, New Zealand.

result of the toxin, and follow-up work, such as traps, hunting with dogs, etc, would be needed to eliminate those individuals that do not succumb to the poisoning regime.

One predator dog team can effectively hunt approximately 50-60ha per day (K. Vincent, pers. comm.). Currently there are 14 fully certified predator dog handlers in New Zealand (with 2 additional handlers currently holding interim certification), and not all of them are certified for all of the target species. Given the scale of Stewart Island, at the rate they hunt, it would take 15 dog teams 190 days to cover the entire island.

Therefore, using current best practise techniques, methods, and technology, it is not feasible to eradicate rats, possums, and feral cats from Stewart Island at this time. This project is not simply a matter of 'scaling up' our existing methods – we consider there is a significant risk of failure using our current best practise on an island of this magnitude.

However, we have identified several critical technical innovations and knowledge gaps that would 'change the game' for this project (and most large scale predator control work in New Zealand). If these innovation challenges were solved, we consider they would go a long way towards determining the success of a project of this scale.

<u>Stepping stone approach</u>
The Department of Conservation has a history of incremental improvements in island eradications – taking on islands of increasing size or complexity, learning all the while to do even bigger islands. An example of this being the combined rat and cat eradication on Raoul Island (2938ha) in 2002 led onto the multi-species eradications on Rangitoto and Motutapu Islands (combined 3842ha) in 2009. Given the two orders of magnitude size difference involved and the requirement for significant changes in how we undertake eradications of this scale (outlined throughout this report), the value in this stepping stone approach appears limited. Where a stepping stone approach is likely to be of benefit, is as trial sites for some of the technical innovations described further in this report.

ISSUES IDENTIFICATION

Social engagement and ownership

There are very few eradications that have taken place on islands with resident populations, let alone of the size of Stewart Island's community. There are approx. 380 residents on Stewart Island at present. There is a growing concern over the viability of the island community (with a shrinking population, reduced school pupil numbers, and expensive diesel generated electricity identified as the key drivers of these concerns; D. Belworthy, pers. comm.). This entire project hinges on its social acceptance by this community – every aspect has a 'social dimension' underpinning it. Even if all of the technical feasibility challenges are met, the social aspect has the ability to prevent any operation ever taking place (e.g. if the local community does not want it, it will not happen).

Genuine engagement with the community is critical, but its success will be dependent on the community developing a sense of ownership of the project. The community needs to feel that this project delivers some of the aspects for their 'vision' of the island. What that 'vision' for the island is is not well understood, but improved economic prospects are one result we would expect from this proposed major gain in ecological capital and biodiversity (e.g. via increased tourism).

Likewise, in advancing this project, we need to understand and respect the community's attitudes to eradication, biodiversity, the various methodologies and technologies, their support and their opposition.

Starting the journey:
To develop this sense of ownership from within the Stewart Island community of this project, we consider that the immediate operational goal should be to build on, and enhance, the biodiversity gains around the Halfmoon Bay area. There are already a number of small scale community-driven projects happening in that area:

- Stewart Island Rakiura Community and Environment Trust (SIRCET) predator control and restoration work around Halfmoon Bay
- Dancing Stars Foundation predator-proof fenced sanctuary
- Partnership between DOC and Air New Zealand to increase biodiversity around the Rakiura Track
- Ulva Island open sanctuary (with the Ulva Island Trust)

An appetite for conservation and biodiversity restoration already exists in some parts of the community – after all, the community 'demanded' that the invading rat population on Ulva Island was re-eradicated in 2011.

We propose building on that work by targeting an area encompassing the township (somewhere between 1000ha and 5000ha) for elimination of all the target species (including hedgehogs). The exact size of the area and methods used to eliminate these predators would be for the community to decide. In essence, we recommend the community be allowed to make the biodiversity gains 'on their terms'.

This smaller-scale project would enable us to enhance our relationship with the community and understand their motivations, attitudes to eradication and the techniques involved, and their willingness to engage with or own a large scale project. At the same time, the project will 'bring more biodiversity to the community's backdoor' – building enthusiasm and understanding of the connection between eliminating predators and restoring native biodiversity.

Target Species

Hedgehogs:
We consider that any future work should include hedgehogs, which are known predators of ground-nesting birds, as well as having impacts on invertebrate and reptile populations. The current population of hedgehogs is believed to be small and localised near the township of Oban (B. Beaven, pers. comm.) – however this needs to be confirmed.

Hedgehogs offer the possibility of an 'early win' for eradication, if their limited distribution is confirmed. However, a small eradication targeting the hedgehogs alone may have limited visibility, as there appears to be a lack of community recognition of the presence or damage of the hedgehogs.

Mice:
There is no current evidence to suggest that mice are present on the island. The presence of cats and rats may have prevented mice from establishing; conversely, the mice may be suppressed to below currently detectable levels on the island.

Mice have been caught on occasion at the main wharf in Oban (B. Beaven, pers. comm.), so they are a known invasion risk. No mice have ever been detected within the Dancing Stars Foundation management area in the six years it has been managed to zero density of all predators (behind a predator-proof fence), suggesting that they have not become established on the island (or at least not in that area of the Island).

The presence of mice on the salmon farm in Big Glory Bay needs clarification. It is understood that mice have arrived there on occasion with salmon feed (A. Roberts, pers. comm.). If they are present on the farm, discussions should be held with the salmon farm company with the goal of eradicating them and reducing the risk of reinvasion. This is critical, given the farm presents a high risk of introducing mice onto Stewart Island.

If the elimination of rats and cats proceeds, it could greatly increase the likelihood of mice becoming established on the island (due to the lack of natural enemies and competitors). Building understanding about the likelihood of mouse establishment and eruption, and the ecological consequences of those events, will be critical to many future aspects of this project – choice of target species, biosecurity requirements, etc.

Rats:
Generally, where rat species co-exist, habitat partitioning tends to occur. Harper et al[3] found on Stewart Island that ship rats dominated in podocarp-broadleaf forest and riparian shrub land; Norway rats were most common in subalpine shrub land; and kiore dominated in manuka shrub land. However, ship rats (and Norway rats in smaller numbers) were found in all vegetation/habitat types. It will be important to understand the distribution and habitat usage by each rat species to determine whether there is any competitive interplay for resources (and therefore how that may influence bait or device access for each species).

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[3] Harper, G.A., Dickinson, K.J.M., and Seddon, P.J. (2005) *Habitat use by three rat species (*Rattus *spp.) on Stewart Island/Rakiura, New Zealand.*, New Zealand Journal of Ecology, 29(2): 251-260.

In addition, understanding the relationship between the rats and the feral cats will be important. It has been suggested[4] that removing all of the rats could place significant pressure on the feral cats and potentially drive them to extinction by starvation. This theory needs to be robustly tested.

Cats:
Discussions with local DOC staff on Stewart Island has suggested that the distribution of cats is limited, possibly to habitat that provides best protection from wet weather. This needs investigation; however it may open up the possibility of treating sections of the island with cat-specific techniques (rather than the whole island).

There is a strong possibility that a number of cats would be killed via secondary poisoning in any bait operation (involving 1080 or brodifacoum) targeting rats and/or possums. In a small experiment on Stewart Island, 9 out of 10 radio-collared cats were killed during a 1080 operation targeting possums (the cats were found to be scavenging dead possums). As mentioned above, the relationship between cats and rats needs to be studied to identify if there are dependences to be exploited in an elimination operation.

However, secondary poisoning can not be relied on to account for all of the feral cats on the island – cats survived the aerial eradication of rats on Raoul Island; and Rangitoto/Motutapu Islands. As such, we need to determine how to conduct the follow up work to detect and kill the remaining animals. The current use of dogs and hunters is logistically and technically infeasible on an island the size and scale of Stewart Island. We need new tools of sufficient high sensitivity to detect low numbers of animals across large landscapes.

Some Stewart Islanders own cats as pets. There is the potential for some pets to be killed as a result of an elimination operation. This may damage any public support for the project. Mitigation measures need to be investigated (and tested with the community for acceptance) – measures could include keeping the animal indoors during the operation (or at least the duration of the operation around the town); or holding the cats off the island for the full duration of the elimination project (to be returned, desexed, once success has been determined).

The Southland Regional Pest Management Strategy (RPMS) requires all pets to be neutered and micro-chipped on Stewart Island. If enforced, this will greatly assist in controlling cat numbers on the island during and after any elimination. There may be scope to seek additional changes to the RPMS to further restrict the ownership of cats (and other animals) to maintain the biodiversity gains of any elimination project.

Possums:
Discussions with local DOC staff on Stewart Island have suggested that the distribution of possums is limited, possibly driven by availability of preferred habitat. This theory needs investigation; however it may open up the possibility of treating sections of the island for possums (rather than the whole island).

Based on experiences from other eradication operations (e.g. Kapiti Island, Codfish Island), it seems unlikely that poisoning can be relied on to account for all possums on the island. As such, we need to determine how to conduct the follow up work to detect and kill the remaining animals. The current use of dogs and hunters is logistically and

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[4] Harper, G.A. (2005) *Numerical and functional response of feral cats (*Felis catus*) to variations in abundance of primary prey on Stewart Island (Rakiura), New Zealand.*, Wildlife Research 32: 597-604.

technically infeasible on an island the size and scale of Stewart Island. We need new tools with sufficiently high enough sensitivity to detect low numbers of animals across large landscapes.

While a number of mainland sites have been treated for possum and rat control with aerially applied 1080 with good results, these have been *control* operations – by nature, they are not seeking to remove every individual. Understanding the issues with inter-species competition in an eradication context (e.g. does one species have a competitive advantage that may result in the creation of gaps in the bait coverage such that some individuals do not ever encounter any bait) will enable robust planning of the methodology to reduce this risk.

Target make-up and sequencing:
There is a choice to be made as to what suite of predators is targeted in what order. There appears to be merit in investigating the costs and benefits of a range of targeting approaches (e.g. single species at a time, multi-species, etc). The choice made here will have direct flow-on effects to the other areas of the project – namely, biosecurity (e.g. possums are easier to keep off an island than rodents).

Critical to the decision of target make-up will be full understanding of the ecological consequences of taking one (or more) predator out of the system, and leaving others present. Will taking cats out create a mesopredator release situation whereby the rat populations explode? If cats and rats are removed, will mice establish and erupt? Are there ecological benefits (or costs) in removing possums but leaving the rats and cats present for a time? It will be critical to understand the population dynamics and interdependencies of the target predators (and their prey), in order to design the optimal programme to enhance biodiversity gains on the island.

One potential scenario raised in a number of discussions during the investigation stage of this project has been the removal of possums from the entire island in the immediate future. Given the constraints outlined above (e.g. not able to secure complete eradiation using toxin alone, the number of dog teams required to hunt the island, etc), removing possums from Stewart Island does not appear feasible at this time. Advancements in predator (possum) detection tools and understanding of reinvasion behaviour (which could allow us to 'defend' areas) may enable a possum eradication to occur in the future, potentially targeting zones one at a time rather than the entire island.

Methods

Aerial application:
Our current best practise of using helicopters to spread the bait would not work for an island of this size. Currently, helicopters can spread around 800kg of bait per flying hour[5]. Therefore, spreading 4240 tonnes of bait over Stewart Island would take one helicopter 5300 hours or 663 days flying 8 hours a day (or alternatively, 67 helicopters flying for 8 hours a day for 10 days)! As such, we need to find improved efficiencies in delivering bait across large landscapes that significantly speeds up and increases coverage of the target area (e.g. utilising fixed wing aircraft that can carry and distribute larger loads).

[5] Island Eradication Advisory Group (IEAG) meeting notes (15-16 December 2010): Stewart Island Review key stage 1 (docdm-687601).

Presently, in eradications, we apply a considerable amount of bait to the island to ensure that every individual has access to the quantity needed to kill them. However, we do not know if we are overloading the area with more toxin than is sufficient (to kill all individuals). In some operations, this is likely to be the case given some bait is still evident on the ground some weeks after the aerial application has taken place. If we could detect in real time (or close to it) how many individuals are still present after each application, it could allow for different treatment regimes over time, potentially resulting in less toxin and labour being used. If we are able to reduce the amount of toxin used to only that which is necessary, it could result in significantly lower application times and requirements, saving time and resources.

Ground-based components:
Our current tools for detection (e.g. tracking cards/tunnels) and trapping (e.g. DOC series traps in boxes) are too labour intensive for a project of this scale. The track network (and subsequent maintenance) alone would be beyond our capacity (as well as being undesirable across those ecosystems) - not to mention the sheer number of devices needing regular checking, baiting, resetting, and maintaining. The need for new and improved detection tools (with high sensitivity to detect low numbers of animals over large landscapes) is abundantly apparent. If we knew where the animal(s) is, we would be in a position to target our follow-up or response actions with greater precision.

Our current lures for traps (e.g. egg, rabbit meat, etc) do not have the optimum 'pull' to draw in the target animals over a large area, nor to draw them consistently into the device they encounter. As such, we are required to have our devices relatively close together across the landscape which results in a high number of devices and a maintenance regime that becomes prohibitive in a project this size. If we could develop a 'super lure' (or a series of lures for each target species) it would enable us to set our device networks wider and reduce the number of devices within them – pulling the animal to the device, rather than putting the device where the animal is.

One area that does not appear to have been considered in any great detail before now is the idea of deterrents or repellents. Could we develop some form of deterrent that repels animals away from certain areas? This technology could then be used much like predator-proof fencing, and could allow us to establish zones or buffers that the target animals would be very reluctant to enter (or cross) because of the power of the deterrent.

The township of Oban will likely need to be treated using ground-based techniques (e.g. toxin in bait stations, traps, etc). How this is integrated into the methodology and timing of the rest of the operation will need serious consideration, to avoid issues with target animals moving between untreated and treated areas. The idea of a predator-proof fence close to the township has been raised for this project. The merits of this approach will need to be investigated, taking account of the community's views and perceptions (e.g. being excluded from the rest of the island, etc). Predator-proof fencing is discussed again later in the document.

Zoning:
The potentially limited distributions of possums and cats add weight to the possibility of dividing the island into zones to be targeted separately, rather than attempting the elimination over the entire island. Some eradications on large islands (e.g. Macquarie Island) have applied bait over multiple days, and have retreated small buffer zones (over previously treated areas) to reduce the risk of rats moving from untreated into previously treated zones and avoiding encountering bait. The current South Georgia Island Norway rat eradication has been operating under a strategy of treating the island as a series of

islands (or zones) due to the many large glaciers that divide up the island (and are large enough that rats can not cross them). However, no continuous island has been broken up into zones for treatment at different times.

We would need to better understand the invasion behaviour of the target animals, as well as our ability to eliminate predators from areas facing constant invasion pressures, and our ability to defend those areas from reinvasion. Critical to this will be our ability to establish and maintain some kind of buffer area between the zones, be it with a predator-proof fence and/or a network of devices etc.

Tools

Toxins:
Brodifacoum is the most commonly used toxin for rodent eradications on islands. 1080 (sodium flouroacetate) has been used for a number of years to target possums and rats in control operations in New Zealand. These are the only viable toxins that are currently registered in New Zealand for aerial application under specific conditions.

Currently, brodifacoum can not be broadcast aerially on Stewart Island due to the label restrictions (for aerially applied use only on unstocked off-shore islands or mainland areas behind predator-proof fences). Stewart Island would be considered part of the mainland for the purpose of an elimination campaign of this scale (A. Fairweather, pers. comm.). Therefore, it would require a change to its registration – there is a precedent here, with the registration changed to allow brodifacoum to be aerially applied at mainland sites behind predator-proof fences.

The recent development of new humane toxins has largely proven unsuccessful, with only paraminopropiophenone (PAPP) showing promise thus far. PAPP has recently been registered in New Zealand for use in fresh meat bait in bait stations to target cats and stoats. The Australian authorities are trialling some methods for encapsulating PAPP [and separately, 1080] into a bait for aerial application[6] – this work is in its early stages. It is possible that aerial application of PAPP targeting cats would be of benefit for this project, therefore it will require additional trialling and registration here in New Zealand..

There is a considerable amount of research going on into new vertebrate toxic agents (VTAs) for possums at present. These include zinc phosphide (nearly registered); sodium nitrite; and C+C (where two toxins, cholecalciferol and coumatetralyl, are combined). For any of these VTAs to be registered in New Zealand by the Agricultural Compounds and Veterinary Medicines Group, a data efficacy package needs to be submitted that shows the VTA is humane. PAPP and sodium nitrite could be considered the most humane of these 4 VTAs, but all of them will be sufficiently humane to pass registration.

There are field trials underway to look at the efficacy of aerially distributed cholecalciferol; zinc phosphide; and sodium nitrite. However, it will likely be 5+ years before any of these would be available for aerial distribution (because aerial application of these VTAs will need to be approved by the Environmental Protection Authority) (A. Fairweather, pers. comm.).

[6] Johnston, M., Gigliotti, F., O'Donoghue, M., Holdsworth, M., Robinson, S., Herrod, A. and Eklom, K. (2012) *Field assessment of the Curiosity® bait for management of feral cats in the semi-arid zone (Flinders Ranges National Park).* Arthur Rylah Institute for Environmental Research Technical Report Series No. 234. Department of Sustainability and Environment, Heidelberg, Victoria.

Traps and devices:
The 'Good Nature' series of self resetting traps (for possums and rats, with a cat trap being trialled by US authorities in Hawaii) offer a way to reduce the trapping burden (mentioned above in the ground based operations section). This technology is improving all the time, with the number of resets per traps increasing from a single reset (at prototype) to 24 resets for the stoat/rat trap; and 12 resets for the possum trap. The Department is currently undertaking trials of both the rat/stoat; and the possum resetting traps to investigate their reliability, effectiveness and their efficacy compared with the DOC series of traps. As this technology develops and our understanding grows of how best to use it, these resetting traps may offer effective ways of carrying out the ground-based components of an elimination strategy.

Coupled with the development of PAPP, outlined above, has been the development of a new toxin delivery device known as the 'Spitfire', being developed by Connovation Ltd., in association with Lincoln University. This device squirts toxin onto the animal's body as they move through the box. The animal ingests the toxin as they self-groom and then dies. The mechanism of the Spitfire is the same for all target species, but the 'housing' will be tailored for each species – for example, the rat and stoat spitfire mechanism can fit into a standard DOC200 trap box. It is hoped the Spitfire device will have the ability to deliver approx. 100 doses of toxin before it requires refilling. Successful pen trials have been conducted at Lincoln University using PAPP for stoats & cats; 1080 for ship & Norway rats; and zinc phosphide for possums (E. Murphy, pers. comm.). Field trials are being planned for all species.

Use of predator-proof fences
The use of a predator-proof fence has been suggested by many people when they contemplate this project and its scale. One area that could benefit from having such a fence would be behind the township area. Predator-proof fencing technology is sufficiently advanced to enable an order of magnitude shift in the biodiversity gains being achieved around the town. It could potentially serve as a clear demarcation of where aerial application methods end and ground based operations start (depending on how large the area to be treated is); and it could prove to be a key biosecurity tool in stopping invading animals from reaching the rest of the island once clear of predators. Of course, before any fence can be constructed, the Stewart Island community need to agree to it.

However, if fencing technology is going to be used in this project, we need to understand it better. While a number of conservation projects in New Zealand are currently using predator-proof fencing (e.g. Zealandia, Maungatautiri Ecological Island), we consider there are some critical knowledge gaps which need to be answered; such as how animals interact with these fences, how different designs (height, hoods, mesh shape and size, etc) affect performance, and how to manage 'leaks' or breaches of the fence, particularly around the ends (e.g. understanding the use of 'wings' at the fence ends protruding down cliffs or into the ocean).

Deer repellents:
With deer being excluded from this project, it is important that we use cost-effective methods that limit the impact on the deer populations and the associated hunting activities. Key to this will likely be the need to further develop effective deer repellents (both operationally and cost-wise) that prevents deer from ingesting toxin or interacting with devices.

EPRO have developed a deer repellent that is currently used in aerial 1080 operations, but it is labour intensive to apply to the bait and therefore is very expensive. Currently adding deer repellent to aerial 1080 possum operations using very low bait application rates adds approx. $6 per ha to the project cost[7] – as a crude indication, that would add a minimum of $2.04 million to the cost of the bait (at the volumes used above). Not to mention whether it is even possible to manufacture the quantity of repellent likely to be required for an operation of this scale.

Deer repellent has never been used in New Zealand in any toxin other than 1080 (A Fairweather, pers. comm.). Research with deer repellent in 1080 has been shown to reduce red deer by-kill; however further research is needed to determine whether it can be equally (or more) effective in baits containing brodifacoum. Likewise, research is needed to test the effectiveness of deer repellent on white-tailed deer (the more recreationally valued of the deer species on Stewart Island). In addition, we need to understand the effect deer repellents have on the attractiveness, palatability, and efficacy of toxins or devices for the target animals (and other non-target species e.g. native birds – all research/trials to date indicate that the attractiveness of baits to native non-target species is not increased by the use of the repellent).

Bait matrix:
Stewart Island's climate offers a challenge when it comes to the right bait matrix. In current eradication operations, brodifacoum is used in a cereal-based bait matrix. However, this matrix does not handle wet conditions well, becoming 'mushy' and potentially losing palatability. Stewart Island averages 204 wet days a year (days with 1mm of rain or more) according to NIWA's National Climate Database. Bell Laboratories (a US company) produced brodifacoum bait in a more-weather resistant matrix for the Rat Island Norway rat eradication (in the Aleutian Islands) in 2009. If toxic baits are used on Stewart Island, testing will be required to ensure that the matrix selected can withstand conditions on the island without adversely affecting the attractiveness or palatability to the target species (and non-target species).

The bait matrix used to house the toxin could be coupled with the potential advances in lure development (outlined above) to create a stronger attraction for the target animals. It could allow us to use less bait by 'pulling' animals to the bait, rather than placing the bait where the target animal is. Of course, any changes in the bait matrix make-up will need to be thoroughly tested for attractiveness and palatability in both the target and non-target species.

Detection/Monitoring
As outlined above, large scale detection tools are one of the key missing pieces of technology for this project. These detection tools would not only tell us if we missed any individuals, but ideally they would also be able to tell us where those animals are to begin with. As such, it could change how we approach the whole operation – enabling us to selectively target areas with particular tools and/or devices at selected densities depending on the size of the populations detected. These tools could open up the possibility to 'spot treat' areas or divide the island into zones, rather than potentially unnecessarily needing to cover the entire island with toxin or devices.

[7] IEAG meeting notes (15-16 December 2010): Stewart Island Review key stage 1 (docdm-687601).

Non-target species

Deer:
Although deer are out of the scope of this project, they do require serious consideration – especially if toxic bait is used. Deer have the potential to consume large quantities of the bait (unless an effective repellent is used) and create gaps in the coverage, while also killing some of the deer. These gaps could result in not all target species having access to the bait and therefore surviving that aspect of the operation.

Any consumption of bait (if brodifacoum is used) may result in sub-lethal levels of the toxin being present in deer. Brodifacoum residues have been found in some deer samples, in the livers and (to a lesser extent) in muscle tissue, following some brodifacoum operations[8]. Due to the toxin's persistence in the food chain, a ban on consumption of deer meat from Stewart Island will need to be investigated. The current withholding or caution period used by DOC is 36 months (for a bait station operation). With the presence of deer on Stewart Island, it is likely a withholding period of this length would be needed (A. Fairweather, pers. comm..).

Obviously, any withholding periods will have an impact on deer hunting on the island. We consider that the deer hunters should be involved in investigating mitigation measures (e.g. trials of deer repellent involving white-tailed deer, closing zones of the island to hunting during treatment periods, etc) to reduce the impact on deer and hunting activities. This involvement could go some way to achieving greater buy-in from that section of the community, and reduce the perception of any research being captured or biased by DOC.

Native species:
In all eradication operations, there is some level of non-target by-kill of native species (namely birds via primary and secondary poisoning). However, it is impossible to accurately predict the level of non-target losses. It will be important to understand which native species on Stewart Island are at most risk (via bait acceptance trials etc), so that appropriate mitigation measures (e.g. captive holding or translocation off the island for return post-operation) can be investigated and tested.

Stock:
There is a small number of sheep on Rakiura Maori Land Trust land near The Neck. These animals will need to be prevented from eating the bait (if used) – this may best be done by removing the animals from the island to be returned after the operation is completed.

Ngai Tahu

Stewart Island/Rakiura lies within the tribal area of Ngai Tahu. It is absolutely critical that Ngai Tahu is represented on any governance structure that is set up for this project. Without their support for a project of this magnitude, it is extremely unlikely this project will succeed.

The recent eradication work undertaken on the Maori-owned Titi (muttonbird) Islands, off the south-west coast of Stewart Island, has been hugely successful in demonstrating the biodiversity gains that can be made here. Not only has this work illustrated the

[8] Broome, K.G.; Fairweather, A.A.C.; Fisher, P. 2012: *Brodifacoum Pesticide Information Review*. Version 2012/2. Unpublished report docdm-25439, Department of Conservation, Hamilton, NZ. 110p.

damage being done by invasive rats, but also our ability to halt that damage through current eradication techniques. A number of land owners have changed their views on toxins, eradications, etc; moving from 'anti' to 'pro' due to seeing the operation and the results firsthand (P. McClelland, pers. comm.). These land owners could be strong allies and advocates in progressing the Stewart Island project.

Kiore is a valued taonga species by some Maori. Initial conversations with local iwi members suggest that the removal of kiore from Stewart Island will not create significant concern, so long as a population of kiore is maintained within the tribal area of Southland (S. Bull and G. Thompson, pers. comm.). Further discussions will be required with local iwi to determine an appropriate management approach for kiore to address the concerns that a population of kiore is maintained.

Rakiura Maori Land Trust

Rakiura Maori Land Trust manages approx. 8% of Stewart Island, on behalf of Maori landowners. This land is predominately on the east/south-east coast of the Island. It is absolutely critical that they are part of any community engagement (and any governance structure that is set up for this project). Without their support and the ability to access their land, it is extremely unlikely this project will have any chance of success.

Biosecurity

Pathways:
There are a number of pathways for potential reintroduction of predators onto Stewart Island – ferry, plane, fishing vessels, freight, etc. We need to understand these pathway risks and the subsequent invasion and establishment risks. This knowledge will enable us to develop appropriate interventions on those pathways that could greatly reduce the risk of an incursion. As noted above, the choice of target species has implications for the biosecurity risks associated (as different measures will be needed to keep possums off the island, than would be required to keep rats out).

Detection probabilities:
There have been recent advances in our understanding of detection probabilities with regards to island biosecurity, particularly the work on Barrow Island in Australia. It is important that we take those learnings and develop robust New Zealand-centric methodology for understanding the probabilities of arrival, and (arguably more importantly) of detection of an invading individual. This knowledge will enable us to develop appropriate methods of intervention at likely departure and arrival/detection points that could greatly reduce the risk of an incursion developing into an establishing population. There are clear links between this knowledge and the innovation required on large scale detection tools mentioned above.

Invasion biology:
Related to the wider suite of biosecurity issues, we do not know how invading individuals behave at large scale sites. Experiments at smaller sites indicate that individuals move throughout the area (potentially searching for a mate), but we do not know if this type of behaviour holds true over large scale areas nor how the behaviour changes as the establishing populations grows and invades further. This knowledge, coupled with the development of large scale detection tools (outlined above), will likely result in a better methods for responding to biosecurity incursion events (e.g. spot treatment of areas).

Impacts on way of life:
It has been suggested that the biosecurity standards required to maintain predator-free status on Stewart Island would need to be akin to that when entering New Zealand. It is highly unlikely that the residents and visitors to the island would tolerate such an intensive process. If the biosecurity requirements are considered too onerous, people are less likely to conform to them – biosecurity needs to be seen as a 'normal' part of life. Coupled with the developments in detection theory and detection tools, we need to develop a biosecurity system that is effective, but does not unduly impact on individuals and their lifestyles on the island.

Maintenance of the system:
Biosecurity is forever (or for as long as the island is deliberately maintained free from that species). But biosecurity measures cost – both in the prevention and the response side. Any system that is developed will need to take into account the ongoing maintenance involved in having prevention and response components. Likewise, systems will need to be established around who is responsible for detecting and responding to incursion events.

WHERE TO FROM HERE?

As noted above, using current best practise techniques, methods, and technology, it is not feasible to eradicate rats, possums, and feral cats from Stewart Island at this time. However, there are a number of challenges that if met would go a long way to determining whether we could be successful with a project of this scale.

<u>The Halfmoon Bay project</u>
As outlined above, we recommend that the immediate operational goal for this project should be to significantly enhance the biodiversity gains around Halfmoon Bay. Our proposal to achieve this is to target an area encompassing the township (somewhere between 1000ha and 5000ha) for elimination of all the target species (including hedgehogs). We consider that this scale of project is feasible using our current suite of tools and techniques (so long as the community wants the project to happen).

In order to facilitate community engagement and subsequent ownership of this project, we believe that the exact size of the area and methods used to eliminate these predators should be for the community to decide. In essence, we recommend the community be allowed to make the biodiversity gains 'on their terms'.

This smaller-scale project would enable us to ensure a close relationship is in place with the community; and their motivations, attitudes to eradication and the techniques involved, and their willingness to engage with or own a project of scale are completely understood. At the same time, the project will 'bring more biodiversity to the community's backdoor' – building enthusiasm and understanding of the connection between eliminating predators and restoring native biodiversity

A small-scale project around the town will provide the testing ground to determine if we can eliminate predators in the presence of a resident human population. Furthermore, it would help identify whether we are able to defend those biodiversity gains, in the presence of constant invasion pressure. This invasion pressure would allow valuable learning about reinvasion rates onto the island, identifying common pathways and origins for invading species.

We consider that the initial work towards this aspect of the project – namely, the community engagement and building that relationship – could begin immediately. The timing of the subsequent components, depending on what those are (e.g. construction of a predator-proof fence, elimination of the target species, funding models, planning permissions, etc.), will be determined in conjunction with the community.

<u>Critical technical innovations</u>
We have identified several critical technical innovations that would 'change the game' for this project (and most large scale predator control work in New Zealand):

Large scale detection tools – we do not have any proven method that is technically and logistically feasible to detect very low numbers of predators across large landscapes at high sensitivity. Our current tools (tracking cards, etc) are not appropriate for this scale of project. This is our number one technical innovation challenge.
Targeted application of toxin [this innovation would flow on from the detection innovation] – if we are able to solve the detection problem, it could significantly change how we use toxin. Rather than covering all areas at all times with toxin and bait as we do now (to ensure that every animal can access it), we could potentially selectively target areas for treatment based on where we know the animals are present.

Improved efficiency of bait spreading – our current best practise of using helicopters with buckets to spread the bait becomes cost and capacity prohibitive at the scale of this project. This is compounded by our use of bait in quantities that ensures all individuals gain access to it, not knowing whether this is excessive or not. We need to develop techniques or methodologies that require less bait, and/or find ways to deliver bait across large landscapes that significantly speeds up coverage of the target area (e.g. fixed wing aircraft).
Lure development – our current lures (for traps and bait matrix) do not have optimum 'pull' to draw target animals in from large areas. This holds true for all of the target species of this project. We need to develop lures that will generate attraction across landscape scale areas, thereby reduce the need to put devices or toxin where the animal is but rather draw the animal(s) to where the device or toxin is. In addition, we require lures that greatly increase the interaction rate of animals once they encounter our devices – in other words, we need to get more animals going into our traps.
Deer repellent – in order for this project to gain the public support to proceed, we need to develop methods that reduce the impact on deer. Key to this will be the development of effective deer repellent that prevents deer from ingesting toxin or interacting with devices. Associated with that is the need to understand the effect deer repellents have on the use of toxins or devices for the target animals (and other non-target species e.g. native birds).

Knowledge gaps
In addition to the critical technical innovations, a number of important knowledge gaps have been uncovered during this analysis:

Predator interactions: we need to understand how these target species behave in the presence of each other on Stewart Island, especially in relation to habitat usage and competition for resources. There are a number of key questions that require answering, as they will greatly inform the methods, techniques, sequencing of species targeted, and the timing of any operation.
Mice: we need to know if mice are present on the island. This question has never been categorically answered. We need to understand the likelihood of mouse establishment, and a consequential eruption, if all (or some) of the target species are removed from the island; and the ecological consequences of such an event. This knowledge will enable decisions to be made on critical matters such as biosecurity requirements etc.
Predator-proof fencing refinement: if fencing technology is going to be used in this project (potentially to create biodiversity gains around Halfmoon Bay) we need to understand it better. Critical issues to be focussed on include how animals interact with these fences, how different designs affect performance, and how to manage 'leaks' or breaches of the fence.
New toxin application methods: we need to expand the development of toxin application methods, building on the registration of PAPP and the invention of the 'Spitfire' into avenues and methods applicable to large scale projects (e.g. aerially applied PAPP for cats etc.).
Biosecurity: we need to understand the pathway and incursion risks for the island. We need to better understand the probabilities of arrival, and of detection, of an invading individual. This knowledge will enable us to develop appropriate methods of intervention that could greatly reduce the risk of an incursion developing into an establishing population. There are clear links between this knowledge and the innovation required on large scale detection tools.
Invasion biology: related to the wider suite of biosecurity issues, we do not know how invading individuals behave at large scale sites. This knowledge, coupled with the

development of large scale detection tools, will likely result in a better methodology for responding to biosecurity incursion events.

It is our opinion that to drive this innovation forward and address the important knowledge gaps will require a minimum investment of $1 million per annum for the next 5 years.

<u>Governance and Technical Guidance</u>
How this project is governed depends on how it proceeds into the future. There are two clear streams of work outlined in this report:

1) Operational: the Halfmoon Bay project – planning, developing, and executing the elimination of predators to achieve community-driven goals
2) Technical: solving the innovation challenges; while being informed and learning from the operational stream

If the Halfmoon Bay project goes ahead, it would appear logical to have a Stewart Island-centric governance group guiding the operational stream. As a community-driven project, the governance group also needs to come largely from the community. Therefore, membership should span the community – capturing the cultural, economic, societal, and environmental views of the Stewart Island residents (and community at large).

The technical innovation challenges in this report are not Stewart Island-specific, but rather challenges that we will face at most large scale projects throughout the country. As such, the technical group guiding this work could have a much wider focus. Its membership could include experts from the Crown Research Institutes (CRI's), universities, central government, non-Government environmental organisations, and the technological community.

APPENDIX ONE – Identified significant risks and potential risk mitigation projects

Identified Risk	Risk Profile[9]	Potential projects to mitigate risk	Mitigation Success:
The Stewart Island community does not support the project to create a predator-free Island	Likelihood: M Impact: H	▪ Regular community meetings for full disclosure of information for community members ▪ Creation of a Predator Free Governance Board, made up of members of the community, to drive this project forward ▪ Undertake the Halfmoon Bay project, using techniques as decided by the community themselves, to grow biodiversity gains in Oban and illustrate the benefits of a predator-free island	Likelihood: H Benefit: H Likelihood: H Benefit: H Likelihood: H Benefit: H
The scale of the island means some individuals from the target predators are missed during the operation / Inability to detect or find surviving animals	Likelihood: H Impact: H	▪ Development of high sensitivity tools for the detection of low abundance predators at large scale sites ▪ Development of improved lures to greatly increase the attractiveness of our devices to the target species ▪ Continue development of toxin application methods and trap designs to provide more tools for predator elimination ▪ Development of techniques that enable targeted application of toxin or devices (e.g. spot treatment) ▪ Research techniques for defending areas that allow the island to be broken into zones, allowing treatment of smaller areas one at a time (e.g. predator proof fencing; buffer lines of traps; etc) ▪ Research into targeting eradication of individual species, including how the target species behave in the presence and absence of each other on Stewart Island, to identify any unwanted consequences of their removal ▪ Investigate methodologies to enable more efficient treatment of large areas (e.g. faster bait spreading, etc)	Likelihood: M Benefit: H Likelihood: H Benefit: H Likelihood: H Benefit: H Likelihood: L Benefit: M Likelihood: L/M Benefit: H Likelihood: M Benefit: L Likelihood: L Benefit: M

[9] If conducted using current tools and techniques (as per current agreed best practise).

Identified Risk	Risk Profile[9]	Potential projects to mitigate risk	Mitigation Success:
Our current best practise techniques are too labour intensive to be used at this scale	Likelihood: H Impact: H	▪ Development of high sensitivity tools for the detection of low abundance predators at large scale sites	Likelihood: M Benefit: H
		▪ Development of improved lures to greatly increase the attractiveness of our devices to the target species	Likelihood: H Benefit: H
		▪ Continue development of 'resetting' toxin application systems and predator traps to reduce the labour burden	Likelihood: H Benefit: H
		▪ Development of techniques that enable targeted application of toxin or devices (e.g. spot treatment)	Likelihood: L Benefit: M
Reinvasion by rats (and invasion by mice) across the island	Likelihood: M /H Impact: H	▪ Development of high sensitivity tools for the detection of low abundance predators at large scale sites	Likelihood: M Benefit: H
		▪ Research to understand the invasion behaviour of rats at large scale sites, to help with the design of the biosecurity system	Likelihood: M Benefit: H
		▪ Establishment of a biosecurity system to eliminate any arriving animal, based on improved understanding of pathways and probabilities of arrival	Likelihood: H Benefit: H
		▪ Design the biosecurity system with a long-term view to identify how it will continue beyond the immediate future	Likelihood: H Benefit: H
		▪ Predator-proof fence could be constructed between Halfmoon Bay project area and the rest of the island to reduce the risk of invasion spreading to the rest of the island (a second line of defence concept)	Likelihood: M Benefit: H
		▪ Improve predator-proof fencing technology to reduce the number of breaches (particularly at the ends)	Likelihood: H Benefit: H
Inability to access all land to conduct operation	Likelihood: L Impact: H	▪ Regular community meetings for full disclosure of information for community members	Likelihood: H Benefit: H
		▪ Representatives from Ngai Tahu and Rakiura Maori Land Trust are invited to be part of the governance structures for this project	Likelihood: H Benefit: H

Identified Risk	Risk Profile[9]	Potential projects to mitigate risk	Mitigation Success:
		▪ Undertake direct consultation with landowners as to the design of any operation to allow concerns to be aired and (hopefully) resolved	Likelihood: H Benefit: H
Operation inadvertently kills some deer	Likelihood: M Impact: L (H for deer hunters)	▪ Develop a deer repellent suitable for use on any toxins selected for this operation ▪ Selection of low risk (to deer) methods and techniques where appropriate	Likelihood: L Benefit: M Likelihood: L Benefit: M
Operation inadvertently kills some native species	Likelihood: M Impact: L (at population level)	▪ Research whether any proposed operational actions will impact on native species ▪ Investigate mitigation measures to prevent significant impacts (e.g. removing some of the population from the island to maintain in safety for reintroduction etc).	Likelihood: M Benefit: M Likelihood: M Benefit: M
Some pet cats are killed during the operation	Likelihood: L Impact: L (H for pet owners)	▪ Investigation of mitigation measures acceptable to the public (i.e. keeping pets indoors for the duration of the operation; removal from the island for duration of the operation; etc.)	Likelihood: H Benefit: M