5. Discussion

An aerial 1080 operation using carrot baits over the entire Waihaha Ecological Area was carried out between 21 July and 12 August 1994. Results show that none of the 20 kaka and 18 blue ducks monitored throughout possum control operations in this area were directly affected by 1080. However, these results must be interpreted cautiously. It is possible that a small number of kaka deaths may have occurred and not been detected within the sample of 20 radio-tagged birds (less than a 50% chance of picking up a 3% kill rate — see 3.2.1). There is also significant potential for increased predation linked to a predator prey switch to still occur and impact on both the populations of kaka and blue duck.

The possibility of mortality escaping detection and the impact of indirect affects on kaka and blue duck populations are discussed below.

5.1 CARROT BAITS AND THE POTENTIAL FOR NON-TARGET SPECIES DEATHS

The potential for non-target species deaths is dependent on the physical characteristics and distribution of the baits within the environment as well as the foraging behaviours of the species themselves. The aquatic habitat of blue ducks and the very high dilution of 1080 in such an environment, suggests they are unlikely to be directly affected by 1080 delivered by carrot baits unlike kaka and other non-target species.

Features common to all carrot based 1080 operations, such as the proportion of baits available to kaka, size of these baits, bait toxicity, and the effectiveness of dyes and repellents, combined with inherent characteristics of kaka feeding behaviour such as the species' (or individual's) disposition to investigate novel food items, age of birds and the abundance of natural foods, may mean that 1080 poses a significant risk to some kaka in some situations. What are these risks?

5.1.1 Lethal dose

Using figures derived from the susceptibility of 8 Australian parrot species to 1080 (McIlroy 1984), Lloyd and Hackwell (1993) estimated the LD_{50} (lethal dose required to kill 50% of birds) for an average sized kaka to be 'about 2.14 g of carrot bait with 0.08% 1080 loading'. The consumption of only one moderate sized carrot bait is, therefore, probably sufficient to provide a lethal dose of 1080 to any individual kaka.

5.1.2 Bait size and availability

Kaka feed largely within the forest canopy, so only that proportion of baits caught there will be available to foraging birds. Trials on Kapiti Island using non-toxic carrot baits showed that at least 15% of baits >5 mm were caught in the canopy for the first few days following the 1080 drop (Lloyd and Hackwell 1993). In older areas of forest with a denser canopy and a higher proportion of epiphytes (such as Pureora), a greater proportion of baits is likely to be caught in the canopy and remain there for a longer period. Observations by Spurr (1992) and Lloyd and Hackwell (1993) also suggest that kaka prefer larger food items. Spurr (1992) noted that captive kaka preferred carrot pieces larger than 2 g i.e., >5 mm in length. During the Waihaha possum control operation, more than 90% of carrot baits (toxic) were >5 mm in length (Mason 1994b).

5.1.3 Carrot consumption by kaka

There is some evidence showing that carrot baits will be consumed by kaka. Research by Spurr (1992) showed that kaka will eat small quantities of both plain and dyed/cinnamon flavoured baits in captivity. Trials by Lloyd and Hackwell (1993) on Kapiti Island using non-toxic dyed/cinnamon flavoured baits also showed that small quantities of bait might be consumed by wild kaka, particularly juveniles.

5.1.4 Exposure to non-toxic prefeed

To increase the effectiveness of pest control operations when using carrot baits, the area is often pre-fed with non-toxic carrots (Spurr 1993). This effectively exposes non-target species to carrot baits for significantly longer periods even though application rates may be considerably less. Spurr (1992) found that un-dyed non-toxic baits were readily accepted by captive kaka with 15% of baits eaten or partly eaten each day. Although dyed/cinnamon flavoured baits were not eaten until the third day in these trials, that they were eaten here as well as on Kapiti Island is cause for concern. Spurr (1992) suggests that the consumption of dyed and flavoured baits during these trials may be influenced by their exposure to plain non-toxic baits such as pre-feed.

5.1.5 Variations in toxic bait quality

Green dye and cinnamon lure are considered effective deterrents to the consumption of baits by most bird species including kaka (Caithness and Williams 1971, Udy and Pracy 1981). However, evidence from Spurr's (1992) trials suggested that while fresh cinnamon was repellent, this effect quickly wore off. Therefore, any significant decrease in the quantities or coverage of cinnamon lure and/or dye on toxic baits may further accelerate the decline in the repellent nature of the bait. Observations of toxic baits prior to and following their application suggested that these problems did occur. Some baits were not completely dyed green with patches of orange still showing (Mason 1994, J. Fraser pers. comm.), carrot baits in some areas (mainly to the north of our core study area) were bright orange but still highly toxic (R. Lorrigen pers. comm.) and for most of the Waihaha Ecological Area the amount of cinnamon oil used was reduced by half (from one litre/tonne to a half litre/tonne, R. Lorrigen pers. comm.). The reasons for these variations are discussed further below.

5.1.6 Availability of natural food sources

The abundance of the natural food resource available during this 1080 operation may affect the probability of kaka taking baits, particularly if winter food sources are significantly reduced. Baits may be more acceptable if birds are faced with a shortage of food.

5.2 CARROT BAITS AS A NOVEL FOOD SOURCE

Despite the perceived risk to kaka from carrot baits and repeated poisoning of some areas of the study area in the past, no deaths were recorded during this study. The likelihood of significant numbers of deaths escaping detection is remote (see section 3.2.1) and the chances of even a small number of deaths occurring is also small. Given the potential risks of carrot based operations to kaka, some feature of their foraging behaviour must significantly reduce this level of risk.

Recent research indicates that kaka, particularly adults, show a strong aversion to novel items (i.e., are neophobic) even if these items have considerable food value (Wilson *et al*. 1991, R. Moorhouse pers. comm.). Research on South Island kaka showed that while adults consistently refused supplementary food, juveniles were more likely to show an interest in novel items (Wilson *et al*. 1991). Evidence from the Kapiti Island trials suggests that because of this interest young kaka are probably at most risk from carrot based 1080 operations (Lloyd and Hackwell 1993). The single juvenile kaka captured in Pureora (a female, see Appendix 2.) was the only juvenile seen or heard. Whether its survival means that this risk is also minimal is unknown. Possum control in forests where significant numbers of juveniles are present may prove otherwise.

5.3 INDIRECT EFFECTS OF COMPOUND 1080

If the direct risk to populations of non-target species of large-scale use of toxins such as 1080 is relatively poorly understood, the indirect consequences are even less so. Although the aerial distribution of 1080 is largely targeted at the control of browsers such as possums and deer, populations of ship rats (*Rattus rattus*) may also be reduced by more than 90% (Warburton 1989). As ship rats may form a significant part of forest dwelling predator's (i.e., cats and stoats) diets, a significant decrease in prey numbers may encourage a switch by predators to other sources of food such as birds (Murphy and Bradfield 1992). The potential impact of such a prey-switch on bird species, particularly those considered to be threatened (e.g., kaka and blue duck), is not yet known.

5.3.1 Kaka

Like other hole-nesting birds, kaka are susceptible to predation by arboreal predators such as stoats (*Mustela erminea*). This applies particularly to incubating females as well as their eggs and chicks. Although most possum control is carried out during the winter months, the effect of a prey switch may last for 3 (or more) months following the application of toxic baits (Murphy pers. comm.). If this period extends into the kaka breeding season (peak laying in December, Moorhouse pers. comm.), the overall effect of any increase in predation pressure on the population may be severe, particularly if the sex ratio apparent in our captures (18 males to only 3 females) is real rather than just an artefact of the capture methods used.

5.3.2 Blue duck

Because of their strongly territorial behaviour and much earlier breeding season, blue ducks may be more at risk from predators than kaka. To date, no direct or indirect effect of the 1080 operation has been detected despite an estimated 80% of the blue duck population on the Waihaha River being monitored. The potential for the effects of a prey-switch to be felt for up to three months following a 1080 operation (Murphy and Bradfield 1992) may have significant consequences for populations of blue ducks. Peak egg laying occurs between August and October (O'Brien 1990), directly exposing incubating females, eggs and chicks to that period when the effects of a prey-switch will be at their peak. The effect of any significant increase in predation pressure if it is does occur is unclear. Although blue duck pairs on the Waihaha River appear to be highly productive, with 3–4 offspring often produced (pers. obs.), selective predation of incubating females (only 6 were caught from a total of 20 adults) is likely to have a more severe long term effect.

Without further long term monitoring the effect of events such as prey-switching on populations of kaka and blue duck cannot be determined.

5.4 BAIT PREPARATION AND QUALITY CONTROL

As already noted, a number of features inherent in carrot baits present a potentially high risk to non-target species. These risks have been dramatically reduced since 1978 by: (a) screening carrot baits to remove chaff (Harrison 1978), (b) dyeing toxic carrots green to reduce their visibility to birds (Caithness and Williams 1971) and (c) adding cinnamon which acts as a repellent to birds (Udy and Pracey 19981).

Despite Department of Conservation policy requiring that carrot baits be screened to remove small fragments, more dead birds are found after 1080 operations using screened carrot baits than after operations using other types of baits (e.g., pollard baits) (Spurr 1993). Some operations have found that, despite screening, 31% of baits (by weight) were less than 5 mm long (Lloyd and Hackwell 1993). During this operation samples of screened bait were taken from the mouth of the carrot cutter prior to the application of non-toxic carrots. 15% (by weight) of baits were between 5–10 mm long (Mason 1994a). This level was considered too high. However, during the preparation of the toxic baits the speed of the rotating screen was slowed significantly (R. Lorrigen pers. comm.) resulting in only 8% (by weight) of the toxic baits being between 5–10 mm (Mason 1994b).

Problems with the dye were also apparent. Some baits appeared to be only partly dyed both prior to their application (Mason 1994b) and once on the ground (J. Fraser pers. comm.). Even more disturbing were reports that some highly toxic baits found around the northern boundary of the Waihaha Ecological Area showed no trace of dye following only a small amount of rain (R. Lorrigen pers. comm.). These problems were thought to relate to the amount of liquid on the carrots prior to the application of dye, lure and toxin. Wet carrots (resulting from moisture generated while stored or rain at preparation sites) were thought likely to both retard the penetration of dye by diluting it and making it easier for the dye and lure to be flicked off by the spinner and slipstream of the helicopter. Small amounts of rain may have been sufficient to wash off any remaining dye and lure (R. Lorrigen pers. comm.). Fragmentation of baits by the bucket spinner and/or impacts with trees and the ground as they were dropped may have also contributed to some of the baits partially dyed appearance.

Immediate steps were taken to try and stop these problems. This essentially involved cutting by half the amount of oil based cinnamon lure applied to the baits without changing the concentration of dye (R. Lorrigen pers. comm.). Although this approach seemed to work, we cannot explain why the dye should 'wash' off while the 1080 (which is also water-based) remained on (or in) the bait. Investigations into more effective dyes may be warranted.

The effect of reducing the concentration of cinnamon repellent by half on non-target species is difficult to determine. We can be fairly certain that there was no effect on kaka and blue duck but it is not known whether this may have influenced the number of deaths of other non-target species, particularly the smaller passerines.

5.5 OTHER NON-TARGET SPECIES DEATHS

Deaths of smaller insectivorous bird species are more common in possum control operations using carrot baits than those using pollard baits despite dramatic improvements in bait preparation (Spurr 1993). Most of these deaths appear to be caused by the presence of small fragments which have either escaped the screening process prior to application, or appeared following application as a result of fragmentation from impacts. Fortunately, there is little evidence that the deaths of these more common species has a significant detrimental impact on the survival of the larger populations (Spurr 1993). Casual observations of forest bird numbers following this poison operation suggested there was little change, particularly for species such as robins (*Petroica australis*) which seem to feature consistently in mortality figures following other 1080 operations where their numbers have been monitored (Spurr 1993). Although pigeons were still common within the study area following this operation, the number of pigeon corpses located was of some concern. As this is a species capable of consuming quite large pieces of carrot bait, bait acceptance trials using carrot baits may be worthwhile as well as monitoring pigeon populations during any future carrot based operations.

6. Conclusions

No effect of 1080 was detected on any of the 20 North Island kaka or 18 blue duck monitored following the application of toxic carrot baits.

The merits of each method of monitoring radio-tagged birds during the possum control operation in the Waihaha Ecological Area depended on the particular species being examined.

The mobility of kaka (more pronounced in some individuals than others) resulted in a number of disadvantages for ground based monitoring. Topographic distortion of signals, observer bias and the associated difficulties in simultaneously triangulating positions of all birds throughout the study area meant that accurate position fixes were not possible. Despite these limitations, monitoring most radio-tagged kaka from fixed points provided sufficient information to determine whether or not birds were still alive following the application of toxic baits.

Position fixes on radio-tagged birds from the aerial monitoring were considerably more accurate and time efficient than ground based monitoring, and could easily locate individual birds that wandered widely throughout the study area and out of the range of ground based observers. The use of mortality transmitters greatly increased the efficiency with which the status of individual birds could be determined.

As blue duck are highly territorial and relatively sedentary, they are more effectively monitored from the ground. However, if mortality transmitters were used, aerial monitoring would be significantly more efficient and cost effective.

Kaka deaths have been recorded following 1080 operations in the past (Spurr 1991) and there is a remote possibility that undetected kaka deaths occurred during the Waihaha operation. If some deaths did occur, numbers must have been very small and unlikely to have had any impact on the kaka population as a whole. Observations of groups of 6–8 kaka were common following the poison operation. In one instance 11 kaka were seen in a single matai tree (A. Jones pers. comm.).

Of particular concern is the apparent imbalance in the sex ratio of the kaka caught (18 males to 3 females). Although this may be an artefact of the method used to capture kaka, (i.e., more males responded to recorded calls) there is some evidence that this is not the case. On Kapiti Island, where kaka were caught using identical methods, the sex ratio was 14 males to 11 females (R. Moorhouse, pers. comm.).

While direct effects of 1080 are readily observable on non-target species following possum control operations, indirect effects such as prey-switching are potentially significant but poorly understood. Longer term monitoring is required to accurately assess the benefits or dangers of such operations to threatened species.

7. Recommendations

- If carrot baits are to be used in possum control operations, the quality of toxic baits requires particular attention. Carrot bait preparation protocols for possum control operations should be reviewed and modified to both improve the penetration of dyes and the further exclusion of small fragments rather than relying on the operator to detect and deal with these problems as they arise.

- Mortality transmitters should be used in all future monitoring operations where highly mobile birds may be at risk of 1080 poisoning. This will avoid having to duplicate monitoring methods and allow more cost effective and efficient monitoring to be conducted from the air.
- The diameter of the aerials used for blue duck transmitters (0.03 inch) should be increased (to 0.05 inch) to prevent the occurrence of breakages and associated degradation of signals (see Appendix 6).
- An effective harness should be developed for blue ducks incorporating a degradable link to avoid the necessity of re-capturing birds and preventing damage to feathers on the back (see Appendix 6).
- For future monitoring, kaka should be captured during the spring, summer and autumn months when the weather is reasonable and the response to recorded calls is strong.
- The monitoring period should take into account both the immediate direct and long term indirect effects of 1080 on non-target populations. Both kaka and blue duck should continue to be monitored so that indirect effects (if any) can be ascertained.
- If indirect effects such as prey-switching are suspected or considered likely, the relative densities of rats and their predators should also be assessed to determine the actual level of risk.
- Because of the effort required to fit radio-transmitters to species such as kaka and blue duck, an attempt should be made to maximise the amount of information gained. For this reason, aspects of both kaka and blue duck behaviour and ecology should continue to be monitored for the life of the transmitters.
- The apparent imbalance of the kaka sex ratio requires further investigation to determine its possible significance to the population as a whole.
- The survival of New Zealand pigeons should be monitored during future 1080 operations using carrot baits.

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APPENDIX 1

Birds and mammals of the Waihaha Ecological Area

Birds

Black shag	*Phalacrocorax carbo*
Little shag	*Phalacrocorax melanoleucos*
Paradise shelduck	*Tadorna variegata*
Blue duck	*Hymenolaimus malacorhynchos*
Mallard	*Anas platyrhynchos*
Grey duck	*Anas superciliosa*
Australasian harrier	*Circus approximans*
New Zealand falcon	*Falco novaeseelandiae*
New Zealand pigeon	*Hemiphaga novaeseelandiae*
North Island kaka	*Nestor meridionalis septentrionalis*
Kakariki	*Cyanoramphus auriceps*
Shining cuckoo	*Chrysococcyx lucidus*
Long-tailed cuckoo	*Eudynamys taitensis*
Morepork	*Ninox novaeseelandiae*
New Zealand kingfisher	*Halcyon sancta vagans*
Rifleman	*Acanthisitta chloris*
Welcome swallow	*Hirundo tahitica neoxena*
Dunnock	*Prunella modularis*
Blackbird	*Turdus merula*
Song thrush	*Turdus philomelos*
North Island fernbird	*Bowdleria punctata vealeae*
Whitehead	*Mohoua albicilla*
Grey warbler	*Gerygone igata*
Fantail	*Rhipidura fuliginosa placabilis*
North Island tomtit	*Petroica macrocephala toitoi*
North Island robin	*Petroica australis longipes*
Silvereye	*Zosterops lateralis lateralis*
Bellbird	*Anthornis melanura*
Tui	*Prosthemadera novaeseelandiae*
Yellowhammer	*Emberiza citrinella*
Chaffinch	*Fringilla coelebs*
Greenfinch	*Carduelis chloris*
Goldfinch	*Carduelis carduelis*
Starling	*Sturnus vulgaris*

Mammals

New Zealand long-tailed bat	*Chalinolobus tuberculatus*
Brushtail possum	*Trichosurus vulpecula*
Brown hare	*Lepus europaeus occidentalis*
Ship rat	*Rattus rattus*
House mouse	*Mus musculus*
House cat	*Felis catus*
Feral pig	*Sus scrofus*
Red deer	*Cervus elaphus*

APPENDIX 2

Kaka capture, banding and transmitter details

DATE	NET SITE #	GRID REFERENCE	SEX	WEIGHT	BILL LENGTH	BILL WIDTH	BILL DEPTH	TARSUS	WING	TAIL	LEFT LEG BAND	RIGHT LEG BAND	Tx (TR4) FREQUENCY
06/01/94	FRI #1	330 686	Male	5058	50.9mm	13.7mm		36.5mm	275mm	157mm	Y W R	L-14151	52/-1
06/01/94	FRI #1	330 686	Male	4839	48.Omm	13.3mm		36.2mm	285mm	158mm	Y W G	L-14152	50/-1
06/01/94	FRI #1	330 686	Male	4968	50.7mm	13.5mm		37.Omm	278mm	156mm	Y W B	L-14153	56/-1
06/01/94	FRI #1	330 686	Female	5309	43.1mm	13.8mm		36.8mm	275mm	165mm	L-14154	Y G O	60/-1
18/2/94	Waihaha Hut #1	348 751	Male	4809	52.2mm	13.5mm		36.2mm	267mm	143mm	Y W O	L-14155	42/-0.5
18/2/94	" "	348 751	Male	4609	52.1mm	12.2mm		37.3mm	268mm	149mm	Y R W	L-14156	44/
18/2/94	" "	348 751	Male	4689	53.Omm	14.Omm		39.4mm	287mm	147mm	Y R B	L-14157	48/-1
18/2/94		348 751	Male	4559	52.4mm	13.5mm		35.4mm	286mm	148mm	Y B W	L-14158	54/
22/2/94	Waihaha Hut #2	367 755	Male	5009	49.8mm	14.4mm		37.5mm	270mm	149mm	Y B O	L-14159	46/
22/2/94	" °	367 755	Male	4538	49.7mm	12.5mm		36.6mm	269mm	166mm	Y O W	L-14160	58/
24/2/94		367 755	Male	4638	50.1mm	12.8mm	20.1mm	34.8mm	281mm	155mm	Y O G	L-31571	66/-3
24/2/94		367 755	Male	4769	53.9mm	14.5mm	20.2mm	39.5mm	287mm	153mm	Y R O	L-31572	72/-1
24/2/94	" `	367 755	Male	4949	49.8mm	14.5mm	19.5mm	38.5mm	279mm	150mm	Y B Y	L-31573	76/-1.5
24/2/94	" °	367 755	Male	4289	47.5mm	13.7mm	18.6mm	37.1mm	280mm	146mm	Y G W	L-31574	64/-1.5
19/4/94	Te Awaiti 1	333 718	Male	5409	49.4mm	13.1mm	19.5mm	36.4mm	259mm	148mm	Y B R	L-31575	68/
2/5/94	Te Awaiti 1	333 718	Female	4609	42.Omm	11.0mm	11.0mm	36.0mm	274mm	156mm	L-31582	Y B G	70/-1
2/5/94	Te Awaiti 1	333 718	Male	4858	48.8mm	14.3mm	20.1mm	38.1mm	274mm	144mm	Y B G	L-31580	74/-1
30/5/94	Pokaiora	372 735	Male	4879	50.6mm	15.2mm	20.5mm	36.9mm	280mm	157mm	Y W Y	L-31576	82/0
17/6/94	Central Waihaha	345 710	Male	4749	50.Omm	13.7mm	19.2mm	37.3mm	272mm	144mm	Y R G	L-31577	84/+0.5
17/6/94	" "	345 710	Male	4819	48.Omm	14.3mm	19.5mm	36.8mm	280mm	153mm	Y G R	L-31578	86/-0.5
17/6/94	" "	345 710	Female	3908	42.8mm	13.8mm	11.9mm	36.2mm	271mm	147mm	L-31579	Y W R	88/-1.5

APPENDIX 3

Blue duck capture, banding and transmitter details

DATE	RIVER	GRID REFERENCE	SEX	WEIGHT	LEFT LEG BAND	RIGHT LEG BAND	Tx (TR4) FREQUENCY
11/04/94	Waihaha	328 697	Female	6708	S-71850	W W	02/-1
12/04/94	Waihaha	329 695	Male	9208	W W	S-72966	04/-1
12/01/94	Waihaha	329 695	Female		S-72967		
12/01/94	Waihaha	329 695	Female		S-72968		
20/02/94	Waihaha Te Awaiti	340 730	Male	7408	Y Y	S-72969	06/-1
20/02/94		340 730	Male	8508	R Y	S-72970	08/-3
24/02/94	Below Hut	373 750	Male	9008	O O	S-72971	10/-1.5
17/3/94	Waihaha	376 750	Male	9608	L L	S-72972	12/
17/3/94	Waihaha	394 746	Male	11458	R R	S-72973	14/-3
27/3/94	Waihaha	331 701	Male	8508	W O	S-72974	16/
27/3/94	Waihaha	328 697	Male	8118	Y W	S-72975	18/
1/4/94	Waihaha	327 696	Female	7108	S-72976	W R	20/-2
14/4/94	Waihaha	343 734	Male	7309	Y L	S-72977	22/-1.5
16/4/94	Waihaha	337 725	Female		S-72978		
16/4/94	Waihaha	337 725	Female	7058	S-72979	O L	24/
16/4/94	Waihaha	337 725	Male	8608	O L	S-72980	26/
20/4/94	Waihaha	333 716	Female		S-72981		
1/5/94	Waihaha	336 723	Male	8358	O W	S-72982	28/-3
14/5/94	Waihaha	319 697	Female	6358	S-72983	R O	30/-1
14/5/94	Waihaha	319 697	Male	8758	R O	S-72984	34/-1
16/5/94	Waihaha	315 693	Female	6968	S-72985	W Y	32/
16/5/94	Waihaha	315 693	Male	8958	W Y	S-72986	36/-1
17/5/94	Waihaha	331 701	Female	7208	S-72987	W O	38/
17/5/94	Waihaha	325 696	Male	8908	W R	S-72988	40/-0.5

APPENDIX 4

AERIAL SURVEY TECHNIQUES

by Sid Marsh

Introduction

We have compiled this section as a guide for any future pilots or air crew contemplating aerial tracking of radio-tagged birds.

With 40 radio-tagged birds (21 kaka and 19 blue duck respectively) scattered throughout the Waihaha study area (approximately 60 km^2) position fixes had to be obtained from the air as well as from the ground. Ground teams equipped with Telonics TR-4 receivers and hand-held aerials could only locate birds accurately within a localised area. However, a light aircraft fitted with two wing strut-mounted aerials and Telonics TR-2 receiver could quickly and effectively cover the whole study area searching for the widely dispersed, and sometimes, highly mobile birds. We found that the ground and aerial teams complimented each other by either confirming the whereabouts of certain birds, or at the very least determining that the birds concerned were still moving (i.e., still alive) following the application of toxic baits.

Equipment required

- one aircraft (Cessna 172).
- brackets, hose clips, U-bolts and padding to attach aerials to wing struts (two sets).
- two three element Yagi-type aerials with approx. 4 m of cable.
- one three position aerial switch-box (port/starboard/both) controlling the aerial(s) in use and connecting aerials to receiver,
- one Telonics TR-2 receiver (TR-4 units do not work in the plane).
- one mono double plug adapter to fit receiver and headset connections.
- two headsets.
- one handheld VHF radio for air/ground communications.
- list of transmitter frequencies.
- map of the area (laminated)/water-based marker pen.
- binoculars.
- pilot and observer/map reader.

Methods

- develop a survey technique.
- familiarise ourselves with the TR-2 receiver, switch box, wing-mounted antennae and the study area as viewed from the air. In the latter case, prominent landmarks such as swamps, distinctive high points, major stream junctions, huts, etc. were utilised as reference points within the forest.
- carry out a roll call of radio-tagged birds still present in the area and still sending out signals.

Following a drop of toxic baits (and in some cases while it was still being dropped), the aerial team first overflew the ground team(s) to exchange data on bird positions in order to follow up any questionable fixes. When searching for birds the aerial team would cruise straight and level at between 500 feet and 1,000 feet AGL, using the bad-weather configuration (20 degrees of flap) to keep the airspeed at 80 knots or thereabouts. In most cases kaka and blue duck remained in the same general area where they were caught. Therefore, in order to make our daily searches more systematic, we divided the study area into five sectors:

1. lower Waihaha.
2. Waihaha Hut/Pokaiora Clearing.
3. middle Waihaha (centred around Te Awaiti Forks).
4. central area (centred around spot height .705).
5. upper Waihaha/FRI Hut.

Working a sector at a time, the aerial team would plot bird positions as they were found, before moving to a new sector to start again.

Fixing the positions of kaka

With the aircraft cruising straight and level both aerials were set to receive signals. When a signal was received the TR-2 operator would then switch to either the port or starboard aerial, depending which side the bird concerned was on. The aircraft would continue on its original course until the signal strength peaked. Once the signal strength began to fall an immediate 90 degree turn would be made toward this signal. This pattern was repeated resulting in something resembling a box-search which gradually narrowed down the bird's whereabouts until the pilot was orbiting the aircraft (in a 30 degree angle of bank) and holding station over a consistently strong transmitter signal. The angle of bank would be maintained until the TR-2 operator, using known landmarks, plotted a grid reference for it. The aircraft would then move on to the next kaka to be looked for in that sector. Position changes for each bird following consecutive flights indicated movement and therefore that the bird concerned was still alive.

Throughout the above search procedure it is recommended to occasionally switch to the opposite antenna to ensure the aircraft isn't tracking a back-signal.

Fixing positions of blue ducks

With the two wing-mounted aerials pointing down and outwards at 45 degree angles from each side of the fuselage, the aircraft had to be flown 200 to 300 metres parallel to the Waihaha River which in places is deeply incised. This ensured that the main axis of the active antenna was pointed directly at the body of water where blue ducks were most likely to be found. When a signal was picked up, the air crew would listen for peak signal strength, and the aircraft would then orbit overhead while the bird's position was plotted - a procedure identical to that used for kaka.

Miscellaneous

Only two radio-tagged birds were never found using these techniques (one kaka and one blue duck). It is assumed that these birds either moved out of the area altogether or the transmitters themselves failed.

It is also worth noting that significant changes in transmitter frequencies can and do occur often resulting in `lost' birds. Considerable `fine' tuning of the receiver may be required before some signals are able to be received.

Finally, as far as determining whether individual birds are alive or dead after a 1080 poison operation, mortality transmitters should be utilised as they would simplify the airborne operation considerably.

APPENDIX 5

Kaka ground bearings

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
42	A	22/7/94	246	Weak
			230	Weak
			242	Weak
		23/7/94	224	Weak
			221	Weak
			239	Weak
			241	Weak
	B	23/7/94	188	Weak
			222	Weak
			242	Weak
			224	Weak
	C	22/7/94	194	Moderate
			261	Weak
			198	Weak
			292	Weak
		23/7/94	244	Weak
			240	Weak
			300	Weak
			218	Weak
		24/7/94	226	Weak
		31/7/94	31	Strong
			184	Moderate
			200	Moderate
	D	23/7/94	130	Weak
			1 48	Weak
			190	Weak
	E	31/7/94	245	Weak
		1/8/94	157	Weak
		2/8/94	246	Weak
	F	31/7/94	24	Moderate
	G	2/8/94	20	Weak
		4/8/94	14	Weak
		16/8/94	6	Weak
			1	Weak
			353	Weak
44	A	24/7/94	302	Strong
			1 80	Strong
			199	Strong
	B	23/7/94	292	Weak
	C	24/7/94	156	Strong
		31/7/94	131	Moderate
			284	Moderate
		1/8/94	257	Strong
			253	Strong
			256	Strong
		2/8/94	330	Strong
			315	Strong
		3/8/94	140	Strong
			8	Moderate
			74	Strong
	E	31/7/94	268	Strong
			80	Moderate
			6	Moderate
			1	Moderate
			305	Moderate
		31/7/94	20	Weak
		6/8/94	28	Weak
		7/8/94	351	Moderate
			330	Moderate
		12/8/94	344	Moderate
			338	Moderate
			353	Weak
		13/8/94	350	Moderate
			358	Weak
		14/8/94	350	Weak
		1	359	Moderate
		16/8/94	347	Weak
			347	Weak
46	A	22/7/94	304	Moderate
			308	Moderate
			308	Strong
		31/7/94	325	Strong
			349	Strong
			306	Strong
		1/8/94	296	Strong
			320	Strong
		3/8/94	292	Weak
	B	22/7/94	63	Moderate
			36	Strong
			194	Strong
			140	Strong
		23/7/94	52	Weak
			70	Weak
			110	Weak

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
			174	Weak
	C	22/7/94	42	Moderate
			39	Strong
		23/7/94	358	Weak
			4	Weak
			354	Weak
			10	Weak
		24/7/94	50	Moderate
		2/8/94	185	Moderate
			185	Moderate
			175	Weak
		3/8/94	60	Strong
			34	Moderate
			63	Strong
	F	2/8/94	58	Strong
	G	31/7/94	20	Weak
			12	Weak
		2/8/94	52	Weak
			52	Moderate
			56	Moderate
		7/8/94	231	Moderate
			228	Weak
		12/8/94	261	Strong
			281	Strong
			273	Strong
			254	Moderate
		13/8/94	258	Weak
			229	Strong
		14/8/94	274	Moderate
			15	Moderate
			244	Strong
		15/8/94	234	Moderate
		16/8/94	205	Moderate
			264	Moderate
			267	Moderate
	H	12/8/94	224	Weak
			246	Weak
			222	Weak
		13/8/94	274	Weak
		14/8/94	242	Weak
			312	Moderate
			248	Moderate
		16/8/94	119	Weak
52	A	22/7/94	208	Weak
			176	Weak
			180	Weak
		3/8/94	195	Weak

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
	C	23/7/94	182	Weak
		24/7/94	184	Weak
		31/7/94	195	Weak
			170	Weak
			180	Weak
		1/8/94	165	Weak
		2/8/94	180	Weak
		3/8/94	186	Moderate
			169	Weak
			204	Weak
	F	1/8/94	178	Weak
			148	Moderate
			188	Weak
		2/8/94	108	Moderate
		13/8/94	80	Strong
			72	Moderate
			63	Moderate
	G	30/7/94	191	Weak
			164	Weak
		31/7/94	344	Weak
			292	Moderate
			120	Moderate
		1/8/94	160	Strong
			112	Moderate
			78	Strong
			240	Weak
		2/8/94	198	Strong
			180	Weak
			140	Moderate
			200	Weak
			134	Strong
		4/8/94	313	Strong
			108	Strong
			94	Strong
			120	Strong
		6/8/94	95	Strong
			97	Strong
		7/8/94	92	Strong
			1	Strong
		12/8/94	144	Strong
			116	Strong
			136	Strong
			173	Strong
		13/8/94	288	Weak
			217	Strong
		14/8/94	201	Strong
			358	Moderate
			31	Strong

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
		16/8/94	250	Moderate
			206	Moderate
	H	12/8/94	211	Weak
			191	Strong
			190	Weak
		13/8/94	276	Weak
		14/8/94	254	Strong
			276	Moderate
			240	Moderate
		16/8/94	223	Weak
			259	Weak
			228	Weak
54	A	22/7/94	246	Weak
			242	Weak
		23/7/94	232	Moderate
			250	Moderate
			274	Weak
			241	Weak
			256	Weak
			247	Weak
			256	Weak
		24/7/94	28	Weak
		31/7/94	210	Weak
			153	Weak
			192	Weak
		1/8/94	215	Moderate
			241	Weak
		3/8/94	77	
	B	22/7/94	219	Moderate
		31/7/94	164	Moderate
			167	Moderate
			190	Moderate
		1/8/94	330	Moderate
			205	Moderate
		3/8/94	234	Weak
	B	21/7/94	304	Weak
		22/7/94	264	Moderate
			267	Weak
			254	Weak
		23/7/94	302	Weak
			313	Weak
			282	Weak
			212	Moderate
			218	Weak
			178	Moderate
		31/7/94	283	Weak
			286	Weak

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
			290	Weak
	C	23/7/94	322	Weak
			316	Moderate
			323	Weak
			312	Weak
		2/8/94	10	Weak
			45	Weak
			50	Moderate
		3/8/94	17	Moderate
			50	Strong
	G	7/8/94	38	Weak
			1	Weak
60	C	31/7/94	211	Moderate
		1/8/94	182	Weak
		2/8/94	185	Moderate
			180	Weak
		3/8/94	188	Weak
	F	13/8/94	92	Strong
			104	Strong
			222	Strong
	G	30/7/94	191	Weak
			204	Weak
		31/7/94	302	Weak
			306	Strong
			184	Weak
		1/8/94	214	Strong
			182	Moderate
			238	Moderate
			244	Weak
		2/8/94	229	Strong
			270	Weak
			188	Strong
			230	Strong
			200	Weak
			170	Strong
		4/8/94	204	Weak
			238	Weak
		6/8/94	234	Weak
			271	Moderate
		7/8/94	247	Weak
			154	Weak
		12/8/94	159	Strong
			149	Strong
			140	Strong
			257	Strong
		13/8/94	263	Weak
			98	Strong

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
			349	Moderate
			353	Strong
		15/8/94	233	Moderate
		16/8/94	125	Moderate
			44	Moderate
			268	Moderate
	H	12/8/94	205	Moderate
			202	Moderate
			199	Moderate
		13/8/94	223	Weak
			247	Weak
			273	Weak
		14/8/94	332	Strong
			314	Weak
			246	Moderate
		16/8/94	170	Weak
			152	Weak
64	A	22/7/94	210	Weak
		3/8/94	189	Weak
	C	23/7/94	184	Weak
		31/7/94	176	Weak
		1/8/94	185	Weak
			173	Weak
		3/8/94	197	Weak
			84	Weak
	D	23/7/94	162	Weak
	F	31/7/94	152	Weak
		1/8/94	160	Strong
			126	Strong
			152	Strong
		2/8/94	90	Strong
	G	30/7/94	20	Strong
			48	Strong
		31/7/94	44	Strong
			32	Moderate
			360	Strong
		1/8/94	84	Strong
			24	Strong
		13/8/94	48	Moderate
			45	Weak
			44	Weak
	G	30/7/94	8	Weak
		31/7/94	20	Weak
			20	Weak
			50	Moderate
		1/8/94	5	Strong
			32	Strong

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
			22	Strong
		2/8/94	75	Moderate
			90	Strong
			78	Strong
			90	Moderate
			52	Weak
			48	Weak
		4/8/94	32	Strong
			70	Strong
			54	Strong
			51	Strong
		6/8/94	18	Strong
			13	Strong
		7/8/94	83	Strong
			65	Strong
		12/8/94	355	Strong
			351	Strong
			353	Strong
			1	Strong
		13/8/94	21	Strong
			32	Strong
			25	Strong
			26	Strong
		14/8/94	9	Strong
			7	Strong
			20	Strong
		15/8/94	52	Strong
		16/8/94	1	Moderate
			3	Moderate
			17	Strong
	H	12/8/94	18	Strong
			333	Strong
			335	Strong
		13/8/94	248	Weak
			242	Moderate
			255	Strong
		14/8/94	320	Strong
			313	Strong
			310	Strong
		16/8/94	294	Strong
			317	Moderate
			299	Strong
			297	Moderate
72	A	22/7/94	246	Strong
			244	Moderate
			256	Moderate
		3/7/94	248	Weak

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
			239	Weak
			213	Weak
			256	Weak
			267	Moderate
			270	Strong
			280	Moderate
		24/7/94	360	Strong
		2/8/94	228	Weak
		3/8/94	243	Moderate
			110	Moderate
	B	21/7/94	128	Moderate
			181	Strong
			131	Weak
			170	Moderate
		22/7/94	182	Moderate
			185	Moderate
			161	Moderate
				Moderate
		23/7/94	288	Weak
			193	Strong
			188	Moderate
			161	Strong
			212	Strong
			222	Strong
			201	Strong
	C	22/7/94	73	Strong
			79	Strong
			50	Moderate
			83	Moderate
		23/7/94	76	Strong
			88	Strong
			274	Strong
			312	Strong
		24/7/94	80	Strong
		31/7/94	285	Strong
			252	Strong
			271	Strong
		1/8/94	321	Weak
			316	Weak
		2/8/94	190	Weak
			165	Strong
			95	Strong
		3/8/94	22	Strong
			95	Strong
			68	Strong
	D	23/7/94	72	Weak
			84	Weak
			94	Weak
		6/8/94	360	Weak
			351	Moderate
		12/8/94	1	Strong
			22	Strong
			17	Strong
			9	Moderate
		14/8/94	15	Moderate
			5	Moderate
			352	Moderate
		15/8/94	2	Weak
	H	12/8/94	352	Moderate
		14/8/94	340	Weak
			326	Weak
			353	Weak
84	A	23/7/94	163	Moderate
		2/8/94	140	Weak
			193	Moderate
		3/8/94	163	Weak
			167	Weak
	B	21/7/94	156	Moderate
		23/7/94	173	Moderate
	C	23/7/94	164	Weak
			164	Weak
			164	Weak
		24/7/94	138	Moderate
		2/8/94	140	Weak
		3/8/94	158	Moderate
			177	Moderate
	G	30/7/94	44	Weak
		31/7/94	40	Weak
		1/8/94	68	Weak
		2/8/94	40	Weak
		6/8/94	62	Weak
			16	Moderate
		7/8/94	14	Moderate
		12/8/94	37	Moderate
			88	Weak
		14/8/94	5	Weak
86	A	22/7/94	184	Weak
			186	Weak
			198	Weak
		31/7/94	190	Weak
	C	23/7/94	176	Weak
			170	Weak
			170	Weak
		31/7/94	184	Moderate

KAKA IDENTITY (TR-4 FREQUENCY)	OBSERVATION SITE	DATE	COMPASS BEARING	SIGNAL STRENGTH
			125	Moderate
		1/8/94	195	Moderate
			184	Moderate
		2/8/94	155	Moderate
			170	Weak
			190	Weak
	F	31/7/94	86	Weak
		1/8/94	6	Weak
			6	Weak
			250	Strong
		13/8/94	29	Weak
			34	Weak
			32	Weak
	G	30/7/94	28	Weak
			8	Weak
		31/7/94	12	Weak
			44	Weak
			24	Weak
		1/8/94	18	Weak
			26	Weak
			40	Weak
		2/8/94	20	Weak
			16	Weak
			4	Weak
		4/8/94	16	Weak
			30	Weak
			50	Weak
		6/8/94	355	Weak
			355	Moderate
		7/8/94	38	Moderate
			349	Moderate
		12/8/94	27	Weak
			3	Strong
			3	Strong
			327	Moderate
		14/8/94	4	Moderate
			12	Moderate
			8	Moderate
		15/8/94	2	Moderate
		16/8/94	358	Weak
			21	Weak
	H	12/8/94	11	Weak
			355	Weak
88	C	23/7/94	164	Weak
			164	Weak
			170	Weak
		2/8/94	160	Weak
		3/8/94	178	Moderate
			172	Moderate
			172	
	G	4/8/94	34	Weak
			20	Weak
		14/8/94	42	Weak

APPENDIX 6

Blue duck recaptures and notes on transmitters

As a condition of being able to capture and attach radio-transmitters to blue ducks all radio-tags were to be removed at the conclusion of the study. This is currently being conducted in stages as battery life deteriorates. At present seventeen of the 19 blue ducks have been recaptured and their transmitters removed. Details of the recaptures to date are recorded below.

In other studies using radio transmitters on blue ducks significant wear to the feathers has been detected. This has led to the modification of the harness system for this project in an attempt to reduce this damage. Particular note was, therefore, made of feather damage that could be directly attributed to the wearing of the transmitter or harness when removed.

Feather damage was assessed using the following subjective scale:

1. No feather wear or damage
2. Minor feather wear or damage
3. Significant feather wear or damage

These results are recorded in the table below.

DUCK IDENTITY	Tx (TR-4) FREQUENCY	RECAPTURE DATE	GRID REFERENCE	PERIOD Tx CARRIED	FEATHER DAMAGE
00-M	10	26/8/94	361 752	184 days	2
LL-M	12	27/8/94	371 754	164	1
M-OL	24	28/8/94	339 728	135	2
OW-M	28	28/8/94	339 728	120	1
YY-M	06	28/8/94	339 728	190	1
RY-M	08	29/8/94	339 728	191	3 "
0 L-M	26	30/8/94	336 722	137	2
M-WW	02	9/9/94	328 697	242	1
WW-M	04	9/9/94	328 697	241	2
M-WR	20	17/12/94	324 696	261	3
WR-M	40	17/12/94	324 696	215	3
M-WO	38	17/12/94	330 770	215	2
WO-M	16	17/12/94	330 770	266	3
WY-M	36	19/12/94	308 686	218	Dead!
M-WY	32	19/12/94	315 693	218	1
M-RO	30	19/12/94	322 696	220	2
RO-M	34	19/12/94	322 696	220	2

Feathers under the transmitter carried by RY-M were completely absent. A small 'match head' sized lesion was also present and assumed to be the result of rubbing (S. Marsh pers. comm.). The general condition of this bird was otherwise excellent and showed no apparent stress.

Transmitter aerials

Apart from some problems with feather wear, the only other problem encountered was aerial breakage. The transmitter aerials on four of the seventeen ducks recovered to date had been broken off cleanly where the wire entered the rubber tube leading into the body of the transmitter. It is unlikely that a blue duck would be physically capable of biting through the aerial. Metal fatigue resulting from the continual bending of the wire is more likely although how this occurs is unknown. At least two other transmitters are showing signs of this type of wear so the problem does not appear to be an isolated incident. For future studies requiring the use of transmitters the diameter of the aerial should be increased from 0.03 inches to 0.05 inches.

Kaka transmitters

All kaka transmitters functioned without problems during the study. Only one bird (YWY-M) managed to remove its transmitter but this occurred some time after monitoring for the effects of 1080 had concluded. This transmitter (one of the four mortality transmitters used) was able to be quickly recovered.