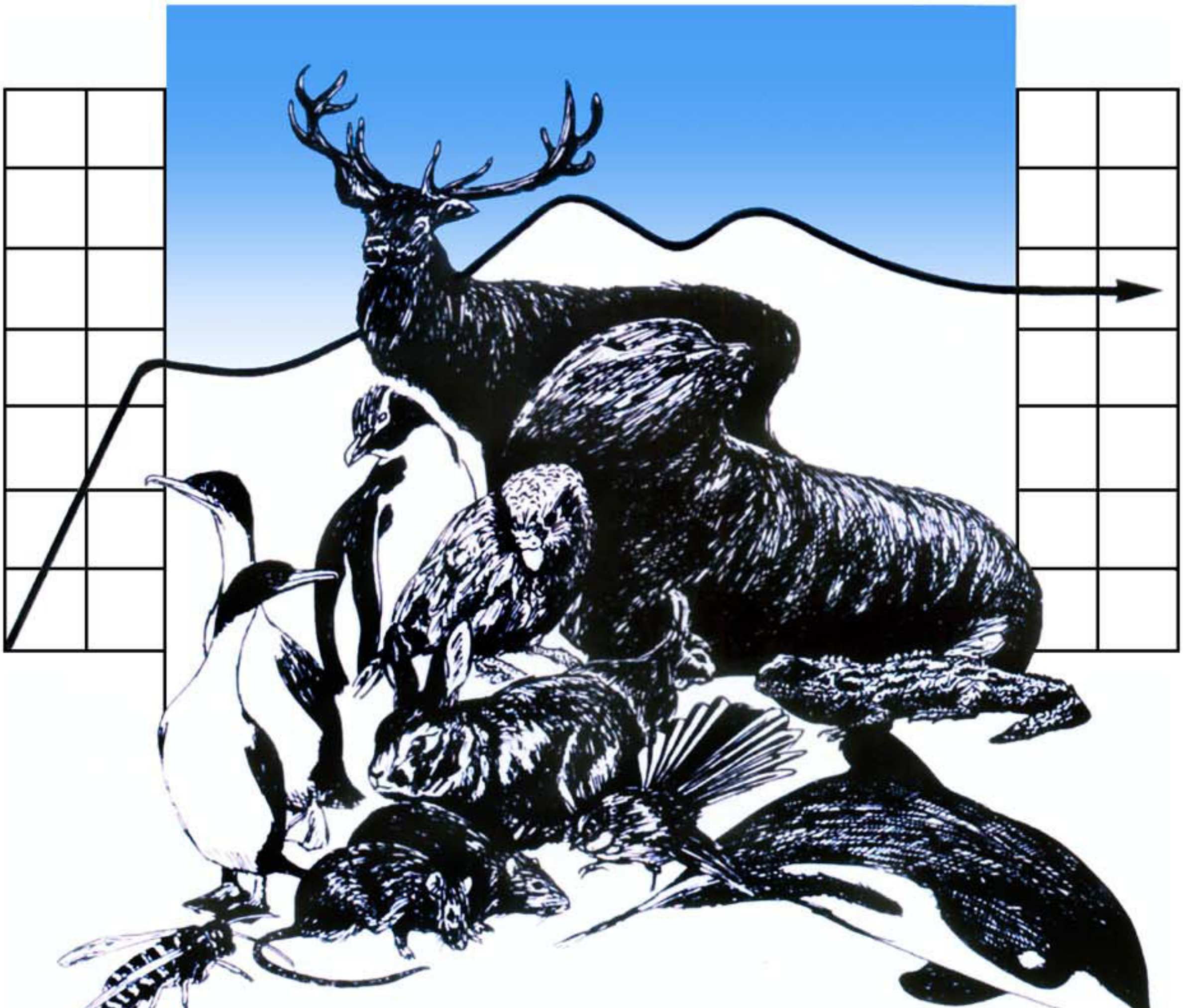
DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Can a landscape scale predator control regime be employed to ensure sustainable recruitment in endangered mohua (Mohua ochrocephala) populations, South Island New Zealand.

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Can a landscape scale predator control regime be employed to ensure sustainable recruitment in endangered mohua (*Mohua ochrocephala*) populations, South Island New Zealand.

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Abstract

In the last 200 years many of New Zealand's native avifauna have under gone drastic reductions in range and as a result have become very rare or even extinct. New Zealand conservationists are world leaders in island conservation, yet the ultimate goal remains in managing species, in large forest tracts on the mainland in the face of introduced predators bought on by human colonisation.

The aim of this study was to investigate options for cost effective landscape scale predator control by monitoring the effects of each on a sensitive indicator species, the mohua (*Mohua ochrocephala*). By studying the beech tree phenology as the driver for the predator plagues and using tracking tunnels to index predators the study concluded that high rat (*Rattus spp.*) tracking rates resulted in high nest predation and poor breeding performance in our indicator species. This study revealed aerial 1080 to be a cost effective method in reducing rats during beech masts to a level where mohua could be productive to a sustainable level and thus ensure longevity of mainland populations.

Keywords: *Mohua ochrocephala*, Masting, *Nothofagus*, *Rattus*, 1080, brodifacoum, Catlins forest park, Dart valley, Predation, tracking tunnels, nesting success, predator control.

Introduction

The mohua (or yellowhead, *Mohua ochrocephala*) is a small insectivorous, hole nesting passerine, endemic to the South Island of New Zealand. It belongs to the endemic genus that includes the whitehead (*M. albicilla*) and brown creeper (*M. novaezelandiae*). All three species have been faced with habitat destruction brought on by the arrival of Europeans in New Zealand but only the mohua has disappeared from extensive areas of relatively unmodified forests and is continuing to decline (Elliott & Suggate 2003). Historical records report they were present in most forest habitats in the South Island and Stewart Island (O'Donnell 1996). They are now all but absent from 75% of their former range, this contraction has occurred largely in the last 30 years as small remnant populations lost the battle with introduced predators and became extinct (Gaze 1985, O'Donnell & Dilks 1986, O'Donnell 1996a and Elliott pers. comm.)

Mammalian predators introduced to New Zealand with Polynesian and European settlers have been blamed for the decline of many native bird species (King 1984). Elliott (1996) suggested that adult mohua mortality outside of the breeding season was uncommon as mohua forage high in the trees, however stoats (*Mustela erminea)*, at least in the Eglinton valley, were responsible for mortality on the hole nesting females. When stoat numbers were high 67% of nests and 50% of females were predated by stoats.

Their range has contracted southwards and mohua are now only found in large forest blocks in the south of the South Island. Several populations (Mt Stokes & Burwood Bush) have become extinct as a direct result of an influx in predator numbers in response to a Beech (*Nothofagus spp.*) masting event. While others have required supplementary transfers of birds from more productive sites as the period between predation events is insufficient for the population to remain viable. Most of the forests which mohua remain are now part of large scale predator control programmes with the key sites falling under the umbrella of the Operation Ark project.

Mohua are considered “nationally vulnerable” with conservation dependency as their qualifier under the Conservation Status of NZ Birds (Miskely et al. 2008).

Operation Ark began in 2004 with its purpose is to preserve sustainable populations of five key species on the mainland South Island. The operational objective is to ensure integrated management and protection of the species on the sites and to counter the effect of predator plagues in beech forests in the South Island. The species targeted for protection were Kakariki karaka (*Cyanoramphus malherbi*), Mohua, Whio (*Hymenolaimus malachorhynchos*) and Pekapeka (*Mystacina tuberculata tuberculata* , *Chalinolobus tuberculata*)

Rats, Stoats and Possums are the main predators to be controlled to prevent further threatened species decline. Although large scale predator control is possible, it is expensive. Therefore the Department of Conservation has prioritised control in 10 sites throughout the range of the key species for maximum conservation benefit

Extensive beech flowering and seeding follows warm summers in the previous year. Rat plagues follow heavy beech seeding. The increased food supply from seeds, insects and mice increased stoat and rat numbers which then reduced populations of the key species by up to 90% in some unprotected areas (Elliott & Suggate 2003).

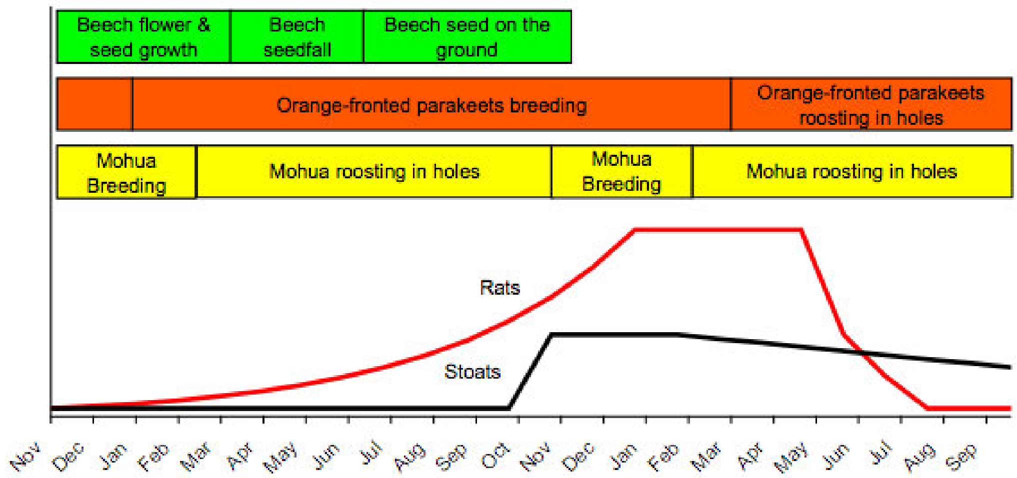

Figure 1. Predator Cycle

This report presents the monitoring results of mohua nesting success from the Catlins and Dart Operation Ark areas in response to a range of predator control methods. The aim of the study was to find a cost effective management solution to ensure mohua remain a part of the South Island beech forest ecosystem.

Methods

Study Sites

This study was undertaken in two sites between 2004-2010 during summer in beach mast years (04/05, 06/07 and 09/10)

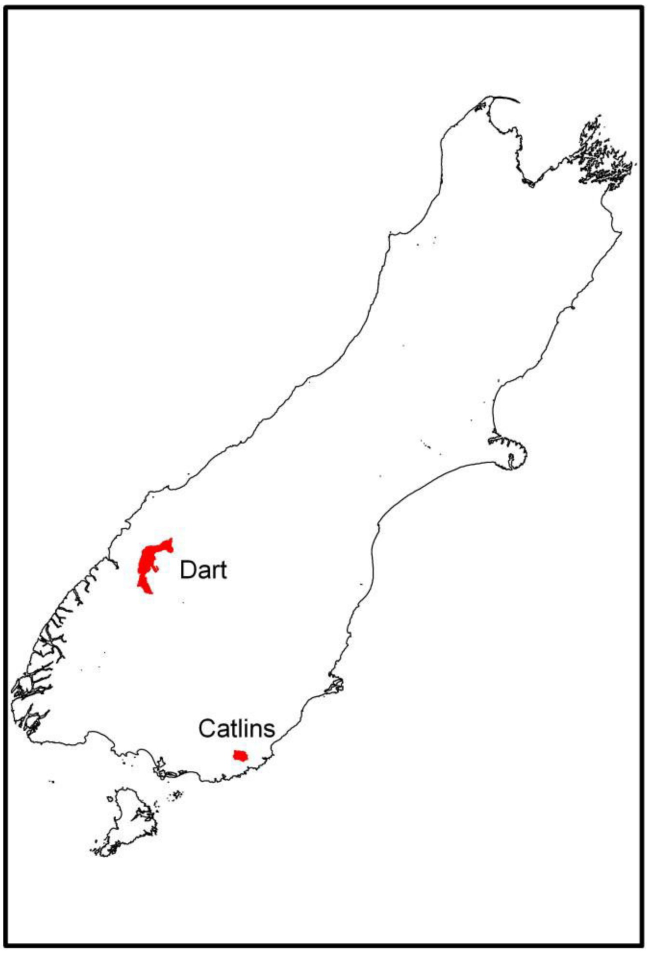

Figure 2: Study site locations

The Dart- Caples

The Dart-Caples Operation Ark site (fig 3) comprises 72,000 ha of native forest, and alpine tops (or 25,000 ha of forest) in Mt Aspiring National Park (35,5543 ha) about 30 km west of Queenstown.

The operational area comprises a mosaic of red beech at low altitudes in the valley floors and silver and mountain beech elsewhere. It has one of the three largest remaining populations of nationally endangered mohua, probably about 25% of the current population. Mohua are the focus of predator control efforts in the Dart-Caples and the aim of the predator control is to maintain mohua populations at approximately their current levels (Elliott & Suggate 2003).

The mohua monitoring was carried out in the Dart catchment in two subsites acting as treatment and control areas.

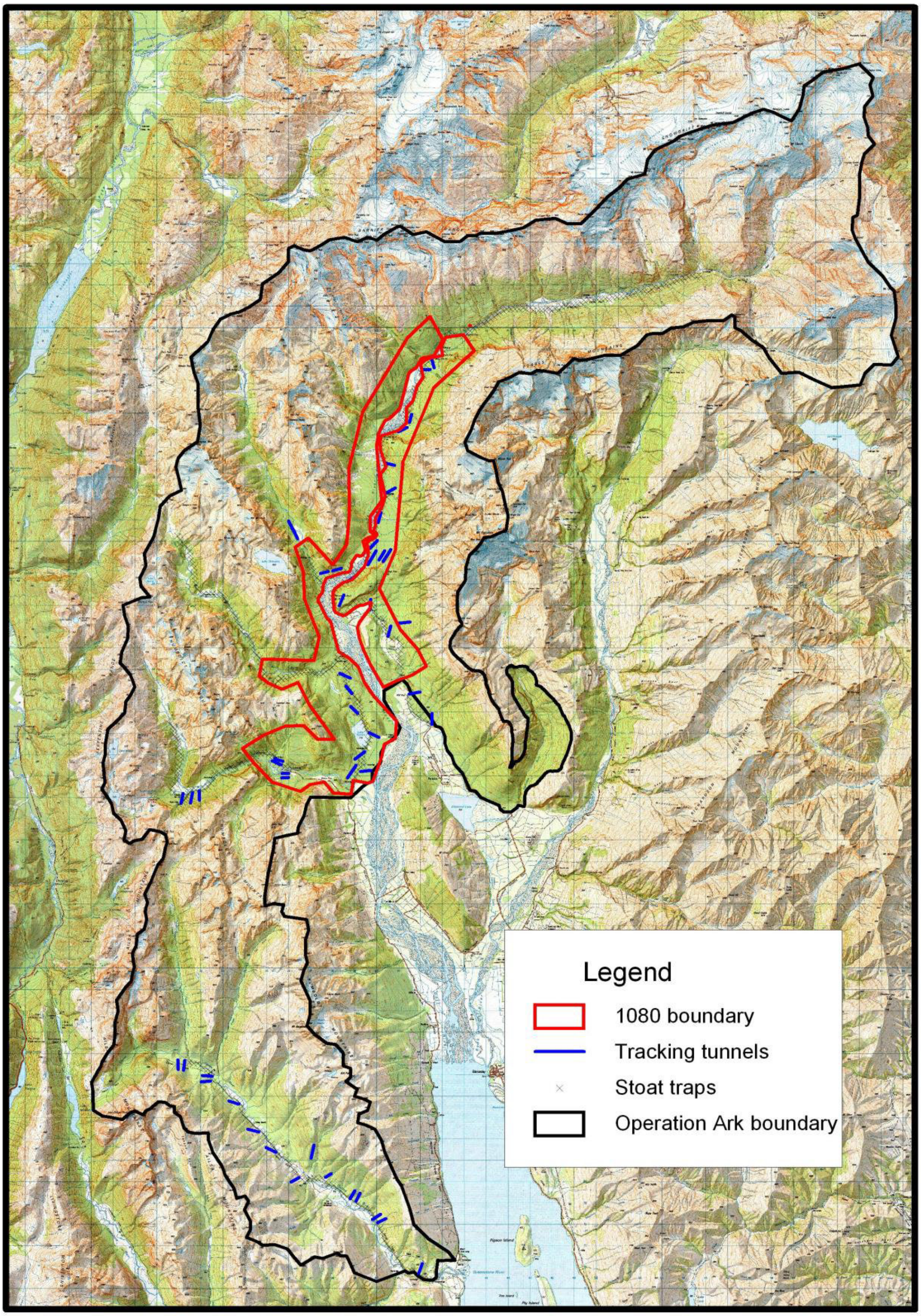

Figure 3: Dart study site

Catlins

The Catlins Operation Ark site (fig 4) comprises 12,651 ha of native forest, which is part of the Catlins Conservation Park (53,000 ha), is about 100 km southwest of Dunedin. This forest is the largest remaining area of native forest on the east coast of the South Island.

The Operational Area comprises a mosaic of predominantly silver beech, with fringes of Podocarp-hardwood forest, and subalpine yellow-silver pine (Lepidothamnus intermedius) - cedar (Libocedrus bidwillii) forest. The Catlins has one of the three largest remaining populations of nationally endangered mohua, probably about 25% of the current population. Recent surveys show that two to three thousand mohua are present in about 8500 ha of the operational area (Elliott & Suggate 2003).

Mohua are the focus of predator control efforts in the Catlins, the aim of the predator control is to maintain mohua populations at approximately their current levels.

Mohua monitoring was undertaken in the Thisbe and Daphne catchments with the Thisbe acting as the treatment area and Daphne as the control.

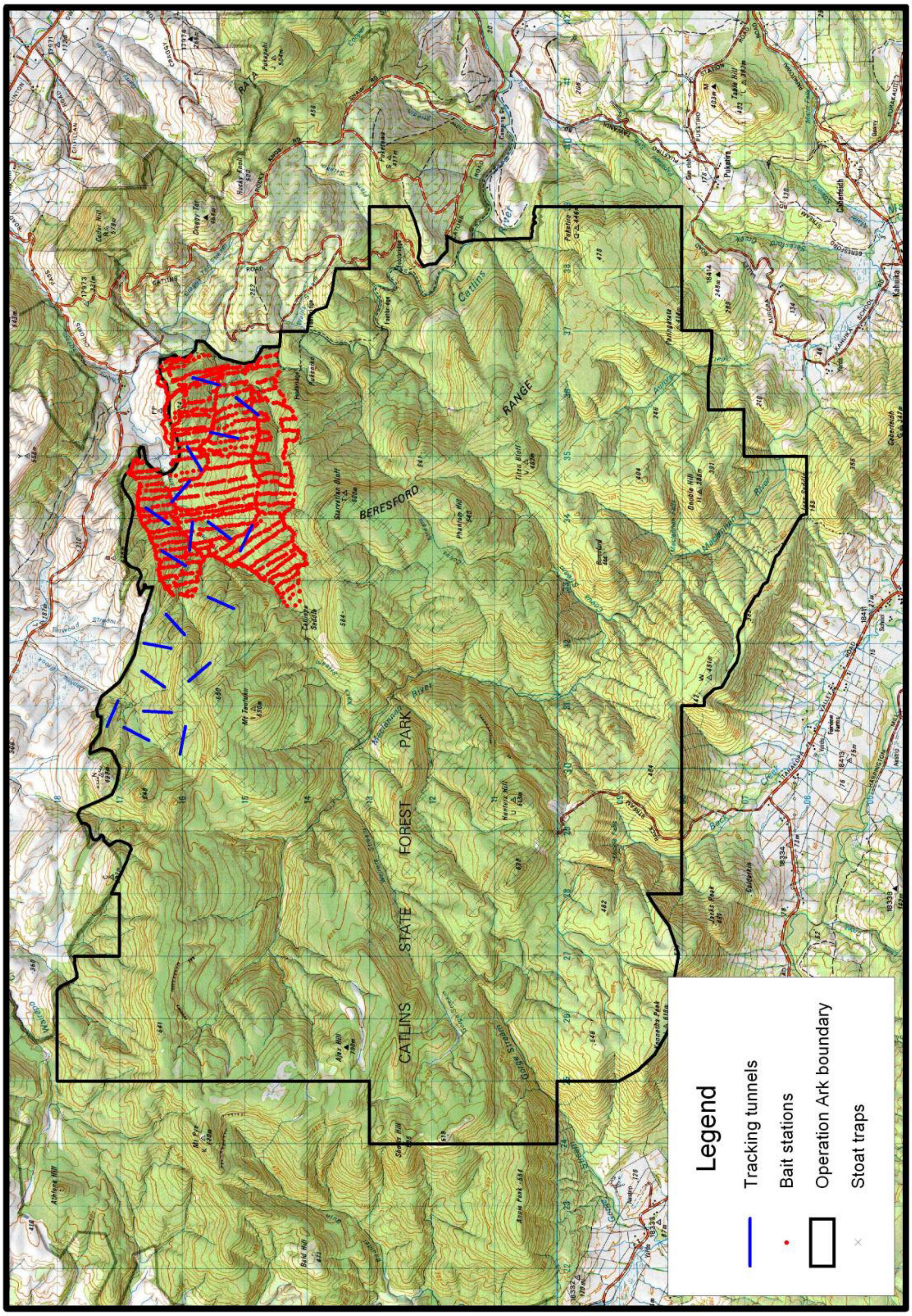

Figure 4: Catlins study site

Beech mast- seed trays

Determining the occurrence and scale of a beech mast was undertaken by the use of a network of seed collection funnels placed randomly through the operational areas at each locality. Each funnel collects the seeds that fall following the summertime flowering. Seeds are caught in a stocking secured to the end of the funnel. The seeds are dried and counted with the count being multiplied by the size of the upper aperture of the funnel (0.28m2) so it can be expressed in seeds per m2.

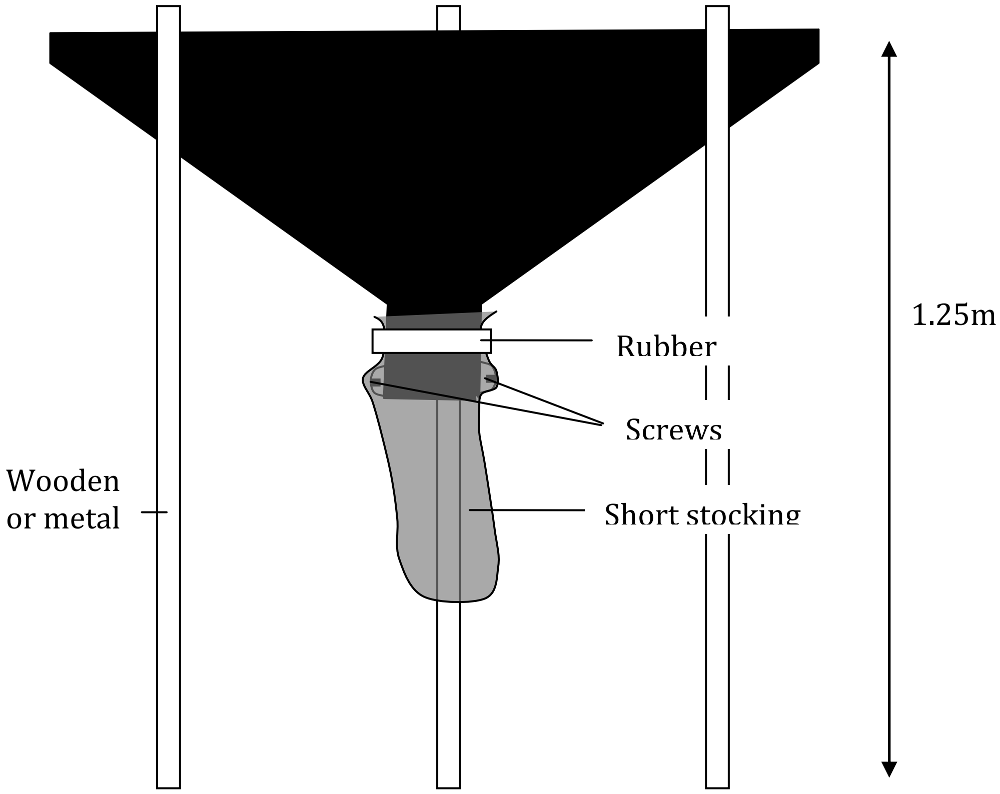

Figure 5: Seed tray

High seedfalls in the seed trays indicated the potential onset of a predator plague in the following summer, which initiated a management response to predator control and mohua nest monitoring.

Tracking tunnels

Tracking tunnel lines are in place at both sites to measure the seasonal pulses in predator density as the beech masting cycle feeds the system. The tunnels are run monthly over three days. The first night the tunnels are baited with peanut butter to track rats and mice and the second night the tunnels are baited with rabbit meat and let to run for the next two nights to track mustelids. The animals enter the tunnel to get the bait and step in ink on route leaving footprints on a tracking card upon exiting the tunnel. The tunnels were run using "Trakka" pre inked cards (http://www.gotchatraps.co.nz/) and the methodology set out in Gillies & Williams (2002) .

Predator control operation methods

Both localities have an existing network of stoat traps which ran for the entire length of this study in both the treatment and control sites. The trap network used a mixture of "Fenn mark 6" and "DOC 200" traps double set in boxes.

A variety of other predator control methods were trialled and are detailed below.

Table 1: Predator control methods

Site	Year	Method
Catlins Treatment	2004	Ditrac in bait stations at 125m x 50m intervals
Catlins Treatment	2006	1080 & Brodifacoum bait stations at 125m x 50m intervals
Dart Treatment	2006	Brodifacoum in bait stations at 100x100 intervals then pre fed Aerial 1080 3kg/ha, 0.15%
Catlins Control	2007	Animal Health Board Aerial 1080
Catlins Control &	2009	Pre fed Aerial 1080 1kg/ha, 0.15%
Dart Treatment	2009	Pre fed Aerial 1080 1kg/ha, 0.15%

Mohua nest monitoring

Nests were found by locating singing males in the forest. The males are generally flying around their territory singing their territorial song. The males were then followed to see if they were attending a nesting female. Females generally spend 40-60 minutes incubating then 15-20 minutes feeding off the nest with the male. The male is followed until either a female turns up or one hour has elapsed indicating the male does not have a partner.

The behaviour of the pair during the feeding period can only be described as “frantic” with the female constantly foraging only pausing for the male to feed her. During this courtship feeding the female will flutter her wings begging for the food item often emitting a high pitch trill. The female will then make a f purposeful flight back to her nest. At this stage the female is pursued and with luck a nest is located, although this often takes more than one incubation cycle to pinpoint the nest. The process is made more complicated by the occurrence of helper birds that can be confused with females or make the pair appear non-nesting and the fact that all this is going on 20m above you in the canopy of the forest.

Once the nest is located the tree is climbed to confirm that it is indeed a nest and to establish what the contents and stage of the nest is. A ring of sticky string is placed around the base of the tree with the theory being that any potential predator will leave some hair on the sticky string en route to the nest. The nest is then visited every 3-5 days to see if the nest is still active. Two scenarios arise from the nest observations, either the nest successfully fledges or it fails, if the latter occurs the nest is re-climbed and nest cavity inspected if it looks to be a predation event the contents is swabbed for DNA analysis along with any hair from the sticky string around the base of the tree.

Statistical Analysis

From the nest observations a data set was obtained consisting of season start, day nest found (*i*), checked and found still active (*j*) date found failed (*k*) and fate (*f*). This dataset is then imported into program MARK using the nest survival function. The Nest records were divided into groups comprising of site (Catlins or Dart) and treatment or control. The productivity values in Elliott (1990) were averaged to 1.5 broods per season and a linear relationship was assumed between productivity, survival and nesting success.

Table 2: Brood averaged productivity values from Elliott (1990).

Normal Year			
	0	0	0.97165
	0.2246	0	0
	0	0.8295	0.78975
Beech Mast Year			
	0	0	0.4545
	0.2246	0	0
	0	0.8295	0.4853

The corresponding formula from the slope and intercept (productivity=2.7655x-0.6517, survival=1.6281x-0.1659, x= nesting success) were used to construct matrices for each treatment and control based on the nesting success outputs from MARK. Each matrix was an average of one masting year and two intermediate years which is slightly pessimistic given beech masting occurs every 3-4 years (Wardle, 1984) The population growth rates from the dominant eigen values of the transition matricies were calculated(Groenendail et al 1988) using the “eigen” function in the stats package “R” to gauge the success of the treatment regimes.

Results

Beech mast- seed trays

Beech masts occurred in the summers of 2004/2005, 2006/2007 and 2009/2010 in the Catlins and in 2006/2007 and 2009/2010 (fig 6). As a result different predator control methods were trialled in each year.

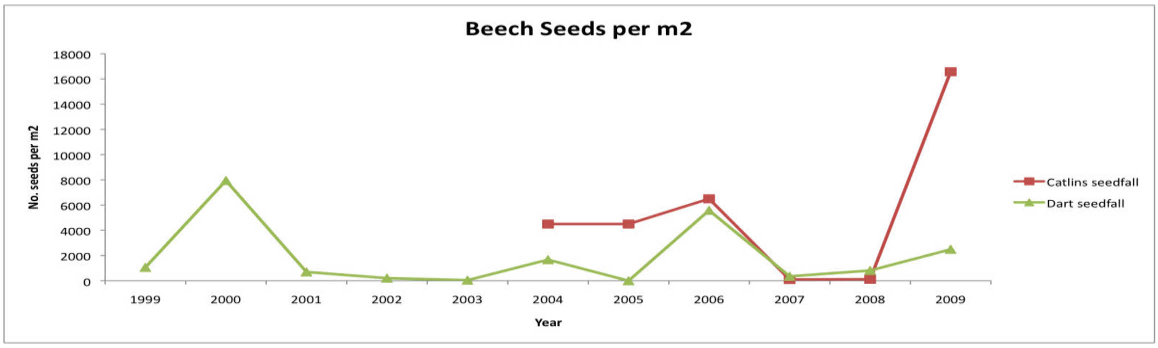

Figure 6: Seed tray results

Mohua Nesting success

The nesting success of mohua varied greatly in response to a range of factors present in the complex forest ecosystem. This study monitored 153 nests over 3 beech mast years and recorded 32 nest failures. The differing scale of each mast and the differing scale of the rat population eruption make it difficult for tight comparisons between treatment methods. The presence of expansive trap networks for stoats, which are available to catch rats in the control areas, coupled by the poor nesting success prove that trapping is not effective at controlling rats in a masting year. High rat numbers seemed to be the biggest drivers of predation events and although we could not confirm rats actually predating nests, the high tracking and high predation rates appear highly correlated. When a rat population explosion occurred and the treatment was efficient the difference in nesting success of mohua was significant.

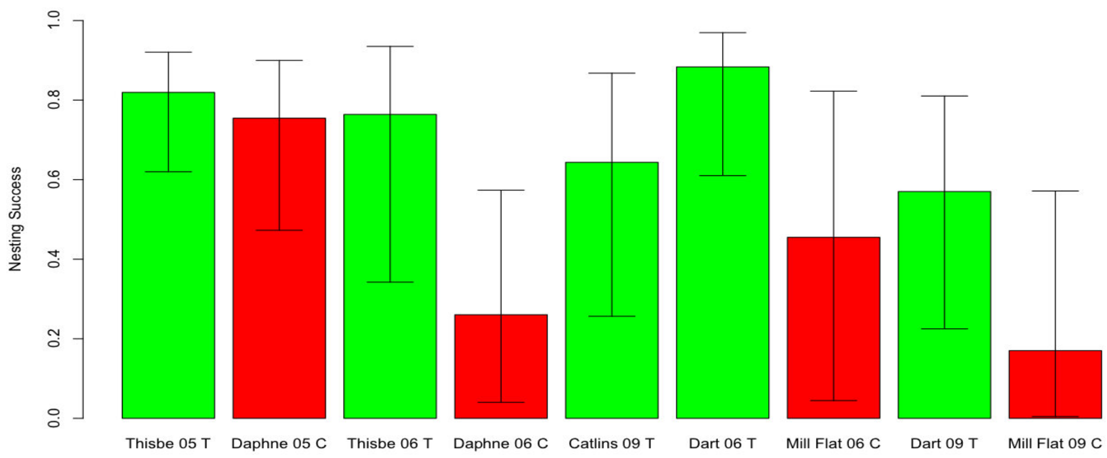

Figure 7: Nesting Success at all sites

All results need to be taken in the context of the tracking tunnel and treatment results in order to piece together a picture of what is occurring within the system. Nest failures were broken down between sites as well as between treatment and control areas. Predation events were only recorded if obvious predated remains were found upon climbing the tree and observing the nest. All predated nest trees were checked to see if the sticky string around the tree had picked up hair from the predator. Unfortunately this method was not effective for mohua as only two predation events were confirmed by this method during the course of the study. The unknown category contains many possible scenarios including abandonment, inability to access the nest and cryptic predation events.

The results from the breakdown of predators are inconclusive if treatment sites receive less predation events from the nest failures than the control sites.

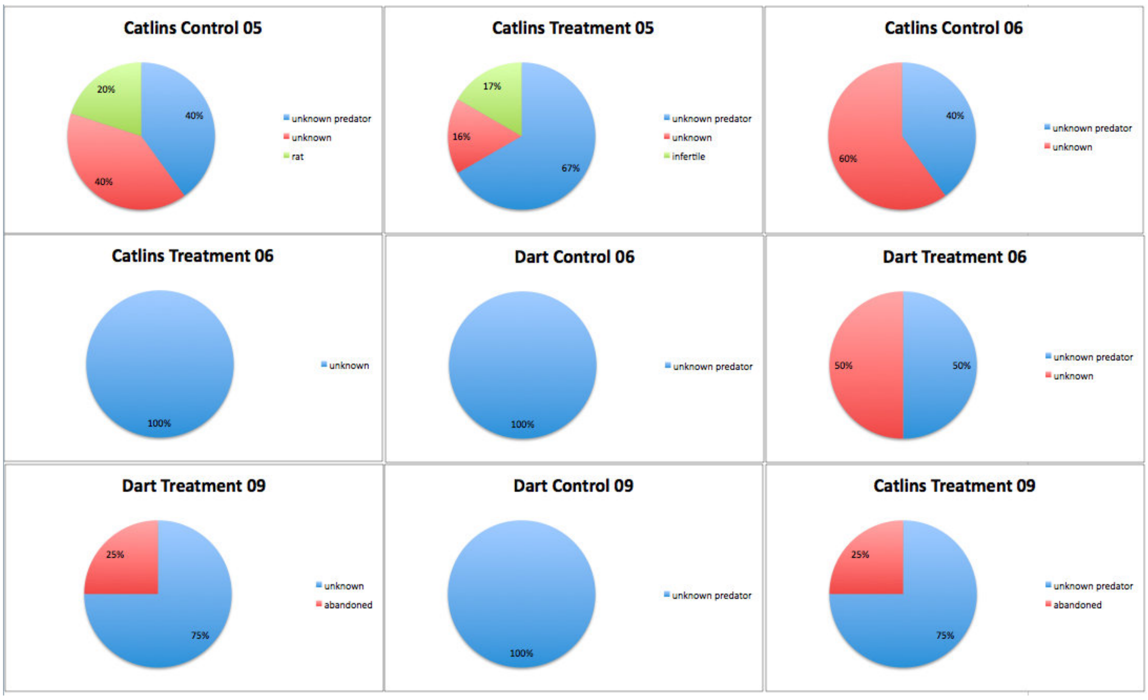

Figure 8: Breakdown of failed nesting attempts

Predator control response

Rat tracking

Rats showed the greatest response to the predator control operations of all introduced animals tracked. However it is clear that some predator control operations are vastly more effective than others. There is also great variability in the size of mast and the size of the rat population peak, which is very hard to predict when planning a predator control operation.

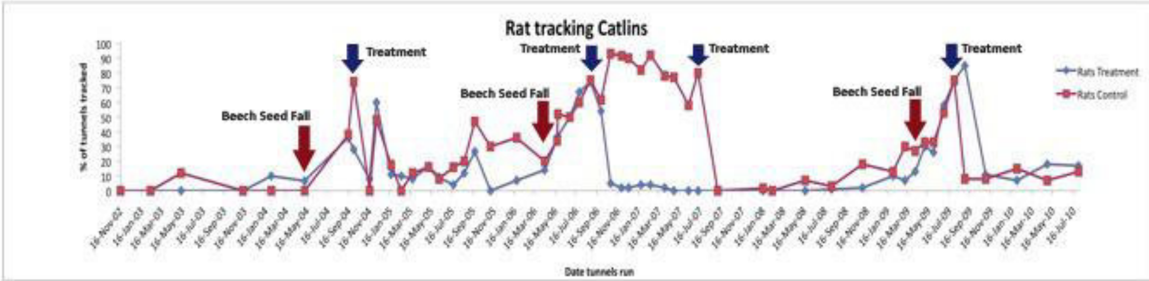

Figure 9: Catlins rat tracking

Catlins 04/05 Ditrac bait stations

The Ditrac bait stations trial showed rats took a significant reduction in population size as a result of the poison, however they were still tracking at a high enough rate to recover to their original peak. This is a little concerning as the potential scale of the beech mast didn't really eventuate according to the seedfall results (fig 6). The ineffectiveness of this method is also confirmed with the very similar nesting success results (82% Treatment & 75% control) from the treatment and control areas (table 3).

Catlins 06/07 1080/ brodifacoum bait stations

The ground based bait station treatment was very effective in this moderate sized masting event in the Catlins. It instantly reduced the rat population to very low tracking results while the control site continued tracking a very high number of rats. The Animal health board conducted an aerial 1080 drop targeted at possums (*Trichosurus vulpecula*) to control bovine tuberculosis in the control area in June. The rat numbers in the control site dropped as a result, although the rat numbers were expected to drop at that time anyway as the seed was germinating. This expected collapse in the rat population happened in the Dart (fig 10) at the same time without the poison. Mohua experienced significantly better breeding success in the treatment area than in the control with 76% and 26% respectively.

Catlins 09/10 aerial 1080 1kg/ha

The Catlins experienced the biggest masting event recorded since seed collection began. The seedfall was over twice as heavy as recorded in previous masting years. The low sow rate of 1080 at 1kg/ha was effective in reducing the rat population immediately to low levels but still detectable levels. There was no control for this study as the whole of the Catlins Operation Ark area was poisoned. The reasoning for this was that from the results of the 06/07 year it was clear the mohua population could be decimated with no rat control in a heavy beech mast year.

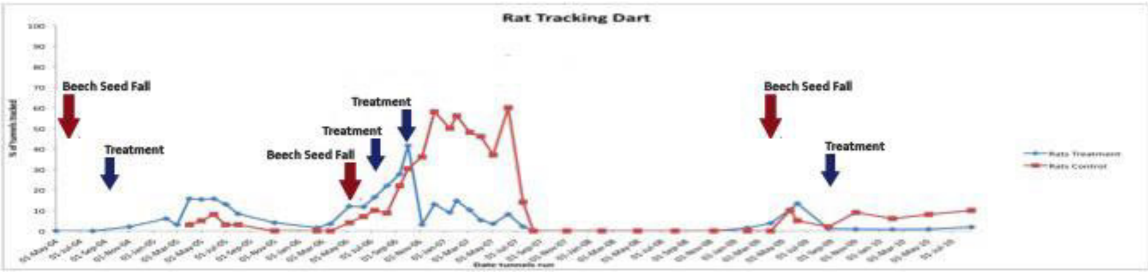

Figure 10: Dart rat tracking

Dart 06/07 brodifacoum bait stations, then aerial 1080

The use of brodifacoum bait stations was originally intended to act as a replicate to the Catlins study however it was clear from the tracking rates that the rat population was still increasing and poison was not being taken by the rats at the expected rate. From this it is reasonable to conclude that when food is super abundant rats are less likely to encounter bait stations and therefore will continue to experience population growth. To save the mohua population from a potentially disastrous breeding season the decision was made to conduct an aerial 1080 “rescue” operation at 3kg/ha. This proved to be very effective even when there was abundant food present in the forest and reduced rats to low but, still detectable levels.

Dart 09/10 aerial 1080 1kg/ha

The Dart experienced a small beech mast in 2009. The methodology was the same as the Catlins operation. The treatment reduced rats to undetectable tracking rates, although from the control area the rat population never really took off. The mohua still had considerably better nesting success in the treatment area 57% to the 17% in the control. The nesting success in the treatment area was still not sustainable. It was thought by the field workers that nests were being abandoned rather than suffering from predation events due to the fact that the banded females were often found after the nest had failed which is not normally the case.

The true measure of success of the predator control operation is whether or not the level of improvement in nesting success results in a sustainable recruitment into the population and a resultant population growth rate (λ). The results for the 2005 summer in the Catlins show both the treatment and control are sustainable but the rat plauge never really eventuated. The results from 2006 in the Catlins show the treatment was very effective and good sustainable nesting success was achieved in the treatment area, while the control had no chance of long term survival. The Aerial 1080 treatment in the same year in the Dart again showed sustainable recruitment in the treatment, and the population to be in steep decline in the control. The 2009 operation in the Catlins was also effective and resulted in a positive population trend. There was no control for that year as the whole Operation Ark area was treated leaving no comparable site for a control. The results for the Dart for the same year showed the treatment was successful, yet the nesting success was not sustainable but was still much worse in the control. There is potential that other factors played a part in the lower observed nesting success in the treatment site such as abandonment due to starvation, as suggested by the field workers which is backed up by the nesting failure breakdown (fig 8) with no sign of predation at any of the failed nests.

Table 3: Productivity values and population growth rates

Site	*Observed Nesting Success*	*3yr average nesting success*	*Productivity*	*Survival*	*Growth rate λ*
Catlins 05 T	0.819289672	0.664429891	1.1858	0.9158	1.649226
Catlins 05 C	0.754540825	0.642846942	1.1261	0.8807	1.415814
Catlins 06 T	0.763963516	0.645987839	1.1348	0.8858	1.44804
Catlins 06 C	0.260447523	0.478149174	0.6706	0.6125	0.3553211
Catlins 09 T	0.643517594	0.605839198	1.0237	0.8204	1.075799
Dart 06 T	0.883501246	0.685833749	1.2450	0.9507	1.910012
Dart 06 C	0.455030033	0.543010011	0.8500	0.7181	0.6467531
Dart 09 T	0.570108493	0.581369498	0.9561	0.7806	0.8887604
Dart 09 C	0.170254962	0.448084987	0.5875	0.5636	0.2603089

Mouse tracking

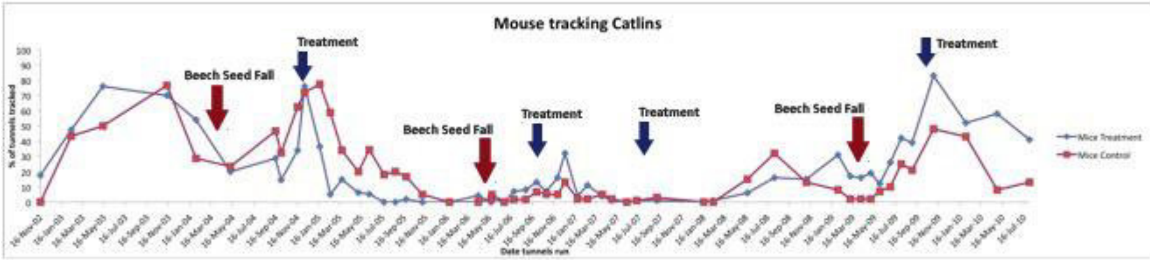

Figure 11: Catlins mouse tracking

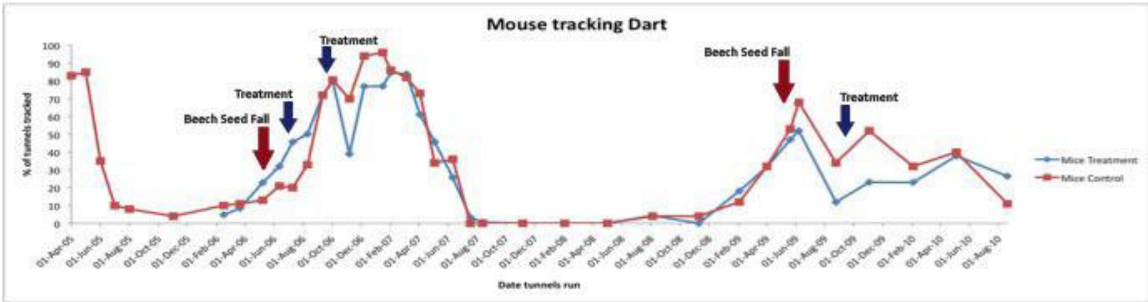

Figure 12: Dart mouse tracking

Mice seemed to follow a seasonal influx in population over the summer months and a more pronounced population spike following a beech masting. The mouse tracking stabilises then decreases significantly after seed germination, presumably as food availability becomes a limiting factor. Mice do not seem to be significantly affected by any of the predator control operations trialled in this study as the control sites followed the same trend.

Stoat Tracking

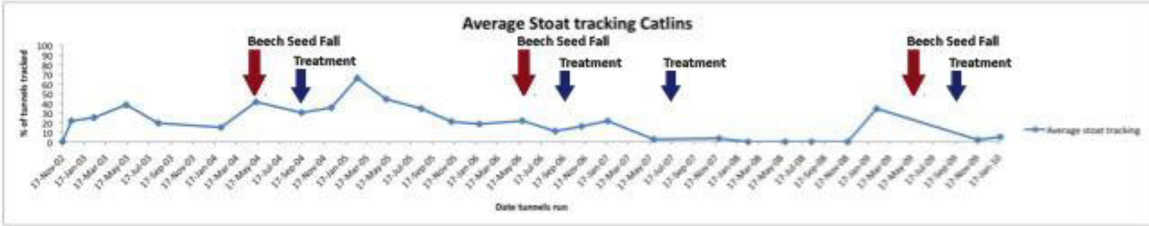

Figure 13: Catlins stoat tracking

Figure 14: Dart stoat tracking

Stoat tracking remained fairly low with a small peak in tracking rates over the summer at both sites during the study. The reason for the slowly declining winter tracking rates in the Catlins was due to the trap network been expanded in the early stages of the study. Low to no stoat tracking rates indicates an effective stoat trapping network and is consistently the case across the country, tracking tunnels are therefore not an effective tool to index stoats as low density (G. Elliott pers comm). Stoats did not seem to be affected by the poison operations but they were in low densities before the poison drop due to the trap network in place, therefore not much can be concluded from this portion of the study.

Discussion

The rat tracking and mohua nesting success results show a significant response to the intensive bait station and aerial 1080 treatments trialled in this study and therefore it would be reasonable to conclude that rats play a large role in the predation of mohua, at least in the Catlins and the Dart, and most probably elsewhere in the South Island. As the treatment and control sites had an existing trap network targeting stoats, but with the potential to control rats, it would also be reasonable to conclude that trapping is not an effective control method for rats in beech forest experiencing regular masting events, at least in the 100m spacing's of the existing networks in this study. Tighter trap spacing may prove to be an effective management tool but very costly and inefficient in remote locations.

The question of which treatment method should be used long term comes down to two key elements, being cost and effectiveness. Both treatments were effective in most years of the study but the bait stations failed in the Dart in the 2006/07 summer where no detectable knock down of rats occurred and bait take by rats was low. Aerial 1080 in this scenario was however still very effective. The reasons for this can possibly be attributed to an overabundance of food in the forest ecosystem therefore that rats did not need to travel far to find food making them less likely to encounter a bait station. The aerial 1080 is presumably more available to the rats in this situation.

The difference in cost between the two methods is substantial. The cost for an aerial 1080 operation at 1kg/ha is between $20-24 per hectare while the cost of running existing bait station network following a beech mast at $72-108 per hectare.

Aerial 1080 was not as effective at the low sow rate of 1kg/ha as 3kg/ha aerial 1080 or the Catlins Bait station operation. There are a number of possible reasons why a complete knock down of rats was not achieved, either the treatment was not as effective or there was so much food due to the scale of the beech mast that the rat population was able to recover quickly or that there were not as likely to eat bait. The question that really needs to be asked is do rat numbers need to be reduced to the level achieved by bait stations or higher amounts of 1080? Nesting success was in fact highest following the 3kg/ha drop in the Dart with a population growth rate of λ=1.91 with the low sow 1080 rate of 1kg/ha achieving a population rate of λ= 1.07 in the Catlins and λ=0.88 in the Dart. The Dart result is cast in doubt by a high abandonment rate. In reality the low sow 1080 regime needs more rigours trialling over a few more seasons to rule out the other potential variables before a decision on its effectiveness can be made.

It seems that if the tracking tunnels are tracking rats prior to the beech seedfall then they will peak at very high numbers, where if the rats are not detectable prior to the beech mast, they will not reach a problem level. When you consider the rat population going through an exponential growth phase if they start with one rat per hectare compared to 4 rats per hectare the peak of the population will be four times higher even though the initial populations were both small. More work is required on tracking rats at low densities to better understand this part of the process. One thing that is clear is that in all control sites, when the masting results in a rat plague, nesting mohua were heavily predated and not able to sustain their population at its current level. Therefore ongoing aerial 1080 at a sow rate somewhere in between 1 & 3kg/ha remains only way to currently maintain sustainable recruitment in mohua over large tracts of forest.

Acknowledgements

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