Predator control and the health and abundance of North Island weka—a report on the Motu region project

November 1999 – June 2012

Department of Conservation
Te Papa Atawhai

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Abstract

A population of North Island weka *(Gallirallus australis greyii),* a threatened flightless rail, was monitored in both predator trapped and non- trapped areas of forest and pasture from 1999 to 2012. The aim of the study was to determine if predator control would lead to long-term increases in weka health and abundance, thereby increasing the resilience of the treated population to stochastic events. 800 stoats, 209 feral cats and 40 ferrets were removed from the trapped area. Adult and juvenile weka in both the trapped and non-trapped areas appeared healthy (based on weight and visual checks) and have increased in numbers. Survival of juveniles to 12 months of age was 69% in the trapped area and 64% in the non trapped area, with predation by mustelids (both confirmed and suspected) being the largest cause of death in both areas. Between 2003 to 2010 adult density in the trapped area increased from 0.14 to 0.36 weka per hectare and in the non- trapped area from 0.24 to 0.30 weka per hectare. Fifty seven weka were inadvertently captured in mustelid and cat traps and trapping tunnels were repeatedly modified to try to exclude weka. These changes have resulted in a decrease in the number of weka being trapped. The opportunity to monitor the effects of mustelid trapping on a weka population during a major non predator related stochastic event did not arise during the term of the project.

Background

The weka *(Gallirallus australis)* is a flightless rail that is endemic to New Zealand. Four sub-species are recognised of which one, the North Island weka *(Gallirallus australis greyii),* is found in the North Island and on some off-shore islands. All sub-species have undergone large declines within the last 50 years and in 2005 the North Island weka had a threat classification of "nationally endangered" by the Department of Conservation (Hitchmough: 2005). This classification has remained unchanged (Hitchmough *et al:* 2007).

Reasons for the decline in weka populations are poorly understood but populations have historically varied due to mortality and migration. The most likely causes of decline are combinations of droughts, floods, land management practices, predation (mainly ferrets and stoats but also cats and dogs), vehicular and possibly disease (Beauchamp *et al:* 1999 and Bramley: 1994).

Weka are normally robust birds, living up to 15 years, breeding after their first year, laying up to three clutches per year and commonly fledging 2-3 chicks per clutch[1]. This high fecundity enables weka to recover from isolated "agents of decline" events, but occasionally these events appear to coincide, leading to dramatic declines, and to the extinction of local populations.

North Island weka were common throughout the North Island up until the late 19th century. By the 1960s the population had become restricted to the Gisborne region where it was thriving in various types of farmland and the Gisborne urban area. There were so many weka that their habits of uprooting seedlings in search of insects, pecking and destroying soft food crops such as tomatoes, melons and pumpkins, stealing eggs from domestic chickens and entering homes stealing anything portable (pers. obs.) began to frustrate local

1 Banding and observation records held at Motu Field Office.

residents and some were relocated by the Wildlife Service, resulting in their establishment on a number of islands during the 1950s to 1970s.

Despite high abundance this seemingly robust population crashed in the mid 1980s leaving only a small patchy population mainly concentrated in the north-west part of its former range centred around Motu (Fig 1). This area, predominately high country farm, scrub and forest land with reliable rainfall, now represents essentially the entire natural mainland population, estimated, in 1999, to be between 2000-3000 birds (Beauchamp *et al*: 1999).

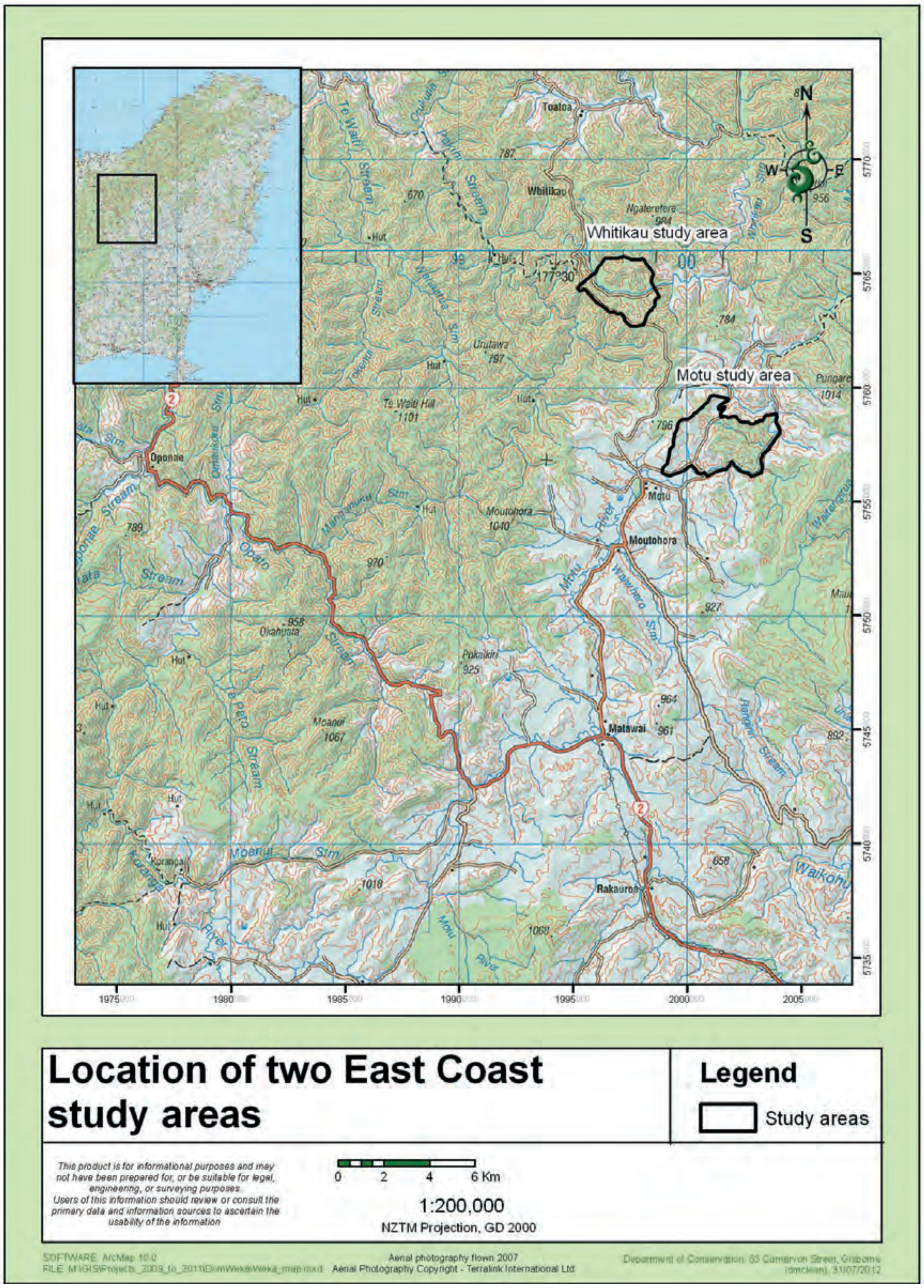

Figure 1. Location of two East Coast study areas

The weka population crash in the Gisborne district is thought to be primarily due to a drought in the early 1980s. The initial effect of the drought was to make water scarce and foraging for food difficult. Wet ground, rotten logs and leaf litter hold a much greater accumulation of food (including invertebrates) than dry ground, as well as being easier to probe.

A secondary effect of the drought on weka was habitat depletion. Farmers were often forced to resort to roadside grazing which lead to the trampling and destruction of scrubby cover vital for protection against predators and weather. This effect, combined with reduced opportunities for food and water, lead to reduced fitness which was reflected in less breeding activity and increased potential to succumb to predators. Weka were restricted to areas, such as Motu, that were less affected by the drought.

The timing of the drought in the Gisborne area coincided with the release of ferrets from failed ferret farms at several sites within Poverty Bay. Bramley (1994) suggested that predation of weka by ferrets could have a significant effect on weka populations. Also, it is commonly suggested (pers. obs.) that disease played a major role in the virtual disappearance of weka from the Gisborne region but there is no evidence to support this theory.

It is estimated that the Gisborne weka population decreased by about 98% in the mid 1980s (Bassett: 1996). Results from questionnaires sent out to locals (1991 and 1995) and an annual weka call count survey (Rakauroa, 1991 to 1996) carried out in the Gisborne region pointed to a continuing decline in the weka population over the following decade. Extinction seemed very probable given that regional extinctions had occurred everywhere else in the last century and there was no apparent reason why the existing population should be different.

In order to gain knowledge and develop conservation management techniques to improve the security of North Island weka on mainland New Zealand a study was established in late 1996 approximately 70km north-west of Gisborne (Fig 1). This area was selected as it held by far the largest population of weka and was considered to have a stable habitat and climate, making this population the strongest and most viable for management and study.

The study aimed to determine if predator control would lead to long-term increases in weka health and abundance, thereby increasing the resilience of the treated population to stochastic events. Predator control was tested because this is likely to be a leading factor in the periodic decline of weka and will be more important when other population stresses are present, and it is also the only realistic management option that is able to be implemented on an effective scale. The effectiveness of predator control was determined by monitoring both weka and predator indices as well as weka health and survival statistics.

Although the project was set up at the end of 1996 this report focuses on the years between November 1999 and June 2012 when the study was based at Motu and Whitikau. Methods used and results obtained between 1996 and 1998 when the study was based at Toatoa and Whitikau are recorded in the appendices.

Objectives of the Project

(1) To determine the effects of sustained predator control on a weka population and

(2) To determine the key factors influencing the abundance and dispersal of North Island weka.

Methods

Study areas

The project was based in the central East Cape region of New Zealand's North Island, midway between Gisborne and Opotiki (Fig 1). Two study sites, of approximately 800ha each, were established at Motu and Whitikau, the latter is about seven kilometres north of Motu. The Motu site is intensively trapped for mustelids and less intensively for cats while no trapping takes place in Whitikau.

Originally, the trapped site was located at Toatoa, approximately seven kilometres north of Whitikau (Fig 1). In 1999 the trapped site was transferred to Motu because Toatoa appeared to have very few predators. Three stoats were caught in 79 double trap sets from November 1998 to April 1999. A higher potential predator abundance was needed to more rigorously test the predator control regime, and Motu fulfilled this requirement (Sawyer: 1999).

The second trapped site, Motu (Fig 2), comprised 429 hectares of podocarp dominated primary lowland forest (Whinray Scenic Reserve), pasture with patches of second growth forest, scrub and wetland, and roadside scrub. Sheep and cattle are farmed with reasonable intensity which included some roadside grazing and draining of swamps. The Whitikau site (Fig 3) is part of a valley; the valley floor comprised wetland (kahikatea and carex spps) and pasture, while the valley sides are second growth forest, scrub and pasture. Cattle are farmed at low intensity and since 2004 some scrub has been sprayed and some wetland areas drained. Most of the study area is privately owned and a small strip along the south western boundary is part of the Whitikau Scenic Reserve.

Predator control

Objectives of Predator Control

- To reduce predation by stoats, ferrets and cats on NI weka in the Motu study area through trapping.
- To compare predation levels on NI weka between the trapped area and the non trapped area.
- To provide conclusive evidence that stoats are present in Whitikau as well as in Motu.
- To investigate whether stoat densities are comparable between the trapped and non-trapped areas.
- To investigate the presence of weka remains in stoats.
- To record the density of rodents in two main habitats in the Motu study area and any seasonal and annual fluctuations in it.
- To identify any differences in the relative abundance of rodents between the two main habitat types within the study area.

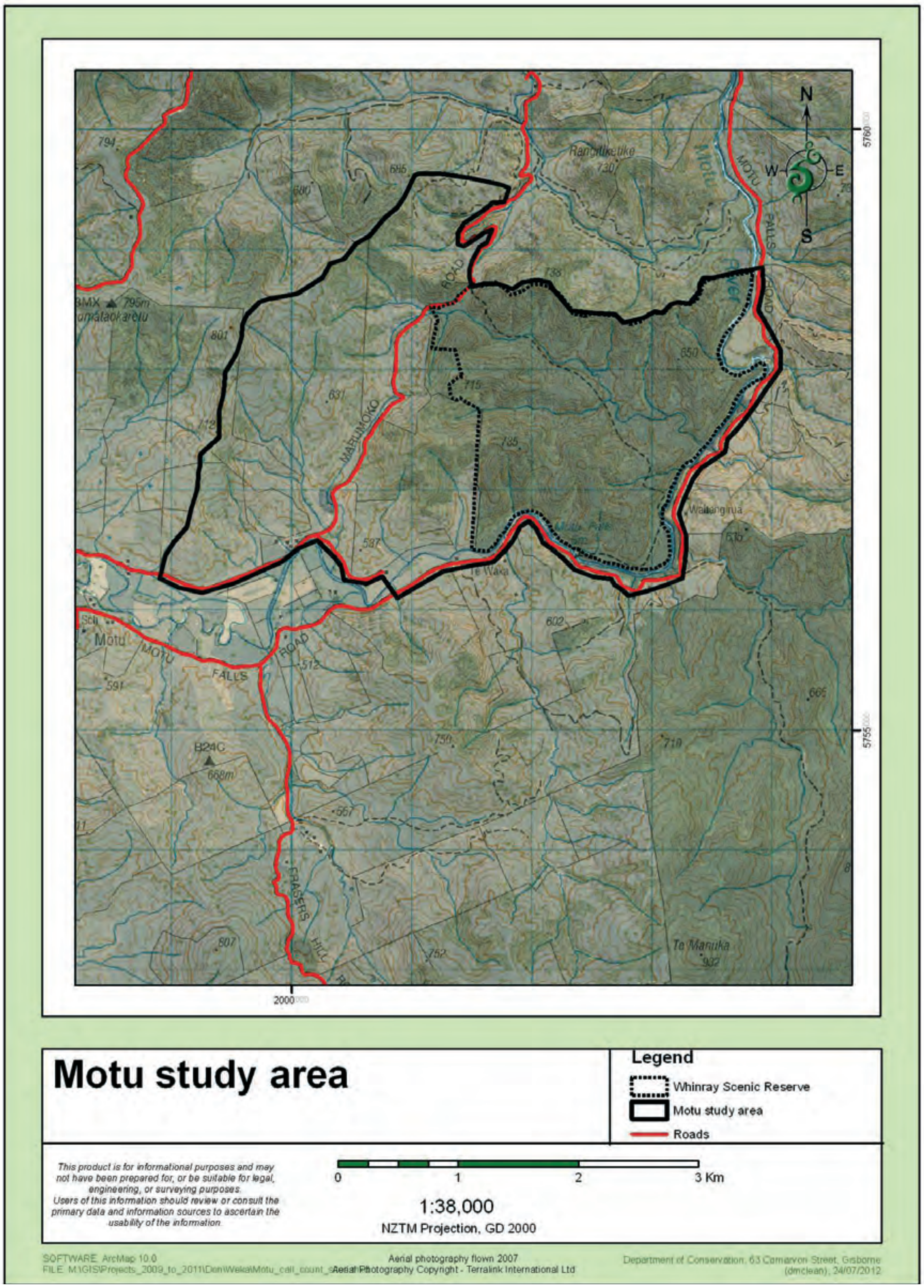

Figure 2. Motu study area

Each predator trapping season began on 1 July and ended on 30 June each year. The only exception was in the first season of trapping when traps were not activated until November 1999.

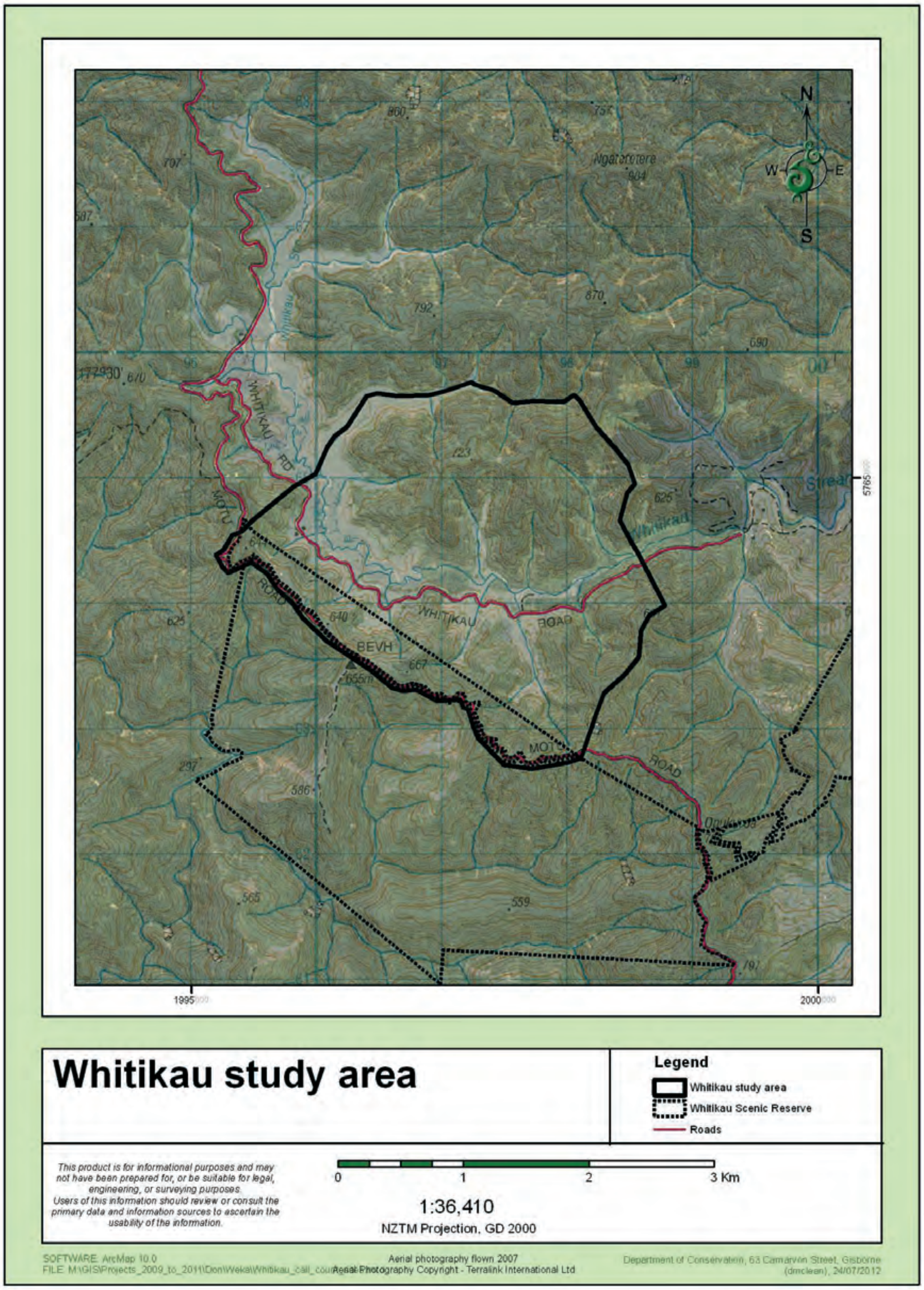

Figure 3. Whitikau study area

Stoat control

Trap types

From 1999 to 2003 Mark VI Fenn traps were the only type of trap used to target stoats. They were all presented as double sets. Fenn traps were completely phased out by the 2009-

10 season. Thumper traps with weka bars were used only in the 2003-4 season and only alongside already established Fenn trap sets.

DOC200 sets were first set up in the 2004-5 season and were set up to alternate with Fenn traps. They were presented as both single and double sets. Trap box specifications are given in Appendix 2.

In November 1999 tunnels were made with 13mm galvanized steel aviary mesh. They were 600mm long and had no baffle system and no floor. They were pegged to the ground with wire pegs. Various other tunnel designs were trialled over the next few seasons.

From the 2004-5 season all tunnels measured 800mm in length and were made from wood. They included a floor and a double, off-set baffle system made with 13mm galvanized steel mesh. They had either one entrance or no entrance depending on whether they housed a single or double trap set. See Appendix 2 for tunnel design specifications and illustrations.

Bait types

From November 1999 to June 2006 all traps were baited with a single pricked hen egg. From July 2006 traps were baited with a single egg that had not been pricked. In August and September 2008 eggs were replaced with freshly minced rabbit meat. Since then, each October freshly minced rabbit meat has replaced eggs as bait.

Trap servicing

The servicing of traps (checking, clearing and re-baiting) has varied in intensity as the project has developed. In the first few seasons traps were checked weekly over the summer months and then were often closed for maintenance over the winter months.

From July 2005 traps were checked monthly from February to November and fortnightly in December and January. They were also checked fortnightly when rabbit meat replaced eggs in October each year from 2008 (Appendix 4).

When traps were re-baited old eggs and meat were discarded at least five metres from the trap rather than being carried out of the area.

Trap line number and distribution

The number of trap lines increased over the course of the project from 11 in 1999 (Fig 4a) to 23 in 2011 (Fig 4b). Before 2004 the focus of the trapping project was Whinray Scenic Reserve which comprised about half of the Motu study area. Most lines were inside the reserve and lines outside the reserve acted as buffers to reduce the chance of predators entering the reserve. Tunnels within lines were approximately 200m apart and the distance between lines varied from a few hundred metres to over 1000m. The lines followed geographical features such as ridges, streams, boundaries, tracks and roads.

In the 2004-5 season the trapping regime was increased to include the entire Motu study area. The lines followed similar geographical features as before such as ridges, streams, boundaries, tracks and roads. Lines were no more than 1000m apart throughout the study area and traps were approximately 200m apart. This programme remained in place until the end of the project. From 2004-5 two further lines were added to the trapping regime (Fig 4b). For further detail on trap lines see Appendices 5 and 7.

Sexing stoats

All stoats caught were sexed except those whose bodies were too decomposed to be able to determine sex with confidence. Sex was determined by the presence or absence of the baculum (King *et al*: 1994).

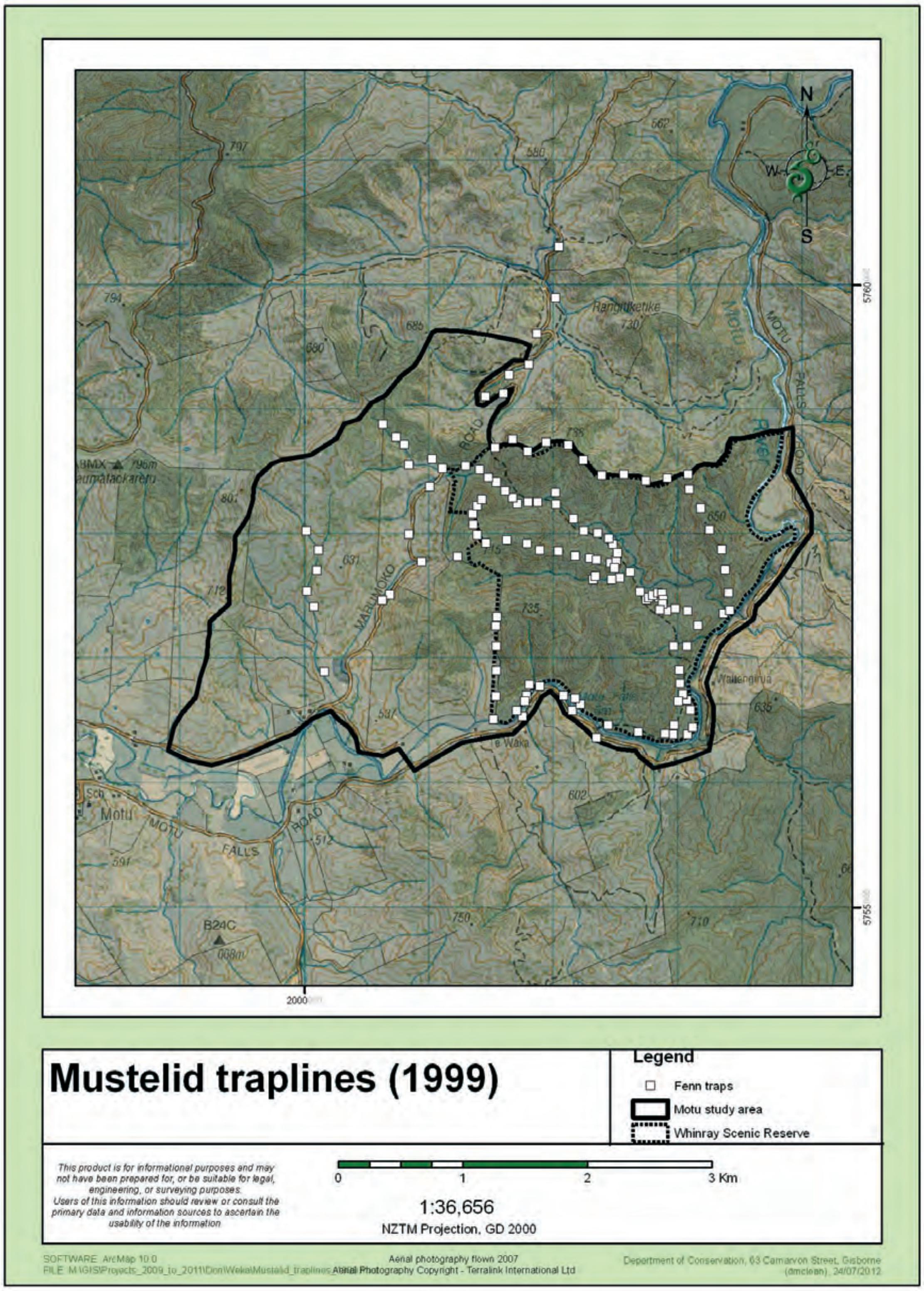

Figure 4a. Mustelid trap locations in 1999

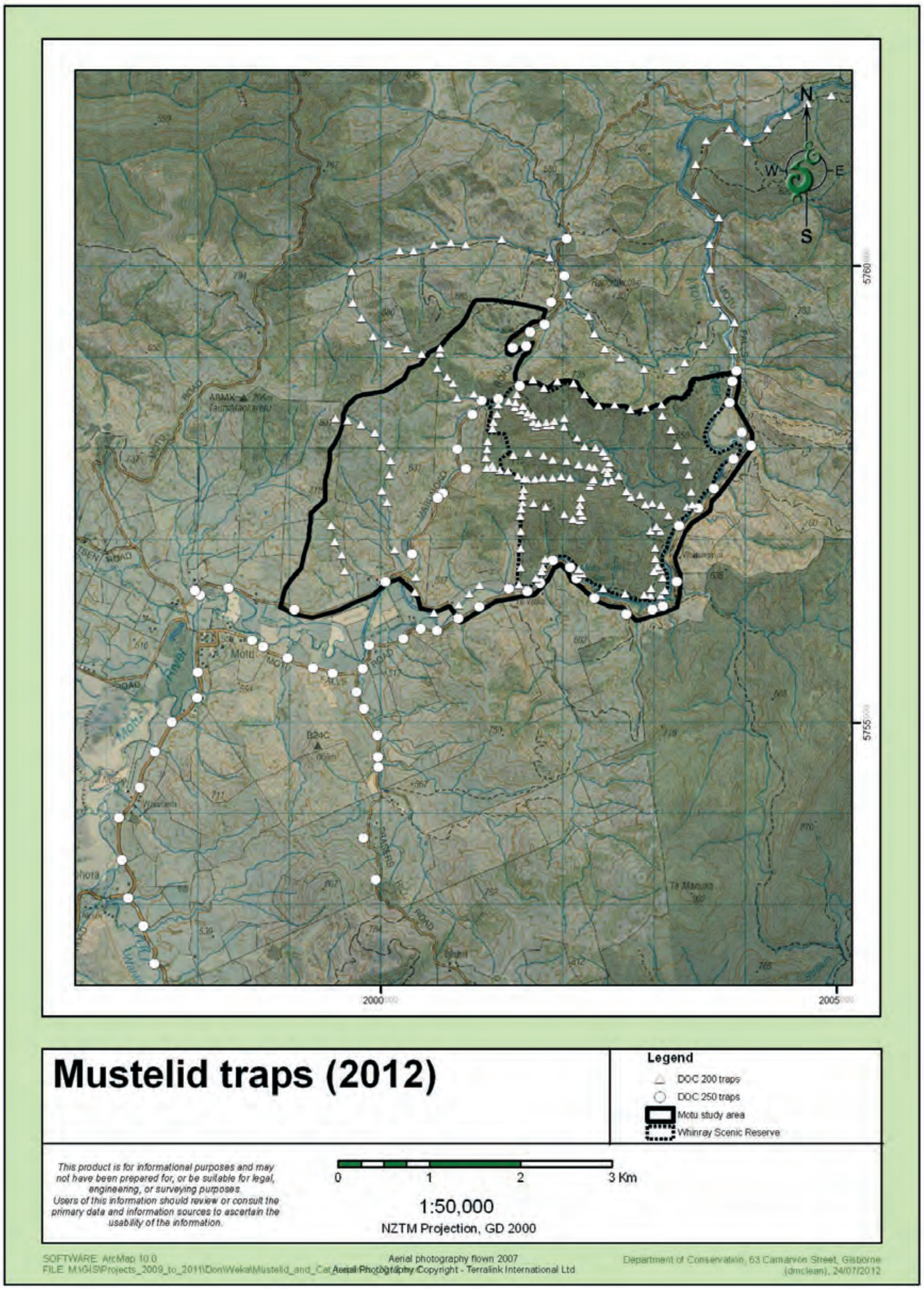

Figure 4b. Mustelid trap locations in 2012

Gut sampling of stoats

The stomach contents of dead stoats were examined from July 2001 to June 2003. Content was divided into five categories: empty, invertebrates, rodents, eggs and birds. Eggshells and feathers belonging to weka were specifically identified whenever possible.

Calculating a density index

A density index for stoat captures per session was calculated using the formula provided in "Monitoring and control of mustelids on conservation lands" (C.M. King, 1994). A session was the duration of one trapping season. An index was also calculated to compare the success of trap types in catching mustelids and weka. A density index was not calculated for the 1999-2000 and the 2000-2001 seasons as traps that had recorded no captures and sprung traps had not been recorded and there was insufficient information to allow for the calculation.

Ferret control

Trap type

DOC250 traps were the only type of trap used to target ferrets. They were first set up in December 2006. Trap box specifications are given in Appendix 3.

Trap layout and servicing

Eleven traps were first set up along part of the southern boundary of the study area in December 2006. From 2008 DOC250 traps began to replace Fenn traps and DOC200 traps. By July 2009 a total of 70 DOC250 traps had been set up. These traps were checked and cleared at the same time as the stoat traps (Fig 4b). For further detail on trap lines see Appendices 6 and 7.

Bait type

The traps were baited with an un-pricked hen egg. From 2008, eggs were replaced with freshly minced rabbit meat in October. In 2012 eggs were replaced with freshly minced rabbit meat in March.

Sexing ferrets

All ferrets caught were sexed. Sex was determined by the presence or absence of the baculum (King *et al*: 1994).

Cat control

Trap type

Between July 2001 and December 2002 sixteen conibear traps[2] were attached to tree trunks at a height of 600mm. A ramp, one metre long and 200mm wide, which was parallel to the ground, led to the trap. Weka managed to gain access to these traps so in December 2002, traps were raised to a height of 1300mm. A same sized ramp sloped up to the trap from an initial height of 1200mm (Appendix 9).

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2 Modified by Steve Allen, formerly Department of Conservation, Whangarei Area Office.

Trap layout and servicing

Traps were set up throughout the study area along the mustelid trap lines (Map 4c). They were serviced at the same time as the mustelid traps. For further detail on trap lines see Appendix 9.

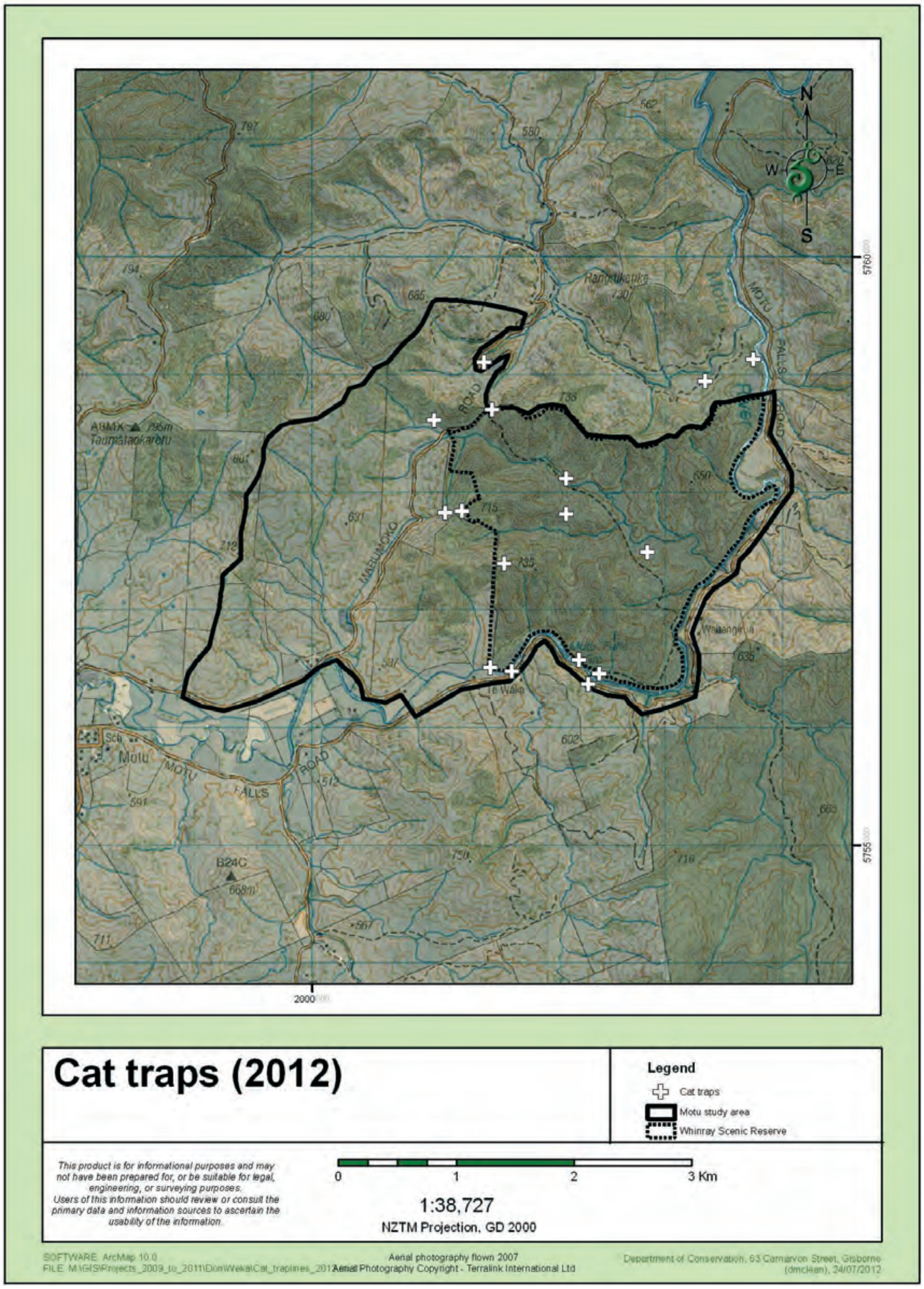

Figure 4c. Cat trap locations in 2012

Bait type

Traps were baited with freshly minced rabbit or hare meat.

Sexing cats

All cats caught were sexed.

Mustelid monitoring

Observations

Prior to 2007, evidence of the presence of stoats at Whitikau included stoat sightings reported by local residents and Department of Conservation staff, monitored juvenile weka killed by stoats and also stoats captured in a stoat trap line run by Opotiki Area Office[3] (from April 2002 to June 2007) approximately 2km from the study site.

Tracking tunnels

Mustelid monitoring lines using tracking tunnels were run in Motu and Whitikau from February 2007 to February 2010. The method used followed that prescribed by Gillies and Williams. In both study areas there were five lines no closer than one kilometre apart. Each line consisted of five tunnels spaced 50 metres apart along the line.

Lines were monitored in February, May, August and November from February 2007 to February 2008. They were monitored in November, December, January and February from November 2008 to January 2010. Tracking cards were supplied by Connovations and a fresh two cm cube of rabbit or hare meat was placed at either end of the tracking card.

Rodent monitoring

Tracking tunnels

Rodent monitoring lines using Philproof tracking tunnels were run in Motu from February 2002 to November 2003. The method used followed that prescribed by Gillies and Williams (2001). Five lines were set up in pasture habitat (farmland and forest gullies) and five lines were set up in forest habitat (Whinray Scenic Reserve). Lines were no closer than one kilometer apart. Each line consisted of ten tunnels spaced 100 metres apart.

Lines were monitored quarterly for four consecutive nights. Lines in the pasture habitat were monitored until March 2002. Tunnels were baited with two half teaspoons of peanut butter placed at either end of the tunnel. The tracking cards were made from A4 xerox paper cut to size. The tracking ink was made with food colouring and soaked in pieces of foam that were placed at either end of the tunnel.

Weka monitoring

Objectives

- Carry out call counts to obtain annual density estimates from the treatment area (Motu) and the non treatment area (Whitikau) in order to provide reliable indicators of density.

3 This line was run by Opotiki Area Office as part of a Whio Protection Programme.

- Use call count results to compare weka density estimates within and between the treatment area and the non treatment area, and over time, to provide a reliable indicator of density trends.
- To establish an index of the adult population health using weight information.
- To monitor and compare the survival rates of juvenile weka to 12 months of age in both
  the treatment and non treatment study blocks.
- To determine and compare juvenile dispersal between the treatment and non treatment study blocks.

General monitoring

Population and individual health monitoring

In December and January each year juvenile and adult weka from both study areas were targeted for capture to collect data on individual and population health, juvenile survival and causes of death. Live capture possum traps (710mm high x 300mm wide x 300mm high) were set in dry weather, baited with cheese and checked daily. On each initial capture weka were banded with a 27-series (Department of Conservation National Banding Series) stainless steel leg band for future identification.

On the initial and any subsequent captures every bird underwent a visual examination. Ears, eyes and nostrils were checked for any discharge, the body was checked for abnormalities and mites and ticks. The presence or absence of any of these was noted.

Various measurements were also taken including culmen length and depth, tarsus length and width, mid toe and mid toe to claw length, wing and tail lengths, eye colour, and weight. Wing spur length and shape were recorded and used to determine the age category of birds (Table 1) (Beauchamp *et al*: 1999). Where spurs were different sizes on the same bird the spur with the youngest characteristics was recorded. These measurements were used to determine the sex and health of individual birds and were then collated to give an indication of the health of the population as a whole (Beauchamp: 1987).

Table 1 Age categories of weka as determined by wing spur characteristics

SPUR CATEGORY	AGE OF WEKA	LENGTH OF SPUR	DESCRIPTION OF SPUR TIP
S1	<1 year old (juvenile)	4–6 mm	Sharp, curved back
S2	1–3 years old (adult)	6–12 mm	Sharp, not curved back
S3	3–15 years old (adult)	>10–14 mm	Blunt tip, dark grey
S4	>7–15 years old (adult)	<10 mm	Blunt tip, grey
S5	>7–15 years old (adult)	<5 mm	Blunt tip, grey

In December 2004 a blood sample, a blood smear and cloacal swab were taken from the first ten birds caught from each study site. These samples were sent to veterinarians at Massey University and screened for haemoparasites, *Salmonella* spp., *Yersinia* spp., *Campylobacter* spp. and *Escherichia coli*.

The local community was encouraged to report any dead or injured weka they found to the Department of Conservation (DOC). Any weka found by DOC staff or local residents were visually examined in order to try to assess the cause of death or injury. Up until 2005 dead birds that were found in excellent condition were sent to Massey University for an independent autopsy and pathology report. Injured weka were treated and released or, in severe cases, euthanized.

Adult monitoring

Call Counts

Call count surveys were set up in Motu and Whitikau in April 2002 and carried out on an annual basis until April 2011. The method used for call counts followed DOC protocol (Beauchamp *et al:* 1999).

There were six listening posts in Motu (Fig 5a) and five in Whitikau (Fig 5b). See Appendix 10 for further information on the location of listening posts. An observer was assigned a post and recorded each single and paired weka spacing call[4] they heard over 1½ hours for three nights. Listening began half an hour before sunset and finished one hour after sunset. The position of the calling weka individuals and pairs were recorded on a separate 1:10 000 scale map for each night. The three nights were as close together as possible depending on the weather and staff availability. The records from the three maps from each post were then collated onto one map to represent the combined locations of the single and paired weka recorded for that post.

The observer also recorded weather details (temperature, wind, moon, cloud cover, rainfall), the habitat of weka calling within the polygon, any noise that might affect the observer's ability to hear and plot weka calls, other animals seen or heard and ground moistness.

From April 2002 to April 2007 all calls that could be plotted with reasonable accuracy were mapped. In April 2008 the observer drew an area of coverage (known as a polygon) on the map which encompassed all calls that could be accurately plotted with a high degree of confidence in their exact location. Calls plotted outside the polygon could not be accurately mapped with the same level of confidence but were still recorded and plotted to approximate location. From April 2009 observers plotted calls on maps that included an identical polygon to that determined in 2008.

The number of single and paired calls within each polygon was divided by the number of hectares within that polygon to give a density estimate of weka per hectare. The area within each polygon was calculated using 'Map toaster'. Call count results collected from 2002 to 2007 were made comparable to those collected from 2008 by superimposing the relevant polygon from each listening post onto the relevant map.

Several photographs were taken from each listening post every two years to document any habitat changes that may have affected weka densities.

4 Spacing calls (defined by Beauchamp: 1987) are made only by adult weka.

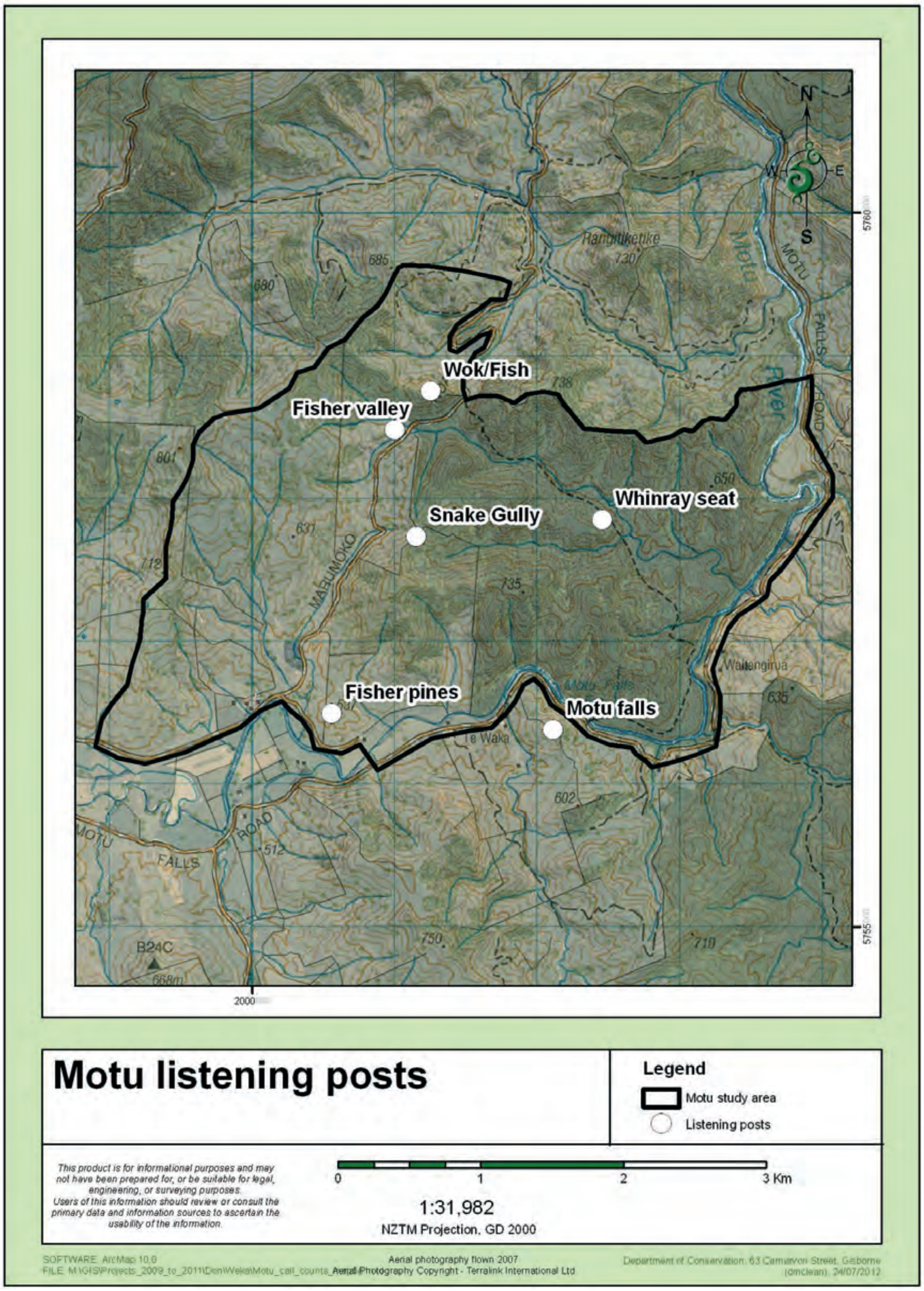

Figure 5a. Motu listening posts

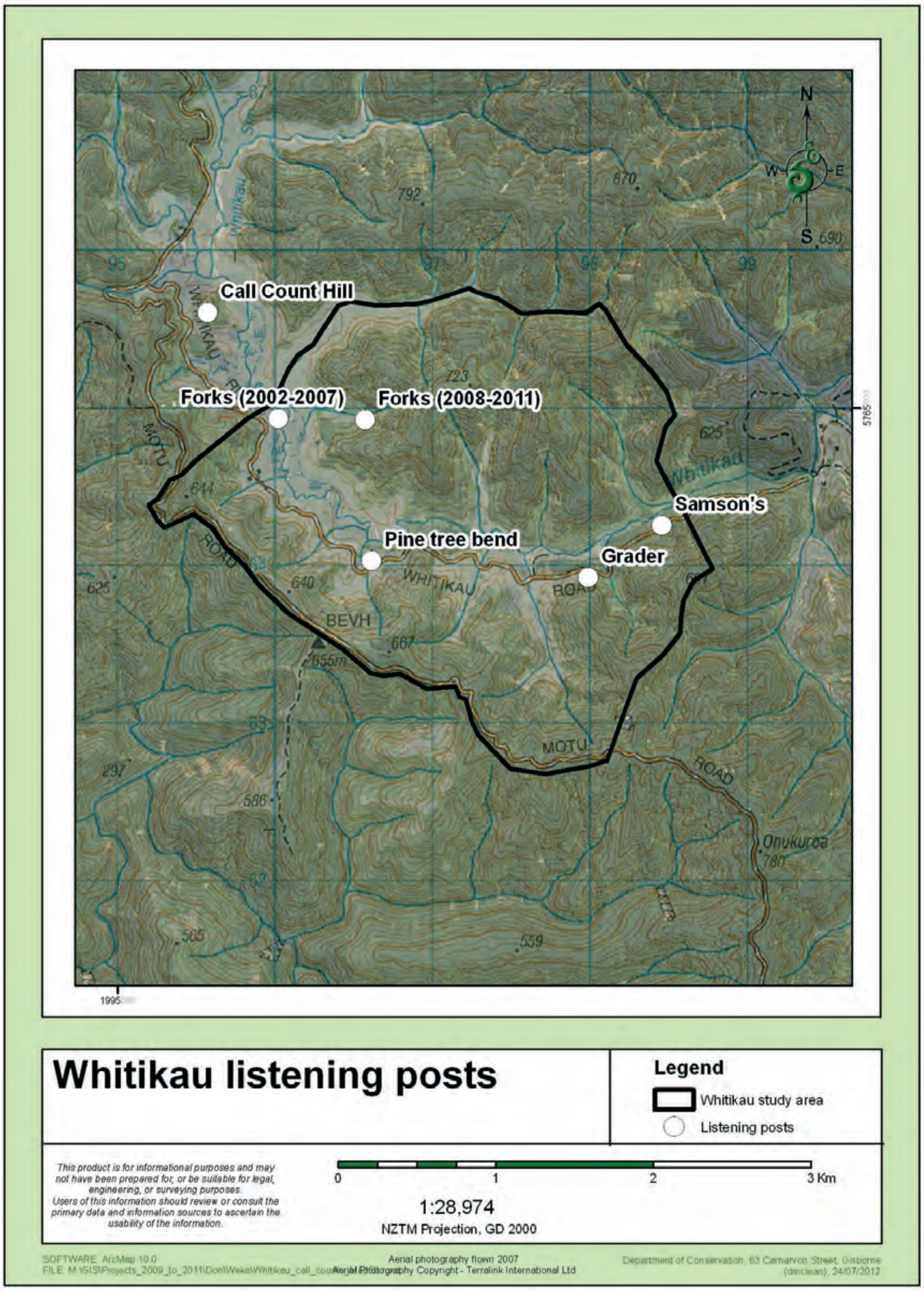

Figure 5b. Whitikau listening posts

Weight monitoring

All weka had their weights recorded at every initial capture of the trapping season. Weka in Whitikau were targeted for capture in December each year and weka in Motu were targeted in January each year. Adult weights were used to measure individual and population health by comparing them to Beauchamp's (1987) guidelines which state that populations can be considered under stress if the median male weight is below 780gms and the median female weight is below 600gms.

Juvenile monitoring

Survival and causes of death

In December and January each year (up to and including the 2010-11 season) 12 juvenile weka from each study area were targeted for capture[5]. After banding and a visual examination, a transmitter was attached to juveniles of at least 450 grams in weight to enable the collection of information on survivorship rates and causes of death in weka up to 12 months of age. The transmitter (Sirtrack N.Z. Ltd), weighed 20g, had a mortality function and was loosely attached with a backpack style harness to allow for growth.

Signals were checked twice weekly throughout the year in order to increase the chances of recovering dead weka in good condition and accurately identifying any causes of death. On the first check the observer approached to within approximately 100m of the bird and recorded a GPS position. The second check was done from a much larger distance.

If a transmitter had switched onto its mortality mode it was immediately located. If a dead bird was found a thorough investigation of it and its immediate surroundings was carried out in an attempt to correctly ascertain the cause of death.

All monitored juveniles were targeted for capture the following year in order to remove as many transmitters as possible.

Dispersal

Transmitters were used to collect dispersal information. The natal location of each juvenile was recorded at the initial capture and then subsequent locations were recorded weekly until monitoring ceased, when the bird reached 12 months of age. The distance between the natal location and the final location was then measured. Between 1999 to 2003 dispersal distances were estimated using a 1:50 000 map and a ruler. Since 2004 the position information was collected with a GPS and software has been used to calculate the distances.

Habitat

The habitat type that each weka was using at the time of its weekly visit was recorded until 2004.

Nest and chick monitoring

Between 1999 and 2002 six adult female weka were caught annually in August from each study area. They had transmitters attached to allow monitoring of nesting activity and survival rates and causes of death of chicks aged between zero and six weeks

5 Twelve weka are targeted to increase the chances of getting 10 definitive results each year. This allows for the possibility of faulty transmitters, dispersal by weka of distances great enough that the signal can no longer be located and slipped transmitters.

Monitored females were approached weekly to within approximately 50m of their location. If they were recorded at the same location for three consecutive weeks they were considered to be nesting. After the eggs had hatched the female weka were tracked to location and a spotting scope was used to observe the chicks. Alternatively, feeding stations, consisting of plastic poultry feeders and poultry pellets, were installed within territories and chicks were observed feeding at these stations with either a spotting scope or 24 hour surveillance cameras. The number of chicks observed at each visit was recorded.

Results

Predator control

Stoat control

A total of 800 stoats (mean 62, range 36-99 per annum) were captured in stoat traps in Motu between November 1999 and June 2012 (Table 1.1) with higher numbers of males being recorded (Table 1.2). Most stoats were caught between December and February of each season (Figure 1.3). Several other non target species (including 51 weka) were also caught in the mustelid traps (Table 1.4).

Table 1.1 Total stoats caught each year (beginning July 1 and ending June 30) in Motu from November 1999 to June 2012

SEASON	NO. STOAT TRAPS	NO. CHECKS THAT TOOK PLACE EACH SEASON	NO. STOATS CAUGHT IN MUSTELID TRAPS EACH SEASON
1999-00	264	6	74
2000-01	264	10	90
2001-02	292	11	36
2002-03	368	11	91
2003-04	480	11	88
2004-05	442	15	69
2005-06	442	15	99
2006-07	422	14	41
2007-08	422	18	57
2008-09	363	16	39
2009-10	268	15	41
2010-11	268	15	38
2011-12	268	15	37

Table 1.2 Sex of stoats caught in Motu from November 1999 to June 2012

SEX	MALE	FEMALE	UNKNOWN	TOTAL
NUMBER	488	263	49	800

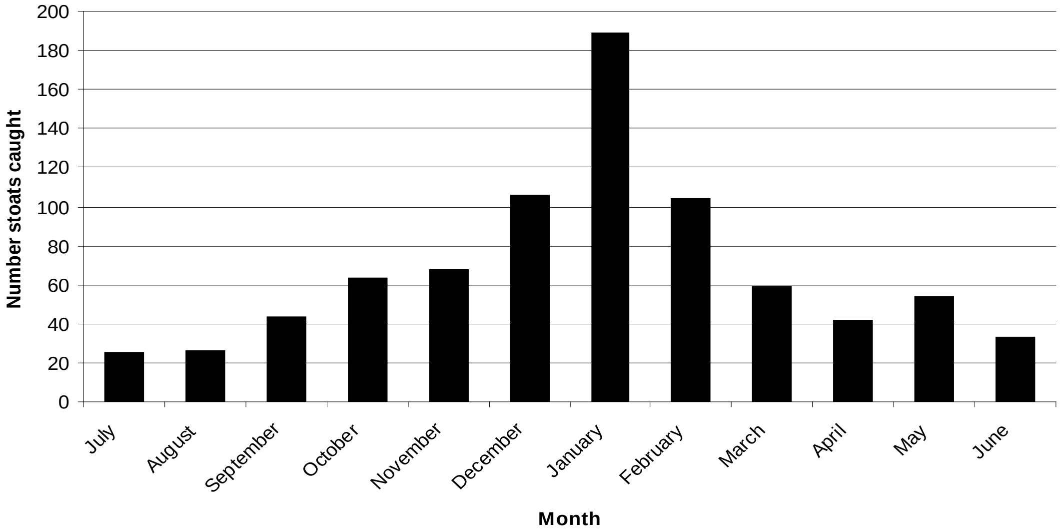

Figure 1.3. Number of stoats caught each season from November 1999 to June 2012

Table 1.4 Bycatch in mustelid traps from November 1999 to June 2012

SPECIES	NUMBER
Rat	3950
Hedgehog	630
Cat	76
Rabbit	61
Blackbird and thrush	52
Weka	51
Weasel	42
Possum	8

Weka as by catch

A total of 51 weka (mean 4, range 0-9 per annum) were caught as by catch in mustelid traps. In 30 instances the age of the weka was not recorded. Three adults and 18 and juveniles were caught. In all but one instance the trap killed the weka. One weka was released from a Mark VI Fenn trap with no obvious injuries.

Table 1.5 Weka caught in mustelid traps each trapping season from November 1999 to June 2012

1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012
2	3	8	9	7	0	4	3	5	4	1	2	3

Density index

The number of stoats caught per 100 trap nights ranged from 0.35 to 1.93 with an average of 0.99. The number of ferrets caught per 100 trap nights ranged from 0.02 to 0.27 with an average of 0.13. The number of weka caught per 100 trap nights ranged from 0.02 to 0.10 with an average of 0.07. See Appendix 8.

Table 1.6 The number of stoats, ferrets and weka caught per 100 trap nights each season from July 2001 to June 2012. A dash indicates that species was not caught that season

SEASON	NUMBER STOATS PER 100 TRAP NIGHTS	NUMBER FERRETS PER 100 TRAP NIGHTS	NUMBER WEKA PER 100 TRAP NIGHTS
2001–02	0.35	–	0.08
2002–03	0.91	–	0.09
2003–04	1.21	–	0.10
2004–05	1.79	0.05	-
2005–06	1.93	0.04	0.08
2006-07	0.94	–	0.07
2007–08	0.74	–	0.06
2008–09	0.59	0.02	0.06
2009–10	0.86	0.17	0.02
2010–11	0.80	0.27	0.04
2011–12	0.75	0.24	0.06

The DOC200 and the Mark VI Fenn trap types were the most successful for catching stoats (0.95 stoats per 100 trap nights) and the Thumper trap was the least successful (0.29 stoats per 100 trap nights). The DOC200 trap type caught the least weka (0.03 per 100 trap nights) while the Thumper and DOC250 trap types caught the most weka (0.19 and 0.20 weka per 100 trap nights respectively). See Appendix 8.

Table 1.7. A comparison of the number of stoats, ferrets and weka caught per 100 trap nights in each trap type. These results do not include data from the 1999 to 2001 seasons. A dash indicates that species was not caught that season

TRAP TYPE	NUMBER STOATS PER 100 TRAP NIGHTS	NUMBER FERRETS PER 100 TRAP NIGHTS	NUMBER WEKA PER 100 TRAP NIGHTS
DOC 200	0.95	0.11	0.03
DOC 250	0.67	0.20	0.20
Mark VI Fenn	0.95	0.01	0.06
Thumper	0.29	–	0.19

Gut sampling

An attempt was made to examine the stomach contents of all (127) stoats caught in the 2001-02 and 2002-03 seasons (Table 1.8). Some stoats were too decomposed to allow identification of their stomach contents. Some stoats had more than one food group present. All eggshell remains were identified as hen eggs (trap bait). Eight stoats had the remains of feathers in their stomachs and in one instance the feathers were identified as being weka feathers.

Table 1.8 Number of stoat stomachs with each group of items (July 2001 and June 2003)

SEASON	N	EMPTY	INVERTEBRATES	FUR	SHELL OF HEN'S EGGS	PASSERINE FEATHERS	WEKA FEATHERS	TOO DECOMPOSED
2001–02	36	12	11	5	4	2	0	5
2002–03	91	32	8	22	3	5	1	27

Bait type

Traps baited with freshly minced rabbit meat in October each season from 2008 were successful at increasing the average number of stoats caught in the month of October. From 1999 to 2007 the number of stoats caught in the month of October was 32 (average 4, range 0-8). From 2008 to 2012 the number of stoats caught in the month of October was 30 (average 6, range 2-9).

Ferret Control

A total of 40 ferrets were caught (mean 3, range 0-13 per annum). Most ferrets were caught in DOC200 traps (Table 1.9).

Table 1.9 Ferrets caught by trap type

Trap type	DOC250	DOC200	Mark VI Fenn	Thumper
Number ferrets caught	8	25	7	0

Cat control

A total of 209 feral cats were removed from the Motu study area from July 2002 (76 in mustelid traps, 102 in conibear traps and 31 in weka live capture traps). Any cats caught prior to this were not recorded. Five feral cats were caught in weka traps in Whitikau and were subsequently released as part of the non treatment protocol.

Six weka were caught in conibear traps (five before their height was raised in 2002 and one in the 2010-11 trapping season).

Mustelid monitoring

In January 2010 one set of stoat prints was detected on a card in Motu. No mustelid tracks were detected in any tracking tunnel in Motu or Whitikau prior to this occasion.

Evidence to suggest that stoats were present in the Whitikau includes observations by staff and locals. Staff also reported dead juvenile weka wearing transmitters that were tracked to stoat dens and stoats were trapped in a stoat trap line run 2km outside the Whitikau study area by Opotiki Area Office. No ferrets were recorded in Whitikau.

Rodent monitoring

After the initial tracking rat densities remained high in the forest habitat (between 63% and 96%). Mouse densities were lower and more varied (between 0% and 34%) compared to the rat densities (Table 1.10). Rat and mouse densities remained low in the pasture habitat throughout 2002-03 (Table 1.11).

Table 1.10 Rodent monitoring in forest habitat (Motu) from February 2002 to November 2003

YEAR	MONTH	RAT TRACKING (SE)	MOUSE TRACKING (SE)
2002	February	18 (±6%)	0 (±0%)
	April	63 (±5%)	6 (±2%)
	August	78 (±5%)	8 (±6%)
	November	96 (±4%)	12 (±6%)
2003	March	92 (±6%)	34 (±11%)
	May	72 (±10%)	18 (±9%)
	August	80 (±8%)	6 (±4%)
	November	90 (±5%)	2 (±2%)

Table 1.11 Rodent monitoring in pasture habitat (Motu) from February 2002 to March 2003

YEAR	MONTH	RAT TRACKING (SE)	MOUSE TRACKING (SE)
2002	February	2 (±2%)	0 (±0%)
	April	2 (±2%)	2 (±2%)
	August	2 (±2%)	4 (±4%)
	November	4 (±2%)	12 (±6%)
2003	March	6 (±4%)	10 (±5%)

Weka monitoring

General monitoring

Population and individual health monitoring

A total of 835 individual weka were caught in live capture traps and banded within the operational areas from 1999 to 2012 (Table 2.1). There were also 689 instances of recaptures making a total of 1524 captures.

Table 2.1 Sex of weka caught and banded from 1999 to 2012

AREA	MALES	FEMALES	UNKNOWN SEX	TOTAL
Motu	325	169	3	497
Whitikau	199	131	8	338
Total	524	300	11	835

For every season from 1999 to 2012 the number of males caught always exceeded the number of females caught in both areas (Table 2.2).

Table 2.2 The number of adult and juvenile male and adult female captures and recaptures from 1999 to 2012.

	MALES	FEMALES	TOTAL
Motu	627	287	914
Whitikau	412	198	610
Total	1039	485	1524

Most of these new and recaptured birds appeared visually healthy. Only four birds were captured with severe impairments. One was severely underweight and had a skin condition similar to excema on its left side. One had lost its leg at the top of the tarsometatarsus, the injury was healed and the bird hopped and moved well. The other two weka were limping badly; one with severe lacerations on one leg and the other had recently lost a leg. These two latter birds were removed from the field and taken into care. Both amputations were thought to have been caused by possum traps (Joe Waikari pers. comm. 2012).

Forty two birds had leg and foot injuries most commonly including missing toes or claws, deformed legs or toes, pea sized lumps on foot pads or toes and swollen foot pads. There were 100 instances of light infestations of mites around ears and eyes (between 0-20 mites could be quickly seen) and one instance of a heavy infestation (over 40 mites could be quickly seen). There were seven instances of eye injuries including a milky covering over the eye and blindness (Table 2.3). None of these injuries appeared to be causing a large amount of discomfort or affecting mobility (F. Kemp and J. Waikari pers. obs.).

Table 2.3 Number and type of minor injury observed in captured birds. Some birds had more than one injury type

INJURY TYPE	MISSING TOES	MISSING CLAWS	DEFORMED LEGS OR	LUMPS ON FOOT PADS	LUMPS ON ON LEG OR	MITES PRESENT	EYE INJURIES
Number	9	4	6	18	12	100	7

There were 835 initial captures made from 1999 to 2011. The spur shape of 816 of these weka was recorded (Table 2.4). The population structure of adult and juvenile weka comprised similar age classes of weka between study areas (Figure 2.5).

Table 2.4 Spur shape categories of male and female weka caught and banded in Motu and Whitikau from 1999 to 2012

SPUR SHAPE CATEGORY	MOTU MALES	WHITIKAU MALES	MOTU FEMALES	WHITIKAU FEMALES
S1	153	96	95	92
S2	74	48	42	23
S3	50	27	19	11
S4	36	25	11	3
S5	10	0	1	0
Total	323	196	168	129

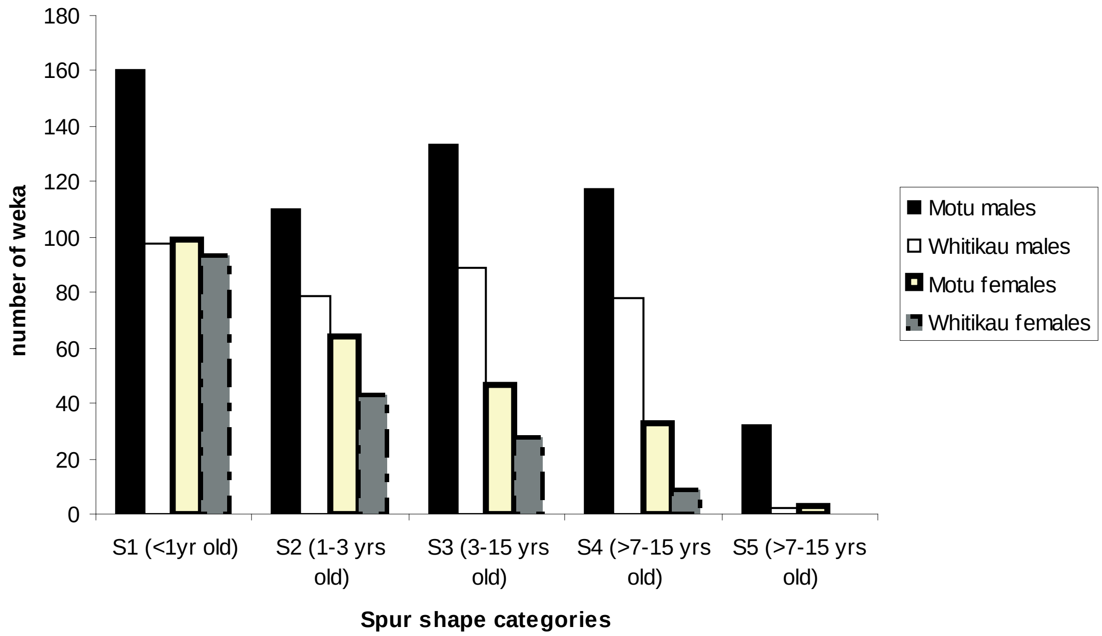

Figure 2.5 A comparison of spur shape categories of initial captures of male and female weka in Motu and Whitikau from 1999 to 2011

Screening results for haemoparasites, *Salmonella, Yersinia, Campylobacter* and *Escherichia coli* were negative except one bird from Whitikau which tested positive to *Yersinia*.

A total of 217 weka were found dead in the wider Motu, and Whitikau areas (Table 2.6) due to management and non-management related causes. This includes eight injured weka, released after treatment that would have died without intervention. Ten of these weka were sent to Massey University for an independent autopsy and pathology report. Two of these birds were found to have intestinal coccidia and tapeworm ova.

Table 2.6 Non management and management related causes of death from 1999 to 2012

NUMBER	CAUSE OF DEATH
60	Vehicle
39	Tunnel or trap design (mustelid and cat)
37	Unknown
32	Predation by mustelid
11	Predation by cat
10	Private possum traps
8	Predation by dog
5	Cage trauma
4	Tangled in litter
3	Starvation
2	Poison (rat poison and cyanide)
2	Drowning
2	Predation by hawk
1	Stress from handling
1	Strangled from transmitter harness

Adult monitoring

Call counts

Weka density indices in Motu and Whitikau were compared for the years 2003 to 2010 as not all posts were operating in 2002 and 2011.

Density indices were lower in Motu compared to Whitikau in 2003. By 2010 density indices in Motu were higher than in Whitikau despite density indices increasing in both areas over this time. From 2003-2010 the estimated number of weka counted in the Motu polygons increased by 275% and the estimated number of weka counted in the Whitikau polygons increased by 27% (Tables 2.7 and 2.8). See Appendix 10.

Table 2.7 Number of site-fixed adult weka based on calling birds inside five polygons in Motu, 2003 to 2010

YEAR	NUMBER OF PAIRS	TOTAL WEKA	ANNUAL CHANGE IN TOTAL WEKA NUMBERS (%)
2003	27	59	-
2004	34	74	+25
2005	37	87	+18
2006	51	122	+40
2007	69	150	+23
2008	74	177	+18
2009	72	153	-16
2010	76	162	+6

Table 2.8 Number of site-fixed adult weka based on calling birds inside four polygons in Whitikau, 2003 to 2010

YEAR	NUMBER OF PAIRS	TOTAL WEKA	ANNUAL CHANGE IN TOTAL WEKA NUMBERS (%)
2003	38	86	-
2004	46	96	+12
2005	51	111	+16
2006	49	116	+6
2007	61	133	+15
2008	55	125	-7
2009	43	93	-34
2010	50	109	+17

Results from all polygons were combined to allow a comparison of estimated weka densities per hectare in both study sites over time (Table 2.9). Results from 2002 and 2011 were not included in this table as counts were not carried out at some posts in these years.

At both study sites estimated pairs per hectare and estimated total weka per hectare increased between the start and end of the period, 2003 to 2010. In Motu the estimated density of pairs per hectare increased by 267% and the estimated density of all weka per hectare increased by 258%. In Whitikau the estimated density of pairs per hectare increased by 40% and the estimated density of all weka per hectare increased by 25% (Figure 2.10).

Table 2.9 Combined density estimates of weka from all listening posts in Motu and Whitikau in 2003 and 2010

YEAR	PAIRS PER HECTARE INSIDE POLYGON		TOTAL WEKA PER HECTARE INSIDE POLYGON	
	Motu	Whitikau	Motu	Whitikau
2003	0.06	0.10	0.14	0.24
2010	0.16	0.14	0.36	0.30

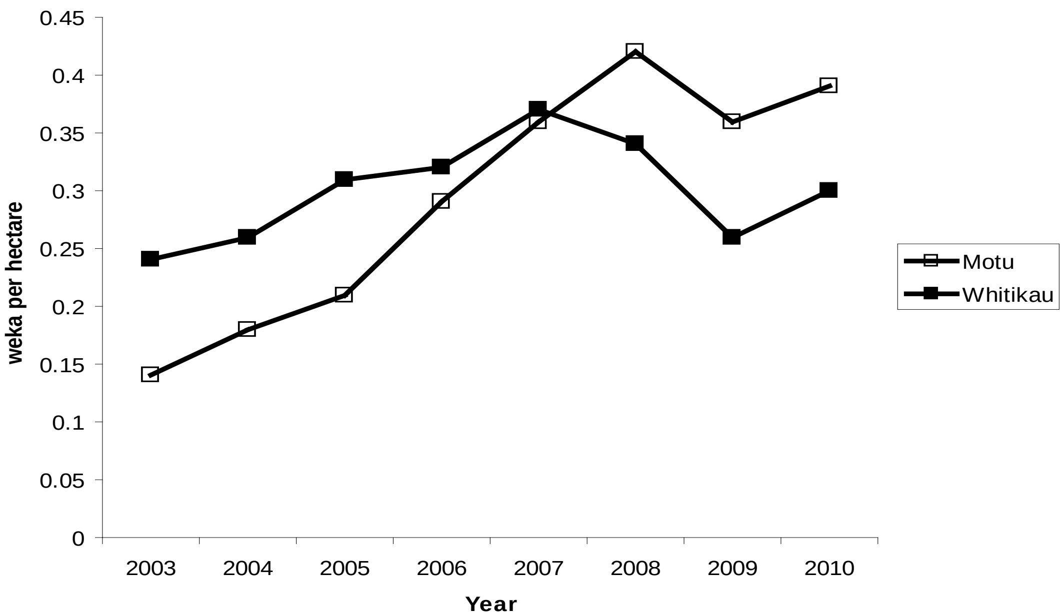

Figure 2.10 Total estimated weka densities per hectare in Motu and Whitikau from 2003 to 2010

Changes to habitat within polygons

Photographs taken to record changes to habitat within polygons showed evidence of scrub clearance and swamp drainage in Whitikau. The size of the affected areas was estimated to be approximately 10 hectares of scrub clearance at the Call Count Hill listening post and approximately 50 hectares of swamp drainage at the Pine Tree Bend listening post. There were no changes to habitat recorded within any polygons in Motu.

Weight monitoring

From 1999-2012 947 adult weka weights were recorded in Motu and Whitikau. The median weight across these years was above the population poor condition threshold defined as 780 grams for males and 600 grams for females (Beauchamp: 1987).

The lowest female median weight of 610 grams was recorded in Motu in the 2001-02 season. The lowest male median weight of 783 grams was recorded in Motu in the 2001-02 season. See Appendix 11 for details.

Table 2.11 Weights (grams) of all adult weka caught between 1999-2012. The sample size includes every initial capture of individual birds each season

STUDY AREA	SEX	SAMPLE (N)	RANGE	MEAN (SE)	MEDIAN
Motu	male	403	650-1600	950 (6.4)	942.5
Whitikau	male	304	695-1240	941 (5.7)	950
Motu	female	162	460-910	690 (6.8)	700
Whitikau	female	78	580-925	731 (8.5)	725

3. Juvenile monitoring

Survival and causes of death

A total of 439 initial captures of juvenile weka were made in live capture within the operational area from 1999 to 2012 (Table 3.1). This figure does not include subsequent recaptures.

Table 3.1 Number of juvenile weka caught and banded, 1999-2012

STUDY AREA	MALES	FEMALES	UNKNOWN SEX	TOTAL
Motu	154	95	3	252
Whitikau	91	90	6	187
Total	245	185	9	439

Of these 439 juvenile weka, 260 had transmitters attached. Two hundred and thirty one of these transmitters yielded a result with juveniles being tracked until death or 12 months of age. This number includes two birds whose signals were lost and three birds that slipped their transmitters and were later recaptured. The remaining 29 juveniles either slipped their transmitters or their transmitter signal disappeared and they were never recaptured (Table 3.2).

Table 3.2 Fate of transmitters attached to juveniles, 1999-2012

STUDY AREA	TX ATTACHED	RESULT OBTAINED	LOST SIGNAL (NO RECAPTURE)	SLIPPED TRANSMITTER (NO RECAPTURE)
Motu	135	124	11	0
Whitikau	125	107	16	2
Total	260	231	27	2

The mean juvenile survival rate in Motu was 69% (range 40%-83%) and in Whitikau was 64% (range 0%-100%). Certain or suspected mustelid predation events accounted for 12% of all transmittered juveniles in Motu and 18% in Whitikau. Certain or suspected mustelid predation events were the single largest cause of death in both study areas (38.5% in Motu and 50% in Whitikau). (See Appendix 15).

In Table 3.3 the 'mustelid' total includes certain and suspected predation by ferrets and stoats. The 'unknown' total includes those birds whose deaths could not be attributed to any reason with confidence. Some had no marks on them but most of these birds were recovered in very poor condition or all that remained was a few bones. The 'other' total includes other causes of death such as vehicles and management and predation by dogs and hawks.

Table 3.3 Causes of death among monitored juvenile weka from 1999 to 2012 in Motu and Whitikau.

STUDY AREA	TXS	NO RESULTS	NO ALIVE	% ALIVE	MUSTELID	UNKNOWN	CAT	OTHER
Motu	135	124	85	69	15	13	3	8
Whitikau	125	107	69	64	19	13	3	3
Total	260	231	154	67	34	26	6	11

Dispersal

Dispersal distances were collected from 147 juveniles. These birds survived to 12 months of age and at that time they were at a location that could be accessed. Sixty two percent (96/147) of these juveniles (57% of Motu juveniles and 43% of Whitikau juveniles) were found less than 500m from where they were first captured (Figure 3.4). (See Appendix 15).

The smallest dispersal distances from each study area were 13m in Motu and 14m in Whitikau. Some juveniles moved several kilometres from their initial capture location. The largest dispersal distances from each study area were 8000m in Motu and 2979m in Whitikau (Table 3.5).

Figure 3.4 Juvenile dispersal distances in Motu and Whitikau from 1999 to 2011.

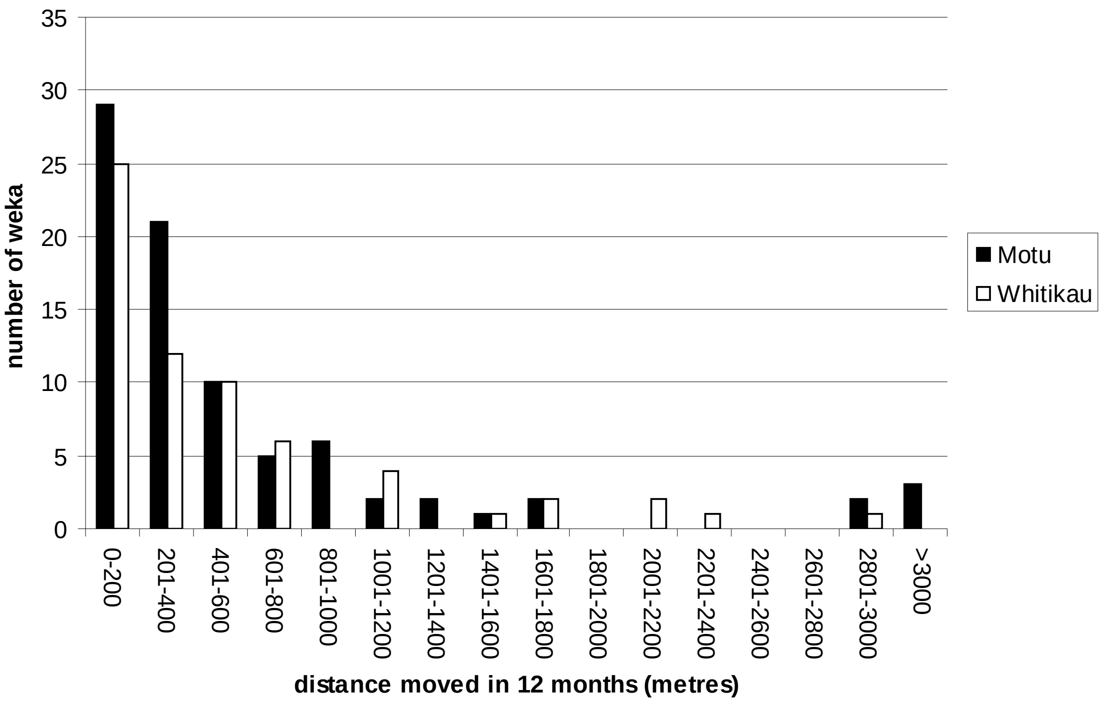

Table 3.5 Differences in juvenile dispersal (m) from 1999 to 2011.

STUDY AREA	SAMPLE SIZE	AVERAGE DISPERSAL DISTANCE (SE)	DISPERSAL RANGE (M)	NUMBER THAT DISPERSED <500M (%)	NUMBER THAT DISPERSED ≥500M (%)
Motu	83	1287.3 (325.3)	13-8000	55 (66)	28 (34)
Whitikau	64	404.4 (73.4)	14-2979	41 (64)	23 (36)

Habitat

The most common habitat of juveniles monitored in the Motu and Whitikau sites from 1999 to 2004 was regenerating scrub, including roadside scrub and farmland gullies. Other most common habitats include areas of swamp and the edge of forest patches.

Nest and chick monitoring

The fledging rate of juveniles varied from 50% to 100% of the chicks observed feeding with their parents prior to fledging (Table 3.6). The mean fledging rate of chicks in Motu was 75% and at Whitikau, 89%. No chicks were found dead although part of a body of a dead chick was seen being carried away by a parent (pers. obs.). No nests were monitored in the 2000-2001 season. (See Appendices 12, 13 and 14).

Table 3.6 Comparison of the maximum number of observed chicks hatched and the number of chicks that fledged from each study area.

SEASON	STUDY AREA	NO. PAIRS MONITORED	CHICKS HATCHED	CHICKS FLEDGED	PERCENT FLEDGED
1999-2000	Motu	3	8	4	50
	Whitikau	3	6	6	100
2001-2002	Motu	5	7	7	100
	Whitikau	6	9	7	78

Discussion

Predator control

Stoat control

Stoat captures

The number of stoats caught annually has ranged from 36 to 99. The least number of stoats were caught in the 2001-2 season (36 stoats) and the 2011-12 season (37 stoats). The greatest number of stoats was caught in the 2002-3 season (91) and the 2005-6 season (99). There does not appear to be any reason to explain the nature of the variation in the range of stoats trapped annually. However, this variation does highlight the need to maintain a consistent trapping regime against an ongoing tide of stoats coming into the area.

Trap types

Thumper traps were trialled from July 2003 to June 2004. They were removed from the field following this season because four weka were caught in them (the second highest catch rate for a trap type recorded in this project) despite them being fitted with specially designed weka proof bars.

Mark VI Fenn traps recorded the highest equal stoat catch rate per 100 trap nights and the second lowest weka catch rate. Housed in the later tunnel design (as described in Appendix 2) they were a very successful trap type. They were completely replaced by DOC200 traps in August 2009, keeping with Department of Conservation best practice methods for trapping.

DOC 200 trap types were a very successful trap type with the highest equal catch rate for stoats and the lowest catch rate for weka. DOC250 traps were also successful, catching the most ferrets per 100 trap nights of any trap type. They caught the most weka per 100 trap nights; most of these were juveniles. Due to the size of ferrets the entrance to the tunnels needs to be larger than for the tunnels housing other trap types and a certain level of weka captures should be expected and accepted.

Bait types

At the beginning of the project fresh rabbit meat was trialed as bait but it was found to be fly-blown within minutes (Sawyer: 1999). Intact hen eggs replaced pricked eggs in July 2006 to increase the longevity of the bait. From 2008 fresh minced rabbit meat replaced eggs as the bait for one month in an effort to target pregnant females before they gave birth. Rabbit meat was successful at increasing the number of stoats captured in October. Also, the bait remained fresh for several days and did not become fly blown because temperatures in Motu generally remain cool until December.

Tunnel design

As weka numbers increased in Motu the chances of weka encountering a trap increased. Most of the weka killed by traps either stretched their necks onto the trap from the tunnel entrance or burrowed under tunnels without floors with their bill. In order to limit the capture of weka the design of tunnels housing traps continuously improved over the course of the project.

Trap layout

The increase in trap lines from 11 in 1999 to 23 in 2011 reflected an increase in the area that was trapped more than an increase in the density of traps. These changes were made on the advice of Craig Gillies during a visit to Motu in 2004.

Gut sampling

The stomach contents of dead stoats ceased to be examined after June 2003 because the information collected was not adding knowledge to the project. After two seasons and 127 stomach investigations one incidence of weka ingestion had been found. This indicates a relatively high incidence of weka predation by stoats (T. Beauchamp pers. comm. 2012). The chances of finding weka remains in a stoat stomach are small as it requires a stoat to eat a weka not long before entering a trap due to their high metabolic rate. Remains of hen eggs were found in seven instances. As stoats are killed before they reach the bait these remains must have been from old discarded bait.

Ferret control

Increase in ferret numbers in Motu area

The ferret farming industry collapsed nationwide in 1984. As a result of this collapse some ferret farmers in the Matawai area (20km south of Motu) released ferrets into this previously ferret free area. It was expected that these releases would speed up the gradual expansion of the ferret population but they are still found in low numbers in the Motu area. Until 2006 just six had been caught in the Motu study area, all on its southern boundary.

Anedoctal evidence suggests that ferret numbers are increasing within the wider Motu area. One ferret was captured in the centre of the study area in May 2006 and in July 2007 one was implicated in the deaths of two adult kiwi in Whinray Scenic Reserve. This may be due to increased rabbit numbers in the area. One local reported that 40 years ago, when he was a child living in Motu, he did not know what a rabbit was. Now they are a very common sight.

Specific targeting of ferrets

Ferrets were not specifically targeted prior to 2006 because of their low numbers and the difficulty of excluding weka from the traps (the entrance holes into DOC200 and Fenn traps were kept small). Ferrets are believed to be a major predator of weka (Bramley: 1994) and are potentially a key element in weka extinctions. As their numbers appeared to be increasing in the Motu area there was a focus on effective management in order to monitor and mitigate any effect they may have.

Although the DOC 200 trap can catch and kill ferrets, the greater size of ferrets mean that DOC200 traps are not classified as humane against ferrets and there is a reasonable risk that they will escape and subsequently become trap shy. The DOC250 trap is a larger version of the DOC 200 trap and specifically designed to humanely kill ferrets.

Tunnel design

Tunnels housing DOC250 traps necessarily have a larger entrance hole in order to allow ferrets, the target species, entry onto the trap. Their design has only been used since December 2006 and has not been tested to any extent against weka.

Bait type

Freshly minced rabbit meat was used in March 2012 to target ferrets during the month when most ferrets were being caught. Just one ferret was caught in March 2012 compared to a range of 0-2 ferrets caught in the month of March from 1999 to 2011. Baiting traps with rabbit meat in March would need to be repeated for more years to determine if it would be a successful method of targeting ferrets.

Cat control

Low intensity

Just sixteen connibear traps were used to catch cats in the Motu region. These traps were put in place because over the last twelve years the project attributed 11 weka deaths to cats or suspected cats (seven monitored weka and four weka found by locals). The trap density was low intensity because feral cats have large home range and because domestic cats were living within the study area.

Ramp design

The height of the ramp leading to the cat trap was raised in 2002 because five weka had been killed in the traps. This change in design to the ramp was successful with only one weka successfully managing to gain access to the trap in the ten years following the change.

Weka by catch in predator traps

Weka are well known for their inquisitive nature and designing a trap that is completely weka proof may not be possible. Over the 13 seasons that this project has been running tunnel designs have been constantly modified in order to try and minimize the number of weka that do succeed in negotiating the tunnel to reach the trap.

Modifications that appear to have been successful include lengthening the tunnel which forces the weka to enter the tunnel rather than use the length of its neck to reach the bait and the trap. A floor stops weka from burrowing under a tunnel and reaching the trap. The double off set baffle system forces the weka to jump through small holes as it cannot twist its neck to negotiate the off set baffles.

Having the access holes (through the entrance and the baffles) at a height, rather than ground level, also poses another obstacle. Having to jump into an entrance hole is especially difficult for a chick and because of their small size chicks are difficult to exclude from tunnels because the entrance hole has to be large enough to admit the target species.

The highest number of weka caught per 100 trap nights was 0.10 which equates to one weka death in a mustelid trap for every 1000 trap nights. This level of by catch is extremely low and its impact on the weka population as a whole is non existent.

Mustelid monitoring

Justification

To have a measure of mustelid abundance was important to this project. Their detection in the Whitikau would provide proof of their existence there as well as providing information on the relative abundance of mustelids between the two study areas. The expectation was that there would be a greater abundance in Whitikau as Motu was trapped. Changes in the relative abundance of mustelids within and between the two study areas may have been reflected in juvenile weka survival. Ferrets are known to be in the Motu area but they have not yet been recorded in Whitikau. As they are thought to be a major threat to weka, detecting their presence and any changes in their abundance in both study areas is important.

Problems encountered with mustelid monitoring on farmland

A large amount of each study area was made up of grazed farmland that could not be monitored as tracking tunnels are not suitable in this habitat. During several months of the year grass growth completely hid tunnels and all the year round tunnels were likely to be crushed by stock (pers. obs., F.Kemp). Markers were not practical to show the location of tunnels as they could be too easily knocked over by stock. That was the reason for having just five monitoring lines in each study area, all of them within patches of forest.

Limited robustness of results

Having just five lines made the measure very crude, especially when mustelids were in low numbers. Gillies and Williams suggest between seven to eight lines in each area. This would increase the chances of detecting mustelid activity but five lines was the maximum number of lines that would fit into each area without putting lines on farmland and meet the requirement that lines be a minimum of 1000m apart. Because the measure was so crude a 'not detected' result could only be treated with caution.

Using this crude measure no mustelids were being detected in either area. Trapping results in Motu and stoat sightings in Whitikau suggested otherwise. In order to maximize the chances of detecting mustelids monitoring was changed from quarterly to once a month over the summer period when the mustelid population is at its highest. This change was suggested by Craig Gillies. The detection rate remained at zero until January 2010 when one set of stoat prints was found on a tracking card in Motu. Because the detection rate was so low and not a true reflection on the mustelid presence in Motu it could not be relied on to give an accurate reflection on the mustelid presence in Whitikau and it was abandoned in January 2010.

Rat monitoring

Justification

Predator populations, particularly those of mustelids, often mirror population changes of rodents. The rational behind monitoring rodent populations in Motu was that it may help predict when the weka population could be under increased threat from mustelids. The intensity of the mustelid trapping project could have varied between seasons based on these projections with savings to the project being made when mustelid abundance projections were low.

Interpretation of results

The large initial increase in rat densities in the forest was likely to be due to a number of factors. These include the possible effects of the initial baiting in February and an expectation of high rat numbers in April (C. Gillies; per. comm. June 2002). Also, there was a strong tawa fruiting in February but by April this food source had virtually disappeared making tunnels a more attractive alternative.

Tracking tunnels are a very blunt method for determining rodent densities. Craig Gillies (pers. comm. 2004) suggests that anything between 0-5% indicates a low density, between 5-50% indicates a medium density and any thing over that indicates a high density. Rodent monitoring in the forest habitat was stopped after November 2003 because the results clearly showed that rat densities remained high both within and between years. Rodent monitoring in the pasture habitat was stopped after March 2003 because the results showed a clear difference in the relative abundance of rodents in the two habitats.

Limitations with the method in this project

Tunnels in the pasture habitat were difficult to monitor as spring grass growth often hid them. Cattle could easily knock over tunnel markers as well as the tunnels themselves.

Consistently high densities within and between years meant that rodent population monitoring could not be used as a predictor of mustelid population fluctuations (and danger times for weka) in Motu.

Weka monitoring

General monitoring

Population and individual health monitoring

Sex ratio

The sex ratio of captured weka can be used to give an indication of the stability of the population. Comparatively low numbers of one sex compared to the other sex between years could indicate a problem. More male weka were consistently caught in all age categories than female weka (except S1 males in Whitikau). Overall, approximately one male was caught for every 2.5 females. Beauchamp (1987) noted that a higher proportion of females tend to be wary of traps making them more difficult to catch. Since this bias was consistently present throughout the study suggesting it was normal and there was no evidence of high numbers of single males in the call count results it would appear that there is a stable sex ratio and a stable weka population in Motu and Whitikau.

Spur shape

Spur shape can only be used as a general guide to the age of weka as wear and tear of the spur is dependant on the individual habits of the weka and their particular habitat. Used in a broad sense the age spread of captured weka can be used to provide information on the age composition of a population (Beauchamp: 1987). A stable population can be expected to comprise older breeding birds (generally with wing spurs between S2 and S3), several potential breeders (S1) and few much older birds (S4). Males and females in the S1 to S3 categories were all well represented in both Motu and Whitikau and this suggests that there are plenty of breeding and potential breeding pairs.

Trapping effort

The focus of trapping weka was to catch 12 juvenile in each study area. When this was achieved, trapping stopped. The number of traps put out and the daily trapping effort was not recorded. A similar number of traps were always set in Whitikau in December of each year and in Motu in January of each year and they were always set in the most favourable habitats. In the first few years of the project (1999 to 2004) it would take several weeks to catch 12 juveniles from each area and in the last few years (2006 to 2011) it would take sometimes less than one week to catch the required juveniles. This would suggest large increases in the number of juvenile weka in both areas over the course of the study.

Autopsies

Dead weka that were found in very good condition were sent to veterinarians at Massey University for an autopsy in the first few years of the project. It was hoped that these autopsies would provide an independent cause of death which would corroborate our findings. Weka ceased to be sent because of the difficulty of couriering the weka to the university from a relatively remote location. Often the body would not be in good enough condition for a thorough investigation by the time it reached the university.

Rehabilitation of injured weka

Weka with injuries were sometimes found by staff and locals. Very often injuries that would have proved fatal over time were easily managed. The most common injuries picked up from locals were from sheep wool or baling twine becoming entangled in the wekas' toes and hindering mobility. These could easily be removed and an antiseptic was sprayed onto any open cuts. Some weka were discovered in a state of shock, often due to a failed predator attack. They were kept in a warm, dark place and rehydrated with water and released the following day. Weka with serious injuries were euthanized rather than being taken to a veterinarian due to the cost.

Disease screening

Weka populations have a history of extreme fluctuations which are often attributed to disease but there is no evidence to support this. Prior to the disease screenings carried out in Motu and Whitikau in December 2004 no screenings had been carried out on live weka. These screenings were valuable for producing baseline data on what are tolerable, intolerable or normal loadings of parasites and bacteria. One bird from Whitikau tested positive to Yersinia and this was the first reported incidence of it in wild weka (pers. comm. Beauchamp: 2005).

Forty two predation events and 60 deaths due to vehicles were reported by both Department of Conservation staff and local residents from the wider Motu, Whitikau and Toatoa areas. These causes of death are more visible and more likely to be detected and reported than deaths in remote areas. All weka caught in the mustelid trap network will be found and most road deaths will be found. Deaths in farmland, bush or roadside are very unlikely to be detected.

Weka and vehicles

Vehicles are a major cause of death for weka. Staff and locals reported finding 60 weka that had been killed by vehicles. Many more weka are hit by vehicles and their deaths go unreported (F. Kemp, pers. comm.). Little can be done to reduce this. Road signs informing motorists that weka are in the area can be seen on SH2, a few kilometers north and south of the Matawai township, and on the road to the Motu township. These signs do increase awareness of weka but they do not slow traffic (pers. obs.). Also, weka have a tendency to shoot out from the roadside and onto the road at any time of the day and night so quickly and unpredictably that they give a driver almost no opportunity to avoid hitting them.

Adult monitoring

Call counts

Call counts as a survey tool

Call count surveys are an effective method of measuring and monitoring adult weka densities over large areas. They are a relatively cheap survey method, requiring intensive staff input for a few hours in the evening for approximately two weeks per year but virtually no other resources. Another major advantage with using the call count method is that it is a remote sensing method that does not involve any capturing or handling of weka and therefore avoids stress and potential capture-related injuries.

Historical data

Counts were carried out in Whitikau in December 1996 to January 1997 in order to get baseline weka call rates. The same listening posts initially used in the Whitikau were adopted when counts resumed in 2002 but different counting methods made attempts to compare results not feasible. Baseline counts were not carried out in Toatoa or in Motu and low estimates for Motu are based on anecdotal evidence. Sawyer (1999) estimated a population of between 15-20 birds living in the Whinray Scenic Reserve and Motu township areas and local opinions corroborate this low estimation.

A change in method

From 2002 to 2007 all calls that could be heard and plotted with even a slight degree of accuracy were recorded. Often, during a night, there would be so many calls happening simultaneously that it was impossible to record them all. The results therefore lacked the level of accuracy needed to recognize trends in the two populations. On the advice of Beauchamp (pers. comm.. 2007) the polygon method was introduced in 2008. The observer only concentrated on calls that were close enough to be recorded with a high degree of confidence. A high level of accuracy was attained which made it possible to have a high level of confidence in the results.

Exclusion of some data from the results

Counts were carried out from 2002 to 2011 but only calls from 2003 to 2010 were used in the results. Results from 2002 were not used as the Falls post in Motu was only set up in 2003. Results from 2011 were not used as there was a lot of variation in methods used by observers making results non comparable to earlier years and counts were not carried out at all posts. The Forks post at Whitikau was excluded because the post site was moved in 2008.

Location of listening posts

Post sites in the Whitikau were chosen as these same five sites were used in 1996 when the initial counts were carried out at the outset of the project. By using the same posts it was hoped that results could be compared. An attempt was made to compare results but it was not possible due to different methods. The decision on where to locate posts in Motu and Rakauroa was based on several factors including ease of access and geographical features. One post in Motu (Falls) was outside the study area boundary because the emphasis was on ease of access and at the same time covering an area that was not already covered by neighbouring posts.

Number of listening posts

From 2008 staff from Opotiki Area Office set up several listening posts in the Takaputahi and Toatoa areas, in-between Whitikau and Opotiki and counts were carried out using the same method as the one used in this project. Results would be shared, giving an increase in the number of non treatment sites being monitored. If the weka population in Motu increased or at least maintained itself against several other weka populations, rather than just the Whitikau population, it would add strength to the hypothesis that predator trapping was making the difference between a strong and resilient population and one perpetually liable to extinction. A relatively resilient Motu population would support a case for multiplying the number of treatment sites with the aim of building weka densities in a widening network of areas. Analysis of the call count data from Opotiki has yet to be done.

Consistency in results

In order for the call count results to be meaningful it was vital that they were consistent. Consistency in results was more important than accuracy because it was accuracy in measuring upward and downward trends in densities that was the focus of the counts and not actual numbers of weka. The best way to achieve this level of consistency was to ensure that the same observer was allocated the same listening post each year. In this way personal interpretations had no effect on the end result. Whenever this was not possible fluctuations in density very often showed up that were not mirrored in neighbouring listening posts.

Weka densities in Motu and Whitikau

Motu and Whitikau had a different number of listening posts as well different terrain and habitat which makes a direct comparison of population density not as valid as a comparison of trends at each site between years. The slightly greater increase in call counts in Motu compared to Whitikau is consistent with the increase in weka density per hectare in Motu compared to Whitikau.

Changes to habitat within polygons

Photographs taken of habitat within polygons revealed some scrub clearance and swamp drainage in Whitikau. Both swamp and scrub habitats are important to weka as sources of food and cover. The areas affected were relatively small and while they had an effect on individual weka they would not have had any effect on the population as a whole.

Weights

Juvenile weights

Juvenile weights were not used as an indication of general health because of the large variance in weights between a one month old chick and a three month old chick. Also, sex determination in young chicks by visual means alone is difficult and unreliable because of frequent overlaps in morphological measurements.

Adult weights

Weights from both captures and recaptures were used in the analysis as it was assumed that all weka had an equal chance of capture and recapture. Using Beauchamp's (1987) weight criteria both the Motu and Whitikau weka populations appear to be in good health with all of the population median weights and most of the individual weights over the 13 years of the study being above the stress-related weight threshold.

Juvenile monitoring

Use of transmitters

Using transmitters to monitor survival rates and causes of death on a small sample of juveniles in two study areas was very successful. Almost all of the transmitters yielded a result. There were also several disadvantages to this method. These included the purchase cost of the transmitters, the monetary cost of attaching them and the important, but not measurable, personal cost to the individual weka in terms of its comfort and health. Because juvenile survival rates from 1999 to 2010 were so similar between Motu and Whitikau and because of the many disadvantages of transmitters it was decided in June 2011 to stop monitoring juvenile weka. The success of the predator trapping programme would be measured using weka call count monitoring only.

Survival and causes of death

Transmitter harness design

The backpack harness design proved to be very successful. Transmitters were always attached to juveniles loosely to allow room for growth but only 2% of weka managed to slip their transmitters off. Any recaptured weka carrying transmitters were always checked to make sure the harness was fitting well. No problems were ever found even if the transmitter had been on for a number of years. Occasionally some light rubbing had occurred but the skin was never found to have broken. There was only one recorded incident of a harness causing a problem which resulted in the fatality of the weka. It managed to slip a length of wire, which was protruding from a fence, between the harness and itself. It then turned around several times causing the harness to twist round the wire and tighten as a tourniquet would.

A weak link in the harness design was trialed for a short time but it was found to be too fragile in typical weka habitat with some birds breaking their harness within days of attachment (Sawyer: 1998). Because there is no weak link incorporated into the harness design weka can potentially wear their harness for several years. Each year, when the next juvenile cohort was being targeted for capture, an effort was made to recapture weka with transmitters attached so they can be removed. Approximately half these weka were recaptured. One weka was only caught six years later and the harness was still in good condition, the weka only had some light rubbing under its wings.

Missing transmitter signals

Twenty nine signals (11% of transmitters attached) were lost over the course of the project. This may have been due to the transmitter being faulty, the battery expiring earlier than expected or the bird dispersing out of range and not returning while the transmitter was operating. Until 2005 several hours were spent searching for signals that disappeared and only in a small number of cases was the search successful. In 2005 it was decided not to put extra time into these searches as usually only one or two signals were affected each season leaving at least 10 signals to produce definitive results.

Live capture of juvenile weka

Because of travel times for staff live capture weka traps were set in the morning and checked 24 hours later which meant weka could potentially be trapped overnight. The optimal trapping period was subjected to guidelines in order to minimize the possibility of young chicks being trapped overnight and subjected to stress and exposure. Juvenile weka were targeted for capture in December and January of each season when most juveniles were slightly older (around two to three months of age) and the weather was relatively warm. Traps were set in sheltered places and not when rain or cold weather were forecast. Over the 12 year period of this project five juveniles (less than one month old) were found dead in the traps. They probably died from a combination of factors including their age, and stress and exposure after being left alone in a trap potentially overnight.

A comparison of juvenile survival rates in Motu and Whitikau

After 12 years juvenile survival rates in Motu and Whitikau were very similar. This is not surprising since during these years an event, where several "agents of decline" operated simultaneously on the weka population, did not occur. Therefore there was not an opportunity to compare juvenile survival rates and causes of death between the two study areas during a period when the Whitikau population would have been subjected to the extra stress of not having any predator control. It is not possible to predict when this event may occur although, based on the history of North Island weka, it is realistic to expect it.

Dispersal

Justification

Dispersal information was collected in order to compare strategies between juvenile weka living in Motu and Whitikau. Different strategies may have indicated different densities, availability of suitable habitats and chances of encountering a partner.

Dispersal of male and female weka

It is possible that male and female weka have different dispersal strategies. It was not possible to test this because when transmitters were attached juveniles were too young to be sexed with a high degree of accuracy. Since a recapture cannot be guaranteed it was not possible to determine with high confidence dispersal differences between sexes.

Differences in terrain

There were different challenges to consider when measuring dispersal in the two study areas. The Whitikau had a road along a ridge that ran parallel to the valley for most of its length making it relatively easy to track birds that had dispersed within the valley. If birds left the valley there was no road system and it was too time consuming to find them. Motu lacked any easily accessible high vantage points but did have a far greater network of roads making travel to potential locations to search for missing weka a lot easier.

Dispersal results

Most birds from both study areas dispersed less than 500m from their natal territory during the 12 months they were monitored. This would suggest that both Motu and Whitikau currently offer an acceptable availability of suitable habitat including a food source and shelter at an acceptable density. Weka are able to find partners and are also not overcrowded.

Habitat

The habitat types in which juvenile weka were observed in during weekly tracking was recorded up until 2004. If weka displayed a preference to particular habitats those habitats could be encouraged and maintained to help ensure survival of weka. The most popular habitats were roadside scrub and farmland gullies.

Much information was collected but interpretation of results was made difficult because not all habitats were equally available to all weka and no habitat mapping was carried out. Also, most monitored weka were trapped on roadsides (which required the least trapping effort for the most reward) and they dispersed less than a few hundred metres over the following 12 months. Almost no weka were trapped in forest habitats because it involved a relatively large trapping effort. This may have biased the results towards the most common roadside habitats.

Nest and chick monitoring

Nest and egg monitoring

Female weka were tracked to monitor nesting activity because they predominantly incubate the eggs from early morning to late afternoon. Nest monitoring ceased in 2002 after four seasons of data collection showed that almost every monitored pair in both study sites attempted to nest at least once each season, suggesting that current conditions were acceptable for weka to breed.

Collecting nest monitoring information was both problematic and risky. It was very time consuming because female weka had to be caught in order to have transmitters attached to them and they are typically wary of traps. It could take up to six weeks to catch six weka in each area (pers. obs.). Then tracking the female to the location of the nest was risky as it could result in permanent nest desertion if the observer accidentally got too close and disturbed the female.

Chick monitoring

Visual monitoring techniques were chosen to monitor chicks aged between zero to six weeks in order to collect information on the extent and causes of young chick mortality. Transmitters were not attached as handling birds of this age can cause so much stress to the parents that they will abandon their chicks (Sawyer:2000).

Visual monitoring was problematic for a number of reasons. Observations were almost invariably time consuming to collect and they gave inconclusive results. An initial problem with this method was that the number of chicks hatched from a clutch was never known (nest inspection could lead to nest desertion). Therefore it could never be known if any chick(s) had been lost before the first observation. Also, parent birds would take food to chick(s) that would often remain well hidden. Often, hour long observations could not reveal if all previously observed chicks were present and if a chick did disappear it may be hidden or dead. No dead chicks were ever recovered and if it had been ascertained that a chick had died it would have been almost impossible to find the body and identify a cause of death as chicks were often well hidden in thick scrub and it is common for parents to consume their dead chicks (Beauchamp: pers. comm.).

Chick monitoring ceased in 2002 because of these difficulties and because research by Beauchamp (1987) suggested that survivorship of young weka chicks under the care of their parents is high. Predation events are far more common when juveniles and sub-adults leave their natal home ranges and start foraging for themselves (usually around two to three months old) and up to 12 months old. During these months they are more vulnerable to predation as they are more mobile and less weary than adults.

Possible Impacts on the Project

Possum trapping

Possum control operations were carried out by the Department of Conservation in Whinray Scenic Reserve in 2001, 2002 and 2004 and kill traps were set up throughout the reserve in 2011. The aim of these possum operations was to maintain a 5% residual trap catch in the reserve. Also, local residents in both Motu and Whitikau trap possums and some report having accidentally killed weka in their possum traps.

The impacts of possum control by the Department of Conservation and local people on the weka population have not been measured. However there is no evidence to suggest that possum trapping operations have any significant effect on weka predators or weka at the population level (Beauchamp: pers. comm. 2007).

Whio Protection in Whitikau

From April 2002 to June 2007 the Opotiki Area Office of the Department of Conservation ran a stoat and cat trap line in the Whitikau valley for Whio protection. At its closest point it was 2km from the Whitikau study area boundary. The trap line ran for 26 kilometres along the Takaputahi River.

Land Management in Motu and Whitikau

Land management practices by landowners in both the Motu and Whitikau study sites affected the amount of suitable habitat available to weka. These practices included draining swamps, roadside grazing, clearing scrub and increasing stock levels. While they must have had an effect on individuals , these practices, at their current intensity, did not appear to have any negative effect on weka at a population level (pers. obs.). This observation is supported by the call count results.

The end of the project

Gisborne Area Office of the Department of Conservation made the decision to bring the project to an end at 30 June 2012. Several factors led to this decision being reached. Firstly, in order to fulfill its aim the project required a stochastic event that would place weka in the two study areas under excessive duress. This event would have provided the opportunity to monitor and compare the ability of the two populations to survive and recover when one population had the advantage of living in a predator trapped environment. After 13 years such an event had not arisen and the 11 year cycle had changed from El Nino dominated to La Nina dominated making such an event less likely (Beauchamp *et al*; 2009). It was not practical to wait indeterminately for an unpredictable event.

In November 2011 access into the privately owned Whitikau valley by the Department of Conservation was cut off meaning that the non treatment area of the project could no longer be monitored. In 2011 the Department of Conservation moved to a system of prioritizing land and funding according to various sets of values called the National Inventory of Management Systems (NHMS). The Whinray Scenic Reserve, which made up half of the treatment area in Motu, did not rank in this system. This meant that the trapping programme in the reserve was of low priority to other areas that required funding.

Each of these reasons alone would have been enough to have a major effect on the project. When they all lined up together it made sense to bring the project to a close. Although a stochastic event never occurred in the required timeframe a significant amount of information on weka has been collected. This information will be invaluable to all those wanting to study weka throughout the country both now and in the future.

Community Support

A great interest in and support for the weka project has been shown by both the Motu and Whitikau communities. This support has improved the quality of the project by giving information on causes of death that would otherwise have gone undetected and reporting observations including mustelid sightings and previously unrecorded weka behaviours. This community involvement reflects a high level of interest in the remaining weka population and conservation in general which is extremely valuable for both the project and the Department of Conservation.

Appendix 1:
Stoat Control at Toatoa (1998–1999)

Stoat control lines operated in Toatoa from early November 1998 to April 1999. a total of 79 double set Mark VI Fenn traps were set up on the perimeter of the study block and along gullies and ridges within the block. They were baited with a pricked hen egg. Tunnels were 600mm in length and made from 13mm galvanized aviary mesh. They were pegged to the ground and did not have a floor.

Over this time three stoats were captured. This equated to 0.41 captures per 1000 corrected trap nights (Sawyer:1999). Sawyer ran a comparative line in Motu and 16 stoats were captured (7.2 captures per 1000 corrected trap nights). These results indicated a higher stoat density in Motu. A higher stoat density would make evidence on the effects of a predator control programme on juvenile weka easier to detect and the treatment block was moved to Motu. Trapping in Motu began in November 1999.

Appendix 2:
Stoat Control at Motu (1999–2012)

Number and type of trap used each season to target stoats

Table 2.1 Number and type of trap used each season to target stoats in Motu. A dash (-) indicates that trap type was not available in that season.

Season	Mark V1 Fenn Double set	Thumper	DOC200 Double set	DOC200 Single set	Total traps
1999-2000	132	-	-	-	264
2000-2001	148	-	-	-	296
2001-2002	148	-	-	-	296
2002-2003	179	-	-	-	358
2003-2004	172	70	-	-	484
2004-2005	129	0	92	0	442
2005-2006	120	0	100	0	440
2006-2007	120	0	91	0	422
2007-2008	129	0	91	21	461
2008-2009	95	0	73	27	363
2009-2010	0	0	76	116	268
2010-2011	0	0	76	116	268
2011-2012	0	0	76	116	268

Tunnel design specifications for traps targeting stoats

Table 2.2 Specifications of tunnels housing various stoat trap types since July 2005

Specifications	Fenn	DOC200 single	DOC200 double
Length (mm)	810	450	810
Width (mm)	250	260	250
Number entrances	2	1	2
Distance between baffles (mm)	210	200	210
External baffle position	Bottom left 13mm in and 13mm up	Bottom left 13mm in and 13mm up	Bottom left 13mm in and 13mm up
External baffle size (length x width)	65mm x 52mm	65mm x 52mm	65mm x 52mm
Internal baffle position	Centre 78mm in and 65mm up	Middle right 39mm in and 65mm up	Middle right 39mm in and 65mm up
Internal baffle size (length x width)	65mm x 52mm	65mm x 52mm	65mm x 52mm

Photographs of tunnels housing Mark VI Fenn traps

Figure 2.1a Double fenn sets box dimensions

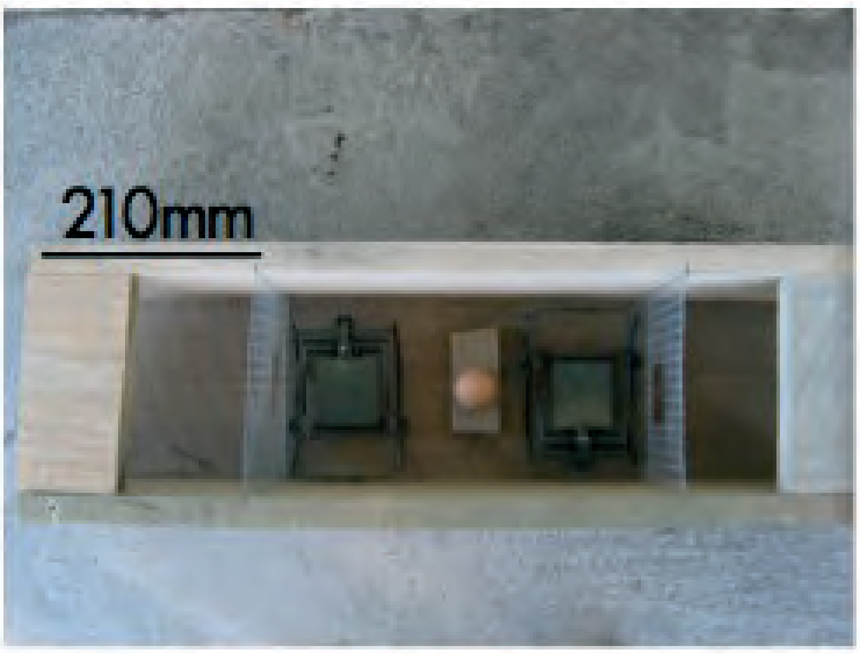

Figure 2.1b Double fenn sets – middle baffle

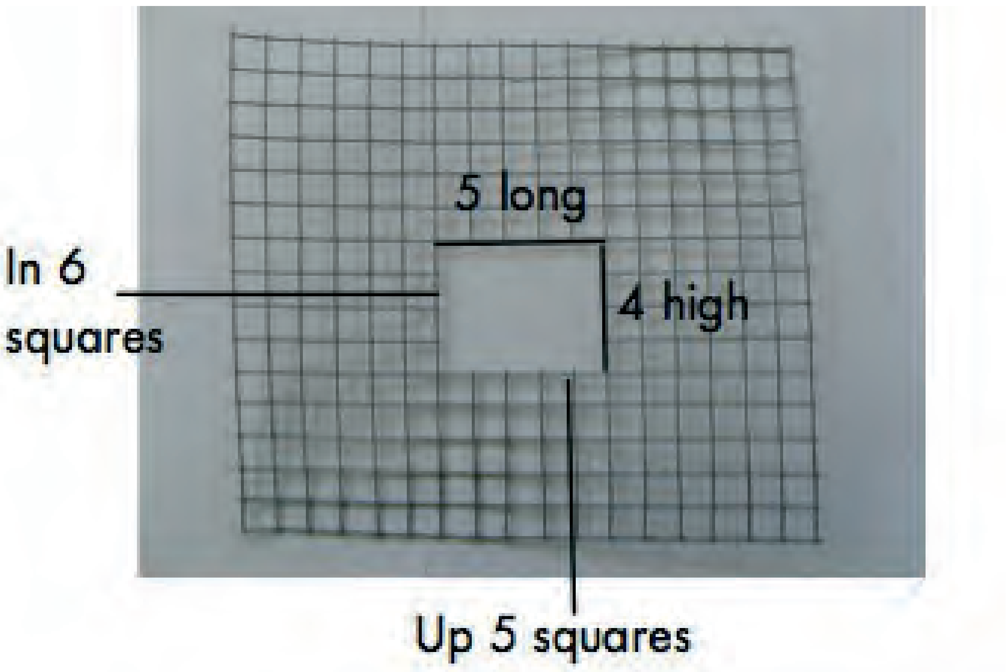

Figure 2.1c Double fenn sets – internal baffle dimensions

Figure 2.1d Double fenn sets – internal baffle set up in a box

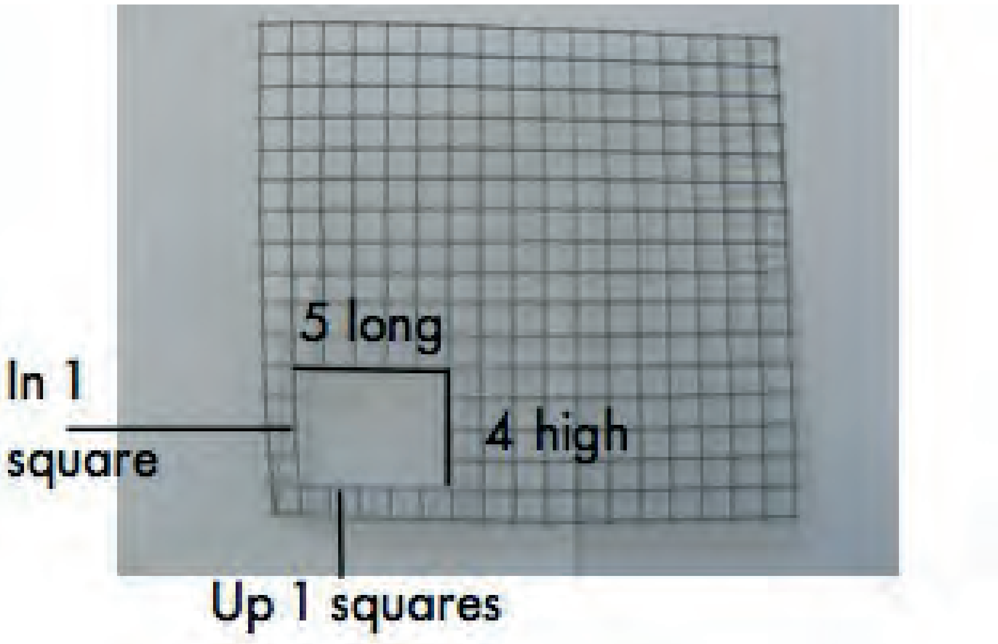

Figure 2.1e Double fenn sets – external baffle dimensions

Figure 2.1f Double fenn sets – external baffle set up in box (offset)

Photographs of tunnels housing single set DOC200 traps

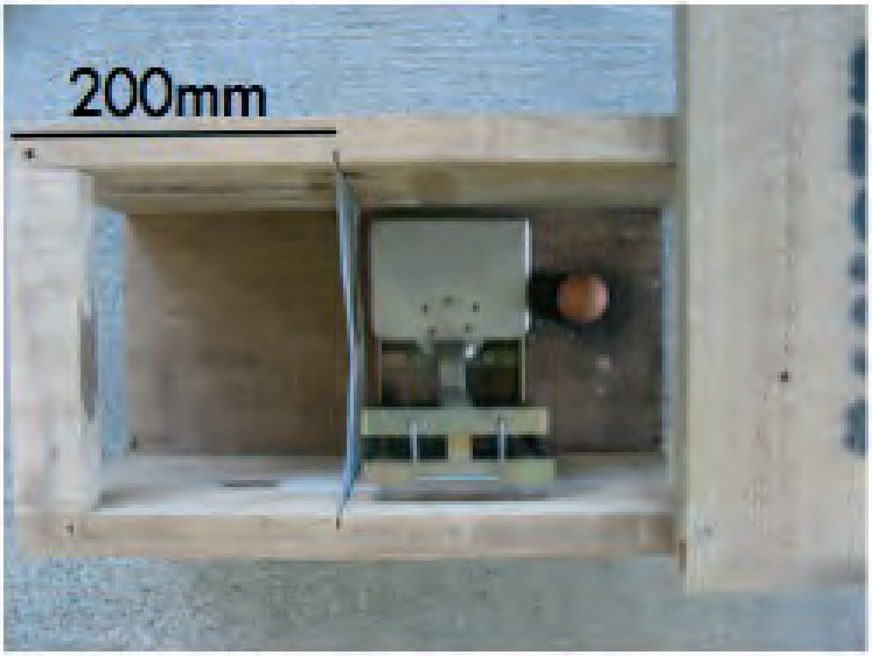

Figure 2.2a DOC 200 single set – internal baffle

Figure 2.2b DOC 200 single set – internal baffle set up in a box

Figure 2.2c DOC 200 single set – external baffle set up in a box (offset)

Photographs of tunnels housing double set DOC200 traps

Figure 2.3a DOC 200 double sets – box dimensions

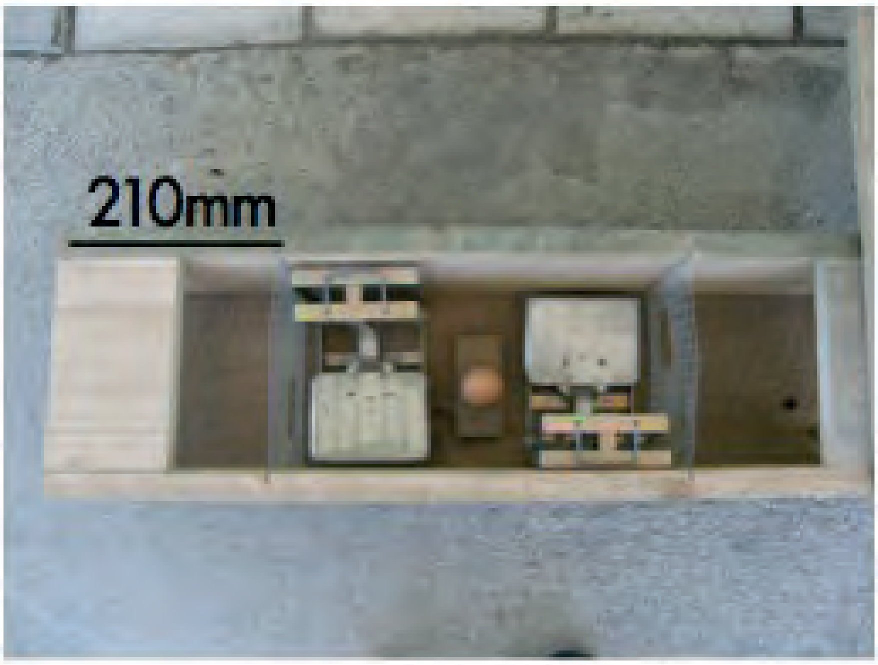

Figure 2.3b DOC 200 double sets – internal baffle

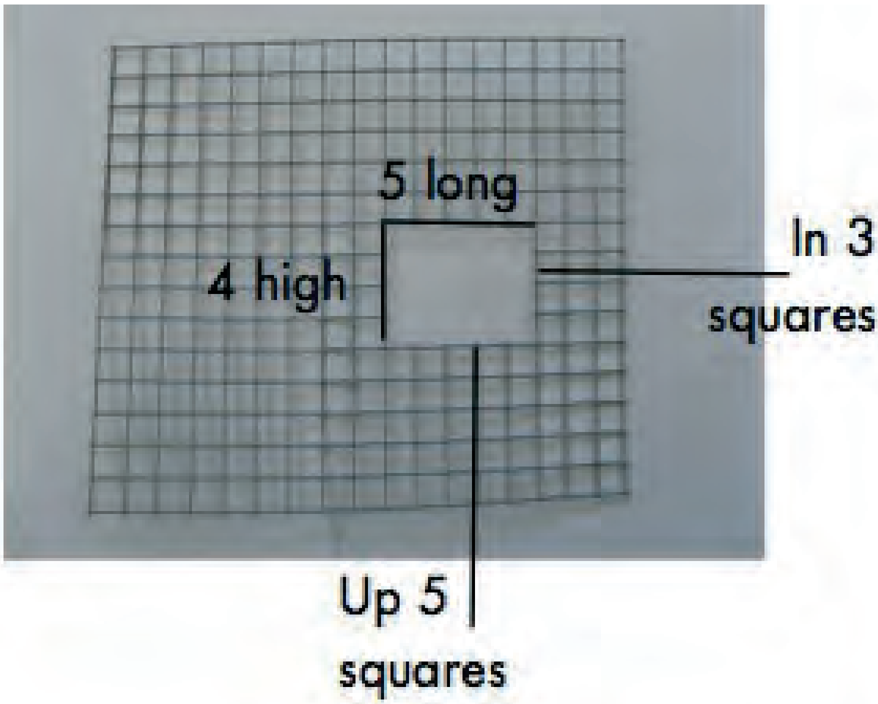

Figure 2.3c DOC 200 double sets – internal baffle dimension

Figure 2.3d DOC 200 double sets – internal baffle set up in a box

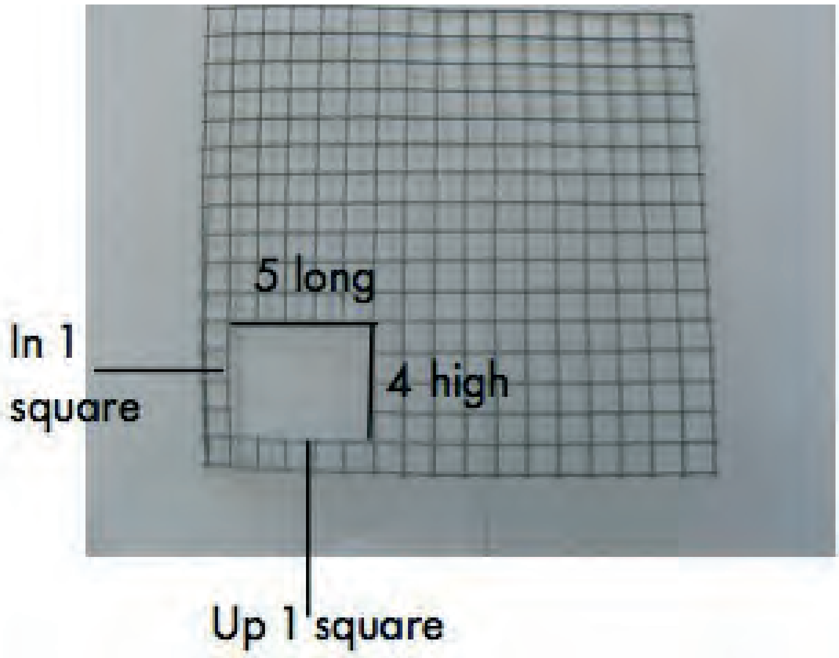

Figure 2.3e DOC 200 double sets – external baffle dimensions

Figure 2.3f DOC 200 double sets – external baffle set up in a box (offset)

Appendix 3: Ferret Control at Motu (2006–2012)

Tunnel design specifications for traps targeting ferrets

Table 3.1 This design was used from June 2008. All traps were single set

Specifications	Doc250
Length (mm)	600
Width (mm)	300
Number entrances	1
Distance between baffles (mm)	250
External baffle position	Centre left 13mm in and 91mm up
External baffle size (length x width)	78mm x 65mm
Internal baffle position	Centre right 52mm in and 78mm up
Internal baffle size (length x width)	78mm x 65mm

Figure 3.1a DOC 250 single set – box dimensions

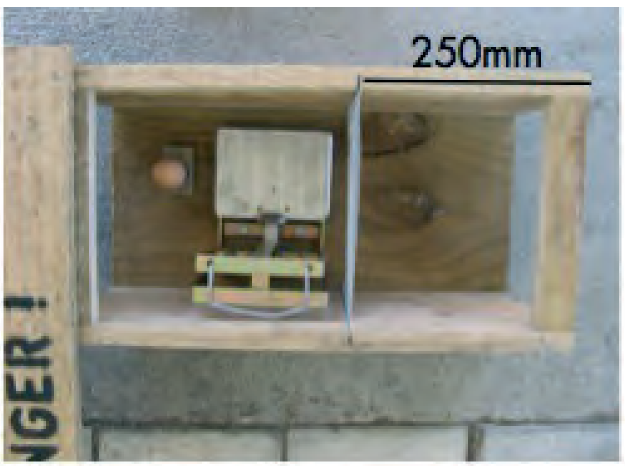

Figure 3.1b DOC 250 single set – internal baffle

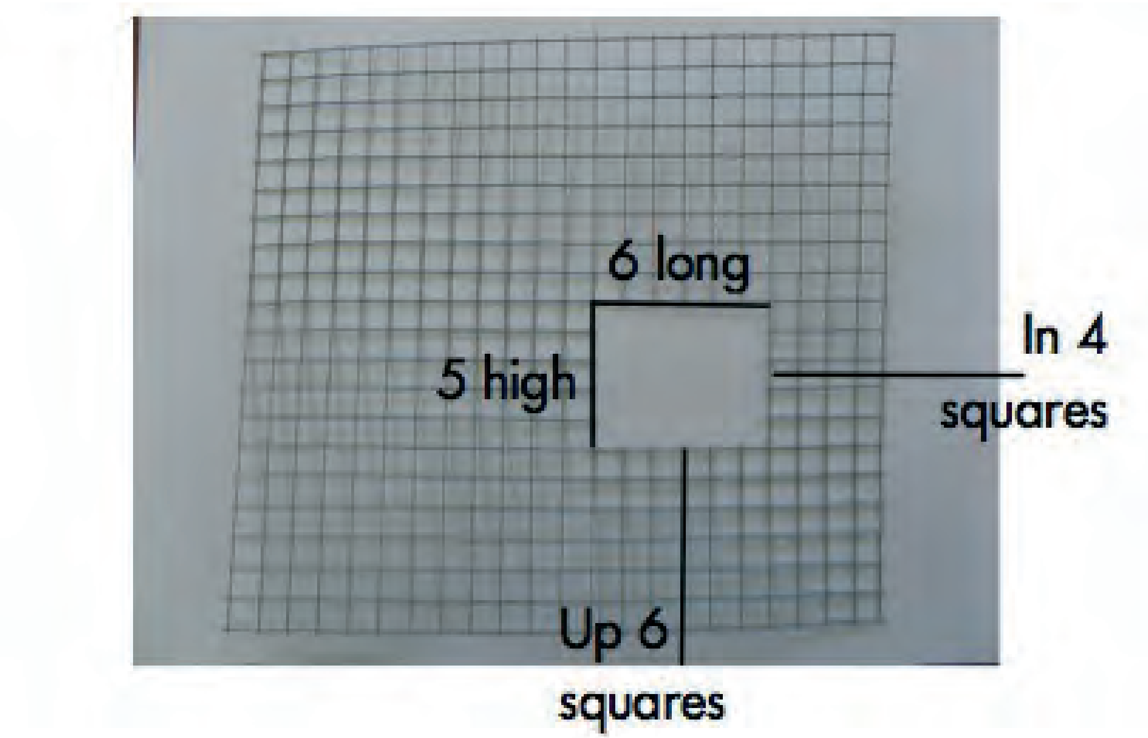

Figure 3.1c DOC 250 single set – internal baffle dimensions

Figure 3.1d DOC 250 single set – internal baffle set up in a box

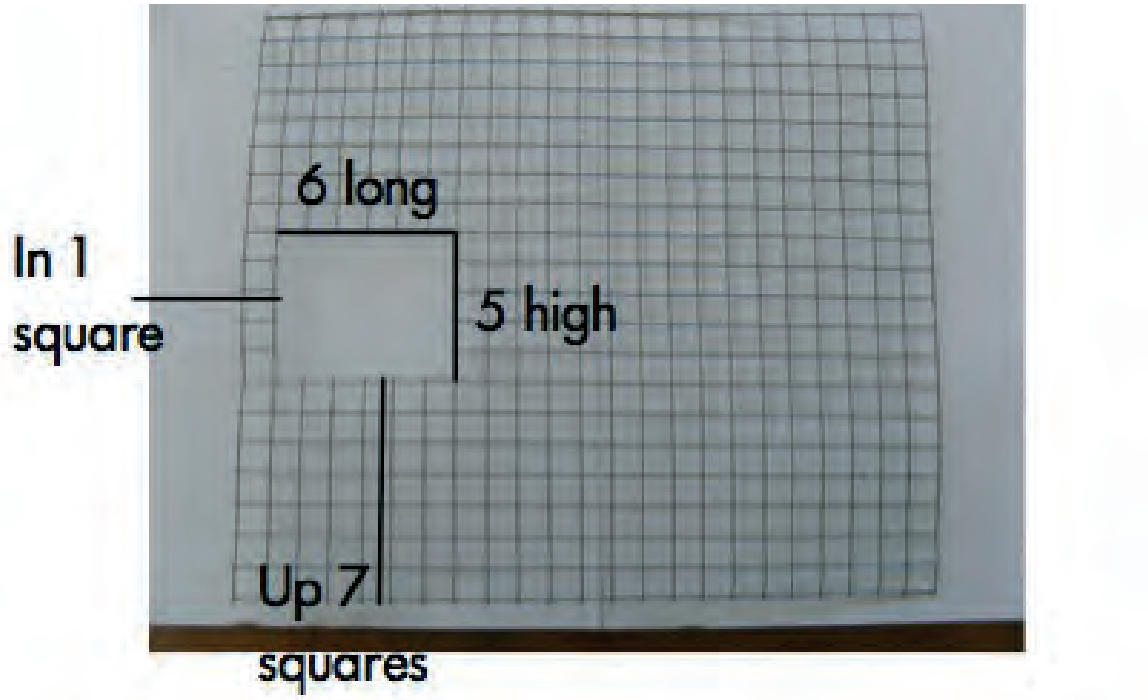

Figure 3.1e DOC 250 single set – external baffle dimensions

Figure 3.1f DOC 250 single set – external baffle set up in a box (offset)

Appendix 4:
Mustelid Control at Motu (1999–2012)

Number of trap services completed each month

Table 4.1 Trap services completed each month

Season	Ju	Au	Se	Oc	No	De	Ja	Fe	Ma	Ap	Ma	Ju
1999-00	0	0	0	0	4	4	4	4	4	4	0	0
2000-01	0	3	4	4	4	4	4	4	4	4	2	0
2001-02	0	2	4	4	4	4	4	4	4	4	0	1
2002-03	1	1	4	4	4	3	4	4	4	3	1	1
2003-04	0	0	2	2	2	2	2	2	2	2	1	1
2004-05	0	0	1	1	1	1	1	1	1	1	1	0
2005-06	1	1	1	1	1	1	1	1	1	1	1	1
2006-07	1	1	1	1	1	1	2	1	1	1	1	1
2007-08	1	1	4	3	1	2	2	1	1	1	1	1
2008-09	1	1	1	1	2	2	2	1	1	1	1	1
2009-10	1	1	1	2	1	2	2	1	1	1	1	1
2010-11	1	1	1	2	1	2	2	1	1	1	1	1
2011-12	1	1	1	2	1	2	2	1	1	1	1	1

Appendix 5: DOC200 trap layout

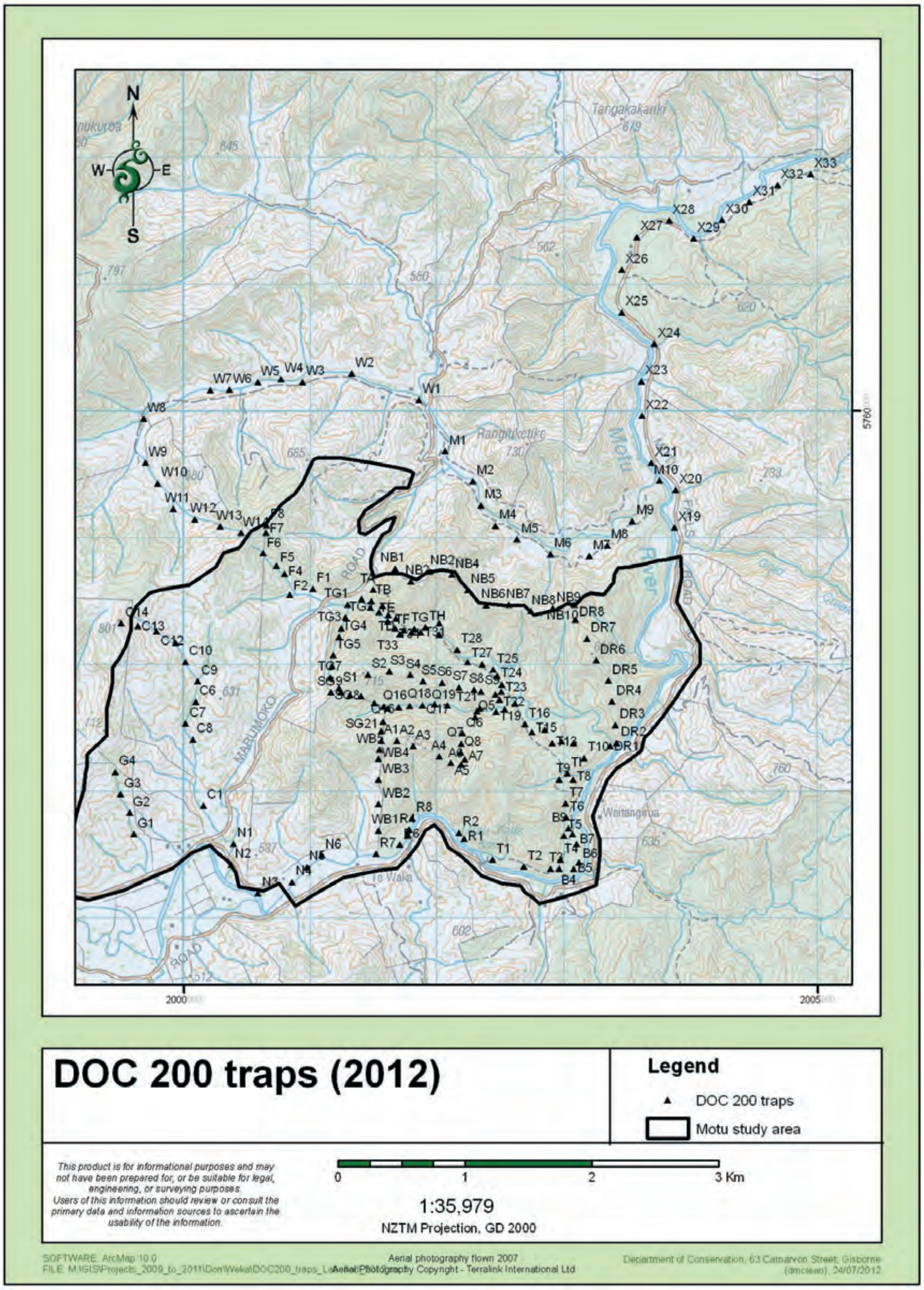

Figure 5.1 DOC200 trap lines

Appendix 6:
DOC250 trap layout

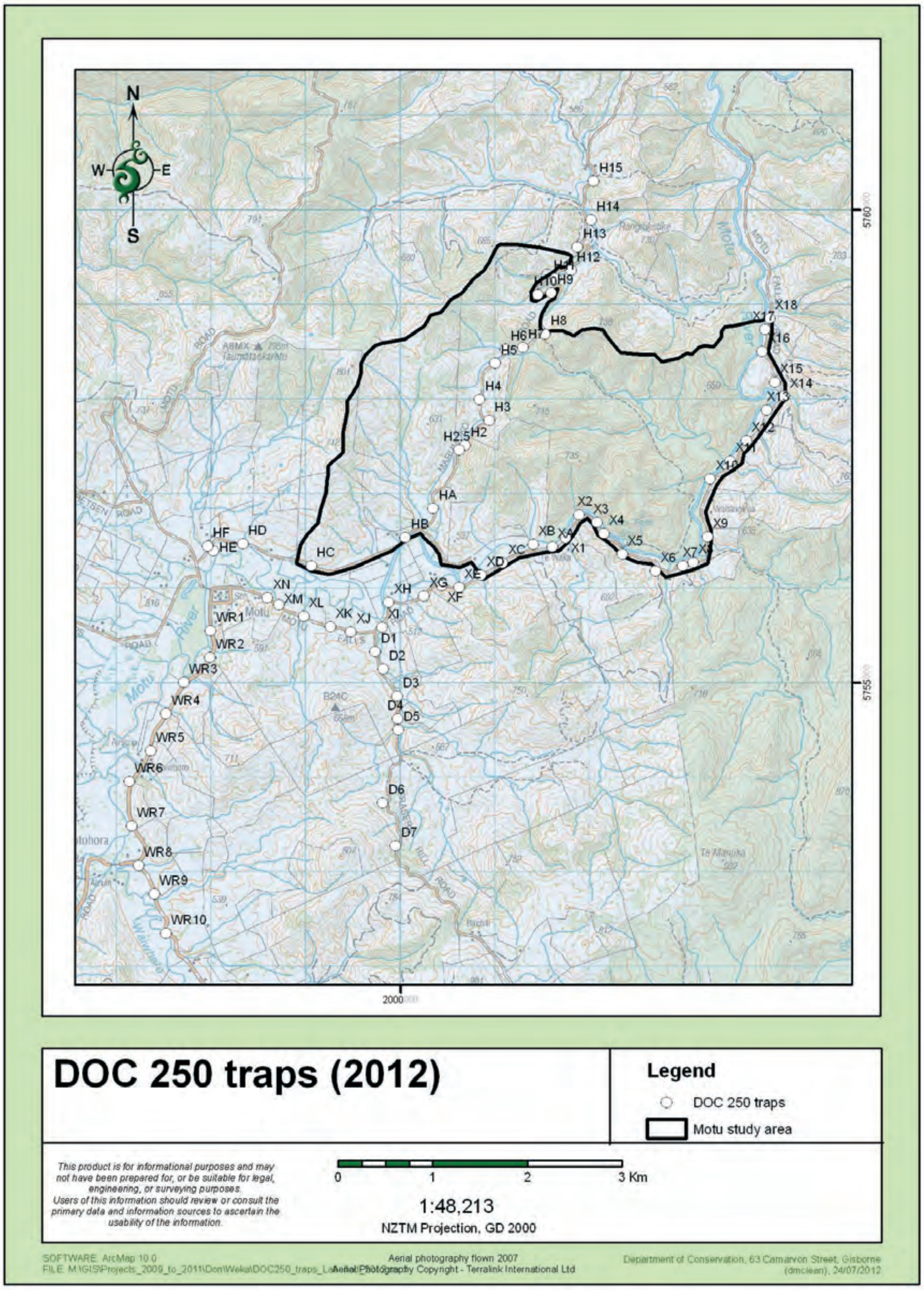

Figure 6.1 DOC250 trap lines

Appendix 7: Location of DOC200 and DOC250 traps

Table 7.1 GPS co-ordinates of DOC200 and DOC250 traps

TRAP LABEL	TRAP TYPE	EASTING	NORTHING	NUMBER OF TRAPS
A1	DOC 200	2001561	5757402	Single set
A2	DOC 200	2001681	5757399	Double set
A3	DOC 200	2001810	5757359	Single set
A4	DOC 200	2002016	5757276	Double set
A5	DOC 200	2002108	5757228	Single set
A6	DOC 200	2002190	5757215	Double set
A7	DOC 200	2002220	5757255	Single set
B4	DOC 200	2002961	5756388	Single set
B5	DOC 200	2003077	5756388	Double set
B6	DOC 200	2003120	5756442	Single set
B7	DOC 200	2003098	5756585	Double set
B8	DOC 200	2003070	5756664	Single set
B9	DOC 200	2003038	5756708	Double set
C1	DOC 200	2000156	5756889	Single set
C10	DOC 200	2000014	5758022	Double set
C11	DOC 200	1999937	5758171	Single set
C12	DOC 200	1999787	5758264	Double set
C13	DOC 200	1999638	5758304	Single set
C14	DOC 200	1999509	5758328	Double set
C6	DOC 200	2000098	5757707	Double set
C7	DOC 200	2000017	5757537	Single set
C8	DOC 200	2000075	5757411	Double set
C9	DOC 200	2000110	5757869	Single set
DR1	DOC 200	2003363	5757357	Single set
DR2	DOC 200	2003417	5757383	Double set
DR3	DOC 200	2003408	5757525	Single set
DR4	DOC 200	2003381	5757709	Double set
DR5	DOC 200	2003352	5757875	Single set
DR6	DOC 200	2003255	5758034	Double set
DR7	DOC 200	2003182	5758206	Single set
DR8	DOC 200	2003090	5758357	Double set
F1	DOC 200	2001022	5758600	Single set
F2	DOC 200	2000839	5758552	Double set
F4	DOC 200	2000798	5758715	Single set
F5	DOC 200	2000733	5758779	Double set
F6	DOC 200	2000627	5758880	Single set
F7	DOC 200	2000650	5759043	Double set
F8	DOC 200	2000654	5759102	Single set
G1	DOC 200	1999609	5756663	Single set
G2	DOC 200	1999574	5756832	Double set
G3	DOC 200	1999502	5756978	Single set
G4	DOC 200	1999462	5757154	Double set
M1	DOC 200	2002063	5759685	Single set
M10	DOC 200	2003753	5759452	Double set
M2	DOC 200	2002282	5759449	Double set
M3	DOC 200	2002344	5759256	Single set
M4	DOC 200	2002460	5759096	Double set
M5	DOC 200	2002630	5758990	Single set
M6	DOC 200	2002894	5758873	Double set
M7	DOC 200	2003200	5758857	Single set
M8	DOC 200	2003340	5758942	Double set
M9	DOC 200	2003540	5759133	Single set

TRAP LABEL	TRAP TYPE	EASTING	NORTHING	NUMBER OF TRAPS
N1	DOC 200	2000392	5756589	Single set
N2	DOC 200	2000374	5756424	Double set
N3	DOC 200	2000588	5756200	Single set
N4	DOC 200	2000857	5756286	Double set
N5	DOC 200	2000975	5756404	Single set
N6	DOC 200	2001089	5756499	Double set
NB1	DOC 200	2001671	5758759	Single set
NB10	DOC 200	2003083	5758475	Double set
NB2	DOC 200	2001792	5758659	Double set
NB2	DOC 200	2001942	5758737	Single set
NB4	DOC 200	2002116	5758710	Double set
NB5	DOC 200	2002239	5758590	Single set
NB6	DOC 200	2002389	5758471	Double set
NB7	DOC 200	2002566	5758474	Single set
NB8	DOC 200	2002741	5758424	Double set
NB9	DOC 200	2002914	5758446	Single set
Q14	DOC 200	2001612	5757658	Single set
Q15	DOC 200	2001697	5757667	Single set
Q16	DOC 200	2001782	5757674	Single set
Q17	DOC 200	2001886	5757680	Single set
Q18	DOC 200	2001982	5757687	Single set
Q19	DOC 200	2002079	5757677	Single set
Q5	DOC 200	2002298	5757589	Single set
Q6	DOC 200	2002201	5757458	Double set
Q7	DOC 200	2002189	5757378	Single set
Q8	DOC 200	2002186	5757307	Double set
R1	DOC 200	2002213	5756628	Single set
R2	DOC 200	2002172	5756675	Double set
R4	DOC 200	2001781	5756701	Double set
R5	DOC 200	2001767	5756653	Single set
R6	DOC 200	2001705	5756580	Double set
R7	DOC 200	2001518	5756508	Single set
R8	DOC 200	2001804	5756790	Single set
S1	DOC 200	2001227	5757816	Single set
S10	DOC 200	2002458	5757766	Double set
S11	DOC 200	2002504	5757787	Single set
S2	DOC 200	2001455	5757923	Double set
S3	DOC 200	2001625	5757948	Single set
S4	DOC 200	2001786	5757921	Double set
S5	DOC 200	2001887	5757871	Single set
S6	DOC 200	2002040	5757859	Double set
S7	DOC 200	2002173	5757822	Single set
S8	DOC 200	2002289	5757804	Double set
S9	DOC 200	2002347	5757790	Single set
SG10	DOC 200	2001311	5757760	Single set
SG11	DOC 200	2001401	5757750	Single set
SG12	DOC 200	2001507	5757696	Single set
SG13	DOC 200	2001578	5757671	Single set
SG20	DOC 200	2001573	5757549	Single set
SG21	DOC 200	2001561	5757479	Single set
SG8	DOC 200	2001162	5757782	Single set
SG9	DOC 200	2001240	5757784	Single set
T1	DOC 200	2002439	5756462	Double set
T10	DOC 200	2003160	5757265	Single set
T11	DOC 200	2003077	5757381	Double set
T12	DOC 200	2002980	5757398	Single set
T13	DOC 200	2002908	5757382	Double set
T14	DOC 200	2002848	5757488	Single set
T15	DOC 200	2002746	5757468	Double set
T16	DOC 200	2002693	5757532	Single set

TRAP LABEL	TRAP TYPE	EASTING	NORTHING	NUMBER OF TRAPS
T17	DOC 200	2002614	5757693	Double set
T18	DOC 200	2002534	5757645	Single set
T19	DOC 200	2002466	5757630	Double set
T2	DOC 200	2002682	5756407	Single set
T20	DOC 200	2002316	5757633	Single set
T21	DOC 200	2002337	5757658	Double set
T22	DOC 200	2002492	5757725	Single set
T23	DOC 200	2002511	5757845	Double set
T24	DOC 200	2002474	5757913	Single set
T25	DOC 200	2002441	5757962	Double set
T26	DOC 200	2002356	5758004	Single set
T27	DOC 200	2002241	5758022	Double set
T28	DOC 200	2002158	5758118	Single set
T29	DOC 200	2002018	5758237	Double set
T3	DOC 200	2002893	5756391	Double set
T30	DOC 200	2002016	5758329	Single set
T31	DOC 200	2001870	5758253	Double set
T32	DOC 200	2001797	5758255	Single set
T33	DOC 200	2001707	5758240	Double set
T34	DOC 200	2001671	5758287	Single set
T35	DOC 200	2001611	5758343	Double set
T36	DOC 200	2001541	5758413	Single set
T37	DOC 200	2001474	5758452	Double set
T38	DOC 200	2001405	5758518	Single set
T4	DOC 200	2002971	5756462	Single set
T5	DOC 200	2003001	5756652	Double set
T6	DOC 200	2003016	5756797	Single set
T7	DOC 200	2003013	5756906	Double set
T8	DOC 200	2003072	5757095	Single set
T9	DOC 200	2002964	5757096	Double set
TA	DOC 200	2001495	5758591	Single set
TB	DOC 200	2001482	5758503	Double set
TC	DOC 200	2001568	5758465	Single set
TD	DOC 200	2001614	5758391	Double set
TE	DOC 200	2001674	5758363	Single set
TF	DOC 200	2001739	5758271	Double set
TG	DOC 200	2001822	5758284	Single set
TG1	DOC 200	2001293	5758476	Single set
TG2	DOC 200	2001277	5758373	Single set
TG3	DOC 200	2001243	5758288	Single set
TG4	DOC 200	2001226	5758219	Single set
TG5	DOC 200	2001179	5758076	Single set
TG6	DOC 200	2001170	5757989	Single set
TG7	DOC 200	2001158	5757900	Single set
TH	DOC 200	2001906	5758297	Double set
TI	DOC 200	2003028	5757144	Single set
W1	DOC 200	2001857	5760088	Single set
W10	DOC 200	1999794	5759431	Double set
W11	DOC 200	1999917	5759229	Single set
W12	DOC 200	2000088	5759147	Double set
W13	DOC 200	2000291	5759091	Single set
W14	DOC 200	2000452	5759039	Double set
W2	DOC 200	2001328	5760296	Double set
W3	DOC 200	2000939	5760231	Single set
W4	DOC 200	2000770	5760253	Double set
W5	DOC 200	2000584	5760229	Single set
W6	DOC 200	2000364	5760168	Double set
W7	DOC 200	2000210	5760166	Single set
W8	DOC 200	1999687	5759940	Double set
W9	DOC 200	1999698	5759592	Single set

TRAP LABEL	TRAP TYPE	EASTING	NORTHING	NUMBER OF TRAPS
WB1	DOC 200	2001537	5756693	Double set
WB2	DOC 200	2001539	5756900	Single set
WB3	DOC 200	2001538	5757094	Double set
WB4	DOC 200	2001535	5757258	Single set
WB5	DOC 200	2001546	5757331	Double set
X19	DOC 200	2003872	5759081	Single set
X20	DOC 200	2003881	5759379	Single set
X21	DOC 200	2003689	5759594	Single set
X22	DOC 200	2003617	5759963	Single set
X23	DOC 200	2003612	5760235	Single set
X24	DOC 200	2003713	5760531	Single set
X25	DOC 200	2003458	5760778	Single set
X26	DOC 200	2003456	5761114	Single set
X27	DOC 200	2003575	5761373	Single set
X28	DOC 200	2003829	5761504	Single set
X29	DOC 200	2004023	5761362	Single set
X30	DOC 200	2004247	5761507	Single set
X31	DOC 200	2004464	5761650	Single set
X32	DOC 200	2004684	5761783	Single set
X33	DOC 200	2004946	5761868	Single set
D1	DOC 250	1999734	5755333	Single set
D2	DOC 250	1999821	5755148	Single set
D3	DOC 250	1999967	5754856	Single set
D4	DOC 250	1999973	5754619	Single set
D5	DOC 250	1999975	5754506	Single set
D6	DOC 250	1999812	5753731	Single set
D7	DOC 250	1999948	5753277	Single set
H10	DOC 250	2001453	5759104	Single set
H11	DOC 250	2001643	5759276	Single set
H12	DOC 250	2001802	5759359	Single set
H13	DOC 250	2001868	5759607	Single set
H14	DOC 250	2002014	5759895	Single set
H15	DOC 250	2002042	5760303	Single set
H2	DOC 250	2000683	5757511	Single set
H2.5	DOC 250	2000622	5757463	Single set
H3	DOC 250	2000937	5757776	Single set
H4	DOC 250	2000838	5757995	Single set
H5	DOC 250	2001003	5758378	Single set
H6	DOC 250	2001109	5758525	Single set
H7	DOC 250	2001292	5758544	Single set
H8	DOC 250	2001529	5758688	Single set
H9	DOC 250	2001597	5759124	Single set
HA	DOC 250	2000346	5756844	Single set
HB	DOC 250	2000050	5756539	Single set
HC	DOC 250	1999056	5756237	Single set
HD	DOC 250	1998335	5756469	Single set
HE	DOC 250	1998023	5756393	Single set
HF	DOC 250	1997963	5756446	Single set
WR1	DOC 250	1997996	5755551	Single set
WR10	DOC 250	1997520	5752354	Single set
WR2	DOC 250	1997990	5755267	Single set
WR3	DOC 250	1997709	5755003	Single set
WR4	DOC 250	1997524	5754676	Single set
WR5	DOC 250	1997362	5754282	Single set
WR6	DOC 250	1997133	5753956	Single set
WR7	DOC 250	1997161	5753488	Single set
WR8	DOC 250	1997235	5753071	Single set
WR9	DOC 250	1997399	5752770	Single set
X1	DOC 250	2001748	5756530	Single set
X10	DOC 250	2003274	5757154	Single set

TRAP LABEL	TRAP TYPE	EASTING	NORTHING	NUMBER OF TRAPS
X11	DOC 250	2003486	5757346	Single set
X12	DOC 250	2003657	5757560	Single set
X13	DOC 250	2003873	5757887	Single set
X14	DOC 250	2004058	5758034	Single set
X15	DOC 250	2003959	5758178	Single set
X16	DOC 250	2003823	5758503	Single set
X17	DOC 250	2003856	5758735	Single set
X18	DOC 250	2003903	5758850	Single set
X2	DOC 250	2001888	5756775	Single set
X3	DOC 250	2002079	5756698	Single set
X4	DOC 250	2002150	5756578	Single set
X5	DOC 250	2002346	5756362	Single set
X6	DOC 250	2002698	5756182	Single set
X7	DOC 250	2002983	5756236	Single set
X8	DOC 250	2003093	5756276	Single set
X9	DOC 250	2003247	5756540	Single set
XA	DOC 250	2001607	5756437	Single set
XB	DOC 250	2001405	5756461	Single set
XC	DOC 250	2001081	5756265	Single set
XD	DOC 250	2000856	5756137	Single set
XE	DOC 250	2000619	5756007	Single set
XF	DOC 250	2000438	5756026	Single set
XG	DOC 250	2000248	5755918	Single set
XH	DOC 250	1999876	5755850	Single set
XI	DOC 250	1999807	5755587	Single set
XJ	DOC 250	1999478	5755538	Single set
XK	DOC 250	1999262	5755596	Single set
XL	DOC 250	1998978	5755706	Single set
XM	DOC 250	1998713	5755829	Single set
XN	DOC 250	1998591	5755898	Single set

Appendix 8: Density index calculations

A session was defined as one trapping season (from 1 July to 30 June each year). The total number of trap nights available to catch mustelids or weka was calculated by adding columns C+D+E+F+G, dividing the total by 2 (column H) and then subtracting column H from column A. This method is fully explained in C.M. King et al (1994).

Column G included all by catch (rats, hedgehogs, weasels, cats, blackbirds, possums and rabbits) and any traps that were missing (due to a flood or having been removed by someone etc).

In the 2001-02 season the total number of trap nights available to catch stoats was 10230. The corrected density index is 36/10230 x 100 = 0.35.

Table 8.1 Total trap nights available to catch mustelids and weka for each session (trapping season)

season	A Total traps	B Traps untouched	C stoats	D ferrets	E weka	F sprung	G other	H C+D+E+F+G divided by 2	I (A-H)
2001-02	10532	9928	36	0	8	273	287	302	10230
2002-03	10875	9034	91	0	9	435	1306	920.5	9954.5
2003-04	8627	5899	88	0	7	517	2116	1364	7263
2004-05	4398	3331	69	2	0	333	663	53305	3864.5
2005-06	5702	4560	99	2	4	413	624	571	5131
2006-07	4744	4021	41	0	3	253	426	361.5	4382.5
2007-08	8379	7051	57	0	5	235	1031	664	7715
2008-09	7134	6162	39	1	4	307	621	486	6648
2009-10	5154	4417	41	8	1	209	478	368.5	4785.5
2010-11	5063	4425	38	13	2	159	426	319	4744
2011-12	5408	4469	37	12	3	192	695	469.5	4938.5

The same formula as above was used to calculate the number of mustelids and weka captured per 100 trap nights for each trap type used.

Table 8.2 Total trap nights available to catch mustelids and weka for each trap type

Trap type	A Total traps	B Traps untouched	C stoats	D ferrets	E weka	F sprung	G other	H C+D+E+F+G divided by 2	I (A-H)
DOC200	25584	21493	224	25	8	1141	2693	2045.5	23538.5
DOC250	4321	3742	27	8	8	206	330	289.5	4031.5
Fenn	43789	36286	379	5	26	1882	5211	3751.5	40037.5
Thumper	2418	1776	6	0	4	97	535	321	2097

Appendix 9: Cat Control at Motu (2002–2012)

Photographs of cat traps

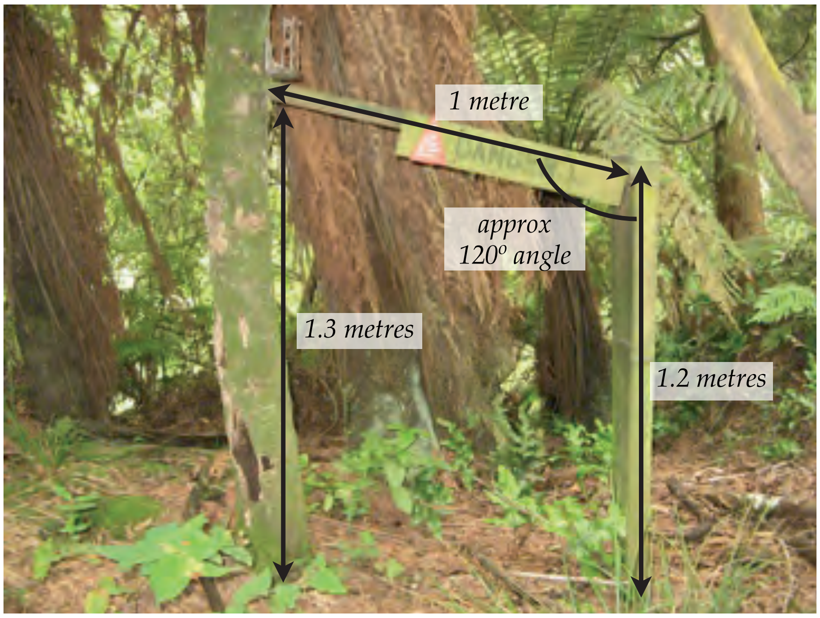

Fig 9.1 Overview of ramp

Fig 9.2 The ramp leading up to the trap

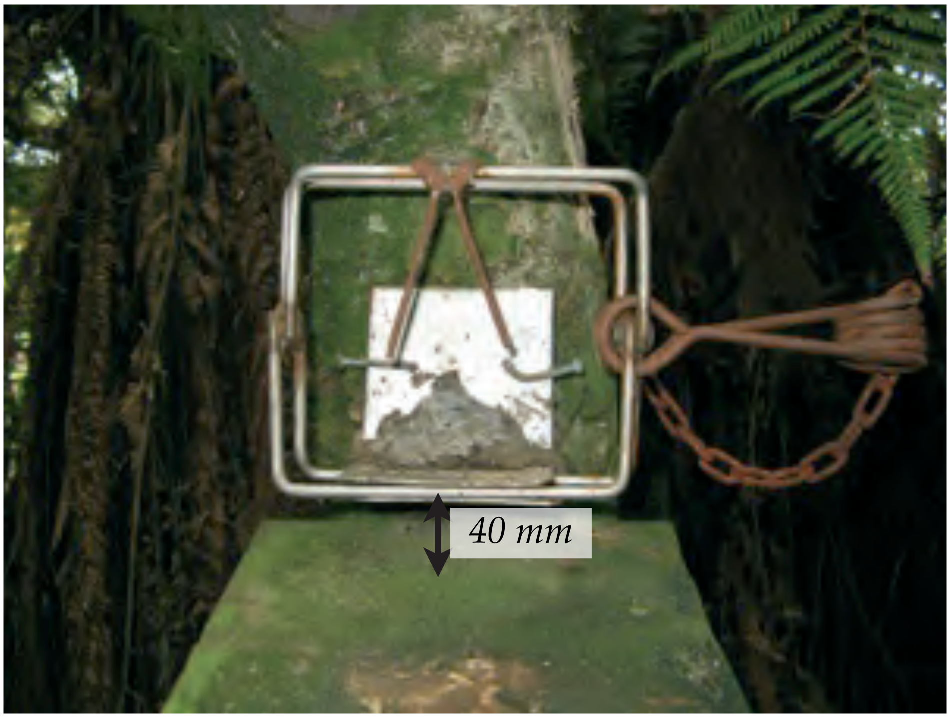

Fig 9.3 The baited trap raised from the ramp

Fig 9.4 Cat caught in trap

Location of cat traps

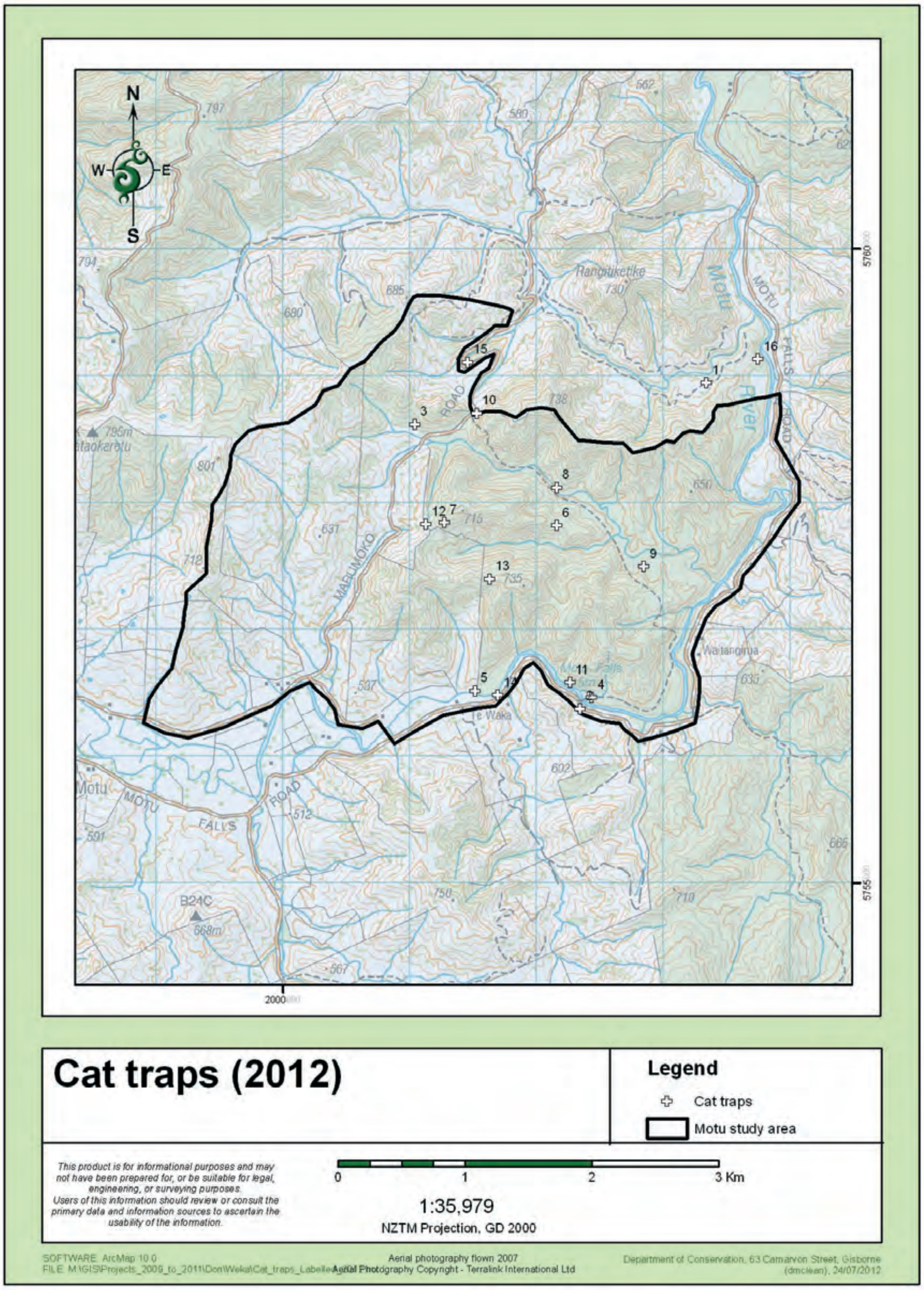

Fig 9.5 Labelled cat traps

Table 9.1 GPS coordinates of cat traps.

TRAP LABEL	TRAP TYPE	EASTING	NORTHING
1	Cat trap	2003341	5758942
2	Cat trap	2002347	5756373
3	Cat trap	2001040	5758617
4	Cat trap	2002438	5756461
5	Cat trap	2001516	5756515
6	Cat trap	2002161	5757819
7	Cat trap	2001274	5757841
8	Cat trap	2002161	5758117
9	Cat trap	2002847	5757494
10	Cat trap	2001529	5758702
11	Cat trap	2002269	5756580
12	Cat trap	2001131	5757827
13	Cat trap	2001633	5757396
14	Cat trap	2001696	5756480
15	Cat trap	2001460	5759105
16	Cat trap	2003749	5759131

Appendix 10: Call counts

Population density indices at Motu

The table below compares population density estimates at Motu between listening posts and years. Counts at the Seat post were not carried out in 2011. The Motu total count was calculated under the assumption that estimates at the Falls post were the same in 2002 as they were in 2003 and estimates at the Seat post were the same in 2011 as they were in 2010.

Table 10.1 Population density estimates at Motu listening posts from 2002 to 2011

POST (AREA IN HECTARES)	YEAR	PAIRS INSIDE POLYGON	PAIRS PER HECTARE INSIDE POLYGON	TOTAL WEKA INSIDE POLYGON	TOTAL WEKA PER HECTARE INSIDE POLYGON
Wok/Fish (84)	2002	7	0.08	15	0.18
	2003	10	0.12	21	0.25
	2004	14	0.17	29	0.35
	2005	14	0.17	31	0.37
	2006	13	0.15	30	0.36
	2007	16	0.19	33	0.39
	2008	26	0.31	58	0.69
	2009	22	0.27	45	0.54
	2010	20	0.24	44	0.52
	2011	19	0.23	38	0.45
Road paddock (57)	2002	5	0.09	10	0.18
	2003	5	0.09	11	0.19
	2004	5	0.09	10	0.18
	2005	8	0.14	19	0.33
	2006	13	0.23	28	0.49
	2007	12	0.21	25	0.44
	2008	10	0.18	25	0.44
	2009	15	0.26	31	0.54
	2010	16	0.28	35	0.61
	2011	14	0.25	32	0.56
Fisher pines (142)	2002	1	0.00	3	0.02
	2003	6	0.04	13	0.09
	2004	6	0.04	13	0.09
	2005	5	0.04	13	0.09
	2006	12	0.08	29	0.20
	2007	21	0.15	42	0.30
	2008	17	0.12	38	0.27
	2009	17	0.12	34	0.24
	2010	19	0.13	38	0.27
	2011	18	0.13	37	0.26

POST (AREA IN HECTARES)	YEAR	PAIRS INSIDE POLYGON	PAIRS PER HECTARE INSIDE POLYGON	TOTAL WEKA INSIDE POLYGON	TOTAL WEKA PER HECTARE INSIDE POLYGON
Snake gully (34)	2002	0	0.00	4	0.12
	2003	4	0.12	8	0.24
	2004	6	0.18	14	0.41
	2005	8	0.24	18	0.53
	2006	6	0.18	13	0.38
	2007	8	0.24	16	0.47
	2008	12	0.35	25	0.74
	2009	8	0.24	19	0.56
	2010	11	0.32	23	0.68
	2011	11	0.32	23	0.68
Seat (81)	2002	4	0.05	8	0.10
	2003	2	0.02	6	0.07
	2004	6	0.07	12	0.15
	2005	18	0.22	41	0.51
	2006	10	0.12	26	0.32
	2007	9	0.11	18	0.22
	2008	11	0.14	27	0.33
	2009	20	0.25	43	0.53
	2010	8	0.10	16	0.20
	2011	-	-	-	-
Falls (103) Set up in 2003	2002	-	-	-	-
	2003	2	0.02	6	0.06
	2004	3	0.03	8	0.08
	2005	2	0.02	6	0.06
	2006	7	0.07	22	0.21
	2007	12	0.12	34	0.33
	2008	9	0.09	31	0.30
	2009	10	0.10	24	0.23
	2010	10	0.10	22	0.21
	2011	7	0.07	22	0.21
MOTU TOTAL (501)	2002	19	0.04	46	0.09
	2003	29	0.06	65	0.13
	2004	40	0.08	86	0.17
	2005	55	0.11	128	0.23
	2006	61	0.12	148	0.30
	2007	78	0.16	168	0.34
	2008	85	0.17	204	0.41
	2009	92	0.18	196	0.39
	2010	84	0.17	178	0.36
	2011	77	0.15	168	0.34

Population density indices at Whitikau

The table below compares population density estimates at Whitikau between listening posts and years. The Forks post was moved in 2008 when the polygon system was introduced. This meant that density estimates from 2002 to 2007 could not be compared to those made within the polygon at a different location and they have been omitted from the table below. Counts were not carried out at the Forks post in 2011. For these reasons density estimates from the Forks post have not been included in the Whitikau total density estimates at the bottom of this table.

Counts at Samson's post were not carried out in 2011. The Whitikau total count was calculated under the assumption that estimates at the Fork's post were the same in 2011 as they were in 2010.

Table 10.2 Population density estimates at Whitikau listening posts from 2002 to 2011

POST	YEAR	PAIRS INSIDE POLYGON	PAIRS PER HECTARE INSIDE POLYGON	TOTAL WEKA INSIDE POLYGON	TOTAL WEKA PER HECTARE INSIDE POLYGON
Call count hill (116)	2002	12	0.10	24	0.21
	2003	13	0.11	28	0.24
	2004	13	0.11	28	0.24
	2005	20	0.17	42	0.36
	2006	13	0.11	30	0.26
	2007	22	0.19	48	0.41
	2008	10	0.09	23	0.20
	2009	12	0.10	27	0.23
	2010	14	0.12	29	0.25
	2011	11	0.09	24	0.21
Forks (25)	2002				
	2003				
	2004				
	2005				
	2006				
	2007				
	2008	14	0.56	31	1.24
	2009	8	0.32	17	0.68
	2010	7	0.28	16	0.64
	2011	-	-	-	-
Pine tree bend (77)	2002	9	0.12	18	0.23
	2003	11	0.14	25	0.32
	2004	15	0.19	31	0.40
	2005	11	0.14	25	0.32
	2006	17	0.22	39	0.51
	2007	24	0.31	50	0.65
	2008	21	0.27	49	0.64
	2009	8	0.10	18	0.23
	2010	12	0.16	27	0.35
	2011	8	0.10	16	0.21
Grader (89)	2002	6	0.07	14	0.16
	2003	8	0.09	17	0.19
	2004	12	0.13	24	0.27
	2005	7	0.08	16	0.18
	2006	13	0.15	30	0.34
	2007	9	0.10	20	0.22
	2008	16	0.18	36	0.40
	2009	18	0.20	38	0.43
	2010	16	0.18	36	0.40
	2011	11	0.12	24	0.27

POST	YEAR	PAIRS INSIDE POLYGON	PAIRS PER HECTARE INSIDE POLYGON	TOTAL WEKA INSIDE POLYGON	TOTAL WEKA PER HECTARE INSIDE POLYGON
Samson's (81)	2002	5	0.06	12	0.15
	2003	6	0.07	16	0.20
	2004	6	0.07	13	0.16
	2005	13	0.16	28	0.35
	2006	6	0.07	17	0.21
	2007	6	0.07	15	0.19
	2008	8	0.10	17	0.21
	2009	5	0.06	10	0.12
	2010	8	0.10	17	0.21
	2011	-	-	-	-
TOTAL (363) (excluding Forks post)	2002	32	0.09	68	0.19
	2003	38	0.10	86	0.24
	2004	46	0.13	96	0.26
	2005	51	0.14	111	0.31
	2006	49	0.13	116	0.32
	2007	61	0.17	133	0.37
	2008	55	0.15	125	0.34
	2009	43	0.12	93	0.26
	2010	50	0.14	109	0.30
	2011	38	0.10	81	0.22

Table 10.3 Names and locations of listening posts at Motu

LISTENING POST	EASTINGS	NORTHINGS
Fisher Pines	2910544	6317890
Fisher Valley	2910987	6319874
Wok/Fish	2911239	6320146
Snake Gully	2911135	6319125
Whinray Seat	2912440	6319241
Motu Falls	2912091	6317775

Names and locations of listening posts at Motu and Whitikau

Table 10.4 Names and locations of listening posts at Whitikau

LISTENING POST	EASTINGS	NORTHINGS
Call count hill	2905574	6326994
Forks valley	2906572	6326314
Pine tree bend	2906612	6325419
Grader	2907986	6325313
Samson's	2908453	6325640

Appendix 11:
Population and Adult health

Number and sex of weka caught

The total number of male weka (including adults and juveniles) caught each season always exceeded the total number of female weka (including adults and juveniles) caught in both study areas. The sex of a few weka was either not recorded or was unknown. These weka have been excluded from the two tables below.

Table 11.1 The number of male and female weka caught each season in Motu

SEASON	MALE WEKA	FEMALE WEKA
1999-00	13	5
2000-01	6	0
2001-02	31	14
2002-03	51	26
2003-04	43	20
2004-05	44	21
2005-06	56	15
2006-07	52	28
2007-08	55	32
2008-09	50	33
2009-10	62	27
2010-11	64	28
2011-12	100	38
Total	627	287

Table 11.2 The number of male and female weka caught each season in Whitikau

SEASON	MALE WEKA	FEMALE WEKA
1999-00	19	10
2000-01	6	0
2001-02	25	8
2002-03	69	18
2003-04	24	10
2004-05	33	17
2005-06	52	13
2006-07	32	21
2007-08	38	24
2008-09	32	19
2009-10	37	23
2010-11	44	30
Total	412	198

Weights of adult weka

No trapping occurred in Whitikau in the 2011—2012 season because access was denied to the Department of Conservation. No female weka were caught in either Motu or Whitikau in the 2000-01 season.

Table 11.3 A summary of the median weights of adult weka (grams) for each season

SEASON	MOTU MALES MEDIAN WEIGHT	WHITIKAU MALES MEDIAN WEIGHT	MOTU FEMALES MEDIAN WEIGHT	WHITIKAU FEMALES MEDIAN WEIGHT
1999-00	975	1050	800	825
2000-01	975	988	-	-
2001-02	783	870	610	713
2002-03	855	930	665	750
2003-04	935	860	650	625
2004-05	1000	930	725	690
2005-06	975	975	750	750
2006-07	940	940	650	700
2007-08	955	950	680	670
2008-09	920	940	730	700
2009-10	960	1000	720	765
2010-11	960	965	730	710
2011-12	950	x	720	x

The tables that follow show weight information (grams) for all adult male and female weka caught in both study areas for each season. Information includes the average weights of weka (with SE), the range of weights and median weight.

Table 11.4 Motu males

SEASON	SAMPLE SIZE	AVERAGE WEIGHT (SE)	RANGE	MEDIAN WEIGHT
1999-00	6	999 (29.1)	925-1100	975
2000-01	2	975 (75.0)	900-1050	975
2001-02	25	805 (15.8)	685-1000	783
2002-03	33	862 (17.0)	705-1100	855
2003-04	28	924 (15.3)	750-1050	935
2004-05	23	991 (15.8)	875-1100	1000
2005-06	31	985 (18.4)	675-1100	975
2006-07	33	962 (27.6)	650-1400	940
2007-08	38	1015 (31.5)	760-1600	955
2008-09	36	934 (16.2)	730-1170	920
2009-10	48	974 (16.7)	780-1260	960
2010-11	47	970 (17.1)	770-1300	960
2011-12	53	961 (14.3)	760-1360	950

Table 11.5 Whitikau males

SEASON	SAMPLE SIZE	AVERAGE WEIGHT (SE)	RANGE	MEDIAN WEIGHT
1999-00	9	997 (35.5)	850-1150	1050
2000-01	4	1006 (32.6)	950-1100	988
2001-02	21	867 (20.4)	695-1045	870
2002-03	61	930 (10.1)	700-1090	930
2003-04	17	896 (27.8)	710-1150	860
2004-05	23	912 (19.7)	755-1050	930
2005-06	30	986 (15.7)	850-1100	975
2006-07	27	938 (18.7)	800-1200	940
2007-08	25	945 (25.8)	750-1200	950
2008-09	23	943 (17.9)	760-1110	940
2009-10	28	987 (18.5)	800-1240	1000
2010-11	36	952 (14.7)	760-1100	965
2011-12	-	-	-	-

Table 11.6 Motu females

SEASON	SAMPLE SIZE	AVERAGE WEIGHT (SE)	RANGE	MEDIAN WEIGHT
1999-00	2	800 (50.0)	750-850	800
2000-01	0	0	0	-
2001-02	10	607 (21.1)	520-745	610
2002-03	16	641 (18.6)	460-760	665
2003-04	8	655 (19.6)	600-705	650
2004-05	9	708 (13.2)	625-750	725
2005-06	8	753 (13.7)	700-825	750
2006-07	15	669 (22.2)	540-800	650
2007-08	12	685 (29.4)	530-840	680
2008-09	20	695 (20.4)	540-880	730
2009-10	17	723 (17.6)	600-850	720
2010-11	19	701 (23.4)	530-910	730
2011-12	18	722 (21.0)	550-900	720

Table 11.7 Whitikau females

SEASON	SAMPLE SIZE	AVERAGE WEIGHT (SE)	RANGE	MEDIAN WEIGHT
1999-00	3	792 (33.3)	725-825	825
2000-01	0	0	0	-
2001-02	4	699 (20.7)	640-730	713
2002-03	7	728 (30.4)	620-845	750
2003-04	1	625 (-)	625-625	625
2004-05	12	728 (31.3)	600-925	690
2005-06	10	755 (25.7)	700-825	750
2006-07	7	713 (25.8)	650-850	700
2007-08	7	690 (29.4)	580-820	670
2008-09	3	760 (60.3)	700-880	700
2009-10	10	773 (25.0)	640-920	765
2010-11	14	715 (14.4)	650-830	710
2011-12	-	-	-	-

Appendix 12: Nest Monitoring (1997–2002)

From 1999 to 2002 a maximum of six adult female weka were captured in August from each study area and transmitters were attached.

Transmitters allowed an observer to monitor the percentage of pairs that nested. Females incubate the eggs during the day. Transmitter signals were checked weekly and if a female was in the same place for three consecutive weeks it was assumed she was incubating. Females were approached with caution and the observer always maintained a distance of at least 50m. Female weka are wary and will desert a nest if they feel threatened.

From 1997 to 2002 a high percentage of monitored female weka from the treatment areas (Toatoa from 1997 to 1998 and Motu from 1999 to 2002) and Whitikau attempted to breed at least once during each season (Table 12.1).

Table 12.1 Proportion of monitored female weka that attempted to breed at least once during the season in Toatoa, Motu and Whitikau from 1997 to 2002. The information was not collected in the 2000-01 season

SEASON	SAMPLE SIZE WHITIKAU	% ATTEMPTING TO BREED	SAMPLE SIZE TOATOA AND MOTU	% ATTEMPTING TO BREED
1997-98	6	83	6	100
1998-99	6	83	6	100
1999-00	3	100	3	100
2001-02	6	100	5	100

Appendix 13: Chick Monitoring (1997–2002)

After hatching the transmitter allowed an observer to monitor chick survival from the age of hatching to six weeks of age. Transmitters could not be attached to these chicks because of their size and because the parent weka could abandon the chicks during their capture.

Table 13.1 Comparison of the maximum number of observed chicks hatched and the number of chicks that fledged from each study area

SEASON	STUDY AREA	NO. PAIRS MONITORED	CHICKS HATCHED	CHICKS FLEDGED	PERCENT FLEDGED
1997-1998	Toatoa	6	9	5	56
	Whitikau	6	11	6	55
1998-1999	Toatoa	6	8	6	75
	Whitikau	6	10	8	80
1999-2000	Motu	3	8	4	50
	Whitikau	3	6	6	100
2001-2002	Motu	5	7	7	100
	Whitikau	6	9	7	78

Appendix 14: Juvenile Monitoring (1997–1999)

Over this period juvenile survival rates and causes of death were monitored until juveniles reached six months of age. The stoat and cat columns include certain and suspected predation events. The 'other' column includes deaths with unknown causes.

Table 14.1 Survival rates and causes of death of monitored juvenile weka to six months of age

SEASON	STUDY AREA	NO. TXS	NO. RESULTS OBTAINED	NO. ALIVE	% ALIVE	STOAT	CAT	OTHER
1997-98	Toatoa	12	11	10	91	0	0	1
1997-98	Whitikau	13	11	7	64	2	1	1
1998-99	Toatoa	9	9	8	89	0	0	1
1998-99	Whitikau	8	6	5	75	0	1	0

Appendix 15: Juvenile Monitoring (1999–2011)

Survival and causes of death

Table 15.1 Survival rates and causes of death of monitored juvenile weka to 12 months of age in Motu

SEASON	NO. TXS	NO. RESULTS	NO. ALIVE	% ALIVE	CUMULATIVE MEAN	MUSTELID	CAT	OTHER
1999-00	8	7	5	71	71	2	0	0
2000-01	5	5	4	80	76	1	0	0
2001-02	5	5	4	80	77	0	0	1
2002-03	13	11	7	64	74	1	0	3
2003-04	16	15	9	60	70	3	0	3
2004-05	11	10	6	60	69	2	2	0
2005-06	12	12	10	83	71	1	0	1
2006-07	13	12	8	67	71	1	0	3
2007-08	15	15	12	80	72	0	1	2
2008-09	13	12	9	75	72	1	0	2
2009-10	12	10	4	40	69	1	1	4
2010-11	12	10	7	70	69	2	0	1
Total	135	124	85	69	69	15	4	20

Table 15.2 Survival rates and causes of death of monitored juvenile weka to 12 months of age in Whitikau

SEASON	NO. TXS	NO. RESULTS	NO. ALIVE	% ALIVE	CUMULATIVE MEAN	MUSTELID	CAT	OTHER
1999-00	8	8	5	63	63	2	1	0
2000-01	4	4	1	25	44	1	1	1
2001-02	2	1	0	0	29	0	0	1
2002-03	13	12	7	58	37	4	0	1
2003-04	9	8	6	75	44	1	0	1
2004-05	12	9	9	100	54	0	0	0
2005-06	13	11	9	82	58	0	1	1
2006-07	12	11	7	64	58	1	0	3
2007-08	15	14	5	36	56	7	0	2
2008-09	13	11	6	55	56	2	0	3
2009-10	12	8	6	75	58	0	0	2
2010-11	12	10	8	80	59	1	0	1
Total	125	107	69	64	64	19	3	16

Dispersal

The sample size includes birds that survived to 12 months and whose dispersal distance was measured at 12 months. Some birds were recorded as missing at 12 months of age but were recaptured several months later. These birds are recorded as alive but do not have a dispersal distance.

Table 15.3 Differences in juvenile dispersal (m) in Motu

COHORT	SAMPLE SIZE	AVERAGE DISPERSAL DISTANCE (SE)	GREATEST DISPERSAL DISTANCE	SMALLEST DISPERSAL DISTANCE	%THAT DISPERSED < 500M	% THAT DISPERSED ≥500M
1999-00	5	1370 (467.9)	3000	200	20	80
2000-01	4	525 (160.1)	1000	300	75	25
2001-02	4	744 (168.9)	1220	440	25	75
2002-03	6	959 (391.4)	3000	38	33	67
2003-04	10	1132 (357.8)	6000	52	50	50
2004-05	6	521 (212.8)	1588	130	83	17
2005-06	10	421 (140.4)	1689	41	80	20
2006-07	8	450 (159.1)	728	176	50	50
2007-08	12	246 (44.3)	526	21	83	17
2008-09	9	628 (447.6)	4192	16	89	11
2009-10	3	132 (52.9)	221	38	100	0
2010-11	7	1287 (486.5)	8000	13	86	14

Table 15.4 Differences in juvenile dispersal (m) in Whitikau

COHORT	SAMPLE SIZE	AVERAGE DISPERSAL DISTANCE (SE)	GREATEST DISPERSAL DISTANCE	SMALLEST DISPERSAL DISTANCE	%THAT DISPERSED < 500M	% THAT DISPERSED ≥500M
1999-00	5	230 (106.8)	650	100	80	20
2000-01	1	800 (-)	800	800	0	100
2001-02	0	-	-	-	-	-
2002-03	6	1338 (374.6)	2979	509	0	100
2003-04	6	489 (139.8)	1075	166	67	33
2004-05	9	615 (253.8)	2295	14	67	33
2005-06	9	265 (120.6)	1198	49	89	11
2006-07	6	592 (241.7)	2044	224	83	17
2007-08	5	321 (137.1)	756	35	60	40
2008-09	5	723 (363.5)	2124	154	60	40
2009-10	4	410 (155.4)	793	140	50	50
2010-11	8	404 (143.0)	1800	47	75	25

Appendix 16: Weather and climate

Information on the weather, including rainfall and minimum and maximum air temperatures in Motu, was collected from January 2004 to December 2011. The purpose of collecting this information was to have it available for building potential relationships between weka survival rates and weather conditions. Rainfall, temperatures and weka survival rates were steady over the period that records were kept with no large variations and no analysis was carried out.

Rain

The rain gauge was located in Motu at grid reference 107 177. Rainfall was recorded weekly from January 2004 to December 2011.

Table 16.1 Monthly rainfall (mm) from January 2004 to June 2011

MONTH	2004	2005	2006	2007	2008	2009	2010	2011
January	67	30	157	169	69	61	249	386
February	226	59	96	17	38	191	35	25
March	84	199	204	151	102	57	67	210
April	69	25	212	84	213	60	82	192
May	247	234	180	80	203	217	244	447
June	343	192	359	191	165	259	340	270
July	250	194	203	259	327	290	177	196
August	196	112	255	150	290	260	449	76
September	124	185	97	156	182	242	280	92
October	216	269	179	246	195	291	223	246
November	127	234	227	50	139	54	34	101
December	215	156	277	172	101	67	200	226
TOTAL	2164	1889	2446	1725	2024	2049	2380	2467

Air temperature

Minimum and maximum air temperatures were measured at Motu at grid reference 107 177. Temperatures were recorded weekly from January 2004 to December 2011. The thermometer was located on the outside wall of a building and was always in the shade. Frosts of up to -6°C and highs of and exceeding 30°C were commonly recorded by locals living nearby. The position of the thermometer used for these recordings meant that these extremes were not recorded.

Minimum air temperatures

The table below shows the average weekly minimum temperatures for each month (°C) in Motu from January 2004 to December 2011. The top number in each cell is the average temperature for that month. The range of temperatures recorded that month is shown underneath.

Table 16.2 Average weekly minimum temperatures (°C) for each month in Motu from January 2004 to December 2011

MONTH	2004	2005	2006	2007	2008	2009	2010	2011
January	7.75 5-10	9	8.5 6-12	8.25 6-11	7.5 5-9	8 6-10	9 6-13	11.5 8-18
February	7.5 5-11	7	9.25 5-13	7.25 5-8	7.5 7-9	9.25 8-11	9.5 6-12	11.75 11-12
March	5.5 3-7	9	5.5 2-10	7.75 6-11	8.5 7-10	3.25 1-6	7 2-12	8.25 5-11
April	0.75 -2-4	2	4.75 3-10	3.25 1-6	4.5 3-5	1.5 -2-6	4.5 0-9	5 1-12
May	2.5 -1-5	3	0.5 -1-4	2.5 1-4	0 -2-5	-2.75 -6--1	2.5 -1-7	-4.75 -1-11
June	-4.5 -6--2	-3	-2 -4-1	-1.25 -3-1	-2.25 -4-1	-3.25 -5--2	0 -3-2	1 0-3
July	-2.75 -5--1	-0.75 -3-1	1.25 -4-4	-1.5 -3-3	-1.5 -5-1	-0.75 -2-1	-0.5 -2-2	-0.25 -3-2
August	-2 -4-3	-2.25 0--5	-1 -5-4	0.25 -1-2	-1.5 -4-0	-0.25 -5-5	0.75 -3-2	-0.75 -3-2
September	-2 -3--1	1.5 -2-7	0.5 -2-3	1 -3-6	1.25 0-2	2.25 2-3	3 -2-5	0.5 0-2
October	4	3.75 2-5	0 -2-3	1.75 -2-7	1 1-1	2.25 1-3	4.25 1-7	4.75 2-8
November	3	4.75 3-7	4 0-8	4 1-6	4.75 1-9	5 2-8	4.5 2-10	6 4-8
December	1	9.5 5-13	4.5 3-7	8.25 5-11	7.5 6-9	7.25 7-8	10 8-13	9.5 7-11

Maximum air temperatures

Table 16.3 Average weekly maximum temperatures (°C) for each month in Motu from January 2004 to December 2011

MONTH	2004	2005	2006	2007	2008	2009	2010	2011
January	25.75 23-28	26	24.25 23-26	24.25 23-26	25.25 23-27	25.25 24-27	24.5 22-27	27.5 24-29
February	22.25 21-23	27	23 21-24	23.5 22-25	24.5 23-26	25 22-28	25.25 23-26	28 25-31
March	22.25 20-25	23	21.25 21-22	23 22-24	21.75 21-23	21.25 20-22	24.75 24-25	22.75 22-24
April	18.75 16-22	28	20 19-21	19.75 18-22	20.25 18-25	19.25 18-23	20.25 20-21	18.5 16-20
May	17.25 15-19	17	16.5 15-19	21.25 19-25	17.25 14-20	18.25 17-20	16 14-19	16.75 15-19
June	14.25 13-15	13	17.75 15-20	15.5 12-20	16.5 13-18	12.25 10-16	10.5 6-14	14.25 12-17
July	11.75 10-13	13 12-15	19.25 15-23	14.75 14-17	16 13 -19	12.75 12-14	11 9-13	12.25 10-14
August	12 10-13	13.75 12-15	15.25 14-17	14.5 14-16	14.5 14-15	14.5 12-16	13 7-16	14.5 11-19
September	14.25 12-16	17.75 17-20	18.75 15-24	17.75 17-18	16.75 15-19	17.25 15-19	17.25 15-21	15.75 15-17
October	20	18.25 15-21	21.5 19-26	18 17-20	17.5 17-18	18 17-19	20 19-21	21.25 19-23
November	24	21.25 19-24	19.5 18-21	22 19-25	20.25 19-22	23.25 19-30	23 21-26	22.75 21-24
December	24	23.5 21-26	23.25 20-25	22.5 22-24	23.75 23-24	25.5 19-29	27 25-30	21.5 21-23

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References

Bassett, A (1996) New Threatened Species Funding, North Island Weka Management – Toatoa, East Coast Conservancy 1996. On file, Motu FC.

Beauchamp, AJ (1987) A population study of the weka (*Gallirallus australis*) on Kapiti Island, Unpubl PhD thesis, Victoria University, Wellington.

Beauchamp AJ, Butler D, King D (1999) Weka (*Gallirallus australis*) Recovery Plan 1999-2009. Threatened Species Recovery Plan 29, Department of Conservation, Wellington.

Beauchamp AJ, Hanbury J, Hanbury R (2009) Changes in the population size of North Island weka (*Gallirallus australis greyi*) during establishment on Pakatoa Island, Hauraki Gulf, New Zealand. Notornis 56(3):124-133.

Bramley, G (1994) The autecology and conservation of North Island weka, Unpubl MSc thesis, Massey University, Palmerston North.

Gillies C, Williams D: Using tracking tunnels to monitor rodents and mustelids (OLDDM-118330), Department of Conservation.

Glaser A, (2008) Takaputahi and Te Waiiti Environmental Enhancement Whio Monitoring Summary Report, April 2002 to June 2008 (DOCDM-321476).

Griffin, J (2004) North Island Weka Strategy (2004-2009), Department of Conservation, Gisborne.

Hitchmough R, (2002) New Zealand Threat Classification System Lists, Threatened Species Occasional Publication 23, Department of Conservation, Wellington.

Hitchmough R, Bull, Cromarty (2007) New Zealand Threat Classification System lists 2005, Department of Conservation, Wellington.

Joyce S, (1996) Rakauroa Call Count Results (1991-1996) held at Motu Field Centre.

Kemp F, (2001-2) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2002-3) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2003-4) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2004-5) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2005-6) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2006) Minutes of Annual Weka Meeting 2006

Kemp F, (2006-7) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2008) Rakauroa Call Count Results Summary, Motu Field Centre.

Kemp F, (2007-8) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2008-9) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2009-10) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2010-11) North Island Weka Project Annual Report, Motu Field Centre.

Kemp F, (2011-12) North Island Weka Project Annual Report, Motu Field Centre.

King, C.M.; O'Donnell, C.F.J.; Phillipson, S.M. (1994) Monitoring and control of mustelids on conservation lands. Part 2. Field and workshop guide Department of Conservation Technical Series, No. 4. Department of Conservation, Wellington, New Zealand.

Sawyer S, (1998) North Island Weka Project 1997-1998 Annual Report, Department of Conservation, Gisborne Area Office.

Sawyer S, (1999) North Island Weka Recovery Project, Motu, September 1999. Department of Conservation, Gisborne Area Office.

Sawyer S, (2000) North Island Weka Project, May 2000, Department of Conservation, Gisborne.

Sawyer S, (2000) North Island Weka Project Annual Report 1999-2000 Breeding Season. Department of Conservation, Gisborne.

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