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Low-cost aerial poisoning IV: Modified broadcast sowing, Hauhungaroa 2013

TBfree New Zealand
R-10710 & R-10743

Low-cost aerial poisoning IV: Modified broadcast sowing, Hauhungaroa 2013

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Summary

Project and Client

- The relative efficacy of full vs partial coverage of control areas with aerial-broadcast 1080 bait against possums and rats was compared and differences in bird counts measured in a field trial in the western Hauhungaroa Range conducted by Landcare Research for TBfree New Zealand from April to November 2013.

Objectives

Determine the efficacy and impacts of aerial-broadcast 1080 baiting in two partial-coverage, two full coverage, and two unpoisoned blocks by;

- Comparing possum and rat abundance indices before and after control as measured using 7-day chewcard (CCI$_7$) and (rats only) 1-night tracking tunnel (TTI) indices.
- Comparing bird abundance indices before and immediately after control measured using five-minute bird counts.

Results

- Possum abundance (CCI$_7$) before control was much higher in one of the full-coverage blocks (AS2 E) than elsewhere and equated to a trap catch index (TCI) of 4% (assuming a 6:1 CCI:TCI ratio). The TCI after control was 0.5%, indicating an 88.3% reduction in possum abundance in that block. No possums were detected after control in the other three poisoned blocks, suggesting high reductions in those blocks. Of the 27 possums found dead during post-poison monitoring, 16 were in AS2 E, consistent with the higher CCI$_7$ recorded there. No possums were detected before or after control in one of the unpoisoned blocks, and the CCI$_7$ remained unchanged in the other.
- Rat numbers were extremely high before control, with CCI$_7$s exceeding 95% in all six blocks. There was no reduction in CCI$_7$s in the unpoisoned blocks after control. In contrast, near total reductions were recorded in the two full-coverage blocks, with chewcard detections recorded on only one of 32 transects. In the partial-coverage blocks there were lesser (but still large) reductions. These were not spatially uniform: there were 100% reductions in CCIs on 20 transects, partial reductions on 8, and no reduction (from 100% CCI$_7$s) on 4 transects. The pattern of post-control detection from tracking tunnels was almost identical to post-control CCI$_7$ detections.
- A total of 16 529 birds from 38 species were recorded in the surveys, the 10 most common (comprising 88% of the total) being silvereye, whitehead, tomtit, tūī, bellbird, grey warbler, robin, rifleman, kererū and fantail. Overall-counts were almost a quarter lower post- than pre-poisoning, but a 39% decline in one unpoisoned block suggests the overall declines were unrelated to the poisoning. There were no consistent changes within species in relation to poisoning treatment except that blackbirds declined in all poisoned blocks but not in the unpoisoned blocks.
- After control 15 birds were found dead (1 tūī, 3 kererū, 11 blackbirds). Most carcasses were too degraded for 1080 residue analysis but the tūī, 2 kererū and 2 blackbirds were

analysed. No 1080 was detected in the native species but it was present in both the blackbirds.

- Our counts for the 18 most common bird species in May 2013 showed a strong similarity to the historical community composition of Pureora Forest Park indicated by bird counts in 1978–81.

Discussion

- The pre-control chewcard surveys in AS2 E confirmed that a previous poisoning in 2011 had been an operational failure. The reduction in 2013 to levels equivalent to an RTCI of c. 0.5% exceeded the <2% RTCI target usually applied by TBfree New Zealand. However, this reduction was not as low as expected from a dual-prefed operation. In contrast, the total reduction in CCI_7 in AS2 W and AS4 suggests that combining either full or partial coverage with dual prefeeding could be highly effective against already-low possum densities.
- The full-coverage blocks results showed that with dual prefeeding and full coverage, 80 baits per hectare were sufficient to deliver near total kills at 7–9 rats/ha. In the two partial-coverage blocks, near total saturation of the abundance indices suggest densities in those blocks were higher than 10/ha, possibly much higher. We speculate that localised very high numbers of rats in those two blocks may have led to bait depletion, leaving some rats unable to find bait, and, further, that bait depletion may have been exacerbated by higher than usual bait caching by rats as a result of increased food competition at very high densities.
- There was no evidence of any major overall decline in the bird counts that could be clearly attributed to non-target mortality from the 1080 operation. For almost all species for which counts declined substantially, similar or larger declines occurred in either one or both of the unpoisoned blocks. However, we recorded the largest declines in blackbird counts in poisoned areas, and 2–4 dead blackbirds (some containing 1080) in each poisoned block, but none in the unpoisoned block, suggesting that a modest proportion of that species were killed.

Recommendations

- Further trials should be conducted to assess the efficacy of partial-coverage broadcast baiting for ‘maintenance’ control of possum populations that are already low. This trial indicates some promise for this technique, but only from a single block.
- Where rat densities are extremely high (>90% one-night Tracking Tunnel Index in parts of the target area) bait densities higher than in this study should be used to ensure sufficient bait for all rats present. For areas with very low possum density but high rat density, this could be achieved by sowing 1–2 kg/ha of 6–8-g 1080 baits.
- TBfree New Zealand should commission field research to determine whether or not caching of 1080 baits by rats occurs more commonly than indicated by previous research when rat density (and therefore competition for food between them) is very high.

1 Introduction

This report spans two projects (R-10710 *Low-cost aerial poisoning* and R-10743 *Deer repellent and cluster sowing effect on non-target species during aerial 1080 poisoning*) and summarises field trials conducted in 2013. These projects aimed to compare outcomes under 'best practice' aerial 1080 poisoning in which the whole operational area is baited (full coverage) with those achieved by a lower-cost variant in which parts of the area are left unbaited (partial coverage). Effects of these two baiting regimes on abundance were compared firstly for the target rats and possums and secondly for non-target birds.

The relative efficacy of full vs partial coverage of control areas with aerial-broadcast 1080 bait against possums and rats was compared and differences in bird counts measured in a field trial in the western Hauhungaroa Range conducted by Landcare Research for TBfree New Zealand from April to November 2013.

2 Background

The aerial control operations were conducted in parts of the western Hauhungaroa Range (Appendix 1), for two reasons. In the AS2 Vector Control Zone (VCZ) – a 2011 poisoning operation had failed to reduce possum abundance in the eastern part of the zone (AS2 E, Appendix 1) to the desired operational target (Nugent et al. 2012), so TBfree New Zealand scheduled additional control. In two VCZs to the south of AS2 – AS4 and AS6 N – poisoning was undertaken primarily to reduce rat numbers to low levels, as part of a third project (R-10753 *Maintaining low possum and rat densities*). That ongoing project aims to determine whether high frequency (biennial) low-cost aerial baiting results in lower average annual densities of rats (and therefore reduced bird predation) than does aerial baiting at the 5-year intervals usually implemented for TB-possum control using 1080 aerial baiting. The experimental design for R-10753 compares annual measures of possum, rat, and bird abundance in the AS4 and AS6 N VCZs and a further two VCZs (AS6 S and Tihoi 3B; Appendix 1) that were aerially poisoned in 2011 but not in 2013.

The specifications for the two aerial-broadcast baiting regimes implemented in 2013 for R-10710 and R-10753 were decided in consultation with TBfree New Zealand operational staff, and were more similar than originally anticipated (i.e. R-10710 had originally proposed that some form of ultra-low-cost strip or cluster sowing would be used as the high-frequency control treatment). The aim here was therefore to assess whether the cost of broadcast baiting could be reduced by leaving some part of the area unbaited, as a result of the baited swaths being narrower than the distance between between the flight paths. At present, during broadcast baiting, operators typically match flight path spacing to the width of the baited swaths, ensuring completely coverage. However, possum range over tens or hundreds of meters each night (Yockney et al 2013), so would encounter bait even if there were narrow unbaited strips between the swaths. Leaving such gaps would reduce the average amount and cost of bait used and flying required per hectare.

Although possum numbers in the AS2 VCZ after control in 2011 were considered higher than desirable (the Residual Trap-Catch Indices (RTCI; NPCA 2011) recorded 6–8 months after control were 2.5% ± 1.4% (95% CI) for AS2 E and 1.3% ± 1.1% for AS2 W; Nugent et al. 2012) they were still low relative to the levels likely to have prevailed before control (RTCI >

20%; Coleman et al. 2000). In contrast, in the AS4 and AS6 N VCZ, possums were at very low density (RTCI 0.0% and 0.2% ± 0.5% respectively) making it unlikely the effect of the 2013 operation on possums could be usefully measured.

3 Objectives

Determine the efficacy and impacts of aerial-broadcast 1080 baiting in two partial-coverage, two full coverage, and two unpoisoned blocks by;

- Comparing possum and rat abundance indices before and after control as measured using 7-day chewcard (CCI_7) and (rats only) 1-night tracking tunnel (TTI) indices.
- Comparing bird abundance indices before and immediately after control measured using five-minute bird counts.

4 Methods

4.1 Study areas and experimental treatments

Study areas

The four trial areas in the western Hauhungaroa Range (AS2 E, AS2 W, AS4, AS6 N; Appendix 1) were aerially poisoned in September 2013, with full-coverage broadcast baiting applied in AS2 E and W, and partial-coverage in AS4 and AS6 N. Pre-control assessment of possum, rat, and bird abundance was conducted 4–5 months before poisoning, and 2–7 weeks afterwards, in these four poisoned blocks and in two adjacent areas (AS6 S and Tihoi 3B) that had been poisoned in 2011. These study areas comprised mostly mixed podocarp–broadleaved forest with scattered rimu (*Dacrydium cupressinum*) and mataī (*Prumnopitys taxifolia*) over broadleaved canopies dominated by tawa (*Beilschmiedia tawa*). The baiting poison operations covered a total area of 15 355 ha with the size of the areas baited varying from 1580 to 5420 ha (Table 1).

Experimental treatments

The dual-prefed poisoning operation was managed by Epro and carried out in September and October 2013 as suitable weather windows occurred. Baiting was conducted using Iroquois and Squirrel helicopters (Heli Resources and Lakeview Helicopters). The two baiting regimes used as our experimental treatments are, for convenience, designated as ‘full coverage’ and ‘partial coverage’ treatments. Both involved aerial-broadcast 1080 baiting with bait spread laterally (at different rates) from a helicopter flown along parallel flight paths 180 m apart, as follows (and see Table 1). Toxic baiting on the 1 October 2013 was followed by eight fine nights before 31.6 mm of rain was recorded on 9 October 2013.

- *Full-coverage broadcast baiting.* In study blocks AS2 E and W, dual prefeeds of non-toxic cereal bait (cinnamon-lured 6–8-g RS5 baits; Animal Control Products, Wanganui) were broadcast at 0.75 kg/ha 15 days apart, and were followed 14 days later by 0.15% 1080 cereal bait (cinnamon-lured 12-g RS5 baits) broadcast at 1.5 kg/ha, with no alignment of the prefeed and toxic bait flight paths. Flight path spacings (FPS) for prefeeding were 160 m but were 180 m for toxic baiting – the prefeed and toxic bait swath widths were assumed to be the same as the flight path spacing, so that the entire operational area was covered.

- *Partial-coverage broadcast baiting.* In study blocks AS4 and AS6 N dual prefeeds of non-toxic cereal baits (cinnamon-lured 2-g RS5 baits) were sown in 120-m-wide swaths at 0.5 kg/ha 16 days apart. The flight paths were 180 m apart, with those for the second prefeed being parallel to and halfway between those for the first prefeed, so that the entire study blocks were covered with prefeed at least once. Prefeeding was followed 13 days later by toxic baiting with 0.15% 1080 cereal bait (cinnamon-lured 6–8-g RS5 baits) sown in 140-m-wide swaths at 0.5 kg/ha. Toxic bait was sown along the flight paths used for the second prefeed leaving a 40-m strip between flight lines that was prefed but not covered with 1080 bait.

  The lower coverage, toxic sowing rate, and smaller bait size reflected the rat-control focus of this treatment, and the desire to demonstrate lower-cost control than full-coverage baiting. These differences in multiple operational parameters precluded any analysis of which factor(s) might cause any observed difference in the treatments.

4.2 Baiting regime effects on possums and rats

Chewcard (CCI; Sweetapple & Nugent 2011) and tracking tunnel indices (TTI; King & Edgar 1977; NPCA 2007) were used to assess operational efficacy in reducing possum and rat abundance. We used the same monitoring design and lines as used previously in 2011 and 2012 to assess the outcomes of the 2011 aerial baiting operations (Nugent et al. 2012). Each line comprised 10 chewcards alternating with 10 tracking tunnels with a spacing of 25 m between each device (total line length ~500 m). For logistic convenience, each set of four lines was arranged in a square ~700 × 700 m (Appendix 1), with one line positioned in the middle of each side of the square and with the ends of each line at least 200 m from other lines within the set.

Chewcards were baited with a mixture of peanut butter, icing sugar and ground lucerne (10:2:0.5; Sweetapple & Nugent 2011). The cards were nailed to tree trunks, 15–20 cm above the ground to allow easy access by rodents, with replacement cards subsequently being placed on different nearby trees.

Tracking tunnels, which had been in place since 2011, were baited with peanut butter smeared on the wooden blocks at each end and set with ‘Black Tracker’ tracking cards (Gotcha Traps, Warkworth) that were in place for one night during each monitoring session.

Table 1 Study blocks used for the Spring 2013 trials in the Hauhungaroa Range, showing the TBfree New Zealand acronym for the Vector Control Zone (VCZ) designation for the block (see Appendix 1 for locations), area, and treatment details. Also included are two blocks that were not poisoned in 2013 but had been in 2011 and were monitored in the same way as the poisoned blocks for comparison

Study block	Area (ha)	Sowing method	Prefeed (non-toxic RS5)				Toxic (0.15% 1080 RS5)			
			Flight path spacing (m)	Swath width (m)	Bait size (g)	Sowing rate (kg/ha)	Flight path spacing (m)	Swath width (m)	Bait size (g)	Sowing rate (kg/ha)
AS2 E	5420	Full coverage	160	160	6–8	0.75	180	180	12	1.5
AS2 W	5303	Full coverage	160	160	6–8	0.75	180	180	12	1.5
AS4	3052	Partial coverage	180	120	2	0.50	180	140	6–8	0.5
AS6 N	1580	Partial coverage	180	120	2	0.50	180	140	6–8	0.5
Tihoi 3B (T3B)	13 811	Unpoisoned	-	-	-	-	-	-	-	-
AS6 S	1820	Unpoisoned								

Chewcards and tracking cards were first deployed between 30 April and 10 May 2013. Approximately 7 days after deployment the chewcards were checked and replaced (to provide a 7-day Chewcard Index [CCI_7]) and the tracking cards were placed in the tracking tunnels at the same time. The tracking cards were then collected one day later to provide a standard one-night Tracking Tunnel Index (TTI_1) of rodent abundance.

Post-control monitoring was carried out between 19 October and 15 November 2013 (i.e. 3–7 weeks after baiting). Chewcards were checked and replaced ~170 days after the pre-control monitoring and then checked and removed 7 days later, with 170-day data being used to calculate a 'long-run' pre-control CCI [CCI_{170}]). Tracking tunnel cards were reinstalled and checked one day later as above.

Because the indices were sometimes very high (close to 1.0) the data were Poisson transformed in an effort to increase the linearity in the assumed relationship between the index and actual pest density; $tCCI = -\log_n (1-CCI)$ or $tTTI = -\log_n (1-TTI)$ where tCCI and tTTI are the transformed indices and CCI and TTI are the measured indices expressed as a proportion. The percentage reduction in the transformed indices was then assumed to be likely more accurately the actual reduction in pest density when the initial index was high. For example, the pre- and post-control TTIs for AS4 were 96.3% and 13.1% respectively, an 87% reduction in the untransformed index. The transformed indices however are 3.29 and 0.14, indicating a reduction in the transformed index of 96%.

4.3 Baiting regime effect on birds

Design

To ensure compatibility with the data collected in Project R-10753 *Maintaining low possum and rat densities* we again used the five-minute bird count technique (Dawson & Bull 1975), as was done in 2011 (Nugent et al. 2012), to determine whether there were any changes in abundance of common birds after 1080 baiting that might suggest significant mortality of non-target birds. Two replicates of each treatment (full and partial coverage) were compared. In an effort to account for seasonal changes in bird detectability not related to poisoning (i.e. changes in calling behaviour or visibility, or natural changes in abundance) we also collected five-minute bird count data from the two nearby unpoisoned areas (Table 1) that acted as an experimental control.

Field protocol

In each of the six study blocks, a series of parallel transects spaced 200 m apart was established (Appendix 2), and five-minute counts were made at count stations spaced at 200-m intervals along those transects. During each five-minute count, all birds seen or heard within 100 m of the stationary observer were recorded. As far as practicable, the same observers conducted both the pre- and post-control counts in each block. A count was conducted once at each station between 7 and 27 May 2013 (4–5 months before poisoning depending on the block), and again between 16 October and 3 November 2013, 2−5 weeks after poisoning depending on the block.

4.4 Mammals and birds found dead

Both before and after the poisoning, field staff recorded all mammals and birds found dead during the course of their fieldwork. No formal carcass searches were carried out but staff deliberately travelled different routes to and from monitoring lines to increase the chance of encountering carcasses. Dead birds that were not too decomposed were retained for 1080-residue analysis at the IANZ-accredited Landcare Research Toxicology Laboratory, Lincoln.

5 Results

5.1 Baiting regime effect on possums

As expected from monitoring in 2012 (Nugent et al. 2012), pre-control possum CCIs were much higher in AS2 E (23.7%) than in the other VCZs (0.0–9.4%) (Table 2). Unusually the CCIs recorded over the subsequent 170 days were similar to the 7-day indices, rather than markedly higher, possibly as a result of complete removal by rats of all the lure on the chewcards (Table 2).

No possums were detected before or after control in one of the unpoisoned blocks (AS6 S), and the CCI was unchanged in the other (T3B).

We used a 6:1 CCI:RTCI ratio (Nugent et al. 2012) to transform our CCI results to trap-catch indices. The CCI_7s for AS2 E equate to a pre-control TCI of 4% and a post-control RTCI of 0.5%, and indicated an 88.3% reduction in possum abundance (on the basis of the reduction in the Poisson-transformed CCIs). No possums were detected after control in the other three poisoned VCZs, suggesting 100% reductions in those blocks.

Table 2 Pre- and post-control Chewcard Indices recorded over 7 days (CCI_7) or 170 days (CCI_{170}), and the percentage reductions in Poisson-transformed CCI_7s, by poisoning treatment

	VCZ	Pre-control CCI_7 (%)	Pre-control CCI_{170} (%)	Post-control CCI_7 (%)	%reduction
		(a) Possum			
Full coverage	AS2 E	23.7	21.4	3.1	88.3
	AS2 W	9.4	7.5	0.0	100.0
Partial coverage	AS4	5.6	5.0	0.0	100.0
	AS6 N	0.6	1.2	0.0	100.0
No control	AS6 S	0.00	0.0	0.0	-
	T3B	1.9	3.1	1.9	0.6
		(b) Rats			
Full coverage	AS2 E	95.6	100.0	0.0	100.0
	AS2 W	98.1	100.0	3.7	99.0
Partial coverage	AS4	98.7	100.0	15.6	96.1
	AS6 N	99.4	100.0	36.9	90.0
No control	AS6 S	99.4	100.0	99.4	0.0
	T3B	98.8	100.0	100.0	0.0

5.2 Baiting regime effect on rats

Rat numbers were extremely high with CCI_7s exceeding 95% in all six blocks, and CCI_{170}s of 100% also recorded in all blocks (Table 2). There was no reduction in transformed CCI_{7s} in the unpoisoned blocks, but near total reductions in the two full-coverage blocks. The only six chewcard detections in AS2 were recorded on a single transect in AS2 W. There were lesser (but still large) reductions in the partial-coverage blocks.

The TTI_1s showed very similar results (Table 3). The reductions were not spatially uniform. Across both partial-coverage blocks there were 100% reductions in CCIs on 20 transects, partial reductions on 8 transects, and no reduction (from 100% CCI_7s) on 4 transects. The spatial pattern of post-control detection from tracking tunnels was almost identical to post-control chewcard detections.

Table 3 Pre- and post-control Tracking Tunnel Indices recorded over 1 night (TTI_1) and the percentage reductions in Poisson-transformed CCI_7s, by poisoning treatment

	VCZ	Pre-control TTI_1 (%)	Post-control TTI_1 (%)	% reduction
Full coverage	AS2 E	71.9	0.0	100.0
	AS2 W	91.3	0.0	100.0
Partial coverage	AS4	96.3	13.1	95.7
	AS6 N	94.4	28.1	88.5
No control	AS6 S	78.8	86.7	−30.3
	T3B	87.5	87.5	0.0

5.3 Baiting regime effect on birds

The pre- and post-control surveys counted 16 529 birds from 38 species (Appendix 3). Native species predominated (93% of the total). Silvereye, whitehead, tomtit, tūī, bellbird, grey warbler, robin, rifleman, kererū and fantail were, in order, the 10 most commonly counted native species, and comprised 88% of the birds counted. Chaffinch, blackbird, song thrush, and redpoll were, in order, the most commonly counted exotic species, comprising 6% of the total counted.

For some species, counts increased dramatically from zero or near-zero counts in May to much higher levels in October–November, most notably the migrant cuckoos and the song thrush (Table 4). Of the 16 most rarely heard species (those counted fewer than 50 times) four were recorded only in May, and six only in October–November. Overall counts were almost a quarter lower in October–November, largely reflecting the pattern for native species (Figure 1). The decline varied widely between blocks, but was largest (39%) in one of the unpoisoned blocks.

Table 4 Mean counts per station recorded during five-minute bird counts both before (Pre, May 2013) and after (Post, Oct.–Nov. 2013; shaded grey) aerial 1080 baiting in six blocks in the central Western Hauhungaroa Range. Blocks are arranged in three groups, according to '1080 treatment' (full-coverage, part coverage, or none, see Methods). The data for native species are shaded brown. Only the 20 most commonly counted species are shown), but all 38 species recorded are included in the total (ordered from highest to lowest total pre-control count)

	Full-coverage 1080				Partial-coverage 1080				No 1080				All blocks	
	AS2 E		AS2 W		AS4		AS6 N		AS6 S		T3B			
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Number of stations	179	179	179	180	180	180	136	140	180	181	159	179		
Silvereye	3.41	1.32	2.57	0.58	3.40	0.29	2.52	0.74	2.22	0.15	3.03	0.62	2.86	0.62
Whitehead	0.34	0.93	1.46	2.03	0.29	1.06	1.55	2.09	0.65	0.80	1.64	1.64	0.99	1.43
Tomtit	0.99	1.27	1.24	0.93	0.39	0.68	0.68	0.80	0.61	0.59	0.83	0.69	0.79	0.83
Bellbird	0.90	1.03	1.32	0.89	0.52	0.24	0.65	0.74	0.60	0.09	0.92	0.27	0.82	0.54
Tūī	1.17	0.77	1.30	1.16	0.42	0.44	0.55	0.25	0.89	0.11	0.99	0.06	0.89	0.47
Robin	0.23	0.31	0.82	0.82	0.44	0.92	0.72	1.17	0.43	0.58	0.68	0.48	0.55	0.71
Grey warbler	0.59	0.89	0.33	0.65	0.12	0.83	0.22	0.89	0.36	1.28	0.33	1.00	0.33	0.92
Rifleman	0.63	0.46	0.20	0.19	0.33	0.25	0.42	0.19	0.24	0.17	0.29	0.24	0.35	0.25
Kererū	0.47	0.16	0.63	0.16	0.11	0.05	0.29	0.10	0.53	0.05	0.34	0.07	0.40	0.10
Fantail	0.17	0.10	0.73	0.26	0.02	0.01	0.25	0.11	0.23	0.09	0.46	0.18	0.31	0.13
Chaffinch	0.17	0.26	0.09	0.24	0.10	0.14	0.07	0.29	0.13	0.13	0.12	0.11	0.11	0.20
Blackbird	0.34	0.19	0.25	0.09	0.09	0.13	0.23	0.11	0.09	0.07	0.18	0.06	0.20	0.11
Kākāriki	0.18	0.08	0.34	0.18	0.01	0.02	0.08	0.08	0.33	0.20	0.07	0.04	0.17	0.10
Song thrush	0.01	0.36	0.02	0.17	0.00	0.02	0.00	0.26	0.00	0.02	0.03	0.12	0.01	0.16
Long-tailedcuckoo	0.00	0.42	0.00	0.28	0.00	0.16	0.00	0.10	0.00	0.01	0.01	0.03	0.00	0.17
Redpoll	0.18	0.09	0.19	0.02	0.02	0.02	0.13	0.06	0.03	0.01	0.19	0.04	0.12	0.04
Kākā	0.02	0.06	0.04	0.03	0.00	0.00	0.02	0.01	0.30	0.23	0.03	0.01	0.07	0.06
Shining cuckoo	0.01	0.19	0.03	0.16	0.00	0.03	0.00	0.19	0.00	0.00	0.00	0.02	0.01	0.10
Goldfinch	0.12	0.00	0.08	0.02	0.02	0.00	0.04	0.01	0.03	0.02	0.07	0.02	0.06	0.01
Dunnock	0.01	0.14	0.02	0.05	0.01	0.00	0.00	0.02	0.01	0.01	0.00	0.04	0.01	0.04
Total	10.03	0.93	9.06	0.87	11.7	1.02	9.06	0.94	10.3	0.99	5.81	0.7	9.09	7.04

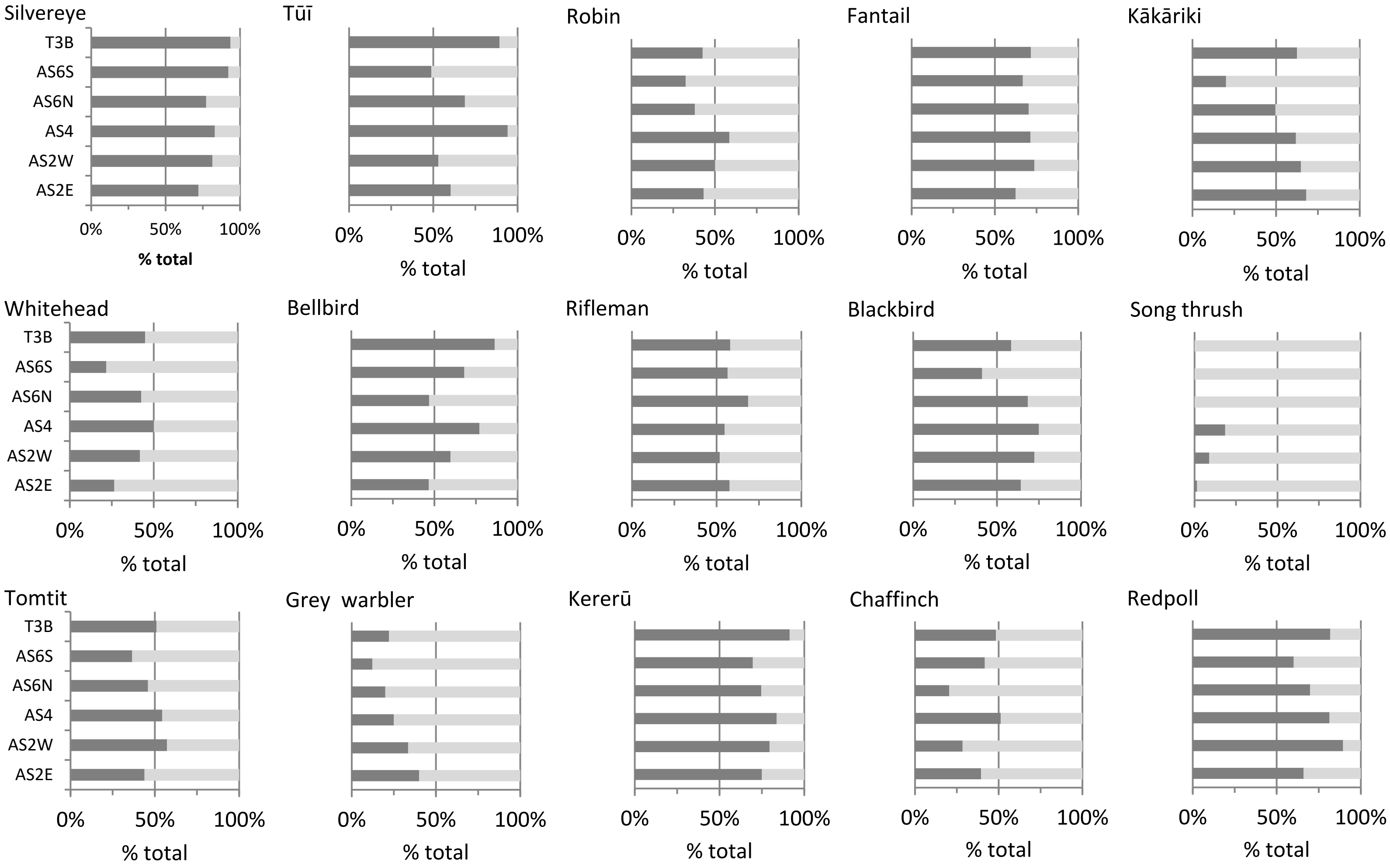

Figure 1 Relative changes between May and October–November 2013 in mean counts per station recorded during five-minute bird counts in the Hauhungaroa Range, with the dark and light bars representing the percentage of the total number of the species recorded in the specified block in May and October–November respectively. Dark bars >50% represent declines, and light bars increases. The top-most bars in each graph (T3B and AS6 S) represent unpoisoned blocks, the next two (AS6 N, AS4) represent blocks with partial-coverage 1080 baiting, and the bottom two (AS2 E, W) represent blocks with full-coverage 1080 baiting.

There was no consistent pattern of change between blocks across species. Excluding the 20 species that comprised less than 1% of the total count, and also those rarely heard in May, the 14 most common species were each ranked across blocks (i.e. from 1 to 6) in order of the magnitude of the change between May and October–November. The unpoisoned AS6 S and T3B blocks had the lowest and highest average ranks respectively, indicating that (averaged across species) they had the biggest and smallest changes respectively.

The changes were highly variable between species. Grey warbler counts increased in all blocks, with the smallest increases in the poisoned areas. Whitehead counts also increased, with the variation between unpoisoned areas matching that between poisoned areas. Robin and tomtit counts declined in one or two (respectively) of the poisoned blocks but otherwise were unchanged or increased.

Post-poisoning silvereye and kererū counts were lower in all blocks, but with particularly large declines in one or both of the unpoisoned blocks. Fantail and redpoll counts also declined in all blocks, with greater variation between blocks for redpolls, but no indication of a consistent smaller decline in the unpoisoned blocks. Tūī and bellbird counts declined in some blocks but not others, with the two greatest declines for both species in one poisoned block (AS4) and one unpoisoned block (T3B).

Only for blackbirds were the declines in the poisoned blocks larger than in the unpoisoned blocks. In the two unpoisoned blocks the mean blackbird count increased by 7%, but fell by 57% in the four poisoned blocks.

Comparison with counts conducted in part of Pureora Forest Park in 1978–81 (Figure 2) indicates an overall strong similarity to the composition of the current community of the 18 most common species in our May 2013 count. The relative abundance of 15 species was much the same, but two species (silvereye and whitehead) were counted more often in 2013 while grey warbler was counted far less often. The former two can form large difficult-to-count flocks, so the increase in the counts may simply be a technical artefact. The lower counts for grey warbler matched the lower counts Smith and Westbrooke (2004) report for counts conducted in two other parts of Pureora Forest Park in 1997–98. They also reported lower counts at that time for other small insectivores (fantail, rifleman, tomtit) but we did not.

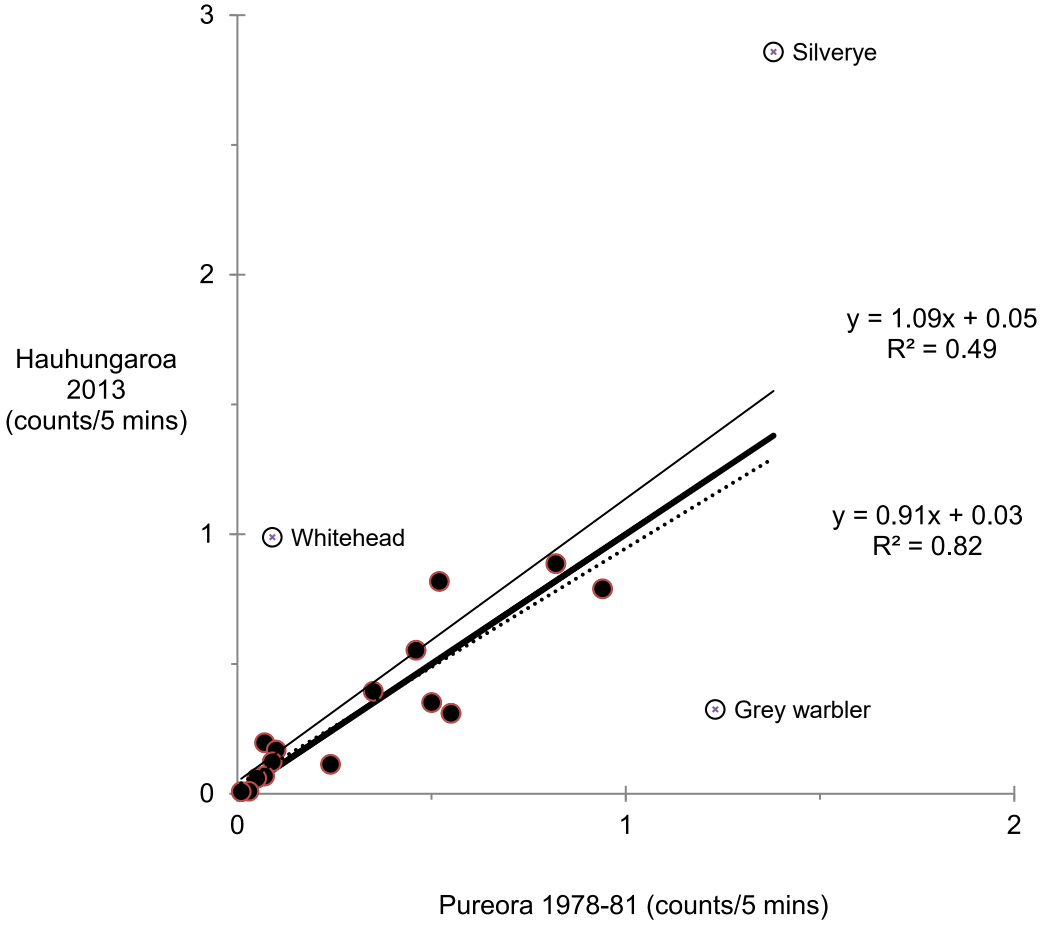

Figure 2 Comparison across species of mean five-minute bird counts from a survey conducted in Pureora Forest in 1978–81 (Smith & Westbrooke 2004) and the May 2013 counts from this study. Species with mean counts <0.01 in 1978–81 are excluded. The thick solid line indicates a 1:1 relationship between the two sets of counts, while the thin solid and dashed lines show the acutal relationships with, respectively, all 18 species included and with the three named outliers excluded.

5.4 Mammals and birds found dead

One dead deer was found in AS2 E before poisoning; the cause of death was not identified. After poisoning, 23 dead deer were found (10 in AS2 E, 2 in AS2 W, 4 in AS4, and 7 in AS6 N, and none in the two unpoisoned blocks). The state of decomposition suggested most had died around the time of the poison operation. Similar numbers were found dead in the full-coverage blocks (12) and partial-coverage blocks (11). Only one dead pig was found, after control, in AS2 E (full-coverage block).

Project staff found one dead kererū before poison baiting. It had obvious signs of predation and was not retained for 1080 analysis. After control 15 dead birds and 51 dead small mammals were found (Table 5). The latter were mostly possums (27) and rats (20), but there were three hedgehogs and one cat also. The birds were 11 blackbirds, 3 kererū, and 1 tūī. Of these, only five (2 kererū, 1 tūī and 2 blackbirds) were sufficiently intact for 1080 analysis. No 1080 residue was found in any of the three native birds, but 1080 was present in both the blackbirds at concentrations of 0.48–1.66 mg/kg (MDL = method detection limit of 0.001 mg/kg).

Table 5 Birds and small mammals found dead after aerial 1080 baiting, Hauhungaroa Range, Spring 2013. Observations were made during the course of other monitoring work.

	Poisoned				Unpoisoned	
VCZ	AS2 W	AS2 E	AS4	AS6 N	AS6 S	T3B
Possum	9	16	1	1	0	0
Rat	6	8	2	4	0	0
Hedgehog	0	3	0	0	0	0
Cat	0	1	0	0	0	0
Kererū	2	1	0	0	0	0
Blackbird	4	2	2	3	0	0
Tūi	1	0	0	0	0	0

During the course of this and related projects, a total of 18 deer and 11 pigs were killed and necropsied, mostly from AS2 (5 deer, 8 pigs) or the neighbouring AS3 (8 deer, 3 pigs) but also AS4 (4 deer) and AS6 N (1 deer). None had lesions typical of TB, and no *Mycobacterium bovis* bacilli have been detected in any of the 14 deer and 10 pigs for which the final results from tissue culture (sampled from retropharyngeal or submaxillary lymph nodes) are so far available.

6 Conclusions

6.1 Baiting regime effect on possums

The pre-control chewcard surveys confirmed that the 2011 operations had been least successful in the eastern part of AS2. Curiously, the 23.7% CCI_7 recorded there in Autumn 2013 was little different to that recorded in Spring 2011 (28.7%) or in early 2012 (22.0%) (Nugent et al. 2012). Given that rates of increase in this forest are high (Sweetapple & Nugent 2009), it appears that the 2011 estimate in particular may have been biased high by sampling error. If so, the poisoning operation was probably more successful than first thought (but clearly still less effective than desirable). Alternatively, the 2013 estimate may have been biased low by increase rat interference rates, but recent evidence from the Hauhungaroa indicates that is unlikely to be a major effect (P. Sweetapple, unpubl. data).

The post-control CCI_7 of 3.1% (equating to an RTCI of c. 0.5%) in AS2 E appears to be comfortably below the 2% RTCI target usually applied by TBfree New Zealand. However, for a dual-prefed operation, it was not as low as the 0.04% RTCI recorded by the very large dual-prefed operation conducted in the Hauhungaroa Range in 2005 (Coleman et al. 2007). The difference could reflect the lower 1080 sowing rate used than in 2005 (3–5 kg/ha vs 1.5 kg/ha respectively). However, that seems unlikely given that density: index calibrations for the Hauhungaroa Range (Nugent et al. 2014) suggest that a CCI_7 of about 24% equates to a density of 0.3 possums/ha), which at the sowing rate of 80 baits/ha would equate to over 200 baits per possum. Alternatively, it may reflect the presence of some bait- or toxin-shy survivors from the 2011 operation. The total reductions (to zero possums detected) in CCI_7 from 9.4% in AS2 W and 5.0% in AS4 suggest that combining dual prefeeding with either full or partial coverage can be highly effective against already-low possum densities.

6.2 Baiting regime effect on rats

Rat numbers were very high, especially in the two southern partial-coverage blocks. A close correlation between one-night TTIs and rat density at Kaharoa in the central North Island (Brown et al. 1996) suggests that densities in these blocks exceeded 10 rats/ha. With near-total saturation of the index in the two southern blocks, it is possible that densities in those blocks may have been much higher than that. The AS2 blocks indicate that with dual prefeeding, and full coverage, 80 baits/ha is sufficient to deliver near-total kills at 7–9 rats ha.

The much lower efficacy in the partial coverage blocks is puzzling. It could refect the smaller (6–8 g) baits used in those blocks than in AS2, but that seems unlikely given that even a 6-g bait contains much more than a lethal dose for rats. Also, if that were the explanation, survivors are likely to have been spread throughout the block. That logic also applies to the difference in coverage – if rats survived in the gaps between baited swaths, they would have occurred throughout the block, and not been highly clustered. Instead, the operation appeared to have been highly successful over about 70% of the combined area of both blocks (0% post-control TTI) and moderately successful (<40% post-control TTI) on a further 10% of the area, but appeared to have only a minor effect in the remaining 20% of the area.

The lines on which high numbers of rats were detected after control were highly clustered with those clusters spanning adjacent flight paths. That indicates that sowing failure due to some interruption in bait delivery is unlikely to have been the cause. By default, we speculate that the quantity of bait may have been insufficient at these sites – we have no way of knowing whether the density of rats at sites with one-night TTIs of >99% was much much higher than 10 rats/ha, but suggest that in places it may have been, given that in two of the eight clusters of four transects, every tunnel was visited by rats before control. One of these two had the worst outcome (87% TTI) after control. It is possible that partial coverage may have contibuted to the poor outcome, if some of the rats in the unbaited areas were slow to enter the baited areas and if rats in the baited areas cached some bait before dying. We have previously concluded that caching of toxic bait by rats was unlikely to be a major problem (Morriss et al. 2012), but perhaps at very high densities there may be more pressure on rats to protect food sources, and of course, the number of baits available per rat would be lower than usual.

6.3 Baiting regime effect on birds – abundance and mortality

There was no evidence of any major decline in the bird counts that could be clearly attributed to non-target mortality during the 1080 operation. Statisitical analysis was not required to support this inference, as simple inspection of the data indicated that for almost all species for which counts declined substantially, similar or larger declines occurred in either one or both of the the unpoisoned blocks (Figure 1). The same was broadly true for species for which the counts declined only modestly, or increased after control.

The large variation between blocks in the pre-post changes in bird counts preclude any conclusions in relation to whether a small proportion of some species may have been killed. Although for robin, tomtits, kākāriki, rifleman, and grey warbler the largest declines (or smallest increases) were in poisoned blocks, counts of these species increased overall or were little changed.

Only declines in blackbird counts were larger in all four poisoned blocks compared with both the unpoisoned blocks. That finding aligns with the recovery of 2–4 dead blackbirds in each poisoned block, but none in either of the unpoisoned blocks. Although the four native birds were found dead after poisoning were all in poisoned block, the three tested contained no 1080. Blackbirds comprised <3% of the total counts but 11 of the 15 birds found dead (with the two analysed both containing 1080). Unless blackbirds are many tens of times less conspicuous than the much more commonly counted species, our ability to find their carcasses (and those of other similarly small species such as rats) indicates that few birds of other species were killed.

7 Recommendations

- Further trials should be conducted to assess the efficacy of partial-coverage broadcast baiting for 'maintenance' control of possum populations that are already low. This trial indicates some promise for this technique, but only from a single block because no possums were detected before control in one of the two blocks studied.
- Where rat densities are extremely high (>90% one-night TTI in parts of the target area) bait densities higher than in this study should be used, to mitigate the possibility that there was insufficient bait in parts of our study area. In the context of areas such as AS4 and AS6 N (very low possum density, but high rat density) this could be achieved by sowing 1–2 kg/ha of 6–8-g 1080 baits.
- TBfree New Zealand should commission field research to determine whether or not caching of 1080 baits by rats occurs much more commonly than indicated by previous research when rat density (and therefore competition for food between them) is very high.

8 Acknowledgements

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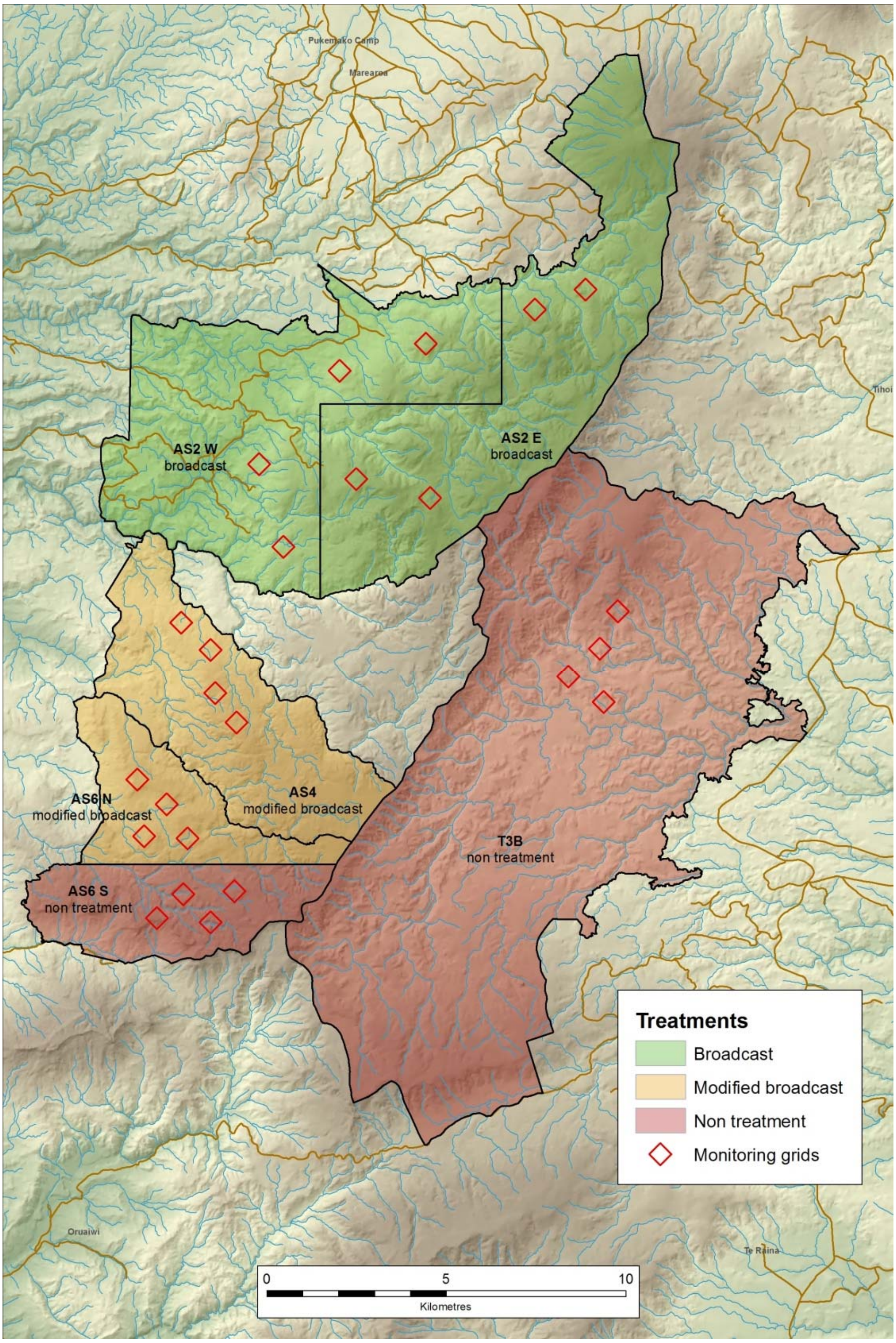
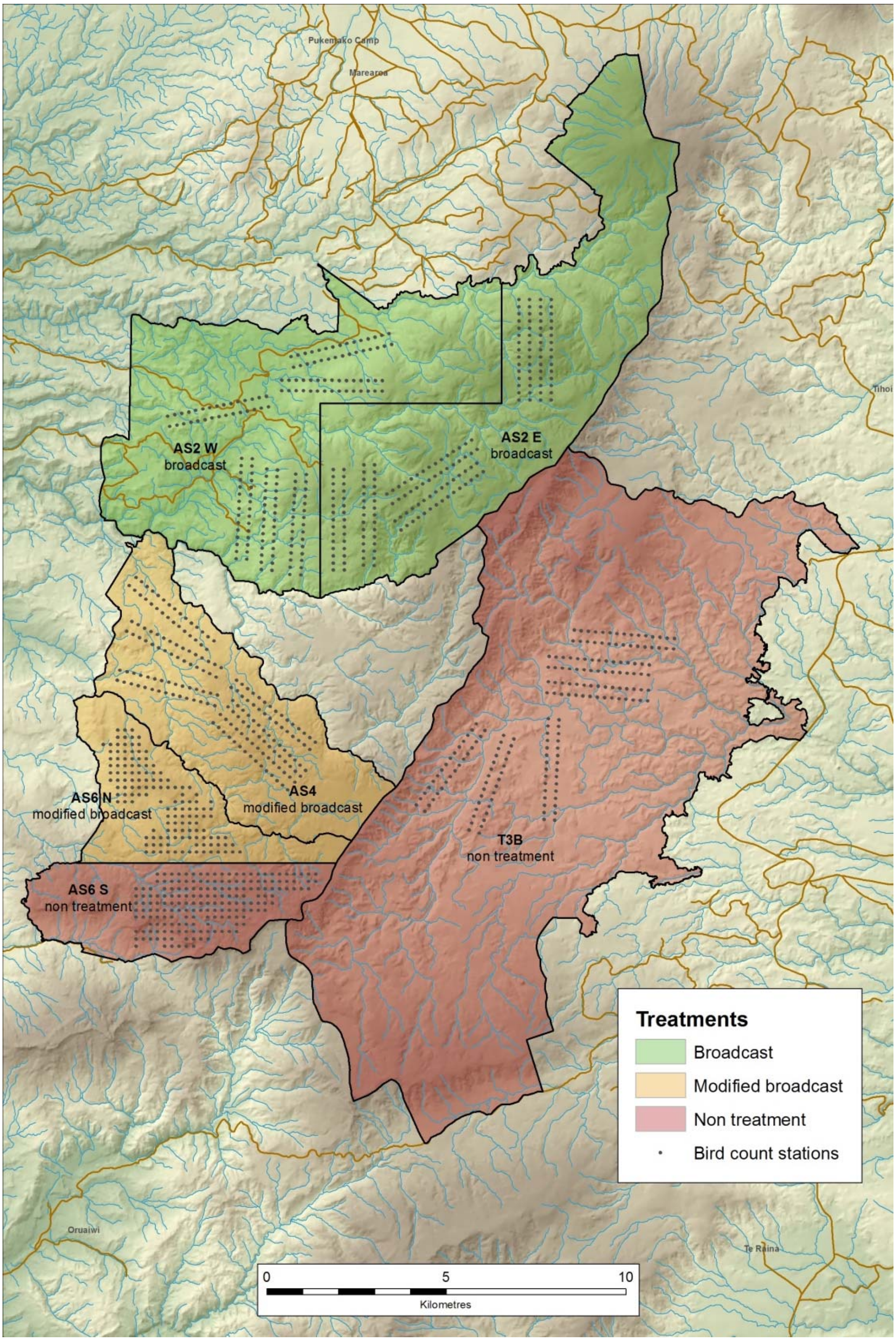
Appendix 1 – Study areas in the Hauhungaroa Range

Map of the six study blocks used in this project, showing the different aerial 1080 baiting treatments applied, and the chewcard and tracking tunnel grids ($n = 4$ per block) used to survey the blocks.



Appendix 2 – Bird count lines

Map of the study areas used to assess non-target impacts. As in Appendix 1, the various aerial 1080 baiting treatments are shown, along with the sites at which five-minute bird counts were conducted.



Appendix 3 – Bird count summary, Hauhungaroa Range, 2013

Total counts, by species (listed in descending order of percentage of total counts), recorded during five-minute bird counts before (Pre, May 2013) and after (Post, Oct.–Nov. 2013) treatment in six blocks in the central western Hauhungaroa Range. Blocks are arranged in three groups, according to '1080 treatment' (full coverage, part coverage, or none, see Methods). The data for native species are shaded brown.

	Full-coverage 1080				Part-coverage 1080				No 1080					
	AS2 E		AS2 W		AS4		AS6 N		AS6 S		T3B		Total	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	*N*	%
N stations	179	179	179	180	180	180	136	140	180	181	159	179	2052	
Silvereye	611	236	459	105	545	111	343	104	612	52	353	27	3559	21.5
Whitehead	60	166	261	365	296	295	210	293	53	192	104	144	2440	14.8
Tomtit	178	228	222	167	149	125	92	112	70	123	97	105	1669	10.1
Tūī	209	137	233	208	178	11	75	35	76	80	142	19	1403	8.5
Bellbird	161	184	235	160	165	49	88	103	93	44	95	17	1394	8.4
Grey warbler	106	159	58	117	60	180	30	124	21	150	58	229	1292	7.8
Robin	42	55	146	147	122	86	97	164	79	166	68	103	1276	7.7
Rifleman	113	83	36	34	52	43	57	27	59	46	38	31	620	3.8
Kererū	84	28	112	29	62	12	40	14	20	9	84	9	503	3.0
Fantail	30	18	131	47	82	33	34	15	4	2	36	16	448	2.7
Chaffinch	30	46	17	43	21	20	10	40	18	26	20	24	315	1.9
Blackbird	61	34	44	17	33	11	31	15	16	23	15	12	312	1.9
Kākāriki	32	15	60	33	13	8	10	11	1	4	52	35	275	1.7
Long-tailed cuckoo	0	75	0	50	1	5	0	14	0	29	0	1	175	1.1
Song thrush	1	64	3	31	5	22	0	37	0	4	0	4	171	1.0
Redpoll	33	17	34	4	35	8	18	8	4	3	4	1	169	1.0

Kākā	4	11	8	6	6	1	3	1	0	0	48	41	129	0.8
Shining cuckoo	1	34	5	29	0	3	0	26	0	6	0	0	104	0.6
Goldfinch	21	0	14	3	12	3	5	2	3	0	4	3	70	0.4
Dunnock	1	25	3	9	0	7	0	3	1	0	1	1	51	0.3
Greenfinch	1	0	0	0	0	1	0	0	11	5	0	3	21	0.1
Fernbird	0	0	0	0	0	3	1	2	2	9	0	0	17	0.1
Starling	9	0	1	0	4	0	0	0	0	0	0	1	15	0.1
Falcon	1	2	0	3	0	0	2	1	1	1	2	1	14	0.1
Magpie	0	0	2	8	2	0	0	0	0	1	0	0	13	0.1
Eastern rosella,	3	2	4	3	0	0	0	1	0	0	0	0	13	0.1
Kingfisher	0	2	0	4	0	1	0	2	0	0	0	2	11	0.1
Paradise shelduck	0	0	0	6	0	0	0	0	0	0	0	4	10	0.1
Spur-winged plover	0	0	10	0	0	0	0	0	0	0	0	0	10	0.1
Harrier	0	0	1	0	0	1	0	1	0	2	0	2	7	0.0
White-faced heron	0	0	0	0	0	2	0	2	0	0	0	0	4	0.0
Morepork	0	0	0	0	3	0	0	0	0	0	0	0	3	0.0
Pheasant	0	0	0	1	0	2	0	0	0	0	0	0	3	0.0
Turkey	1	0	0	0	2	0	0	0	0	0	0	0	3	0.0
Canada goose	0	0	0	0	0	0	0	0	0	1	0	0	1	0.0
House Sparrow	0	0	0	1	0	0	0	0	0	0	0	0	1	0.0%
Californian quail	0	0	1	0	0	0	0	0	0	0	0	0	1	0.0%
Yellowhammer	0	0	0	1	0	0	0	0	0	0	0	0	1	0.0%
Total	1793	1621	2104	1631	1848	1043	1150	1157	1147	978	1221	835	16529	