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Using Self-resetting Traps for Sustained Control of Stoats on an Inshore Island in New Zealand

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ABSTRACT: Stoats are a major predator of endemic forest-dwelling bird species in New Zealand and are responsible for several local extinctions. Thus, their eradication is key for biodiversity conservation. However, sustained control of stoats is required on islands within an impressive swimming distance of the mainland. Our objective here was to test the use of toxicant-free, automatic traps as a sole means of stoat control on a near-shore island with very high reinvasion potential. We installed a grid of Goodnature® A24 self-resetting traps on Great Island, part of a World Heritage site within Fiordland National Park on the South Island of New Zealand, in October 2016 and undertook pre-feeding and monitoring through March 2017, when traps were set. Within four weeks of setting traps, tracking indices for stoats decreased from 95% to 5% and have so far remained at or near effectively 0% throughout the ongoing project.

KEY WORDS: automatic trap, Goodnature A24, invasive mammals, island biosecurity, *Mustela erminea*, mustelids, New Zealand, stoats

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INTRODUCTION

Invasive species are one of the main drivers of biodiversity loss (Courchamp et al. 2003, MacDonald et al. 2007, Pascal et al. 2010), especially in isolated ecosystems, such as islands, that have high levels of endemism (Blackburn et al. 2004). Introduced mammals, in particular, have had wide-ranging detrimental impacts on native species and human economies, and their eradication is a global conservation focus (Pitt and Witmer 2006). In New Zealand, the Predator Free New Zealand (https://predatorfreenz.org) and Battle for Our Birds (http://www.doc.govt.nz) programmes are continually employing a variety of methods to eradicate introduced pests, including mammals, from the entire country.

Stoats (*Mustela erminea*) were introduced intentionally to mainland Aotearoa/New Zealand by British farmers in the 1880s as a means of controlling the (also non-native and intentionally introduced) rabbit populations (*Oryctolagus cuniculus*) that were negatively impacting the agricultural industry (Gibb and Flux 1973). However, seemingly unaware that they were only meant to consume feral rabbits, stoats rapidly became the most common top predator in New Zealand beech (*Nothofagus* spp.) forest habitats (King 1983, King and Powell 2011), where they were already well-adapted to take advantage of fluctuating prey populations facilitated by mast events (King and Powell 2007). Stoats are a major predator of endemic birds, in particular, and predation on juveniles has been identified as the most important factor contributing to reduction in populations of kiwi (*Apteryx* spp.) on the New Zealand mainland (McLennan et al. 1996). Within 20 years of their introduction into agricultural areas on the mainland South Island, stoats had reached the inshore islands of Fiordland (Hill and Hill 2015). Since 1999, eradication of stoats from New Zealand has been the focus of multiple, multi-million dollar efforts (DOC 2017). However, stoats and other mustelids have proven notoriously difficult to eradicate (King et al. 2009).

Most pest-control efforts in New Zealand, the majority of which have targeted rodents (Towns et al. 2012), have been undertaken using toxicant-based methods (Keitt et al. 2015, Blackie et al. 2013). However, stoats have typically not been directly targeted with toxicants. Stoat eradications have relied on either secondary (more so than primary) poisoning of rats and/or mice (Murphy et al. 1999, Griffiths et al. 2015) or have been an apparent, indirect outcome of rodent eradications that eliminate their primary food source (Griffiths et al. 2015). However, these outcomes imply that toxicant-based control of stoats requires the presence of multiple pest mammals, which is not a given. Direct targeting of stoats has relied primarily on standard trapping methods (e.g., Dilks et al. 2003, McMurtrie et al. 2008), though early efforts to develop humane, stoat-specific traps were relatively unsuccessful (Murphy and Fechney 2003). Regardless of the method(s) used, complete eradication of stoats has been achieved only on a few islands that are outside their swimming range (DOC 2017). Inshore islands inevitably experience occasional incursions.

Because stoats can swim at least three km across open water and may be able to cover twice that distance (Veale et al. 2012, King et al. 2014), a ‘controlled-to-zero’ density of stoats, in which invading individuals are rapidly intercepted and do not reproduce, is currently the best-case scenario for locations that are vulnerable to re-invasion (Anderson et al. 2016). However, continued reproduction of a few, trap-averse individuals has made even this scenario an unlikely outcome for the foreseeable future. Importantly, a reduction in trapping efforts could allow stoat populations to return to pre-control densities, with few founders, within only 2 - 3 years (Anderson et al. 2016). Thus, maintaining stoat populations at effectively-zero levels, or at least levels low enough to benefit native populations (Innes et al. 1999, Hooson and Jamieson 2003,

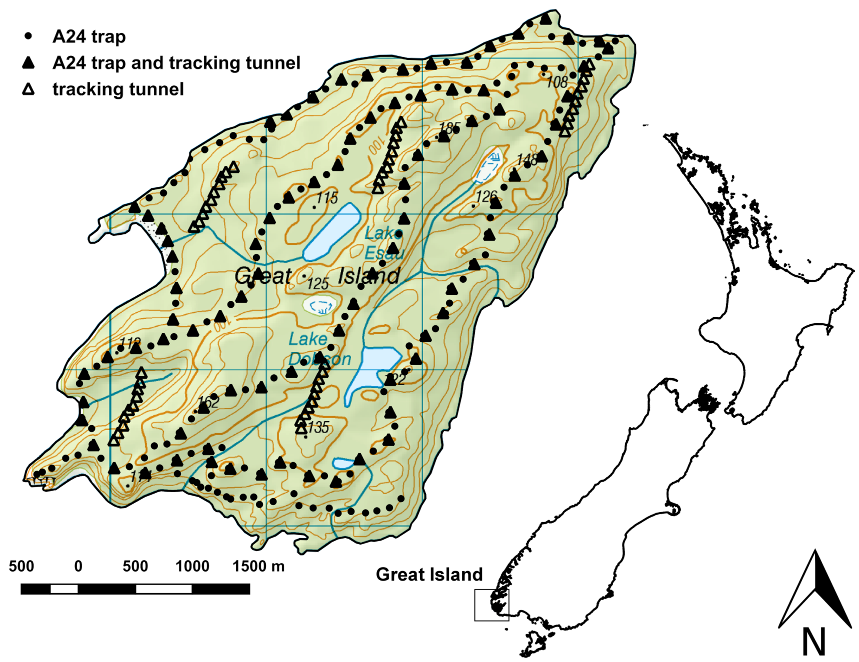

Figure 1. Locations of A24 traps and tracking tunnels on Great Island, New Zealand.

Prada et al. 2014), requires continual, active trapping (Edge et al. 2011). This requirement is true for any location with a high probability of incursion, whether a mainland or near-shore island site. Recent advances in humane, multi-set trapping devices provides a means to maintain an active trapping network with reduced effort.

Self-resetting, toxicant-free traps have been used successfully in multiple pest-control operations, including for simultaneous control of rats and possums on an inshore island (Carter et al. 2016) and rats and mice within a mainland site, during a beech masting event (Carter and Peters 2016) in New Zealand. However, they have no previously been used for direct control of stoats in the wild. Warburton and Gormley (2015), using simulated 30-day control efforts for several different species of pest mammals, including stoats, suggest that the relatively higher equipment costs of self-resetting traps reduces their appeal as a sole means of pest management, if the density of single-set devices is increased to meet the capacity of multi-set traps.

However, Carter et al. (2016) and Carter and Peters (2016) show that, over years-long trapping periods, the costs of using self-resetting traps are comparable to, often lower than, the costs of using single-set traps, especially when maintenance is carried out by contractors, as opposed to volunteers. Franklin (2013) reported that self-resetting traps were more cost-efficient than single-set devices, in terms of labour costs. Thus, while self-resetting traps may be more expensive than single-set devices initially, the reduction in person-hours and associated labour expenditures can substantially lower long-term costs. Importantly, the person-hours that would otherwise be used for resetting single-use traps on a continual basis can, instead, be transferred to additional sites, increasing the spatial coverage of control efforts without increasing labour costs. Here, we tested the use of self-resetting traps as the sole means of controlling stoats on a small island that, because of its close proximity to the New Zealand mainland, has a very high potential for continued incursions.

METHODS

Study Site

Great Island (45°59'46.1"S, 166°33'41.1"E) is a 736 ha, inshore island in the southwestern part of Fiordland National Park, a 1.2-million ha World Heritage Area located on Te Waipounamu/South Island of New Zealand (Figure 1). The Park, which is itself one of the largest national parks in the world (DOC 2017), contains historic habitat for multiple, critically-endangered species of flightless, endemic birds. Thus, control of invasive mammals, particularly stoats, is a high priority, and they have been trapped on at least ten inshore islands within the Park since 1999 (DOC 2017).

Because Great Island is located only about 270 m from the New Zealand mainland and 80 m from its nearest island neighbour, effective control of stoats necessitates the ability to both eliminate the established population and respond rapidly to an incursion. In fact, previous eradication attempts on two Fiordland Islands: Kā-Tū-Waewae-o Tū/Secretary Island and Mauikatau/Resolution Island, which are 900 m and 550 m, respectively, from the mainland, have resulted in control of stoats to sustained, very low levels (Clayton et al. 2011, Edge et al. 2011, DOC 2017). However, true eradication (Simberloff 2011) has proven elusive. Inevitable incursions have not been completely prevented by the current trapping array (DOC 2017). Immediate inter-

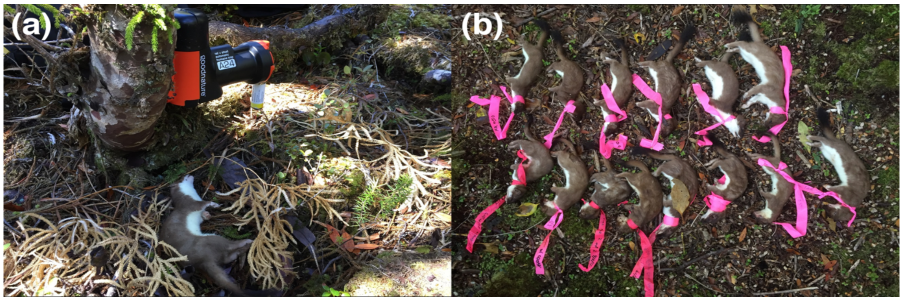

Figure 2. (a) A24 trap and killed stoat on Great Island and (b) stoats trapped during the Great Island stoat control project. Photos courtesy of (a) Mike Butcher and (b) Lindsay Wilson.

ception of new stoats, whether present via incursion or reproduction of the few remaining, hard-to-capture individuals on these islands, is likely the best possible outcome for stoat control in Fiordland National Park until they are eradicated from mainland New Zealand.

Trapping

In October 2016, we deployed 209 Goodnature® A24 self-resetting mammal traps (Goodnature® Ltd., Wellington, New Zealand; https://www.goodnature.co.nz) at 100 m intervals along trap lines, which were established at distances of 300-700 m part, following island contours (Figure 1). The resultant trapping density is higher than that used on, for example, nearby Resolution Island (McMurtrie et al. 2008), where the maximum distance to any single-set trap was 700 m, but where Clayton et al. (2011) estimated stoat home ranges to have a radius of 486 m. Current guidelines recommend maximum trap spacing 800 m to 1,000 m for control of stoats (DOC 2009). However, Smith et al. (2015) recommend a maximum between-trap distance of 400m to ensure that all female home-ranges are intersected.

Traps on Great Island were not set initially (Elliot et al. 2010, McMurtie et al. 2011), but trap sites were pre-fed with rabbit meat. In January 2017, the trap sites were pre-fed with solid Erayz, an extended-life, toxicant-free bait made from reconstituted rabbit (Connovation, Auckland, New Zealand; http://www.connovation.co.nz). The traps were set in early March 2017 and baited with solid Erayz. Baits were subsequently replaced every 2-3 months, and the CO_2 canisters used to power the trapping mechanism were replaced approximately every six months, following manufacturer specifications. In June 2017, baits at 50% of the traps were switched from Erayz to a proprietary, auto-dispensing lure pump (Goodnature® Ltd.), which only had to be replaced twice per year (Carter et al. 2019). Killed stoats were counted at the same intervals at which baits were replaced.

Monitoring

We deployed 105 tracking tunnels [Pest Control Research (PCR) Ltd., Christchurch, NZ] and inked tracking cards (Black Trakka®, Gotcha Traps, Auckland, NZ) at alternating trap sites (i.e., at intervals of approx.-imately 200 m) and an additional 50 tracking tunnels at 100-m intervals along five randomly-located transects (Gillies and Williams 2013) to act as a control (Figure 1). Tracking tunnels were initially baited with salted rabbit meat, in October 2016, then with Erayz, from January 2017. Baits were suspended in a bait cage from the centre of each tunnel, and both baits and tracking cards were replaced every 2-3 months. Replacement dates were opportunistic and varied for tracking cards within the trap sites versus those along random transects.

Published Department of Conservation guidelines for stoat monitoring specify using 3-night monitoring intervals, with tunnels placed at 100-m intervals (Gillies and Williams 2013). However, methods for stoat monitoring in New Zealand are currently under review (pers. obs.). For this project, tracking indices were estimated for the entire preceding 2-3 month period, because rodent (i.e., rat and mouse) activity at the study site is unusually low, reducing the prevalence of interference or misidentification of tracks. In addition, available person-hours were insufficient for undertaking additional monitoring. Thus, tracking indices estimated for this study are likely higher than would be observed on 3-night intervals for a comparable trapping project, even though the density of tracking tunnels within trapping lines was lower.

The locations of traps and tracking tunnels were plotted using QGIS software v 3.0 (QGIS Development Team 2018), using underlying geospatial layers downloaded from Land Information New Zealand (LINZ) Data Service (http://www.data.linz.govt.nz). Results were plotted using the ggplot2 package (Wickham 2009) for R software v 3.4.1 (R Core Team 2017).

RESULTS

Trapping

The first killed stoat observation occurred within the first two hours of trapping. After three days of trapping (7 to 10 March 2017), 17 dead stoats had been located under traps, with a total of 19 dead stoats observed during the first trap-checking period, including one double-kill (Figure 2). Subsequent trap checks in April, June, and September located an additional eight dead stoats, three of which were killed by traps baited with an auto-dispensing lure pump (Figure 3). No additional dead stoats were observed during the most recent trap check, in December

2017. The true number of killed stoats may be higher, since the open trapping mechanism allows for the scavenging of carcasses. However, the observed kills indicate that the initial density of stoats on Great Island was at least one stoat per 30-40 ha.

Monitoring

Prior to the commencement of trapping, tracking indices were similar within the trapping lines and transects. Once trapping started, tracking indices decreased sharply within the trapping lines, but not on the un-trapped transects. The most recent tracking index was 22% within the trapping lines (Figure 3). Occasional rat footprints were also observed on the tracking cards but did not obscure stoat tracks.

DISCUSSION

The A24 self-resetting traps used in this control operation are clearly able to reduce a stoat population to effectively-zero levels within a few weeks, even with a widely-spaced and relatively irregular schedule of site visits. Eradication campaigns for multiple species have shown that, as density declines, remaining individuals become more difficult to catch (Gosling and Baker 1989, Veitch 2001). Predator trapping during summer months, when 'natural' food sources are most abundant, is typically

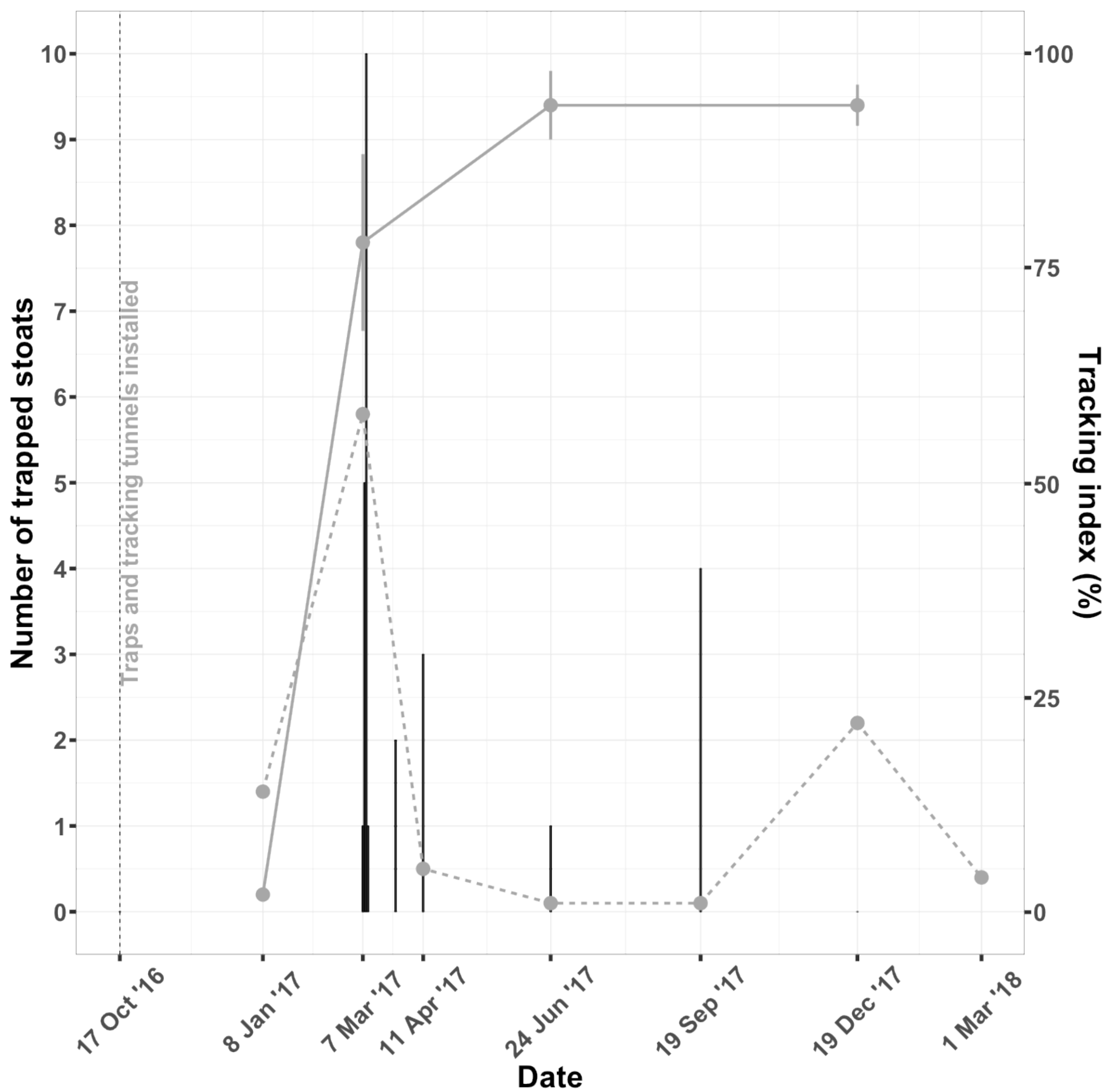

Figure 3. Summary of trapping and monitoring data from Great Island. Traps were set on 6 March 2017. Vertical bars indicate the total number of dead stoats observed, shown on the left axis. Lines indicate tracking indices estimated from tunnels installed on within the trap lines (dashed line) and on separate transects (solid line), shown on the right axis. Tracking indices from transect lines include standard errors.

more difficult, since predators may be less inclined to visit baited traps. Previous work has found that trapping of mustelids can be subject to seasonal, though irregular, variations in capture patterns (King et al. 2009). In addition, female mustelids, in particular, are known to display learned trap avoidance (Murphy and Dowding 1995). The Great Island project is ongoing, and continued monitoring will elucidate whether the higher tracking index in December 2017 was an anomaly or indicative of a pulsed pattern in stoat numbers. Most likely, a few individuals from the non-trapped areas of the island, where tracking tunnels were installed in transects and activity levels remain extremely high, have gradually shifted their ranges to encompass the trapping lines and have yet to be captured. Now that the efficacy of self-resetting traps for stoat control is apparent, expanding the trapping grid to encompass the entire island, rather than maintaining an un-trapped control area, may be considered.

Seasonal beech mast events, which precipitate increases in mean predator abundance (Smith and Jamieson 2003), are predicted to increase in frequency as a consequence of climate change (Tomkins et al. 2013). At locations with populations of both stoats and other pest mammals, such as many mainland forests, control of all predators (e.g., rats, mice, and stoats) is necessary to maximize benefits to native species. The self-resetting traps used on Great Island have the advantage of targeting both mustelids and rodents. However, these two pest groups are attracted by different bait formulae. Barring the development of a universal bait, additional work should be undertaken to determine the optimal order in which pest mammals should be targeted within a single project site to minimize prey-switching (i.e., from rodents to native species) by stoats at sites with multiple species.

Invasive mustelids are a worldwide problem. For example, American mink (*Neovison vison*) are highly invasive in Europe, where they were intentionally introduced, and a conservation-management priority (Nordström et al. 2003, Bonesi et al. 2007). The use of self-resetting kill-traps for control of mustelid populations in Europe is made especially difficult by the presence of native species of both rodents and mustelids. However, two avenues for exploration may include 1) the development of species-specific pheromone-based, as opposed to prey-based, lures that would be less likely to attract native mustelids and 2) the design of trapping plans that exclude native species by targeting species-specific behaviours, including reproductive behaviours. For example, in its introduced range, the American mink reproduces about a month earlier than its European conspecific (Heptner et al. 2002). A carefully planned control operation could take advantage of this and other among-species behavioural differences and habitat preferences to minimize non-target kills in locations with populations of native mustelids.

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