UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

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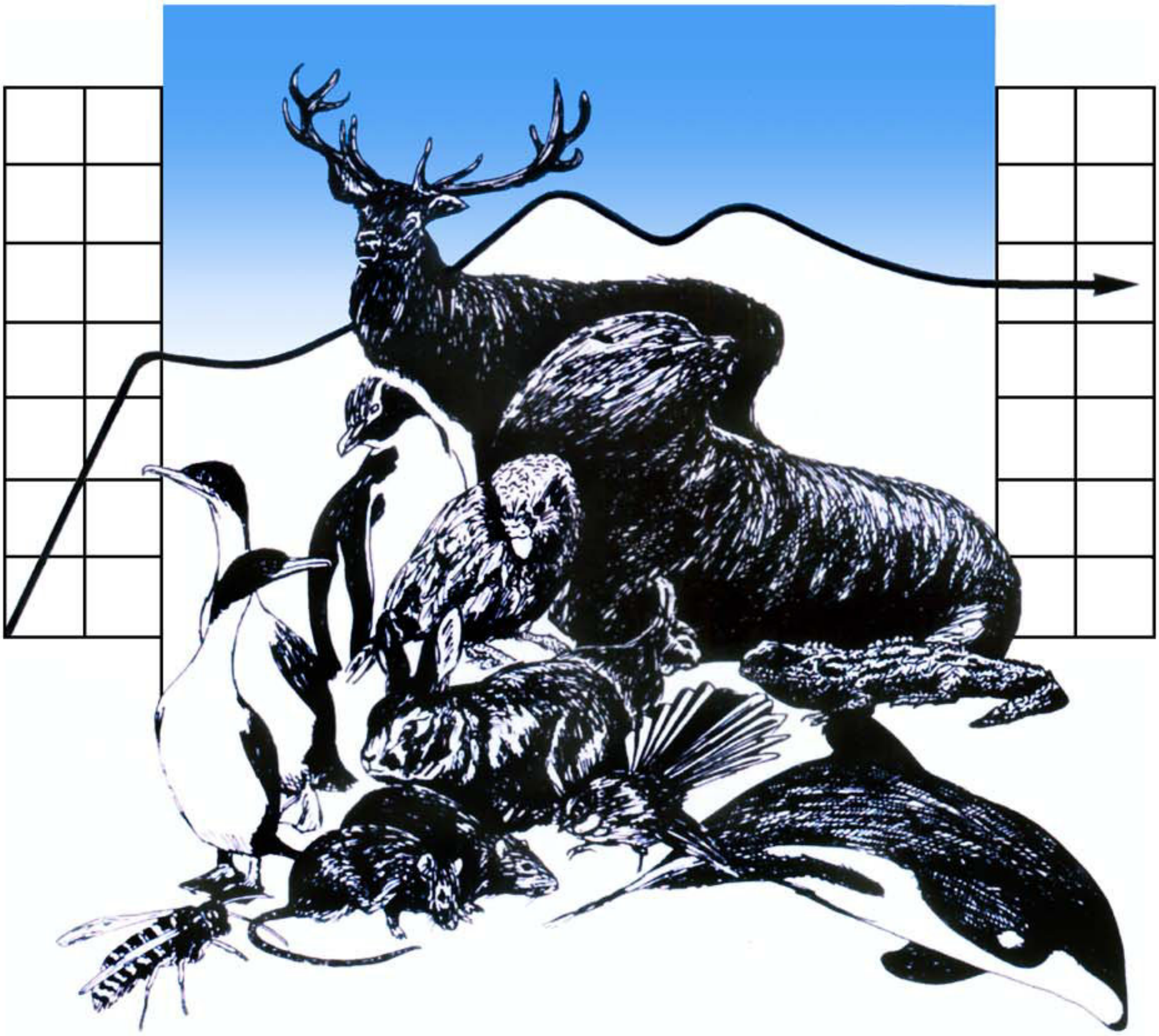
DEPARTMENT OF ZOOLOGY



# WILDLIFE MANAGEMENT

# Effectiveness of Rodent Control in Jewelled Gecko (Naultinus gemmeus) Habitat, Including an Investigation into Tracking Tunnel Use as a Means of Detecting Jewelled Gecko.

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A report submitted in partial fulfilment of the
Post-graduate Diploma in Wildlife Management

**University of Otago**

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# Effectiveness of Rodent Control in Jewelled Gecko (*Naultinus gemmeus)* Habitat, Including an Investigation into Tracking Tunnel Use as a Means of Detecting Jewelled Gecko.

WILM403 (Wildlife Management) research placement

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Photo: F. H. Gordon

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## *Executive Summary*

**Title:** Effectiveness of Rodent Control in Jewelled Gecko (*Naultinus gemmeus*) Habitat, Including an Investigation into Tracking Tunnel Use as a Means of Detecting Jewelled Gecko.

**Study Site:** SDHM and PCPA, Otago Peninsula (See foreword regarding use of code names).

**Author:** Fiona Gordon

**Finish Date:** March 2010

The jewelled gecko, (*Natultinus gemmus*) is an arboreal lizard endemic to the south island of New Zealand. Jewelled geckos are green in colour with unique dorso-lateral and ventro-lateral markings which allow them to be individually identified. The species is deemed to be in a state of gradual decline. Predation, poaching, and habitat loss, degradation, and fragmentation have all contributed to the decline of jewelled gecko.

This study investigates the effectiveness of rodent control as a possible measure to improve jewelled gecko habitat, comparing a site which had undertaken rodent control measures for 18 months (using flocoumafen baits, rat snap traps and Mk IV Fenn traps) with an adjacent unmanaged site. A difference was discovered in mean tracking rates between the two sites (2% in Rats, 7% in Mice) with less activity in the managed area. These results were not found to be statistically significant ($p=0.82$ in Rats, $p=0.45$ in Mice).

Tracking tunnel indexes were used to identify areas of high rodent activity to target control methods at the end of the study period. Results have been positive, with the landowner catching more rodents after adopting this method.

Visual searches for jewelled gecko were also undertaken to provide baseline data for future comparison. A total of four individuals were detected during the study, sighting a single gecko in 7 of the 14 searches conducted, resighting one individual on four occasions. In this study, and in records collected by the landowner and Knox, twice as many jewelled gecko were sighted in the managed area (12 in managed vs. 6 in unmanaged site) as well as a larger proportion of adult females (25% vs. 17%) and juveniles (50% vs. 17%).

Jewelled geckos are difficult to detect due to their cryptic markings, seasonal movements and opportunistic basking. This study also sought to determine if tracking tunnels could be used to reliably detect jewelled gecko presence. A range of baits were tested in tracking tunnels placed in an area with a high known density of jewelled gecko. Tracks were successfully obtained once using canned pear as bait. Further research into tracking tunnel use is recommended using pear as an attractant.

If explored further, the study duration should be increased to improve statistical power of results.

**Keywords**: *Naultinus gemmeus*, detection, tracking tunnel, rodent control, population survey, Otago Peninsula

**Effectiveness of Rodent Control in Jewelled Gecko (*Naultinus gemmeus*) Habitat, Including an Investigation into Tracking Tunnel Use as a Means of Detecting Jewelled Gecko.**

## *Foreword*

Jewelled gecko (*Naultinus gemmeus*) are sought by international lizard collectors and though the taking of wild individuals is prohibited under the Wildlife Act 1953, poaching has been recorded previously on the Otago Peninsula (including an incident this summer where 16 individuals were taken) and is believed to have contributed to the decline of some gecko populations.

Due to the potential risk of poachers identifying sites containing jewelled gecko, code names have been used in this report, such as PCPA and SDHM. The names of land owners are also not included for the same reasons. For further information on code names please contact the author.

## *Acknowledgments*

I'd like to thank Shaun and Family for their friendship, thoughtful suggestions and countless cups of tea. A special thanks to Carey Knox, without whom this project would never have occurred, for getting me "hooked on geckos" and fuelling that addiction by showing me the ropes, and facilitating the process in so many other ways. I'd also like to thank Josh for being the voice of discipline when I was not; my family Jean, Denis and Emma Gordon for their love, support and patience; and Alma Gordon for being my role model. Arohanui, this is for you.

# 1. *Introduction*

## *1.1.Jewelled Gecko/moko-k•k•riki*

New Zealand's early separation from Gondwanaland, and subsequent geographic isolation, 80 million years ago has resulted in high levels of endemism, and the retainment of primitive forms amongst its biota (Chapple et al., 2009; Cooper and Millener, 1993; Gibbs, 2006). An example of this is New Zealand's two genera of gekkonidae: the diurnal *Naultinus* commonly referred to as "green geckos", and the nocturnal *Hoplodactylus*.

There are nine known species of the *Naultinus* genera, all of which are arboreal and viviparous (Jewell and McQueen, 2007). One of these is the Jewelled gecko/moko-k•k•riki (*Naultinus gemmeus*) (McCann, 1955), a lizard endemic to the south island of New Zealand, found in isolated pockets east of the divide (Shaw, 1994).

To regulate their temperature jewelled geckos will bask amongst the edge of scrubby vegetation, especially on warm, sunny mornings, and do so for most of the year on Otago Peninsula (Wilson and Cree, 2003). Jewelled gecko are largely diurnal, but have been recorded feeding nocturnally, and inhabit native and exotic forest and scrub, predominantly amongst *Coprosma* spp. and k•nuka (*kunzea ericoides*) shrubland (Duggan, 1991; pers. obs.; Carey Knox. pers. comm.; Duggan and Cree, 1992; Jewell, 2006; Knox, 2010b; Schneyer, 2001). The dense, twiggy structure of *Coprosma* species is believed to provide good food sources, and protection for jewelled gecko from predation by larger mammals such as cats and ferrets, and elemental conditions (Jewell and McQueen, 2007; Knox, 2010b; Sherwood, 2009). Jewelled gecko sightings have also been recorded in a range of other plant species (See Table 1).

Jewelled geckos are distinctive and attractive in appearance, usually bright green; with pale green, white or yellow dorso-lateral and ventro-lateral markings in diamond-shaped patches, continuous stripes or a combination of the two, often outlined with dark brown or black (see *fig* 1), with a blue tongue and mouth lining in the Otago Jewelled gecko (Sherwood, 2009). These markings are

**Table 1: List of plant species geckos have been found in on Otago Peninsula (Knox, 2010b)**

| | |
|---|---|
| *Coprosma areolata* | *Helichrysum glomeratum* |
| *Coprosma crassifolia* | *Ileostylus micranthus* (Green mistletoe) |
| *Coprosma propinqua* (Mingimingi) | *Kunzea ericoides* (K•nuka) |
| *Coprosma rhamnoides* | *Leptospermum scoparium* (M•nuka) |
| *Coprosma rugosa* | *Muehlenbeckia australis* (Pohuehue) |
| *Corokia cotoneaster* | *Podocarpus hallii* (Halls t•tara) |
| *Cupressus macrocarpa* (Macrocarpa) | *Ulex europaeus* (Gorse) |
| *Cytisus scoparius* (Broom) | *Myrsine australis* (Red Mapou) |
| *Pinus radiata* (Pine) | *Pteridium esculentum* (Bracken) |
| *Clematis foetida* (Native clematis) | *Melicope simplex* |
| *Pseudowintera colorata (*Pepper tree*)* | Climbing rata |
| *Olearia aviceniifolia* (Tree daisy) | |

believed to be unique to each gecko, which allow for animals to be individually identified using photographic records (Knox, 2009; Shaw, 1994).

Jewelled geckos are currently listed as being in a state of gradual decline under the Department of Conservation New Zealand threat classification schedule due to human induced causes (Hitchmough et al., 2007; Whitaker et al., 2002). However the true status of the species may be more serious than this categorisation suggests (Duggan, 1991; Jewell, 2006; Whitaker et al., 2002).

Individual animals are hard to detect and count because of their camouflage and cryptic behaviour. As such it is difficult to calculate or accurately estimate the total number present at sites surveyed (Jewell, 2006; Sherwood, 2009).

The Otago Peninsula jewelled gecko population is made up of small clusters

**Figure 1: Illustrating visual differences between individual gecko markings allowing for individual identification, showing diamond, "barbed wire", and line stripe markings.**

Photo: F. H. Gordon

in often unlinked habitat fragments (Sherwood, 2009; Whitaker et al., 2002). Knox has photographed over 800 individuals on the Otago Peninsula and, based on his research, estimates the total population for the area to be around 2000-3000 individuals (Carey Knox, pers. comm.; Knox, 2010a).

### *1.2.Threats*

A number of factors have influenced the current decline in jewelled gecko abundance. As with a number of New Zealand's native species, the position of jewelled gecko has deteriorated following the arrival of humans. Prior to human settlement the Otago Peninsula was coved in native vegetation, including podocarp-broadleaved forest. Following extensive burning and clearance large areas of this have been transformed into grassland, with only 5.25% native vegetative cover remaining, of which very little is protected (Jewell, 2006; Jewell and McQueen, 2007; Johnson, 2004; Whitaker et al., 2002).

These modifications have resulted in a decrease in the range of habitat available to jewelled gecko, with remnants becoming increasingly fragmented through further clearance of lowland forest and shrubland habitats for exotic forestry, agriculture or pastoral farming (Duggan, 1991; Knox, 2009; Sherwood, 2009). The continued loss and degradation of habitat has led to the isolation of some jewelled gecko populations. The small size of these populations makes them vulnerable to stochastic events such as fire (Murphy, 2010), disease, and genetic bottlenecking through restricted genetic exchange (Sherwood, 2009). Urban development on the Otago Peninsula and surrounding area may also pose a threat for jewelled gecko through further accelerated habitat loss and a potential increase in predation (Whitaker et al., 2002).

One of the major factors believed to be influencing the decline of jewelled geckos is increased predation pressure from introduced mammalian species such as: Norway rats (*rattus norwegicus*), weasels (*mustela nivalis vulgaris*), ferrets (*mustela furo*), European hedgehog (*erinaceus europaeus*), brush-tail possums (*trichosurus vulpecula*), feral cats (*felix catus*), but particularly house mice (*mus musculus*), ship rats (*rattus rattus)* and stoats (*mustela ermine*) (Jewell and McQueen, 2007; Knox, 2010a; Shaw, 1994; Sherwood, 2009). Jewelled gecko are also believed to be predated on by introduced avian predators such as magpies (*gymnorhina tibicen*), and native species such as kingfishers (*halcyon sancta*) (Van Winkel, 2008; Whitaker et al., 2002).

Jewelled gecko are also sought by international lizard collectors and though the taking of wild individuals is prohibited under the Wildlife Act 1953, poaching has been recorded previously on the Otago Peninsula and is believed to have contributed significantly to the decline of some gecko populations (Jewell, 2006; Whitaker et al., 2002).

Groups such as the Save The Otago Peninsula (STOP) Inc. society have worked to mitigate such aforementioned threats, through the creation of the NGL reserve, removing pest plants, and assisting and educating land owners. A large proportion of the extant jewelled gecko population on the Otago Peninsula is on private land making it important to keep land owners informed and involved in endeavours to protect jewelled gecko and to investigate actions which interested landowners can deploy independently to assist this process.

Several sites on the Otago Peninsula are protected under QEII covenant. The QEII Trust helps private landowners in New Zealand protect significant natural and cultural features on their land through open space covenants in perpetuity, preventing future development even if the property is sold as subsequent land owners are bound by the covenant; therefore still protecting the area (see http://www.qe2.org.nz; Godoy and Hyde, 2009).

The QEII Trust advocates for the exclusion of domestic stock from native forests and shrublands (Godoy and Hyde, 2009). Other agencies involved in conservation such as the Department of Conservation and Forest and Bird have also frequently advocated retiring land from domestic grazing stock to aid in regeneration of native bush (Jewell and McQueen, 2007; Knox, 2009). As such, many landowners wishing to conserve or increase native biodiversity on their properties have been encouraged to exclude grazing stock (Knox, 2009). It was believed that grazing would negatively affect jewelled gecko numbers due to the impact of domestic grazers on habitat quality, through browsing on vegetation. Consequently past conservation measures for jewelled gecko have often involved the removal of stock to enhance regeneration to increase available habitat for geckos (Innes et al., 2010).

However the effects of stock removal from coastal grassland may not be as beneficial for jewelled gecko as once believed, with resulting increases in rank grass having been linked to decreased abundance of New Zealand skinks and geckos in some areas (See Hoare et al., 2007; Newman, 1994). This is presumed to be due to corresponding increases in rodent abundance, and by extension predation. Previous studies have found that when introduced grasses were allowed to proliferate, following the removal of domestic grazing stock, rodent irruptions occurred periodically, which in turn caused influxes in a number of other introduced mammalian predators, presumably due to the increased availability of food (grass seed and invertebrates for rodents, resulting in more abundant prey for other larger mammals such as stoats and cats) and shelter for these species (See Alterio, 1998; Alterio and Moller, 1997; Hoare et al., 2007; Knox, 2009; Ratz, 2000) .

This highlights a dilemma for conservation efforts in forest fragments; on one hand fencing and stock removal protect vegetation which in theory aids habitat regeneration, but conversely also increases rodent abundance due to increased food and shelter, destroying seeds, invertebrates and native fauna (Innes et al., 2010).

The impact of rodents is rarely observed and as such often overlooked and understated due to their size and nocturnal activity, while attention is focused on other more visible threats. Rodents are known to predate on New Zealand lizards (Schneyer, 2001; Wissel, 2008) and while the impact of rodents on jewelled geckos has not been studied in detail, increased rodent abundance due to the removal of grazers is thought to have contributed to the decline of jewelled gecko at the NGL reserve (See Knox, 2009; Schneyer, 2001).

## *1.3. Objectives*

The main purpose of this study is to provide baseline data which can be used in future to further assess the effectiveness of pest management methods employed. I hope to provide valuable information for land owners interested in the conservation of jewelled gecko on their properties.

### *1.3.1. Effectiveness of Rodent Control*

Predation by rodents is one of the main factors believed to be affecting the survival of jewelled gecko (Jewell, 2006; Knox, 2010b; Sherwood, 2009). Knox (2010) found in his research that rodent activity was higher in un-grazed areas (1.5X more mouse and 8X more rat activity), and conversely that jewelled gecko abundance and mean density was lower in un-grazed coprosma (mean density was one quarter that of grazed coprosma) and advocates low intensity grazing to improve gecko survival by reducing rodent numbers and thereby predation upon jewelled geckos (Knox, 2010a).

Few sites where jewelled geckos are present on the Otago Peninsula are currently protected and those which are tend to be under QEII covenant and as such are encouraged to remove or exclude stock from protected areas, thus potentially increasing the predation risk from rodents (Knox, 2009). Some landowners may not wish or be able to run stock on their property but would like to improve the habitat for resident geckos. Land owners in this situation could potentially manage rodent abundance, and as such predation risk, with strategic pest control.

The primary objective of this study is to assess the effectiveness of the current method of rodent control being implemented at SDHM, investigating whether rodent control could be effective in assisting gecko abundance by reducing pest numbers to low densities, and assisting land owners who do not wish to graze but want to help improve habitat quality for gecko by making recommendations on effective management techniques to improve gecko survival on their properties.

Given the associated costs (time and money) and impact of poisons on the surrounding ecosystem and non target species it is important to be confident that baits used and the method of delivery is going to be effective. A similar control regime is being considered by landowners in an adjacent site and may be adopted at other sites should this regime be found to be successful. It is hoped this method will prove to be a viable alternative to grazing in reducing rodent abundance, thereby potentially increasing jewelled gecko numbers in places where stock are not wanted.

Tracking tunnels have been used as an effective tool in enabling managers to determine whether rodent activity is low enough to achieve desired conservation benefits and will be used in this study to gauge if rodent control will prove successful enough to improve jewelled gecko habitat quality. Tracking tunnel results can also be used to target pest control if necessary by identifying areas of high activity.

### *1.3.2. Detection of Jewelled Gecko Presence*

Jewelled geckos have not been widely studied in the past, owing to the difficulty associated with locating animals due to their cryptic basking behavior (Shaw, 1994). Detectability can vary widely based on the season, weather conditions, and observer error to name but a few. The development of an effective and objective manner of detecting presence absence in this cryptic species, independent of environmental variables and observer error, would help protection of jewelled gecko immensely by allowing more consistent and robust distribution estimates to be made.

Another objective of this study is to attempt to find a reliable means of detecting jeweled gecko which avoids these errors, exploring whether tracking tunnels could be an effective method for detecting the presence of jewelled gecko.

Tunnels have been used in tracking terrestrial herpetofauna (Agnew and van Winkel, 2009; Bell, 2009; Van Winkel, 2008) but not in arboreal species such as the jewelled gecko. If proven successful methods discovered could also potentially be applied to other arboreal herpetofauna.

### *1.3.3. Baseline Population Survey*

The cryptic colouration and behaviour of jewelled gecko make it difficult to locate individuals, and as such gauge the size of population fragments (Shaw, 1994). Mark-recapture estimations have been used to assess population size in gecko previously, either by physically marking individuals (using methods such as staining animals with non-toxic ink (see Shaw, 1994) and toe clipping) or through photographic 'marking' (Knox, 2009, 2010b). Shaw (1994) found that variation in jewelled gecko markings (particularly ventro lateral, dorso lateral and head markings) was sufficient to allow individual animals to be identified (Shaw, 1994). Individuals are photographed, being 'recaptured' when identified by matching the markings seen to those in photographic records (Knox, 2009, 2010b).

To develop a robust estimate of resident population size, years of monitoring data is often required and as such was not possible within the time span of this study. Instead this study sought to record gecko seen during the rodent monitoring process at SDHM to act as a baseline, allowing for future comparison to assess the effectiveness of the rodent control regime in improving gecko abundance, and survival rate.

## 2. *Methods*

This study was undertaken between December 2009 and March 2010. The study was ceased for 6 weeks between January and mid February when conditions for searching were deemed unfavourable, and detectability was low.

## *2.1. Study Site*

Both study sites are located on the Otago Peninsula on the south east coast of New Zealand. The Otago Peninsula experiences a temperate coastal climate with mild winter and summer temperatures (6.7 degrees C in winter and 15 degrees C in summer on average), even rainfall throughout the year, and predominantly south-west and north-easterly winds (Johnson, 2004).

The vegetative cover on the Otago Peninsula is varied, primarily consisting of remnant pockets of native shrubland within pasture, or regenerating broadleaf forest patches, predominantly consisting of divaricating shrubs (mainly coprosma species), and m•nuka and k•nuka (Johnson, 2004; Knox, 2010b). Suitable jewelled gecko habitat on the Otago Peninsula remains limited and patchy in many areas and population densities vary considerably between sites (Jewell and McQueen, 2007).

### *2.1.1. SDHM*

SDHM consists of 20.5 ha of moderately sloping, east facing land mainly covered in regenerating k•nuka, which links partially with a band of regenerating k•nuka spread across the Otago Peninsula. Domestic grazing stock have been excluded from the site for the past 5 years. The managed and control sites are separated by an area of rank grass 60m wide at the narrowest point (see *fig* 2)

The control site is around 0.9 ha, consisting of regenerating k•nuka, bordered by a large area of rank grass, and contains one of the few clusters of *Coprosma* spp. on the property (mainly *coprosma crassifolia)*.

The pest management area is approximately 0.7 ha and consists of 2 small meadows mostly containing rank grass, surrounded by regenerating k•nuka. Pest management has been undertaken in this area continuously, in pulses, for the past 18 months using Storm poison baits, containing a second generation anticoagulant flocoumafen (See Hoque and Olvida, 1988), in bait stations on the ground (3 bait stations, See *fig* 3) and in trees (5 bait stations, See *fig* 4). Bait stations on the ground also contained rat snap tracks set in front of laid poison, which were baited with peanut butter (See *fig* 3). Aquarium glue was laid at the opening of bait stations as a gecko deterrent (Shaun Murphy, pers. comm.; Mandy Tocher, pers. comm.).

The poison in ground bait stations was last laid two weeks before the study commenced, on 12th November 2009. The 5 bait stations in the trees remained loaded with Storm poison baits throughout the monitoring period. An additional 4 rat snap traps were also laid.

The control regime was changed, in January with the landowner introducing 3 additional "departure lounge" bait stations also baited with Storm poison baits. Shortly after 3 Mk IV Fenn traps, baited with egg, were introduced to the managed area. Both became operational 4 days before the second survey period began, on 15th February 2010.

**Figure 2: SDHM site illustrating pest management and control sites.**


Photo: www.dunedin.govt.nz

### 2.1.2. PCPA

The PCPA site, approximately 0.3ha in size, is on an exposed, steep north west facing embankment, predominantly covered by introduced grasses lightly grazed by sheep (*ovis aries*), interspersed with small, thick patches of *coprosma propinqua*. This site was chosen due to its high known density of resident jewelled gecko, to test effectiveness of tunnels in detection of the presence of gecko thus maximising the likelihood of successfully attracting gecko through the tunnels.

## 2.2. Tracking Tunnels

### 2.2.1. Rodents

To assess the distribution and activity of rodent predators in SHDM ink tracking tunnels were used. Tracking tunnels are commonly used as a method of indexing

**Figure 3: Ground bait stations**

Photo: F. H. Gordon

Figure 4: Arboreal bait stations

Photo: F. H. Gordon

rodent abundance, providing a coarse index of relative abundance and a measure of activity, allowing for simultaneous comparison or monitoring of gross changes in these over time at a single site (Gillies and Williams, 2010). It is assumed that tracking indices directly correlate to absolute densities, and as such can be used to reveal population trends (Wissel, 2008).

Tracking tunnels can be reasonably sensitive to the presence of rodents (particularly rats) when they are present at low densities making them a useful management indicator for determining the success of rodent control operations (Gillies and Williams, 2010).

On Thursday November 26th 2009, 12 tracking tunnels (see *fig* 5) (coreflute, with wooden bases) were placed at SDHM at 50 m intervals (Gillies and Williams, 2002, 2010; Wissel, 2008) with a total of six tunnels in the managed area and six in the control area. Tunnels were placed predominantly 2-3m in from the edge of regenerating k•nuka surrounded grass land, with the exception of one tunnel in each area (one tunnel was placed in *coprosma propinqua* patch in control area, and one was placed amongst grass in managed area). Tunnels were kept in place by pegging the ends of the tunnels down using two loops of No.8 wire. Papers here also held in place using drawing pins to prevent their being disturbed by possums.

A blank survey was run in the first week (no papers laid) to ensure any resident animals became conditioned to the presence of the tunnels before formal surveys began. Tunnels were left in place between survey sessions.

Once a week from Thursday December 3rd 2009 till Wednesday January 7th 2010 (6 ink tunnel surveys) and from Friday February 19th 2010 till Thursday March 4th 2010 (3 ink tunnel surveys), ink papers were laid in tunnels, baited with

**Figure 5: Coreflute tracking tunnel used to examine the activity of rodents at SDHM. Tracking paper is inserted over wooden base and secured with drawing pins to prevent animal disturbance. Papers were laid once a week overnight and baited with peanut butter. Tunnels were secured using no. 8 wire to hold tunnel in place.**


Photo: F. H. Gordon

peanut butter, and left overnight. The following day papers and remaining bait were collected.

The activity of mammalian predators was assessed using the proportion of tunnels tracked each week by each of the species monitored to develop an average tracking rate. This was tested further using a two sample t test using Minitab 15 (Minitab, 2007). Efficacy of the pest control regime was measured by the difference in activity index means between treatment areas over the study period.

### 2.2.2. *Gecko*

Specialised (smaller gecko-sized) tunnels were constructed (coreflute, with wooden bases). Tunnels were placed above ground (approx 1m) in *coprosma* *propinqua* bushes at PCPA, ensuring tunnels were level and the ends obscured by covering these with vegetation to make tunnels more conspicuous and to prevent disturbance. These were baited with banana, honey, pear (known lizard attractants (Bell, 2009; Carey Knox, pers. comm.)) or peanut butter. Three tunnels were placed in PCPA on Thursday December $10^{th}$ 2009. Once a week, from December $10^{th}$ 2009 till Wednesday January $7^{th}$ 2010 (4 ink tunnel surveys), ink papers were laid and baited. Papers were collected and replaced the following week and were rebaiting with a different attractant.

A second course of surveys was planned but to attempt to obtain gecko tracks from an area with a lower density of jewelled geckos and from an area where jewelled geckos are not known from (but may potentially be present). However given poor success with tunnels in high density site it was decided to abandon further investigation at present.

## 2.3. *Population Surveys*

14 visual searches for jewelled gecko were undertaken between December 2009 and March 2010 at SDHM site to record the distribution and abundance of jewelled gecko in the managed and control areas. In the future gecko numbers and individual sightings can serve as a baseline for comparison to assess whether the rodent control has positively influenced gecko abundance relative to the control area.

Bush line surveys were conducted initially by visually scanning vegetation from a distance, followed by closer inspection in which the vegetation was parted to look for individuals just off foliage edge. The same search path was followed for each of the 14 searches (see *fig* 6). For each survey the date, search time, search duration, cloud cover before and after search and maximum temperature were recorded. Cloud cover was graded by observer on a scale from 1 to 8, with 1 being clear sky and 8 being full cloud cover. Temperature was recorded from metservice.com records for the day search was undertaken.

In previous studies it was found that jewelled gecko were more likely to emerge on clear, warm mornings with low cloud cover and humidity (Duggan, 1991; Knox, 2009; Shaw, 1994). Consequently, searches were undertaken in such conditions where possible to maximise sightings and ensure consistency of search conditions. On occasion searches were delayed, till later in the day or until the following day, when conditions became more favourable.

Duggan (1991) found that searching on consecutive days did not markedly diminish detectability. Searches were conducted on two consecutive days a week when ink tunnel papers were laid and collected, weather permitting (Duggan, 1991).

Individuals sighted during searches were photographed whilst basking and identified by comparing markings of sighted individuals to those of individuals documented at that site in photographic records to determine if it has been seen previously (Using records by Knox, 2010b, pers. obs). Gender, life history stage (adult, sub adult, or juvenile/newborn), vegetation found on (eg k•nuka) and a

**Figure 6: Official search paths undertaken during each of the 14 Jewelled Gecko population surveys at SDHM**

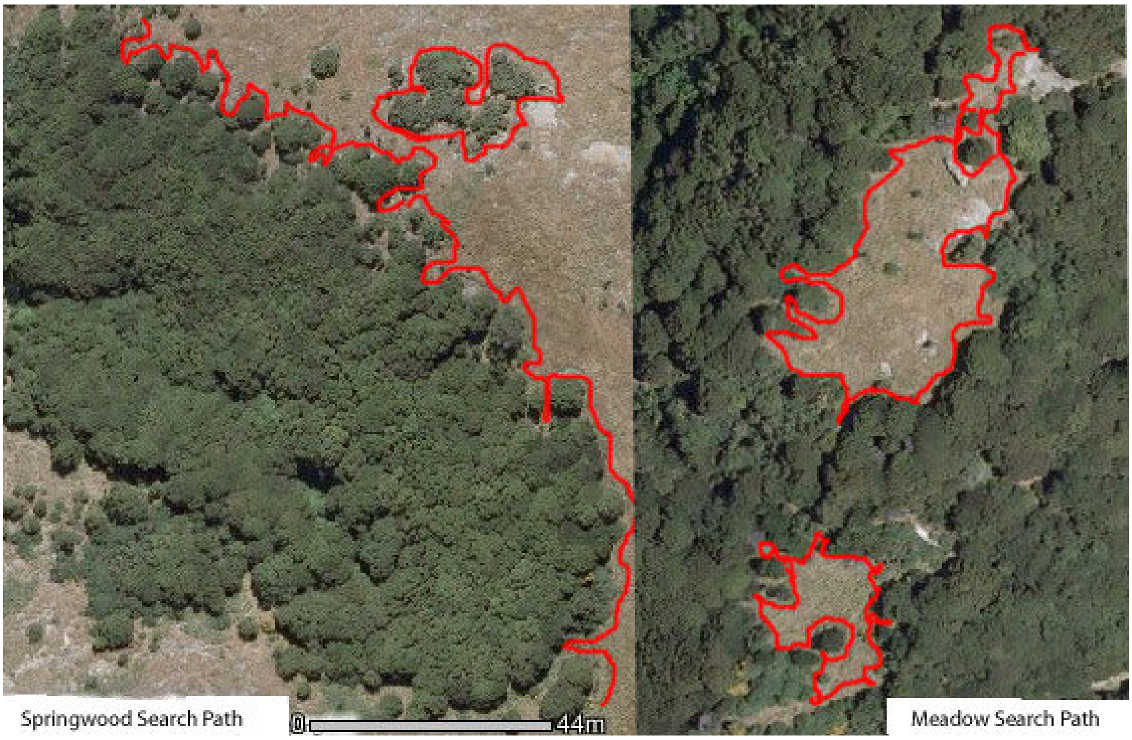



Photo: http://www.dunedin.govt.nz

description of appearance (eg white diamonds with dark border) and distinguishing features (such as scars or tail loss) were also recorded. Gender was determined by presence (male) or absence (female) of hemipenal sac. Life history stage was determined by size of individual and colouration.

## 3. *Results*

### *3.1. Rodent Tracking Tunnels*

No rodent activity was detected in the first survey. Mean mice activity varied from week to week but remained relatively constant throughout the study period fluctuating between 66% and 50% in the unmanaged area, and between 66% and 33% in the managed site (see *fig* 7). Rat activity was not detected until the fourth survey, with mean activity varying widely in the unmanaged site. Mean rat activity remained relatively constant in the managed site at 33% when were detected.

A marginal difference was discovered between the means of the two treatment areas, with the managed area having 7% less mice and 2% less rat activity on average (see *fig* 8). This, however, did not prove to be statistically significantly different in either of the species monitored (p=0.821 in rats and p=0.455 in mice).

Tunnels were also used to identify areas of high activity with some tunnels being more consistently tracked than others (see *fig* 9). The tunnels placed in rank grass (R1) in the managed area, and amongst a patch of *coprosma* (C4) in the control area were tracked by mice more frequently than most other tunnels, being tracked in 89% of surveys. A high frequency of rodent tracking was also seen in tunnels C1 and C2 in the unmanaged area (89% and 78% respectively).

Rat activity was less frequently observed than that of mice. In the managed area rat tracking rates were comparatively higher in tunnels closer to the landowner's house (R5 44% and R6 33%). Similar rates were seen in two tunnels in the control area, including the tunnel placed amongst a patch of coprosma (C2 44% and C4 33%).

**Figure 7: Mean Activity in Rodents over study period at SDHM**

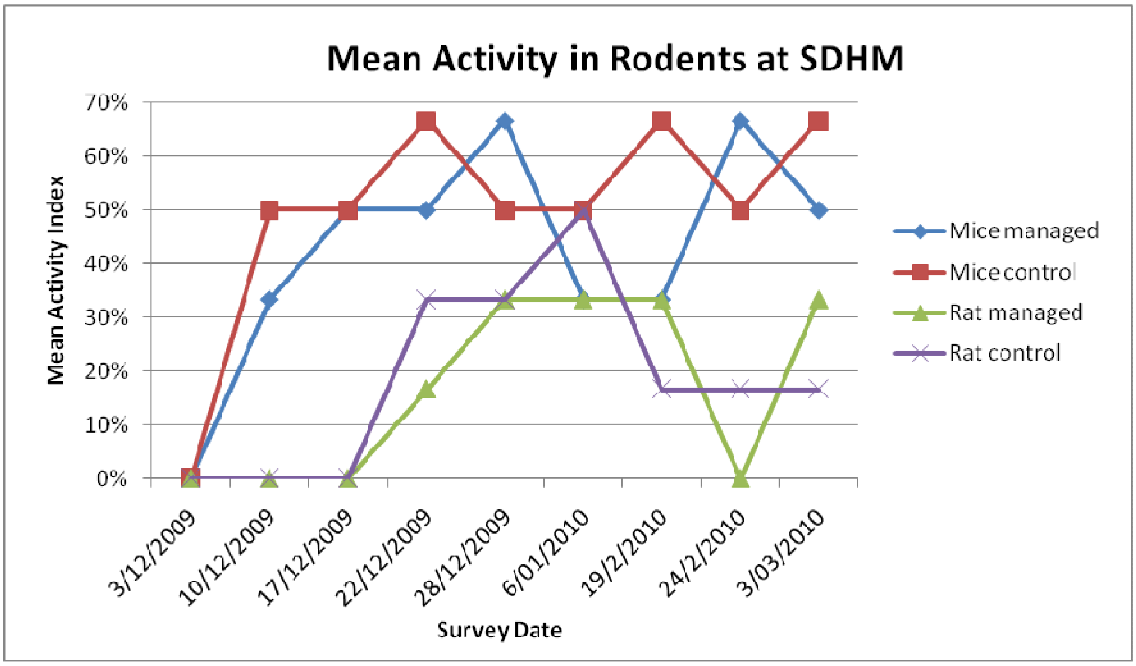



**Figure 8: Mean Activity Index observed of rats and mice at managed and control sites**

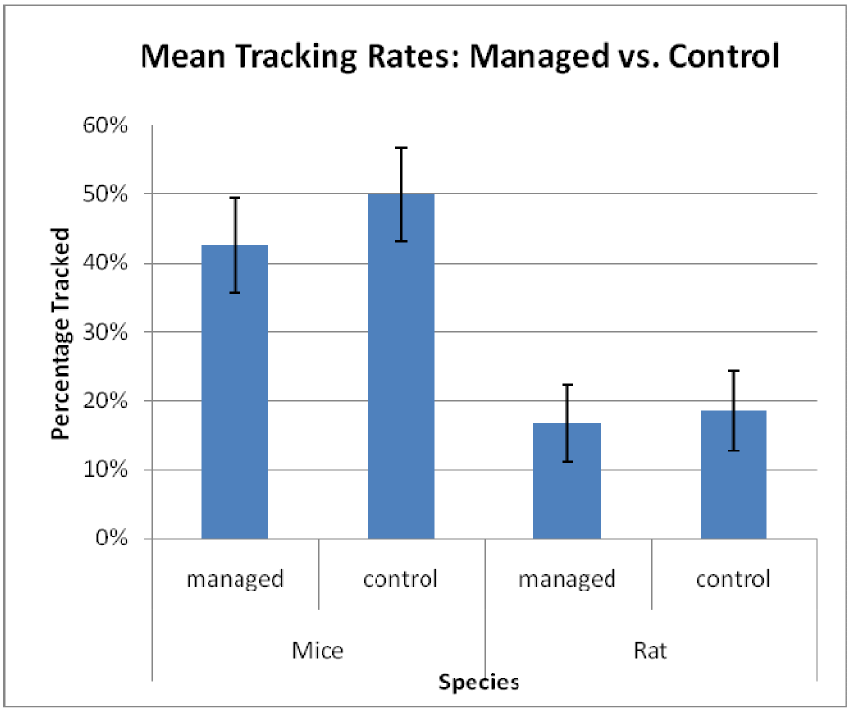
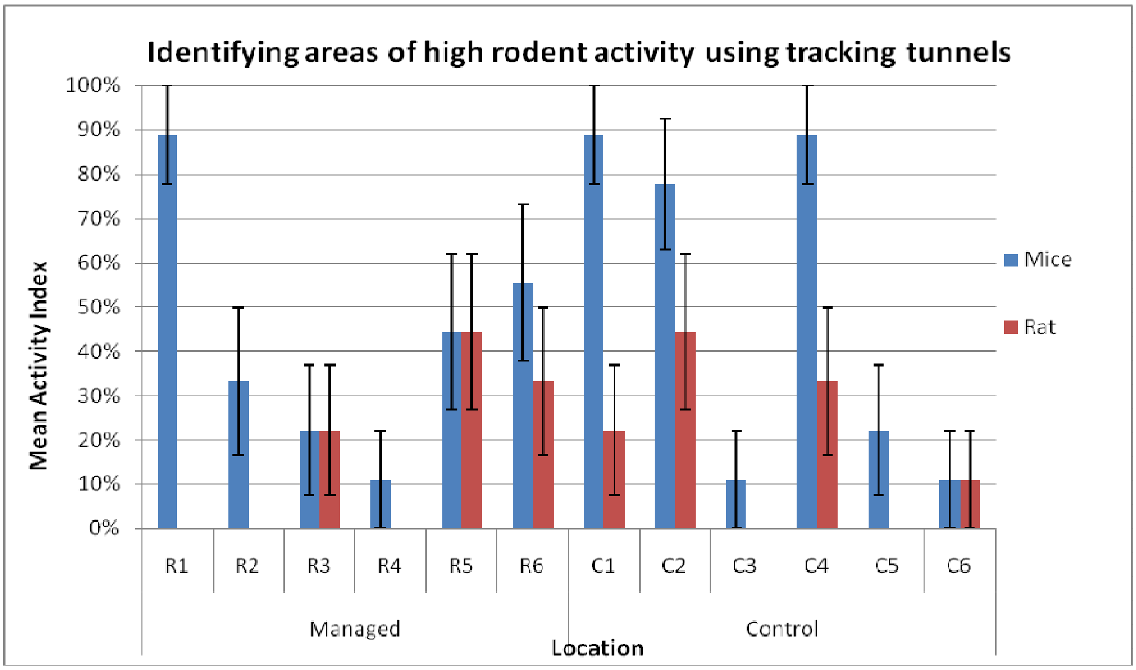


**Figure 9: Identifying Areas of High Rodent Activity Using Tracking Tunnel Indecies**




Arboreal bait stations remained baited throughout the monitoring period though only one of these received any take during this time. Two rats were caught in snap traps around managed site in January between the survey periods.

## *3.2. Gecko Tracking Tunnels*

Four series of tunnels were run using different attractants. Earlier in the study, tunnels were often disturbed by possums, with tunnels being removed completely from the bush in several instances. Tunnels that have been interfered with by possums could not be counted, voiding some results.

Gecko prints were only successfully obtained on a single occasion in one tunnel using canned pear bait (see *fig.* 10). Due to the poor success of these surveys, the gecko tracking tunnels were not resumed in the second period of the study.

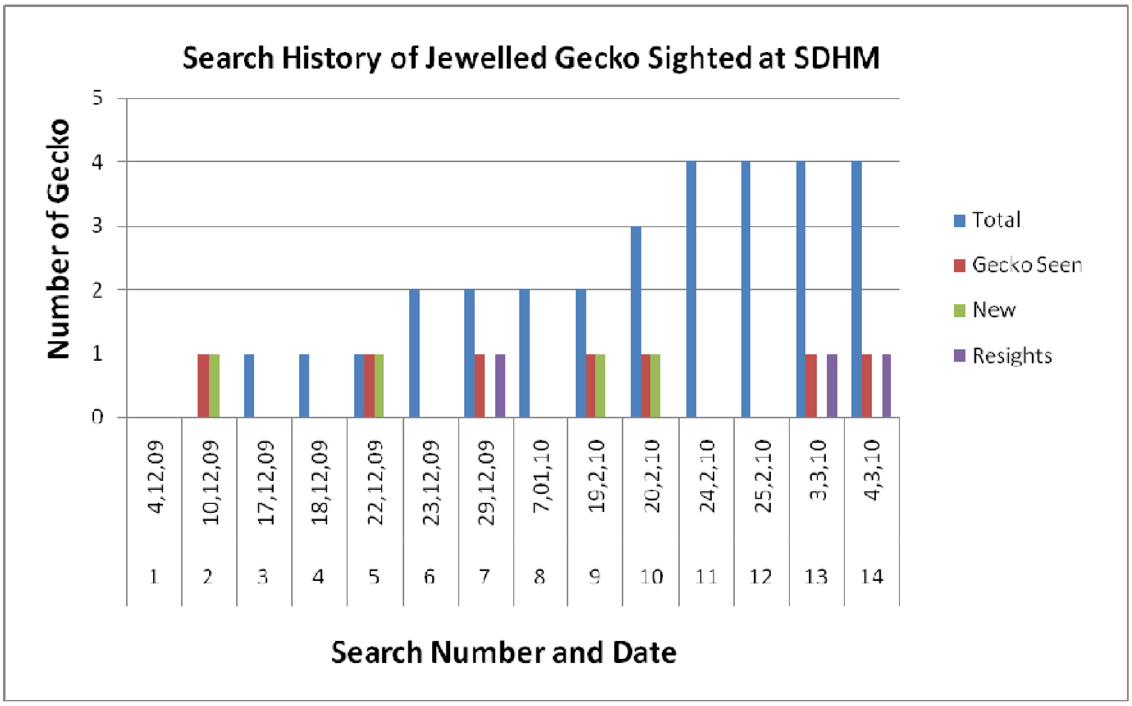
**Figure 10: Gecko prints obtained from tracking tunnels at PCPA using canned pear bait**

## *3.3.Population Surveys*

A total of seven captures were made of four different individuals during the 14 searches undertaken, with a maximum of one individual per search. One individual was sighted on four occasions. Two previously unrecorded individuals were also sighted (see *fig* 11). All individuals were found basking in k•nuka.

The majority of sightings occurred in managed area (based on sightings collected during this study, land owner observations and records collected by Carey Knox) with fewer total sightings in unmanaged area (half that of managed site, 12 vs. 6). A greater proportion of adult females (25% vs. 17%) and juveniles (50% vs. 17%) were detected in the managed site (see *fig* 12). Relatively

**Figure 11: Search History showing number of new individuals and resights in each survey, including total number of individuals sighted**




equal numbers of adult males and sub adult females were sighted in managed and control areas. No sub adult males have been sighted in the study areas. The majority of individuals sighted over the rest of the property were adult males (see *fig*. 13).

## 4. *Discussion*

### *4.1. Tracking Tunnels*

The true efficacy of the pest control methods used at SDHM was not able to be determined during the duration of this study, with the number of surveys being too few to detect a significant difference. No rodent activity was detected in

**Figure 12: Proportions of life history class of jewelled gecko detected across sites at SDHM**

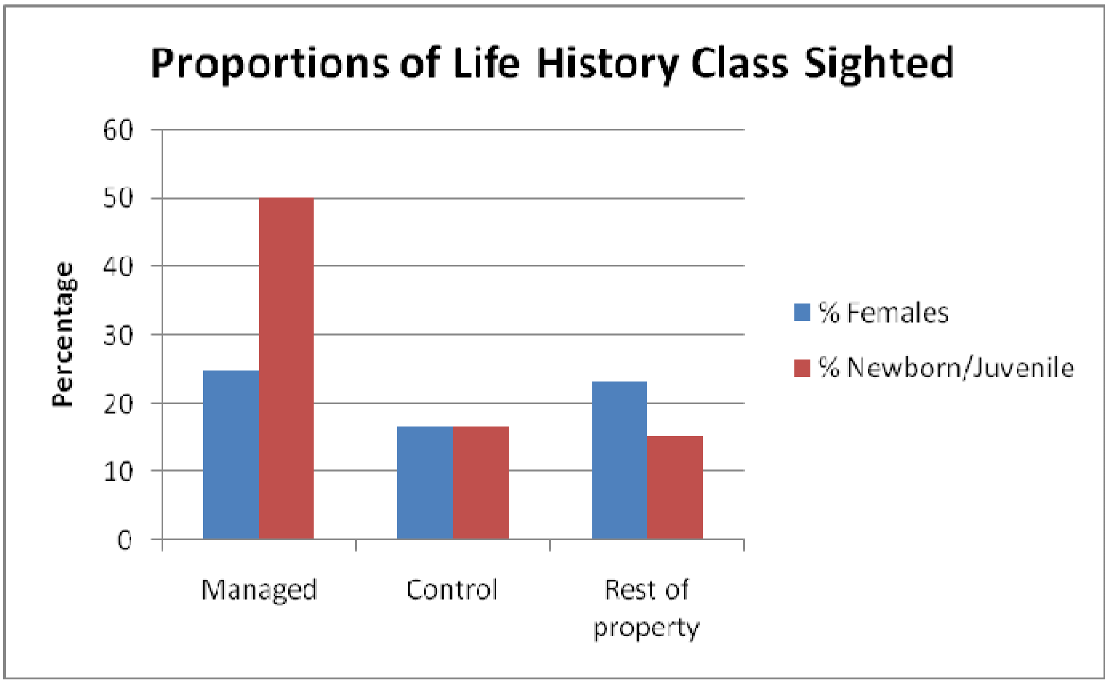
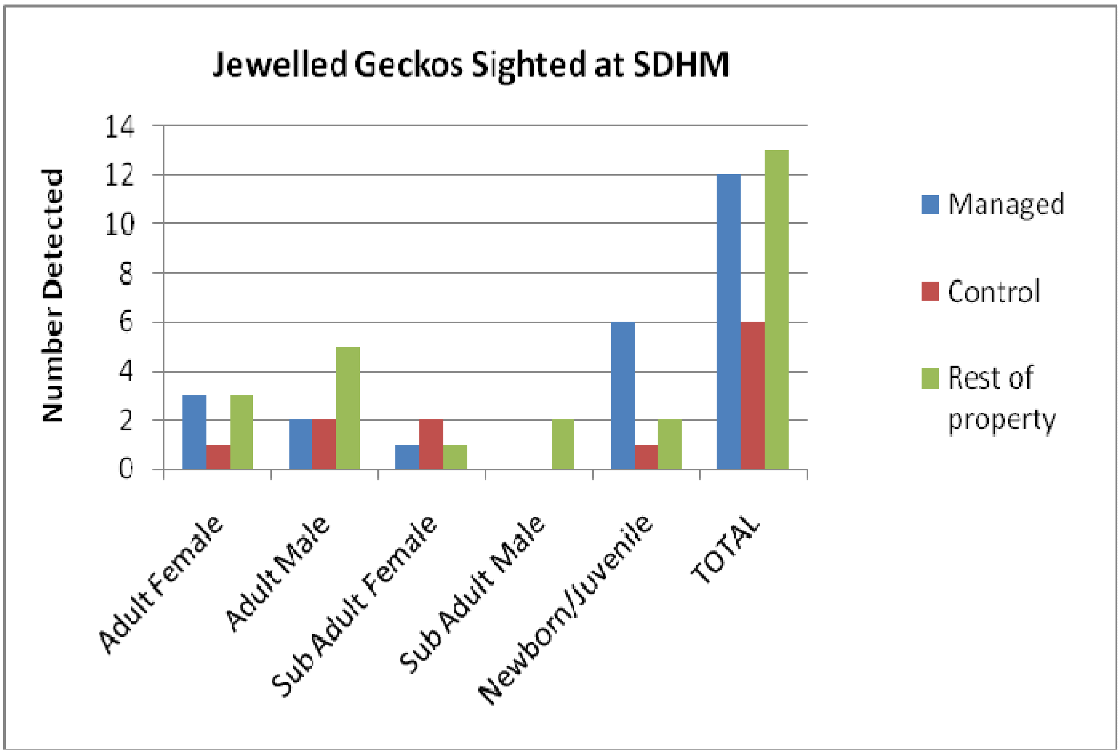



**Figure 13: Comparison of life history class of jewelled gecko detected across sites at SDHM**



the first week of surveys in either of the treatment areas (see *fig.* 7). This is believed to be due to extant animals still acclimatising to the presence of the tunnels. To fully determine the impacts of rodent control in this area and to improve statistical power of activity estimates, surveys would need to be run for a longer period of time.

The same is true with regards to the tunnels used to detect gecko presence. Resident geckos may have required a longer time period to acclimatise to the presence of tunnels in their habitat. Further replication is required to determine whether canned pear is an effective attractant for jewelled gecko rather than the tracks being obtained purely by chance.

The placement of gecko tunnels may also have influenced results obtained. Future studies should investigate placing tunnels at different aspects and heights as the impact of these was not tested in this study.

Findings from rodent surveys can be used as a baseline for future studies. Carey Knox plans on continuing with the tracking tunnels and gecko monitoring at SDHM.

## *4.2. Rodent Abundance*

Other factors may have confounded the results seen in rodent tracking tunnel surveys such as the proximity of tunnels to rodent attractants. There are a greater number of attractants close to the managed site (such as shelter, household rubbish, the landowner's home, and chickens) potentially making the area more prone to reinfestation, supporting a greater number of rodents despite the control regime, with tunnels in these areas were tracked more frequently as a result (See *fig.* 9). Mean activity observed in R5 and R6, those closest to the landowner's home, was among the highest observed across all tunnels. As such the differences detected between the managed and control sites may not truly reflect the impact of rodent control measures used due to a higher natural abundance in some locations.

The abundance of alternative food sources may also have contributed to the inconclusive result observed in ink tracking tunnels (Gillies, 2002). Were the surveys to coincide with a high prevalence of food, such as grass seeding, rats may be less likely to consume baits laid, due to the availability of other potentially more palatable food sources, resulting in a seasonal decrease in rodent activity and bait take. Knox found in his research that rodent activity on the Otago Peninsula, in both rats and mice, was higher during autumn and winter and at its lowest through midsummer (December/January), though these differences between seasons were not found to be statistically significant (Carey Knox pers. comm.). The landowner reported having had little take on baits laid during the study period. This may have been due to the prevalence of alternative food resources, with grass seeding through the study, and an acclimatisation of rodents to bait laid reducing its attractiveness to extant rodents, as take on baits has increased following the conclusion of the study and a change in baits used (See section 4.4 of this report for further details). Conversely an influx in food may support a greater number of rodents, increasing activity in an area (Innes et al., 2010).

While it is unclear whether these factors influenced the results found in this study it is still important to consider the potential effects of such seasonal influxes and contributing environmental factors in design of pest management regimes, such as increasing trap density or bait toxicity during periods of high seeding or high risk to gecko, such as when females are gravid or giving birth eradicated (Innes et al., 1995).

Reinvasion may also have influenced rodent activity observed with some areas being more prone to immigration that others. Wissel (2008) found high levels of rodent reinvasion occurred in sites adjacent to unmanaged forest, but not in those by exotic forest or pasture (Wissel, 2008). The managed area at SDHM is surrounded by kanuka forest, with little or no pest management being undertaken, whereas the control site is surrounded by exotic grassland. Consequently the control area may be less likely to experience immigration than the managed area, further obscuring the efficacy of pest management methods used.

Rats were not detected until the forth survey (22$^{nd}$ December 2009). This could possibly indicate that rats had been eradicated from the area following last poison pulse (12$^{th}$ November 2009) and that reinvasion did not occur until this point. If this was the case we would expect to see a decrease in the mean activity index of rats in the second study period as landowner had laid another pulse of poison between the two phases. No rats were detected in managed area in the first survey of the second period, undertaken on the 24th February. However activity index rates returned to the same level as seen before poison pulse and trap introduction in the remaining two surveys (19th February, 3rd March) both tracked by rats in 33% of tunnels (See *fig.* 7).

In other studies, rats were found to take several months to reinvade an area once eradicated (Innes et al., 2010; Innes et al., 1995). Given the rapid return of tracking rates to pre-poison pulse levels, it is unlikely that rats were eradicated at SDHM during the study, rather that they were reduced to less detectable levels. A larger area of pest control may be required, potentially creating a periphery buffer zone with a higher density of traps and bait boxes to reduce reinvasion (Innes et al., 1995).

### *4.3. Pest Species Interactions*

It was speculated that mouse activity might be suppressed by rat activity, and as such would increase when rat activity decreased. Mice activity dropped from 67% to 33% in the survey following a peak and plateau of rat activity at 33% from 28th December 2009. Conversely in the survey on February 24th 2010, where no rats were detected, mice activity spiked again to 67% (See *fig.* 7).

The interaction between mice and other rodents such as rats, and further food web implications is not well understood (Gillies, 2002; Wissel, 2008). Mice are notoriously difficult to control and efforts to control their numbers on the mainland have rarely been successful with populations recovering rapidly following management efforts (Wissel, 2008). Previous studies have observed mice outbreaks following intensive predator control, with mice numbers increasing as rat number declined, probably due to the decrease in both predation and food competition (Innes et al., 1995; Wissel, 2008).

This in turn has greater food web implications, as mice numbers increase so too does the food availability for rats, observed in increased rat numbers following mouse population eruptions during beech mast years, which in turn impacts stoats abundance as they commonly prey on rats (Innes et al., 1995). This highlights the complicated relationship between pest species and the need to take these relationships into account when designing predator management strategies. (Wissel, 2008).

## 4.4. *Pest Management Regime*

Results observed in this study do not give a clear indication of the effect of rodent control on rodent and gecko abundance at SDHM though this is difficult to gauge given the given small number of geckos detected in these areas and the number of surveys run (see *fig.* 11). A small difference was observed between sites with greater numbers of geckos, and a larger proportion of females and juvenile individuals, being sighted in the managed area (see *fig.* 12). Conversely less rodent activity was observed than in the control area (see *fig* 8). Knox (2010) found in his research that he saw greater numbers of juveniles and adult females in grazed sites, and believes this may be due to reduced predation in these sites (Knox, 2010a, b). These findings are consistent with those seen in this study which a greater proportion of adult female and juveniles being seen in the managed area (in study sightings, and based on records from Carey Knox and landowner) (pers obs.; Carey Knox, pers. comm.).

One of the difficulties of the pest management regime used at SDHM is public acceptance of toxin use. Some landowners will be uncomfortable using toxins on their land due to the environmental impacts of these (such as bioaccumulation), effects on non target species and potential risk to themselves and their pets. Furthermore it is more difficult to determine kill rate with poisons as animals hide when they go to die, and take is not necessarily an indication of mortality (unless high concentration of bait is visible in scat). The Department of Conservation considers second generation anti coagulants, such as broadificum and flocoumafen, to be effective but not sustainable in the long term (Gillies, 2002).

Trapping regimes tend to be viewed more positively than poison use, and offer more transparent results. Traps have an added curiosity value in that pests only have to investigate trap boxes to be culled whereas they may not ingest poison if investigating a bait box. While trapping is an effective method of pest control, it is also more labour intensive but nevertheless offers a long term alternative or supplement to poison pest control regimes (Gillies, 2002).

Utilising a more strategic rodent control regime could improve the effectiveness of pest management undertaken. Tracking tunnels successfully indicate areas of high activity, such as close to the landowner's house and other rodent attractants, where control methods used could be strategically focused for the pests present (see *fig* 9). The landowner has continued to run ink tracking tunnel surveys, placing additional ink papers in some of the bait boxes used in the managed area to determine what species, if any, are taking bait. At the conclusion of the study, traps and bait stations were shifted to target areas of high activity or where gravid females and newborns had been sighted. Following this the landowner has successfully caught a further 3 rats (one in MK VI Fenn, 2 in rat snap traps) in an area where rat tracks had been observed. The landowner has also changed baits used switching to Rat Abate, a diphacinone based anticoagulant, which does not bio accumulate and as such will not contaminate food-webs. These baits have been receiving greater take and appear to be more effective than storm baits so far.

### *4.5. Gecko Behaviour as an Explanation for Life History Class and Number of Gecko Detected*

Basking in jewelled gecko is believed to be a response to the relatively cold environments in which they are found, emerging opportunistically till their preferred body temperature is reached. Once preferred body temperature is attained, jewelled gecko will retreat further into foliage until later in the day when their body temperature decreases. Retreating into foliage assists in thermoregulation but is also believed to be in response to predation threat, being less accessible and visible to native avian predators once deeper in vegetation (Duggan, 1991; Knox, 2010b). This behaviour makes consistent detection difficult as extant individuals may not be visible at various points in the day. Geckos were more likely to be seen in the morning before retreating and were far less visible and difficult to detect following this (pers obs.; Carey Knox, pers. comm..; Duggan, 1991; Shaw, 1994).

The majority of females sighted during the study period were gravid. Duggan and Cree (1992) reported that pregnant females were easier to find than other ages and sex. This was presumed to be due to a greater need for females to bask, to enhance embryonic development thus making it more likely to see females (Duggan and Cree, 1992; Sherwood, 2009). Knox found a greater number of juveniles and adult females in areas with lower predation risk, such as grazed or pest managed sites (Carey Knox, pers. comm.; Knox 2010b). This combination of a greater physiological need to bask and the sensitivity to rodent presence can explain the higher number of sightings of females and juveniles in the managed area (see *fig*. 13).

Knox reported having seen males occupy larger areas of habitat, moving greater distances between sightings (Carey Knox, pers. comm.; Shaw, 1994). As such sighting females may be more likely as they are more likely to be resighted in a similar area.

When findings from this study were combined with data recorded by Knox and the landowner, trends in sightings were more apparent. At other times of the year both Knox and the landowner would normally sight a greater number of individuals at this site (Carey Knox pers. comm.). Knox and the landowner believe that over summer gecko move into the canopy in k•nuka, returning to lower boughs at the beginning of autumn.

It was not possible to accurately estimate the population size in study sites used, however these findings can be used as a baseline for future study and as an indication of individual survival.

## *4.6. Other Investigations into Detection Methods for Jewelled Gecko*

The difficulty of locating gecko species, such as the jewelled gecko, within their habitat has lead to the investigation of a range of alternative techniques to improve detection. Researcher Rosmarie Muller (2009) has been investigating the use of artificial retreats and vocalisations in detecting jewelled gecko and has found the use of clear PVC solariums attached to vegetation to be successful in detecting and monitoring jewelled gecko (Sherwood, 2009). Similar techniques have been tested by Trent Bell (Landcare Research) and Mandy Tocher (DOC) on other cryptic lizard species, including the Harlequin gecko (Bell, 2009).

A number of other methods have been used previously in the detection of gecko including lizard houses, g-minnow traps, pitfall traps, artificial retreats, and spotlighting (Carey Knox, pers. comm.; Shaun Murphy, pers. comm.; Bell, 2009; Jewell and McQueen, 2007; Knox, 2009). Such methods could potentially be incorporated into future tracking tunnel use and design to improve the likelihood of detecting gecko activity. Alternatively tracking papers could be placed in these refuga as a secondary means of detection.

## *5. Recommendations*

Results from this study suggest that rodent control may only have a marginal effect on rodent abundance. Utilising a more strategic rodent control regime, targeting areas of high activity, could improve the effectiveness of pest management undertaken. This could be achieved using ink tunnel surveys to reveal areas where certain species are detected more consistently; highlighting sites which required further attention (see *fig.* 9).

Since conclusion of the study the landowner has continued to run ink tunnel surveys to indicate where best to target pest management effort. This has been successful with an additional three rats being caught since then after moving traps to an area which was regularly tracked by rats.

The pest management methods used did not seem to positively affect gecko numbers in this study, though this is difficult to gauge given the given small number of geckos detected in these areas. A greater number of geckos have been sighted in the managed area previously. A difference was also seen in the proportions of females and juveniles sighted, with these individuals being seen far less frequently in non managed areas (see *fig.* 12). A longer period of monitoring is required to improve the statistical power of estimates, giving a more accurate reflection of site population size and by extension the effectiveness of pest control methods used.

The true efficacy of pest management methods used could be better detected by replicating this study at a number of different sites, comparing gecko abundance between managed and unmanaged locations. At present there are few sites undertaking pest control regimes meaning further replication was not possible during this study.

Additional research into tracking tunnel use in detecting arboreal gecko species is also recommended, using pear as an attractant. Poor success and frequent possum disturbance led to this study being discontinued. Future studies should investigate the effect of placing tunnels at a range of different aspects, heights and other such potentially confounding factors as the impact of these was not tested in this study. A variety of other baits should also be explored.

Tracking tunnels have been used successfully in terrestrial gecko (Agnew and van Winkel, 2009; Van Winkel, 2008) and with further exploration could be useful management tool in discovering new populations of arboreal geckos such as the jewelled gecko. A number of gecko detection techniques are currently being researched (Bell, 2009) and could potentially be incorporated into future tunnel designs to improve likelihood of detection.

## *Table of Tables*



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## *References*

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