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THE FATE OF BIRDS AND SELECTED INVERTEBRATES DURING A 1080 OPERATION

by

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ABSTRACT

An aerial 1080 poison operation for possums at Waipoua Forest in spring 1990 applied cereal pellets lured with cinnamon. Numbers of brown kiwi, moreporks, fernbirds, kokako and common diurnal birds were monitored before, during and after the operation, while small numbers of insects and kauri snails were tested for 1080 uptake. Of the birds only blackbird and tomtit showed possible declines after the poisoning. Although some kiwi had consumed non-toxic baits, no 1080 related deaths were detected following the poison operation. Low concentrations of 1080 were found in the insects, but none of the kauri snails had detectable levels of 1080.

INTRODUCTION

During aerial 1080 operations for possum control in the 1960's and 1970's there was sometimes high mortality of non-target species of birds. Trials to determine safer baits showed that screening out fragments and using a green dye with a cinnamon lure all helped to lower mortality for most common bird species (Harrison 1978, Spurr 1979, Warren 1984, Calder and Deuss 1985).

The impact of 1080 on many species of animal however, including several in the previously unpoisoned Northland forests, remained uncertain. Thus, when a 1080 programme was planned for Waipoua in 1990 there was a need for some preliminary experimental work as well as monitoring before and after the poison operation. The area studied in shown in Figure 1.

The concerns addressed at Waipoua included:-

1. Brown kiwi *(Apteryx australis) :* The omnivorous diet of kiwi could lead to birds consuming 1080 pellets.

2. Morepork or ruru *(Ninox novaeseelandiae) :* This species feeds largely on rodents (which feed on 1080 baits and obtain lethal doses) and invertebrates (some of which are attracted to baits). Moreporks could, therefore, obtain quantities of 1080 via their prey (Spurr 1991).

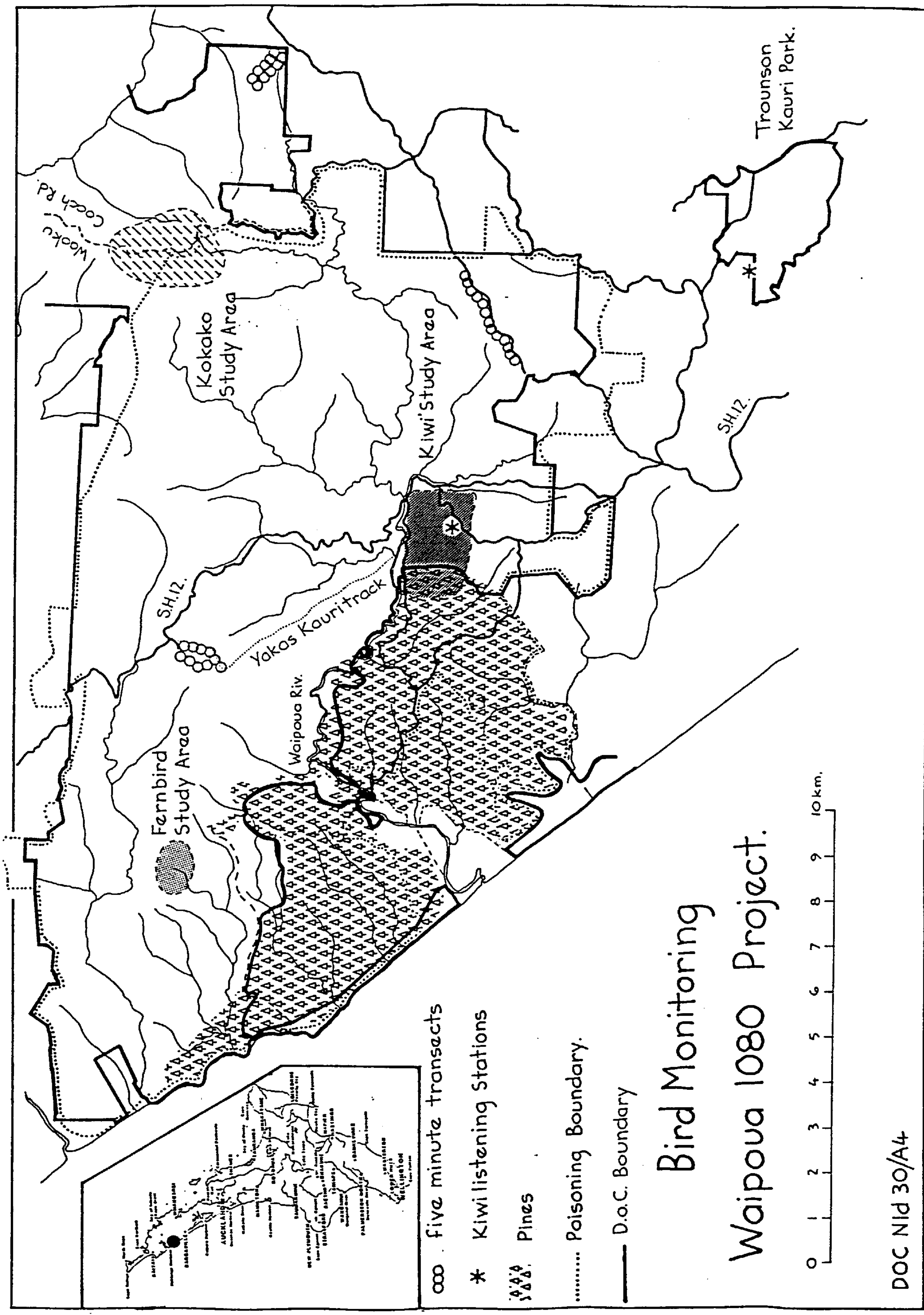

Figure 1. The study area.

3. Fernbird *(Bowdleria punctata) :* This insectivorous species could potentially suffer secondary poisoning.

4. Kokako *(Callaeas cinerea) :* This species was located in the eastern Waipoua forest (Mataraua plateau) by Wildlife Service staff in 1979 (P Anderson pers. comm.). In 1990 the population consisted of at least six pairs and five singles (P Montgomery in prep.). In six previous 1080 operations in the central North Island a total of 83 kokako have been monitored revealing low risk, but monitoring in kauri forest was a recommendation of these earlier studies (Innes in prep.).

5. Common forest birds : This was the first time an aerial 1080 operation had taken place in a Northland/kauri forest ecosystem. Kukupa *(Hemiphaga novaeseelandiae)* take some green fruit (the colour of the baits) while insectivorous birds could be susceptible to secondary poisoning.

6. Invertebrates : The fate of different invertebrates during 1080 operations has not been adequately researched. Limited work on kauri snails (carnivorous but a possible candidate for secondary poisoning) and insects (potential for direct or secondary poisoning) was carried out here.

Of these six groups, previous field testing of the effects of 1080 have been inadequate or non-existent for kiwi, morepork, fernbirds and kauri snails. Waipoua forest and other Northland forests are important habitats for all of these species and others such as NZ pigeon (Eadie et al. 1987). It was important, therefore, that adequate monitoring was in place in order to help assess undesirable impacts of this and future 1080 programmes in Northland.

METHODS

The Poison Operation

The 1080 pellets were cereal based (Wanganui No. 7) weighing an average of 8 grams with a toxicity of 0.08% w/w. They were dyed green and lured with cinnamon. Baits were scattered at an average density of 5kg/ha or 1 pellet/10m^2 by fixed wing aircraft and helicopter on 11 to 13 September 1990 (McKenzie in prep.).

Kiwi

During a trial of possum bait takes, rhodamine B dye was used in non-toxic, brown, cinnamon-lured Wanganui No. 7 baits in an area of 1km^2 near Waipoua lookout (McKenzie in prep.). For three weeks after this trial kiwi scats were collected from this trial area and examined under an ultraviolet lamp for presence of the dye.

Radio-transmitters (standard kiwi packages, R Colbourne pers. comm.) were placed on 7 kiwi which had been captured in nets or by using a trained "kiwi dog". Each transmitter was placed on the tibia and a numbered metal band covered in reflector tape was placed on the tarsus. The core home range areas were established and, for five birds (from three pairs) along the Waipoua Lookout Road, toxic baits were thrown into their core home ranges. For three birds this operation was repeated due to early rainfall (on the second night). Bait distribution simulated an actual 1080 drop with coverage at approximately 1 bait/10m^2. Birds were relocated to establish if they had survived.

These same birds were monitored following the 1080 operation in September, being relocated at approximately ten day intervals until December when transmitters were removed. Two transmitters fell off soon after the 1080 operation and an additional incubating male was found, bringing the number of post-poison monitored birds to six.

A larger sample of kiwi was monitored by call counts. Listening stations were operated from Waipoua lookout and at Trounson (control) before and after the poison operation. Calls were counted during the first hour of darkness following recommendations of the Kiwi Call Scheme (R Colbourne pers. comm.). We recorded sex of bird, compass direction of call, approximate distance, weather and moonlight. Four people carried out these counts, each with similar abilities to detect kiwi. We avoided windy nights which produced low counts.

Moreporks (Ruru)

Ruru were monitored during the kiwi counts at Waipoua lookout and Trounson. During the first and last ten minutes of each kiwi count we recorded the minimum number of ruru individuals heard calling. This provided an index of conspicuousness which was compared between the poison and control areas before and after the poison operation. A total of 19 counts was made, nine in the pre-poison period and ten in the post-poison period. Four listeners were used.

Fernbirds

Searches for fernbirds were carried out in several shrubland areas in Waipoua. Where birds were located three pre-poison visits were made. At three sites fernbirds were seen on all three visits so were used in the monitoring programme and visited again after poisoning. In addition two birds were caught and metal-banded to assist in identification of individuals.

Kokako

We used a simplified version of techniques established for monitoring kokako through 1080 operations which basically entails territory mapping and three roll calls before and after the poison operation (Speed et al. 1988, Innes in prep.). Our monitoring method involved partial territory mapping and one roll call before and after the poison operation. This design assumes that kokako have the same levels of conspicuousness before and after the 1080 operation and that the same individuals occupy the same -territories.

Six pairs and five individuals had been located in about 1000ha of eastern Waipoua forest on the Mataraua plateau before the poisoning (Montgomery et al in prep.). We decided to monitor the six pairs only because with pairs twice as many birds can be monitored with virtually the same amount of effort as with singles. In addition the ranges/territories of the pairs were better known than those of the singles. Post-poison roll calls occurred in the period 18 October 1990 to 9 November 1990.

Five Minute Bird Counts

The design and methods of the five minute bird counts were similar to those of earlier operations (eg. Spurr 1979). The count data provided an index of conspicuousness which was compared between two "poisoned" and one "control" transect, both before and after the poison operation. The percent change in conspicuousness is based on the formula:

% change	-(1-O/E)*100
Where O	observed post-treated mean
and E	(pre-treated/pre non-treated)*post non-treated mean

The two poisoned transects were -

(i) a circuit transect at the north end of Yakas track, and
(ii) a transect along Marlborough Road.

The control transect was in adjoining Mataraua forest 2km east of Waipoua forest and 12km from the nearest poison transect.

All three transects were on a gently rolling westward sloping plateau with underlying late tertiary basalt which weathered to a soft reddish brown clay, generally strongly leached, up to 30m deep (Department of Lands and Survey 1980, 1982). The transects were located at 300-360m asl (Yakas), 410-440m (Marlborough Road) and 500-530m (control), with corresponding increases in estimated annual rainfall - 2100-2400mm (Yakas) and 2500-2800mm (Marlborough Road and control).

Vegetation varied somewhat with the Yakas track being dominated by the canopy species totara, miro, rimu, northern rata, rewarewa, hinau, towai, kauri and tawari, with kauri grass and ferns on the forest floor. The Marlborough Road and control sites were dominated by rimu, northern rata, taraire and towai with the forest floor often moss and fern covered. All three blocks had the same common species of bird.

Each transect had ten stations set at 200m intervals. At each station all birds seen or heard during a five minute period were counted. Other variables which may have influenced the count (Appendix 1) were also noted. The transects and the stations were visited in the same order each day which lessened the number of variables. It also meant that the most exposed transect could be attempted first and so the suitability of weather for the day was quickly found. All counts occurred in fine weather between 0930 and 1630h which avoided changes in bird conspicuousness in early morning and late afternoon.

The counts occurred on ten days from 1 to 16 June 1990 (in the pre-poison period) and on ten days from 18 October to 4 November 1990 after the poisoning. Some preliminary counts identified the best control site (selected on the basis of similar composition of bird species) and enabled familiarity with local bird vocalisations. The wide gap between before and after assessments was a result of the poison operation being delayed by bad weather for three months.

The data were analysed by E Spurr of FRI. Two methods of analysis were used on the data:

1. The first method was standard repeated measures Analysis of Variance and Randomisation (ANOVA), looking specifically for a significant interaction between the pre and post-operation readings over the treated and non-treated transects. That is, is the before and after change different depending upon whether the transect was treated with poison or not? This method assumes parity in all regards other than treatment between compared transects.

2. The second method used a non-parametric randomisation test to see if the mean difference between the daily treated and non-treated differences pre and post-operation is greater than the random fluctuations that occur in the differences.

   The daily differences between treated and non-treated areas were calculated from the means of the ten stations in each area.

Invertebrates

Invertebrates were kept in eight 1 m^2 enclosures of chicken netting and hessian contained within a larger possum-proofed enclosure near Waipoua lookout. The floors of the 1m^2 enclosures were covered in litter, logs and vegetation.

Two kauri snails were placed in each of four enclosures and a variety of invertebrates, including bush weta, cave weta, centipedes, millipedes, beetles and cockroaches in the other four. Four toxic baits were placed in two of the kauri snail enclosures (two baits in each enclosure) and the remaining kauri snail enclosures were kept as controls. This treatment was repeated exactly for the other invertebrates, ie. two enclosures with toxic baits, two controls. The experiment ran for 14 days in June before all invertebrates that could be found were collected and frozen, before being despatched to FRI Christchurch where they were tested for 1080 residues. No weta were recovered at the end of the experiment and were assumed to have escaped. All insects were blended together including 3 centipedes, 3 millipedes, 4 cockroaches, 2 beetles, 12 termites, 3 red ants and 1 unidentified insect (C T Eason, G R Wright pers. comm.).

Weta counts at night were carried out during the hour long kiwi listening counts at Waipoua lookout and the control site (Trounson).

TABLE 1: Mean number and ratios of kiwi calls heard in treated (T) and control (C) areas.

Note: "Ratios" refers to ratio of calls between treated and control areas.

	PRE-POISON COUNTS				POISON	POST-POISON	
	18 May-13 June		29 Aug-10 Sept		11 Sept to 13 Sept	17 Oct-3 Nov	
Area	T	C	T	C		T	C
Means	28.1	13.9	9.3	15.0		23.7	7.2
Ratios	2.02	1	0.62	1		3.29	1

TABLE 2: Mean number and ratios of moreporks heard calling in treated (T) and control (C) areas.

	PRE-POISON COUNTS				POISON	POST-POISON	
	18 May-13 June		29 Aug-10 Sept		11 Sept to 13 Sept	17 Oct-3 Nov	
Area	T	C	T	C		T	C
Means	8.8	5.3	6.7	9.0		13.2	2.2
Ratios	1.66	1	0.74	1		6	1

TABLE 3A: Five minute bird count means (and standard errors) for 10 stations counted 8 times (counts 2-9) at Yakas Track, Waipoua Forest (transect 1) and Mataraua Forest (Transect 3).

	Yakas Track				Mataraua Forest			
	Pre		Post		Pre		Post	
Fantail	1.050	(0.188)	0.625	(0.049)	1.150	(0.119)	0.425	(0.090)
Grey warbler	1.163	(0.083)	2.263	(0.123)	1.025	(0.100)	2.763	(0.200)
Kukupa	0.188	(0.065)	0.125	(0.042)	0.275	(0.045)	0.100	(0.036)
Silvereye	4.213	(0.235)	0.663	(0.243)	6.438	(0.448)	0.675	(0.128)
Tit	1.475	(0.120)	1.175	(0.118)	1.575	(0.129)	2.188	(0.188)
Tui	0.450	(0.060)	1.788	(0.196)	0.250	(0.089)	0.863	(0.084)
Blackbird	0.350	(0.072)	0.225	(0.076)	0.488	(0.160)	1.013	(0.206)
E. rosella	0.425	(0.095)	1.263	(0.259)	0.275	(0.069)	1.000	(0.136)
Myna	0.125	(0.053)	0.350	(0.081)	0.138	(0.051)	0.163	(0.042)

RESULTS AND DISCUSSION

Kiwi

Results

Of 17 scats collected following the Rhodamine B trial, one contained much dye, one contained a little dye and 15 no dye at all. The two scats containing dye were collected 15 and 19 days respectively after the trial by which time surviving baits were soft and saturated with water. All baits were soft and wet through within 12 days of sowing. Several instances were found where kiwi had probed for food along paths but did not peck at or eat any of the baits which lay in their path.

The five transmittered kiwi which had toxic baits experimentally provided all survived. Following the full poison operation on 11-13 September 1990 five out of six bird survived to the late December cessation of monitoring. The sixth bird died near the Waipoua lookout. It had broken vertebrae which was consistent with the individual having been hit by a solid object, eg. a vehicle. After transmitters were removed (or fell off) in December one of these birds and an unbanded bird were also found dead on the Waipoua Lookout Road, their injuries consistent with having been killed by vehicles.

During the poison period Waipoua kiwi were nesting. Three of the four pairs monitored by radiotelemetry were found nesting and all three had their first nests fail due to egg disappearing (1 nest); egg infertile and deserted (1 nest), and one egg broken/one gone (1 nest). One of these pairs re-nested.

Kiwi call counts from Waipoua forest and Trounson (control) are given in Table 1. Before the poison operation twice as many kiwi calls were recorded in the poison versus the control blocks. This was not unexpected due to the greater listening coverage possible at the Waipoua forest site. Call rates were, however, several times lower at Waipoua immediately prior to the poison operation despite good listening conditions. After the poison drop call counts in the poisoned area were again at a high level (Table 1).

Discussion

The rhodamine experiment revealed that kiwi will sometimes consume all or part of Wanganui No. 7 pellets lured with cinnamon. It is not known whether the baits were consumed intentionally or inadvertently during probing, although the quantity of dye in one scat suggests the former in that case.

That no 1080-related mortality of kiwi was detected suggests that bait consumption, if it took place at all, was delayed until the bait was wet and largely detoxified (21 days after the poison operation the mean concentration of 1080 in baits was about 20% of the original concentration), and/or the birds took baits in insignificant quantities. LD50s of the kiwi are another unknown factor which may have contributed to the resistance of the Waipoua birds.

The vehicle-induced deaths may be exceptional. While some "road-kills" have been found in the past, mauling by dogs is the most common cause of death of Northland kiwi reported to the Department of Conservation.

Moreporks

Results

In the treated area the numbers of birds detected doubled after the poison operation but declined in the control area (Table 2). Two birds were found using a roost site beneath nikau fronds near Waipoua lookout in May 1990. Both birds survived experimental poisoning of their roost area and they survived the main 1080 operation.

Discussion

The post-poison increase in morepork detected in the poisoned area may reflect seasonal differences in conspicuousness but the decrease in the control was a surprise. The decline at the control site may be attributable in part to a 'new' listener being employed there at this time. It is not known if moreporks scavenge on 1080-killed animals as do some diurnal raptors, eg. harriers (Pierce and Maloney 1989).

Although high morepork numbers were maintained after this operation it is not clear what effects the poisoning may have had on their feeding behaviour and productivity. Recent studies have shown 95-100% reductions of ship rats through use of 1080 (Warburton 1989, J Innes pers. comm). In Waipoua too, rodent numbers declined to low levels immediately after the operation (R Pierce unpub. data). As rodents contribute significantly to morepork diet it is probable that the 1080 operation greatly altered their diet and possibly also productivity. These impacts are likely to be of limited duration however, due to high recolonisation/recovery rates of rats at least (J Innes pers. comm.; unpub. data).

Fernbirds

Results

All 14 fernbirds (including the two banded birds) were relocated five weeks after the 1080 operation.

TABLE 3B: Five minute bird count means (and standard errors) for 10 stations counted 10 times (counts 1-10) at Marlborough Road, Waipoua forest (transect 2) and Mataraua forest (transect 3).

	Marlborough Rd				Mataraua Forest			
	Pre		Post		Pre		Post	
Fantail	1.300	(0.060)	0.740	(0.098)	1.230	(0.093)	0.510	(0.102)
Grey warbler	1.140	(0.124)	2.890	(0.207)	1.120	(0.105)	2.750	(0.171)
Kukupa	0.260	(0.083)	0.240	(0.037)	0.270	(0.054)	0.110	(0.038)
Silvereye	6.090	(0.449)	1.350	(0.189)	6.700	(0.399)	0.700	(0.092)
Tit	1.720	(0.088)	2.010	(0.170)	1.650	(0.110)	2.220	(0.174)
Tui	0.350	(0.031)	1.620	(0.106)	0.270	(0.086)	0.890	(0.084)
Blackbird	0.280	(0.059)	0.520	(0.093)	0.490	(0.157)	1.070	(0.190)
E. rosella	0.290	(0.074)	0.480	(0.087)	0.230	(0.060)	0.990	(0.126)
Myna	0.320	(0.098)	0.360	(0.097)	0.160	(0.048)	0.190	(0.055)

TABLE 4: Percent changes in five minute bird count means from pre to post-poison, Waipoua 1990.

Transect 1 (Yakas)

	Pre-Poison		Post-Poison		% Change
	Yakas	Control	Yakas	Control	
Blackbird	0.350	0.488	0.225	1.013	-69.03
Fantail	1.050	1.150	0.625	0.425	61.06
Grey warbler	1.163	1.025	2.263	2.763	-27.81
Myna	0.125	0.138	0.350	0.163	137.06
Kukupa	0.188	0.275	0.125	0.100	82.85
Rosella	0.425	0.275	1.263	1.000	-18.28
Silvereye	4.213	6.438	0.663	0.675	50.10
Tit	1.475	1.575	1.175	2.188	-42.66
Tui	0.450	0.250	1.788	0.863	15.10

Transect 2 (Marlborough Rd)

	Pre-Poison		Post-Poison		% Change
	Yakas	Control	Yakas	Control	
Blackbird	0.280	0.490	0.520	1.070	-14.95
Fantail	1.300	1.230	0.740	0.510	37.29
Grey warbler	1.140	1.200	2.890	2.750	10.62
Myna	0.320	0.160	0.360	0.190	-5.26
Kukupa	0.260	0.270	0.240	0.110	126.57
Rosella	0.290	0.230	0.480	0.990	-61.55
Silvereye	6.090	6.700	1.350	0.700	112.17
Tit	1.720	1.650	2.010	2.220	-13.14
Tui	0.350	0.270	1.620	0.890	40.42

Discussion

The survival of all monitored fernbirds during this operation suggests that risk of secondary poisoning was not high under these conditions.

Kokako

Results

The poison operation covered 5.5 of the six kokako territories occupied by pairs. Five of the six pairs were relocated, both members of the pair being seen in each case. A further three single birds were seen after the poisoning although singles were not specifically roll called. One pair was not relocated after the poisoning.

Discussion

Kokako largely or totally survived the 1080 operation. The one pair that was not found after the poisoning was the least well known of all the local pairs. It had been followed once only prior to their roll call in the week before the poison operation. This pair least fitted the two basic assumptions for kokako monitoring (same levels of conspicuousness and occupy the same territories before and after) and probably should not have been included in the assessment. We feel that the most likely explanations for not relocating this pair are (in decreasing order of likelihood): utilising a different part of their territory, may be breeding (and therefore cryptic), may have died from poisoning or other causes, may in fact be the same as one of the other pairs of kokako.

Common Forest Birds

Results

Silvereye

ANOVA indicated a significant decrease in silvereye conspicuousness with time (pre to post-poison) in all three transects (Tables 3 and 4). There was also, however, a significant time/area interaction with the decrease in each of the treatment transects being significantly less than that in the non-treatment area. The results of the randomisation test agree with those of ANOVA for transect 1 v 3, but for 2 v 3 there was no significant difference (Table 5).

Tui

ANOVA indicated a significant increase in tui conspicuousness with time (pre to post-poison) overall. There was, however, a significant time/area interaction with the increases in both transects 1 and 2 being significantly greater than in transect 3 (non-treated control). The results of the randomisation test agree with those of ANOVA.

TABLE 5: P-values for time x area interaction from (A) Analysis of Variance and (R) Randomisation test.

Control vs

	Transect 1		Transect 2		Transects 1 & 2	
	A	R	A	R	A	R
Rosella	-	0.59	-	0.01	-	0.20
Kukupa	-	0.12	0.18	0.14	0.15	0.09
Grey warbler	0.004	0.05	0.65	0.54	0.48	0.19
Fantail	0.10	0.04	0.28	0.28	0.17	0.10
Tomtit	0.001	0.002	0.26	0.35	0.02	0.02
Silvereye	0.001	0.002	0.03	0.13	0.04	0.001
Blackbird	0.001	0.001	0.03	0.12	0.004	0.004
Tui	0.005	0.001	0.001	0.01	0.001	0.001
Myna	-	0.12	-	0.94	0.46	0.36

- = unable to test

TABLE 6: Mean number of weta heard per count in treated (T) and control (C) areas.

	PRE-POISON COUNTS				POISON	POST-POISON	
	18 May-13 June		29 Aug-10 Sept		11 Sept to 13 Sept	17 Oct-3 Nov	
Area	T	C	T	C		T	C
Means	0.9	0.0	0.0	0.0		2.7	1.4

Blackbird

ANOVA indicated a significant increase in blackbird conspicuousness with time. There was a significant time/area interaction with conspicuousness increasing in the non-treated area, but not in either of the treated areas (Tables 3 and 4). The results of the randomisation test agree with those of ANOVA for transect 1 v 3, but not for transect 2 v 3 for which there was no significant difference.

Tomtit

For transect 1 v 3 ANOVA indicated no change in tit conspicuousness with time overall. There was a significant time/area interaction, however, with a conspicuous decrease in the treated area, but an increase in the non-treated area. The results of the randomisation test agree with those of ANOVA.

For transect 2 v 3 ANOVA inidicated an increase in tit conspicuousness with time, but there was no significant time/area interaction. The results of the randomisation test agree with those of ANOVA.

Fantail

ANOVA indicated a significant decrease in fantail conspicuousness with time overall. There was no significant time/area interaction. The results of the randomisation tests agree with those of ANOVA for transect 2, but for transect 1 the decrease was significantly smaller (Table 5).

Grey warbler

ANOVA indicated a significant increase in grey warbler conspicuousness with time overall. There was no significant time/area interaction.

Kukupa

ANOVA indicated no significant difference in kukupa conspicuousness with time. There was a suggestion of increased conspicuousness on transect 2 (Tables 4 and 5) but this was not significant.

Eastern rosella

These were detected in increased numbers with time overall (Tables 4 and 5). Randomisation tests indicated that numbers recorded in transect 2 were less than expected.

Myna

Myna were detected in increased numbers with time overall (Tables 4 and 5). There was a suggestion of increased numbers in transect 1 but this was not significant.

Discussion

The causes of decreased detection of blackbirds in both treated areas (and tomtits in transect 1) are unknown but could be attributable to poisoning. Instances were found of blackbirds taking non-toxic red-dyed baits prior to the operation and peck marks on toxic baits were consistent with those of blackbird.

The lower than expected post-treatment conspicuousness of blackbirds and tomtits in transect 1 could also reflect other factors, eg. food supply or altitudinal shifts, transect 1 being the lowest of the transects (140-230m lower than transect 3).

Similarly it was not known whether silvereyes or tui (which were recorded in greater numbers than expected in the treatment areas after the operation) responded positively because of the effects of the possum poisoning. These and other species, eg. rosella and myna, are very mobile in the forest seasonally (R Pierce pers. obs.) and could have simply followed changed food availability or other seasonal habitat choice.

Invertebrates

Results

All invertebrates left in the enclosures, with the exception of one beetle, were alive when finally sampled. None of the kauri snails had detectable levels of 1080. A low concentration of 1080 was found in the insects (0.05-0.75mg 1080/g tissue).

Weta data from listening stations were of very limited use. Seasonal changes in weta activity and possibly the poorer control habitat prevented useful comparisons of weta abundance between the treated and control areas. More weta were heard in the treated area after the 1080 drop, however, indicating that substantial numbers had survived (Table 6).

Kauri snails of varying ages were also frequently encountered at night before and after the poison operation, but no attempt was made to quantify any changes.

Two mice (*Mus musculus*) were found dead in the enclosures and both contained significant levels of 1080 in their bodies.

Discussion

The enclosure experiments and nocturnal counts, however crude, produced no evidence of 1080 uptake in kauri snails and a small uptake in insects. Hutcheson (1989) found that captive weta can obtain lethal and sublethal amounts of 1080 by consuming pellets. It is not known, however, what impacts there may be on wild invertebrates. In order to assess this, intensive field monitoring of terrestrial species in particular is needed before and after 1080 operations. These data would then need to be balanced against the damage caused by possums and the depredations of rats, the effects of which are reduced by 1080 programmes.

CONCLUSIONS AND RECOMMENDATIONS

Species monitored during the Waipoua operation included brown kiwi, morepork, NZ pigeon, eastern rosella, fantail, tomtit, grey warbler, fernbird, blackbird, silvereye, tui, myna, kokako and kauri snail. Of these, only blackbird and tomtit (one transect) were recorded with lower than expected numbers in the treated area after the poison operation and these declines could have been attributable to poisoning. Both blackbirds and tomtits are multiple-brooded so have greater potential for rapid recovery than some of the species which were unaffected, especially in a rodent-depleted environment. Rats (important nest predators) were heavily depleted for most of the 1990-91 breeding season so blackbirds and tomtits should have quickly recovered in numbers.

Recommendations for further work are:-

1. For future 1080 operations in Northland forests we believe there is no need to closely monitor the common forest birds, with the possible exception of tomtit. Instead, rarer species should be researched and more emphasis placed on invertebrates, lizards and the breakdown of 1080 in soil.

2. Find conditions under which kiwi will consume baits and what levels of 1080 ingestion kiwi can survive unaffected.

3. Trials for kiwi acceptance of non-toxic lured baits should be carried out before all large-scale 1080 operations and kiwi monitored during 1080 applications until results and recommendations from 1. indicate that this is unnecessary.

4. Morepork numbers and diet should be examined during 1080 operations in other forests, especially those with high mouse densities.

5. Monitor invertebrate populations during 1080 operations to assess any changes in species composition and biomass. This includes surface and subsurface macro and micro-organisms including those living beneath decomposing baits.

6. Carry out bait and lure acceptance experiments on any sensitive invertebrates identified in 5.

7. Examine impacts of 1080 on rodents and predators and particularly on survival and behavioural shifts of mustelids and cats.

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REFERENCES

Montgomery P J, K Brown and N C Miller (in prep.) : A Survey for North Island Kokako in Eastern Waipoua-Mataraua Forests Plateau Region, Northland Spring 1990. Unpublished report, Northland Conservancy, Department of Conservation.

Calder B and F Deuss 1985 : The effect of 1080 poisoning on bird populations in Motere, Pureora Forest Park, Winter 1984. NZ Forest Service internal report, Auckland Conservation.

Department of Lands and Survey 1980 : New Zealand Land Inventory. Soils NZMS 290 sheet 006/07,1:100 000. P D Hasselberg, Government Printer, Wellington.

------1982: New Zealand Land Inventory, Rock Types, NZMS sheet 006/07, 1:100 000.

Eadie F M, B R Burns and J L Leathwick 1987 : Ecological Survey of Waipoua Forest Sanctuary and Kauri Management Areas. Department of Conservation, Auckland.

Harrison M 1978 : The use of poisons and their effect on bird life. In: Proceedings of the Seminar on the Takahe and its Habitat. pp. 203-221. Fiordland National Park Board, Invercargill.

Hutcheson J 1989 : Impact of 1080 on weta populations. Forest Research Institute report to Department of Conservation.

Innes G J (in prep.) : The impact of possum control on kokako populations. NZ Journal of Ecology.

Pierce R J, R F Maloney 1989 : Responses of harriers in the MacKenzie Basin to the abundance of rabbits. Notornis 36:1-12.

Speed H J, P M F Bradfield, P J Montgomery, D R King, G J Innes 1988 : The Monitoring of North Island Kokako during an Aerial 1080 Operation in the Cowan Wildlife Refuge and Ohakakura State Forest, Northern King Country. Unpublished Report, Department of Conservation, Te Kuiti.

Spurr E B 1979 : Assessment of the impact of 1080 poisoning on bird populations. Paper given at ANZAAS, January 1979. Forest Research Institute.

Spurr E B 1991 : Effects of brushtail possum control operations on non-target bird populations. Proceedings of 20th International Ornithological Congress : 2534-2545.

Warburton B 1989 : The effect of a routine aerial 1080 poison operation on rat numbers. (Report prepared for Department of Conservation) Forest Research Institute, Christchurch.

Warren A 1984 : The effects of 1080 poisoning on bird populations in Tihoi, Pureora State Forest Park, Winter 1983. New Zealand Forest Service Interest Report, Auckland Conservancy.