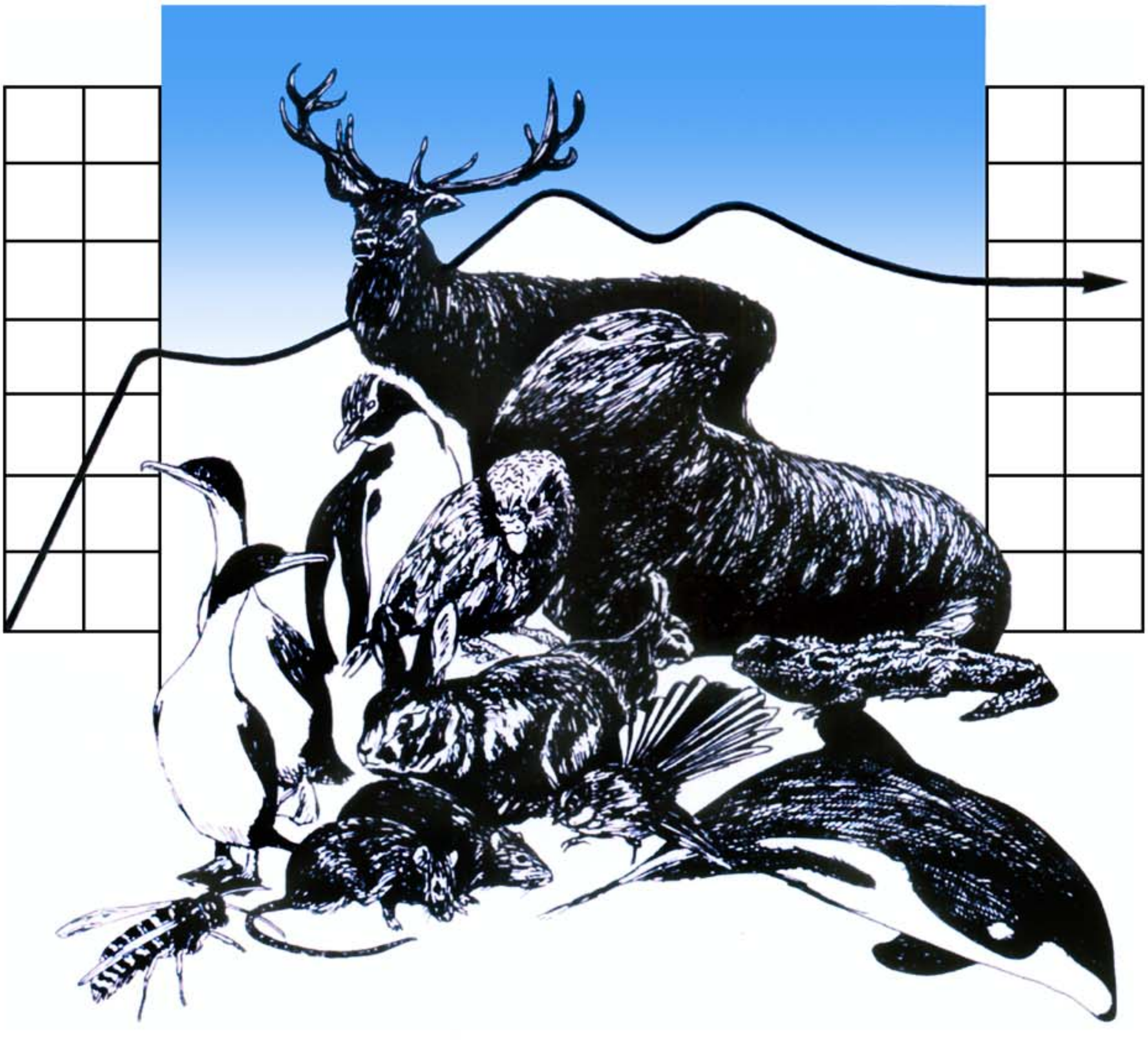
DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Effects of predator trapping on predator demographics and abundance at Macraes Flat, Otago, New Zealand.

Judd

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University of Otago
Department of Zoology
P.O. Box 56, Dunedin
New Zealand

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Executive summary

- Grand (*Oligosoma grande*) and Otago (*O. otagense*) skinks are listed in New Zealand as 'nationally critical', and extinction is likely within 10 years for both species unless the cause of decline is identified and halted.

- Mammalian predation is accepted as one of the main causes of decline. From 1999-2003 a predator control operation took place at Macraes Flat, Otago in the hope of reversing the decline of grand and Otago skinks in this area. This control targeted cats and reliably also caught ferrets.

- Data from this trapping period was analysed to see if there was a change in predator abundance and predator interactions within the system, and/or a change in demographics or body condition.

- Cat catch increased over time, therefore cat abundance increased over time. Ferret abundance showed no change over the trapping period. A relationship between cats and mesopredators was seen, with mesopredators declining as cat numbers increased.

- Age class of cats trapped over time showed no significant change, nor did body condition of trapped cats and ferrets.

- Studies are required to understand the predator prey interactions that are taking place in tussock grassland ecosystems so trapping programmes can be carried out scientifically.

Introduction

Study Area

Macraes flat is located North North-East of Dunedin, at approximately 45° 24'S 170° 24'E. It is a tussock grassland system of which large portions of land have been modified for farming. The Macraes reserve was purchased by the Department of Conservation during the 1990s, and is approximately 2500ha in size. This reserve acts as the last strong hold for the eastern populations of the grand and Otago skinks. The reserve consists of separate blocks of land situated within developed farmland, and is not continuous in area.

Grand and Otago skinks

The grand (*Oligosoma grande*) and Otago (*O. otagense*) skinks are among the rarest lizard species in New Zealand. They are currently listed as nationally critical, with population estimates being around 2000 individuals of each species left (Hitchmough 2002). Both species are now restricted to <10% of their former range (Whitaker and Loh, 1995). Grand and Otago skinks are continuing to decline in numbers, and unless the cause of decline is halted, both species are likely to be extinct within 10 years (Tocher & Norbury 2005). The cause of decline of the grand and Otago skinks has not been identified, although the two most likely causes for decline are habitat loss through land use intensification, and mammalian predation (Whitaker & Loh, 1995; Towns, 1985; Whitaker, 1996).

Land use intensification

Extensive conversion of tussock grasslands to productive farmland has taken place in the Macraes area since the arrival of Europeans. Tussock paddocks are either grazed by stock or cleared by burning, and replaced by introduced pasture species through over sowing and topdressing (Whitaker & Loh, 1995). Much of the low-lying land that is accessible to tractors has been ploughed and sown with higher yielding feed crops. Studies have shown that grand and Otago skinks are less common in areas that have been intensively farmed for extended periods (Berry *et al.*, 2005; Whitaker, 1996; Whitaker & Loh, 1995). A study by Whitaker (1996) showed that grand skinks underwent serious decline in pasture areas, with the most likely cause for this being that loss of tussock reduces habitat structure, restricts movement and can break down meta-population structure. Ecosat images available for the Macraes area in 1990 and 2003 show an increase in the proportion of developed land surrounding the Redbank reserve (Appendix 1).

Rabbit abundance and its affect on skink predation

Land use intensification may also influence the impact of predation on grand and Otago skink numbers by allowing an increased number of rabbits (*Oryctolagus cuniculus*) into the system, which damage native vegetation (Norbury & Norbury, 1996; Norbury, 2001), and can support a higher density of introduced mammalian predators. Rabbit count surveys were carried out in the Macraes area by the Department of Conservation from 1996 through till September 2002 (Tocher, submitted). Rabbit count data for this period shows an increase in rabbit numbers over time (Appendix 2). This is consistent with the theory that land development enables systems to support higher densities of rabbits (Tocher, submitted).

Dry tussock grasslands support high numbers of rabbits, which in turn sustain populations of mammalian predators (Norbury &Reddiex, 2005) of which grand and Otago skinks are a secondary prey source. Known skink predators include the feral cats, (*Felis cattus*), ferrets (*Mustela furo*), stoats (*Mustela ermina*), rats (*Rattus* spp.) and the European hedgehog (*Erinaceus europaeus occidentalis*). Weasels (*Mustela nivalis*) and mice (*Mus musculus*) are also suspected of being predators of skinks. Avian predators such as the falcon (*Falco novazealanae*), Australasian harrier (*Circus approximanus*) and introduced magpie (*Gymnorhina tibicen*) are also present in the system, but their effects on grand and Otago skinks have not been quantified. Rabbits are the main prey source for introduced mammalian predators such as feral cats and ferrets (Norbury, 2001; Norbury &Reddiex, 2005). Through the depletion of food and shelter and the supporting of high densities of predators, rabbits have partly contributed to the decline of skink populations in New Zealand grasslands (Norbury, 2001).

A sudden decline in rabbits due to control measures or disease such as RCD can negatively impact a predator's secondary prey source. Immediately following a rapid decline of rabbits, predator numbers are still high, and this is known as a lag effect. During this time hungry predators such as ferrets and cats will prey switch, increasing consumption of secondary prey sources (Norbury & McGlinchy, 1996; Courchamp *et al.*, 1999b; Haselmayer & Jamieson, 2001; Keedwell & Brown, 2001; Norbury 2001; Clapperton & Byrom, 2005).

Hyperpredation is caused by the introduction of a prey source such as rabbits into the system. This increases predators beyond a level that can be sustained by indigenous prey (Courchamp *et al.*, 1999b; Smith and Quin, 1996). High numbers of predators continue to prey upon skinks even when they are scarce, resulting in increased offtake of skinks as densities decline (Norbury, 2001).

1999-2003 trapping programme

Department of Conservation investigations in the early 1990s identified cats as the main threat to skinks because skink remains have been found in scats and digestive systems, and they have diurnal periods of activity as do the grand and Otago skinks (Baker, 1989; Middlesmiss, 1995). In response to these findings a cat control operation was carried out at the Macraes reserve beginning in 1999. Trapping lines consisted of Victor soft-catch leg hold traps that were set on the ground inside metal surrounds and baited with rabbit meat (Tocher, submitted). This trapping method also reliably trapped ferrets from the system, as they are of similar size and are easily caught in this trap type. A study by Tocher (submitted) on the survival of grand and Otago skinks following three years of predator control in this way found that grand and Otago skink rates of decline in study populations did not change in response to cat control.

Current mammal control programme

In November 2004 a new trapping system was initiated. This system is targeting the entire suite of mammals present in the Macraes area (except rodents) and utilises a number of different trap types and baits in order to catch different species (E. Smith, pers. comm.). The new programme targets a larger area than the pervious trapping programme (1200 ha) and is also incorporating other means of mammal control such as spotlight shooting and using a predator dog. A cat GPS study is now underway to analyse home range activity of feral cats which will contribute to the design of future trap line positioning and extent.

This report aims to investigate the effect of trapping between 1999-2003 on predator abundance, and also identify possible changes in the demographics and body condition of catch. Four main hypotheses will be tested against the data.

> *Hypothesis 1.*
> *Predator numbers have increased in the Macraes area due to continued land development capable of supporting higher rabbit densities.*

Assuming trapping effort remain the same and predator catchability remains constant, an increase in the number of cats and ferrets being caught each year is due to an increase in abundance of these predators in the system.

If resources are limiting, competition between top order predators (superpredators) may occur, with one species determining the other's abundance. Competitive interactions between these species are largely unknown, however theories for competitive interactions between superpredators and mesopredators predict changes in mesopredator abundance in response to changes in superpredator abundance (Courchamp *et al.,* 1999a). For the purpose of this report, a mesopredator is defined as a small predator that is a prey item for superpredators, but also the predator of shared prey species. In the case of Macraes Flat, cats and ferrets are classed as superpredators and the remaining mammal species are mesopredators.

> *Hypothesis 2.*
> *Trapping has caused a change in predator guild composition due to the targeting and removal of superpredators.*

> *Hypothesis 3.*
> *Cat control removes large dominant animals (both cats and ferrets) allowing an influx of juveniles, leading to an increase in juvenile cat and ferret catch.*

Body condition of predators may be negatively affected by increased predator numbers leading to competition for prey. In contrast, increased rabbit numbers in the system could lead to more available food for individuals, increasing body condition.

Hypothesis 4
A change in the abundance of predators in the system due to trapping may alter the body condition of trapped animals in response to increased resources or competition

Data from the 1999-2003 trapping programme contains many inconsistencies and gaps in recording. Therefore it is being analysed with caution, and only simple analyses of the data will be carried out to provide gross trends over time.

As the trapping programme only targeted the superpredators in the system, trap catch and data for these two species can be analysed for trends with reasonable confidence. This is the same for hedgehogs, which were also caught in high numbers, although not a targeted species. While mesopredators were caught as incidental catch in the trapping programme, these numbers were often very low, and the use of these figures in predicting changes in predator numbers is used with little confidence. Trap catch from the 04/05 season is not comparable to the 1999-2003 data as the change in trapping methods and effort will alter the ratio and numbers of pests caught.

Methods

Trap catch data is from the Microsoft Access Predator Trapping database maintained by the Department of Conservation Grand and Otago Skink Recovery Programme. For each of the four trapping years (99/00, 00/01, 01/02, 02/03), only trapping data from 1 December to 31 May was used. This is because trapping data is missing for some years during other months of the year. Analysing the same trapping months each year removes seasonal catch bias between years.

Change in cat and ferret abundance

Trap nights were not corrected as data on sprung traps was not recorded for the 01/02 trapping season. Therefore effort is based on uncorrected trap nights and is considered to be equal across all trapping periods that are examined in this report (B. McKinlay, pers. comm.). Data was sorted using Microsoft Excel and analysed in Minitab version 14.20. Regression analysis was used to see if there was an increase in the number of cats and ferrets caught each year. A confidence interval of 95% (i.e. $p<0.05$) was used to determine a significant value for all analyses.

Interaction between predator guilds

In order to see if trapping caused an interaction between predator guilds, comparison of multiple regression slopes was used. This plotted the abundance of cats, ferrets, hedgehogs and mesopredators (stoats, weasels, rats and mice) trapped each year and looked for changes over time.

Change in demographics

Length and weight measurements for cats and ferrets were taken from the Macraes Dissection database. Not all individuals that were caught were dissected, therefore it is assumed that the dissected animals constitute a representative sample of all trapped animals.

The distinction between cat juvenile and adult age classes is an estimation based on the distinction between age classes made in the current trapping programme. Cat catch data from the current trapping programme was graphed and separated according to the age distinctions made by the trappers. In the field a cat is 'aged' by a number of factors, including size and weight, tooth condition (i.e. sharpness of teeth, grooves down edge of canines, and general appearance e.g. looking 'weather beaten') (A. Hutcheon, pers. comm.). For the purpose of this analysis a cat was classed as juvenile if below 440mm and 2200g, and adult if equal to or above these measurements. In cases where an animal was close to the cut-off point, a personal judgement was made as to which group it was placed in. Binary logistic regression was used to analyse a change in age class in cats.

Ferret data was not analysed for a change in demographics. This is due to the fact that ferrets exhibit large weight and length differences between the sexes. Average ferret weights and lengths for Otago and Southland are, males 391mm, 1078g and females 343mm, 634g (Ragg, unpublished)

Body condition

Body Mass Index was calculated for each individual as weight/length^2, and is used as a surrogate of body condition. Simple regression was used to see if body condition changed over the trapping period.

Results

1. Cat and ferret catch over the trapping period

There is evidence to support a significant increase in cat catch over the trapping period ($p=0.018$). There is no significant evidence to support a similar trend in ferret catch ($p=0.382$) (fig. 1).

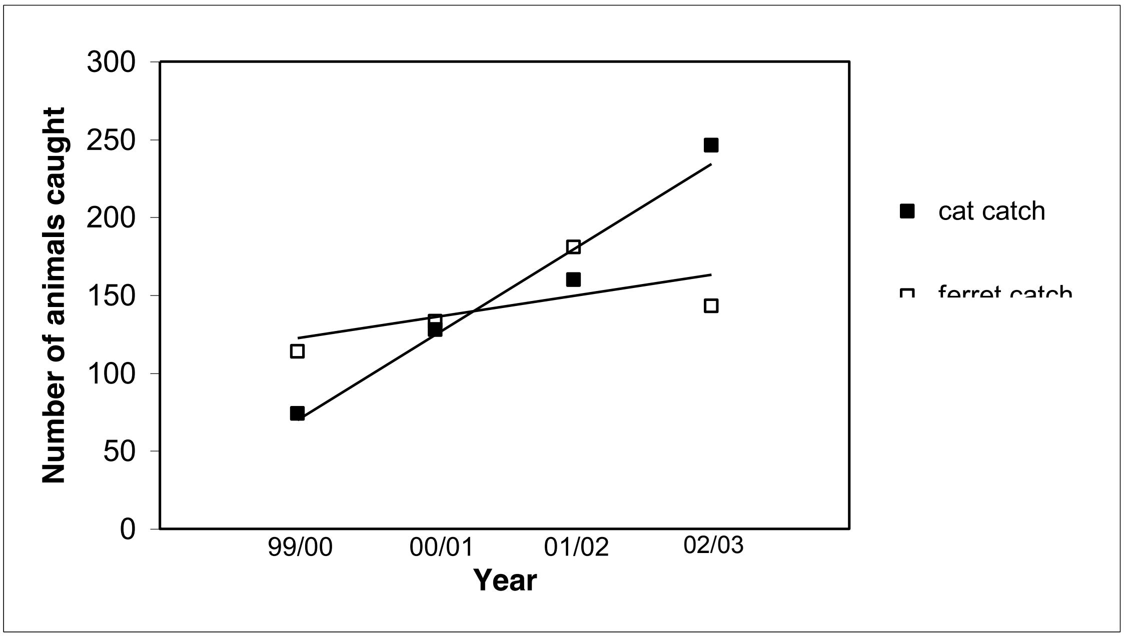

Figure 1. Regression slopes fitting the number of cats and ferrets trapped each year at Macraes Flat. The linear regression best fit lines are described as *Cat catch=15.0+54.8 year,* and *Ferret catch=109+13.5 year*.

2. Predator guild composition

Using a comparison of regression slopes there is evidence to suggest a significant negative interaction between abundance of cats and mesopredators (p=0.023). There is no evidence to suggest a relationship between cat and ferret numbers (p=0.100), or cat and hedgehog numbers (p=0.058) (fig.2).

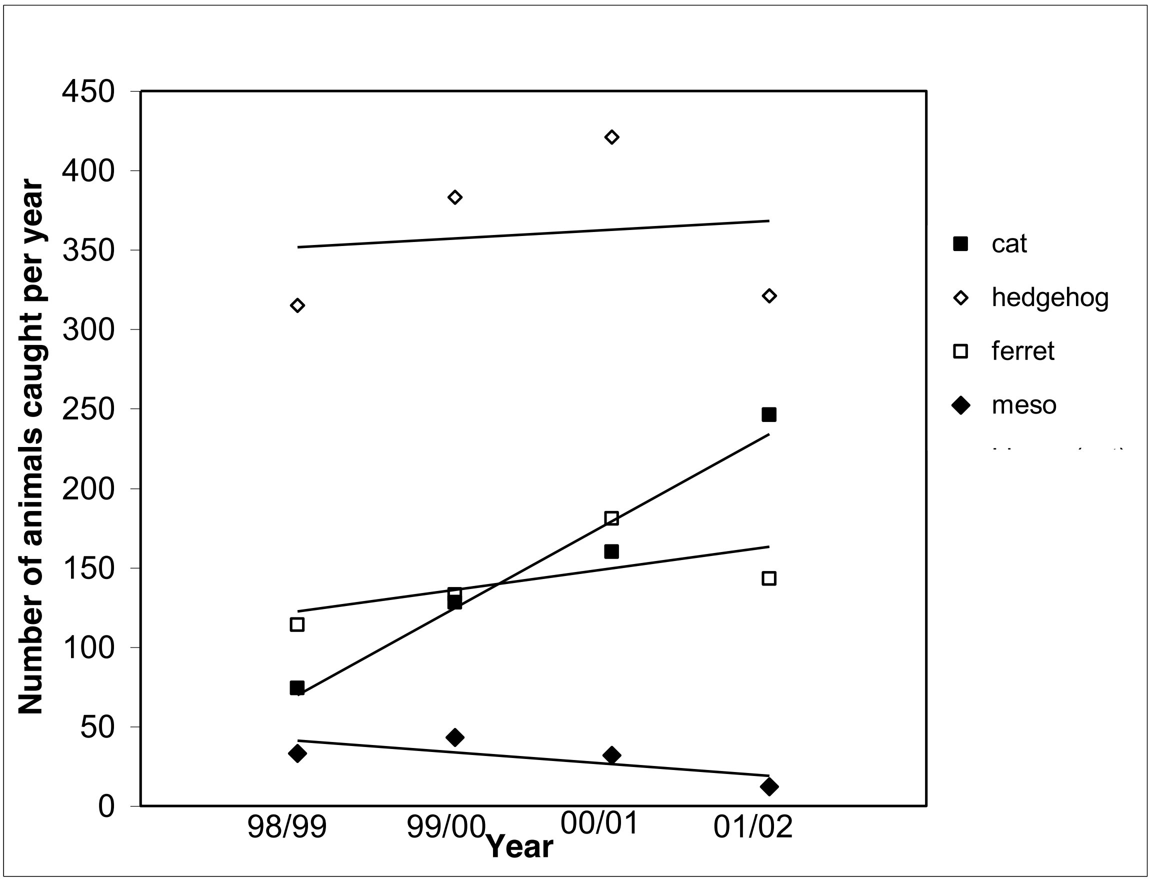

Figure 2. Scatter plot of annual catch of predator species at Macraes Flat, fitted with regression lines. The regression equation is *capture = 15.0 + 54.8 year + 331 h_v_c + 94.0 f_v_c + 33.5 m_v_c - 49.2 h_v_c*t - 41.3 f_v_c*t - 62.2 m_v_c*t*

3. Change in demographics of cat numbers following trapping

There is no evidence to support a change in the proportion of adult and juvenile cats caught over time (p=0.916) (fig. 3).

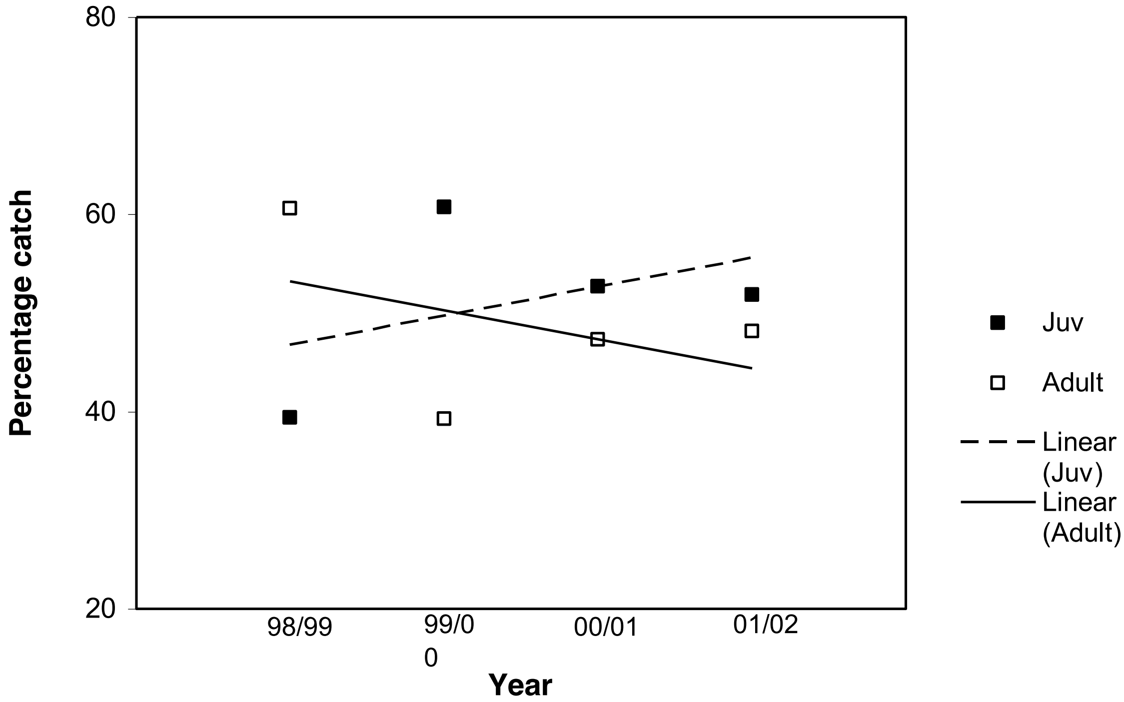

Figure 3. Proportions of adult and juvenile cats caught over four trapping seasons.

4. Change in Body Condition of cat and ferrets

There is no evidence to suggest a significant change in body condition (BMI) in either cats (p=0.152) or ferrets (p=0.782) trapped each year (fig. 4).

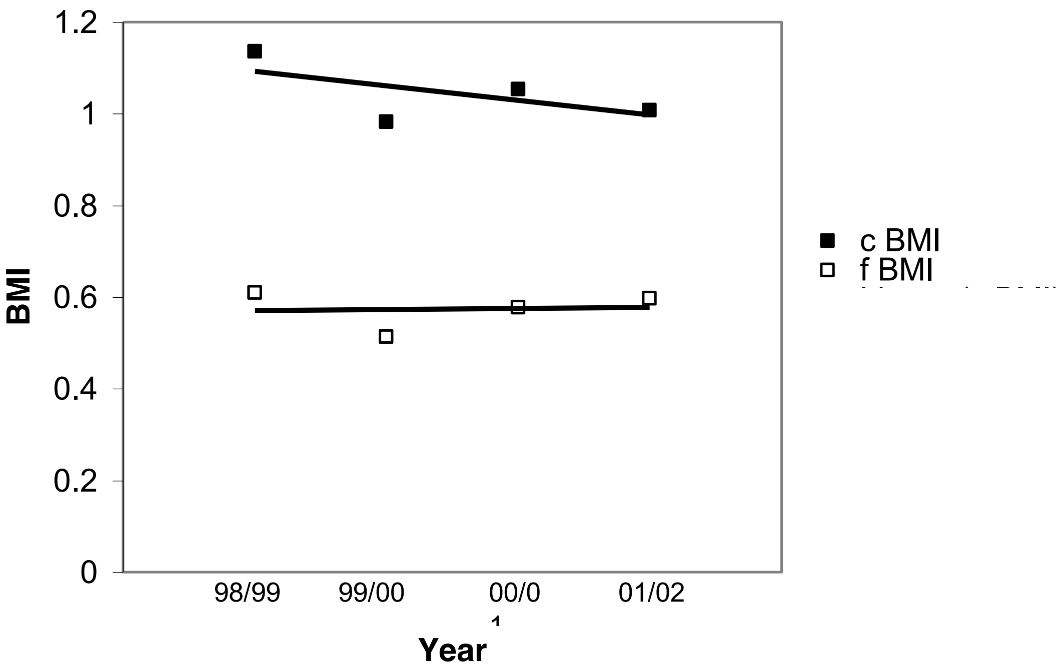

Figure 4. Body mass index of cats and ferrets caught over four trapping seasons at Macraes Flat (where BMI=weight/length^2). The regression equations for BMI are *Cat BMI*=1.25 - 0.0607 year, and *Ferret BMI=0.570 + 0.0063 year.*

Discussion

Regression analysis showed an increase in the number of cats caught over the trapping period. As trapping effort was equal over time it can be assumed that an increase in cat catch is due to an increase in abundance of cats in the system. This could be due to the increase in rabbit numbers over the same period, supplying food for a larger number of predators and off-setting the efforts of predator control. Ferret catch did not significantly change over the trapping period. This could be due to the fact that ferret numbers were slower to recover from the decline in rabbit numbers following the introduction of RCD, as rabbits make up around 80% of ferret diet (Ragg, 1998). A notable decline in both ferret and cat numbers was observed by Norbury & McGlinchy (1996) as a consequence of rabbit control.

That there was no decline in either cat or ferret numbers over the trapping period could be because the trapping operation was not on a large enough scale and of high enough intensity. It was recommended by Hitchmough (2003) that the buffer zones of the trapping operation were not large enough. Buffer zones of at least 5km are recommended to keep around 50% of juvenile ferrets from entering into an area (Byrom, 2002). As the trapping area was <10 km in diameter, this may help to explain the trends observed in the trapping data. Without adequate buffer zones, the removal of predators from an area could potentially create a predator sink, where there is surplus prey and empty home ranges that can be filled.

There was evidence to suggest that as cat numbers increased, numbers of mesopredators declined. Due to the very low numbers of mesopredators caught over the trapping period it is difficult to tell if there is a real interaction between these species. Studies support the theory that superpredators are able to suppress numbers of mesopredators in a system, and in some cases the presence of the superpredator can indirectly protect a shared prey from a mesopredator (e.g. Courchamp *et al*., 1999a).

Had there been a decline in cats and ferret numbers following predator trapping, the opposite could have been seen, known as 'mesopredator release'. Mesopredator release is the removal of dominant predators from the system, allowing lower order predators to increase in numbers (Soulé *et al*., 1988; Courchamp *et al*., 1999a). This could have been very dangerous, as the trapping programme was not designed to catch the smaller mammals, and the effects of this may not have been realised until too late. Stoats exhibit the same diurnal activities as the endangered lizards and have a diet that includes the highest number of skinks out of all three mustelid species in New Zealand (Middlemiss, 1995). Stoats are kept to low numbers in the presence of ferrets and cats through interference competition (King & Murphy, 2005), but if allowed to reach high densities they have the potential to quickly devastate skink numbers and are of serious conservation concern (Middlemiss, 1995; King & Murphy, 2005). Rats are also threats to the lizards as they are omnivores and are capable of maintaining high populations and predation pressure even when prey population size is low (Courchamp *et al*., 1999a), yet historic and current trapping operations do not adequately account for rats in their spatial design.

The effects of hedgehogs on New Zealand fauna have not been quantified (Jones & Sanders, 2005) and little is known about the impacts of hedgehogs on the grand and Otago skinks. Hedgehogs are nocturnal so are unlikely to be a serious threat to the grand and Otago skinks through predation, however van der Sluijs (2000) recorded common and McCann's skinks in 27% of hedgehog stomachs examined at Macraes. They are also insectivorous, thus they may be a threat to the lizards due to competition for food (Middlemiss, 1995). Middlemiss (1995) recommended further investigation into the possible diet overlap of hedgehogs and the lizards.

No significant change was observed in the proportion of adult and juvenile cats caught over the trapping period. It would be of interest to compare how trapping affects demographics between cats and ferrets, as ferrets are known to have high juvenile dispersal, particularly into areas that have been trapped (Byrom, 2002). A study by Byrom (2002) showed that juvenile survival and establishment was significantly higher than in areas that had been trapped in comparison to nontrapped areas. Effective ferret control may be compromised by rapid immigration of juvenile ferrets (Byrom, 2002).

Ferrets can be aged by a number of ways, including dental eruption, fusion of cranial sutures, post orbital ratio, and the baculum weight of males (see Ragg, 1998 or Clapperton & Byrom, 2005 for a summary of these methods). Most of these methods are both time consuming and impractical in the field. However it would be valuable to gain a greater understanding of ferret demographics and movement in the environment.

Analysis of the data collected over the fours year trapping programme has reinforced the importance of keeping accurate records. As the data was not recorded consistently over the trapping period, the opportunity for credible trends to be observed in the data was significantly decreased. The current mammal control programme at Macraes Flat has begun to rectify this problem, with accurate data recording an important part of the programme.

In a review of the grand and Otago skink recovery programme (Hitchmough, 2003) the predator control programme was accused of failing to use adaptive management. It is important that when planning and undertaking mammal control operations, all available information is used. Collaboration of information from different control programmes will increase overall knowledge and hopefully efficiency of mammal control. The current trapping programme is incorporating new knowledge of predators into the programme and undertaking their own studies to improve understanding of cat home ranges in the system.

For the threat of predation on grand and Otago skinks to be reduced, the entire system must be carefully monitored. Courchamp *et al.* (1999b) recommend that simultaneous control of predator and prey species is the best strategy for recovery of indigenous species. Further study of predator-prey interactions in tussock ecosystems is imperative if effective mammal control is to be achieved. The importance of the different predators in the system needs to be better understood. The impacts of mesopredators on grand and Otago skinks need to be quantified, particularly rats as so little is known about their role in the system.

It is important that rabbit control is incorporated into future mammal control at Macraes Flat, given the key role rabbits play in determining predator densities. When more is understood about containing rabbit densities to levels which keep predators at a less damaging level to native fauna, rabbit control can take place in response to changes in densities rather than at random or opportunistically. The ideal situation would be to avoid large fluctuations in rabbit numbers and contain them at a low and stable level (Norbury, 2001). Actively controlling rabbits can also have the advantage of allowing the recovery of native vegetation important to the lizards for food and shelter.

I believe the current trapping programme is adequate for mammal control, as long as trapping methods and techniques are always seeking to be improved and updated. Intensive monitoring of prey interactions should be carried out from the trapping data, so changes in predator guilds can be identified quickly and acted upon.

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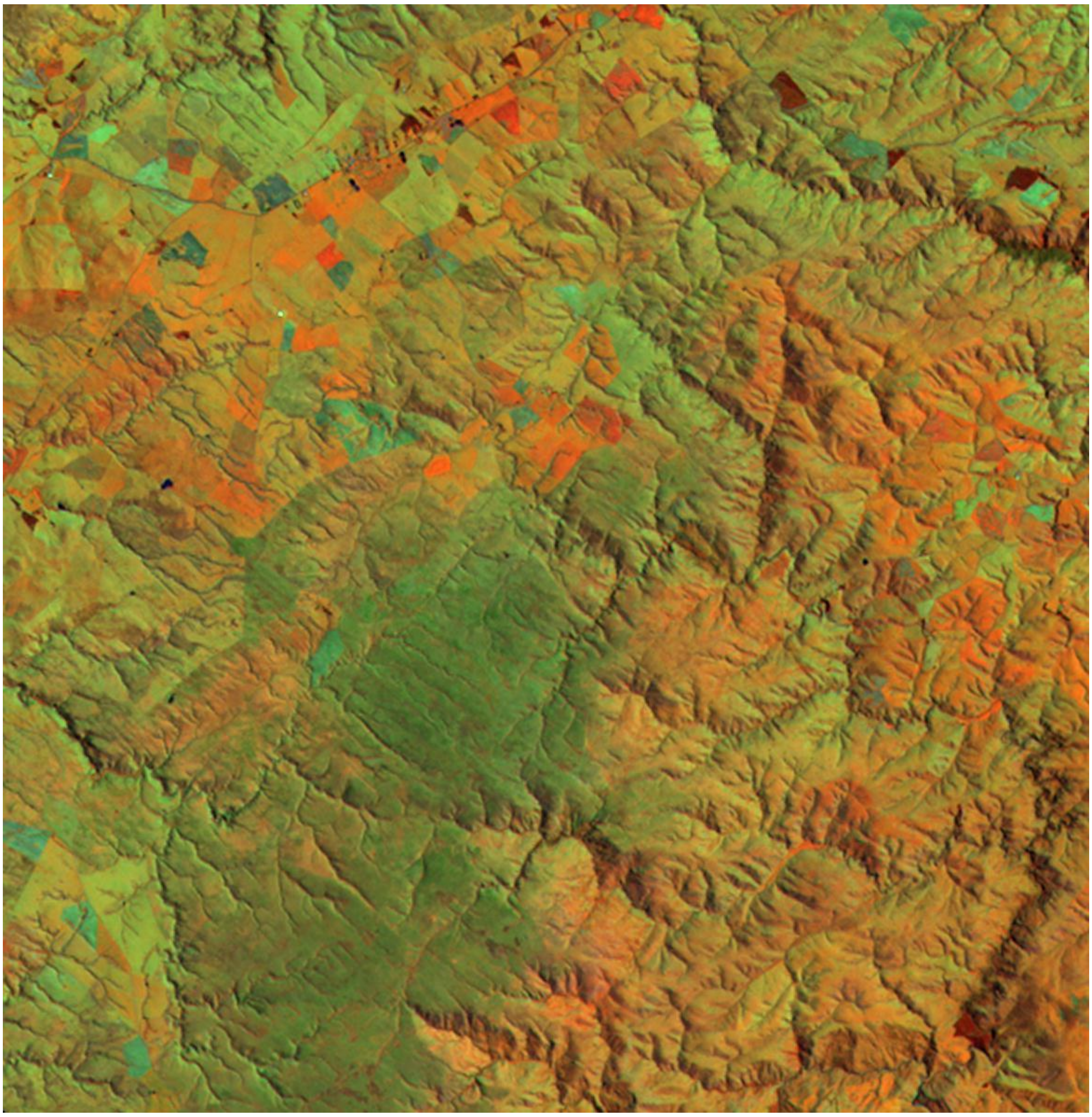
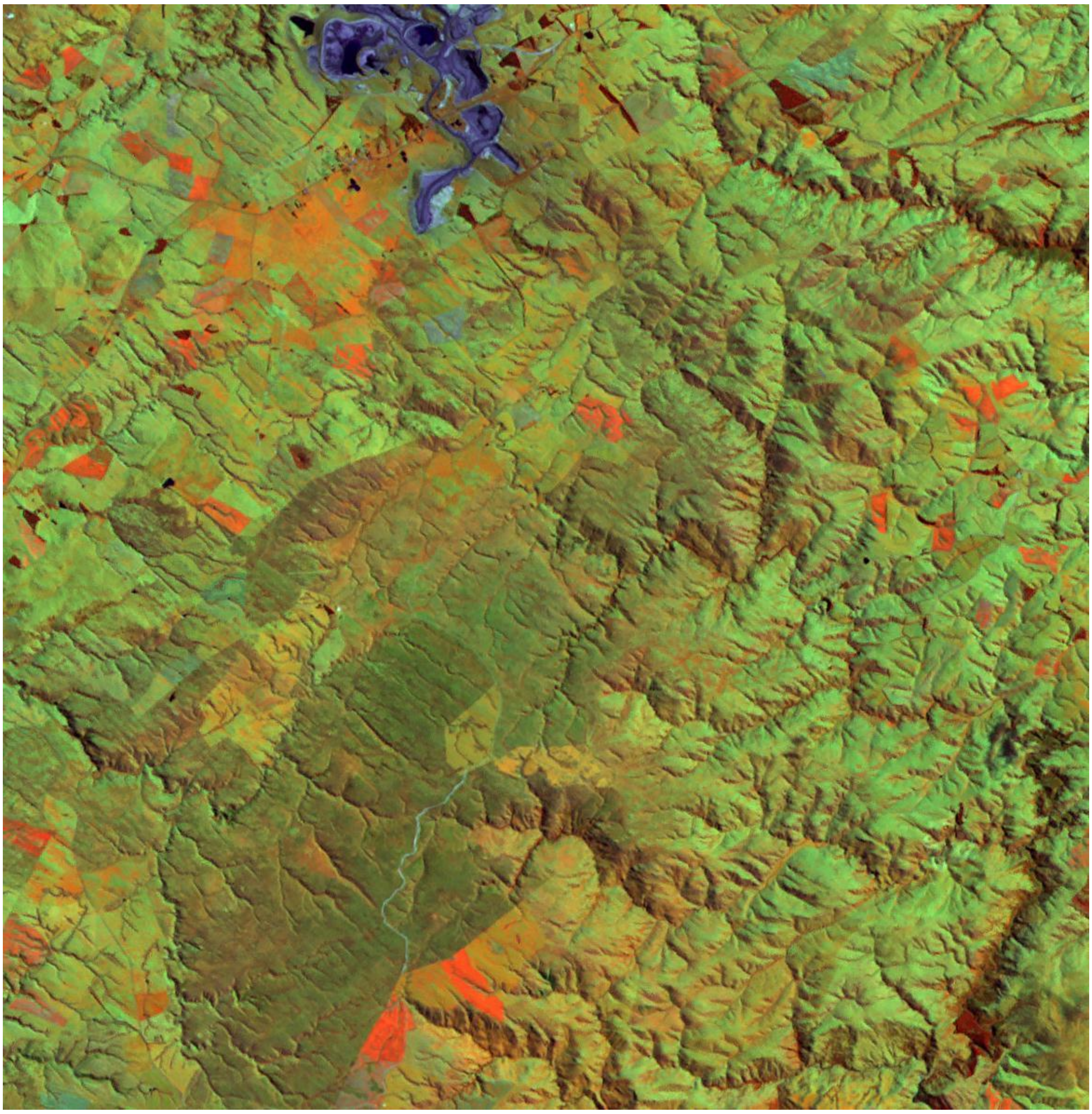
Appendix 1. Ecosat images of Macraes Flat in (a) 1990 and (b) 2003, showing an increase in the amount of land development over time. Bright orange denotes modified farmland. The Department of Conservation reserve area is to the bottom of the images and is identifiable by the dark green colour representing unmodified tussock.



(a) Ecosat Image, Macraes Flat 1990



(b) Ecosat Image, Macraes Flat 2003

Appendix 2.

Rabbit count data for Macraes flat, 1996-2002 (Dave Houston, unpublished data)