Appendix O: Exposure and Risk Assessment (Cyanide and Trapping): Non-Target Species

Contents

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Key points

- By-kill of non-target organisms from cyanide/trapping operations has been observed but there are few quantitative data. Wekas appear particularly vulnerable. The Agency evaluates that effects on weka populations at the local level could be major.
- The introduction of Feratox pellets onto the market in 1997 will have changed the potential exposure of non-target organisms.
- Changes in cyanide and trapping protocols on Department of Conservation (DoC) land where ground birds are present appear to have reduced by-kill, but quantitative data are lacking. The application of such protocols to land not managed by DoC is unknown.
- Secondary poisoning by cyanide is unlikely.
- The Agency has collected some information on the comparative efficacy of cyanide/trapping and 1080 operations and concludes that, in areas amenable to cyanide/trapping, the possum kill rate can be as high as that for 1080, but this is not always achieved.

- The success of pest control operations is dependent on the treatment of large blocks of land and some terrain is unsuitable for cyanide/trapping. The applicant estimates areas of land that would not be treated under a cyanide/trapping scenario based on cost compared to an aerial 1080 scenario, but there is too little justification in the application for the Agency to evaluate this analysis.

O1 Cyanide

O1.1 Transport and manufacturing process

The applicant states that transport and manufacturing processes are either:

- contained, or
- treated in the sewer system.

Exposure has therefore not been further considered other than to state that animals living or feeding in landfill could be exposed. The Agency concurs with this view.

O1.2 Use pattern

Feratox is a pea-sized encapsulated pellet. Pellets are mixed with cereal feed pellets or mixed in peanut-butter paste (Eason and Wickstrom, 2001). Feratox formulations are always used within contained bait feeders or bait bags.

Cyanide pastes are supplied in a tube and applied in bait feeders or bait bags, or laid by hand as pea-sized baits on natural features such as twigs and rocks.

Bait feeders contain 200 g or more of pellets or paste, and should be distributed 50-100 m apart in a grid. Bait bags contain about 40 g and should be distributed at 10-15 m intervals along lines 100 m apart, depending on the density of the possum population (Henderson et al 1999)

Hand-laid paste should not be applied directly to soil or plants, to minimise degradation of the bait. Two nights after application hand-laid baits that are not taken should be destroyed by forcing the bait into the ground where they will degrade. This practice reduces the chance of ‘bait-shyness’ developing (Henderson et al 1999).

Cyanide is often used in combination with traps with operators using cyanide baits between traps (Henderson et al 1999).

ACVM (2002) provide more recent advice including:

- Pellets:
  - Mix with non-toxic cereal feed pellets or peanut based feed paste and presented to possums in specially designed pellet feeders.

  - Optimum height off the ground for the feeder is 17 cm or 2 m if stock are present.
  - Position feeder against post or tree, away from direct sunlight and the prevailing wind.
  - Locate in clear area of bush showing signs of possum.
  - Ideally locate on slope so carcases roll away from beneath it.
- Paste:
  - Position 10 cm off ground or >2 m off ground if stock have access.
  - In a position, for example, in hollows or cracks in branches or trunks of trees, where cannot be dislodged by passing possums or stock.
  - Never use near a place with public access, particularly by children.

O1.3 Aquatic life

O1.3.1 Expected concentration of cyanide in water

Since cyanide pastes are applied in bait stations/bags or by hand, operators should ensure that they are kept away from water. Feratox pellets are only used in bait stations or bait bags, which should also be kept away from waterways. Consequently, cyanide baits are unlikely to enter water if applied properly. Conceivably spilt baits, for example from rodent damage to bait bags, might be washed into waterways after very heavy rainfall. If this occurs, the concentration of cyanide in the water will be affected by the amount entering the waterway, rapidity of degradation and the flow and volume of the waterway. Cyanide is expected to volatilise rapidly from water or degrade (Appendix D). Cyanide may also form iron complexes that will be removed via sedimentation (Eisler 1991).

The experiment described by Wright and Manning (2003) (Appendix D) suggests that Feratox pellets spilled into waterways, or washed there in a flood, could continue to release cyanide over several weeks. Such cyanide would rapidly volatilise, degrade or precipitate. Cyanide pastes, if they did get into waterways, would be expected to be less persistent.

No data from monitoring of environmental concentrations has been identified.

O1.3.2 Risk to aquatic organisms

Despite the high acute toxicity of cyanide to aquatic organisms, the expected low exposure is very unlikely to lead to effects in waterways.

O1.4 Soil organisms

O1.4.1 Concentrations of cyanide in soil

Paste formulations in bait stations are unlikely to get onto soil. Non-contained pastes may be placed on rocks or twigs and therefore will come into direct contact with soil, indeed, it is recommended that hand-laid baits be ground into the soil if they are not taken.

The results of field studies have shown that rodent interference with bait bags can lead to a large proportion of baits being spilled onto soil. In one field trial, Mehrtens and Gaze (2003) found that 450 bait bags were removed from trees after 3-4 nights although only 97 dead possums were found. The authors concluded that a high proportion of bait bags may be damaged by rodents leading to pellets dropping to the ground beneath the bait station.

Some additional work has been performed to test other designs of bait station. Morgan (2004) looked at six devices containing various vertebrate toxic agents to determine their longevity and suitability for maintenance control. One of these devices was Feratox in paste, sheathed in an inverted bottom half a 1.25 litre soft-drink bottle. The reduction in cyanide (Feratox) concentration was rapid compared to the other toxicants (Feracol, PestOff 1080 pellets, PestOff brodifacoum pellets, No Possums 1080 gel, No Possums chloecalciferol gel), but it is not clear to what extent this was due to the bait station and to what extent to the type of bait. By 10 months there had been approximately 80% loss of cyanide.

Presumably where Feratox pellets are dislodged from bait stations/bags, any contamination will be limited to under the bait station.

'Clean' soil may contain a background concentration of cyanide of 0.48 mg/kg. Concentrations around pellets may reach 8 mg/kg (Wright and Manning, 2003), although there is some uncertainty about this figure (Appendix D).

O1.4.2 Risk to soil organisms

Soil is very likely to be contaminated with cyanide during cyanide operations. Concentrations around pellets or paste spilled on soil could be sufficient to cause an effect on the soil microbial community given toxicity values of 0.3 mg/kg (Appendix D). Any such effects are likely to be extremely localised. The Agency is unaware of any data on toxicity of cyanide to soil macro invertebrates.

O1.5 Plants

O1.5.1 Exposure of plants to cyanide

Plants can take up cyanide (Eisler 1991) and some are also capable of degrading cyanide into non-toxic compounds (Yu et al 2005). The exposure of plants is likely to be low reflecting slow leaching of cyanide from pellets and rapid loss of cyanide from the soil whether introduced from non-encapsulated paste or pellets.

No monitoring data of soil concentrations of cyanide during cyanide-trapping operations has been identified.

O1.5.2 Risk to plants

There is very little information on the toxicity of cyanide to plants exposed through the soil. However, the low concentrations of cyanide in soil and the localised distribution of such contamination are considered very unlikely to give rise to effects on plants.

O1.6 Non-target animals

O1.6.1 Exposure of non-target animals to cyanide: Direct

Exposure of non-target animals will occur either through direct access to paste or bait stations or spilled bait. The Agency is unaware of any quantitative information on direct access to baits although weka, for example, have been recorded visiting bait stations (Sweetapple et al, 2006). It would seem very likely that non-target animals would be exposed to pastes and spilled pellets.

The applicant states that the HSNO controls will lead to a reduction in exposure to cyanide baits.

> The controls in Gazette Notice No 141, Hazardous Substances (Vertebrate toxic agents) Transfer Notice 2004, that reduce birds being exposed to cyanide are:
>
> - 10(1) specifies the colour baits may be: green or blue. This makes them less attractive to birds whose colour vision is more focussed at the red/orange end of the spectrum; and
> - Schedule 3: 3(1), the requirement to obtain permission to use cyanide on land administered or managed by DoC. This enables DoC to impose conditions on the use of cyanide if there are concerns about potential effects on native species at a particular site.

DoC's procedures on land where flightless ground birds occur were altered in 2005 to ensure that bait stations/bags containing are raised at least 70 cm above the ground. More recently, DoC has stopped the use of Feratox[1] on its land after it became clear that baits are still spilled even from raised bait stations. These restrictions will not always be applied on land not managed by DoC.

Ongoing research is looking to develop Feratox pellets by devices to which weka do not have access. Prototype devices include Feratox pellets inserted into liquorice inside a section of plastic tube suspended on fishing line, and a spring-based device on a stake that exposed the Feratox pellet only when an outer sheath was pulled down. Early experiments (Morriss

1 Feratox (475 g/kg encapsulated cyanide pellet) with prefeed cereal pellets in bait stations; Feratox (Biobag/striker) (475 g/kg encapsulated cyanide pellet) with prefeed paste in bait bags; Feratox (Hard block) (475 g/kg encapsulated cyanide pellet) with prefeed block in bait stations; Feratox (Hard block) (475 g/kg encapsulated cyanide pellet) with prefeed block in bait bags.

et al 2006) showed that possums access the bait in both devices, rats and weka cannot access the bait in either device, deer accessed the Feratox in the first device but not the second and cattle can destroy the spring-loaded device by trampling. Morriss et al (2006) comment that both devices need further development.

O1.6.2 Monitoring of non-target organisms

Agency conclusion

- Qualitative records of by-kill
- Few quantitative studies of by-kill available.

The Agency notes that the introduction of Feratox pellets onto the market in 1997 will have changed the exposure of non-target organisms, in particular the pellets are more persistent than non-encapsulated baits. Data from old monitoring studies may therefore not be directly applicable to ongoing operations.

Daniel and Williams (1984) reporting on the conservation status of New Zealand's bat species review the cause of death for the 40 bats where this has been recorded. Cyanide poisoning was attributed to one bat found on a cyanide bait line. The authors speculate that this cause of death may be under-reported particular for the short-tailed bat (*Mysticina tuberculatus*) due to its terrestrial feeding habit and the fruit-lures used to attract possums to cyanide baits. The applicant concludes that *it appears unlikely that native bat populations are affected by the use of cyanide pastes laid on the ground,* but justification for this conclusion is not provided.

Spurr (1991) states populations of 18 bird species were monitored during a combined trapping and cyanide poisoning operation in Charleston Forest in 1978. Most species showed no change in abundance, but weka numbers decreased and fantail and tomtit numbers increased one week after the operation. Spurr concludes that it is not possible to conclude that weka numbers decreased since the trial was unreplicated. Spurr (1991) also report that kokako numbers were monitored during a combined trapping and cyanide poisoning operation in Mapara Forest in 1988. Forty-one kokako were identified before the operation, 40 were re-located afterwards. No kokako were found dead although one harrier was found.

Spurr (2000) quotes the information contained in Reid (1985, 1986) and Pracy (1958) indicating weka and kiwi deaths resulting from cyanide usage and states that as a result, DoC stipulates that cyanide baits must be raised above 70 cm in known weka and kiwi areas on land managed by the Department. Spurr (2000) does not state how successful this has been in reducing by-catch, although the applicant says that it "appears to have significantly reduced the numbers of weka and kiwi killed". Tomtit, robin, silvereye and tui deaths have also been reported after the use of hand laid cyanide (Spurr 2000). Spurr (2000) states that there has been little research into the long-term impacts of cyanide poisoning on non-target species populations although the applicant states (p 354 and p 355 of the application) that:

> these deaths do not appear to have a significant impact at a population level [and] Assuming that cyanide baits are raised above 70 cm in kiwi and weka areas (in all lands not just DoC lands), it is unlikely that any native bird species will be affected at a population level from the use of uncontained cyanide pastes.

Mehrtens and Gaze (2003) report on ad hoc recoveries of dead weka from areas being treated with Feratox, in which the corpses have tested positive for cyanide. They drew attention to the uncoordinated reporting of such events and to try to get a better picture of weka deaths from cyanide poisoning initiated a study in which the survival of 21 weka fitted with transmitters at two sites being treated with Feratox was monitored. The Feratox baits were fixed to trees but at what height is not reported. Two birds died before the Feratox operation began and a third lost its transmitter. Three birds died close to the bait lines and a further four, untagged weka were found dead. It was assumed that all seven birds had died of cyanide poisoning, but the results of residue analysis are not included in this reference.

Subsequent analysis may have confirmed the cause of death since the applicants say that of the 3 weka with radio transmitters all tested positive for cyanide and of the four without transmitters three were tested and all tested positive for cyanide. The authors noted that of the 450 baits only 20 were still attached to trees after 3 or 4 nights, but only 97 possums were found dead. Chew marks on many of the bags indicated rodents had dislodged the bags and made them accessible to weka. They also commented that the dead weka were often found near a dead possum, which could indicate the weka accessed the cyanide from a possum-damaged pellet. The authors recommend that cyanide should not be used in areas in which weka are present and this has now been put into practice on DoC managed land (DoC SOP Assessing Applications for DoC Consent NH3008 v2.6). However, weka deaths from Feratox use could still occur outside the known range of weka and off public conservation land.

Fisher and Fairweather (2004) quote records of deaths during operations using cyanide.

Table O1: Non-target native species deaths

TABLE 4 NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING OPERATIONS USING CYANIDE

SPECIES	TOTAL FOUND DEAD	NUMBER OF OPERATIONS INVOLVED	NUMBER OF CASES WHERE RESIDUES CONFIRMED	SOWING RATE	REFERENCE
Feratox in bait bags					
Birds					
Weka	14	4	8	With prefeed paste Recent sign	Nelco-38812
Feratox in bait stations					
Birds					
Weka	3	3	1	With prefeed paste Ferafeed bait stations	(Peter Gaze & A MacAlister pers comm)
Weka	2	Unknown		Feratox in Kilmore bait stations	(Adrian Couchman pers comm)
Cyanide paste in bait bags					
Birds					
Weka	1	1	1		(Geoff Woodhouse pers. comm)
Cyanide paste in bait stations					
Birds					
Kea	1	1	1	With apple prefeed paste in a Romark bait station	(Mark Beardsley pers comm)

Source: Fisher and Fairweather, 2004

The applicants have stated that in drawing up the studies shown in Table O1, account was taken only of operations that included a single control technique and reported percentage kill.

Recent monitoring data are not available for species other than weka. The Agency concludes that in the absence of such data the risks of cyanide to other bird species are unknown.

Eason and Wickstrom (2001) quote (PCE 1994) stating that there have been several reports of sheep, cattle and dogs ingesting lethal amounts of recently laid baits.

O1.6.3 Exposure of non-target organisms to cyanide: Indirect

Exposure of non-target animals could occur through consumption of animals killed by cyanide or having received a sub-lethal dose. The only relevant information relates to Feratox pellets, and so this information has to be read-across to pastes.

Eisler (1991) reported that prompt analysis is required after poisoning for residue data to have any meaning, since cyanide can form in carcasses. It is assumed that this was done in the data that have been reported.

Morriss et al (2003) fed possums Feratox pellets embedded in peanut butter-based FeraFeed® and sampled body tissues at intervals up to 336 h after the possums died. The mean cyanide residues are shown in Table O2.

Table O2: Mean cyanide residue concentrations in possums killed by Feratox

Table 1 Mean cyanide residue concentration (± SE) present in possum tissue and blood after being killed by Feratox

Time (h)	Mean (± SE) cyanide residue			
	Stomach contents (μg/g)	Liver (μg/g)	Blood (μg/ml)	Muscle (μg/g)
0	589.8 ± 191.7	6.9 ± 0.8	14.8 ± 1.6	0.3 ± 0.1
6	292.3 ± 75.1	25.7 ± 7.1	27.8 ± 5.7	1.1 ± 0.4
12	64.9 ± 28.0	31.8 ± 11.0	NA	0.3 ± 0.2
48	94.0 ± 39.6	48.5 ± 15.0	NA	0.3 ± 0.1
168	14.0 ± 3.2	24.8 ± 3.1	NA	0.2 ± 0.1
336	1.9 ± 0.7	1.9 ± 0.6	NA	0.0

NA: not assessed

Source: Morriss et al (2003)

Using a dog bodyweight of 8.1 kg and an LD_{50} of 4.1 mg/kg, the authors conclude that a dog would need to eat 56 g or approximately half a possum's stomach contents to receive the LD_{50}. Six hours after a possum's death, the dog would have to eat a whole stomach contents. Residues in other tissues are unlikely to have been sufficiently high for such a dog to consume the LD_{50}. The authors stress that insect activity or warmer conditions in the field might lead to more rapid decrease in residues, but cooler conditions could lead to less rapid decrease. The applicants conclude that on this basis secondary residues *are probably insufficient to cause secondary exposure* (sic, result in exposure equivalent to the LD_{50}). Given the rate of decrease in residues after death and assuming that a dog would not eat stomach contents exclusively, this conclusion is justified for dogs. Clearly, a smaller predator than a dog would need to consume a smaller proportion of a possum's stomach contents. A 1 kg weka with an estimated LD_{50} of 10 mg/kg bw would have to consume approximately 14 g of stomach contents from a freshly killed possum to receive the LD_{50} and would have to open the stomach first.

Morriss et al (2003) also looked at whether Feratox pellets swallowed whole would kill possums. Six animals had a Feratox pellet placed down their throats. One animal subsequently died, 2 excreted the pellet partially digested and leaking cyanide (7-11 ug HCN/h when first recovered, 18-54 ug HCN/h, 3 days later, compared to 0.2-0.3 ug HCN/h for intact pellets) and the other three did not excrete the pellet and showed no signs of toxicity. Residues in the possum that died were 4.2 ug/g (liver) and 1.9 ug/g (stomach contents). Detected were 0.51 ug/g residues in the liver of one of the three possums that appeared to digest the pellets. Comparison of these data with those for possums that crushed the pellet (Table O2) indicates that residues in possums that swallow pellets whole are unlikely to cause a risk to dogs or other predators that subsequently consume them.

The Agency has no information on how frequently possums consume Feratox pellets whole.

Fisher and Fairweather (2004) report a range of residues in kea, weka and dog carcasses recovered during pest control operations.

Table O3: Cyanide residues in carcasses

TABLE 3 CYANIDE RESIDUE LEVELS RECORDED IN CARCASSES IN NEW ZEALAND DURING PEST CONTROL OPERATIONS

SPECIES	SAMPLE TYPE	RANGE OF RESIDUES (mg/kg)	REFERENCE
Birds			
Kea (*Nestor notabilis*)	Liver	1.2	VPRD[1]
	Stomach	0.15	VPRD
Weka (*Gallirallus australis*)	Liver	0.13 - 50	VPRD
	Muscle	0.51 - 4.33	VPRD
Mammals			
Dog (*Canis familiaris*)	Liver	0.39	VPRD

[1] VPRD = Vertebrate Pesticide Residue Database 2004

The information in this table has been derived from studies which carried out direct analyses of free cyanide in animal tissues following a lethal dose/death from cyanide poisoning

Source: Fisher and Fairweather (2004)

Fisher and Fairweather (2004) also quote G. Woodhouse (personal communication) giving a residue in weka of 26 mg/kg from a pest control operation using cyanide paste in bait bags.

O1.6.4 Risk to non-target organisms

The applicants considered that exposure of birds, other than weka, native mammals, terrestrial invertebrates and herpetofauna is not expected to occur. The Agency considers that the data on exposure and population monitoring during Feratox operations are insufficient to draw conclusions for anything other than weka. The Agency has interpreted effects on fauna in terms of effects on weka.

Use of Feratox pellets will lead to pellets falling to the ground, for example after rodent interference with bait bags. Such baits will be available to non-target organisms. A single pellet contains sufficient cyanide to kill birds and smaller mammals. More than one pellet would be needed to kill larger livestock. However, the ability of smaller animals to break the Feratox pellet has not been demonstrated. The only animals shown in trials and monitoring of field operations to be adversely affected by Feratox operations are weka. The kill of weka in such operations is anticipated to have a major effect on weka populations at a local level, although there is no population monitoring or modelling of long-term trials to determine whether this would lead to local extinction. Assuming that effects at a local level could lead to the viability of local populations, widespread use of Feratox could lead to an effect on the species' viability.

The impact on weka populations is sufficiently major that DoC have banned the use of Feratox on DoC land where weka are present.

The applicants considered that exposure of birds, other than weka, native mammals, terrestrial invertebrates and herpetofauna during the use of paste in contained situations is not expected to occur. The Agency considers that the data on exposure and population monitoring during cyanide paste operations are insufficient to draw conclusions for anything other than weka. The applicants consider that the likely magnitude of effect on weka will be minor, on the basis that few deaths have been reported through the use of cyanide paste in bait stations. The Agency concludes that given the dearth of information there is substantial uncertainty around this conclusion.

There are accounts of mortality during operations using hand-laid (uncontained) cyanide paste, including a lesser short-tailed bat and birds including tomtit, robin, silvereye, tui, weka and kiwi. There has been little research into the long-term impacts of cyanide poisoning on non-target species populations although the applicants state that effects at the population level are unlikely to be significant. Given the number of bird deaths DoC has stipulated that cyanide baits must be placed above 70 cm in areas where weka and kiwi are foraging. It is not known to what extent this has reduced the number of birds killed. The applicants estimated the magnitude of any effects to be minor, the likelihood unlikely (birds) and very unlikely (bats). The Agency concludes that given the dearth of information there is substantial uncertainty around this conclusion.

On the basis of the low residues seen in the carcasses of possums poisoned by cyanide, the Agency considers it improbable that secondary poisoning would occur.

O2 Trapping

O2.1 Use pattern

The applicant states that leg-hold and kill traps are used but does not discriminate between them in terms of their effects. Spurr (2000) quotes Warburton (1992) as stating that there is no evidence that different sorts of leg-hold traps result in different capture rates.

Kill traps of various designs are also available. The Timms trap was designed specifically for possums, but is not commonly used by commercial trappers due to its size, weight and inefficiency at catching possums (Miller 1993, in Warburton and Orchard 1996). Warburton and Orchard (1996) tested the killing efficiency of five models of kill-trap used at that time and concluded that only one of them met all the standards set in a draft ISO standard under development at that time (Warburton and Orchard, 1996 ref Gilbert 1991). The Agency has no information on the extent of use of kill traps today.

Henderson et al (1999) state that traps are set at sites frequently used by possums. Generally 5-15 traps are set per hectare for at least three nights. Traps should be visited every 24 h. In areas with ground birds, traps can be placed in trees with similar capture efficiency to those placed on the ground.

O2.2 Non-target animals

Consideration of the risks traps pose to non-target species is restricted to field information on the catch rate and kill/maiming rate of caught animals. The applicant considered birds only.

O2.2.1 Weka

Weka are ground foraging birds and their weight is sufficient to trigger traps set for possums. The applicant states that:

> Significant numbers of weka have been caught where they gain access to traps. For example, traps have been used as a tool for eradicating weka introduced to some offshore islands, for example, Whenua Hou. Where weka numbers are low or in decline, the numbers accidentally caught during pest control operations can place weka populations in jeopardy.

The applicants also state that during the eradication of possums from Kapiti Island between 1980 and 1987, all practical precautions were taken to minimise bird captures (Spurr 2000) and accidental captures of ground birds, including weka were reduced by raising leg-hold traps 700 mm above the ground. Based on these results, DoC introduced Standard Operating Procedures that require traps being used on lands managed by the Department, where ground birds are known to be present, to be set 700 mm above the ground, either on platforms, attached directly to tree trunks, or attached to a sloping board set at 38º to the ground. To comply with these guidelines the National Possum Control Agencies have developed a raised trap set protocol for monitoring possum control operations.

However, research has shown that weka are able to jump 90 cm (but not 100 cm) and can walk up boards and poles sloped at up to 45º (but not 55º)(Thomson et al 2001). Sweetapple et al (2006) also looked at kill-traps fitted with weka excluder devices and concluded that the devices needed modification before they could be recommended. They also recommended that the possum-killing efficiency of traps set >1 m above the ground needs to be compared with weka-excluded traps on the ground and leg-hold traps on boards.

The applicants state that:

> catch rates of weka have been reduced since the implementation of DoC guidelines on trap heights, [but] weka continue to be caught in traps during pest control operations. It is thought that the current capture rates are not high enough to have a significant population level effect.

However, the effectiveness of the new guidelines is not known since a consolidated report has not been compiled since the new guidelines were introduced (Sara Clark, personal communication).

O2.2.2 Kiwi

Reid (1986) reported on trappers tallies from Urewera National Park. Over the period 1979-1983, among those trappers that mention non-target kills the following trap and other (cyanide) kills were reported:

Table O4: Trap and other (cyanide) non-target kills

	Opossum	Rats	Cats	Mustelids	Deer	Pigs	Kiwi
Number killed	150,000	17,960	565	437	572	584	14
Ratio	10,720	1,280	40	31	41	42	1

Source: Reid, 1986

Since, the total number of possum killed in the park over this period is 800000. The number of kiwi killed would extrapolate to 75.

Reid (1986) also reported on a survey of 59 trappers working throughout New Zealand in areas where kiwi were known or believed to be present, showed a kiwi:possum kill ratio of 1:10800, that broke down to 1:16700 from poisoning, 1:3500 from trapping. The report from Reid (1986) states that 60-65% of the trapped kiwi were released (particularly those caught by one or two toes or suffering only a bruised or strained upper leg), about half of the remainder were packed out for veterinary or other treatment and the remainder were ‘put down’.

Reid (1986) extrapolates from these numbers to assume that over the period 1977-1983 the average number of kiwi lost nationwide to possum hunters (trapping and cyanide), would be 175 birds. The relevance of these figures today is not known, the intensity of trapping may have changed and populations have decreased. For example, in the late 1990’s the north island brown kiwi was estimated to be decreasing by 5.8% a year (McLennan et al, 1996). Reid (1985) provided slightly different figures presumed to be based on a preliminary analysis of the same survey.

The catch rates reported by Reid (1986) may nevertheless represent a significant percentage of the kiwi population. McLennan et al (1996) report that extensive surveys showed that about 10% of adult kiwi had damaged feet or toes, which they attributed to having been caught in leg-hold traps over the previous two to three decades. The authors add that the actual catch rate will be higher taking account of birds injured fatally, and the natural attrition of the ‘marked’ population that will have occurred if the incidence of trapping has reduced. They estimate that taking account of fatal trappings would increase the catch rate by 30-50% above that indicated by the number of maimed birds. The authors conclude that while they have no measures of annual mortality rates attributable to traps and cyanide, in years of high fur prices, such losses may exceed 5% and significantly reduce the average longevity and lifetime of kiwi in mainland forests.

The applicants refer to the measures taken to reduce catch of ground birds during the eradication of possums from Kapiti Island that led to DoC guidelines stipulating that traps be set 700 mm above the ground, either on platforms, attached directly to tree trunks, or attached to a sloping board set at 38º to the ground. They state that this has significantly reduced kiwi death although occasional deaths and injuries in traps still occur outside kiwi's known range or where the guidelines have not been followed.

O2.2.3 Other birds

Blue penguin (*Eudyptula minor*), paradise shelduck (*Tadorna variegata*), brown teal (*Anas aucklandica*), Australasian harrier (*Circus approximans*), pukeko (*Porphyrio melanotus*), southern black-backed gulls (*Larus dominicanus*), kereru (*Hemiphaga novaeseelandiae*), kakapo (*Strigops habroptilus*), kaka (*Nestor meridionalis*), kea (*Nestor notabilis*), kakariki (*Cyanoramphus* sp), long tailed cuckoo (*Eudynamys taitensis*), morepork (*Nonox novaeseelandiae*), pipit (*Anthus novaeseelandiae*), fantail (*Rhipidura fuliginosa*), tomtit (*Petroica macrocephala*), robin (*Petroica macrocephala*), bellbird (*Anthornis melanura*), tui (*Prosthemadera novaeseelandiae*) and kokako (*Callaeas cinerea*) have all been caught in traps. Most of these birds have been caught in leg-hold traps that have been set on the ground without surrounding barriers to reduce accidental capture of non-target species. Spurr (2000) states that setting traps off the ground has reduced non-target mortality but adds that traps raised to protect native ground birds have a higher risk of trapping birds such as kereru, morepork, and kaka (Spurr 2000).

Measures have been proposed to reduce bird captures (eg, by placing traps on sloping boards about 0.7 m above the ground). These were used during the eradication of possums from Kapiti Island and resulted in only 181 birds during 1.4 million trap-nights. These were kereru (39%), moreporks (26%), weka (16%) and kaka (9%). No kiwi were caught despite being present on the island (refs in Spurr 2000).

Spurr (2000) notes that these records of bird by-catch include some very small species (eg, fantail, 8 g) indicating that the traps must have been set very lightly.

Little research has been carried out on the long term impacts of trapping on populations of non-target birds (Spurr 2000), but the applicants conclude that "While individual birds will continue to be caught and killed or injured by traps, it is unlikely that there will be a population level effect".

O2.2.4 Other animals

The applicants supplied no information on anything other than birds, stating that native ground birds are the non-target species caught in traps most often. Spurr (2000) reviewed the available literature and concluded that hares *(Lepus europaeus)*, rabbits *(Oryctolagus cuniculus)*, goats *(Capra hircus)*, pigs *(Sus scrofa)*, hedgehogs *(Erniaceus europaeus)*, rats *(Rattus spp.)*, cats *(Felis catus)*, ferrets *(Mustela furo)*, stoats *(Mustela erminea),* dogs (*Cais familiaris*), sheep (*Ovis aries*), cattle (*Bos Taurus*) and horses (*Equus caballus*) had all been caught in traps, with rats being the most frequently caught non-target mammals.

O2.2.5 Risk to non-target organisms

The monitoring data indicate that traps laid on the ground do catch weka and kiwi in significant numbers and there are sporadic accounts of other species also being caught. In response DoC has introduced new guidelines specifying that traps should be elevated in areas where ground birds are known to occur. It is not known how successful this has been in reducing kill of non-target species. There is some indication that weka, at least, may still be able to access traps set according to the DoC guidelines. Thomson et al (2001) who recommended changes to trapping practice in areas with kiwi and/or weka acknowledged that setting traps above the ground is more onerous for the trapper and so leads to less efficient trapping (fewer traps set for the time spent trapping).

O3 Target species: Efficacy

The applicants provided no data on the efficacy of possum trapping, stating (p 391 of the application):

> It is neither possible nor useful to compare efficacy of cyanide to 1080 operations, as cyanide is only registered for the control of possums and it cannot be applied aerially in New Zealand.

The Agency has collected some information on possum-trapping efficacy of different methods including cyanide and trapping and 1080 (aerial and ground-based. The Agency has not collected information on other pest species that may be affected by cyanide, but does note that cyanide is not registered for the control of other species.

The Agency has collected some information on efficacy of cyanide and trapping, some of which is relevant to 1080.

Spurr (1991) references Brockie 1982 and Morgan and Warburton 1987 stating that the reduction in possum numbers as a result of commercial hunting using cyanide/trapping perhaps averages 40%, but adds that complete eradication is possible, as on Kapiti Island.

Henderson et al (1999) reports on questionnaires sent to DoC district managers and private contractors during 1994 (143 responses) and 1998 (112 responses) to assess the types of control used on conservation lands and the effectiveness of these strategies. The results show that from 1994 to 1998 there was an increase in usage of 1080 bait stations, a decrease in the use of traps and that Feratox has largely replaced cyanide paste in bait stations. The average kill achieved with cyanide alone (encapsulated or as paste), was 70% compared to 85.5% for 1080 bait stations and 87.9% for 1080 aerial. Use of traps and cyanide resulted in intermediate kills. The results are shown in the table copied below (Table O5).

Table O5: Results of Department of Conservation questionnaire on efficacy of different possum control methods

TABLE A2.2. EFFECTIVENESS OF DIFFERENT METHODS OF CONTROL (MEASURED AS PERCENTAGE KILL OR RESIDUAL TRAP-CATCH) AND THE COST PER HECTARE OF EACH METHOD. THE COSTS FOR AERIAL CONTROL INCLUDE ADMINISTRATION OVERHEADS (PLANNING AND MONITORING), WHILE FOR GROUND CONTROL THE COSTS ARE CONTRACT PRICES PAID TO HUNTERS OR DEPARTMENTAL COSTS INCURRED DURING CONTROL (I.E. COSTS EXCLUSIVE OF ADMINISTRATION OVERHEADS).

METHOD OF CONTROL REPORTED	PERCENTAGE KILLS OR RESIDUAL TRAP CATCH (%) FOLLOWING INITIAL AND MAINTENANCE CONTROL ± 95% C.I. (NUMBER OF RESPONCES IN PARENTHESES)				COSTS PER HECTARE OF CONTROL IN 1988 $* ±95% C.I. (NUMBER OF RESPONSES IN PARENTHESES)	
	PERCENTAGE KILL		RESIDUAL TRAP CATCH		INITIAL	MAINTENANCE
	INITIAL CONTROL	MAINTENANCE CONTROL	INITIAL CONTROL	MAINTENANCE CONTROL		
Aerial	87.9 ± 4.4 (n = 15)	39.0 (n = 4)	2.2 ± 1.7 (n = 7)	2.9 ± 6.0 (n = 5)	$24.47 ± 5.54 (n = 25)	$18.60 ± 5.64 (n = 7)
Bait stations (1080) control	85.5 ± 19.3 (n = 6)	NR	3.3 ± 2.1 (n = 6)	NR	$18.90 ± 11.0 (n = 3)	NR
Bait stations (brodifacoum)	85.6 ± 10.1 (n = 5)	72.4† (n = 9)	1.3 ± 0.8 (n = 4)	1.8 ± 1.3 (n = 24)	$57.14 ± 31.30 (n = 5)	$28.77 ± 8.95 (n = 8)
Bait stations (cholecalciferol)	76.3 ± 8.0 (n = 3)	NR	NR	NR	$30.50 ± 6.12 (n = 10)	$34.67 ± 7.50 (n = 4)
Traps and cyanide	78.8 ± 7.1 (n = 13)	69.8 ± 17.1 (n = 5)	4.9 ± 1.2 (n = 31)	4.2 ± 1.5 (n = 9)	$18.04 ± 2.69 (n = 19)	$12.25 ± 5.03 (n = 9)
Traps only	79.2 ± 14.8 (n = 5)	78.6 ± 13.7 (n = 7)	5.1 ± 6.0 (n = 4)	3.3 ± 1.1 (n = 6)	$19.00 (n = 1)	NR
Cyanide only	70 ± 17.0 (n = 6)†	NR	NR	5.1 (n = 1)	NR	NR
Encapsulated cyanide	70 ± 0.5 (n = 3)	NR	7.2 ± 3.2 (n = 5)	NR	NR	NR
1080 paste	63.0 (n = 1)	NR	3.5 (n = 1)	4.1 (n = 3)	$10.61 (n = 1)	$10.73 ± 7.59 (n = 5)

* Includes costs previously reported by: Morriss & Henderson (1997), Montague (1997), Warburton & Cullen (1993), Thomas et al. (1995), Thomas et al (1996), and Henderson et al. (1997a).
† Includes trials undertaken by Landcare Research.
NR = Not Reported.

The Agency notes that Feratox came onto the market in 1997 and there was relatively little field experience of its use when this review was performed. Furthermore, since this review, the use of Feratox on DoC land will have reduced since it is no longer used where weka are present.

The effectiveness of aerial 1080, bait-station 1080 and trapping was compared in 1200 m x 1200 m blocks within the Pureora Forest (Warburton and Thomson 2002). Each treatment was applied to two trial blocks, except the untreated control which was not replicated. All blocks, except the untreated control, were treated in Year 1. In Year 2 all plots were treated except Hunter Block 1 and the Untreated Control (Table O6).

Table O6: Results of comparative trial in Pureora Forest

	Year 1			Year 2			Year 3			Year 4
	Before treat	After treat	% kill	Before treat	After treat	% kill	Before treat	After treat	% kill	No treat-ment
Aerial 1 1080[1]	10.2	4.4	56.7	7	0.6	91.1	1.9	No treatment		5.7
Aerial 2 1080[1]	28	10.7	62	15.9	1.2	92.2	7	No treatment		3.9
Bait-station 1 1080[2]	16.3	0	100	10.1	0	100	1.3	No treatment		5.1
Bait-station 2 1080[2]	11.3	1.3	88.8	17.6	0	100	0	No treatment		1.9
Hunter 1 cyanide/trap[3]	17.6	4.4	75.1	3.7	Not treated		6.4	No treatment		4.4
Hunter 2 cyanide/trap[3]	19.7	3.1	64	9.4	1.3	86.6	9.4	1.9	79.8	5.1
No treatment	16.4	Not treated		14.9	Not treated		3.8	No treatment		5.7

Source: Warburton and Thomson, 2002.

Notes

1 Year 1, 0.15% 1080 in RS5 cereal pellet bait at 5 kg/ha; Year 2, pre-fed with carrot, then 0.08% 1080 at 15 kg/ha.

2 Pre-fed twice with non-toxic RS5 cereal baits, then followed with 500 g 0.15% 1080 RS5 bait. Bait left for 1 week. All baits (non-toxic and 1080 treated), lured with 0.1% cinnamon.

3 Trappers user primarily traps with a small amount of cyanide paste. Trappers effort limited to $25/ha.

The authors estimate the cost of these trials (Table O7).

Table O7: Cost of comparative trial in Pureora Forest

Treatment	Total cost/ha ($)
Aerial RS5 cereal pellets	23.00
Aerial carrot (pre-fed)	23.00
Hunter	25.00
Bait-station Year 1	25.14[1]
Bait-station repeats	12.66[2]

Source: Warburton and Thomson, 2002.

Notes

1 Costs based on $20/hr and bait-station costs depreciated over 5 years.

2 Includes time, bait and 20% bait-station costs.

The authors estimate the rates of immigration to these comparatively small plots and the confusion introduced by different treatments to the surrounding forest. The Agency therefore limits its conclusions to a comparison of the percentage kill in the different areas, which indicates that trapping can be as effective as aerial application.

Speedy (2003) reported the results of a block-replicated trial performed in the Kaimanawa Forest Park (Hatepe Trial), to compare the effects of 1080 baits via bait stations (pre-fed), cholecalciferol (FeraCol) baits in bait bags (pre-fed), encapsulated potassium cyanide (Feratox) and trapping, contractors' choice of ground control method (Feratox, trapping and dogs) and aerial application of 1080. The trial site was divided into four blocks each divided into five sectors. The total area subject to each treatment was approximately 1000 ha. The contractors were given performance targets of 3% RTCI and no more than four possums per line of 10 traps (five lines per sector). If the performance target was not reached, the contractor's repeated the treatment. The cost of each treatment was recorded in detail, but is included in the Table O8 for information. The efficacy of the different treatments is shown in Table O8.

Table O8: Results of comparative trial in Pureora Forest

Method	Time to complete (days)	Re-work required	Final result (% RTC) all sectors combined	Post-operational rat index (%)	Standardised cost ($/ha)
1080 in bait stations (pre-fed)	115	Sector W1 – no re-work required Sector C1 – Partial re-work required (gap in original treatment) Sector W1 – Partial re-work required Sector S1 – No re-work required	1.32 (all sectors passed)	0	43.45
Cholecalciferol in bait bags (pre-fed)	66	Sector E2 – 1 re-work Sector C2 – RTC 6.7% but not re-worked Sector W2 – RTC 3.3%, but not re-worked Sector S2 – no re-work required	3.54 (Two sectors failed)	10	37.46
Feratox and trapping	142	Sector E3 – 2 re-works required Sector C3 – 1 re-work required Sector W3 – 1 re-work, final RTCI 3.34 Sector S3 – no re-work required	2.56 (one sector failed)	70	43.80
Contractors' choice (Feratox, trapping and dogs)	131	Sector E4 – no re-work required Sector C4 – 1 re-work Sector W4 – no re-work required Sector S4 – no re-work required	1.34 (all sectors passed)	60	36.77
Aerial 1080 carrot (pre-fed) + deer repellent	8	No-rework in any sector required	0.17 (all sectors passed)	0	26.25[a] 20.25[b]

Source: Warburton and Thomson, 2002.

a With deer repellent.

b Without deer repellent.

A pairwise comparison of efficacy indicates that Feratox and contractor's choice was equally effective but the amount of re-work suggests that the treatments were less efficient.

In an appendix to Speedy (2003), James Ross modelled the frequency of application needed to maintain a possum density of about 2 possums/ha as indicated by an RTCI of <5%. The model he developed took account of the efficacy observed in the above trial, population parameters (intrinsic rate of increase = 30%, Carrying capacity = 10 possums/ha) and bait shyness (for 1080 and cholecalciferol only, since the Feratox treatment 'mopped up' bait shy animals using trapping) but details of the model are not presented in Speedy (2003). The simulation took as a starting point a population density of 10 possums/ha and concluded as in Table O9.

Table O9: Modelling of efficacy of different control methods based on data from Pureora Forest trial

Frequency of treatment	Aerial 1080		1080 Bait stations		Feracol		Feratox and trapping		Contractors' choice	
	Density[a]	Cost[b]	Density	Cost	Density	Cost	Density	Cost	Density	Cost
1			1.16	294	1.77	246	1.28	296	1.14	245
8 out of 10 yrs					**1.99**	**208**				
2	1.49	72	**1.76**	**154**	2.70	129	**2.03**	**155**	**1.78**	**128**
3	**2.07**[c]	**55**	2.47	119			2.91	120	2.54	99
4	2.59	44								

Source: Warburton and Thomson, 2002.

Notes

a Possums/ha.

b Accumulated discounted cost/ha.

c Figures shown in bold throughout the table show the frequency of application judged to be most cost-effective, that is, achieving a possum density close to 2 possums/ha.

The author notes that the performance of the treatments using Feratox (Feratox and trapping, Contractor's choice) may have been affected by poor coverage by the contractor, as determined by random audit, rat interference with the bait, bad weather and possibly bait shyness as a result of a long history of extensive use of cyanide paste in the area. The author also notes that the contractors made little use of trapping and dogs especially in the first treatment.

The Agency concludes that based on this study, achieving a target possum density of 2 possums/ha, may need treatment with Feratox every 2 years whereas aerial 1080 treatment would achieve the same population if made every 3 years.

Fisher and Fairweather (2004) provide figures on possum kill for selected pest control operations (Table O10).

Table O10: Efficacy results of trials using cyanide

TABLE 10 RESULT MONITORING FROM PEST CONTROL OPERATIONS WHERE CYANIDE WAS USED

Feratox in bait bags for possum control			
KILL	LOCATION	SOWING RATE	REFERENCE
100%	Hopkins River winter 2003	Feratox in prefeed paste in bait bags (prefed)	dme: TWIAO-13595

Handlaid cyanide for possum control			
KILL	LOCATION	SOWING RATE	REFERENCE
90%	Raetea Forest Kaitaia July 2003	Handlaying of Cyanara Ferapaste (prefed)	PESTLINK: 0203KAI16
78 7%	Raetea Forest, Kaitaia Mar – May 2003	Handlaying of Cyanara Ferapaste (prefed)	PESTLINK: 0203KAI16
87 9%	Raetea Forest, Kaitaia Mar - -May 2003	Handlaying of Cyanara Ferapaste (prefed)	PESTLINK: 0203KAI16

Combinations for possum control			
KILL	LOCATION	SOWING RATE	REFERENCE
100%	Raetea Forest Kaitaia May - June 2003	Feratox in bait bags (pre-fed) and traps	PESTLINK: 0203KAI16
28 1%	Mimiwhangata, Northland, April 2003	Feratox in ferafeed paste in bait bags and handlaid Cyanara ferapaste	PESTLINK: 0203WNG37
75 3%	Puketi/Omahuta Nov-Dec 2002	Feratox in bait bags and cyanide paste handlaid	PESTLINK: 0203KEK26
52 6%	Puketi/Omahuta Nov-Dec 2002	Feratox in bait bags and cyanide paste handlaid	PESTLINK: 0203KEK26
73 3%-100%	6 Blocks Lake Waikaremoana Aniwaniwa AO June 2000 – Jul 2001	Cyanide Paste for Possum Destruction handlaid & traps set on recent sign	PESTLINK: 0203ANI03

Source: Fisher and Fairweather, 2004.

O3.1 Risk to biodiversity from efficacy of cyanide/trapping compared with 1080

The Agency collected some information on the % possum kill and RTCI from cyanide/trap operations. The data are variable. In some studies cyanide is as effective as 1080, in others it is less effective. Given the uncertainty the Agency ascribes a likelihood of effect as unlikely to likely.