Appendix N: Exposure and Risk Assessment (1080): Non-Target Species

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Key points

Evaluation of literature on the effects of 180 usage are complicated due to the variable reporting of the 1080 formulation used. It is recommended that all reports and papers relating to research and monitoring should include the trade name of the product being evaluated to allow for correct cross-referencing in the future.

Birds

Birds are at risk from exposure to 1080 baits. The nature of the risk varies depending on the bait used, the species' food and foraging habits. Monitoring has indicated deaths of individual birds and modelling of exposure indicates that exposure both to fragments of bait and to residues in bird's food could be sufficient to cause effects.

Risks to bird populations will be dependent on species' dispersal abilities, which affect their colonisation of treated areas, breeding strategies which affect their potential to replace individuals and local abundance which affects both potential for immigration and population recovery by breeding.

Key bird species have been subject to increased monitoring and no direct population level impacts attributable to 1080 poisoning have been identified. However, there have been instances where the use of 1080 has not been successful in adequately managing the risks of predation. Effective, well-timed (coincident with bird breeding periods), and widespread pest control is required in most cases to protect vulnerable species from on-going predation pressure. Considerable work is in progress to improve the efficiency of pest control, and potentially reduce the frequency of control under some circumstances. Research is also in progress to further address the complexities of multiple-pest species management.

Deaths of tomtits and robins have frequently been reported after aerial 1080 operations, but these species, while clearly vulnerable to poisoning, are both capable of wide dispersal and have a high reproductive capacity. In the absence of other significant impacts such as severe weather during key stages of their breeding cycles or high rates of on-going predation, impacts are likely to be short-term. Improvements in bait quality/preparation and reduced sowing rates have contributed to fewer deaths of individual birds, as indicated by monitoring results.

While there is less certainty around the impact of competition by pest species for available food resources, there is sufficient evidence to suggest that such competition can occur for some species, and that widespread pest control can contribute to improved food availability and potentially to improved breeding success.

Risks are related to a series of recommendations that require further investigation.

- **Peanut-based pastes**
  One currently registered paste is peanut-based (Pestoff Exterminator 0.15% registered by ACVM 2003). Testing has shown that of a number of baits tested, peanut is more attractive to native bats than some of the other types of bait. This product is applied in bait stations only (clarified in additional information from applicants 13 February 2007). However, the HSNO control currently for ‘paste containing 1.5 g/kg 1080’, which also covers a fruit-based paste, states ‘ground-based application’ which is less restrictive than ‘contained ground-based application’. Consideration is needed to either:
  - split the current approval to contained and non-contained uses
  - make the entire substance for use in contained applications.
- **Apple-based pastes**
  There have been calls to restrict the use of these pastes. Morgan et al (1997) recommends use of Pest-off Professional off the ground/in bait stations when weka, robins and pukeko likely to be present and Morgan 2000 recommends not using apple paste when the weather is likely to be hot and windy, or on very absorbent, dry, sandy soils due to bait dehydrating.

- **Soluble concentrate containing 20% 1080**
  Consideration needs to be given to restricting the use of soluble concentrate containing 20% 1080 perhaps to bait stations only.
- **Carrots**
  Consideration needs to be given to ways to restrict fines in carrot bait.
- **Oats**
  Treated oats are not allowed on Department of Conservation (DoC) land due to high risk to non-target organisms. Consideration needs to be given to remove grain/oats as an acceptable bait material or to require greater evaluation of risks to non-targets before use

The Agency considers that further trials with bird repellent may be warranted given the problems with trials performed to date, that include lack of replication, issues with monitoring possum indices after the trials and less-than-target toxic loading on the carrot.

Bats

Monitoring data do not indicate a high likelihood of direct poisoning from feeding on baits or mortalities from secondary poisoning. However, given the low reproductive rate of <1 young/adult female per year there is little scope for the populations to sustain the loss of many individuals (Lloyd 1994).

Invertebrates

Due to the level of uncertainty in the toxicity data for invertebrates, and the lack of information on amounts of bait likely to be eaten, the Agency has not attempted to assess direct exposure to invertebrates. Available monitoring data indicate that invertebrates which feed on baits are not adversely affected at a population level, and the extent of any impact is very localized to within a short distance of a toxic bait. While invertebrates feeding on poisoned animal carcasses may be exposed to 1080 residues, the Agency has not assessed exposure from this source. Any effects are likely to be minimal.

Overall, the Agency considers the risks to invertebrate populations from direct and indirect exposure to 1080 to be very low to medium.

Reptiles and amphibians

The Agency has insufficient information to evaluate the attractiveness of currently used baits to skinks and has made no quantitative assessment of the risks of 1080 to skinks. The Agency has made no assessment of risks to frogs, but notes that several monitoring trials have been performed and have shown no evidence of effects on frogs.

Dogs and deer

Deaths of dogs from both primary and secondary poisoning have been reported.

Deer are killed by 1080. Addition of deer repellents has been trialled, but monitoring of its effectiveness has been patchy and frequently inconclusive. There is also an issue in that repellent applied to cereal bait changes its colour such that it is not HSNO Act compliant. Given the complexity of the issues, and the very site-specific nature of deer management, the Agency does not consider that at this stage it is feasible to add a control to any substances containing 1080 that would require the use of a deer repellent.

Aquatic biota

No effects are likely based on the number of baits that have been recorded falling into streams. Monitoring of effects on aquatic biota has been confounded by flooding, but no effects have been recorded.

N1 Background

The detailed ecotoxicity hazard assessment of substances containing 1080 is included in Appendix C, detailed monitoring of target and non-target species is in Appendix F, and environmental media in Appendix E.

The overall approach taken to estimating the exposure of non-target species to 1080 in this appendix is to evaluate potential attractiveness and palatability of various bait formulations, residues in food which may be consumed, and how much of each may be consumed by the species of interest.

In order to assess the risk to an individual, the toxicity (hazard) of 1080 is also considered and incorporating the amount of contaminated food ingested, assimilation efficiency and metabolic activity of the species of interest.

The underlying concern from an ecological perspective is survival of self-sustaining populations. The monitoring data reviewed in Appendix F is drawn on in reaching conclusions on risks to populations of non-target species from the use of substances containing 1080. The Agency has made no attempt to model changes in non-target populations over time given differing levels of pest control with or without 1080.

N1.1 Residues of 1080 in biota

A summary of the 1080 residues which have been reported in various biota is in Table N1. More details on the sources of these values can be found elsewhere in the Evaluation and Review (E&R) Report as noted. The biota residue data will be used in different sections of this appendix for estimating the secondary exposure of consumers to 1080.

Table N1: Residues of 1080 measured in New Zealand biota

Species	Tissue sampled	1080 residues (mg/kg[b])			Field (F) or lab (L) data	Reference
		Min	Max	Mean		
Aquatic species						
Long-fin eel, *Anguilla dieffenbachia*	muscle	0.003	0.32	0.0174 ± 0.0104	L	Lyver et al 2004[a]
Koura/freshwater crayfish, *Paranephrops planifrons*	Tail muscle	-	5	~ 1.2 at Day 1 ~ 0.2 at Day 8	L	Suren and Bonnett 2004[a]
	Viscera	-	3.3	~1.5 at Day 1 ~0.25 at Day 8	L	
	Viscera + muscle	-	7.7		L	
Aquatic plant (assemblage of species)	-	-	0.051 after 1 hour 0.027 after 24 hours 0.005 after 100 hours		L	Eason et al 1993 [a]
Terrestrial Invertebrates						
Striated ant, *Huberia striata*	Whole			5.51 (fed sugar water containing 0.03% 1080 – sub-lethal) 4.78 mg/kg (fed cereal bait containing 0.15%)	L	Booth and Wickstrom 1999[a]
Garden snail, *Helix aspersa*	Whole		1.9 mg/kg after exposure at 500 mg/kg dw soil 23 mg/kg after exposure at 1000 mg/kg dw soil 61 mg/kg after exposure at 1500 mg/kg dw soil		L	O'Halloran and Jones, 2003[a]
Earthworms, *Aporectodea calliginosa*; *Eisenia fetida*	Whole	-	<LOD	-	L	O'Halloran and Jones, 2003[a]
Pooled sample of invertebrates collected from cereal baits containing 0.15% 1080	Whole	12	130	57 ± 25.6 (n=68)	F	Lloyd and McQueen 2000

Species	Tissue sampled	1080 residues (mg/kg[b])			Field (F) or lab (L) data	Reference
		Min	Max	Mean		
Spiders	Whole	14 (n=4)			F	
Cave weta, *Gymnoplectron tuarti*	Whole		130 (n=2)		F	
Tree weta, species unknown	Whole	-	5.8 mg/kg at 4 and 12 hours 5.0 mg/kg at 24 hours 2.8 mg/kg at 48 hours 4.5 mg/kg at 96 hours 0.2 mg/kg at 144 hours 0.033 mg/kg at 240 hours	-	L	Eason et al 1993[a]
Plants						
Rye grass, *Lolium perenne*	shoots			0.08 at Day 3 LOD at Day 7	L	Ogilvie et al 1998[a]
Broadleaf, *Griselinia littoralis*	Whole seedling			0.06 at Day 10 LOD at Day 38	L	Ogilvie et al 1998[a]
Pikopiko, *Asplenium bulbiferum*	Frond			<LOD (0.002)	F	Ogilvie et al 2006[a]
Karamuramu, *Coprosma robusta*	Leaves			0.005 at Day 7 0.0025 at Day 14 <LOD (0.002) at Day 28	F	Ogilvie et al 2006[a]
Vertebrates						
Birds						
tomtits	muscle	1.3	1.9	1.6 (n=3)	F	Powlesland et al 2000[a]
robins	muscle	0.37	3.8	1.7 (n=3)	F	Powlesland et al 1999[a]
blackbirds	muscle	7.2	32		F	Morriss et al 2005[c]
Possum	Stomach contents			30.6 at Day 25 4.9 at Day 75	F	Meenken and Booth 1997[a]

Notes

a For further details, see Appendix C.

b Fresh weight basis unless otherwise specified.

c This appendix – cereal bait deer repellent trial.

N2 Terrestrial biota

N2.1 Birds

N2.1.1 Attractiveness and palatability of baits

Cereal and carrot

In circumstances where threatened species are perceived as being at risk of exposure to 1080 baits, palatability trials using non-toxic and toxic baits may be undertaken in advance of an aerial 1080 operation to determine the most suitable bait type. A couple of examples are summarised below.

At Waipoua Forest, brown kiwis (*Apteryx australis*) were exposed to non-toxic, brown, cinnamon-lured Wanganui cereal bait containing Rhodamine B, a fluorescent marker dye (Pierce and Montgomery 1992). Scats were collected for three weeks and examined for residues of the marker dye. Of the 17 scats collected, two contained dye. Observations were also made of several kiwi probing for food near baits without them actually contacting the baits. In a parallel trial with toxic baits (0.08% cereal, dyed green, cinnamon-lured) five kiwi with radio-transmitters were monitored after baits were hand-sown into their home ranges at approximately 1 bait/10 m^2. All birds survived the trial, and also survived the full-scale aerial operation.

The acceptance of carrot bait by kaka (*Nestor meridionalis*) was assessed on Kapiti Island in May 1993 by aerial sowing non-toxic bait, dyed green over ~170 ha of forest at a target rate of 10 kg/ha (Lloyd and Hackwell 1993). The baits were also coated with 0.3% v/w pyranine as a fluorescent marker and 0.1% v/w cinnamon oil. The baits were screened, but not very well, with a high proportion of baits (31% by weight) < 5mm long. Caged kaka at the Wellington Zoo were given carrot treated with pyranine with no signs of any aversion to the treatment. Baits were regularly inspected for signs of feeding within eight 100 m^2 plots. Kaka were captured in the drop zone and at feeders by the ranger's house and examined for traces of marker dye; droppings from the feeders were also examined. Of the 'many hundreds' of baits examined only three baits over a kilometer apart showed beak marks by kaka but no sign of actual consumption. Twenty kaka were captured and caught in the 11 days after bait application, with five recaptures. Only one showed signs of the tracer dye. Of the droppings examined, those from a number of different species showed fluorescence, including: 10/87 weka droppings; one kereru, one small passerine; one weta. Of five kiwi (*Apteryx oweni*) droppings examined, none fluoresced. A large number of kaka droppings were examined from the feeders, with none showing any fluorescence. The authors concluded that kaka may be at risk from consuming carrot bait, with juveniles more likely to consume bait than adults, with the risk influenced by the abundance of natural food at the time of aerial application.

A summary of birds known to consume either carrot or cereal bait used in 1080 operations is in Table N2, adapted from Spurr and Powlesland

(1997). Introduced species have been included by the Agency based on monitoring data from Appendix F.

A number of bird species are known to have consumed cereal-based baits containing brodifacoum used during aerial rat eradication operations and subsequently died, these include; little spotted kiwi, brown teal, spotless crake, kakariki, and pukeko (Spurr and Powlesland 1997) indicating potential for these species to also consume cereal baits containing 1080.

Table N2: Birds known to consume cereal or carrot baits used in aerial 1080 operations: Summary

Species	Bait type eaten		Found dead after 1080 operation		Possible risk of secondary poisoning	1080 residues found in body tissues
	Cereal	Carrot	Cereal	Carrot		
Native species						
Kereru	?	yes	no	yes	?	yes
Kaka	yes	yes	no	yes	?	yes
Robin	yes	yes	no	yes	?	yes
Tomtit	yes	yes	?	yes	?	yes
Rifleman	?yes	?yes	?	yes	?	yes
Kea	yes	yes	no	yes	?	yes
Morepork	no	no	yes	yes	yes	yes
Weka	yes	yes	yes	?	yes	yes
Kiwi	?	yes	no	no	?	no
Whitehead	yes	yes	?	yes	?	yes
Fernbird	?yes	?yes	no	no	?	no
Yellowhead	?no	?no	no	no	?	yes
Falcon	no	no	no	no	yes	no
Pukeko	yes	yes	no	?	?	?
Kakariki	yes	yes	no	no	no	no
Brown creeper	?	?	no	no	?	no
Yellowhead	?	?	no	no	?	no
Grey warbler	?	?	?	yes	?	?
Fantail	?	?	?	yes	?	?
Silvereye	yes	yes	?	yes	?	?
Bellbird	?	?	no	no	?	no
Tui	?	?	no	yes	?	?
Kokako	yes	yes	yes	no	no	yes
Saddleback	yes	yes	no	no	no	no
Black-back gull	?	?	no	yes	yes	yes
Introduced species						
Blackbird	yes	yes	yes	yes	?	yes
Chaffinch	yes	yes	yes	yes	?	yes
song thrush	?	yes	?	yes	?	?
Dunnock	?	yes	?	yes	?	?
Redpoll	yes	yes	yes	yes	?	?
goldfinch	?	yes	?	yes	?	?
yellowhammer	?	yes	?	yes	?	?

Note: ? = uncertain or not assessed.

Other bait types

Cut apple

The attractiveness to native birds of prepared non-toxic apple baits has been evaluated in cage trials (Thomas et al 2003). Caged kaka, kea, kakariki, silvereye, weka, and kereru were presented with non-toxic carrot and apples baits (size 10–12 g), both of which were dyed green. The carrot bait was coated with 0.3% cinnamon oil and the apple bait with 0.3% orange oil (cinnamon oil turns apple brown, orange oil does not affect the green dye). Kereru ate neither bait type, while kaka, kea, kakariki and silvereye spent more time feeding on apple than carrot. Weka spent equal time feeding on the two bait types.

Carrot and apple were usual components of the birds' diets in captivity with the exception of weka (meat-based diet) and kereru (fruit only), which may bias the results of the study as the birds were already familiar with the bait materials. Given the uncertainty in the extrapolating to the field, the authors recommended that apple bait should only be used in bait stations.

Apple pastes and gel bait block

The palatability of two non-toxic fruit-based paste formulations (code BB13 = superceded formulation, old 'apple jam bait' known to be highly attractive to bees, native birds and bats, BB16 = an alternative formulation, similar to current) and non-toxic gel bait block to native birds has been assessed using both caged and wild birds (Morgan 1999).

Caged kaka (n=3), brown kiwi (n=2), kereru (n=4) and kakariki (n=5) were presented with the 100 g of gel block for 8 hours on each of two days. On separate days, they were presented with 100 g of two apple paste bait formulations. Samples of BB13 paste and gel bait block were placed on tree mounted platforms and on the ground at two sites on the edge of mixed beech forest at Bullock Creek, Paparoa National Park. At the field sites, bowls were observed for two hours after dawn and two hours before dusk each day for seven days. Baits were removed at night to prevent access by possums and rodents.

Of the captive birds, small amounts of the two pastes were eaten by kereru (mean 0.5 g of BB13 and mean 1.0 g of BB16) and kakariki (mean 1.3 g of BB13 and none of BB16). Caged weka ate larger amounts of BB13 (mean 19.6 g) than BB16 (mean 0.3 g), as did kaka (mean 8.7 g and 2.0 g respectively) as did kea (mean 5.1 g and 2.8 g) Brown kiwi consumed more BB16 (mean 17.9 g) compared with BB13 (mean 7 g).

Caged kaka, kereru and kakariki did not consume any of the gel bait while the weka and brown kiwi both ate small amounts (mean 0.1 and 0.4 g respectively).

At the field site, 16 species were observed near the baits but only five species approached within three metres of the bait bowls, on a total of 17 occasions. None of these five species (bellbird, fantail, tui, silvereye, kereru) actually investigated or ate the bait. A family of three weka was observed interacting and feeding on baits placed on the ground, and three robins were observed interacting with baits on the ground and on the platforms. The amount of bait consumed by these birds was not reported, but the weka spent approximately 15 minutes feeding/investigating each bait types, while the robins spent 30 seconds on the paste and 12 seconds on the gel.

The palatability of non-toxic 'improved BB3 apple paste' (stated as being Pestoff Professional paste, the currently approved paste base) to a range of native birds has been evaluated in the wild on Tiritiri-Matangi Island (Morgan et al 1997). Paste was dyed green and contained cinnamon. Baits (~10 g) were laid on upturned earth 'spits' at four locations on the island and birds observed from dawn to dusk for three consecutive days at each location, with frequency, duration of visit and time spent feeding on paste recorded. Additional study sites were also used to ensure that birds identified from earlier studies as likely paste-feeders were adequately represented, that is, robins on Tiritiri-Matangi Island; kereru at a private bush block in Otorohanga, weka in a semi-natural 50 metre by 50 metre enclosure at Karori Reserve, Wellington, and pukeko on farmland near Levin.

Of the 19 bird species observed near the general trial sites on Tiritiri-Matangi Island, seven species visited the baits, and only robins, saddlebacks and blackbirds were observed to visit more than once. Feeding occurred on 29% of visits by robins, 30% of visits by saddlebacks and 37% of visits by blackbirds.

When paste was deliberately placed within the known territories of 25 robins on the island 15 visited baits and 6 fed on baits, with two individuals making repeated visits. Robins were observed to probe the surface of the baits, with later examination of the baits showing a number of invertebrates trapped on the bait surface. A couple of robins were also seen removing bait from their feet having walked over it while foraging in the surrounding area. During the observation of these robins, tui, saddlebacks, whiteheads, bellbirds, fantails and blackbirds were also seen to visit the baits but did not feed.

As kereru are not usually ground-feeders, baits were placed on platforms but none were observed feeding on the paste.

Weka found the paste highly palatable in the enclosure trial and were observed readily feeding on baits during the trial at Karori. Responses of individuals were variable with one individual eating a whole 10 g bait in <2 minutes to a group of 21 weka taking ~ 30 minutes to eat one bait. Weka also remained interested in residues on paste on turf and soil after baits had been consumed.

Pukeko at Levin were observed for three days, and encountered baits 144 times with feeding observed on four visits, and baits probed 11 times. Other species which were observed at these baits included a farm dog, a heifer, sparrows and blackbirds. The dog and heifer were seen seeking out and feeding on the baits. On Tiritiri-Matangi Island pukeko made 44 visits to baits over four days but none were observed feeding.

Effect of lures and repellents on attractiveness and palatability

Cinnamon oil has been routinely added to cereal and carrot baits since the early 1980s to act as a deterrent to birds (Udy and Pracy 1981; Pracy et al 1982) and to mask the odour and taste of 1080 to possums (Morgan 1990). Orange oil is also effective at masking 1080 (Morgan 1990) and may be used for subsequent operations where cinnamon has been used previously and there is potential for a learned aversion to have developed in the possum population. Cinnamon oil at 0.15% has been reported to dissipate from baits after six weeks in storage, with 0.3% frequently used in Department of Conservation operations (Brown and Urlich 2005). At <0.1% cinnamon oil, possums can detect and avoid 1080 baits and at greater then 0.5% baits are less palatable to possums (Henderson and Frampton 1999 cited in Brown and Urlich 2005).

Other lures noted as being routinely used in significant quantities include spearmint and cloves (Additional info from applicants 22 December 2006). Raspberry, juniper, banana, rose and wintergreen were amongst a number of different ‘flavours’ used with 1080 pellets and ‘jam baits’ during the 1970s (and also cyanide pastes) and these were ‘banned’ from use after being identified as attractive to kiwi (Udy and Pracy 1981). Raspberry essence was also associated with high mortality of introduced birds in an aerial 1080 operation in 1977 using undyed cereal bait (Harrison 1978).

An investigation with captive rare birds at Mt Bruce National Wildlife Centre tested the effectiveness of 0.1% cinnamon oil as a bird repellent (Spurr 1993). The birds used in the trials were: Antipodes Island parakeet, *Cyanoramphus unicolor*; Reischek’s parakeet, *C. novaezelandiae hochstetteri*; red-crowned parakeet, *C. novaezelandiae novaezelandiae*; kokako, *Callaea cinerea wilsonii*; North Island saddleback, *Philesturnus carunculatus rufusater*; North Island weka, *Gallirallus australis greyii*; North Island kaka, *Nestor meridionalis septentrionalis*. Birds were presented with non-toxic cereal or carrot bait, both plain and with cinnamon flavour. The Antipodes Island parakeets preferred carrot to cereal, kokako and saddlebacks preferred cereal to carrot, and the other birds showed no preference. Some individuals of all species ate baits with cinnamon but numbers of each species were small. Cinnamon deterred kaka, kokako and Antipodes Island parakeet for the first day only.

The Agency requested further information from the applicants on the current status of research on bird repellents for incorporation into/onto baits. (Refer to the Confidential Appendix to this report for the identification of the bird repellents trialled—restricted to Authority and Agency only because of the information’s potential commercial sensitivity.)

The Animal Health Board (AHB) has funded a number of studies on the identification and use of bird repellents and provided two to the Agency. In the first study, a bird repellent which had previously been tested with caged possums and birds to assess palatability was applied to nominal 0.12% 1080 carrot baits (12 g) and sown across 1400 ha of Wharerino Forest, King Country at a rate of 3 kg/ha and without the bird repellent over an adjacent 1000 ha (Clapperton et al 2005). Analysis of the toxic carrot indicated a lower-than-target concentration of 0.072% 1080 for the no-repellent trial block and 0.094% for the repellent trial block prior to application. Bait collected from the ground in the repellent block immediately after application contained 0.05% 1080, well below the target concentration. All bait used in the trials contained orange flavoured lure and were dyed blue. Bird repellent was added at a nominal 0.2% during the coating of baits with 1080 and dye, measured at ~0.035% after baits had been sown (indicating less-than-adequate application of the repellent).

Numbers of territorial male tomtits were monitored along transects before and after the operation in both blocks. While differences in tomtit disappearances (assumed to be deaths) were not statistically significant between blocks, the authors considered that there was a trend for a lower rate in the repellent block. The RTCI values in the repellent block were 18.6 ± 2.7% pre- and 5.6 ± 1.2% post-operation; and in the no-repellent block 11.8 ± 2.3% pre- and 9.7±1.2%. Post-operative monitoring was delayed until February and may have impacted on the RTCI (the 1080 drop occurred in October 2004). The authors considered that the use of the repellent in this study had a positive impact on tomtit survival and may assist in allaying public concerns regarding deaths of non-target species. Lack of replication limits the conclusions which can be drawn from the study and further field trials were recommended. The AHB indicated that no further trials were undertaken and that the repellent was not to be used in their operations (P. Fairbrother, *in litt*. 19 February 2007).

A trial using the same repellent (P Fairbrother, personal communication, 19 February 2007) on Probait coated apple caused problems with possum palatability (Ross et al 2006). The trial compared 0.15% 1080 Wanganui No 7 cereal bait (12 g) with the treated apple (15–20 g), with both bait types hand-broadcast at 2 kg/ha in native beech forest and in pine plantation in the South Island. Birds feeding on baits were monitored by video.

The authors recommended that Probait coated apple not be used without a more effective bird repellent and that the repellent is not used at 1% w/w due to palatability issues. The reasons for choosing 1% repellent in this trial were not stated, though the authors included data from an earlier possum palatability trial indicating >50% palatability of Probait coated apple with repellent at either 0.04% or 0.20%. The measured 1080 concentrations in the bait was 0.13%, which didn't explain the poor possum kill achieved. If measured, the actual concentration of repellent on the bait was not reported. South Island robins were observed pecking at the apple bait more often than other bird species.

Probait appears to be an additive used with apple to assist with spreading and sticking of the 1080 stock solution and lure (orange flavour) to the apple, and also contains a preservative– the Agency does not know the composition of this additive, but Ross et al 2006 noted that Probait already contains a bird repellent so the use of an additional repellent at a high concentration (at least five times greater than in the carrot trial) may have had an effect on palatability to possums.

The AHB indicated that they considered the studies by Clapperton et al (2005) and Ross et al (2006) to have produced RTCI below target and that the repellent did not deter birds as effectively as they considered desirable and therefore are not considering the use of the bird repellent further. They also cited additional costs of the bird repellent not being supported by the benefits but did not provide any information on those costs (P. Fairbrother *in litt.* 19 February2007).

The Agency considers that further trials with the bird repellent may be warranted given the lack of replication and issues with monitoring possum indices noted in the trial on carrot. The less-than-target toxic loading on the carrot may also have had a role in the lower than expected RTCI, but this is speculation only.

N2.1.2 Primary v secondary poisoning of insectivorous birds

Many New Zealand birds feed on invertebrates and several authors (eg, Spurr 1999; Lloyd and McQueen 2000) have discussed the potential for secondary poisoning via ingestion of invertebrates which may contain 1080 residues from feeding on baits. Hegdal et al (1986) report several cases from the US where deaths of individual birds have been attributed to potential ingestion of ants containing 1080 residues although treated grain baits were also accessible to the birds.

Some birds, including tomtits and robins, may regurgitate food which is not digestible and/or toxic (Powlesland et al 2000) making it difficult to determine whether toxic bait or contaminated insects have been ingested. Information for two non-native insectivorous birds indicates short gut retention times of 10 minutes to two hours, with mean ~50 minutes (Levy and Karasov 1989, 1992, 1994, cited in Lloyd and McQueen 2000). The average time to death is generally >1 hour (McIlroy 1984). Analysis of tissues for 1080 residues can confirm poisoning but cannot be used to attribute the source of 1080.

Invertebrates have been recorded as more abundant on toxic baits at night (Lloyd and McQueen 2001), and ingestion of sub-lethal doses may alter invertebrate behaviour resulting in abnormal daytime activity, and increased likelihood of ingestion by birds (McIntyre 1987; Hutcheson 1989). Residues in sub-lethally poisoned invertebrates decrease over time, in tree weta as shown in Table N1 (Eason et al 1993).

Addition of an effective bird repellent to baits may reduce the incidence of primary poisoning, and the use of an effective invertebrate repellent may reduce the incidence of secondary poisoning. As noted above, some research has been undertaken on both types of repellents, with varying results.

N2.1.3 Estimated exposure to 1080 residues in invertebrates and baits

In order to calculate the potential exposure of an organism to a contaminant in the environment, a number of factors need to be considered, including: daily food intake, concentration of contaminant in food item, proportion of food item in the diet, moisture and energy content of food, assimilation efficiency of the food, and bodyweight of the organism of interest.

A recent extensive review of the literature on the food ingestion, daily energy expenditure and food assimilation by wild birds and mammals has been undertaken (Crocker et al 2002). The authors have developed a new set of allometric equations linking bodyweight with Daily Energy Expenditure (DEE) based on data for metabolic rates of 96 free-living wild birds and 73 mammal species; moisture and energy content of various food types. These equations have been adopted in the European Union for use in risk assessments for birds and mammals under the Pesticides Directive 91/414/EEC (EC 2002). On the basis of the data available, birds are divided into five broad categories for calculation of DEE: desert, hummingbirds, passerine (excluding desert and marine), seabirds and "other". The energy expenditure of birds feeding young may be greater than the general estimates. The Agency notes that the energy expenditure of New Zealand flightless birds may be less than estimated for the 'other' category of birds as greater energy is required for flight.

Estimation of Daily Energy Expenditure (DEE)

$$\text{Log (DEE)} = \text{Log } a + b(\text{log bodyweight}) \qquad \text{(Equation 1)}$$

Where:

for passerine birds (excluding marine and desert species)
log a = 1.0017 and b=0.7034

for 'other birds'
log a= 0.6768 and b=0.7723

Estimation of Daily Food Intake (DFI)

$$\text{Daily Food Intake}_{(\text{wet g})} = \frac{\text{Daily Energy Expenditure}_{(\text{kJ})}}{\text{Energy in Food}_{(\text{kJ/g dry})} \times (1 - \text{Moisture in food}) \times \text{Assimilation Efficiency}} \qquad \text{(Equation 2)}$$

where moisture and assimilation efficiency are proportions between 0 and 1.

Example: Estimate of DEE and DFI for NZ tomtit

For a tomtit weighing 11 grams, and feeding on arthropods (21.9 kJ/g dw, 70.5% moisture, and assimilation efficiency of 76%) the estimated DEE and daily food intake (DFI) are:

Log(DEE) = 1.0017 + 0.07034(log 11) = 1.075 kJ/day (Equation 1)

DEE = Anti-log 1.075 kJ/day = 11.88 **~ 12 kJ/day**

$$DFI = \frac{12\ kJ/day}{21.9\ kJ/g \times (1-0.705) \times 0.76} = 2.4\ g/day\ freshweight \quad (Equation\ 2)$$

The results of calculations for other species are set out in Table N3 below.

The DFI values in the table indicate the amounts of each food type required to satisfy the total DEE if only that food type is consumed each day. For example, to satisfy its entire energy requirements for a day, a tomtit would theoretically need to consume either 2.4 g arthropods or 5.3 g soil invertebrates or 9.5 g fruit. In reality, a mixture of different food types would be included in the daily diet, with proportions varying depending on seasonal availability and other factors. The Agency has made no attempt to assess the actual proportions of different foods in the diet of any bird, making calculations based on the assumption that the total DEE will be derived from a single food type. The food types ‘cereal seed’ and ‘orchard fruit’ are used as surrogates for cereal bait pellets and other bait types respectively, even where the species may not normally be considered to consume these food types.

Table N3: Estimated food intake for selected species of birds

Species	Mean body weight (g)	DEE		Food characteristics[1]			Assimilation[1] efficiency		Daily Food Intake (g/day fresh)
		Equation[1]	DEE (kJ/d)	Food type	Energy (kJ/g dry wt)	Moisture	Food type	Proportion assimilated	
Tomtit	11	Passerine	54	Arthropods	21.9	0.705	Animal	0.76	11
				Soil invert	19.3	0.846	Animal	0.76	24
				Cereal seed	16.7	0.133	Seed	0.80	4.7
				Orchard fruit	11.6	0.837	Fruits	0.67	42.8
Hedge sparrow	21	Passerine	86	Arthropods	21.9	0.705	Animal	0.76	17.5
				Soil invert	19.3	0.846	Animal	0.76	38.1
				Cereal seed	16.7	0.133	Seed	0.80	7.4
				Orchard fruit	11.6	0.837	Fruits	0.67	67.9
NZ robin	35	Passerine	122	Arthropods	21.9	0.705	Animal	0.76	24.8
				Soil invert	19.3	0.846	Animal	0.76	54.0
				Cereal seed	16.7	0.133	Seed	0.80	10.5
				Orchard fruit	11.6	0.837	Fruits	0.67	96.3
Blackbird	90	Passerine	238	Arthropods	21.9	0.705	Animal	0.76	48.5
				Soil invert	19.3	0.846	Animal	0.76	105.4
				Cereal seed	16.7	0.133	Seed	0.80	20.5
				Orchard fruit	11.6	0.837	Fruits	0.67	187.9
Morepork	175	Other bird	257	Arthropods	21.9	0.705	Animal	0.77	51.7
				Small animal	21.7	0.686	Animal	0.77	49.0
Kereru	650	Other bird	707	Orchard fruit	11.6	0.837	Artificial	0.76	492.0
				Tree leaves	20.7	0.514	Artificial	0.76	92.5
				Cereal seed	16.7	0.133	Artificial	0.76	64.2

Species	Mean body weight (g)	DEE		Food characteristics[1]			Assimilation[1] efficiency		Daily Food Intake (g/day fresh)
		Equation[1]	DEE (kJ/d)	Food type	Energy (kJ/g dry wt)	Moisture	Food type	Proportion assimilated	
Weka ♀	700	Other bird	748	Arthropods	21.9	0.705	Animal	0.34	340.5
Weka ♂	1000	Other bird	986	Arthropods	21.9	0.705	Animal	0.34	448.9
				Soil invert	19.3	0.846	Animal	0.34	975.7
				Cereal seed	16.7	0.133	Artificial	0.69	98.7
				Orchard fruit	11.6	0.837	Fruit	0.45	1160
				Non-grass herbs	18.0	0.821	Herbage	0.59	518.7

Note

1 From Crocker et al (2002) unless otherwise stated.

The amount of contaminated invertebrates or other food required to ingest a toxic dose can be estimated for a bird of a given bodyweight, toxicity value and concentration in food item. The proportion of the total DFI which this amount of food represents can also be calculated.

Amount of food to ingest toxic dose (g) =

$$\frac{\text{bodyweight (g) x toxicity value (mg/kg bw)}}{\text{1080 conc in food item mg/kg}} \qquad \text{(Equation 3)}$$

An eastern Australian passerine, the red-browed firetail (*Neochmia temporalis*), is the most sensitive to 1080 of the insectivorous birds which have been tested, with an LD_{50} of 0.63 mg/kg bw (95% CI 0.41–0.96) (McIlroy 1984). The Agency has used this value for birds for which the sensitivity to 1080 has not been tested as an indication of a possible lethal dose.

The toxicity of 1080 to native New Zealand birds has only been tested in two species, the silvereye (approximate lethal dose (ALD) 9.25 mg/kg bw, McIlroy 1984) and the weka (ALD 8.51 mg/kg bw; McIntosh et al 1966). Toxicity values are also available for several introduced birds, that is, blackbird ALD 9.5 mg/kg bw and house sparrow LD_{50} 2.82 mg/kg bw (95% CI 2.24–3.55) (Tucker and Crabtree 1970). (Further details on the toxicity of 1080 to birds are included in Appendix C.)

Example: Estimated quantity of invertebrates for a tomtit

A tomtit weighing 11 g would need to consume 0.58 g of invertebrates containing 12 mg 1080/kg (see Table N1) to receive a lethal dose (based on an LD_{50} of 0.63 mg/kg bw) calculated by:

$$\frac{\text{11 g x 0.63 mg/kg}}{\text{12 mg 1080/kg}} = 0.58 \text{ g}$$

which represents 5.2% of a tomtit's daily food intake of invertebrates, if it ate solely invertebrates.

The results of calculations for other species are set out in Table N4.

Table N4: Estimated amount of contaminated invertebrates, bait and other food required to provide a toxic dose for selected species of birds

Species	Body weight (g)	Food type[1]	DFI (g/day for food type[1])	Acute toxicity value (mg/kg bw)	Amount of food type required to reach toxic dose (g (%DFI))						
					1080 residues in arthropods[2] (mg/kg)			1080 conc in bait (mg/kg)		1080 residues in other foods[2] (mg/kg)	
					min 12	mean 57	max 130	800	1500	Plant max 0.08	Bird muscle max 32
NZ tomtit	11	Arthropods	11	0.63	0.58 (5.2)	0.12 (1.1)	0.05 (0.48)				
		Soil invert	24	0.63	0.58 (2.4)	0.12 (0.51)	0.05 (0.22)				
		Cereal seed	4.7	0.63				0.01 (1)	0.005 (0.5)		
		Orchard fruit	42.8	0.63				0.01 (0.1)	0.005 (0.05)		
Hedge sparrow	21	Arthropods	17.5	0.63	1.10 (6)	0.23 (1)	0.10 (0.6)				
		Soil invert	38.1	0.63	1.10 (3)	0.23 (0.6)	0.10 (0.3)				
		Cereal seed	7.4	0.63				0.02 (0.3)	0.009 (0.1)		
		Orchard fruit	67.9	0.63				0.02 (0.03)	0.009 (0.01)		
NZ robin	35	Arthropods	24.8	0.63	1.84 (7)	0.39 (2)	0.17 (0.7)				
		Soil invert	54.0	0.63	1.84 (3)	0.39 (0.7)	0.17 (0.3)				
		Cereal seed	10.5	0.63				0.03 (0.3)	0.015 (0.1)		
		Orchard fruit	96.3	0.63				0.03 (0.03)	0.015 (0.02)		
Blackbird	90	Arthropods	48.5	9.5	71.25 (150)	15 (31)	6.58 (14)				
		Soil invert	105.4	9.5	71.25 (68)	15 (14)	6.58 (6)				
		Cereal seed	20.5	9.5				1.07 (5)	0.57 (3)		
		Orchard fruit	187.9	9.5				1.07 (0.6)	0.57 (0.3)		

Species	Body weight (g)	Food type[1]	DFI (g/day for food type[1])	Acute toxicity value (mg/kg bw)	Amount of food type required to reach toxic dose (g (%DFI))						
					1080 residues in arthropods[2] (mg/kg)			1080 conc in bait (mg/kg)		1080 residues in other foods[2] (mg/kg)	
					min 12	mean 57	max 130	800	1500	Plant max 0.08	Bird muscle max 32
Morepork	175	Arthropods	51.7	0.63	9.19 (18)	1.93 (4)	0.85 (2)				
		Small animal	49.0	0.63							3.45 (7)
Kereru	650	Orchard fruit	492.0	0.63				0.51 (0.1)	0.27 (0.06)		
		Tree leaves	92.5	0.63						5120 (5500)	
		Cereal seed	64.2	0.63				0.51 (0.8)	0.27 (0.4)		
Weka ♀	700	Arthropods	340.5	8.1	472.50 (140)	99 (30)	43.62 (13)				
weka ♂	1000	Arthropods	448.9	8.1	675.00 (150)	142 (32)	62.31 (14)				
		Soil invert	975.7	8.1	675.00 (70)	142 (15)	62.31 (6)				
		Cereal seed	98.7	8.1				10.13 (10)	5.4 (5)		
		Orchard fruit	1160	8.1				10.13 (0.9)	5.4 (0.5)		
		Non-grass herbs	518.7	8.1						101250 (19 000)	

Notes

1 See section N2.1.3 for explanation and references.

2 See Table N1 for residues in biota and associated references.

There are a number of uncertainties associated with the choice of toxicity value and the estimation of the amount of any particular contaminated food type which may result in a toxic (sub-lethal) or lethal dose.

These uncertainties include:

- intraspecies variation (between tested and untested species)
- interspecies variation (individuals within a species)
- inherent uncertainty in the toxicity value itself
- lack of information on sub-lethal dose levels
- variability in the concentrations of 1080 measured in food items collected from the field (including, delays between collection, storage, analysis for residues; metabolism of sub-lethal doses within the invertebrates)
- estimates of daily food intake based on surrogate species (see Crocker et al (2002) for detailed discussion) effects of reproductive status, seasonal variation in amount and type of food ingested.

The Agency considered undertaking a sensitivity analysis by varying a number of parameters used in the calculations of DEE, DFI and also the toxicity values used. However, with the uncertainties noted above, all estimates are likely to vary an order of magnitude (or more) and it was not considered worthwhile exploring the results further. The conclusions which can be drawn from the information available are in that small bodied birds are more vulnerable to both primary and secondary poisoning, as has been observed in monitored 1080 operations, with much smaller quantities of bait needing to be ingested relative to that of other contaminated foods. In addition, the analysis indicates that a relatively small proportion of a birds' daily food intake could deliver a lethal dose through secondary poisoning and consumption of very small pieces of bait could deliver a lethal dose.

N2.1.4 Life history attributes

Dispersal ability

Populations of birds which are able to disperse over wide areas are more likely to be able to recolonise areas where numbers may have been reduced. Spurr (1979) classified the dispersal capacity of New Zealand land birds based on a number of factors including: adaptive physical and ecological features of the birds; abundance and distribution on the mainland; presence on offshore and outlying islands (see Table N5).

Table N5: Classification of the dispersal capacity of New Zealand land birds

Poor dispersal	Good dispersal
Kiwi	Australasian harrier
Weka	New Zealand falcon
Kaka	Pukeko
Kea	Kereru
Kakariki[1]	New Zealand kingfisher
Rifleman	Morepork
Fernbird	Grey warbler
Brown creeper	Fantail
Whitehead	Tomtit
Yellowhead	Silvereye
Robin	Bellbird
Kokako	Tui

Source: After Spurr (1979).

Note

1 Red- and yellow-crowned kakariki are well-adapted for dispersal but patchy distribution may reflect both lack of habitat, but also low ability to re-colonise.

Breeding strategy

A classification of the reproductive capacity based on maximum annual egg production of New Zealand birds has been made by Spurr (1979) and is included in Table N6. The Agency has not been able to determine whether a more recent evaluation of this approach has been made, but considers the classification by Spurr to be useful in the context of assessing potential for population recovery after loss of individuals. In theory, populations of birds with a higher reproductive capacity are more likely to recover from an impact than those with a lower capacity, however a large number of other factors may also influence recovery such as bad weather during critical periods, low abundance of food reducing ability to successfully raise chicks.

Table N6: Classification of reproductive capacity of New Zealand land birds

Ranges of clutch sizes			
Single-brooded species			
Australasian harrier	2–7 (commonly 4)		
NZ falcon	2–3		
Kaka[4]	4–5		
Kea	2–4		
Morepork	2–3		
Yellowhead[3]	3–4		
Kokako[2]	2–3		
Double-brooded species (probable)			
3 or fewer eggs/clutch		**More than 3 eggs/clutch**	
Brown kiwi	1–2	Weka[1]	3–6
Little spotted kiwi	1	Pukeko[1]	4–7
Great spotted kiwi	1–2	Kakariki	5–9
Kereru	1	Kingfisher	4–5
Fernbird	2–3	Rifleman	4–5
Saddleback	2–3	Brown creeper	3–4
		Whitehead	2–4
		Grey warbler	3–6
		Fantail[1]	3–4
		Tomtit	3–5
		Robin[1]	2–4
		Silvereye	3–4
		Bellbird	3–4
		Tui	2–4

Source: From Spurr (1979).

Notes

1 Multiple-brooded.

2 Now recognised as a potentially multi-brooded species under good conditions (Innes and Flux 1999).

3 Some populations have been identified as predominantly one-brood/season, others may have two broods/season (O'Donnell (1993).

4 May be double-brooded when seed abundant (Moorhouse et al 2003).

N2.1.5 Monitoring data

A provisional classification of the susceptibility of New Zealand land birds to non-recovery from a significant impact was made by Spurr (1979) (Table N7).

In a systematic review of potential impacts of 1080 operations on non-target species, a number of birds were identified as high priorities for further research and monitoring (Spurr and Powlesland 1997). Generally, further monitoring was indicated when less definitive techniques (such as 5-minute call counts) had been used previously and specific techniques needed development, and the species was identified as being of concern (eg, locally threatened, known to consume baits, been found dead in previous pest control operations etc). Some of this information is summarised in Table N7, along with a brief outline of relatively recent monitoring results (further details are included in Appendix F). As noted elsewhere, the monitoring results available to the Agency at the time of this review are likely to be incomplete. The Agency is not aware of any revisions to the list of research priorities.

Table N7: New Zealand land birds susceptible to non-recovery if subject to significant impacts and recent monitoring after 1080 operations

Species	Risk of non-recovery	Research priority in 1997[5] and rationale	Monitoring of specific bird species after aerial 1080 operations[4]
Kiwi	High[1]	Low priority – cereal based on previous monitoring High priority – carrot based only two radio-tagged bird being monitored	North Island brown kiwi 3 operations (cereal Waipoua 1990; carrot & paste Rarewarewa 1995/carrot Tongariro 1995) 43 radio-tagged birds – all survived Great spotted kiwi 2 operations (cereal Gouland Downs 1994, Karamea 1994) 15 radio-tagged birds – all survived
Kaka	High	High priority – restricted distribution in both N and S Islands, will eat bait and only on operation monitored with radio-tagged birds	2 operations (carrot) Whirinaki Forest Forest 2000 – all monitored birds (radio-tagged and colour banded) survived Pureora Forest -1994 - all monitored birds (radio-tagged) survived
Kea	High	High priority – infrequent exposure but will eat carrot bait; no monitoring of marked birds	3 operations (carrot) Dobson Valley 1963 – 4 dead kea Westland National Park 1983 and 1986, 5-minute call counts no change before and after
Fernbird	High	High priority – reference to potential vulnerability to 1080 (At Waituna wetlands where brodifacoum cereal bait was used for rat eradication 15 of 18 banded birds disappeared from the treatment area)	2 operations (cereal) Waipoua 1990 re-sighting of all birds before and after Gouland Downs 1994 5 of 9 banded birds re-sighted; 4 unknown fate
Yellowhead	High	High priority – restricted distribution and rarely exposed but impacts on marked birds not been monitored	1 operation (cereal) Catlins Forest 1999 – population monitored for one year before operation and four years after. No observable effect due to 1080; predation impact in 2001
Kokako	High	Low priority – monitoring to date indicates no population level impacts	Waipoua Forest 1990 (cereal) – 5/6 pairs re-sighted + additional 3 birds sighted Subject of intensive recovery programme and monitoring of predator impacts
Blue duck	High?	Low priority – based on existing monitoring and low likelihood of exposure	Otira Valley (cereal) no reduction in visual counts Pureora Forest – Waihaha 1994 19 radio-tagged adults re-sighted
Weka[b]	Medium[2]	High priority – eats bait and scavenges possum carcasses; only one operation monitored with two radio-tagged birds	Copland and Karangarua valleys, South Westland 2000 15 radio-tagged birds; no impacts attributable to 1080
New Zealand falcon[a]	Medium	High priority – due to lack of information on potential impacts of 1080	

Species	Risk of non-recovery	Research priority in 1997[5] and rationale	Monitoring of specific bird species after aerial 1080 operations[4]
Kereru[a]	Medium	High priority – dead birds found after 1080 operations; no attempts to determine mortality of radio-tagged birds	1 operation (carrot) Whirinaki Forest 2000 re-sighting of all radio-tagged kereru in the operational area on-going predation of kereru nests
Kakariki[b]	Medium	Low priority – no dead kakariki found; but no studies with radio-tagged birds	Summary data 4 aerial operations (2 screened carrot; 2 cereal) No detectable impacts based on 5-minute counts
Morepork[a]	Medium	High priority – dead birds found after 1080 operations and tested positive for 1080 residues; Only 2 operations using radio-tagged birds	
Rifleman[b]	Medium	High priority – dead birds found containing 1080 residues; no quantitative monitoring of marked birds during 1080 operations	Pureora Forest – Waihaha 1994 (screened carrot at 15 kg/ha 5 dead birds containing 1080 residues Summary data for 13 aerial operations (9 screened carrot; 4 cereal) – no measurable impacts 2–8 weeks after operations based on 5-minute bird counts
Brown creeper[b]	Medium	Low priority – none found dead after 1080 operations; species widespread, disperses readily	
Whitehead[b]	Medium	High priority – dead birds found; lives in forests regularly treated with 1080	Kaingaroa State Forest 1977 (carrot screened & unscreened) 80 dead birds Kairoi State Forest 1976 (unscreened carrot) 18 dead birds Summary data 18 aerial operations (11 screened carrot; 7 cereal) no measurable impacts 2–8 weeks after operations based on 5-minute bird counts
Robin[b]	Medium	High priority - dead birds found containing 1080 residues; population mortality 55% in one sample of marked birds; information needed on more marked birds	Specific robin monitoring protocol developed
Australasian harrier	Low[3]	Low priority – few reports of dead birds; widespread species not in decline	
Pukeko	Low	Low priority – national distribution, high productivity, good dispersal, small area of habitat likely to be exposed	Anecdotal reports of dead birds following rabbit control
Grey warbler	Low	Low priority – few found dead since carrot bait screened; widespread; disperses readily	Summary data 20 aerial operations (13 screened carrot; 7 cereal) no measurable impacts 2–8 weeks after operations based on 5-minute bird counts
Fantail	Low	Low priority – few found dead since carrot bait screened; widespread; disperses readily	Summary data 20 aerial operations (13 screened carrot; 7 cereal) no measurable impacts 2–8 weeks after operations based on 5-minute bird counts

Species	Risk of non-recovery	Research priority in 1997[5] and rationale	Monitoring of specific bird species after aerial 1080 operations[4]
Tomtit, *Petroica australis toitoi*	Low	High priority – dead birds found wherever aerial 1080 operations occur; measured residues; population declines after 1080 carrot operations	Cone State Forest 1977 (unscreened carrot at 30 kg/ha) high mortality assessed by 5-minute counts; 3 years for population to recover Pureora Forest - Waimanoa 1997 (screened carrot at 10 kg/ha) 3/14 banded birds re-sighted; 3 dead unbanded, One year post-operation fewer birds seen in treatment area, but birds reared 2 or 3 broods in the following season, indicating high likelihood of recovery Long Ridge 1998 (cereal) 14/14 banded birds re-sighted Waimanoa 2003 (screened carrot at 3 kg/ha) Decreases in territorial male counts in treatment area Mt Pureora 2003 (cereal) small increases in territorial male counts Tongariro Forest 2001 (cereal) 14/15 banded birds re-sighted in treatment;15/15 in control Kokomako Forest 2003 (carrot) and Mohaka Forest 2003 (carrot) Decreases in territorial male counts in treatment area
Bellbird	Low	Low priority – no evidence of impact on populations	One bird found dead after 'jam bait' laid
Tui	Low	Low priority – no evidence of impact on populations	Kapiti Island 1984 (screened carrot) one dead bird; residues unknown

Source: After Spurr (1979).

Notes

1 Based on low reproductive capacity and low dispersal ability (Spurr 1979).

2 Based on either poor reproductive capacity OR poor dispersal capacity [a] poor reproductive capacity; [b] poor dispersal capacity (Spurr 1979).

3 Based on good reproductive capacity and good dispersal ability (Spurr 1979).

4 See Appendix F for further details of the monitoring results.

5 Spurr and Powlesland 1997.

N2.1.6 Conclusions

Key species have been subject to increased monitoring and no direct population level impacts attributable to 1080 poisoning have been identified. However, there have been instances where the use of 1080 has not been successful in adequately managing the risks of predation. Effective, well-timed (coincident with bird breeding periods), and widespread pest control is required in most cases to protect vulnerable species from on-going predation pressure. Considerable work is in progress to improve the efficiency of pest control, and potentially reduce the frequency of control under some circumstances. Research is also in progress to further address the complexities of multiple-pest species management.

Deaths of tomtits and robins have frequently been reported after aerial 1080 operations, but these species, while clearly vulnerable to poisoning, are both capable of wide dispersal and have a high reproductive capacity. In the absence of other significant impacts such as severe weather during key stages of their breeding cycles or high rates of on-going predation, impacts are likely to be short-term. Improvements in bait quality/preparation and reduced sowing rates have contributed to fewer deaths of individual birds, as indicated by monitoring results.

While there is a less certainty around the impact of competition by a variety of pest species for available food resources, there is sufficient evidence to suggest that such competition can occur for some species, and that widespread pest control can contribute to improved food availability and potentially to improved breeding success.

N2.2 Bats

N2.2.1 Attractiveness and palatability of baits

New Zealand short-tailed bats (*Mystacina tuberculata*) are omnivorous and known to feed on a varied diet including fruit, invertebrates, nectar, pollen and are unique amongst bats in that they also feed on the ground and in trees (Lloyd 2005) and can therefore potentially be exposed to most bait types used, including those which may be spilled from bait stations (see Appendix E).

Cereal and carrot

Non-toxic carrot bait, dyed green and cinnamon-lured, was placed near a site in Pureora Forest where short-tailed bats were known to forage (Ecroyd 1993). Synthetic *Dactylanthus* nectar was placed under gauze next to the bait to act as an attractant. Over three nights of video monitoring, bats were seen in the vicinity, but not observed feeding on the carrot.

Captive short-tailed bats were presented with both wet and dry non-toxic cereal baits and carrot bait, including fines along with their normal diet for a period of ‘many months’ (Lloyd 1994). There was no evidence that either type of bait was consumed even in the absence of other food.

In a field trial with non-toxic cereal bait (Agtech) which included the fluorescent tracer dyes Rhodamine B and pyranine, baits were sown over 200 ha of Codfish Island at a rate of 10 kg/ha (Lloyd 1994). Wild short-tailed bats (n=76) captured in the trial area were examined for fluorescent traces, as were droppings collected from known roosts active during a three week period immediately after the aerial drop. No fluorescence was found on bats or in droppings.

Apple paste and gel block

Short-tailed bats may be vulnerable to ground-laid fruit paste baits. Captive bats have been observed to feed on 'jam' bait and one dead bat was found after feeding on fruit-lured cyanide bait near Karamea in April 1977 (Daniel and Williams 1984). In a trial to examine the palatability of a non-toxic version of the 1080 gel block, captive short-tailed bats visited the gel samples 50 times (total visits over two nights by six bats) but were never observed feeding on the gel (Morgan 1999). In the same study, bats were also presented with non-toxic apple paste (BB13) over three nights. Sixty eight visits were made over the observation period and 5.73g of apple paste was consumed. A subsequent report notes that BB13 apple paste (described as 'jam-like') is no longer manufactured due to its attractiveness to bees (Morgan 2000).

In a study to assess the attractiveness of the current apple paste formulation 'improved BB3' to captive short-tailed bats (Morgan et al 1997), 16 bats had their usual diet of honeywater and a range of invertebrates replaced with 50 g of either BB13 or one of three variants (original, improved, improved plus Bitrex) of the BB3 apple paste for the 1st three hours on one night (two nights for the improved BB3 paste). At the end of each observation period bats were provided with their normal diet. The BB13 and original BB3 pastes were relatively attractive to the bats based on the number of times they were observed inspecting the baits or seen in the feeding dish with a few visits resulting in tasting or feeding on the baits. Fewer inspections were made by bats of the improved BB3 pastes, with only one visit resulting in a tasting of the bait and no bats observed feeding on the pastes.

Effect of lures and repellents on attractiveness and palatability

The attractiveness and palatability of a range of non-toxic baits and lures to wild-caught short-tailed bats (4♀, 46♂) were assessed in an enclosure in three separate trials (Beath et al 2004).

In the first trial, 12 baits were tested, not all of which are base matrices for 1080 baits. Those that are known to be used for 1080 baits were: Kiwi Care gel block (orange lure); RS5 cereal pellets (cinnamon lure); Pestoff Paste with aniseed lure or fish sauce (unlured Pestoff paste mixed with honey was used as the control); plain apple. The others were macadamia rodent lure, white chocolate, tasty cheese, bacon or beef dripping, Racumin paste and Feral Control gel.

The plain paste was visited more often than any of the other baits during the 3-hour exposure period. Of the others, apple was visited most frequently followed by RS5 cereal>Racumin>macadamia>white chocolate>Feral Control>fish>Kiwicare gel>cheese>bacon>beef>aniseed. The most time was spent feeding on the plain paste>apple>RS5>macadamia>racumin>Feral control>white chocolate>fish>cheese>Kiwicare>bacon>beef>aniseed. There was no significant difference amongst individual bats in either time spent feeding or in bait preference. Video-monitoring during the trial indicated an average feeding time consistently less than 10 seconds and overall, a general lack of interest in the baits.

In the second trial, the following 10 lures were used as additions to honey-water: cinnamon, peanut, orange, cloves, allspice, lemon, chocolate, eucalyptus, raspberry, spearmint, with plain honey-water as the control. The control was visited most frequently and for the greatest feeding time. Of the other lures, peanut was visited the most frequently, then cloves>orange>lemon>cinnamon>raspberry>chocolate>eucalyptus>allspice >spearmint. More time was spent feeding on peanut>lemon>orange>cloves>raspberry>allspice>chocolate>cinnamon> eucalyptus>spearmint. There was a significant difference between lure preference of individual bats, but not to the time individuals fed on different lures. Longer periods were spent feeding on the lured honeywater than on lured baits in the previous trial. The greatest time was spent feeding on the control.

In the third trial, bats were presented with three paste baits over two different summers: Pestoff peanut-flavoured paste (green dyed), plain paste with no added scent or flavour (composition unknown, assumed to be fruit based) and apple-flavoured paste. In 2000/01 the frequency of visits was peanut>apple>plain and in 2001/02 plain>apple>peanut. The time spent feeding on the different pastes also varied, in 2000/01, more time was spent on peanut>apple>plain and in 2001/02 plain>peanut>apple. The variations were suggested by the authors to be due to same bats having been used in rat bait trials in 2001/02 where they we presented with plain paste/honey as the control sample, and may be become accustomed to feeding on the plain paste.

Observations on the amounts of different bait eaten during the trials indicated that the bats sampled the baits rather than actually eating significant amounts.

N2.2.2 Primary poisoning

As noted in Appendix C, only one value has been reported for the toxicity of 1080 to bats, that is, LD_{50} 0.15 mg/kg for the American big brown bat. Given the taxonomic position of the New Zealand short-tailed bat, the sensitivity of this species relative to the American big brown bat is unknown. Based on a bodyweight of 14 g, a short-tailed bat would need to consume between 0.88 and 17.5 mg of a 0.08% 1080 bait if the LD_{50} were 0.05 mg/kg bw or 1.0 mg/kg bw respectively (Lloyd 1994). The dose at which a sub-lethal, but significant, effect may occur in terms of impaired behaviour (eg, resulting in injury or increased susceptibility to predation) is unknown.

N2.2.3 Secondary poisoning

The short-tailed bat is known to feed on invertebrates which may consume 1080 baits (Lloyd 2001). Secondary poisoning from ingestion of invertebrates containing 1080 residues is a potential risk to short-tailed bats (Lloyd and McQueen 2000).

Long-tailed bats (*Chalinolobulus tuberculatus*) are entirely insectivorous aerial feeders, catching invertebrates in flight (O'Donnell, personal communication, in Spurr and Powlesland 1997) and have not been monitored during 1080 operations as the risk from secondary poisoning is considered minimal (Spurr and Powlesland 1997).

The daily food intake of captive short-tailed bats has been measured at 5.6 g/day and with a body mass of 14 g estimates have been made of the mass of invertebrates which would be required to deliver a lethal dose (Lloyd and McQueen 2000). Using an LD_{50} of 0.15 mg/kg bw, 0.18 g of invertebrates containing 12 mg 1080/kg, or 0.04 g invertebrates containing 57 mg 1080/kg or 0.2 g of invertebrates containing 130 mg 1080/kg, which equates to 3.1%, 0.7% and 0.3% of the total daily food intake respectively.

N2.2.4 Conclusions

While the cage-trials with various baits and lures, and the ground-feeding habits of the short-tailed bat indicate a high potential risk from 1080 poisoning (either aerial or ground-based applications), the available monitoring data do not indicate a high likelihood of direct poisoning from feeding on baits or mortalities from secondary poisoning. However, given the low reproductive rate of <1 young/adult female per year there is little scope for the populations to sustain the loss of many individuals (Lloyd 1994).

N2.3 Invertebrates

N2.3.1 Attractiveness and palatability of baits

Bees

Cut apple

The attractiveness of non-toxic cut apple baits to honeybees has been evaluated (Thomas et al 2003). Bees from two hives were 'trained' with sucrose solution to habituate them to feeding from petri dishes, with numbers of bees feeding recorded every five minutes for one hour. In total 36 observations were made each day for three days. The sucrose solution was replaced with prepared apple and similar observations recorded. Mean numbers of honeybees feeding on sucrose solution were 10.1 bees/5 min count and 0.2 bees/5 min count on apple bait.

Pastes and gel block

Forager bees (n=200) were trained to feed on sucrose solution 20 metres away from a hive, and once trained, the sucrose solution was replaced with dishes containing 2 g non-toxic apple paste (code BB13 = old 'jam bait' formulation) or 2 g non-toxic gel bait block (Morgan 1999). Ten dishes of each bait type were randomly placed and counts made of the number of bees present in a 10 minute period, with 12 sampling periods. A total of 154 bees were counted on the apple paste and 12 on the gel block, with mean number 1.28/10 min. and 0.1/10 min respectively. Bees were considered to be feeding on the paste for the time they were present on the paste, whereas the density of gel block prevented bees penetrating the surface with their proboscis.

BB13 paste has been identified as very attractive to bees and replaced with a formulation which is significantly less attractive to bees (Morgan 2000).

Native invertebrates

A wide range of species has been found feeding on all bait types (see monitoring of invertebrates on baits in Appendix F).

Effect of lures and repellents on attractiveness and palatability

Incorporation of an invertebrate repellent into baits containing 1080 would reduce the potential risk to both invertebrates which may feed on the baits, and to consumers of the invertebrates (Spurr 1999).

An extensive literature review was undertaken into potential antifeedants (Spurr and McGregor 2003), with six identified as being worth further investigation (diethyl toluamide or DEET, dimethyl phthalate, citronella oil, eucalyptus oil, neem oil and alpha-cypermethrin), with the key initial investigative need being palatability to possums and rodents. The trialing of commercial fly sprays or slow-release strips on/around bait stations was also recommended.

Palatability trials with possums, ship rats and Norway rats identified 0.2% DEET and 0.2% neem oil as the most palatable invertebrate antifeedants, though McGregor et al (2004) noted some conflicting results (Spurr et al 2002, cited in McGregor et al 2004). In subsequent testing of both these substances with captive native cave weta, cockroaches and amphipods, DEET was effective at reducing the numbers of cave weta and cockroaches on baits, but neem oil was ineffective (McGregor et al 2004). Amphipods were not observed on any baits. In the same trial, baits with 0.15% cinnamon oil did not affect the number of cave weta or cockroaches observed feeding on baits, in contrast with the field results of Sherley et al (1999) which indicated that significantly lower numbers of invertebrates were observed on baits containing cinnamon oil. The difference may be due to the wider diversity of invertebrates in the field compared to that of the caged trials.

The authors of the DEET/neem oil study had identified a number of limitations flagged for further investigation: that is, a more definitive study on the palatability of 0.2% DEET containing baits to possums, kiore (*Rattus exulans*) and house mice; palatability and efficacy of toxic baits to possums and rodents to ensure that there are no unforeseen interactions between DEET and the toxicant. Trials are also needed to confirm the benefits of an antifeedant to a wider suite of invertebrate species under field conditions. The authors also suggested that the environmental fate of DEET needed investigation.

The presence of cinnamon oil in baits at 0.1% reduced the numbers of invertebrates by >50% compared with 'plain' baits.

The Agency asked the applicants for an update on any on-going research on invertebrate repellents/antifeedants and was advised that they are not aware of any (G. Sherley, personal communication, 28 February 2007).

If a suitable invertebrate repellent were identified at some point in the future, the extra costs of adding the substance to bait would need to be balanced against the benefits of doing so.

N2.3.2 Conclusions

Due to the level of uncertainty in the toxicity data for invertebrates, and the lack of information on amounts of bait likely to be eaten, the Agency has not attempted to assess direct exposure to invertebrates.

Available monitoring data indicates that invertebrates which feed on baits are not adversely affected at a population level, and the extent of any impact is very localized to within a short distance from a toxic bait.

While invertebrates feeding on poisoned animal carcasses may be exposed to 1080 residues, the Agency has not assessed exposure from this source. Any effects are likely to be minimal.

Overall, the Agency considers the risks to invertebrate populations from direct and indirect exposure to 1080 to be very low to medium.

N2.4 Reptiles and amphibians

New Zealand lizards are mainly insectivorous but also feed on nectar, fruit and honeydew. Native frogs are insectivorous and unlikely to feed on other types of food.

N2.4.1 Attractiveness and palatability of baits

Cereal and carrot

The responses of captive skinks, *Leiolopisma maccanni* to green-dyed non-toxic RS5 cereal baits and to Agtech cereal bait containing pindone (an anticoagulant used mainly for rabbit control) have been evaluated over a five day period (Freeman et al 1997). The effect of bait size was also assessed as was the effect of moisture content of the baits. A small pebble was placed alongside the baits as a 'control' object.

Thirty-two of 35 skinks investigated the baits, two did not investigate the RS5 bait and one did not investigate the pindone bait. Skinks rarely attempted to feed on the dry RS5 bait, but did feed on the dry pindone bait.

Consumption of wetted baits increased significantly, with no difference between the two types of bait. Dye and/or bait fragments were found in 55% of faecal pellets from skinks which fed on RS5 baits and in 97% of those from skinks which consumed pindone bait.

Mean consumption of pindone bait was higher at 0.020 g (n=17) compared with 0.012 g of RS5 bait (n-10), with maximum consumption at 0.042 g for RS5 and 0.14 g for pindone bait.

The Agency was not able to locate any information on the palatability of carrot bait to lizards.

Other bait types

Apple paste and gel block

Ten captive common skinks (*Leiolopisma nigriplantare*) were presented with 10 g of non-toxic apple paste (code BB13 = old 'jam bait' formulation) or 10 g non-toxic gel bait block on separate occasions (Morgan 1999). Eight skinks were observed investigating the BB13 paste and two observed feeding on the paste for a total of 2.8 minutes. Quantities consumed were not reported. Two skinks investigated the gel but none was observed feeding on it.

N2.4.2 Conclusion

The Agency has no information on whether these data are representative of the attractiveness of currently used baits to skinks and has made no quantitative assessment of the risks of 1080 to skinks. The Agency has made no assessment of risks to frogs, but notes that several monitoring trials have been performed and have shown no evidence of effects on frogs.

N2.5 Dogs

The 1080 LD_{50} to dogs is lower than that for many other mammals. Deaths of dogs from both primary and secondary poisoning has been reported.

N2.6 Deer

N2.6.1 Attractiveness and palatability of baits

Both carrot and cereal bait have resulted in mortality of deer, either as target or non- target species.

Effect of lures and repellents on attractiveness and palatability

A deer repellent is available and in use on carrot bait. For example, large scale field trials to examine the use of bait with deer repellent have been performed at Hatepe in the Kaimanawa Forest Park (Speedy 2003), and in the Tataraakina area in northern Hawkes Bay (Nugent et al 2004), comparing repellent treated bait with standard 1080 carrot or cereal pellet bait in adjacent areas. A very large area (~25 000 ha) of the Hauhangaroa Ranges were treated as part of a larger aerial 1080 operation over ~83 000 ha (Epro 2005). (In the Haungaroa operation, two pre-feed drops occurred, with the second using bait which was non-toxic but also dyed green rather than the usual undyed bait used in the first pre-feed (Epro 2005)).

Carrot bait

Hatepe includes a recreational hunting area with a population of sika deer (*C. nippon*). The deer repellent had previously been trialled on captive sika deer which showed a strong aversion to the substance on their usual feed. The repellent treated carrot (0.08% 1080) was aerially sown at 5 kg/ha over ~1000 ha, having previously been pre-fed with non-toxic carrot (Speedy 2003). The total area treated was ~5240 ha but the difference was treated with one of four ground-based methods as part of a broader evaluation of relative efficacy and costs.

The aerial application of deer-repellent carrot at Hatepe resulted in a post-operation RTCI of 0.17% and was more cost effective than any of the ground control methods used and resulted in a significant rat by-kill not seen in the other blocks. Five dead deer (♀ two adult, one sub-adult; ♂ two juveniles) were located during a nine-day search of one sector of the repellent treated block. Analysis of muscle tissue for 1080 residues confirmed the cause of death for these animals although the residue data have not been sighted by the Agency. These numbers extrapolated to an estimated kill of up to 40 deer across the whole repellent treated block, representing an estimated kill of ~13% of the estimated 300 deer living in the block. The deer kill resulted in significant ill-feeling from the hunting community who had originally opposed the trial.

No monitoring of birds in the treatment areas was undertaken but the search for deer carcasses revealed carcasses of three tomtits, two blackbirds, two ship rats and one stoat, and many possums. The birds were sampled for 1080 residues, but as for the deer, the results were not appended to the copy of the report accessed by the Agency. The author of the study considered that the greater than expected by-kill of deer may have resulted from the deer-repellent mixture not fully adhering to the carrot, along with 70 mm of rain falling over the first eight days after bait sowing. The small body size of sika deer may also have resulted in a higher kill than may have been expected with the larger red deer. They also noted that the repellent mix has been changed and subsequently used successfully to repel red deer in the trials at Tataraakina, northern Hawkes Bay (Nugent et al 2004). The Agency does not have the formulation details of either deer repellent.

At Tataraakina, toxic carrot bait (0.15% 1080) with deer repellent was aerially applied at 5 kg/ha to 2000 ha of private land and without deer repellent to another 2000 ha on public conservation land. Both blocks had been pre-fed (Nugent et al 2004).

Results of the trial with deer repellent indicated no significant effect on birds, but the 5-minute bird-counts were undertaken on three species (kereru, tomtit and robin) only by inexperienced observers, with the authors acknowledging that the method used didn't have the statistical power to detect anything but a very large degree of mortality. A nine-day search for deer carcasses after the operations located four dead deer in the non-repellent block (♀ one adult; ♂ three fawns), one blackbird in each of the repellent and non-repellent blocks. One pig and three sheep were found dead in the repellent block. The rumens of all dead deer were examined and all contained bait fragments. Muscle residues were also measured at 0.7–1.2 mg 1080/kg tissue. One blackbird was found to contain 1080 residues of 0.014 mg 1080/kg tissue, the other was too decomposed to analyse. No other residue analyses were conducted.

The possum kill rates were comparable in both the repellent and non-repellent blocks, with reduced deer kills (estimated to be near zero) in the repellent block compared with non-repellent block (estimated 56%). Fresh deer sign was observed in the non-repellent block after the operation, despite no actual sightings by field staff. The authors noted that the low numbers of deer seen in all blocks after the operation limited the ability to determine whether the decline in the repellent block was significantly different from the non-repellent block.

Following the completion of the Tataraakina trials, a further 4979 ha of privately owned land was treated by the Hawkes Bay Regional Council with deer repellent-coated carrot bait. No structured monitoring of the block for deer kill was undertaken, but the land manager reported sightings of live deer and fresh sign in the block after the operation (P. Shaw personal communication, in Nugent et al 2004).

The largest operation using deer repellent that the Agency is aware of is outlined in the Case Study on page 67 of the application, where ~25 000 ha of conservation and private land in the Hauhungaroa Ranges was treated out of a total operational area of ~83 000 ha. The Agency requested further information on the operation from the applicants, but only received excerpts from the post-operational report from the contractor to Environment Waikato (the lead Agency for the Hauhungaroa Tb vector control operation). The information provided in the excerpts is very limited in scope. The area treated with deer repellent-coated carrot included a DoC research block where the effects of red deer on vegetation were being investigated. Non-target deaths were noted as one dead red deer on a road in Pureora Forest, with no other assessment apparent except a statement that "numerous sightings of pigs and deer have been reported in the treatment area since the operation", without any clarification as to whether 'treatment area' referred to the whole area treated with 1080, or just the area treated with 1080 containing deer-repellent.

The cost of deer repellent in 2003 was an additional $6/ha for the Hatepe trials (Speedy 2003), that is, $26.25/ha with repellent, $20.25/ha without repellent.

Department of Conservation policy on the use of deer repellent on conservation land is summarised on pp 3–4 of the application. Deer repellent may be used in gazetted Recreational Hunting Areas (RHAs) subject to certain criteria regarding the potential for increased operational costs impacting on the efficacy of possum control or its use impacting indigenous biodiversity which could be interpreted either as deer causing unacceptable damage, or the repellent causing an impact. The eight Gazetted RHAs are Pureora, Kaimanawa, Aorangi, Lake Sumner, Oxford, Wakatipu, Blue Mountain and Kaweka. The applicants note that with a major decline in commercial deer recovery, deer numbers on conservation land are increasing, providing additional hunting opportunities. Where appropriate, the timing of aerial 1080 operations avoids the Roar (March-April) to facilitate recreational hunting, for example in the Tararua Ranges (Brown and Urlich 2005).

Cereal bait

The same repellent has apparently been used in field trials on cereal bait over 1500 ha in Hawkes Bay (Morriss et al 2005), however the colour of the bait (green) is not maintained after the repellent has been applied, turning them brown (P Fairbrother *pers.comm*). The resulting baits are therefore not covered by existing HSNO approvals which currently require baits to be green or blue (see above). The trial results indicated that the repellent is effective against red deer (*Cervus elaphus*) with an estimate of twice as many deer surviving in the repellent block compared to the non-repellent block. The repellent had no observable effect on possum kill, with the target RTCI of <5% achieved in both blocks. Birds were not systematically monitored during the trial, but carcasses found during searches for dead deer were assessed for 1080 residues, as were deer muscle samples. Residues ranged from 7.2 – 32 mg/kg in blackbirds (n=11), with the highest residues (12–32 mg/kg) from the non-repellent block; 1.4–5.8 mg/kg in chaffinch (n=2); 0.23–0.75 mg/kg in tomtits from the repellent block (n=2). The dead pig located in the no-repellent block contained 0.46 mg/kg in muscle samples; and in deer (n=11) from the no-repellent block 0.25–4.4 mg/kg. It is possible that the higher residues in blackbirds from the repellent block indicate that the coating may make the repellent-coated baits more palatable, but there is insufficient information to allow an assessment.

Further work is in progress in an effort to remedy the bait colour and further replication of the single trial is needed, along with more rigorous assessment of palatability to rodents and non-target species.

Given the complexity of the issues, and the very site-specific nature of deer management, the Agency does not consider that at this stage it is feasible to add a control to any substances containing 1080 that would require the use of a deer repellent.

The social, ethical and economic issues associated with deer management are addressed in sections 9.3.5 and 9.3.6 of the E&R report.

N3 Aquatic biota

The Agency has made no quantitative assessment of risks to aquatic biota since exposure is estimated to be very low.

Some pellets are highly likely to fall into small, high-energy streams during an aerial operation. They are likely to remain intact for hours rather than minutes. Leaching of 1080 and dilution over such a period is likely to be significant. Toxicity information available for aquatic life is limited, but indicates effects on fish and invertebrates only at concentrations >10 mg/L. Blue-green algae showed effects at about 1 ug/l. There is also one very old report of effects on mosquito larvae at 25–100 ug/l. It is improbable that the number of pellets falling into streams will produce such concentrations other than on a very local scale, if at all. If algae were adversely affected, the duration of any effects would be short given the high cell turnover and capacity to re-colonise/re-establish after an impact. Natural events such as flooding would have far greater effects on aquatic communities.

Monitoring of effects on aquatic life has been confounded by flooding either prior to, or after, an aerial operation No effects attributable to 1080 have been found.

Laboratory studies on eels and freshwater crayfish have shown no adverse effects from direct or indirect exposure to 1080 baits or for eels, residues in possum tissues.

Note that the applicants refer to controls on aircraft carrying 1080 baits flying over human water supply catchments which are not relevant to consideration of effects on aquatic species. Small streams may not be visible from the air and based on the information reviewed by the Agency, there is no evidence of adverse effects on aquatic life from the deposition of baits in these water bodies.