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Predator-free New Zealand 2050: Fantasy or Reality?

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Predator-free New Zealand 2050: Fantasy or Reality?

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ABSTRACT: Possums, stoats, and rats introduced into previously mammal-free New Zealand (NZ) seriously impact our native flora and fauna. As a result, considerable research effort has focused on their control, with excellent success in the eradication of mammals from offshore islands. Unfortunately, we have run out of defendable, non-human occupied islands and the current focus is the NZ mainland, with a new government goal called Predator Free NZ 2050. In 2010, the Centre for Wildlife Management and Conservation started a research programme investigating new control and monitoring tools that could be used on the NZ mainland. More recently (2015) a privately funded research entity called Zero Invasive Predators Ltd (ZIP; both based at Lincoln University) was established with the goal of developing technologies to remove predators from large mainland areas and then defending them from reinvasion. ZIP has since demonstrated that a modified delivery technique for aerial 1080 can achieve near eradication of rodents and possums at two study sites. ZIP was then able to defend both sites in the short term using a virtual barrier of traps and/or geographical features such as rivers. The CWMC (with the Taranaki Mounga Project) investigated the use of self-resetting traps as a ground-based rodent control tool. The traps were unable to maintain average rodent tracking rates below 5% (avg. 11.5%) without regular trap servicing. To maintain low rodent numbers required a trap service every 3-4 months and this is not cost effective compared with alternatives. To improve detection rates the CWMC (with Cacophony Project) have shown that that thermal cameras are 3.6 times more sensitive than trail cameras for detecting possums. These cameras will quickly find survivors and/or reinvading animals using species recognition software combined with wireless communication. As Predator Free NZ 2050 scales up, more pest control will take place near urbanised areas. As such, the next focus should be the development of control tools with higher social acceptance. Surveys indicate the preferred control options are trapping and species-specific toxins. What this feedback highlights is that future research needs to reduce the cost of trapping so that it is affordable for community groups. In addition to this, funding is required for the registration of species-specific toxins, which have higher public acceptance.

KEY WORDS: brushtail possum, *Mustela erminea*, rat, *Rattus*, rodent control, self-resetting rodent traps, stoat, thermal cameras, *Trichosurus vulpecula*

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INTRODUCTION

Mammal species are some of the most damaging and widespread invaders worldwide. They are a major threat to biodiversity, causing environmental degradation, modification, and species extinctions throughout the world (Mack et al. 2000, Courchamp et al. 2003). When humans first settled New Zealand, in approximately 1280 A.D. (Wilmshurst et al. 2008), the only terrestrial mammals present were three species of bats (King 2005). Since then, 31 species of land mammals have become established with 25 of these now considered pests (Cowan and Tyndale-Biscoe 1997). The arrival of these mammalian species has been the main driver for the loss of over 40% of terrestrial bird species (Duncan and Blackburn 2004). Currently there remain 168 species of native birds in New Zealand. Of these 93 are not found elsewhere and over 30% are considered threatened (PCE 2017), the highest proportion of any country in the world (Clout 2001).

To address these threats, vertebrate pesticides are often used in New Zealand (NZ) to mitigate problems caused by introduced mammal species (Clout 1999, Innes and Barker 1999). For example, compounds such as brodifacoum have been successfully used to conserve endangered species (Innes and Barker 1999) by eradicating rodents and other introduced mammals from offshore islands. To date, NZ has successfully eradicated invasive mammals from 105 islands, being 10% of our offshore island land area (Russell et al. 2015). Because of this, 16 species of invertebrates and 76 species of vertebrates now have improved prospects (Bellingham et al. 2010, Russell et al. 2015). Unfortunately, we have run out of defendable, non-human occupied islands and the current focus is the NZ mainland, with a new government goal of ridding NZ of rats (*Rattus* spp.), possums (*Trichosurus vulpecula*), and stoats (*Mustela ermine*) by 2050 called "Predator Free NZ 2050" (herein PFNZ2050).

To achieve PFNZ2050, new mammal pest control tools and strategies are required (Russell et al. 2015). There is a current reliance on 1080 (sodium fluoroacetate) for the NZ mainland and brodifacoum for offshore island; however, both compounds are under increasing public scrutiny primarily related to animal welfare and risks for non-target species (Cowan 1998, Blackie et al. 2014). Established in 2010, the Centre for Wildlife Management and

Conservation (CWMC; based at Lincoln University) began a research programme investigating new control and monitoring tools that could be used on the NZ mainland (Beausoleil 2016) As such, there was a focus on tools that would have high social acceptance as any mainland eradication attempt will require almost total community buy-in (Russell et al. 2018). More recently (2015), a privately funded, research and development entity called Zero Invasive Predators Ltd (ZIP; with a research facility at Lincoln University) was established with the goal of developing technologies to remove predators from large mainland areas and then defending those areas from reinvasion. This article presents some research highlights from these two research groups with a focus on tools that remove, defend, and detect the PFNZ2050 species on mainland NZ.

RESEARCH HIGHLIGHTS

Removal

Aerial 1080 to Achieve Zero Invasive Predators: ZIP

Whilst effective, the current aerial 1080 prescription does not completely remove possums and rats over large areas. ZIP, in consultation with the Department of Conservation (DoC), OSPRI Ltd and Landcare Research developed a new prescription with two non-toxic prefeeds and 50% overlapping sowing of the prefeed and toxic bait to ensure complete bait coverage (Table 1). A second application of 1080 (with a bait and lure change) can be used if required.

This prescription was first tested in a 400-ha core block on Mt. Taranaki surrounded by a 1-km buffer which was also treated. In order to detect the presence of survivors, 835 chew cards (NPCA 2015), 421 tracking tunnels (Gillies and Williams 2013), and 80 trail cameras were deployed. Pre-trial monitoring using chew cards indicated that possums and rats had relative indices of 6% and 98%, respectively.

After four rounds of monitoring, it was estimated that 15-20 rats (46,755 detection opportunities) remained from an estimated starting population of 2,000 and only one possum was detected with 36,430 detection opportunities. Subsequent live trapping of rats caught 13 adult and five juvenile rats.

Ground Control with Resetting Rat Traps: CWMC with the Taranaki Mounga Project

Also, on Mt. Taranaki, a 1,000-ha site was set up in 2017 using Goodnature A24 rat traps with a 100 × 50 m grid spacing (2,160 traps). Monitoring of rats was done using 12 lines of tracking tunnels (Gillies and Williams 2013) checked at least five times per year. The site was set up to test the effectiveness of resetting traps, and also to protect North Island robin (*Petroica longipes*) reintroduced to the mountain with 100 individuals released during 2017-2018. The traps were serviced every 3-6 months when both the gas canister and lure were replaced with a goal of maintaining an average tracking tunnel index of $\leq$5%.

Following 17 monitors over 31 months there was a total of 187 rat detections (1,680 detection opportunities) with an average tracking tunnel index of 11.5% ($\pm$2.1 SE). The biggest predictor for higher numbers of rat detections was time since last service ($Z = 4.94$, $P < 0.001$) and distance from the centre of the block ($Z = 1.94$, $P = 0.052$), with distance of the tracking tunnel to the nearest Goodnature trap non-significant (Figure 1). Further analysis suggests that the traps were able to protect a core area of 0.56 km from the centre of the block with the probability of detecting a rat within this area at $\leq$5% ($\pm$1.9%, 95% CI). To obtain the best result, traps needed to be serviced every 3-4 months, suggesting that traps on the perimeter of the block were running out of gas and/or lure; this was found to be not cost-effective.

Defense

Virtual Trap Barrier: ZIP

In 2015, a 2-km-wide virtual barrier of traps protecting a 400-ha peninsula at Bottle Rock in the Marlborough Sounds was established This barrier initially consisted of six lines of Tun200s; being two DOC200™ single action stainless steel kill traps set in custom built 'run-through' wooden trap box. These lines were ~100 m apart and each device on a line was 10 m apart and lured with peanut butter (Connovation Ltd, Manukau, NZ).

Over a period of five months the virtual barrier caught 160 ship rats, with at least nine breaching the barrier (~6% leakage; Bell et al. 2019). On average, 40 ship rats/month attempted to cross, and the effectiveness of each line (independent of line position) at trapping individual rats was estimated at 40% (33-46%, 95% CI).

River Barrier: ZIP

Whilst peninsulas may be easier to defend (see above) in large areas on the mainland that are completely surrounded by predators, natural features such as substantial water bodies or alpine ranges present an

Table 1. Modified aerial prescriptions for 1080 control on NZ mainland (ZIP 2017**).**

	Island Eradication Best	Standard Aerial 1080	ZIP Modified Technique
Toxin	Brodifacoum	1080	1080
Number of prefeed applications	0	1	2
Bait sowing rates	8kg/ha + 4.5kg/ha (when targeting a single rodent species)	1kg/ha for prefeed; up to 2kg/ha for toxin	2kg/ha for prefeed; 4kg/ha for toxin
Bait swath overlaps	50% overlap; then 25% overlap	0% overlaps (or up to 5%)	50% overlaps
Exclusion zones	None (as much as possible)	Around huts, waterways, and some tracks	None (as much as possible)
Wind restriction	As little as possible	Must be less than 20 km/hr (typically)	Must be less than 10km/hr (typically)
Repeat operation (with bait and lure change)	No (two applications of same bait occur in single operation)	No	Yes, if surviving rats or possums detected

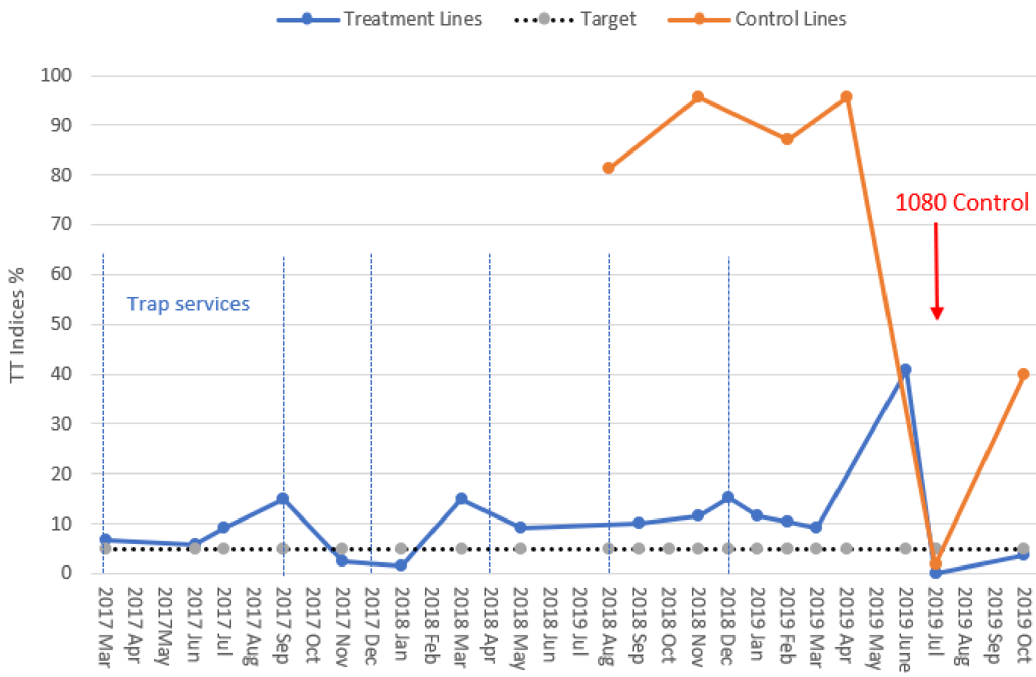

Figure 1. Tracking tunnel monitoring results (2017-19) at Mt. Taranaki, New Plymouth, New Zealand, while Goodnature A24 traps are active (blue, treatment lines) and reference areas without trapping (red, control lines). Dotted vertical line represent trap service dates and dotted horizontal line is 5% target. Treatment lines were within a 1,000-ha treatment area and Control Lines were placed within 1 km of the treatment area. Both Control and Treatment lines were included in an aerial 1080 control operation undertaken in July 2019 over all of Mt. Taranaki.

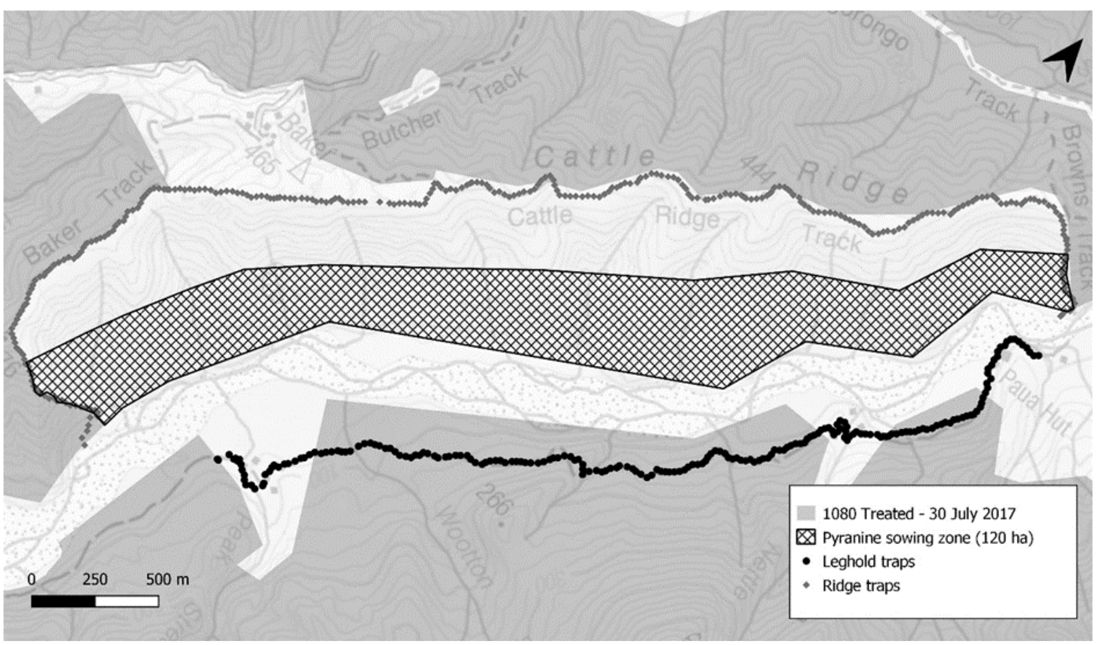

Figure 2. Trial location and layout while using a natural river as a barrier to invasive vertebrate movement, Remutaka Forest Park, Wairarapa, New Zealand. Background is Land Information New Zealand Topo50 licensed by LINZ for re-use under the Creative Commons Attribution 4.0. The Leghold traps were placed below the riverbed and the Ridge traps were placed on Cattle Ridge Track above the first river terrace.

alternative option. To test the effectiveness of a river barrier, researchers deliberately left an exclusion zone of 250 ha bordering a small river located in Remutaka Forest Park (mean flow 2.58 m^3/s; GWRC 2018; Figure 2). The shaded area was treated with aerial 1080 (0.15% concentration) using 6-g baits and an application rate of 2 kg/ha. The top Ridge line of the exclusion zone used 275 Trapinator™ kill traps targeting rats and possums (CMI

Limited; 1 trap/20 m) and the bottom Leghold line was protected using DOC200™ kill traps (for rats) and 205 possum leghold traps (Pest Control Research Ltd; 1 trap/20 m). On the top side of the river, non-toxic 6 g cereal baits were aerially sown containing 0.2% concentration pyranine being a non-toxic biomarker (Pyranine sowing zone). In addition to the aerial baits, bait bags containing six 6-g pyranine baits were placed every 20 m along the river edge and continuously replaced every 4-5 days over a total period of 59 days.

After 59 days, 202 possums and 59 ship rats had been trapped and examined for the presence of the biomarker. The results indicated that even a small river with low flow appears to be a very effective barrier for possums, and somewhat effective for rats, for nearly 60 days post-1080 aerial control (Table 2).

Table 2. Numbers of animals marked with pyranine trapped on both sides of a braided river.

Species	Side	Marked	Unmarked	% Marked
Possum	Top Section (above)	82	76	51.9%
Possum	DoC200 (below)	0	44	0.0%
Rat	Top Section (above)	3	21	12.5%
Rat	DoC200 (below)	2	33	5.8%

Defense

Thermal Cameras: CWMC with Cacophony Project

New Zealand currently has a national standard for rodent monitoring using tracking tunnels baited with peanut butter (Gillies and Williams 2013). Recently there has been concerns about the sensitivity of this technique given a recent study where passive infrared trail cameras detected significantly more hedgehogs and rats than tracking tunnels at 40 monitoring sites in an urban city (ratio 1.84:1; Anton et al. 2018). Whilst trail cameras appear to improve detection rates, it is still likely that other animals were not detected given that we know trail cameras do not always trigger when a small, fast-moving animal moves in front of them (Glen et al. 2013). Additionally, these cameras use infrared illumination at night which may also deter some animals (Newbold and King 2009).

Recently CWMC compared passive infrared cameras with thermal cameras developed by Cacophony Project using captive possums in a 2-ha enclosure. Initial trials indicate that the thermal cameras are 3.6 times more sensitive than off-the-shelf trail cameras and six times more sensitive than chew cards (Table 3). It is likely that the thermal cameras are more sensitive as the motion detection is done using software, so the sensitivity can be adjusted. Additionally, they do not require infrared illumination to operate at night. The videos collected by the thermal cameras are then classified using AI technology (machine learning) to identify the animal species and only keeping a recording for the target pests, which can be stored on-board or sent out using the cellular network. Initially the AI technology struggled with species ID; however, with a higher resolution camera (160 × 120), and a library with >50,000 tagged videos for the machine learning model, the cameras are now getting 87-97% identification accuracy (CP 2018) and will continue to improve with more training.

Table 3. Numbers of possum detections using thermal camera, trail camera and the chew cards at two different distances from camera. Number 1 indicates a detection, number 0 indicates no detection.

Date	Thermal Camera	Trail Camera	Chew Card 10 m	Chew Card 20 m
16-11-2018	1	1	0	0
16-11-2018	1	0	0	0
16-11-2018	1	0	0	0
19-11-2018	1	0	0	0
21-11-2018	1	1	0	0
24-11-2018	1	1	0	0
24-11-2018	1	0	0	0
24-11-2018	1	0	0	1
25-11-2018	1	0	0	0
25-11-2018	1	0	0	0
27-11-2018	0	1	0	0
30-11-2018	1	0	0	0
1-12-2018	1	0	0	0
2-12-2018	1	0	0	0
3-12-2018	1	0	0	1
3-12-2018	1	0	0	0
7-12-2018	1	1	0	1
12-12-2018	1	0	0	0
12-12-2018	1	0	0	0
Total	**18**	**5**	**0**	**3**

CONCLUSIONS

New Zealand has an impressive history of removing invasive mammals off islands; however, many bird species are located in small, isolated populations, on offshore islands, in mainland sanctuaries, and in remnants of habitat remaining at risk of inbreeding. Thus, we need the removal of predators over larger areas of mainland habitat so that bigger populations of birds can thrive. The announcement of the PFNZ2050 goal and significant private investment in conservation is now focusing attention on the eradication of three main predators being stoats, rats, and possums.

Recent research from ZIP and the CWMC have provided some new tools and techniques that should improve the control of predators on the NZ mainland; however, localised eradication is a difficult task requiring six main conditions to be achieved for likely success (Bomford and O'Brien 1995). On the remove side of the equation, the modified aerial 1080 ZIP prescription indicates an ability to get very close to localised eradication first at a 400-ha treatment block in 2016 and then at another 2,300-ha site in South Westland (see details below). Getting the last animal is a difficult task as evidenced on the 1967-ha Kapiti Island where it took seven years to remove all possums (Brown 2002). Ground-based rat control using multi-kill traps was investigated at a 1,000-ha site on Mt. Taranaki in 2017. Whilst unable to keep rat tracking below 5% (average 11.5%), substantial population reductions were achievable with regular trap servicing. With a trap service cost of ~$30/ha NZD, such a trapping regime needs to extend the interval between the services. Currently, there is a requirement to service the traps 3-4 times per year to maintain low rodent numbers. This is certainly not as cost-effective when compared with other control options such as aerial 1080 at ~$20/ha NZD (Ross and Bicknell 2006).

On the defend side of the equation, virtual barriers of traps show promise, as they gave some protection to a 400-ha peninsula; however, there was an estimated 6% leakage and it is possible some animals breached the barrier and remained undetected. There is currently over 7,000 ha of habitat on the NZ mainland protected by some form of predator barrier fence (Scofield et al. 2011). A problem with these exclusion fences is the initial high construction and long-term maintenance cost for the standard 1.8-m-tall predator fence ($400/m NZD) (Bell et al. 2019) and the extreme difficulty building in rugged terrain and/or around waterways. In terms of cost, the cutting of the service track, installation of traps and other capital costs was calculated at $250/m NZD, which compares favourably. This cost also includes the cost of installing a remote-reporting system (when traps are activated) and an automated lure dispenser for each trap with 12-month capacity (Sjoberg and Bell 2018).

River barriers also show potential for possums in the Remutaka Forest Park. Given we know that ship rats can swim across significant ocean waterways to invade offshore islands (Bagasara et al. 2016), we had expected a slow-braided river not to pose a significant impediment to movement; however, very few marked rats were also found to have crossed the river. Following this another trial took place at a 2,300-ha study site in Perth Valley, South Westland. This site is protected by two larger rivers and has a monitoring network of 97 trail cameras, 964 tracking tunnels, and 482 chew cards. Following removal of all possums and rodents, using the modified 1080 prescription, no surviving or reinvading animals were detected for at least 55 days post-control (ZIP 2017). This was possibly the first time that both rodent and possums had been completely removed using aerial 1080; however, confirmation of this result requires very sensitive monitoring equipment, and the trial is ongoing.

This leads to the final part of the equation being defend. To confirm eradication any survivors need to be detected, and our current monitoring standard for rodents using tracking tunnels is not as sensitive as trail cameras. Recent research by the CMWC indicates that thermal cameras are even more sensitive than the trail cameras, and this could be important when populations numbers are very low. For trail cameras another issue has been dealing with the analysis and storage of many photos that can include false positives and false triggers, although software options are being developed to deal with this (Falzon et al. 2019). The potential game changer for the thermal cameras is AI identification combined with instantaneous remote reporting of detections. This will substantially reduce labour costs by eliminating the need to check substantial numbers of images and enable managers to target survivors/invaders immediately. Device sensitivity combined with instantaneous reporting will be paramount; however, this type of system currently has a high battery demand and will require frequent service visits.

In conclusion, the above research is certainly advancing pest control; however, for localised eradication on the NZ mainland we remain reliant on aerial 1080, which can be politically difficult to use (PCE 2013). Additionally, an attempt to eradicate rodents using resetting traps was partially successful in the short term, but considerably more expensive than alternative approaches using toxins. As PFNZ2050 scales up, future control work will increasingly take place in and around urban areas. As such, the next most important advancement would be availability of control tools that can be used by community groups. Public concerns cannot also be overlooked, and research into contraceptive vaccine for possums was stopped in 2010 partly due to the public controversy over genetic engineering (PCE 2011). A recent survey indicates very high public awareness (84%) of the problems introduced pest species pose for conservation (Russell 2014); however, the preferred control tool choice is highly varied and target species dependent. For example, trapping and shooting (62% and 87%, respectively) have high support as control tools for possums (Fitzgerald et al. 2000), whereas a species-specific toxin for rodent control is rated highest with 52% support, which is well ahead of gene-drive technology with only 32% support (Russell 2014). What this feedback reinforces is the need to develop more cost-effective strategies for ground control using smart traps (Bell et al. 2019). In addition to this, funding is required for the registration of species-specific toxins, such as norbormide (Ma et al. 2018), which has higher public support.

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