# Sodium fluoroacetate

## Pesticide Information Review

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| 2014/1 | 29/08/2014 | New data on soil breakdown (Section 2.2.2), water samples (Section 2.3.1), native non-targets (3.2.3), and revised overview for native non-targets |
| 2013/1 | 18/09/2013 | New information on kea (Sections 2.5.4, 3.2.1 and 3.2.3) and morepork, kaka, robins, tomtits, grey warbler and riflemen (3.2.3). |
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| 2012/2 | 17/10/2012 | New information on 1080 resiudes in magpies (*Pica pica*) in 2.5.4, and $LD_{50}$ for magpies in 4.1.1. |
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| 2009/7 | 15/12/2009 | 3.2.3 (skinks and weka); 5.1.7, 6.2.4 (Rats) |
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| 2009/5 | 13/8/2009 | New information in sections 2.5.4 (Quail) & 4.2.1 (0.2% carrot and 0.04% oat operations). |
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| 2006/2 | 10/08/06 | New information in section 3.2.3 (paste baits) |
| 2006/1 | 15/3/06 | New information in sections 2.1.1; 2.5.5; 3.2.3; & 6.2.4. |
| 2005/2 | 17/03/05 | New information in sections 2.1.1; 2.4.2; 2.5.2; & 6.2.4. |
| 2005/1 | 18/01/05 | Up dated Section 1.4 pesticide uses |
| 2004/2 | 8/10/2004 | Residue and non-target native and feral animal information from Speedy (2003) included |

| | | |
|---|---|---|
| 2004/1 | 15/9/2004 | Original document |

**Contents**

# I. Overview

### Introduction

Sodium monofluoroacetate (1080) is the most widely used poison for possum control in New Zealand for situations where possum numbers need to be reduced rapidly over large areas. Vertebrate pesticides containing 1080 are also registered for the control of rabbits, wallabies, deer, goats, cats and rodents. The manufactured 1080 used in toxic baits is chemically identical to the toxic compound found in some poisonous plants, and highly toxic fluoroacetate-producing plants are globally distributed. In plants, fluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

Monofluoroacetate is converted within animals to fluorocitrate, which inhibits the tricarboxylic acid cycle. This results in accumulation of citrate in the tissues and plasma, energy deprivation, and death. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions.

### Fate in the Environment

1080 in baits may be defluorinated in 1–2 weeks under favourable conditions. However, under less favourable conditions breakdown may take several weeks and, in extreme cold and drought, 1080 residues could persist in baits for several months.

Degradation of 1080 is slow in soil and sediments, taking 1-4 weeks under favourable conditions. The rate of degradation will be influenced by the presence of soil or litter micro-organisms, and temperature, soil moisture and rainfall. Sodium monofluoroacetate is highly water soluble so leaching out of soil will occur.

While the concentration of 1080 in deionised (sterile) water remains relatively constant and independent of temperature, 1080 degradation occurs within 1-2 weeks in natural water. Temperature, and the presence of aquatic plants and microbes all affect 1080 degradation in aquatic environments. Water samples have been collected from streams following numerous pest control operations using 1080. 96.6% of these samples contained no residues of 1080. Where residues were found most of these had less than 1 $\mu g\ l^{-1}$ 1080. Where higher 1080 residues have been found in water, the samples were mostly from very small streams and/or associated with the presence of bait, during aerial operations.

While plants can take up 1080, it is unlikely to be in large amounts. If taken up, 1080 residues persist less than 38 days in plants.

1080 has a relatively short half-life in sub-lethally dosed animals and it is metabolised and eliminated from living animals within days. However, it can persist in carcasses for months. The rate of degradation of 1080 in carcasses will depend on moisture, temperature and the presence of micro-organisms.

**Effects on Non-Target Native Species**

Based on the few studies of native species available, and the large number of non-native species studied (Part 4) suggests 1080 is likely to be toxic to most native animals. There is wide variation in sensitivity between taxonomic groups with mammals more sensitive than birds and invertebrates (on a weight for weight basis). Sub-lethal effects have been demonstrated for native invertebrates in the laboratory. The small size of many native species (relative to the target pests) means that toxic baits used for pest control are capable of causing harm to almost any animal that eats the bait. Therefore the level of exposure to the bait becomes important in determining the effects on non-target native species in the field.

Most information on non-target exposure to 1080 bait relates to aerial poisoning as this is thought to be the "worst case scenario" for studying non-target effects. Hand laid baits are sometimes used to approximate aerial poisoning in studies. Bait station studies are scarce. It could be assumed that native species are not more at risk using bait stations than distributing the same bait type aerially.

There are records of a range of native bird species found dead after aerial poisoning operations and many of these individuals have contained residues of 1080. However when records are discounted from:

- operations which did not meet current bait quality standards (e.g. using unscreened, un-dyed carrot bait with berry fruit lures) or
- those animals which did not have detectable 1080 residues,

the Vertebrate Pesticide Residue Database (VPRD) between 1994-2013 recorded only 35 poisoned individuals representing 10 native species across all bait types used in aerial poisoning. No conclusions about population effects can be drawn from this information but it is useful to focus further studies. Some native species (mainly invertebrates) have contained 1080 residues when sampled, an indication of potential risk to insectivores from secondary poisoning.

Loss of individuals in a population of native species as a consequence of 1080 poisoning can have variable significance to the long term viability of the population depending on the context. Those animals with a large population and/or a high rate of increase can compensate for small loses. Poison-related mortality may be replacing deaths from predation or winter starvation. Threatened species usually have a poor ability to recover from additional mortality, making the consequences theoretically more concerning.

There have been numerous studies examining the effects of aerial poisoning on native non-target populations over the last 20 years. 21 species of native birds, particularly threatened species, have been monitored. None of the studies have identified population level mortality which threatened the viability of the species, although the only reliably calculated mortality rates are for kokako, kiwi, kaka, whio and fernbirds. The upper 95% mortality rates for kokako, kiwi, kaka, whio are all less than 8.4%. The mean mortality rate for fernbirds is 9.4%.

Limited monitoring of short tailed bats and native frogs has not indicated detectable mortality due to aerial 1080 poisoning.

Invertebrate populations have been monitored in nine aerial poisoning operations and none have shown significant population effects on any species

studied, nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals. Long term monitoring of native land snails indicates substantial benefits to threatened populations in sites treated with aerial poisoning.

The risks 1080 operations pose to aquatic species is considered very low. Fish are very tolerant to 1080. Additionally, 1080 contamination of water is rarely found during 1080 operations and is at an extremely low level when it has occurred. No mortality of longfin eels, köaro or upland bullies was observed during experiments where high densities of cereal 1080 pellets were placed in water just upstream of them. Eels and koura have survived experimental feeding of cereal 1080 pellets, and eels have survived feeding on possum tissue containing 1080. There have also been no detectable effects on aquatic invertebrate communities in field studies when 1080 baits were placed at high densities in streams.

**Effects on Domestic and Feral Animals**

There is wide variation between species in their susceptibility to 1080 poisoning. Dogs are especially vulnerable and highly likely to die if they eat 1080 baits or scavenge animals killed by 1080. Larger animals such as cattle need several possum baits to receive a lethal dose but deaths have been reported where animals have access to baits, including those contained in bait stations.

Sub-lethal effects at realistic dose rates have been recorded in sheep and other species, typically affecting the heart. Exposure to prolonged high doses resulted in mild foetal abnormalities in pregnant rats and damaged sperm in male rats but no mutagenic properties were found. No antidote is currently available for 1080 poisoning although veterinary treatment can be successful.

Feral deer population mortality from aerial poisoning operations targeting possums is highly variable and does not appear to be consistently influenced by toxic loading, sowing rate, prefeeding or bait type. Most estimates of deer kill fall between 30 and 60%. Nugent et al. (2001) quote productivity figures for red deer populations of around 30% so low to moderate by-kill of deer populations is probably negated within a couple of years.

Birds are generally less susceptible to 1080 than mammals but introduced birds such as blackbirds and chaffinches are found dead after aerial poisoning operations. Lizards and fish appear quite tolerant of 1080, according to research on overseas species.

Although 1080 is toxic to bees, baits used in pest control are generally not attractive to bees. However this may not always be the case if bees are particularly hungry, so beekeepers should always be notified of operations.

**Human Health**

The estimated lethal dose of 1080 in humans lies in the range of 0.7 and 10.0 mg $kg^{-1}$. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions. The onset clinical signs usually range from 30 minutes to about 2-3 hours. Signs of poisoning include nausea, vomiting, and abdominal pain initially,

followed by respiratory distress, anxiety, agitation, muscle spasms, stupor, seizures, and coma.

1080 is not a mutagen and is unlikely to be a carcinogen. It has sub-lethal effects on reproduction and is classified as a teratogen.

There is no effective antidote for 1080 poisoning in humans and any treatment given is largely symptomatic and supportive.

**Operational**

1080 is considered to have medium humaneness for possums, however there has been little formal research into the humaneness of 1080 on other target species. Most deaths of pest species occur 8 – 48 hours after ingestion of a lethal dose.

All the registered target species have relatively high susceptibility to 1080. The short latent period means that bait shyness can develop in animals receiving a sub-lethal dose. Mice exhibit a marked avoidance of 1080 which is likely to result in control operation failures.

The majority of pest control operations using 1080 have target pest kills of greater than 80%.

# 1. Introduction

Sodium monofluoroacetate (1080) is the most widely used poison for possum control in New Zealand for situations where possum numbers need to be reduced rapidly over large areas. Vertebrate pesticides containing 1080 are also registered for the control of rabbits, wallabies, deer, goats, cats and rodents. The manufactured 1080 used in toxic baits is chemically identical to the toxic compound found in some poisonous plants, and highly toxic fluoroacetate-producing plants are globally distributed. In plants, fluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

Monofluoroacetate is converted within animals to fluorocitrate, which inhibits the tricarboxylic acid cycle. This results in accumulation of citrate in the tissues and plasma, energy deprivation, and death. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions.

## 1.1 Chemical name

Sodium monofluoroacetate

## 1.2 Synonyms

Sodium fluoroacetate, Monofluoroacetate, Compound-1080, 1080 ('ten-eighty')

## 1.3 CAS Numbers

62-74-8

## 1.4 Registered pesticides containing 1080 available in New Zealand

0. 2 % 1080 Pellets (2 g $kg^{-1}$ 1080), Pesticide use numbers: 21, 22, 23

0.15% 1080 Pellets (1.5 g $kg^{-1}$ 1080), Pesticide use numbers: 1, 2, 3, 54, 55, 56, 98

0.08 % 1080 Pellets (0.8 g $kg^{-1}$ 1080), Pesticide use numbers: 7, 8, 9

0.08 % 1080 Rodent Pellets (0.8 g $kg^{-1}$ 1080), Pesticide use numbers: 10, 11, 12, 99

0.06% 1080 Pellets (0.6 g $kg^{-1}$ 1080), Pesticide use numbers: 101, 102, 103, 104, 105, 106, 107

0.04% 1080 Pellets (0.4 g $kg^{-1}$ 1080), Pesticide use numbers: 13, 14, 100

1080 solution (200 g $l^{-1}$ 1080), Pesticide use numbers: 5, 6, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 37

No Possums® 1080 gel (1.5 g $kg^{-1}$ 1080), Pesticide use numbers: 91

0.1% 1080 Feral Cat Bait (1.0 g $kg^{-1}$ 1080), Pesticide use numbers: 38, 115

10% 1080 Gel (100 g $kg^{-1}$ 1080), Pesticide use numbers: 15, 39, 97

5% 1080 Gel (50 g $kg^{-1}$ 1080), Pesticide use numbers: 16

Pestoff Exterminator Paste (1.5 g $kg^{-1}$ 1080), Pesticide use numbers: 35, 36

Pestoff Professional 1080 Possum Paste 0.08% (0.8 g $kg^{-1}$ 1080), Pesticide use numbers: 41

Pestoff Professional 1080 Possum Paste 0.15% (1.5 g $kg^{-1}$ 1080), Pesticide use numbers: 42, 96

Pestoff Professional 1080 Possum & Rabbit Paste 0.06% (0.6 g $kg^{-1}$ 1080), Pesticide use numbers: 44

## 1.5 Chemical and physical properties

1080 has an empirical formula of $C_2H_2FNaO_2$ and a molecular weight of 100.3. In its pure form 1080 is an odourless, colourless, non-volatile powder that decomposes at about 200°C. Although the compound is often said to be tasteless, dilute solutions are thought to taste like weak vinegar. Sodium monofluoroacetate is very water-soluble but has low solubility in organic solvents such as ethanol and oils. Monofluoroacetates are chemically stable, hence 1080 as a pure compound in powder form—or when prepared in an aqueous stock solution—will not readily decompose.

This section is from Eason & Wickstrom (2001).

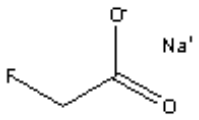


FIGURE 1. THE CHEMICAL STRUCTURE OF SODIUM FLUOROACETATE.

## 1.6 Historical development and use

Sodium monofluoroacetate was first patented as a rodenticide in the late 1930's, with commercial use starting in the United States in 1944 to control gophers, ground squirrels, prairie dogs, field mice, and commensal rodents. In New Zealand the first trials were carried out in 1954, and by 1957 its use had become widespread. Currently in New Zealand the principal target species is possums. It is also registered for use against rabbits, wallabies, deer, goats, cats and rodents. 1080 was also used in a fish-based paste to control wasps in the late 1990s.

Manufactured 1080 for use in toxic baits is chemically identical to the toxic compounds found in a poisonous plant, with naturally produced 1080 inducing the same signs and symptoms in animals (de Moraes-Moreau et al. 1995). In plants, monofluoroacetate appears to be a secondary plant compound that is biosynthesised at high concentrations as a chemical defence mechanism against browsing invertebrates and vertebrates.

Highly toxic fluoroacetate-producing plants are globally distributed. Research in the 1940s identified monofluoroacetate, the active toxin in 1080, as the toxicant in the South African plant gifblaar (*Dichapetalum cymosum*), which has long been recognised as a hazard to livestock. Monofluoroacetate has also been identified as the toxic agent in many other poisonous plants, such as rat weed (*Palicourea margravii*), native to Brazil (de Moraes-Moreau et al. 1995); and ratsbane (*Dichapetalum toxicarium*), native to Africa (Atzert 1971). Monofluoroacetate also occurs naturally in about 40 plant species in Australia.

Levels of monofluoroacetate can reach very high levels in these plants. For example, air-dried leaves of *Gastrolobium bilobum* (heart-leaf poison) and *G. parviflorum* (box poison), two Australian plants, can contain up to 2600 mg $kg^{-1}$ of monofluoroacetate, and seeds of *G. bilobum* can have in excess of 6500 mg $kg^{-1}$ of monofluoroacetate (Twigg 1994; Twigg et al. 1996a; Twigg et al. 1996b; Twigg et al. 1999). The highest monofluoroacetate concentration so far reported from a plant is 8000 mg $kg^{-1}$ in the seeds of the East African *Dichapetalum braunii* (O'Hagan et al. 1993).

Most studies assessing monofluoroacetate concentrations in plants have focused on those species that are overtly toxic to mammals. However, it would appear that the ability of plants to synthesise monofluoroacetate is more widespread than generally supposed, since monofluoroacetate occurs at extremely low concentrations in some Finnish plants (Vartiainen & Kauranen 1980), in tea leaves (Vartiainen & Kauranen 1984) and guar gum (Vartiainen & Gynther 1984; Twigg et al. 1996b). In addition some plants, when exposed to fluoride ions, can biosynthesise fluoroacetate, albeit at very low levels. Fluorocitrate, the toxic metabolite of monofluoroacetate, has also been detected in tea leaves (Peters & Shorthouse 1972). Fluoroacetate biosynthesis can also occur in some bacteria, notably *Streptomyces cattleya* (O'Hagan & Harper 1999). Resistance in mammals, birds, and insects occurs in areas where there is continued exposure to the toxin. Interestingly, the caterpillar moth, *Sindrus albimaculatus*, which feeds on *Dichapetalum cymosum*, can not only detoxify fluoroacetate, but also accumulate it (probably in vacuoles) and uses it as a defence against predation (Meyer & O'Hagan 1992).

This section is from Eason & Wickstrom (2001).

## 1.7 Toxicology and pathology

### 1.7.1 Mode of action

Monofluoroacetate is converted within animals to fluorocitrate, which inhibits the tricarboxylic acid cycle. This results in accumulation of citrate in the tissues and plasma, energy deprivation, and death. Synthesis of fluorocitrate occurs in the mitochondria, and the fluorocitrate formed inhibits mitochondrial aconitate hydratase. There is also evidence to suggest that fluorocitrate inhibits citrate transport into and out of mitochondria, and that fluorocitrate has an inhibitory effect on succinate dehydrogenase. The high levels of citrate concentration that occur during monofluoroacetate intoxication can also have an inhibitory effect on the glycolytic enzyme, phosphofructokinase.

Death from monofluoroacetate poisoning is caused by the inhibition of energy production which, in turn, results in either cardiac or respiratory failure. Fluorocitrate is commonly described as a specific metabolic inhibitor of glial cells in the brain. Glial cells are thought to be important for extracellular fluid ion and pH regulation, and the control of breathing (Erlichman et al. 1998).

This section is from Eason & Wickstrom (2001).

### 1.7.2 Pathology

Known target organs in animals following 1080 exposure include the heart, lungs, liver, kidney, testes, and foetus (Annison et al. 1960; McTaggart 1970; Buffa et al. 1977; Sullivan et al. 1979; Schultz et al. 1982; Trabes et al. 1983; Chung 1984; Savarie 1984; Twigg et al. 1988; Chi et al. 1996; Gregg et al. 1998; Eason et al. 1999). The pathological changes observed at post-mortem appear to be largely the result of progressive cardiac failure with congestion of the abdominal viscera and lungs. Examination of monofluoroacetate-poisoned mammals usually reveals cyanosis of mucous membranes and other tissues. Diffuse visceral haemorrhage has been described in some animals, particularly cattle. Subepicardial haemorrhages on the epicardium and endocardium as well as on the epiglottis and trachea have been observed in sheep and possums poisoned with monofluoroacetate. The presence or absence of tissue damage is likely to be dose-related, and subepicardial haemorrhages have been observed in rabbits receiving a lethal dose of monofluoroacetate but not in those receiving a sub-lethal dose. It is apparent that the target organs vary to some extent in different species, which may relate to the citrate response in different species, or the metabolic activity in different tissue. In birds a target organ appears to be wing muscle (Ataria et al. 2000) as well as the heart, which is a more common target in other species.

This section is from Eason & Wickstrom (2001).

### 1.7.3 Absorption, metabolism, and excretion

Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions.

After oral or intravenous dosing of laboratory rodents, 1080 is rapidly absorbed and distributed through the soft tissues and organs (Hagan et al. 1950; Egeheze &

Oehme 1979; Sykes et al. 1987). This contrasts with the action of commonly used anticoagulant rodenticides, such as brodifacoum, which preferentially bind to liver cells (Bachmann & Sullivan 1983). Sodium monofluoroacetate is excreted as unchanged fluoroacetate and a range of non-toxic metabolites (Gal et al. 1961; Schaefer & Machleidt 1971). Approximately 30% of a dose of 1080 administered to rats was excreted unchanged in the urine over 4 days (Gal et al. 1961). At least seven unidentified metabolites other than fluoroacetate and fluorocitrate, the toxic metabolite of 1080, were also detected in rat urine (Gal et al. 1961).

Administration of $^{14}C$-labelled fluoroacetate to rats showed that fluorocitrate, the toxic metabolite of 1080, accounted for only 3% of the radioactivity (Gal et al. 1961), and this was confirmed by Schafer & Machleidt (1971). The major metabolite, unlike fluorocitrate, does not inhibit the activity of aconitase (Gal et al. 1961). Phillips & Langdon (1955) suggested that the unidentified metabolites include non-saponifiable lipids that probably serve as intermediates for cholesterol, and some radioactivity was found in fatty acids and cholesterol in the liver. Up to 3% of the radioactivity appeared as respiratory $CO_2$, which implied cleavage of the C-F bond (Gal et al. 1961).

Defluorination of 1080 or its metabolites, including fluorocitrate, has been demonstrated in animals and other living organisms (Kirk & Goldman 1970; Smith et al. 1977; Egeheze & Oehme 1979; Soifer & Kostyniak 1983, 1984; Twigg et al. 1986; Tecle & Casida 1989). Although fluoride is extensively excreted, primarily in urine, some deposition occurs in bone (Sykes et al. 1987; Eason et al. 1993a; Eason et al. 1993b; Rammell 1993; Eason et al. 1994b).

This section is from Eason & Wickstrom (2001).

# 2. Fate in the Environment

1080 in baits may be defluorinated in 1–2 weeks under favourable conditions. However, under less favourable conditions breakdown may take several weeks and, in extreme cold and drought, 1080 residues could persist in baits for several months. The 1080 in certain gel block and paste baits, can still be present for up to 18.6 months, or >5000 mm of rain.

Degradation of 1080 is slow in soil and sediments, taking 1-4 weeks under favourable conditions. The rate of degradation will be influenced by the presence of soil or litter micro-organisms, and temperature, soil moisture and rainfall. Sodium monofluoroacetate is highly water soluble so leaching out of soil will occur.

While the concentration of 1080 in deionised (sterile) water remains relatively constant and independent of temperature, 1080 degradation occurs within 1-2 weeks in natural water. Temperature, and the presence of aquatic plants and microbes all affect 1080 degradation in aquatic environments. Water samples have been collected from streams following numerous pest control operations using 1080. 96.9% of these samples contained no residues of 1080. Where residues were found most of these had less than 1 µg $l^{-1}$ 1080. Where higher 1080 residues have been found in water, the samples were mostly from very small streams and/or associated with the presence of bait, during aerial operations.

While plants can take up 1080, it is unlikely to be in large amounts. If taken up, 1080 residues persist less than 38 days in plants.

1080 has a relatively short half-life in sub-lethally dosed animals and it is metabolised and eliminated from living animals within days. However, it can persist in carcasses for months. The rate of degradation of 1080 in carcasses will depend on moisture, temperature and the presence of micro-organisms.

## 2.1 Bait pathway

### 2.1.1 How long do baits remain toxic?

*Under favourable conditions, e.g. 11 – 20°C and 8–15% moisture, 1080 may be significantly defluorinated in 1 – 2 weeks (King et al. 1994). Under less favourable conditions breakdown might take several weeks and, in extreme cold and drought, 1080 residues could persist in baits for several months.*

**Pellets**

*On land*

Booth et al. (1999a) reported that 1080 began leaching out of Wanganui #7, 6 gram, 0.15% 1080 Pellets after 20 mm of simulated rainfall and that the 1080 declined to near the limit of detection after 250 mm simulated rainfall. Bowen et al. (1995) found that both 0.08% and 0.15% 1080 6 gm RS5 cereal pellets lost

1080 more quickly than equivalent 6 gm Wanganui #7 cereal pellets under simulated rainfall. The RS5 cereal pellets were less water resistant and started to disintegrate after approximately 5 mm of rain. 1080, at both concentrations, had been completely leached out of the RS5 cereal pellets after 150 mm rain.

When 10 - 12 g 0.15% 1080 Wanganui #7 cereal pellets were exposed to a simulated rainfall of 20 mm/hour, most of the 1080 concentration was retained after exposure to 50 mm of rain. The 1080 concentration rapidly declined in the pellets over the following 50 mm of rainfall. By comparison, the 1080 concentration in 10 - 12 g 0.15% RS5 pellets declined at a steady rate. By 100 mm the 1080 had completely leached out of both types of pellets (Thomas et al. 2004). The 10 - 12 g cereal pellets in this study retained more 1080 when exposed to <100 mm of simulated rain than the 6 g cereal pellets examined by Bowen et al. (1995).

Ogilvie et al. (2004) reported that Wanganui #7 pellets lying on the ground in the field had a 99% reduction in the 1080 concentrations after 56 days. Over this time period 110 mm of rain fell.

During trials on long-life baits, Morgan (2004) found that 0.15% 1080 Pellets with a double wax coating placed in Philproof bait stations took 9 months for the toxicant concentration to decline by 30%.

Bait breakdown was monitored during the 1990 Rangitoto Island and Waipoua Forest Sanctuary possum control operations. Aerially distributed 6 g 0.08% 1080 Pellets were used in the operations, and most baits had less than 10% of their original 1080 concentration after 28 - 29 days. However, some baits only reached 10% of their original toxic loading after 41 days (Eason et al. 1991a, b).

Wright (2004) monitored the fate of 20 mm (12 g) 0.15% 1080 Wanganui #7 pellet baits at two sites during an 8600 ha aerial operation in the Hutt River upper catchment. On the day of application baits tested contained 1.43 g $kg^{-1}$ 1080. After 29 days baits from the two sites contained 0.05 g $kg^{-1}$ and 0.04 g $kg^{-1}$, and were still dyed green although damp and soft. Site one had received 30 mm of rain by this time and 70 mm for site two. After 40 days baits from both sites were pale green and had no detectable residues. Cumulative rainfall recorded by this time was 88 mm for site one and 186 mm for site two. Baits were still visible after 52 days, but by day 65 and 387 mm of rain they were not discernable at site two.

Thomas et al. (2004) analysed bait breakdown rates from data collected during 19 operations using 0.15% 1080 Wanganui #7 cereal pellets and 11 operations using 0.15% 1080 RS5 cereal pellets. Bait sizes used in the operations ranged from 3 – 12 grams. Most of the 1080 content, of both bait types, was removed following 150 – 200 mm of natural rainfall.

*In water*

Suren (2006) conducted laboratory experiments to examine the fate of pellet baits that fell into moving water and to quantify the rate that 1080 leached from the pellets. 0.15% 1080 Wanganui #7 pellets were placed in flow tanks that had a cobble base and water flowing through them at 20 cm $s^{-1}$. Eleven and 6 g baits were used in the experiment. Both bait sizes followed a similar pattern of breakdown. The baits remained relatively intact for the first 48 hours, but lost their bright green colour. After 72 hours the baits had become swollen and started to fragment. At 84 hours the baits had disintegrated. While baits

remained for up to 72 - 84 hours before they disintegrated, 1080 leached out of the baits far more rapidly. 1080 was rapidly lost from submerged baits within the first 8 - 12 hours. Fifty percent of the 1080 in the baits was lost after the baits had been submerged for 5 hours. By 24 hours, 90% of the original 1080 concentration had been lost, and no 1080 was detected in any baits after 36 hours.

**Carrot**

Thomas et al. (2004) subjected 12 g carrot baits containing 1.5 g $kg^{-1}$ 1080 two different simulated rainfall treatments. The first treatment involved subjecting carrot baits to 20 mm $hr^{-1}$ simulated rainfall starting 1 hour after the 1080 was applied. The 1080 in the carrot leached out of the carrot rapidly, with the carrot losing approximately 74% of the 1080 after 10 mm of simulated rainfall. In the second treatment, which was designed to be more representative of field operations, involved starting the simulated rainfall started 48 hours after the 1080 was applied to the carrot. The carrot in this treatment retained more than 60% of its 1080 concentration after 500 mm of simulated rainfall.

Bowen et al. (1995) reported that 6 g carrot baits containing 0.8 g $kg^{-1}$ 1080 showed no decrease in 1080 concentration after 200 mm simulated rainfall.

Using data collected during five 0.8 g $kg^{-1}$ 1080 carrot operations, Thomas et al. (2004) estimated that most of the 1080 content was lost from the baits following 200 mm of natural rainfall. The authors noted the results conflicted with the simulated rainfall studies. They suggested that the difference may have been a result of the carrots being present in the field for a longer period than the 2 day duration of the simulated rainfall trials. During this period the carrots would have been subjected to decay and microbial action, which may have contributed to the more rapid 1080 loss.

**Blocks**

Morgan (2004) reported that the concentration of 1080 in No Possums® 1080 gel blocks took 18.6 months to decline by 30% under field conditions.

**Pastes**

There was little loss of 1080 from Pestoff Professional 0.15% 1080 paste 49 hours after it was subjected 5 mm of simulated rain. Detoxification of Pestoff Professional 0.15% 1080 paste baits left on upturned spits took 80 days, but this was reduced to 40 days when the baits were buried (Morgan 2000). Pestoff possum paste buried in both dry and damp soil still retained significant concentrations of 1080 after 20 days (Ross & Henderson 2003).

When 10% 1080 Gel with a carbopol carrier was applied to broadleaf (*Griselinia littoralis)*, 90% of the 1080 was washed out of the baits by as little as 81 mm of rain (Batcheler & Challies 1988). Parkes (1991) found that when 10% 1080 Gel in a carbopol carrier was applied to mahoe (Melicytus ramiflorus) leaves, 95.2% of the 1080 had leached from the baits after 208 mm of rain. In contrast, 10% 1080 Gel with a petrolatum carrier is highly resistant to leaching, with 78.8% of the 1080 still remaining in the baits after 64 days and 208 mm of rain. Challies and

Thomson (1988) concluded that >5000 mm of rain was required to leach about 75% of the 1080 out of the baits.

**Other**

Seven months after 0.10% 1080 feral cat baits were handlaid on Raoul Island in August-September 2002, baits lying in the open were observed in good condition (S. Theobald pers. comm. 2003).

The concentration of 1080 in eggs injected with 1 mg 1080 $egg^{-1}$ did not decline after 28 days at temperatures of 15 and 30°C (Spurr et al. 1998). Note: this product is not currently registered in New Zealand.

When 12000 kg of 1080 bait (11000 kg of 0.15% 1080 Wanganui #7 Pellets and approximately 1000 kg of 0.08% 1080 apple paste) was disposed on in a landfill site at Winton, central Southland, in August 1996 the 1080 concentration in the waste material showed a 90% decrease after 10 months (Bowman 1999).

### 2.1.2 How soluble is 1080 in natural water?

Sodium monofluoroacetate is highly water soluble and mobile (Parfitt et al. 1994).

Note: Solubility is the determining factor for the pesticide pathway beyond the bait.

## 2.2 Soil and sediment

### 2.2.1 What is the range of toxic residue levels observed in soil?

On the day 0.15% 1080 Pellets were handlaid in a field trial in the Tararua Forest Park, 0.01 mg $kg^{-1}$ 1080 was detected in one of four litter samples. Following a field trial using 0.15% carrot baits in the Tararua Forest Park, litter samples had 1080 residues of between 0.0 - 0.6 mg $kg^{-1}$ on the day the baits were laid and between 0 - 16 mg $kg^{-1}$ seven days post poisoning (Spurr et al. 2002).

During 1997-98, 118 samples of soil were taken after three different aerial applications of Wanganui #7 0.15% 1080 Pellets. There were detectable, but low (mean 0.0092 mg $kg^{-1}$) 1080 residues in 6 of the soil samples taken from two of the three operations. The mean concentrations of 1080 in soil outside the two baiting areas appeared to be lower than those inside (Wright et al. 2002). During the same study, samples of leaf litter were also taken. There were low, but detectable, amounts of 1080 in the litter at Days 1, 5 and 30 post-baiting. The highest concentration found in a leaf litter sample was 0.19 mg $kg^{-1}$ on Day 5 from inside one treatment area. All remaining leaf litter samples with detectable 1080 were below 0.01 mg $kg^{-1}$ and were from up to 600 m outside one of the treatment areas. It was suggested that these 'outside' results were due to baits or fragments reaching the ground close to the sampling plots (Wright et al. 2002).

Soil samples (n=10) taken from two airstrips in 1997 had 1080 residues ranged from 0 – 0.0035 mg $kg^{-1}$ (P Fisher pers. comm. 2004).

Soil from three tip/landfill sites was sampled for 1080 residues in 1996-97. The Balgownie landfill, Wanganui had 1080 residues ranged from 330 – 930 mg $kg^{-1}$

(n=2). Winton tip, central Southland had 1080 residues ranged from 50 - 1450 mg $kg^{-1}$ (n=4) and at an unspecified landfill site 1080 residues ranged from 0.0008 - 3 mg $kg^{-1}$ (n=11) (P Fisher pers. comm. 2004).

### 2.2.2 How long does degradation of 1080 take in soil or sediment?

*Degradation of 1080 is slow in soil and sediments, taking 1-4 weeks under favourable conditions.*

Laboratory studies on the biodegradation of 1080 have shown that it is defluorinated by soil micro-organisms (Walker & Bong 1981; Wong et al. 1992) and within soils themselves (David & Gardiner 1966; Parfitt et al. 1994). If 1080 is not degraded by micro-organisms present in most NZ soils, it is likely to be removed from soil by leaching (Parfitt et al. 1994).

Northcott et al. (2014) examined the breakdown of 1080 in podzol (Orikaka Sandy Loam, West Coast, South Island), brown soil (Matiri, West Coast, South Island) and pumice soil (Kaingaroa, Taupo, North Island) under laboratory conditions. In all three soil types the degradation products produced and the rate at which these products were formed were similar. The major degradation pathway was through microbial degradation to the hydroxyl metabolite, hydroxyacetic acid, and microbial mineralisation to $CO_2$. The authors reported that the dominant factor affecting the rate of degradation was temperature rather than soil type or moisture content. The transformation half-life (DT50) of 1080 increased with decreasing temperature, ranging from 6-8 days at 20°C, 10-21 days at 10°C and 22-43 days at 5°C.

During laboratory studies, 6.1 mg of 1080 (equivalent to one possum bait) was added to 14 g samples of Kaitoke silt loam. The time taken for the 1080 in the soil to decline by 50% was 10 days at 23°C, and 80 days at 5°C (Parfitt et al. 1994). The authors also reported that when 1080 was added to Conroy sandy loam the degradation was much slower under dry conditions than wetter conditions. In Conroy sandy loam with 20% water content, it took approximately 30 days for a 50% reduction in the 1080.

### 2.2.3 Are there environmental factors that affect degradation in soil?

*The presence of soil or litter micro-organisms, and temperature, soil moisture and rainfall affect the rate of 1080 degradation in soil.*

Some soil micro-organisms, e.g. *Pseudomonas* and *Fusarium* species, can metabolise 1080 (Walker & Bong 1981; King et al. 1994). However, not all micro-organisms can readily defluorinate monofluoroacetate and the rate of metabolism differs between species of soil bacteria and fungi (King et al. 1994). 1080 could be expected to persist in soil much longer in the absence of micro-organisms, however sterile soil is unlikely to occur naturally.

Temperature and soil moisture content affect the rate at which micro-organisms in soil degrade 1080. At lower temperatures/moisture content degradation is slower and 1080 will persist in the soil longer (Parfitt et al. 1994). Studies have shown that substantial defluorination of 1080 occurs in soil at temperatures of 15 - 30°C and with moisture levels above 8.3%.

Rainfall is also a major factor in removing 1080 from soil due to 1080's water solubility. 1080 has a low preference for adsorption on soil minerals, so that 1080 in soil not removed by microbial action is likely to be leached (Parfitt et al. 1994).

Note: Environmental factors will determine how widely the breakdown times reported for specific sites can be applied. For example, because breakdown is significantly affected by temperature, rainfall, leaf litter, presence or types of micro-organisms, it may occur faster or slower than the time quoted in Section 2.2.2.

## 2.3 Fate in water

### 2.3.1 Where available, what is the range of toxic residue levels observed in natural water?

*Between 1990 and October 3 2805 water samples were been collected from streams following aerial 1080 pest control operations throughout New Zealand. The samples were taken within 24 hours of the bait being laid and after subsequent heavy rain. 96.9% of these samples contained no residues of 1080. Residues ranging from 0.1 – 9.0 µg* $l^{-1}$ *were found in 88 samples but most of these had less than 1 µg* $l^{-1}$ *1080. These samples were mostly from very small streams and/or associated with the presence of bait. Four of these six samples were likely to have been as a result of inadvertent contamination (Booth et al. 2007; L. Booth pers. comm. 2014; Wright 2011).*

*985 of the total samples were taken from water used as human or stock drinking supplies, and 4 of these contained detectable 1080 residues at 0.1 µg* $l^{-1}$ *(1 sample) and 0.2 µg* $l^{-1}$ *(3 samples) (L. Booth, Landcare Research, pers. comm.. 2014). All the positive samples were below the Ministry of Health maximum of 3.5 µg/l for 1080 in drinking water (Ministry of Health 2008).*

A water monitoring program following aerial 1080 (0.15% and 0.08% 1080 Wanganui #7 Pellets at 5 kg $ha^{-1}$) possum control operations on Mt Taranaki/Egmont in 1993-94, showed no detectable 1080 in 159 (1993) and 72 (1994) water samples from surface water or treated water supplies (Fowles & Williams 1997).

Following aerial possum baiting (0.08% 1080 Wanganui #7 Pellets) in Tararua Forest Park in 1993, 66 water samples from eight sites collected over 4 months had no detectable 1080 (limit of detection 0.3 µg $l^{-1}$) (Meenken & Eason 1995).

Following aerial rabbit baiting (pre-feed baiting and carrot baits containing 0.023% 1080, sowing rates from 16 – 60 kg $ha^{-1}$ depending on rabbit densities) in Otago during 1992, streams and rivers were monitored for 4 weeks after the operation. 2 out of 29 samples contained measurable amounts of 1080 (0.3 and 0.6 µg $l^{-1}$). These samples occurred within 48 hours of bait application, and all subsequent samples were below the limit of detection (Hamilton & Eason 1994).

No 1080 was detected in 36 water samples taken from six streams over a 4 month period at Waipoua following aerial possum control using 0.08% 1080 Pellets sown at 5 - 6 kg $ha^{-1}$ in 1990. After the 1990 aerial possum control operation using 0.08% 1080 Pellets at 14 kg $ha^{-1}$ on Rangitoto Island 24 water samples were collected over 6 months from 2 surface water and 2 ground water sites. No 1080 was detected in any of these samples (Eason et al. 1992).

Meekin et al. (2000) monitored water in a stream at the bottom of 14 ha catchment for the presence of 1080 after 0.15% Wanganui #7 pellets had been handlaid in a at a rate of 10.7 kg $ha^{-1}$. Monitoring occurred at regular intervals over the 17 hours after the bait was applied and during a rain event two days after the bait was laid. No 1080 was detected in any of the 52 water samples taken.

Srinivasan et al. (2012) investigated the fate of 1080 released from baits during a rainfall event immediately following an aerial 1080 operation. In this field study, stream and soilwater was sampled in a 148.8 ha headwater catchment of the Inangahua River, on the West Coast, following the application of 0.15% 1080 Wanganui #7 pellets. The pellets were applied at a rate of 2.5 kg $ha^{-1}$ within 24 hours of a rainfall event (28 mm in 8 hours, with an additional 100mm falling over the next 9 days). Water sampling occurred between 5 hours and 9 days after the 1080 was applied. The only stream sample that contained 1080 (at 0.1 µg $l^{-1}$) was collected 105 minutes after the rain started. None of the other 15 samples contained 1080 residues. Soilwater samples were taken approximately 200 mm downhill from baits after 34.4, 57.0 and 60.6 mm of rain had fallen. 1080 residues in these soilwater samples ranged from 0.5 – 61 µg $l^{-1}$.

Concentrations of 1080 in bore groundwater surrounding a landfill site at Winton, central Southland, were measured following burial of 12000 kg of 1080 bait. 1080 was detected in 5 of 28 groundwater samples analysed (highest value 24 µg $l^{-1}$). The amount of 1080 in groundwater sampled 5 and 13 metres from the disposal site decreased until none was detected after 10 months (Bowman 1999).

### 2.3.2 How long does degradation of 1080 take in natural water?

*1080 degradation will occur within 1 - 2 weeks in natural water*. The overall degradation rate of 1080 in stream water, when measured in the laboratory, declined by approximately 25% in the first 24 hours. After this the rate of decline was temperature dependent (Ogilvie et al. 1995; Ogilvie et al. 1996).

Eason et al. (Eason et al. 1993b) showed that 1080 declined by approximately 70% in 1 day and dropped to below detectable limits in 4 days in aquaria containing plants and invertebrates.

In an aquarium study by Parfitt et al. (1994) 80 litre aquaria containing biologically active streamwater at 21 °C were spiked with 0.1 mg $l^{-1}$ of 1080 (the equivalent to adding 2-3 pellets per aquarium). Water samples were taken from the tanks at 2, 24, 48, 72, 79, 101 and 141 hours after the addition of the 1080. The 1080 was eliminated from the aquaria water within 48 - 141 hours.

When 40 0.15% 1080 Wanganui #7 pellets were placed in a stream simulator with a 5 litre $s^{-1}$ flow rate, 1080 concentrations at the outlet of the simulator peaked at 1.1 µg $l^{-1}$ after 2 days and no residues were detected in the water after 8 days (Suren & Bonnett 2006).

Note: Natural/stream water implies the presence of aquatic plants, invertebrates and micro-organisms, and sediment.

### 2.3.3 Are there environmental factors that affect degradation in aquatic environments?

A number of factors affect the degradation of 1080 in aquatic environments. These include temperature, *the presence of aquatic plants and microorganisms, and flow and volume of the waterway*.

While the concentration of 1080 in deionised (sterile) water remains relatively constant and independent of temperature, the concentration of 1080 in stream water declines over time (Booth et al. 1999b). The rate at which 1080 degrades in stream water increases significantly as water temperature rises (Ogilvie et al. 1995; Ogilvie et al. 1996). The aquatic plants *Elodea canadensis* (Wright et al. 2001) and *Myriophyllum triphyllum* (Booth et al. 1999b) were found in laboratory trials to reduce the concentration of 1080 in water. In aquaria trials Parfitt et al. (1994) reported that the rate of 1080 degradation was dependent on the species of bacteria present.

Flow and volume of the waterway affect the dilution of 1080 in natural water, but are unlikely to significantly affect degradation at the low concentrations of 1080 that have been found in the environment.

Note: Environmental factors will determine how widely the breakdown times reported for specific sites can be applied. For example, because breakdown is significantly affected by temperature, pH, volume, still/running water, or presence or types of micro-organisms, it may occur faster or slower than the time quoted in Section 2.3.2.

## 2.4 Fate in plants

### 2.4.1 Is it likely that plants could take 1080 up in solution, based on molecular structure?

Many organic acids are phloem-mobile in plants so it is likely that 1080 can be taken up by plants.

### 2.4.2 Is there evidence that plants either take up or don't take 1080 up?

*1080 uptake has been reported* in a number of plants including: käpuka (New Zealand broadleaf, *Griselinia littoralis*) (Ogilvie et al. 1998), käramuramu (*Coprosma robusta*) (Ogilvie et al. 2006), puha (*Sonchus* spp.) (Miller et al. 2009), broad beans (David & Gardiner 1951), cabbage (*Brassica oleracea*) (David & Gardiner 1953), *Elodia canadensis* (Ogilvie et al. 1996), *Helianthus annus* (Cooke 1976), lettuce (Ward & Huskisson 1972), peanut (*Archis hypogeae*) (Preuss & Weinstein 1969), perennial ryegrass (*Lolium perenne*) (Ogilvie et al. 1998) and sugar cane (*Saccharum spp*.) (Hilton et al. 1969).

However, not all plants appear to take up 1080. No uptake of 1080 was reported in pikopiko (*Asplenium bulbiferum*) when single 0.15% 1080 Wanganui #7 pellets were placed at the base of pikopiko in the field, and the plants monitored for 1080 uptake (Ogilvie et al. 2006).

Where uptake occurs, it is unlikely to be in large amounts. Ogilvie et al. (1998) reported that rye grass took up only 0.015% of the available 1080 from pellets placed beside the grass. When single 0.15% 1080 Wanganui #7 pellets were placed at the base of käramuramu in the field, the maximum concentration of 1080 detected in the plants was 5 μg $kg^{-1}$ of plant material. This concentration

occurred 7 days after the bait was place beside the plants, and declined to 2.5 µg 1080 $kg^{-1}$ plant material after 14 days (Ogilvie et al. 2006). In a similar field trial, Miller et al. (2009) placed a single 0.15% 1080 Wanganui #7 pellet at the base of puha plants. The highest level of 1080 detected in puha was 15 µg $kg^{-1}$ of leaf material 3 days after the pellets were placed at the bottom of the plants. Note: in this study 1080 residues were recorded in puha that had been used as controls (i.e. no 1080 pellets placed beside them). The authors could not rule out that 1080 occurs naturally in puha and are currently undertaking further research to confirm this.

To put these figures in perspective, based on the peak concentration observed in ryegrass (0.08 g $kg^{-1}$), a 50 kg sheep would need to eat (using an $LD_{50}$ of 0.4 mg $kg^{-1}$) about 250 kg of grass to have a 50% chance of dying from 1080 (Ogilvie et al. 1998). Using an $LD_{50}$ of 2 mg $kg^{-1}$ for humans, a 70 kg person would need to eat 28 tonnes of käramuramu or 9.3 tonnes of puha in one sitting to receive an $LD_{50}$ and therefore a 50% chance of dying from 1080 (Ogilvie et al. 2006; Miller et al. 2009). Even to reach the chronic toxicity NOEL of 0.05 - 0.1 mg $kg^{-1}$ $day^{-1}$ a person would need to consume 0.7 - 1.4 tonnes of 1080-containing käramuramu daily (Ogilvie et al. 2006).

A laboratory study by David & Gardiner (1951) showed that broad bean plants could take up fluoroacetate through their roots and subsequently become toxic to aphids feeding on them (i.e. 1080 acted as a systemic insecticide). However, 1080 concentrations in the plants necessary to kill the aphids were approximated 1 mg $kg^{-1}$ of plant tissue, when applied to the plant through a cut tap-root. This is a much higher concentration of 1080 than any reported in field soil samples in the context of using 1080 baits for possum control.

Where fluoroacetate is distributed in plants is likely to vary as available publications report conflicting information. For example, in *Helianthus annuus*, ammonium fluoroacetate metabolites were rapidly translocated to the shoot with little accumulation in the roots (Cooke 1976). Conversely, sugarcane was found to strongly adsorb monofluoroacetate ion onto its roots with only minor translocation to leaves and stem (Hilton et al. 1969).

Even where 1080 uptake occurs in plants, most plants are relatively insensitive to the effects of 1080 (Bong et al. 1980). However, duckweeds have been shown to have a high sensitivity, with the growth of *Spirodela polyrrhiza* being totally inhibited by 0.5 mmol of 1080, and total growth inhibition of *S. oligorrhiza* and *Lemma minor* occurring at 1 mmol 1080 (Bong et al. 1980). Oxygen consumption in pea seedling roots was almost completely blocked when exposed to 10 mmol $l^{-1}$ monofluoroacetic acid for more than 6 hours (Polter 1967).

Plants are capable of metabolising and degrading fluoroacetate (peanuts - Preuss & Weinstein 1969; lettuce - Ward & Huskisson 1972; Dichapetalum cymosum - Meyer & Grobbelaar 1991)

### 2.4.3 Where evidence exists for plant uptake, how long do residues persist?

The maximum length of time 1080 residues persist in plants is approximately 38 days (Ogilvie et al. 1998; Miller et al. 2009).

In a laboratory experiment by Ogilvie et al. (1998), single 0.15% 1080 RS5 pellets were added to the soil of pots containing either broadleaf or ryegrass. The 1080 residues in the plants were near the Method Detection Limit (MDL) after 38 days in broadleaf and 7 days in ryegrass.

Ogilvie et al. (2004) reported that after karamu took up 1080 during field trials, the concentration of 1080 in the plants decreased to zero at 28 days. The authors recommended that a withholding period of 30 days after an aerial application of 1080 could be adopted for plants within the operational area that are used for rongoa (medicinal) purposes.

When 0.15% 1080 Wanganui #7 pellets were placed beside puha plants in the field, 1080 that had been taken up by the puha was near the MDL after 28 days and below the MDL after 38 days (Miller et al. 2009). The authors suggested a withholding period of at least 38 days could be observed on harvesting wild grown puha immediately after an aerial 1080 operation. Note: in this study 1080 residues were recorded in puha that had been used as controls (i.e. no 1080 pellets placed beside them). The authors could not rule out that 1080 occurs naturally in puha and are currently undertaking further research to confirm this.

## 2.5 Animal residues

### 2.5.1 What is the range of toxic residue levels recorded for sub-lethally exposed animals?

A number of laboratory studies have measured 1080 residue levels in sub-lethally poisoned mammals, marsupials, birds and insects.

When sheep and goats were orally dosed with an aqueous 1080 solution at 0.1 mg $kg^{-1}$ bw (equivalent to one-quarter of the published $LD_{50}$ for sheep and less than a quarter of the $LD_{50}$ for goats) the maximum 1080 residues recorded in plasma were 0.16 - 0.33 mg $l^{-1}$ and 0.22 - 0.26 mg $l^{-1}$ respectively. In the sheep, 2.5 hours after dosing the mean 1080 concentrations of were 0.098 mg $l^{-1}$ in plasma, 0.042 mg $kg^{-1}$ in muscle, 0.052 mg $kg^{-1}$ in the heart, 0.057 mg $kg^{-1}$ in the kidney and 0.021 mg $kg^{-1}$ in the liver. The mean 1080 concentrations declined to less than 0.003 mg $kg^{-1}$ in all tissues sampled 96 hours after dosing (Eason et al. 1994a).

A deer 'run down and killed' following a poisoning trial using 1080 carrot baits in 1958 had 1080 concentrations of 1.50 mg $kg^{-1}$ in its meat, 0.47 mg $kg^{-1}$ in the heart and 0.92 kg $kg^{-1}$ in the liver (McIntosh & Staples 1959).

Rabbits orally administered a sub-lethal dose of 1080 at 0.1 mg $kg^{-1}$ bw (equivalent to one-quarter of the published $LD_{50}$) and sampled at intervals after dosing had maximum 1080 concentrations of 0.121 – 0.167 mg $l^{-1}$ in plasma, 0.019 – 0.025 mg $kg^{-1}$ in muscle, 0.014 - 0.08 mg $kg^{-1}$ in kidney and 0.001 – 0.002 mg $kg^{-1}$ in liver (Gooneratne et al. 1995).

During both these studies the highest concentrations of 1080 residues were found in the blood/plasma, with moderate levels in muscle and kidneys, and lowest concentration in the liver (Eason et al. 1994a; Gooneratne et al. 1994).

When possums were orally dosed with an aqueous 1080 solution at 0.1 mg $kg^{-1}$ bw the maximum 1080 residues recorded in plasma were 0.11 - 0.31 mg $l^{-1}$ (Eason et al. 1993b).

In sub-lethally poisoned mallard ducks, a maximum concentration of 1080 was 12.95 mg $ml^{-1}$ in serum and 8.01 mg $g^{-1}$ in heart two hours after dosing with 8 mg $kg^{-1}$ 1080 (Ataria et al. 2000).

Lyver et al. (2004) reported that five out of 8 captive long-finned eels fed 1080 contaminated possum muscle had sub-lethal residues of 0.0174 ± 0.0104 mg $kg^{-1}$, while three out of nine eels fed gut tissue containing 1080 had residues of 0.0306 ± 0.0220 mg 1080 $kg^{-1}$ bw.

Two laboratory studies have looked at 1080 residues in sub-lethally poisoned terrestrial invertebrates. Booth and Wickstrom (1999) recorded a mean 1080 concentration of 5.51 mg $kg^{-1}$ in ants (*Huberia striata*) one day after sub-lethally dosing them with 0.3 g 1080 $kg^{-1}$. Tree weta (*Hemideina crassidens*) dosed with 15 g 1080 $kg^{-1}$ had residues of between 0.033 and 5.8 mg $kg^{-1}$ (Eason et al. 1993b).

Suren & Bonnett (2006) exposed caged koura to single 6 g 0.15% 1080 Wanganui #7 baits for up to 8 days. The maximum recorded 1080 residue level in the viscera was 3.3 µg $g^{-1}$ in an animal collected 1 day after being exposed to bait. The maximum recorded 1080 residue in tail muscle was 5 µg $g^{-1}$ in an individual collected after 4 days exposure. The highest recorded total 1080 residue (viscera + muscle tissue) was 7.7 µg $g^{-1}$ from an individual sampled 1 day after the bait was placed in its cage.

Animals have also been sampled during pest control operations to test for sub-lethal 1080 residues. These results are presented in Table 1.

24 hours after an aerial rabbit control operation (0.4 g $kg^{-1}$ aerial carrot at 25 kg $ha^{-1}$) on Motuihe Island, Auckland in July 2002, 5 live cockles and 6 live marine mussels were tested for 1080 residues. None contained 1080 residues (VPRD 4928 - 4938).

During the February 2010 Egmont National Park aerial 1080 operation (0.15% 1080 Wanganui #7 pellets, 2.3 kg $ha^{-1}$) freshwater and marine mussels were monitored for 1080 residues. Freshwater mussels were sampled from 11 sites within the operational area. Marine mussels were sampled at 2 sites approximately 20 km from the operational area. No 1080 was detected in any of the samples (VPRD).

Note: The information in this section is derived from direct analyses for 1080 in animal tissues, from animals known to have received a sub-lethal dose of 1080. Analyses of associated metabolites (e.g. citrate, fluorine) in tissues are difficult to compare directly with analysis of 1080 concentrations, so this information is not included.

TABLE 1. 1080 RESIDUE LEVELS RECORDED IN SUB-LETHALLY EXPOSED ANIMALS DURING PEST CONTROL OPERATIONS.

| SPECIES | SAMPLE TYPE | RESIDUES (mg $kg^{-1}$) | REFERENCE |
|---|---|---|---|
| **Arthropods** | | | |
| Beetles | Mixed samples | <0.1 | 1 |
| Invertebrates (various) | 7 mixed samples | 0.0-0.75 | 2,3 |

1 Spurr et al. (2002); 2 Eason et al. (1991b); 3 VPRD.

### 2.5.2 How long do toxic residues of the pesticide persist in sub-lethally exposed animals?

Rabbits given sub-lethal doses of 1080 showed rapid elevation of plasma 1080 in the first hour post dose. Plasma 1080 concentration then declined rapidly at first and slowly thereafter, with very little 1080 being detected in plasma at 6 hours. The sub-lethal dose was cleared from tissues within 3 hours (Gooneratne et al. 1995). Sub-lethally dosed goats and sheep rapidly eliminated 1080, with only traces detected after 18 hours in goat plasma, and after 96 hours in sheep plasma and tissue (Eason et al. 1994a). Gooneratne et al. (2008) reported serum 1080 concentrations in ewes dosed with 0.30 mg $kg^{-1}$ were undetectable 3 days after dosing and no 1080 was detected in the skeletal muscle, kidneys of liver of animals that survived for 14 days after dosing. In possums only traces of 1080 were detected possum plasma 24 hours after receiving a 1 mg $kg^{-1}$ sub-lethal dose. All traces of 1080 were eliminated from the tissues of the rabbits, possums, goats and sheep within one week (Eason & Gooneratne 1993). A withholding period of 5 days has been suggested as adequate for animals suspected to have received a sub-lethal dose of 1080 (Gooneratne et al. 2008).

Mallard ducks dosed with a 8 mg 1080 $kg^{-1}$ sub-lethal dose substantially eliminated the 1080 from heart muscle and blood within 24 hours (Ataria et al. 2000).

Tree weta orally dosed with 15 µg 1080 $g^{-1}$ eliminated >90% of the 1080 within 4 - 6 days (Eason et al. 1993b). Ants dosed with 0.3 g 1080 $kg^{-1}$ still had detectable levels of 1080 (0.27 mg $kg^{-1}$) seven days after dosing (Booth & Wickstrom 1999).

1080 residues in sub-lethally poisoned koura decrease by a factor of five after eight days, presumably as a result of the animals metabolising or excreting the compound (Suren & Bonnett 2006).

Note: This information is derived from direct analyses for 1080 in tissues from animals known to have received a sub-lethal dose of 1080. Analyses of associated metabolites e.g. citrate, fluorine in tissues are difficult to compare directly with analysis of 1080 concentrations, so this information is not included

### 2.5.3 What is the half life of 1080 in sub-lethally exposed animals?

Data on the half-life of 1080 in blood and tissues are presented in Table 2.

TABLE 2. HALF LIFE OF 1080 IN PLASMA AND TISSUE.

| SPECIES | SAMPLE TYPE | T ½ (hours) | REFERENCE |
|---|---|---|---|
| Sheep | Plasma | 10.8 | 1 |
| | Muscle | 12.0 | 2 |
| | Liver | 3.0 | 2 |
| Goat | Plasma | 5.5 | 1 |
| Possum | Plasma | 9.1 | 3 |

| | | | |
|---|---|---|---|
| Rabbit | Plasma | 1.1 | 4 |
| | Muscle | 0.4 | 4 |
| | Kidney | 0.8 | 4 |
| Mouse | Plasma | 2.0 | 5 |
| | Muscle | 1.7 | 5 |

1 Eason et al. (1994a); 2 Rammell (1993); 3 Eason et al. (1993b); 4 Gooneratne et al. (1994); 5 Sykes et al. (1987).

### 2.5.4 What is the range of residue levels recorded in carcasses of animals killed by 1080?

In sheep dosed with a lethal amount of 1080 (200 µg $kg^{-1}$), the concentration of 1080 in the muscle of sheep sacrificed post-dosing reached a maximum of 111 µg $kg^{-1}$ in 4 hours and declined exponentially thereafter. In the liver a maximum concentration of 38 µg $kg^{-1}$ was recorded at 2 hours with exponential decline thereafter (Rammell 1993). Sheep that died 22 – 25 hours after receiving a 0.30 mg $kg^{-1}$ dose of 1080 had 1080 concentrations of 0.06 1- 0.75 µg $g^{-1}$ in the heart, 0.058 - 0.72 µg $g^{-1}$ in the skeletal muscle and 0.047 - 0.051 µg $g^{-1}$ in the liver. In sheep that died 43 - 52 hours after dosing (0.30 mg $kg^{-1}$) the 1080 residues in skeletal muscle was 0.023 - 0.031 µg $g^{-1}$, but was undetectable in the heart and liver. The concentration of 1080 in the rumin contents of sheep that died within 24 hours of dosing was 0.15 - 0.27 µg $g^{-1}$ (Gooneratne et al. 2008).

Residues in rabbits given lethal doses of 1080 (0.8 mg $kg^{-1}$) were measured in the liver, kidney and muscle at the time of death and at one, two and three weeks after death. The residue concentrations were highly variable, but concentrations measured at 3 weeks were generally lower than other sample times. The maximum residue concentrations were not specified (Gooneratne et al. 1995).

Burns & Connelly (1992) reported that residues of 1080 in the breast muscle of magpies (*Pica pica*) were dose depended, with higher doses resulting in higher 1080 residues. Additionally, within dose levels, birds that survived longer had lower residues. For birds that died within 24 hours of dosing, the mean concentration of 1080 in the breast muscle was 0.73 µg $g^{-1}$ at a 1080 dose of 1.59 mg $kg^{-1}$ b.w., 0.70 µg $g^{-1}$ at a dose of 2.00 mg $kg^{-1}$ b.w., 0.84 µg $g^{-1}$ at a dose of 2.52 mg $kg^{-1}$ b.w. and 1.16 µg $g^{-1}$ at a dose of 2.52 mg $kg^{-1}$ b.w. In birds that died the day after being dosed the concentrations in the breast muscle were: 0.23 µg $g^{-1}$ (1.59 mg $kg^{-1}$ b.w. dose), 0.39 µg $g^{-1}$ (2.00 mg $kg^{-1}$ b.w. dose), 0.50 µg $g^{-1}$ (2.52 mg $kg^{-1}$ b.w. dose) and 0.64 µg $g^{-1}$ (3.17 mg $kg^{-1}$ b.w. dose).

Ants (*Huberia striata*) lethally poisoned with sugar water containing 1.5 g 1080 $L^{-1}$ had 1080 residues of 56 mg $kg^{-1}$, while ants lethally poisoned with 0.15% 1080 Wanganui #7 pellets had residues of 4.78 mg $kg^{-1}$ (Booth & Wickstrom 1999).

1080 residues have also been recorded in animal tissues sampled from field situations. A summary of these 1080 residues is given in Table 3.

TABLE 3. 1080 RESIDUE LEVELS RECORDED IN CARCASSES IN NEW ZEALAND DURING PEST CONTROL OPERATIONS.

| SPECIES | SAMPLE TYPE | RESIDUES (mg $kg^{-1}$) | REFERENCE |
|---|---|---|---|
| **Birds** | | | |
| Blackbird | Muscle | 0.014–5.9 | 1; 2; 3 |
| Chaffinch | Muscle | 0.14–3.3 | 1 |
| Hedge Sparrow | Muscle | 0.03 | 1 |
| Kea | Muscle | 0.46 – 3.44 | 1 |
| Keruru / Kukupa | Muscle | 0.01 | 1 |
| Morepork | Muscle | 0.01 | 1 |
| California Quail | Crop | 18 - 76 | 4 |
| Rifleman | Abdominal cavity | 0.016–0.863 | 1 |
| NI Robin | Muscle | 0.37–3.80 | 5 |
| Tomtit | Abdominal cavity | 0.298–0.406 | 1; 2 |
| | Muscle | 0.28–4.2 | |
| Tui | Muscle | 0.012 | 1 |
| Waxeye | Muscle | 0.68 | 1 |
| Weka | Muscle | 0.012–4.3 | 1 |
| Fernbird | Muscle | 0.14 – 0.75 | 6 |
| **Marsupials** | | | |
| Possum | Bone | 0–0.01 | 1; 7; 8 |
| | Liver | 1.5–8.4 | |
| | Muscle | 0.003–2.3 | |
| | Stomach | 0.05–~70 | |
| **Mammals** | | | |
| Cat | Muscle | 0.06–1.24 | 1 |
| Cattle | Stomach | 0.04–9.1 | 1 |
| | Muscle | 0.003–0.46 | |
| Deer | Stomach | 8.7–35.9 | 1; 2; 3; 9 |
| | Muscle | 0.012–7.37 | |
| | Heart | 0. 85-8.12 | |
| | Liver | 0. 75-4.05 | |

| SPECIES | SAMPLE TYPE | RESIDUES (mg $kg^{-1}$) | REFERENCE |
|---|---|---|---|
| Dog | Stomach | 0.079–0.7 | 1 |
| | Intestine | 0.44 | |
| | Muscle | 0.014–0.41 | |
| | Vomit | 1.07 | |
| Ferret | Muscle | 0.004–13 | 1; 10; 11 |
| Mouse | Liver | 7.8–17.6 | 1 |
| | Muscle | 9.1–10.3 | |
| Pig | Muscle | 0.21 | 1 |
| | Stomach | 56 | |
| **Mammals** | | | |
| Sheep | Liver | 0.04 | 1 |
| | Muscle | 0.023–0.3 | |
| | Plasma | 0.35 | |
| | Stomach | 0.009–0.27 | |
| Stoat | Muscle | 0.002–1.07 | 1; 9; 12; 13 |
| | Stomach | 0–0.146 | |
| **Invertebrates** | | | |
| Bee | 2 whole animals | 0–10.8 | 1 |
| Wasp | wasps | 5–38 | 14 |
| | larvae | 66–255 | |
| | Nest debris | 17–96 | |

Variation in these residue concentrations will be due to: amount of 1080 ingested over what time, time taken to death variation between species and within individuals of that species

1 VPRD; 2 Speedy (2003); 3 Nugent et al. (2004); 4 Evans & Soulsby (1993); 5 Powlesland et al. (1999b); 6 van Klink et al. (2012); 7 Eason et al. (1991a); 8 Meenken & Booth (1997); 9 McIntosh & Staples (1959); 10 Gillies & Pierce (1999); 11 Heyworth & Norbury (1999); 12 Murphy et al. (1999); 13 Dilks & Lawrence (2000); 14 Eason et al. (1991b)

### 2.5.5 How long do residues of 1080 persist in carcasses of animals killed by the pesticide?

*While 1080 is metabolised and eliminated from living animals it can persist in carcasses for months where it will degrade more slowly than indicated by the half-life in living mammalian metabolism. The rate of degradation of 1080 in carcasses will depend on moisture, temperature and the presence of micro-organisms.*

The retention of 1080 in tissue was greater in rabbits dosed with a lethal dose than in those that received a sub-lethal dose. In this study 1080 was detectable

(~0.03 mg $kg^{-1}$) in rabbit muscle 3 weeks after death following a lethal dose of 1080 (Gooneratne et al. 1995).

Tissue from possum carcasses monitored following possum and wallaby control on Rangitoto Island in 1990 still contained high 1080 residues 13 days after the operation. By day 28 the carcasses had significantly decomposed and consisted of pelts and bone so no further samples were taken (Eason et al. 1991a).

The mean concentrations of 1080 in possum stomachs and contents collected 75 days after the estimated date of death from 0.08% 1080 paste in May - June 1994 was 4.90 mg $kg^{-1}$. This was significantly less than the mean of 30.06 mg $kg^{-1}$ in possum stomachs and contents samples taken on day 25 (Meenken & Booth 1997).

Wright (2004) monitored the fate of possum carcasses at two sites after an 8600 ha aerial 1080 operation in the Hutt River upper catchment in 2003. At site one the carcasses had lost most of their fur and were described as "very putrid" 52 days after the bait was applied, 156mm of rain had fallen by this time. By day 65 bones were exposed on carcasses at site two. The stomach remains of carcasses from both sites were tested at day 73 and found to contain 6 mg $kg^{-1}$ and 13 mg $kg^{-1}$ at sites one and two respectively. Cumulative rainfall recorded by this time was 231 mm for site one and 458 mm at site two. Three possum carcasses found downstream at about this time were contained 1080 residues of 6 mg $kg^{-1}$, 7 mg $kg^{-1}$ and <MDL. A red deer carcass also found on the river bank contained 0.5 mg $kg^{-1}$. The last carcass tested for residues 178 days following the bait application was found to contain green dyed bait in its stomach but residue tests were <MDL.

Note: This information is derived from direct analyses for 1080 in tissues from animals known to have died from 1080 poisoning. Analyses of associated metabolites e.g. citrate, fluorine in tissues are difficult to compare directly with analysis of 1080 concentrations, so this information is not included.

# 3. Effects on Non-Target Native Species

Based on the few studies of native species available, and the large number of non-native species studied (Part 4) suggests 1080 is likely to be toxic to most native animals. There is wide variation in sensitivity between taxonomic groups with mammals more sensitive than birds and invertebrates (on a weight for weight basis). Sub-lethal effects have been demonstrated for native invertebrates in the laboratory. The small size of many native species (relative to the target pests) means that toxic baits used for pest control are capable of causing harm to almost any animal that eats the bait. Therefore the level of exposure to the bait becomes important in determining the effects on non-target native species in the field.

Most information on non-target exposure to 1080 bait relates to aerial poisoning as this is thought to be the "worst case scenario" for studying non-target effects. Hand laid baits are sometimes used to approximate aerial poisoning in studies. Bait station studies are scarce. It could be assumed that native species are not more at risk using bait stations than distributing the same bait type aerially.

There are records of a range of native bird species found dead after aerial poisoning operations and many of these individuals have contained residues of 1080. However when records are discounted from:

- operations which did not meet current bait quality standards (e.g. using unscreened, un-dyed carrot bait with berry fruit lures) or
- those animals which did not have detectable 1080 residues,

the Vertebrate Pesticide Residue Database (VPRD) between 1994-2013 recorded only 35 poisoned individuals representing 10 native species across all bait types used in aerial poisoning. No conclusions about population effects can be drawn from this information but it is useful to focus further studies. Some native species (mainly invertebrates) have contained 1080 residues when sampled, an indication of potential risk to insectivores from secondary poisoning.

Loss of individuals in a population of native species as a consequence of 1080 poisoning can have variable significance to the long term viability of the population depending on the context. Those animals with a large population and/or a high rate of increase can compensate for small loses. Poison-related mortality may be replacing deaths from predation or winter starvation. Threatened species usually have a poor ability to recover from additional mortality, making the consequences theoretically more concerning.

There have been numerous studies examining the effects of aerial poisoning on native non-target populations over the last 20 years. 21 species of native birds, particularly threatened species, have been monitored. None of the studies have identified population level mortality which threatened the viability of the species, although the only reliably calculated mortality rates are for kokako, kiwi, kaka, whio and fernbirds. The upper 95% mortality rates for kokako, kiwi, kaka, whio are all less than 8.4%. The mean mortality rate for fernbirds is 9.4%.

Limited monitoring of short tailed bats and native frogs has not indicated detectable mortality due to aerial 1080 poisoning.

Invertebrate populations have been monitored in nine aerial poisoning operations and none have shown significant population effects on any species studied, nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals. Long term monitoring of native land snails indicates substantial benefits to threatened populations in sites treated with aerial poisoning.

The risks 1080 operations pose to aquatic species is considered very low. Fish are very tolerant to 1080. Additionally, 1080 contamination of water is rarely found during 1080 operations and is at an extremely low level when it has occurred. No mortality of longfin eels, köaro or upland bullies was observed during experiments where high densities of cereal 1080 pellets were placed in water just upstream of them. Eels and koura have survived experimental feeding of cereal 1080 pellets, and eels have survived feeding on possum tissue containing 1080. There have also been no detectable effects on aquatic invertebrate communities in field studies when 1080 baits were placed at high densities in streams.

## 3.1 Toxicity

### 3.1.1 What is the lethal dose ($LD_{50}$) range for each taxon?

The $LD_{50}$ values available for native mammals, birds and arthropods are presented in Table 4. While there is no information for any native reptiles, amphibians, fish or molluscs, Section 4 has information on overseas species in these taxa which is useful.

TABLE 4. ACUTE ORAL TOXICITY OF 1080 FOR NATIVE TAXA.

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | REFERENCES |
|---|---|---|
| **Birds** | Range: 8.00 - 9.25 | |
| Silvereye | ~ 9.25 | 1 |
| Weka | ~ 8.1 | 2 |
| **Mammals** | | |
| Short tailed bat | 0.15 ('Worst case' LD value) | 3 |
| **Invertebrates** | Range: 42.00 - 91.00 | |
| NZ ant | 72.00 (24 h $LD_{50}$)<br>42.00 (48 h $LD_{50}$) | 4 |
| Tree weta | 91.00 | 4 |

1 McIlroy (1984); 2 McIntosh et al. (1966); 3 Lloyd and McQueen (2000); 4 Booth & Wickstrom (1999)

***Aquatic Invertebrates***

Based on sub-lethal exposure trials, Suren & Bonnett (2006) suggest that the 1080 $LC_{50}$ for koura is relatively high.

### 3.1.2 Based on the mode of action, are there any taxa that are unlikely to be affected by 1080?

*1080 is considered a broad spectrum toxicant* although variation in $LD_{50}$'s and body size of animals suggests that some native species could survive low exposure to 1080. The susceptibility of a specific animal is linked to its metabolic rate (McIlroy 1994), so cold-blooded animals may be more tolerant to 1080 as their metabolic rate is likely to be much lower. Fish have been found to be highly tolerant of 1080 in overseas studies (Fagerstone et al. 1994).

### 3.1.3 Have sub-lethal effects on birds, mammals, reptiles/amphibians, fish, arthropods, or molluscs been described for 1080?

***Reptiles/amphibians***

An Australian study of shingleback blue tongued lizards (*Tiliqua rugosa*) found a decrease in testosterone levels in the plasma in study animals and a degeneration of seminiferous tubules in some individuals when high sublethal doses of 1080 were administered intraperitoneally (Twigg et al. 1988).

***Invertebrates***

A laboratory study of **ground weta** (*Hemideina thoracica*) by Hutcheson (1990) found poisoned animals, including those sub-lethally poisoned, became active during the day rather than sheltering as is their normal behaviour demonstrated by a control group and a group which fed on non-toxic baits.

**Cockroaches** (*Blattidae*) that had eaten 1080 baits in a laboratory study appeared drugged and their normal response to predators was suppressed (McIntyre 1987).

Smith & Grosch (1976) studied the sub-lethal effects of 1080 on *Bracon hebetor*, a parasitoid wasp found in North America. They found egg production decreased after a single sub-lethal dose. There was also low hatchability of eggs laid in the first few days post dosing.

In compost worms (*Eisenia fetida*), used as an surrogate for native earth worms, cocoon production and the number of live juveniles decreased progressively as 1080 concentrations increased, particularly at 1080 concentrations in the soil of ≥100 mg $kg^{-1}$ (O'Halloran et al. 2004). These soil concentrations were well above those that normally occur following the field use of 1080.

### 3.1.4 How much bait needs to be ingested for poisoning, based on pen trials with native species?

Based on the information given in section 3.1.1, the amount of bait native species need to ingest to be poisoned is given in Table 5.

TABLE 5. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON $LD_{50}$ FOR NATIVE SPECIES.

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT FEMALE (g) | AMOUNT OF 0.4g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.8g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 2.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 50g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 100g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|---|---|---|---|---|
| **Birds** | | | | | | | | | |
| Silvereye | 9.25 | 13 | 0.30 | 0.15 | 0.12 | 0.08 | 0.06 | 0.002 | 0.001 |
| Weka | 8 | 700 | 14.00 | 7.00 | 5.60 | 3.73 | 2.80 | 0.11 | 0.06 |
| **Mammals** | | | | | | | | | |
| Short-tailed bat | 0.15 | 14 | 0.005 | 0.006 | 0.002 | 0.001 | 0.001 | 0.00004 | 0.00002 |
| **Arthropods** | | | | | | | | | |
| NZ ant | 42 | 0.002 | 0.00021 | 0.00011 | 0.00008 | 0.00006[b] | 0.00004 | 0.000002 | 0.0000008 |
| Tree weta | 91 | 1 | 0.228 | 0.114 | 0.091 | 0.061 | 0.046 | 0.002 | 0.001 |

[a] Weights for birds from Heather and Robertson (1996) & weights of bats from Lloyd and McQueen (2000); [b] A single 6 g 0.15% 1080 pellet has enough toxin to deliver an $LD_{50}$ dose to >100 000 ants with a mean bodyweight of 2 mg each (Booth & Wickstrom 1999).

Note: The $LD_{50}$ values given in section 3.1.1 have been used in the calculations. The body weights used to calculate the amount of bait required for an $LD_{50}$ are average weights of females, which are generally more susceptible to poisoning because of smaller body weight and physiological factors therefore a 'worst case scenario' for poisoning.

## 3.2 Exposure

### 3.2.1 What species (individual animals) have been reported as non-target deaths in field operations with 1080 use?

Individual animals have been found dead after aerial, handlaying and bait station operations using 1080 carrot and cereal pellet baits (Tables 6, 7 and 8). The information presented in the tables includes animals found dead, or assumed to have been lethally poisoned from the presence of 1080 residues. The information has been restricted to those operations where the basic performance standards could be verified.

No Possums 1080 Gel Bait in bait stations

One **Kea** (*Nestor notabilis*) was found dead approximately 60 metres away from a No Possums 1080 Gel Bait bait station with beak slash marks in the bait after a possum control operation in the Fox Valley (Stephen Robson pers. comm. 2008). **Kea** or **kaka** markings were also reported on 3 out of 170 No Possums 1080 Gel Bait bait stations removed approximately 26 months after they were placed in the field in the Perry Block, Gouland Downs (Kahurangi National Park) in 2008, although no dead birds were located (Deverell 2008).

38 **Rhytida snails** (*Rhytida patula/perampla*) and one **Powelliphanta** were found dead inside 867 No Possums 1080 Gel Bait bait stations removed approximately 26 months after they were placed in the field in the Gouland Downs (Kahurangi National Park) in 2008 (Deverell 2008).

No information on deaths after the use of other methods and bait types could be located.

TABLE 6. NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING AERIAL OPERATIONS USING 0.08% or 0.15% CARROT BAITS (0.08% 1080 unless stated).

| SPECIES | No. FOUND DEAD | No. OF OPERATIONS | No. OF CASES WHERE RESIDUES CONFIRMED | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|---|
| | | | | Prefeed | Toxic | |
| **Birds** | | | | | 15 | |
| Morepork | 2 | 2[a] | 2 | | 10 - 15 | 1 |
| Tomtit | 8 | 4 [a] | 8 | | 5 | 1; 2 |
| Tomtit | 3 | 1[b] | 3 | | 15 | 3 |
| NI Robin | 3 | 1 [a] | 3 | | 15 | 4 |
| Kereru | 6 | 3 | 1 | | 15 | 1; 5; 6 |
| Rifleman | 5 | 1 | 5 | | 15 | 1 |
| Grey warbler | 1 | 1 | 0 | | ? | 7 |
| Tui | 1 | 1 | 1 | ? | 5 | 8 |
| Weka[c] | 1 | 1 | 1 | | | 9 |

[a] 1 of these operations was at Tahae (Pureora) where there is some evidence that the carrot was not screened adequately to meet bait specifications (Powlesland et al. 1999a); [b] In this operation the carrot bait was coated with deer repellent; [c] 0.15% 1080 carrot

Records of 1 tui and 1 whitehead from Kapiti island 1984 are not included above as there is some evidence that the carrot was below specs and the birds were not residue tested (Sherley 1992).

Records of robin, grey warbler, fantail, morepork, and Tomtit from 1978/79 not included above because carrot bait not to current quality standards.

1 Spurr & Powlesland (1997); 2 VPRD: T0171 & T1195; 3 Speedy (2003); 4 Powlesland et al. (1999a); 5 Greene (1998); 6 VPRD: T1223; 7 Greene (1998); 8 VPRD: T1809; 9 VPRD: 10210

TABLE 7. NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING AERIAL & HANDLAID OPERATIONS USING 0.15% or 0.08% 1080 PELLETS.

| SPECIES | No. FOUND DEAD | No. OF OPERATIONS | No. OF CASES WHERE RESIDUES CONFIRMED | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|---|
| | | | | Prefeed | toxic | |
| **Birds** | | | | | | |
| Silvereye | 1 | 1[a] | 1 | | 2 | 1 |
| Morepork | 2 | 1[b] | 1[c] | | 5 | 2; 3 |
| Tomtit | 5+[d] | 2[a] | 0[e] | | 5 - 7 | 2; 4 |
| Weka | 2 | 2[a] | 2 | | 3 - 5 | 5; 6 |
| Weka | 2 | 2[a,f] | 1[g,h] | | 1 | 7; 8 |
| Kakariki | 2 | 1[a] | 2 | 3 | 3 | 9 |
| Kakariki | 1 | 1 | 0[i] | 2 | 2 | 10 |
| Kereru | 4 | 3[a] | 1[j] | | 2 - 3 | 11 |
| Kiwi | 1 | 1[a,f] | 0[i] | | 1 | 12 |
| Kea | 20 | 3[a] | 12 | 1 - 3 | 1 - 2.5 | 13 |
| Tui | 1 | 1 | 0[i] | 2 | 2 | 14 |
| Fernbird | 3 | 1[a] | 3 | 2 | 1 | 15 |
| **Frogs** | | | | | | |
| Hochstetter's | 1 | 1[a] | 0[i] | | 7 | 16 |

[a] toxic loading of baits 0.15%; [b] toxic loading of baits 0.08%; [c] the second bird was not tested; [d] number found in second operation unspecified, assumed at least 1; [e] none of these birds were tested for residues; [f] baits handlaid; [g] this bird also had cyanide residues which is thought to be the cause of death; [h] the second bird tested negative, assumed to have come from handlaid treatment block – see Pestlink report 0203SND28; [i] tested negative; [j] two other kereru tested negative.

Note: 1 kokako record (Rotoehu 1994) omitted as baits were experimental (Spurr & Powlesland 1997; Flux & Innes 2001).

1 VPRD: T1534; 2 Spurr & Powlesland (1997); 3 VPRD: T0283; 4 Calder & Deuss (1985); 5 Walker (1997); 6 VPRD: T0169 & T2061; 7 VPRD: T1370 & T1467; 8 Pestlink: 0203SND12 & 0203SND28; 9 Rhodes et al. (2008); 10 VPRD 13305; 11 VPRD: T2061; 10206 & 1427; 12 VPRD: T1283; 13 VPRD: L23934, L23949, L35852, L41021, L41026, L23948, T5227 & T5245; 14 VPRD 13306; 15 van Klink et al. (2012); 16 McNaughton & Greene (1994).

TABLE 8. NON-TARGET NATIVE SPECIES DEATHS REPORTED DURING OPERATIONS USING 0.15% 1080 PELLETS IN BAIT STATIONS.

| SPECIES | No. FOUND DEAD | No. OF OPERATIONS | No. OF CASES WHERE RESIDUES CONFIRMED | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|---|
| | | | | Prefeed | Toxic | |
| **Birds** | | | | | | |
| Kea | 1 | 1 | 1 | | 1 | 1 |
| Tui | 1 | 1 | 0[a] | | ? | 2 |

[a] tested negative

1 VPRD: T0597; 2 VPRD: 8692.

### 3.2.2 In which species have residues of 1080 been detected following operations?

1080 residues have been detected in a number of living animals following aerial and handlaying operations using 1080 cereal pellets (Table 9).

24 hours after an aerial rabbit control operation (0.4 g kg$^{-1}$ aerial carrot at 25 kg ha$^{-1}$) on Motuihe Island, Auckland in July 2002, 5 live cockles and 6 live marine mussels were tested for 1080 residues. None contained 1080 residues (VPRD 4928 - 4938).

During the February 2010 Egmont National Park aerial 1080 operation (0.15% 1080 Wanganui #7 pellets, 2.3 kg ha$^{-1}$) freshwater and marine mussels were monitored for 1080 residues. Freshwater mussels were sampled from 11 sites within the operational area. Marine mussels were sampled at 2 sites approximately 20 km from the operational area. No 1080 was detected in any of the samples (VPRD).

The information in this section includes the results of laboratory analysis from live animals captured or killed for sampling from treatment areas. Residues from animals found dead are presented in section 3.2.1 above. The information has been restricted to those operations where the basic performance standards could be verified.

TABLE 9. RESIDUES DETECTED IN LIVE NON-TARGET NATIVE SPECIES DURING AERIAL AND HANDLAID PEST CONTROL OPERATIONS USING 0.15% AND 0.08% 1080 PELLETS.

| SPECIES | RESIDUES (mg kg$^{-1}$) | No. OF SAMPLES | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| **Birds** | | | | | |
| Kiwi | 0.011 | 1[d] | | 3[a] | 1 |
| Weka | 4.35 | 1 [d] | | 5 [a] | 2 |
| **Invertebrates** | | | | | |
| Tree weta | 66 | 1 [e] | | 5 [a] | 3 |
| Tree weta | 8.6 | 1 | | 5 [a] | 4 |
| Cave weta | 32–130 | 4 [f] | | 5 [a] | 3 |
| Cave weta | 4 | 1 | | 5 [a] | 4 |
| Weevil | 10 | 1 | | | 4 |
| Kauri snails | 0 | 4 | | 5[b,c] | 5; 6 |
| Arthropods (mixed) | 0.05–0.75 | 4 | | 5[b,c] | 5; 6 |
| Spiders (mixed) | 14 | 1g | | 5 [a] | 3 |
| Arthropods (mixed) | 14-46 | 3h | | 5 [a] | 3 |
| Arthropods (mixed) | 0-0.006 | 3 | | 5[b] | 7 |

[a] toxic loading of baits 0.15%; [b] toxic loading of baits 0.08%; [c] baits were handlaid; [d] faecal dropping sample; [e] 1 sample totalling 26 individuals collected from pitfall traps in treatment area; [f] four samples totalling 9 individuals; [g] 1 samples of 4 spiders, 2 collected from baits and 2 from pitfall traps; [h] 3 samples totalling 58 individuals collected off 1080 baits.

1 VPRD: T0819; 2 VPRD: T0169; 3 Lloyd & McQueen (2000); 4 Spurr & Berben (2004); 5 Pierce & Montgomery (1992); 6 VPRD: R004; 7 VPRD: 139 & 146

### 3.2.3 What evidence is there to suggest that use of 1080 causes, or doesn't cause, a population decline of native species at sites where it is used?

*Aerial and hand laying operations using 0.15% or 0.08% 1080 Pellets*

**Birds**

44 radio-tagged **great spotted kiwi** (*Apteryx haastii*) have been monitored through four 0.15% 1080 Pellet aerial operations and none died from 1080 poisoning (Table 10).

TABLE 10. GREAT SPOTTED KIWI MONITORED DURING AERIAL 1080 OPERATIONS USING 0.15% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1994 (Aug) Saxon River | 9 | 0 | | 5 | 1 |
| 1994 (Dec) Karamea | 7 | 0 | | 5 | 2 |
| 2009 (Sept) Gouland Downs | 8 | 0 | 1 | 2 | 3 |
| 2009 (Sept) Hawdon | 20 | 0 | 1 | 2 | 4 |

1 Walker (1997); 2 Robertson et al. (1999); 3 S. Forder pers. comm. Pestlink: 0809GDB08; 4 Veltman & Westbrooke (2011)

A total of 131 **NI brown kiwi** (*Aptreyx mantelli*) have been monitored during aerial and handlaid 1080 pellet operations during 5 operations and none have died from poisoning (Table 11). Kiwi call count monitoring during the Waipoua operation did not indicate significant 1080 related mortality (Pierce & Montgomery 1992).

TABLE 11. NI BROWN KIWI MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1990 (June) Waipoua | 5 | 0 | | 5[a] | 1 |
| 1990 (Sept) Waipoua | 6 | 0 | | 5 | 1 |
| 1995 Rewarewa | 22 | 0 | | 3[b,c] | 2 |
| 2001 (Sept) Tongariro Forest | 29 | 0 | | 3[b] | 3 |
| 2006 (Sept) Tongariro Forest | 69 | 0 | 2 | 4 | 4 |

[a] toxic loading of baits 0.8 g kg$^{-1}$; [b] toxic loading of baits 1.5 g kg$^{-1}$; [c] baits were handlaid.

1 Pierce & Montgomery (1992); 2 Robertson et al. (1999); 3 Pestlink: 0203RUA06; 4 Pestlink: 0808RUA01.

46 **Rowi** (*Aptreyx rowi*) were monitored during an aerial 0.15% 1080 Wanganui #7 pellet operation at Okarito in November 1998 with no deaths being reported (Veltman & Westbrooke 2011). 19 Haast **tokoeka** (*A. australis*) were monitored during an aerial 0.15% 1080 Wanganui #7 pellet operation (2 kg ha$^{-1}$ prefeed, 3 kg ha$^{-1}$ toxic) in the Haast Kiwi Sanctuary in May 2001, with no deaths being recorded (H Robertson pers. comm.).

Based on a meta-analysis of 199 kiwi (all species) from 10 surveys between 1994 and 2009, Veltman and Westbrooke (2011) calculated the upper bound of the 95% confidence interval for an estimate of zero mortaility at 1.5%.

A total of 302 NI **kokako** (*Callaeas cinerea wilsoni*) has been exposed to this method and bait type over 13 operations and 2 have disappeared after poisoning (Table 12). Between 1986 and March 1998, 366 kokako (including 6 juveniles) have been monitored through 31 aerial poisoning operations (of all bait types and toxins combined), although the number exposed and known to have survived is greater. Of the monitored birds, 4 have disappeared after poisoning, leading to a maximum estimate for kokako mortality of 1.4% per operation with a 5% chance that it will exceed 4% (Flux & Innes 1999). Based on a meta-analysis of 129 radio tagged and banded kokako that were monitored through 8 aerial 1080 operations between 1986 and 2001, Veltman and Westbrooke (2011) calculated the upper bound of the 95% confidence interval for an estimate of zero mortaility at 2.3%.

TABLE 12. NI KOKAKO MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[a] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1986 Pureora Nth Block | 16 | 0 | | 10-12[b,d] | 1 |
| 1986 Okahukura Forest | 11 | 1 | | 10-12[b,d] | 1 |
| 1986 Meyers Farm (Pureora) | 5 | 0 | | 8-10[c] | 1 |
| 1987 Pureora Nth Block | 23 | 0 | | 8[c,d] | 1 |
| 1988 Mapara | 3 | 0 | | 10[c] | 1 |
| 1988 Cowan WR/ Okahukura Forest | 24 | 0 | | 8-10[c] | 1 |
| 1990 Waipoua | 6 | 1e | | 5[c] | 2 |
| 1990 Mapara | 52 | 0 | | 8[c] | 3 |
| 1989 Moki Forest | 12 | 0 | | 9[c] | 4 |
| 1990 Kaharoa Forest | 24 | 0 | | [b] | 5 |
| 1991 Mapara | 48 | 0 | | 8[c] | 3 |
| 1992 Mapara | 50 | 0 | | 8[c] | 3 |
| 1992 Kaharoa Forest | 28 | 0 | | 6[b] | 6 |

[a] monitoring method assumes birds which disappear have died from poisoning; [b] toxic loading of baits 0.15%; [c] toxic loading of baits 0.08%; [d] These operations used 'mapua' surface coated cereal pellets which are no longer used; [e] this bird least fitted the basic assumptions of the monitoring method and probably should not have been included in the assessment- according to the authors.

1 Innes & Williams (1990); 2 Pierce & Montgomery (1992); 3 Bradfield (1993); 4 Spurr (1994b); 5 Speed (1992); 6 Speed (1993).

A total of 42 **weka** (*Gallirallus australis*) has been exposed to this method and bait type over 5 operations and 1 has died from poisoning (Table 13).

TABLE 13. WEKA MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1994 Saxon River | 7 | 0 | | 5 | 1 |
| 1994 Tennyson inlet | 17 | 1 | | 5 | 1 |
| 1994 Rotumanu | 8 | 0 | | 5 | 2 |
| 2000 Copland | 10 | 0 | | 3 | 3; 4 |

1 Walker (1997); 2 Spurr & Powlesland (1997); 3 Van Klink & Tansell (2003); 4 Pestlink: 02/03SWS22.

A total of 23 radio tagged **morepork** (*Ninox novaeseelandiae*) has been exposed to this method and bait type over 4 operations and none have died from poisoning (Table 14). Call count monitoring at Waipoua did not indicate 1significant 1080 related mortality (Pierce & Montgomery 1992).

TABLE 14. MOREPORK MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1990 Waipoua | 2 | 0 | | 5[a] | 1 |
| 1994 Saxon River | 6 | 0 | | 5[b] | 2 |
| 1994 Tennyson Inlet[c] | 1 | 0 | | 5[b] | 2 |
| 1998 Pureora | 3[d] | 0 | | 5[a] | 3 |
| 2010 Waitutu | 11 | 0 | 1 | 2 [b] | 4 |

[a] toxic loading of baits 0.08%; [b] toxic loading of baits 0.15%; [c] six of the birds monitored were at Gouland Downs; [d] This study followed 28 radio tagged birds over 3 years. Significant natural mortality (18%) was observed over hard winters.

1 Pierce & Montgomery (1992); 2 Walker (1997); 3 Powlesland et al. (1999b); 4 Greene et al. (2013)

A total of 59 **fernbirds** (*Bowdleria punctata*) has been exposed to this method and bait type over 3 operations and 7 have disappeared after poisoning (Table 15).

In the 2010 study in Ianthe Forest, 36 radio-tagged South Island fernbirds were monitored during an aerially applied 1080 cereal pellet operation. 5 birds dropped their transmitters, 1 was killed by a predator and 3 died from 1080 poisoning. Based on this, the mortality of fernbirds due to 1080 poisoning was estimated at 9.4% (2.4-22.6% 95% CI). The authors concluded that the impact of aerial 1080 operations on fernbird numbers is small, and the survival and improved breeding success that would have resulted from introducted predators being reduced during the 1080 operation would have outweighed the losses (van Klink et al. 2012).

TABLE 15. FERNBIRDS MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No.KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1990 Waipoua | 14[d] | 0 | | 5[a] | 1 |
| 1994 Gouland Downs | 9 | 4[c] | | 5[b] | 2 |
| 2010 Ianthe Forest | 36 | 3 | 1 | 2 [b] | 3 |

[a] toxic loading of baits 0.8 g kg$^{-1}$; [b] toxic loading of baits 1.5 g kg$^{-1}$; [c] due to the banded birds not being roll called immediately prior to the poisoning this study was inconclusive about cause of disappearance; [d] includes 2 banded birds.

1 Pierce & Montgomery (1992); 2 Walker (1997); van Klink et al. (2012)

A total of 55 colour banded **NI robins** (*Petroica australis longipes*) have been exposed to this method and bait type over 2 operations and 10 have disappeared after poisoning (Table 16).

21 colour banded and 5 unbanded **SI robins** (*Petroica australis australis*) monitored during 2 aerial 1080 pellet operations all survived (Table 16).

TABLE 16. ROBINS MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[a] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1994 Saxon River | 2 | 0 | | 5 | 1 |
| 1998 Waitotara | 38 | 10 | | 4 | 2 |
| 1998 Long Ridge, Pureora | 17 | 0 | | 5 | 2 |
| 2011 Silver Peaks, Dunedin | 24 | 0 | 1.5 | 2 | 3 |

[a] monitoring method assumes birds which disappear have died from poisoning.

Not included here is monitoring of robins using the 5 minute count method which can only reliably detect very large population changes (Powlesland et al. 1999).

1 Walker (1997); 2 Powlesland et al. (1999b); 3 Schadewinkel & Jamieson (2014).

A total of 29 colour banded **NI tomtit** (*Petroica macrocephala toitoi*) have been monitored during two non-prefed aerial 1080 cereal pellet operations, with 1 bird disappearing (Table 17).

A monitoring study in Tongariro Forest (2001) using distance sampling found no significant difference in the mortality of tomtits between the treatment (2 kg ha$^{-1}$ prefeed followed by 3 kg ha$^{-1}$ 0.15% 1080 pellets) and non-treatment sites (Westbrooke et al. 2003). Distance sampling of tomtits also occurred during an aerial 1080 operation (2 kg ha$^{-1}$ prefeed followed by 2 kg ha$^{-1}$ 0.08% 1080 pellets) on Mt Pureora in 2003. There was no decline in male tomtits counts in this operation (Westbrooke & Powlesland 2005). These results led the Westbrooke & Powlesland (2005) to conclude that aerial poisoning operations using cereal pellets at low sowing rates causes "...little, if any..." short term impacts on tomtit populations.

Monitoring of tomtits using distance sampling has also been undertaken during two operations using cereal pellets coated with deer repellent. Oakes (2008b) monitored tomtits at three sites during an aerial 1080 pellet operation in Rotoaira Forest in 2007. The three sites were: a block where deer repellent coated 1080 pellets were used; a block where standard, uncoated pellets were used; and a non-treatment site where no possum control occured. Tomtit numbers declined by between 20 – 36% at all sites. This led the author to conclude some factor (possibly too long a time period between the pre and post control surveys) other than the use of the deer repellent or 1080 caused the decline. In 2008, **SI tomtits** were monitored during an aerial operation using deer repellent coated pellets (2 kg ha$^{-1}$ prefeed followed by 2 kg ha$^{-1}$ 0.15% 1080 pellets) in the Waianakarua Scenic Reserve southwest of Oamaru and at a nearby non-treatment site when no possum control occurred. At both these sites tomtits increased by similar amounts (~13%) during the post control monitoring (Oates 2008a).

TABLE 17. TOMTITS MONITORED DURING AERIAL AND HANDLAID 1080 OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[c] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1998 Pureora | 14 | 0 | | 5[a] | 1 |
| 2001 Tongariro | 15 | 1 | | 3[b] | 2 |

[a] toxic loading of baits 0.08%; [b] toxic loading of baits 0.15%. 12 g baits used; [c] monitoring method assumes birds which disappear have died from poisoning.

Not included here is monitoring of tomtit using the 5 minute count method which can only reliably detect very large population changes (Powlesland et al. 1999).

1 Powlesland et al. (2000); 2 Westbrooke et al. (2003).

Transect counts of **SI tomtits, grey warbler, SI robins and riflemen** were conducted before and after the 2010 Waitutu aerial 1080 operation (1 kg ha$^{-1}$ prefeed followed by 2 kg ha$^{-1}$ 0.15% 1080 pellets). The transects were located at five sites, three within the operational area and two in a non-treatment area. While the numbers of tomtits and grey warblers detected on the transects changed following the application of the 1080, the scale and direction of the changes (decreases for tomtits and increases for grey warbler) was similar at all five sites. The pre- and post-control counts of riflemen and SI robins were similar between the operational area and non-treatment sites. The authors therefore concluded there was no evidence for population level impacts from 1080 on any of these species (Greene et al. 2013).

**Whio** (*Hymenolaimus malacorhynchos*) are unlikely to eat cereal pellet baits and their aquatic invertebrate prey are unlikely to be contaminated by 1080. However, studies have been done to determine their survival following aerial 1080 operations. There was no reduction in visual counts of whio in the Otira valley after application of 0.15% 1080 Pellets at 6 kg ha$^{-1}$ in 1989 (Spurr & Powlesland 1997). All 19 radio-tagged whio in Waihaha survived for at least four weeks following aerial application of carrot bait (0.08%) at 15 kg ha$^{-1}$ (Greene 1998). None of 15 whio monitored during a pre-fed aerial 0.15% 1080 Wanganui #7 pellet operation at Oparara, West Coast died (Veltman & Westbrooke 2011).Based on the results of these last two operations, Veltman and Westbrooke (2011) calculated the upper bound of the 95% confidence interval for an estimate of zero mortaility at 8.4%.

A total of 60 radio tagged **Kaka** (*Nestor meridionalis*) have been exposed to this method and bait type over 4 operations and none have died from poisoning (Table 18). Additionally, 38 radio tagged birds have been exposed to 0.08% carrot baits over 2 operations and none have died from poisoning (Greene 1998; Powlesland et al. 2003). Based on a meta-analysis of the kaka monitored through the 5 pellet and carrot operations between 1994 and 2008, Veltman and Westbrooke (2011) calculated the upper bound of the 95% confidence interval for an estimate of zero mortaility at 3.5%.

TABLE 18. KAKA MONITORED DURING AERIAL 1080 OPERATIONS USING 0.15% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| Windbag (1998) | 15 | 0 | | 5 | 1 |
| Waipapa (2001) | 20 | 0 | | 5 | 1 |
| Waipapa (2008) | 10 | 0 | 1 | 1.5 | 2 |
| Waitutu (2010) | 15 | 0 | 1 | 2 | 3 |

1 Powlesland et al. (2003); 2 Veltman & Westbrooke (Veltman & Westbrooke 2011); 3 Greene et al. (2013)

**Kereru (NZ pigeon/kukupa)** (*Hemiphaga novaeseelandiae*) have not been monitored individually when exposed to this method and bait type. However none of six birds ate non-toxic cereal pellets offered in a trial on Kapiti island (Spurr & Powlesland 1997). Monitoring of kereru during 5 aerial 1080 operations using cereal pellets did not detect population changes using the five minute count method (Spurr & Powlesland 1997). Additionally, all 15 radio tagged birds exposed to an aerial 1080 operation using carrot bait survived (Powlesland et al. 2003).

**NZ falcon** (*Falco novaeseelandiae*) have not been monitored individually when exposed to this method and bait type. However falcon territories have remained occupied, presumably by the resident birds, during four aerial 1080 operations using cereal pellets (Pureora 1984, Mapara 1990-92) and one using carrot bait (Waihaha 1994) (Spurr & Powlesland 1997). The total number of falcon involved in this monitoring is about 13, although the Mapara birds (3 pair) were exposed in three consecutive years (Calder & Deuss 1985; Bradfield 1993; Greene 1998). Seaton et al. (2009) collected productivity data from 87 falcon nests in Kaingaroa pine plantation during three breeding seasons, 2003 - 2006. During this time 1080 pellets and carrots were ground laid or aerially applied in forest compartments where falcon bred. The numbers of chicks successfully fledged was not related to time since 1080 application (1 month to >3 years), application method or bait type. During the study the breeding falcon population increased from 20 to 36 pairs, leading to the authors concluding that 1080 did not have a negative impact on falcon, and probably had a positive impact by reducing predation pressure on the falcon.

**Kakariki (parakeet)** (*Cyanoramphus spp.*) nests have been monitored during two aerial cereal 1080 operations. Fifteen nests were monitored during the October 2007 Hurunui Valley operation and a further seven nests were monitored during a 1080 operation in the Dart Valley. Dead chicks in a failed nest in the Hurunui Valley operation contained 1080 residues and the female was not seen after the nest failed. All the monitored nests in the Dart Valley operation were successful, however two unmonitored Kakariki were found dead with 1080 residues in their tissues. The combined estimate of mortality of nesting parakeets from these operations was 2.27% (0.1-12 % 0.95 CI) (Rhodes et al. 2008). The

authors concluded that while some Kakariki were killed during the 1080 operations, given the rate of nest predation observed in areas where no predator control was carried out, the net benefit from the 1080 operations was positive. No detectable impact could be determined through five minute bird count monitoring before and after four aerial 1080 operations using carrot or cereal pellet baits (Spurr & Powlesland 1997). Additionally following an intensively monitored aerial 1080 operation in Waihaha in 1994 using carrot bait, Greene (1998) observed "...kakariki remained common within the study area...".

**Australasian harrier** (*Circus approximans*) have not been monitored individually when exposed to this method and bait type. However no detectable impact could be determined through five minute bird count monitoring before and after an aerial 1080 operation using cereal pellets on Rangitoto island and "the small resident population was still seen...throughout the year following the poisoning" (Miller & Anderson 1992). Additionally, Pierce and Maloney (1989) found no evidence of dead harriers after aerial 1080 poisoning of rabbits in the McKenzie basin.

A total of 145 radio tagged **Kea** (*Nestor notabilis*) have been exposed to this method and bait type over 10 operations and 20 have died from poisoning (Table 19). Additionally, 2 radio tagged birds have been exposed to 0.08% carrot baits during 1 operation and none died from poisoning (Kemp & van Klink 2008).

TABLE 19. KEA MONITORED DURING AERIAL 1080 OPERATIONS USING 0.15% 1080 PELLETS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| Arawata Valley (2008) | 10 | 0 | 1 | 4 | 1 |
| Franz-Fox (2008) | 17 | 7 | 3 | 2.5 | 1 |
| Mt Arthur (2009)[a] | 13 | 0 | 1 | 2 | 1 |
| Hawdon (2009)[a] | 10 | 0 | 1 | 2 | 1 |
| Okarito (2011)[a] | 37 | 8 | 1 | 2 | 2 |
| Whangapeka (2011)[a] | 13 | 0 | 1 | 2 | 2 |
| Abbey Rocks (2011)[a] | 8 | 0 | 1 | 1 | 2 |
| Copland Valley (2012) [a] | 2 | 0 | 1 | 2 | 2 |
| Hawdon Valley (2012) [a] | 6 | 0 | 1 | 2 | 2 |
| Otira (2013) [a] | 29 | 5 | 1 | 2 | 2 |

[a] These operations were undertaken using the performance standards adopted by DOC in 2009

1 Veltman & Westbrooke (2011): 2 (J. Kemp pers. comm. 2013).

**Reptiles/amphibians**

Lizards and frogs were not monitored in any 1080 poisoning operations prior to 1994; however, none have been reported killed by 1080. Captive **McCann's skinks** (*Oligosoma maccanni*) ate non-toxic cereal pellets (RS5 and Agtech), especially when the baits were wet, but the level of consumption (0.01 - 0.02 g over 2 days) was probably insufficient for the animals to have received a lethal dose had the baits been toxic (Freeman et al. 1997).

The attractiveness of non-toxic RS5 cereal pellets (dyed green and lured with cinnamon) to wild **grand** (*Oligosoma grande*) and **Otago** (*O. otagense*) **skinks** were tested by Marshall and Jewell (2007). The baits were offered in two sizes – small pieces no larger than 6 mm and large baits (whole pellets). The baits were offered dry or wet. All bait types were sampled (licked, nudged or bitten) by both species of skink, with small pieces sampled more often than large baits. No animals tried to consume large pieces of cereal bait. However, 1/10 grand skinks and 3/20 Otago skinks consumed small, wet pellet fragments.

Monitoring of a population of **Archeys frog** (*Leiopelma archeyi*) in the Coromandel Ranges before and following application of 0.15% 1080 Pellets at 5 kg $ha^{-1}$ in 1995, showed no decline in Archeys frog (Perfect 1996). **Hochstetters frogs** (*Leiopelma hochstetteri*) were counted at 3 sites pre- and post- application at 7 kg $ha^{-1}$, 1994 Hunua Ranges. 1 frog found dead immediately following poison operation tested negative for 1080. Fluctuations in frog numbers counts were influenced so strongly by short term environmental effects that any effect of the poison drop could not be detected (McNaughton & Greene 1994).

**Bats**

**Short-tailed bats** (*Mystacina tuberculata*) have not been individually monitored when exposed to this method and bait type. Lloyd (1994) offered non-toxic cereal pellets to captive bats and hand broadcast baits containing a fluorescent marker throughout an area known to be inhabited by bats and concluded "...short-tailed bats are unlikely to eat carrot or grain-based baits...". However short-tailed bats are possibly vulnerable to secondary poisoning because they are known to feed on arthropods that have been recorded feeding on 1080 baits and residues in these prey can in theory be enough to kill a bat (Lloyd & McQueen 2000).

In a study in Rangataua forest where 0.15% 1080 Pellets were aerially broadcast (3 – 5 kg $ha^{-1}$) over "...almost the entire winter range..." of the study animals, a total of 269 short-tailed bats were caught at their roost following poisoning and held for 48 hours to determine mortality or signs of poisoning. All animals survived and showed no signs of 1080 poisoning (Lloyd & McQueen 2000).

**Fish**

Native fish have not been monitored during 1080 operations. However, a field experiment has been conducted to study the impact of 1080 on longfin eels (*Anguilla dieffenbachia*), koaro (*Galaxias brevipinnis*) and upland bullies (*Gobiomorphus breviceps*). Four headwater streams were selected in the Mawhera Forest in the Grey Valley, West Coast. In each stream four sites were selected – 10 m and 100 m down stream, and 10 m and 100 m upstream from

where 1080 baits were to be placed in the stream. At each site 8 fish of each species were placed in individual cages. Fish mortality was recorded after 1 and 4 days. Baits (6.5 g, 0.15% 1080 Wanganui #7 pellets) were then placed in the streams at a density equivalent to a sowing rate of 25 – 30 kg $ha^{-1}$ (this represented an extreme scenario of 10 x normal sowing rates). Fish survival was monitored 1 and 4 days after the bait was placed in the water. No fish died after the baits were added to the water, suggesting all three species were tolerant to 1080 in water at the concentrations used in the study (Suren & Lambert 2006).

**Terrestrial invertebrates**

Invertebrate populations have been monitored during eight 1080 aerial poisoning operations using cereal pellets. None of these studies suggest significant population effects on any species studied nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals.

An extensive study of forest invertebrates found on 1080 baits by Sherley et al. (1999) found that at any time only a small proportion of baits had invertebrates on them, and the few individuals per bait represented a small section of the fauna present in the litter. The number of invertebrates recorded on baits in treatment grids declined when 0.15% 1080 Pellets were laid at 18 kg $ha^{-1}$, but started to return to original levels (relative to control grids) within 6 days of removal of the toxic baits. The reduction in invertebrate numbers did not extend further than 20 cm around a bait.

Another study by Spurr & Berben (Spurr & Berben 2004) hand laid 0.15% 1080 Pellets at 5 kg $ha^{-1}$ to simulate aerial poisoning in Tararua Forest Park in 1999 and monitored the occupancy of artificial refuges by **tree weta** (*Hemideina crassidens*) and cave weta (*Isoplectron sp.*). No significant impact of bait application was found for these species nor was there any effect observed on numbers of **slugs, spiders** and **cockroaches** which also commonly used the same refuges.

No impact was detected on populations of **weta** in Waipoua Forest and all **cockroaches, centipedes, millipedes, kauri snails** and all but one **beetle** survived in enclosures with 0.08% 1080 Pellets (Pierce & Montgomery 1992).

Spurr (1994a) found no impacts on populations **of amphipods, ants, beetles, collembolans, millipedes, mites, slugs, snails, spiders** and **cave weta** at Puketi Forest or Titirangi Scenic Reserve where 0.08% 1080 Pellets were aerially applied at 5 kg $ha^{-1}$.

In Mapara where 0.08% 1080 Pellets were aerially applied in three consecutive years 1990-92, a comparison of invertebrate fauna showed a greater number of predatory insects in the treatment site, characteristic of a healthy forest, and more fungal eating insects in the non-treatment site, characteristic of unhealthy forest (Bradfield 1993).

A range of invertebrate species on Rangitoto Island were sampled using a range of collection techniques, before and after aerial poisoning with 0.08% 1080 Pellets at 12 kg $ha^{-1}$. No population effects were observed (Anon. 1990).

**Aquatic invertebrates**

In the early 1990's, the Taranaki Regional Council monitored aquatic invertebrates in streams before and after two aerial 1080 operations. No effect of the aerial 1080 operations on the invertebrate communities could be demonstrated. However, the post control samples were collected between 32 and 42 days after the aerial operation, and the sampling protocol could have resulted in any short-term reductions in invertebrate numbers being missed (Suren & Lambert 2006).

Suren and Lambert (2006) therefore conducted an experiment to assess the ecological impact of 1080 leaching from baits on aquatic invertebrate communities. The experiment was conducted in four streams in the Mawhera Forest in the Grey Valley, West Coast. In each stream four sites were selected – 10 m and 100 m down stream, and 10 m and 100 m upstream from where 1080 baits were to be placed in the stream. At each site invertebrate communities on 10 replicate rocks were quantified 4 days and 1 day prior to baits being placed in the stream. The invertebrate communities were dominated by Caddisflies (*Helicopyche, Pycnocentrodes, and Pycnocentria*), orthoclad midges, and the mayfly *Deleatidum*. Baits (6.5 g 0.15% 1080 Wanganui #7 pellets) were then placed in the streams at a density equivalent to a sowing rate of 25 – 30 kg $ha^{-1}$ (this represented an extreme scenario of 10 x normal sowing rates). The invertebrate communities were re-sampled 1 day and 4 days after the bait was placed in the stream. No biologically significant effects on the invertebrate communities as a result of the 1080 were observed.

*Aerial and hand laying operations using 0.08% and 0.15% carrot baits*

Two **NI brown kiwi** (*Apteryx mantelli*) followed in a 0.08% 1080 carrot operation did not die from poisoning (Table 20). Following a non-toxic bait trial on Kapiti Island in May 1993, when carrot containing the biomarker pyranine was aerially sown at 10 kg $ha^{-1}$, none of five **little spotted kiwi** (*Apteryx owenii*) droppings examined fluoresced (Lloyd & Hackwell 1993). Other kiwi species have not been monitored during carrot operations.

TABLE 20. NI BROWN KIWI MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg $ha^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1995 Tongariro Forest | 2 | 0 | | ? | 1 |

1 Robertson et al. (1999).

A total of 44 **NI kokako** (*Callaeas cinerea wilsoni*) has been exposed to 0.08% 1080 carrot baits over 2 operations and none have disappeared after poisoning (Table 21). Between 1986 and March 1998, 366 kokako (including 6 juveniles) have been monitored through 31 aerial poisoning operations (of all bait types and

toxins combined), although the number exposed and known to have survived is greater. Of the monitored birds, 4 have disappeared after poisoning, leading to a maximum estimate for kokako mortality of 1.4% per operation with a 5% chance that it will exceed 4% (Flux & Innes 2001).

TABLE 21. KOKAKO MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[a] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1993 Pureora Nth Block | 10 | 0 | | 10 | 1 |
| 1996 Pureora Nth Block | 34 | 0 | | 15 | 2 |

[a] monitoring method assumes birds which disappear have died from poisoning.

1 Speed et al. (1993); 2 Marsh (1996)

Twenty eight **Weka** (*Gallirallus australis*) were monitored during an aerial 1080 carrot operation at Turiwhate in Central Westland in August 2008. Non-toxic pre-feed carrot (12 g) were sown at a rate of 3 kg ha$^{-1}$. Ten days later toxic carrot (1.5 g kg$^{-1}$ 1080) lured with orange was sown at 5 kg ha$^{-1}$. One bird died for 1080 poisoning (confirmed by residue testing). All the other birds survived for at least two months after the operation. The estimated mortality rate of weka during the operation was 0.2 - 17.8% (95% confidence intervals) (van Klink 2008). 5 minute counts of weka in the Copland valley operation in 1986 (20 kg ha$^{-1}$ 0.2% screened carrot bait) found no detectable effect (Spurr 1988). During a non-toxic carrot bait trial on Kapiti Island in May 1993, carrot containing the biomarker pyranine was aerially sown at 10 kg ha$^{-1}$. 10 of 87 weka droppings examined following the drop fluoresced from the pyranine. Weka were observed feeding on the baits on several occasions (Lloyd & Hackwell 1993).

A total of 6 **morepork** (*Ninox novaeseelandiae*) has been exposed to this method and bait type over 1 operation and one has died from poisoning (Table 22).

TABLE 22. MOREPORK MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1996 Tahae (Pureora) | 6 | 1[a] | | 15 | 1 |

[a] there is some evidence that the carrot was not screened adequately to meet bait specifications

1 Powlesland et al. (1998).

**NZ falcon** (*Falco novaeseelandiae*) have not been monitored individually when exposed to this method and bait type. However falcon territories have remained occupied, presumably by the resident birds, during one aerial 1080 operation

using carrot bait (Waihaha 1994) and four using cereal pellets (Pureora 1984, Mapara 1990-92) (Spurr & Powlesland 1997). The total number of falcon involved in this monitoring was about 13 although the Mapara birds (3 pair) were exposed in three consecutive years (Calder & Deuss 1985; Bradfield 1993; Greene 1998).

Seaton et al. (2009) collected productivity data from 87 **NZ falcon** nests in Kaingaroa pine plantation over three breeding seasons, 2003-06. During this time 1080 carrots and pellets were aerially applied or ground laid in forest compartments where falcon bred. The numbers of chicks successfully fledged was not related to time since 1080 application (1 month to >3 years), application method or bait type. During the study the breeding falcon population increased from 20 to 36 pairs, leading to the authors concluding that 1080 did not have a negative impact on falcon, and probably had a positive impact by reducing predation pressure on the falcon.

A total of 53 colour banded **robins** (*Petroica australis*) has been exposed to this method and bait type over 2 operations and 15 have disappeared after poisoning (Table 23).

TABLE 23. ROBINS MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[a] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1996 Tahae (Pureora) | 22 | 12[b] | | 15 | 1 |
| 1997 Waimanoa (Pureora) | 31 | 3[c] | | 10 | 2 |

[a] monitoring method assumes birds which disappear have died from poisoning.

[b] there is some evidence that the carrot was not screened adequately to meet bait specifications (Powlesland et al. 1999b).

[c] 1 bird also disappeared form the non-treatment site during the study period

Not included is monitoring of robins using the 5 minute count method which can only reliably detect very large population changes (Powlesland et al. 1999b).

1 Powlesland et al. (1998); 2 Powlesland et al. (1999a).

A total of 19 colour banded **tomtit** (*Petroica macrocephala*) has been exposed to this method and bait type over two operations and 16 have disappeared after poisoning (Table 24). During the 1997/98 nesting season, tomtit pairs in the 1997 treatment area had high nesting success (80% of nests fledged chicks, mean of four fledglings per nest). Even so, by the following spring it seemed that the population had not recovered to its pre-poison level. (Powlesland et al. 2000).

TABLE 24. TOMTIT MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[a] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1996 Tahae (Pureora) | 5[c] | 5[b] | | 15 | 1 |
| 1997 Waimanoa (Pureora) | 14 | 11 | | 10 | 1 |

[a] monitoring method assumes birds which disappear have died from poisoning; [b] there is some evidence that the carrot was not screened adequately to meet bait specifications (Powlesland et al. 1999b);

[c] tomtit data in this study was opportunistically collected as part of a robin study. Only 2 of the birds were banded, no non-treatment area was used.

1 Powlesland et al. (2000).

A distance sampling study of an aerial operation in 2002 using carrot bait at 2 kg ha$^{-1}$ found the tomtit population increased by over 60% between pre-poison (winter 2002) and post poison (winter 2003) (Hamilton 2004).

Westbrooke and Powlesland (2005) reported the results of distance sampling of tomtits carried out during three 2003 aerial carrot operations (Kokmoka Forest, Mohaka Forest and Waimanoa). In these operations prefeed carrots were sown at 3-5 kg ha$^{-1}$ followed by 0.8% 1080 carrots sown at 3-5 kg ha$^{-1}$. Tomtit numbers declined by between 15 -47% during each of these operations.

During August-September 2006 transect counts of male tomtits were carried out during an aerial 1080 carrot operation in Aorangi Forest Park, to examine whether carrots with deer-repellent applied to them posed a risk to tomtits. The operation was divided into two blocks: a 1200 ha block where the toxic carrot was applied without deer-repellent, and a 9,800 ha block where the toxic carrot contained deer-repellent. Following pre-operation monitoring of the tomtits, both blocks were prefed at a rate of 3 kg ha$^{-1}$. 13 days later the toxic bait (0.8% 1080) was applied at a rate of 5 kg ha$^{-1}$. Post control, there was no decline in the number of tomtits recorded in either block. It was concluded that the addition of the deer-repellent to carrot baits did not pose an increased risk to tomtits (Ross 2007).

**Whio** (*Hymenolaimus malacorhynchos*) are unlikely to eat carrot baits and their aquatic invertebrate prey is unlikely to be contaminated by 1080. All 19 radio tagged blue ducks survived for at least four weeks following aerial application of carrot bait (0.08%) at 15 kg ha$^{-1}$ (Greene 1998).

A total of 38 radio tagged **Kaka** (*Nestor meridionalis*) has been exposed to this method and bait type over 2 operations and none have died from poisoning (Table 25).

Non-toxic carrot containing the biomarker pyranine was aerially sown at 10 kg ha$^{-1}$ on Kapiti Island in May 1993. Over the 11 days following the drop, 20 kaka were caught a total of 25 times and inspected for fluorescence due to the pyranine. Only one juvenile kaka showed traces of pyranine. A large number of

kaka droppings were also inspected, but no fluorescence was observed (Lloyd & Hackwell 1993).

TABLE 25. KAKA MONITORED DURING AERIAL 1080 OPERATIONS USING 0.08% CARROT BAITS.

| OPERATION | No. OF BIRDS EXPOSED | No. KILLED BY POISON[a] | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|---|
| | | | Prefeed | Toxic | |
| 1994 Waihaha (Pureora) | 21 | 0 | | 15 | 1 |
| 2000 Whirinaki | 17 | 0 | | 10 | 2 |

Kaka monitored using 5 minute count method are not reported here because this technique cannot reliably detect population changes for kaka (Powlesland et al. 2003).

1 Greene (1998); 2 Powlesland et al. (2003).

**Kereru (NZ pigeon/kukupa)** (*Hemiphaga novaeseelandiae*) have been monitored using radio tagged individuals in one aerial operation using carrot bait (0.08%) at 10 kg ha$^{-1}$ in Whirinaki. All 15 birds survived (Powlesland et al. 2003). Monitoring of kereru during 9 aerial 1080 operations using screened carrot bait did not detect population changes using the five minute count method (Spurr & Powlesland 1997).

During a non-toxic carrot bait trial on Kapiti Island in May 1993, carrot containing the biomarker pyranine was aerially sown at 10 kg ha$^{-1}$. Two kereru caught were examined for traces of pyranine, but none was observed. However, fluorescence due to pyranine was observed in one kereru dropping (Lloyd & Hackwell 1993).

**Kakariki (parakeet)** (*Cyanoramphus* spp.*)* have not been monitored individually when exposed to this method and bait type. However no detectable impact could be determined through five minute bird count monitoring before and after four aerial 1080 operations using carrot and cereal pellet baits (Spurr & Powlesland 1997). Additionally following an intensively monitored aerial 1080 operation in Waihaha in 1994 using carrot bait, Greene (1998) observed "…kakariki remained common within the study area…".

None of the three **tui** (*Prosthemedera novaeseelandiae*) and two **bellbirds** (*Anthornis melanura*) examined fluoresced, after non-toxic carrot containing the biomarker pyranine was sown at 10 kg ha$^{-1}$ on Kapiti Island in May 1993. (Lloyd & Hackwell 1993).

**Kea** (*Nestor notabilis*) have been monitored using 2 radio tagged individuals in one aerial operation using carrot bait (0.08%) at 5 kg ha$^{-1}$ in Hohonu Range. Both birds survived (Kemp & van Klink 2008).

### Reptiles/amphibians

Lizards and frogs were not monitored in any 1080 poisoning operations prior to 1994; however, none have been reported killed by 1080. There has been limited

population monitoring of aerial poisoning operations using cereal pellets but none using carrot baits.

The attractiveness of non-toxic carrot baits (dyed green and lured with cinnamon) to wild **grand** (*Oligosoma grande*) and **Otago** (*O. otagense*) **skinks** were tested by Marshall and Jewell (2007). The baits were offered in two sizes – small pieces no larger than 6mm and large baits (whole rounds of sliced carrot). Both bait sizes were sampled (licked, nudged or bitten) by both species of skink, with small pieces sampled more often than large baits. While the carrot baits were sampled, none were consumed.

Monitoring of a population of **Archeys frog** (*Leiopelma archeyi*) in the Coromandel Ranges before and following application of 0.15% 1080 Pellets at 5 kg $ha^{-1}$ in 1995, showed no decline in Archeys frog (Perfect 1996). **Hochstetters frogs** (*Leiopelma hochstetteri*) were counted at 3 sites pre- and post- application at 7 kg $ha^{-1}$, 1994 Hunua Ranges. 1 frog found dead immediately following poison operation tested negative for 1080. Fluctuations in frog numbers counts were influenced so strongly by short term environmental effects that any effect of the poison drop could not be detected (McNaughton & Greene 1994).

### Bats

**Short-tailed bat** (*Mystacina tuberculata*) have not been individually monitored when exposed to this method and bait type. Lloyd (1994) offered non-toxic carrot baits to captive bats and hand broadcast baits containing a fluorescent marker throughout an area known to be inhabited by bats and concluded "...short-tailed bats are unlikely to eat carrot or grain-based baits...". However short-tailed bats are possibly vulnerable to secondary poisoning because they are known to feed on arthropods that have been recorded feeding on 1080 baits and residues in these prey can, in theory, be enough to kill a bat (Lloyd & McQueen 2002).

In a study in Rangataua forest where 0.15% 1080 Pellets were aerially broadcast (3 – 5 kg $ha^{-1}$) over "...almost the entire winter range..." of the study animals, a total of 269 short-tailed bats were caught at their roost following poisoning and held for 48 hours to determine mortality or signs of poisoning. All animals survived and showed no signs of 1080 poisoning (Lloyd & McQueen 2000).

### Invertebrates

Invertebrate populations have been monitored in two 1080 aerial poisoning operations using carrot baits. None of these studies suggest significant population effects on any species studied nor is there evidence to suggest poisoned invertebrates are a significant factor in secondary poisoning of other animals.

No impacts on the numbers of ground-dwelling invertebrates caught in pitfall traps up to 1 year following aerial application of carrot bait at 15 kg $ha^{-1}$ at Waihaha Forest in 1994 (Spurr 2000).

Powlesland et al. (2005) monitored invertebrate numbers every second or third month for a year before a 5 kg $ha^{-1}$ 1080 carrot operation, and for two years afterwards. Numbers of tree weta (*Hemideina thoracica*), cave weta (*Pharmacus* sp. and *Isoplectron* sp.), cockroaches, spiders and harvestmen, and leaf-veined

slugs (*Athoracophorus bitentaculatus*) did not decline substantially in refuges in the treatment area relative to those in the non-treatment area immediately after the poison operation. From the results, the authors concluded that aerial 1080 carrot operations are unlikely to have a detrimental effect on invertebrates that occupy cavities above ground.

An extensive study of forest invertebrates found on 1080 baits by Sherley et al. (1999) found that at any time only a small proportion of baits had invertebrates on them, and the few individuals per bait represented a small section of the fauna present in the litter. Each month between June to October 1995 and from April to October 1996, non-toxic carrot baits were sown at 18 kg $ha^{-1}$ and observed for 7-10 days. Fewer invertebrates were found on non-toxic (green dyed, cinnamon lured) carrot baits than non-toxic cereal pellets. The number of invertebrates visiting the carrot baits increased as time progressed, from a low of 7% usage on day one to 17% on day three. There was no evidence that invertebrates found on baits were drawn from further than 20cm around a bait.

*1080 pellets or carrot baits in bait stations*

11 NI brown kiwi were monitored during a 1080 cereal bait station operation in September 2009 in Northland with no deaths being reported (P Graham pers. comm.).

*No Possum® 1080 gel in bait stations*

No information could be found on population effects. However some testing of non-toxic bait has been done with native species. Note that this study presented bait in open dishes rather than bait stations and the behaviour of captive animals is not always typical of those in the wild. There is also some field evidence that some native species (kea, kaka and snails) may feed on this bait.

**Birds**

Captive birds were offered bait on plastic dishes and wild birds were observed interacting with bait placed in bowls on tree mounted platforms and on the ground. None of three **kaka**, 4 **kereru** and 5 **kakariki** in captivity ate any bait. Two **brown kiwi** and 3 weka in captivity ate tiny amounts. A total of 87g of bait was eaten by 6 kea over the 2 days of the captive trial. **Bellbird, fantail, kereru, silvereye** and **tui** observed within 3m of the bait in the field study showed no interest while South Island **robin** investigated the bait briefly. Three **weka** were observed feeding on the bait placed on the ground during the field trial for a total of 16.9 minutes (Morgan 1999).

**Reptiles**

Of the 10 **Common skinks** (*Oligosoma nigriplantare*) offered non-toxic bait in captivity, 2 investigated the bait but none was eaten (Morgan 1999).

**Bats**

Of the 6 **short-tailed bats** (*Mystacina tuberculata*) offered non-toxic bait in captivity, none fed on it (Morgan 1999).

**Invertebrates**

Of the 8 **tree weta** (*Hemideina crassidens*) offered non-toxic bait in captivity, one fed on it briefly. Of the 8 **large land snails** (*Powelliphanta hochstetteri hochstetteri*) offered non-toxic bait in captivity, 3 fed on it. Of the 6 **ground beetles** (*Megadromus bullatus*) offered non-toxic bait in captivity, none fed on it (Morgan 1999).

*Pestoff Professional Possum Paste (0.08% and 0.15%)*

**Birds**

In pen trials at Orana park, Christchurch, kaka, brown kiwi, weka, kea, kereru and kakariki were offered BB13 and BB16 paste for two days. Kaka, brown kiwi, weka and kea all ate appreciable quantities (greater than 5.1 g of at least one of the paste types) (Morgan 1999).

All 14 monitored **NI brown kiwi** (*Apteryx mantelli*) survived exposure to 0.08% paste baits laid in Northland forest in 1995 (Robertson et al. 1999).

**Bats**

Captive short-tailed bats fed on non-toxic paste bait on all three nights that this food was presented. On average 5.73 g of paste was eaten (Morgan 1999).

**Reptiles**

Two out of 8 common skinks (*Leilopisma nigriplantare*) fed on non-toxic paste over two nights during laboratory trials. The total time spent feeding on the paste was 2.8 minutes (Morgan 1999).

**Invertebrates**

One out of 8 giant land snails (*Powelliphanta hochstetteri hochstetteri*) spent a total of 21.5 minutes feeding on non-toxic paste over two nights during laboratory trials. Two out of 10 weta (*Hemideina crassidens*) fed on non-toxic paste for a total of 5.9 minutes (Morgan 1999).

Bark beetles were observed feeding on 1080 paste in bait bags during a possum control operation at Mount Stanley, Nelson Marlborough Conservancy in April 2002. None were found dead (B. Mehrtens pers. comm.)

*10% 1080 Gel*

No information could be found

*Cut apple bait*

No information could be found on population effects. However some testing of non-toxic bait has been done with native species (Thomas et al. 2003). Note that this study presented bait in open dishes rather than bait stations and the behaviour of captive animals is not always typical of those in the wild.

**Birds**

Of 8 kereru offered non-toxic cut apple bait (green dyed, orange lured), none fed on it. The one kaka tested spent over 11 minutes per day on average feeding on the bait. Kakariki, silvereye and weka spent a similar time feeding on the bait. Four kea spent over an hour feeding on the bait. The authors concluded that this bait presented a risk to native birds and should only be used in bait stations (Thomas et al. 2003).

### 3.2.4 What evidence is there to suggest that 1080 use causes or doesn't cause a population decline of native species in aquatic ecosystems?

The effects of 1080 in aquatic ecosystems have not been well studied in New Zealand because the concentrations of 1080 observed in waterways have been negligible (see Section 2.3). Studies of 1080 toxicity to fish (non-native species see Part 4), suggest fish can tolerate concentrations many thousands of times higher than the highest ever recorded in water sampling after aerial poisoning operations.

Lyver et al. (2004) reported that there was no evidence captive longfinned eels would eat 1080 cereal pellets added to their water, nor was there any 1080 detected in eel tissue from water contaminated by baits. In the same study, eels did eat 1080 contaminated possum tissue but none died.

During trials by Suren & Bonnett (2006),1080 was not detected in any koura exposed to water containing 1080. While koura did eat Wanganui #7 baits, none died.

# 4. Effects on Domestic and Feral Animals

There is wide variation between species in their susceptibility to 1080 poisoning. Dogs are especially vulnerable and highly likely to die if they eat 1080 baits or scavenge animals killed by 1080. Larger animals such as cattle need several possum baits to receive a lethal dose but deaths have been reported where animals have access to baits, including those contained in bait stations.

Sub-lethal effects at realistic dose rates have been recorded in sheep and other species, typically affecting the heart. Exposure to prolonged high doses resulted in mild foetal abnormalities in pregnant rats and damaged sperm in male rats but no mutagenic properties were found. No antidote is currently available for 1080 poisoning although veterinary treatment can be successful.

Feral deer population mortality from aerial poisoning operations targeting possums is highly variable and does not appear to be consistently influenced by toxic loading, sowing rate, prefeeding or bait type. Most estimates of deer kill fall between 30 and 60%. Nugent et al. (2001) quote productivity figures for red deer populations of around 30% so low to moderate by-kill of deer populations is probably negated within a couple of years.

Birds are generally less susceptible to 1080 than mammals but introduced birds such as blackbirds and chaffinches are found dead after aerial poisoning operations. Lizards and fish appear quite tolerant of 1080, according to research on overseas species.

Although 1080 is toxic to bees, baits used in pest control are generally not attractive to bees. However this may not always be the case if bees are particularly hungry, so beekeepers should always be notified of operations.

## 4.1 Toxicity

### 4.1.1 What is the lethal dose range for each taxon?

The $LD_{50}$ values for a range of domestic and feral animals are presented in Table 26. For completeness it includes information on species not present in New Zealand.

While no $LD_{50}$ data is available, mortality rates of pregnant ewes exposed to 1080 are higher compared to non-pregnant ewes (O'Connor et al. 1999)

TABLE 26. ACUTE ORAL TOXICITY ($LD_{50}$ mg $kg^{-1}$) OF 1080 FOR NON TARGET DOMESTIC AND FERAL ANIMALS.

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | REF. |
|---|---|---|
| **Birds** | Range: 2.1 - 12.6 | |
| Mallard duck (*Anas platyrhynchos*) | 4.8 | 1 |
| Pacific black duck (*Anas superciliosa*) | 10.0 | 2 |
| Maned duck (*Chenonetta jubatta*) | 12.6 | 2 |
| Common pigeon (*Columba livia*) | 4.25 | 3 |
| Leghorn hens (*Gallus gallus*) | 10.0 | 4 |
| White leghorn chicken[a] | 7.5 | 5 |
| Rhode Island red chicken | 6.5 | 6 |
| Plymouth rock chicken | 5.5 | 7 |
| Magpie (*Pica pica*) | 2.12 | 8 |
| Chukar partridge (*Alectoris graeca*) | 3.51 | 3 |
| Ring-necked pheasant (*Phasianus colchicus*) | 6.46 | 3 |
| California quail (*Callipepla californica*) | 4.6 | 9 |
| Silvereye (*Zosterops lateralis*) | 9.25 approx | 2 |
| European goldfinch (*Carduelis carduelis*) | 3.5 approx | 2 |
| Australian magpie (*Gymnorhina tibicen*) | 9.9 | 2 |
| House sparrow (*Passer domesticus*) | 2.5 | 10 |
| **Marsupials** | Range: 0.210 - 0.79 | |
| Bennett's wallaby (*Macropus rufogriseus*) | 0.21 | 11 |
| Brush-tailed possum (*Trichosurus vulpecula*) | 0.79 | 12 |
| Dama wallaby (*Macropus eugenii*) | 0.27 | 11 |
| **Mammals** | Range: 0.06 - 8.3 | |
| Dog (*Canis familiaris*) | 0.06 | 7 |
| Cat (*Felis catus*) | 0.28 | 13 |
| Ferret (*Mustela putorious*) | 1.41 | 3 |
| Rabbit (*Oryctolagus cuniculus*) | 0.35 | 14 |
| House mouse (*Mus musculus*) | 8.3 | 15 |
| Rat (wild) (*Rattus norvegicus*) | 0.22-3.0 | 7 |

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | REF. |
|---|---|---|
| Cattle (*Bos taurus*) | 0.393 | 16 |
| Deer (not specified) | 0.5 | 17 |
| Horse (*Equus caballus*) | 0.32-1.00 | 18 |
| Pig (*Sus scrofa*) | 0.4 | 18 |
| Sheep (*Ovis aries*) | 0.25-0.64 | 18 |
| Goat (*Capra capra*) | 0.3-0.7 | 18 |
| **Reptiles/Amphibians** | Range: 43.6 - >500 | |
| Spotted grass frog (*Limnodynastes tasmaniensis*) | 60 | 19 |
| Bullfrog (*Rana catesbeiana*) | 54.4 | 19 |
| Leopard frog (*Rana pipiens*) | 150 | 19 |
| South African clawed frog (*Xenopus laevis*) | >500 | 19 |
| Blue tongued lizard (*Tiliqua nigrolutea*) | 336 | 19 |
| Shingle-back lizard (*Tiliqua rugosa*) | 206[b] | 19 |
| Gould's monitor (*Varanus gouldi*) | 43.6 | 19 |
| **Fish** | Range: 54 - 3500 mg $l^{-1}$ | |
| Bream & bass (Not specified) | > 370[c] | 20 |
| Rainbow trout (*Oncorhynchus mykiss*) | 54 | 21 |
| Fingerling trout | >1000[d] | 17 |
| Harlequin fish (*Rasbara heteromorpha*) | 3500[e] | 22 |
| Bluegill sunfish (*Lepomis macrochirus*) | >970[f] | 21 |
| **Aquatic arthropods** | Range: 0.05 - 3500 mg $l^{-1}$ | |
| Daphnids (*Daphnia magna*) | 350[g] | 21 |
| Mosquito larvae (*Anopheles quadrimaculatus*) | 0.05-0.1 approx | 23 |
| **Terrestrial arthropods** | Range: 8 - 21 | |
| Honeybee (*Apis mellifera*) | 8 | 24 |
| Housefly (Not specified) | 21 | 25 |

[a] laying hens appeared to be more susceptible to 1080 poisoning than hens that were not laying; [b] non-tolerant populations from South Australia, Western Australian populations $LD_{50}$ reported as 525 mg $kg^{-1}$; [c] survived indefinitely at this concentration; [d] survived this concentration; [e] substance tested was Fluoroacetamide (a compound related to 1080); [f] no effects observed at this level; [g] 48-hour $EC_{50}$

1 Hudson et al. (1972); 2 McIlroy (1984); 3 Tucker & Crabtree (1970); 4 Kalmbach (1945); 5 Cottral et al. (1947); 6 Ward & Spencer (1947); 7 Chenoweth (1949); 8 Burns & Connelly (1992); 9 Hudson et al. (1984); 10 Peacock (1964); 11 Munday (1978); 12 Bell (1972); 13 Eason & Frampton (1991); 14 McIlroy (1981); 15 McIlroy (1982); 16 Robison (1970); 17 Rammell & Fleming (1978); 18 Atzert (1971); 19 Eisler (1995); 20 King & Penfound (1946); 21 Fagerstone et al. (1994); 22 Bauermeister et al. (1977); 23 Deonier et al. (1946); 24 Booth & Wickstrom (1999); 25 Matsumura and O'Brien (1963).

### 4.1.2 How much bait needs to be ingested for poisoning, based on pen-trials with non-target feral and domestic species?

The amount of bait needed to be ingested by non-target domestic animals for poisoning is presented in Table 27 and for feral animals in Table 28.

*Fish*

No information relating to bait intake (oral $LD_{50}$ values) could be found. Force-feeding cereal pellets containing approximately 4 mg of 1080 to two fingerling trout and five adult trout, and about 8 mg of 1080 to two adult trout had no visible effect (Rammell & Fleming 1978).

All toxicity values for fish reflect concentration of 1080 in water ($LC_{50}$ values) which is more relevant when assessing likely risks to fish from possum baits. To achieve the 96 hour $LC_{50}$ of 54 mg $l^{-1}$ for rainbow trout, all the 1080 in 3.6kgs of 1.5 g 1080 $kg^{-1}$ bait would have to leach out of the bait, and then remain in 100 litres of still water, without breaking down, for 96 hours. This is highly unlikely to occur in under pest control conditions in New Zealand.

TABLE 27. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON $LD_{50}$ FOR NON TARGET DOMESTIC ANIMALS.

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT FEMALE (g) | AMOUNT OF 0.4g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.8g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 2.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 50g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 100g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|---|---|---|---|---|
| **Birds** | | | | | | | | | |
| Chicken (*Gallus gallus*) | 7.5 | 900 | 16.88 | 8.44 | 6.75 | 4.50 | 3.38 | 0.13 | 0.08 |
| **Mammals** | | | | | | | | | |
| Cat (*Felis catus*) | 0.28 | 2500 | 1.75 | 0.88 | 0.70 | 0.47 | 0.35 | 0.01 | 0.001 |
| Cattle (*Bos Taurus*) | 0.393 | 170000 | 167.03 | 83.51 | 66.81 | 44.54 | 33.41 | 1.34 | 0.67 |
| Red Deer | 0.5 | 80000 | 100.00 | 50.00 | 40.00 | 26.67 | 20.00 | 0.80 | 0.40 |
| Dog (*Canis familiaris*) | 0.06 | 8000 | 1.20 | 0.60 | 0.48 | 0.32 | 0.24 | 0.01 | 0.005 |
| Goat (*Capra capra*) | 0.3 | 35000 | 26.25 | 13.13 | 10.5 | 7.00 | 5.25 | 0.21 | 0.11 |
| Horse (*Equus caballus*) | 0.32 | 190000 | 152.00 | 76.00 | 60.80 | 40.53 | 30.40 | 1.22 | 0.61 |
| Pig (*Sus scrofa*) | 0.4 | 120000 | 120.00 | 60.00 | 48.00 | 32.00 | 24.00 | 0.92 | 0.48 |
| Sheep (*Ovis aries*) | 0.25 | 50000 | 31.25 | 15.63 | 12.50 | 8.33 | 6.25 | 0.25 | 0.13 |
| **Invertebrates** | | | | | | | | | |
| Honeybee (*Apis mellifera*) | 8 | 0.1 | 0.002 | 0.001 | 0.0008 | 0.0005 | 0.0004 | 0.00002 | 0.000008 |

The $LD_{50}$ values given in section 4.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

TABLE 28. AMOUNT OF BAIT NEEDED TO BE INGESTED TO RESULT IN DEATH BASED ON $LD_{50}$ FOR NON TARGET FERAL ANIMALS.

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT FEMALE (g) | AMOUNT OF 0.4g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.8g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 2.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 50g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 100g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|---|---|---|---|---|
| **Birds** | | | | | | | | | |
| Mallard duck (*Anas platyrhynchos*) | 4.8 | 1100 | 13.20 | 6.60 | 5.28 | 3.52 | 2.64 | 0.11 | 0.05 |
| Goldfinch (*Carduelis carduelis*) | 3.5 | 15 | 0.13 | 0.07 | 0.05 | 0.04 | 0.03 | 0.001 | 0.0005 |
| Australian magpie (*Gymnorhina tibicen*) | 9.9 | 350 | 8.66 | 4.33 | 3.47 | 2.31 | 1.73 | 0.07 | 0.03 |
| Chukar partridge (*Alectoris graeca*) | 3.51 | 500 | 4.39 | 2.19 | 1.76 | 1.17 | 0.88 | 0.04 | 0.02 |
| Common pigeon (*Columba livia*) | 4.25 | 400 | 4.25 | 2.13 | 1.70 | 1.13 | 0.85 | 0.03 | 0.02 |
| Pheasant (*Phasianus colchicus*) | 6.46 | 1200 | 19.38 | 9.69 | 7.75 | 5.17 | 3.88 | 0.16 | 0.08 |
| California quail (*Callipepla californica*) | 4.6 | 180 | 2.07 | 1.04 | 0.83 | 0.55 | 0.41 | 0.02 | 0.01 |
| House sparrow (*Passer domesticus*) | 2.5 | 30 | 0.19 | 0.09 | 0.08 | 0.05 | 0.04 | 0.002 | 0.0008 |

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT FEMALE (g) | AMOUNT OF 0.4g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.8g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 2.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 50g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 100g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|---|---|---|---|---|
| **Marsupials** | | | | | | | | | |
| Brush-tailed possum (*Trichosurus vulpecula*) | 0.8 | 3000 | 6.00 | 3.00 | 2.40 | 1.60 | 1.20 | 0.05 | 0.02 |
| Bennett's wallaby (*Macropus rufogriseus*) | 0.21 | 10000 | 5.25 | 2.63 | 2.10 | 1.40 | 1.05 | 0.04 | 0.02 |
| Dama wallaby (*Macropus eugenii*) | 0.27 | 3700 | 2.50 | 1.25 | 1.00 | 0.67 | 0.50 | 0.02 | 0.01 |
| **Mammals** | | | | | | | | | |
| Red Deer | 0.5 | 80000 | 100.00 | 50.00 | 40.00 | 26.67 | 20.00 | 0.80 | 0.40 |
| Ferret (*Mustela putorious*) | 1.41 | 650 | 2.29 | 1.15 | 0.92 | 0.61 | 0.46 | 0.02 | 0.01 |
| Goat (*Capra capra*) | 0.3 | 35,000 | 26.25 | 13.13 | 10.50 | 7.00 | 5.25 | 0.21 | 0.11 |
| Mouse (*Mus musculus*) | 8.3 | 20 | 0.42 | 0.21 | 0.17 | 0.11 | 0.08 | 0.003 | 0.002 |
| Pig (*Sus scrofa*) | 0.4 | 120,000 | 120.00 | 60.00 | 48.00 | 32.00 | 24.00 | 0.92 | 0.48 |
| Rabbit (*Oryctolagus cuniculus*) | 0.35 | 800 | 0.70 | 0.35 | 0.28 | 0.19 | 0.14 | 0.01 | 0.003 |

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT FEMALE (g) | AMOUNT OF 0.4g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.8g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 2.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 50g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 100g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|---|---|---|---|---|
| Rat (wild) (*Rattus norvegicus*) | 0.22 | 220 | 0.12 | 0.06 | 0.05 | 0.03 | 0.02 | 0.001 | 0.0004 |

The $LD_{50}$ values given in section 4.1.1 have been used in the calculations and the average weights of females have been used, as females are generally smaller and therefore a 'worst case scenario' for poisoning. Where LD values were cited as greater (>) or less (<) than a value, this value was used to make the calculations.

### 4.1.3 Based on the mode of action, are there any taxa that are unlikely to be affected by 1080?

No, all species appear to be susceptible to the mode of action of 1080. However, there is a wide variance in dose rates required to produce observable effects. This means the degree of exposure is important in assessing risk.

### 4.1.4 Have sub-lethal effects on birds, mammals, marsupials, reptiles/amphibians, fish, arthropods, or molluscs been described for 1080?

*Domestic animals*

Even small doses of monofluoroacetate result in myocardial damage in sheep, and this damage is cumulative with subsequent exposure (Annison et al. 1960). In sheep that received multiple sub-lethal doses of 1080, myocardial degeneration has been reported as well as necrosis of individual or small groups of myocardial fibres (Schultz et al. 1982). Researchers in Australia noted macroscopic lesions in the heart of sheep, described as acute multifocal injury to the myocardium, after doses as low as 0.11 mg $kg^{-1}$ $day^{-1}$ for 3–7 days. A dose of 0.1 mg $kg^{-1}$ is approximately equivalent to a 30-kg sheep eating one 4 g 0.08% 1080 possum bait. Mild cardiac histopathology at doses of 0.055 mg $kg^{-1}$ $day^{-1}$ has been reported, but the duration of treatment was not specified (Whittem & Murray 1963).

O'Connor et al. (1999) orally administered groups of pregnant ewes with either single (0.25 mg $kg^{-1}$), or multiple (0.05 mg $kg^{-1}$ over 3 consecutive days) doses of 1080 approximately two weeks prior to lambing as part of a trial on the toxicity of 1080 to pregnant ewes. The surviving ewes and their lambs were followed through to weaning. There were no differences in the ewe health, lambing percentages, lamb survival, or lamb growth rates between either of the 1080-dosed groups and a control (0 mg 1080 $kg^{-1}$) group.

In a study of the long-term effects of 1080 in sheep, 21 ewes that survived acute 1080 poison and a control group of 23 animals were monitored for two years (Gooneratne et al. 2008). No adverse effects on general health or condition were observed in any of the animals. There was no increase in the incidence of infectious or metabolic diseases in the 1080-exposed animals compared to the control group. The ewes were mated in both years. There was no difference in lambing percentage, lamb survival or mean lamb birth mass between the groups in either year. At the end of the study 10 ewes from each group were euthanased and post-mortemed. Tissue samples of the heart, brain, kidney, liver, lung, skeletal muscle rumen, abomasums, duodenum and ovaries were collected for histopathology. There were no grossly visible pathological lesions in the 1080-exposed ewes. Histopathological lesions were restricted to the heart and brain. There were scattered foci of fibrous tissue in the muscle of the heart. One animal had small, focal lesions in several regions of the brain, indicating chronic neuronal degeneration. The significance of the heart and brain lesions is uncertain in light of the lack of apparent adverse effects on general health and reproductive performance.

Glial cells in the brain are particularly sensitive to fluorocitrate (Erlichman et al. 1998; Hulsmann et al. 2000).

*Feral animals*

The results from three different, complementary tests (using laboratory rats and mice) indicate that 1080 is not mutagenic, and therefore unlikely to cause cancer. A developmental toxicity study in rats indicated that 1080 causes developmental defects in rats when pregnant females are exposed to relatively high doses (0.33 and 0.75 mg $kg^{-1}$) on a daily basis during the period of organogenesis (from days 6 through to 17 of gestation). The developmental abnormalities observed were mild skeletal effects: slightly curved forelimbs, and bent or 'wavy' ribs (Eason et al. 1999).

Spielman et al. (1973) reported that 1080 at a dose just below the maternal $LD_{50}$ was not teratogenic to **rats** (*Rattus norvegicus*). The embryos in this study showed no macroscopic or skeletal abnormalities. This work involved only a single dose and the results contrast with Eason et al.'s (1999) investigation which followed current international guidelines that require dosing rats from day 6–17 of gestation at three dose levels. Eason et al.(1999) found the NOEL derived from their multi-dose study (0.1 mg $kg^{-1}$ $day^{-1}$) was 10-fold less than the single dose NOEL (1 mg $kg^{-1}$) reported by Spielman et al. (1973).

Reduced testes weight, atrophy of seminferous tubules and damaged spermatids has been reported in **rats** (Smith et al. 1977; Sullivan et al. 1979; Shinoda et al. 2000). Wolfe (1998) reported an increased heart weight in rats of both sexes, and decreased weight of testes/epididymides and abnormal sperm formation in male rats.

In the most recent exposure study in rats (Eason & Turck 2002), the NOEL for rats administered 1080 via oral gavarge for 90 days was 0.075 mg $kg^{-1}$ $day^{-1}$. This study confirmed that the epididymides, testes and heart are the target organs for 1080 sub-lethal effects, with severe hypospermia, severe degeneration of the seminiferous tubulies and cardiomyopathy seen at doses of 0.25 mg $kg^{-1}$ $day^{-1}$.

Decreased body weight and food consumption in **mink** (*Mustela vison*) and **ferrets** (*Mustela putorius furo*), and impaired reproduction in mink has been reported following sub-lethal 1080 poisoning (Hornshaw et al. 1986).

In pen trials 1080 caused damage to the wing muscle in **mallard ducks** (*Anas platyrynchos*) (Ataria et al. 2000) and reduced testes weight in **starlings** (*Sturnus vulgaris*) (Balcomb et al. 1983).

An Australian study of the sub-lethal effects of 1080 on the **shingleback blue tongued lizard** (*Tiliqua rugosa*), a decrease in plasma testosterone concentration in the study animals was reported and there was a suggestion of degeneration of seminiferous tubules in some individuals (Twigg et al. 1988).

Smith & Grosch (1976) studied the effects of 1080 on Bracon hebetor, a **parasitoid wasp** found in North America. They found egg production was disrupted after a sub-lethal dose. Inhibition of reproduction in a **nematode** species (Middendorf & Dusenbery 1993) Metabolism and movement inhibited in Haemonchus **worms** (Ward & Huskisson 1978).

Note: The information in this section includes studies with species not extant in New Zealand

## 4.2 Exposure

### 4.2.1 What species (individual animals) have been reported as non-target deaths in field operations with 1080?

Aerial and hand laid operations using 0.15% or 0.08% 1080 Pellets

A number of domestic and feral non-target deaths have been reported after 1080 cereal pellets have been applied aerially (Table 29). In 2007 during aerial AHB 1080 operations horses and farmed deer were killed.

TABLE 29. FERAL AND DOMESTIC NON-TARGET ANIMAL DEATHS REPORTED DURING AERIAL & HANDLAID OPERATIONS USING 0.15% OR 0.08% 1080 PELLETS.

| SPECIES | TOTAL FOUND DEAD | No. OF OPERATIONS | No. OF CASES WHERE RESIDUES CONFIRMED | SOWING RATE (kg ha$^{-1}$) | REF. |
|---|---|---|---|---|---|
| **Domestic animals** | | | | | |
| Dog (*Canis familiaris*) | 5 | 3 | 5 | | 1 |
| Cat (*Felis catus*) | 1 | 1 | 1 | | 2 |
| Cattle (*Bos Taurus*) | 2 | 2 | 2 | | 3 |
| Pig (*Sus scrofa*) | 1 | 1 | 1 | | 4 |
| **Feral animals** | | | | | |
| Deer (*Cervus elephus*) | 2 | 2 | 2 | | 5 |
| **Introduced birds** | | | | | |
| Blackbird (*Turdus merula*) | 5 | 3 | 5 | 3-7 | 6 |
| Chaffinch (*Fringilla coelebs*) | 5 | 2 | 5 | 3 | 7 |

These animals were found dead or assumed to have been lethally poisoned from the presence of 1080 residues. Reports of animals killed which were not tested for residues have been omitted. The information has been restricted to those operations where the basic performance standards could be verified. Target pests have been excluded from the data.

Blackbirds and chaffinches are commonly found dead after operations but not tested. One starling found dead near a 1080 storage area and tested negative for 1080 residues has been omitted

1. VPRD: T0891; T1694; T1720 & T1657; 2 VPRD: T0971; 3 VPRD: 170 & T1693; 4 VPRD: T0517; 5 VPRD: T1407; 6 VPRD: T1809 & T0422; 7 VPRD: T1809 & T2068.

A **red deer** (*Cervus elephus*) kill of 43% was reported following application at 10 kg $ha^{-1}$, July 1988 at North Pureora. Simultaneous carcass searches over the poisoned area confirmed the pellet-count result (Nugent et al. 2001). A red deer kill of 54% was reported following application at 3 kg $ha^{-1}$ June 1999 in the Orongorongo Valley (Nugent et al. 2001). A red deer kill of 5% was reported following application at 3 kg $ha^{-1}$ overall but sown in strips of 25 kg $ha^{-1}$, with pre-feeding June 1999 at Wainuiomata Valley (Nugent et al. 2001).

**Fallow deer** (*Dama dama*) were monitored during an aerial 1080 operation in the Blue Mountains using 0.15% 1080 Pellets at 2 kg $ha^{-1}$ 12 days after prefeeding with non-toxic bait. All three radio tagged deer were killed and estimates using a range of data available (carcass searches, deer sightings and hunter kill records) led the authors to conclude a best guess kill of 67-75% (Nugent & Yockney 2001).

During an aerial 1080 operation in Rotoehu Forest in October 2004, Fish and Game staff monitored **pheasant** crowing rates using five minute counts in treated and untreated blocks. There was a healthy population throughout the forest and there was no discernable difference in the crowing rates between the blocks following the 1080 operation (McDougall 2005).

**Honey bees** from hives located near the loading zone were observed during one operation to be gathering the green dust from toxic RS5 cereal baits. This loading zone had been used on previous occasions for aerial 1080 operations using the same bait type and no similar observations were made (N. Murray pers. comm.). AHB (2012) conducted trials to investigate the attractiveness of RS5 and Wanganui #7 pellets to bee. Bees were trained to visit wet and dry cereal baits coated with a sugar-syrup attractant. The attractiveness of the baits was determined by swirching the sugar-coated bait with standard non-toxic baits. Within 10 minutes, the bees lost interest in the standard baits. When EDR coated pellets were used, bees continued to visit the baits for approximately 30 minutes after the sugar-coated baits had been switched with the EDR coated pellets. When 1080 cereal pellets were placed within 80 metres of hives, no bees were observed visiting or landing on the baits. To test the risk of dust to honey bees, six hives were put out during an actual 1080 operation at Buller South. 1080 was not detected in bees, wax, nectar or pollen samples collected within 24 hours of the operation or when the monitoring was repeated after 15 – 16 days. Additionally, there was no evidence of 1080 dust on flowers on which bees were observed foraging (AHB 2012).

*Aerial and hand laid operations using 0.15% or 0.08% 1080 carrot baits*

A number of domestic and feral non-target deaths have been reported after 1080 carrot baits have been applied aerially (Table 30).

**TABLE 30.** FERAL AND DOMESTIC NON-TARGET ANIMAL DEATHS REPORTED DURING AERIAL & HANDLAID OPERATIONS USING 0.15% OR 0.08% CARROT BAITS.

| SPECIES | TOTAL FOUND DEAD | No. OF OPERATIONS | No. OF CASES WHERE RESIDUES CONFIRMED | SOWING RATE (kg ha$^{-1}$) | REF. |
|---|---|---|---|---|---|
| **Domestic animals** | | | | | |
| Sheep (*Ovis aries*) | 1? | 1 | 1 | | 1 |
| Feral animals | | | | | |
| Red deer (*Cervus elephus*) | 4 | 1 | 4 | 5 | 2 |
| Sika deer (*Cervus nippon*) | 5 | 1[a] | 5 | 5 | 3 |
| **Introduced birds** | | | | | |
| Blackbird (*Turdus merula*) | 1 | 1 | 1 | 5 | 2 |
| Chaffinch (*Fringilla coelebs*) | 1 | 1 | 1 | | 4 |
| Hedge sparrow | 1 | 1 | 1 | | 4 |

[a] In this operation the carrot baits were coated with deer repellent.

These animals were found dead or assumed to have been lethally poisoned from the presence of 1080 residues. Reports of animals killed which were not tested for residues have been omitted. The information has been restricted to those operations where the basic performance standards could be verified. Target pests have been excluded from the data.

Blackbirds and chaffinches are commonly found dead after operations but not tested.

1 VPRD: 050; 2 Nugent et al. (2004); 3 Speedy (2003); 4 VPRD: T1195; Pestlink: 0304RAN08

A study of **red deer** mortality during 1080 carrot operations (0.15%) in Pureora in 1994 resulted in kills of 30% and 31% following application at 15 kg ha$^{-1}$, with non-toxic pre-feeding, and 42% where no prefeed was used (Fraser et al. 1995). Deer faecal pellet densities in this study area declined by about 40% 15 months after poisoning but returned to pre-control levels a year later, and then apparently doubled over the ensuing two years (Coleman et al. 2000).

A **red deer** kill of 57% was reported following application of 0.09% toxic loading, with pre-feeding at 15 kg ha$^{-1}$, May 1996 at North Pureora (Sweetapple & Fraser

1997). A red deer kill of 93% was reported following application in August 1997 of 0.08% carrot bait and at 15 kg $ha^{-1}$, with pre-feeding at Titiraupenga. In the same study using 0.15% bait at 15 kg $ha^{-1}$ (prefed) the reported kill was 92% (Fraser & Sweetapple 2000).

During an aerial 1080 operation in Rotoehu Forest in October 2004, Fish and Game staff monitored **pheasant** crowing rates using five minute counts in treated and untreated blocks. There was a healthy population throughout the forest and there was no discernable difference in the crowing rates between the blocks following the 1080 operation (McDougall 2005).

*Aerial and handlaying operations using 0.02% 1080 carrot baits*

Evans & Soulsby (1993) recorded 27 **California Quail** dying during three 1080 carrot rabbit control operations between 1985 and 1991. In all three operations, the deaths could be attributed to 1080 either through residue testing or observing carrot in the crop. The authors also reported **Chukar** being found dead following two other rabbit control operations using carrot.

During an aerial 1080 rabbit control operation on Dovedale Station, Central Otago in August 1993, five **California quail** coveys were monitored inside (treatment coveys) and a further two outside (non-treatment coveys) the operational area. The operational area received two prefeeds of unscreened carrot bait 7 days apart. Seven days later unscreened green dyed toxic bait was applied at a rate of 25 kg $ha^{-1}$. California quail survived inside the operational area in significant numbers. Following the operation, of the coveys inside the operational area, quail numbers remaining the same in two and dropped in one. The other two coveys in the treatment are could not be located. One non-treatment covey's numbers remained the same and the other one appeared to break up for breeding. Insufficient information was obtained to determine whether the change in covey sizes were as a result of non-location, breeding dispersal, emigration or poisoning (Evans & Soulsby 1993).

*Aerial and handlaid operations using 0.04% 1080 oat baits*

Four California quail deaths were reported during two rabbit control operations using 1080 oat in the 1980-90's (Evans & Soulsby 1993).

*Bait station operations using 0.15% or 0.08% 1080 Pellets*

Domestic and feral non-target deaths reported after the use of 1080 cereal pellets in bait stations are reported in Table 31.

TABLE 31. FERAL AND DOMESTIC NON-TARGET ANIMAL DEATHS REPORTED DURING BAIT STATION OPERATIONS USING 0.15% 1080 PELLETS.

| SPECIES | TOTAL FOUND DEAD | No. OF OPERATIONS INVOLVED | No. OF CASES WHERE RESIDUES CONFIRMED | SOWING RATE (kg ha$^{-1}$) | REF. |
|---|---|---|---|---|---|
| **Domestic animals** | | | | | |
| Dog | 2 | 1 | 1 | | 1; 2 |
| Cattle | 16 | 1 | 2 | | 3 |

1 VPRD: 6461-1; 2 Pestlink: 0405WNG12; 3 VPRD: T2109.

*Pestoff Professional 1080 Possum Paste (0.08 & 0.15%)*

Honey bees were known to be attracted to 1080 paste baits (sometimes referred to as jam baits) used in pest control prior to 1995. Changes in formulation of 'Pestoff Professional' possum paste since then have been found to be unattractive to bees (Morgan 2000).

*No Possums® gel block bait*

Honey bees offered this bait near their hive appeared to be unable to penetrate the firm gel matrix with their proboscis and were seldom observed on the bait compared with control baits offered (Morgan 1999).

*Cut apple bait*

Honey bees offered this bait near their hive were seldom observed on the bait compared with control baits offered (Thomas et al. 2003).

### 4.2.2 For which species have residues of this pesticide been detected following 1080 operations?

The information in this section includes the results of laboratory analysis from live animals captured or killed for sampling from treatment areas. Residues from animals found dead are presented in section 4.2.1 above.

*Aerially applied 0.15% 1080 Pellets*

Samples taken by a vet from a sick dog following application at 5 kg ha$^{-1}$ June 1999 Nelson/Marlborough Takaka had 1.07 mg kg$^{-1}$ 1080 in its vomit, 0.44 mg kg$^{-1}$ 1080 in its intestine and 0.3 mg kg$^{-1}$ 1080 in its stomach (VPRD T0891).

*0.15% 1080 Pellets in bait stations*

Muscle samples from 8 trout had no detectable 1080 following application in bait stations at 100g/station, approximately 1 station/ha, October 1997, Lake Rotoiti (VPRD T0543, T0642).

## 4.3 Treatment

### 4.3.1 Is there an effective treatment of 1080 poisoning that is practical to administer?

No antidotes for 1080 poisoning are currently available but research is continuing (Ataria et al. 1995; Cook et al. 2001).

# 5. Human Health

The estimated lethal dose of 1080 in humans lies in the range of 0.7 and 10.0 mg $kg^{-1}$. Sodium monofluoroacetate (1080) is absorbed through the gastrointestinal tract or via the lungs if inhaled. Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions. The onset clinical signs usually range from 30 minutes to about 2-3 hours. Signs of poisoning include nausea, vomiting, and abdominal pain initially, followed by respiratory distress, anxiety, agitation, muscle spasms, stupor, seizures, and coma.

1080 is not a mutagen and is unlikely to be a carcinogen. It has sub-lethal effects on reproduction and is classified as a teratogen.

There is no effective antidote for 1080 poisoning in humans and any treatment given is largely symptomatic and supportive.

## 5.1 Toxicity

### 5.1.1 What is the oral $LD_{50}$ (mg $kg^{-1}$ bw)?

The oral $LD_{50}$ for humans has been estimated as being between 0.7 and 10.0 mg $kg^{-1}$ (Chenoweth 1949; Kaye 1970; Eisler 1995). 2.5 mg $kg^{-1}$ is used a working $LD_{50}$ for all the calculations in this review.

### 5.1.2 How much bait would children and adults need to ingest for poisoning?

The information on bait consumption required for poisoning is presented in Table 32.

TABLE 32. AMOUNT OF 1080 BAIT NEEDED TO BE INGESTED BY A HUMAN TO RESULT IN DEATH BASED ON THE $LD_{50}$.

| | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT (kg) | AMOUNT OF 0.8 g $kg^{-1}$ 1080 BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5 g $kg^{-1}$ 1080 BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|
| Child | 2.5 | 15 | 46.9 | 25 |
| Adolescent | 2.5 | 30 | 93.8 | 50 |
| Small adult | 2.5 | 60 | 187.5 | 100 |
| Large adult | 2.5 | 90 | 281.3 | 150 |

These figures represent the amount of bait that would have to be consumed in one sitting for a 50% chance of death. This is a straightforward acute toxicity calculation without any “safety factors’ that are used to extrapolate the results of animal studies to humans.

### 5.1.3 What is the dermal $LD_{50}$ (mg $kg^{-1}$ bw)?

Monofluoroacetate is not readily absorbed through intact skin, but it can be absorbed more readily through cuts and abrasions. Fagerstone et al. (1994) estimated the dermal $LD_{50}$ at 300 mg $kg^{-1}$. Exposure guidelines (Threshold Limit Values, TLV) for 1080 have been set in USA, with a Time-weighted average (TLV-TWA) of 0.05 mg/$m^3$ for skin exposure (Anon. 1991). In New Zealand the Occupational Health and Safety Service (OSH) has set a Biological Exposure Index (BEI) of 15 μg $l^{-1}$ (0.015 ppm) for 1080 in human urine (Occupational Safety and Health Service 2002).

### 5.1.4 Where the pesticide involves a gaseous form, what is the gaseous $LC_{50}$ (ppm in air)?

This is not applicable for 1080.

### 5.1.5 Where there is dust or mist associated 1080 use, what is the dust and mist $LC_{50}$ (ppm in air)?

There is no published information on the $LC_{50}$ for 1080 in dust or mist. A Biological Exposure Index (BEI) of 15 μg $l^{-1}$ (0.015 ppm) for 1080 has been set by Occupational Health and Safety Service (OSH) New Zealand (Occupational Safety and Health Service 2002).

### 5.1.6 Is there evidence that 1080 may have mutagenic and/or carcinogenic properties? If known, what are the LOEL or NOEL values?

Three different complementary tests indicate that 1080 is not a mutagen and is therefore unlikely to be a carcinogen (Eason et al. 1999).

### 5.1.7 Is there evidence that 1080 may have sub-lethal effects on reproduction or lactation, or is classified as a teratogen? If known, what are the LOEL or NOEL values for these reproductive and developmental effects?

1080 has sub-lethal effects on reproduction and is classified as a teratogen (de Meyer & de Plaen 1964; Spielmann et al. 1973).

It is a male reproductive toxicant with effects on testes of mammals (Wolfe 1998; Shinoda et al. 2000; Eason & Turck 2002). Wolfe (1998) reported a decreased weight of testes and epididymides, and abnormal sperm formation in male rats. In a 90 day toxicology study of 1080, Eason & Turck (2002) reported hypospermia in the epididymides and degeneration of the seminiferous tubules of the testes of male rats dosed with 1080 at 0.25 mg $kg^{-1}$ $day^{-1}$. The NOEL for rats administered 1080 via oral gavage for 90 days was 0.075 mg $kg^{-1}$ $day^{-1}$.

Neither 1080 nor its active metabolite fluorocitrate bound to human androgen or alpha oestrogen receptors during in vitro assays (Tremblay et al. 2005). 1080 and fluorocitrate did not bind to sheep oestrogen receptors either (Tremblay et al. 2004). Therefore, while 1080 is a male reproductive toxicant, it is not considered an endocrine disruptor.

Sub-lethal doses of 1080 to pregnant rats alters skeletal development of rat foetuses (Eason et al. 1997; 1999). Teratogenic effects have been reported at 0.75 mg $kg^{-1}$ $day^{-1}$ (Eason et al. 1999) and the developmental NOEL is 0.1 mg $kg^{-1}$ $day^{-1}$.

### 5.1.8 Is there evidence that 1080 may have sub-lethal effects on target organs? If known, what are the LOEL or NOEL values for these effects?

Sub-lethal effects on target organs have been reported. Small testes and epididymis in male rats were observed following doses of 1080 at 0.25 mg $kg^{-1}$ $day^{-1}$, and these observations were corroborated by a reduction in the weight of the testes. 1080-related increases in heart weight were noted in both males and females at 0.25 mg $kg^{-1}$ $day^{-1}$ when compared with controls. The NOEL for rats administered 1080 via oral gavage for 90 days was 0.075 mg $kg^{-1}$ $day^{-1}$ (Eason & Turck 2002).

Changes in testes in male rats and in heart weights in both sexes of rats were reported by Wolfe (1998). Based on these findings the NOEL for sodium fluoroacetate, when given orally to Sprague-Dawley rats for 13 weeks, was 0.05 mg $kg^{-1}$ $day^{-1}$ (Wolfe 1998).

### 5.1.9 How rapid is the onset of toxicity for 1080 in humans?

The onset clinical signs usually ranges from 30 minutes to about 2-3 hours (Eason & Wickstrom 2001), however, in one case of acute poisoning, onset of symptoms was described as within minutes (Williams 1948). Relatively few cases of human poisoning (accidental or deliberate) have been reported in the literature (22 cases, 16 of which were fatal) (Harrison et al. 1952; Brockmann et al. 1955; Trabes et al. 1983; Ellenhorn & Barceloux 1988; Anon. 1992).

Poisoning symptoms experienced include nausea, vomiting, and abdominal pain initially, followed by respiratory distress, anxiety, agitation, muscle spasms, stupor, seizures, and coma. Hypotension is thought to be one of the more important predictors of mortality in 1080 intoxication (Chi et al. 1996; Chi et al. 1999).

## 5.2 Treatment

### 5.2.1 Is there an effective treatment or antidote for 1080 poisoning in humans?

There is no effective antidote for 1080 poisoning in humans. Treatment is largely symptomatic and supportive, with special attention focused on stabilising cardiac and central nervous system functions (Goncharov et al. 2006). The success of the treatment is likely to depend on whether the dose was acute or sub-lethal.

There is ongoing research into antidotes for 1080 (e.g. Goncharov et al. 2006).

# 6. Operational

1080 is considered to have medium humaneness for possums, however there has been little formal research into the humaneness of 1080 on other target species. Most deaths of pest species occur 8 – 48 hours after ingestion of a lethal dose.

All the registered target species have relatively high susceptibility to 1080. The short latent period means that bait shyness can develop in animals receiving a sub-lethal dose. Mice exhibit a marked avoidance of 1080 which is likely to result in control operation failures.

The majority of pest control operations using 1080 have target pest kills of greater than 80%.

## 6.1 Animal Welfare

### 6.1.2 What are the animal welfare impacts of 1080 on the target pest?

1080 toxicosis generally has a characteristic 'lag time' in mammalian species, where following intake of a lethal dose, the animal will show no visible signs of poisoning for up to a number of hours, before beginning to display symptoms (Eason & Wickstrom 2001). The onset clinical signs usually ranges from 30 minutes to about 2 - 3 hours with most deaths in mammals generally occurring 8 – 48 hours after ingestion of a lethal dose (Eason & Wickstrom 2001).

***Possums***

Littin et al. (2009) reported that the onset of symptoms in eight unhandled lethally dosed possums occurred at 1 hour 50 minutes (±0:09 s.e.m) with animals exhibiting abnormal appearances and postures. Seven of the animals showed retching, and three vomited starting at 2 hours 53 minutes. Lack of coordination began at 3 hours 37 minutes, after which possums spent most of the time until death lying, showing spasms and tremors. Five of the possums had seizures while lying prostrate. The mean time to death was 11 hours 26 minute (±1:55 s.e.m).

In possums the animal welfare impacts of 1080 is described as intermediate when compared to other vertebrate toxic agents used to kill possums in New Zealand (Littin et al. 2009; MAFBNZ 2010).

***Rodents***

Cook (1998) reported laboratory rats orally dosed with 1080 exhibited hypersensitivity to light and sound, an increased incidence of grooming or scratching of the abdomen, increased cage pacing and increased curled-but-awake posture. Five of the ten rats dosed with 1080 showed convulsive behaviour between 4 to 10 hours after the 1080 was administered.

McIlroy (1982) reported that ship rats exhibited a 0.8 - 27.8 hour latent period and died 2.4 - 36.5 hours after a lethal dose of 1080 was administered. Norway rats had a 0.4 – 2.3 hour latent period and a 2.5 – 112.0 hour time to death. Mice had a 1.3 – 2.8 hour latent period and 2.2 - 68.3 hour time to death. In rats observed syptoms included animals initially appearing depressed, often sitting quietly hunched in a corner or lying on their side, back or stomach with their eyes

partially closed: hypersensitivity to touch or sounds; and uncoordinated movement with unsteady balance. Respiration was initially very rapid, but became slower, shallower and more irregular until death occurred. Convulsions were commonly observed.

In rats the animal welfare impacts of 1080 is described as intermediate when compared to other vertebrate toxic agents used to kill rats in New Zealand (MAFBNZ 2010).

***Cats***

The main poisoning symptoms in cats are lethargy and disorientation, which are unusual for carnivores and more closely resemble those seen in herbivores. Other symptoms include uncoordinated movements and occasional vocalisation (Eason & Frampton 1991). Neurological signs associated with 1080 exposure are generally less severe in cats than in dogs (Eason & Wickstrom 2001). McIlroy reported a latent period of 1.0 - 5.6 hours and time to death between 20.7 - 21.0 hours. In cats the animal welfare impacts of 1080 are described as intermediate when compared to other vertebrate toxic agents (MAFBNZ 2010).

***Rabbits***

In rabbits the animal welfare impacts of 1080 are described as intermediate (MAFBNZ 2010). The onset of symptoms has been reported as ocurring between 1.1 - 10.1 hours after exposure to a lethal dose and death occuring after 3.0 - 44.3 hours (McIlroy 1981). Gooneratne et al. (1994) reported the time to death ranging from 1 to 7.5 hours in rabbits following a lethal dose. Lying prone, lethargy, respiratory distress, sensitivity to noise or disturbance and convulsions have been reported in poisoned rabbits (McIlroy 1981; MAFBNZ 2010).

**Wallabies**

McIlroy (1981) reported symptoms in poisoned wallabies included animals sitting hunched up; generally appearing non-alert, with shivering or shaking forelimbs and unsteady balance; convulsions and a white froth exuded from the mouth and nostrils. The latent period in Bennett's wallabies was <16.9 to 23.2 hours (7 wallbaies observed), and the time to death was 8.9 – 38.9 hours (23 wallabies observed). For dama wallabies the time to death was 13.8 - 37.1 hours. MAFBNZ (2010) describe the overall animal welfare impacts of 1080 on wallabies as intermediate compared to other vertebrate toxic agents.

***Deer***

In general, herbivores experience cardiac failure, whereas carnivores experience central nervous system disturbances and convulsions then die of respiratory failure (Egeheze & Oehme 1979).

Daniel (1966) reported that deer became lethargic and lay down quietly without any of the convulsions or leg-thrashing commonly reported in Canidae. He reported that deer died between 2 and 30 hours after eating a lethal dose.

## 6.2 Efficacy

### 6.2.1 Is 1080 effective on the target pest, based on the $LD_{50}$?

All the registered target species have relatively high susceptibility to 1080. The $LD_{50}$ values are presented in Table 33.

TABLE 33. ACUTE ORAL TOXICITY ($LD_{50}$ mg $kg^{-1}$) OF 1080 TO THE TARGET PESTS.

| TARGET PEST | $LD_{50}$ (mg $kg^{-1}$) | REF. |
|---|---|---|
| Cat *Felis catus* | 0.28 | 1 |
| Deer not specified | 0.50 | 2 |
| Mule deer | 0.27 – 0.90 | 3 |
| House mouse *Mus musculus* | 8.30 | 4 |
| Brush-tailed possum *Trichosurus vulpecula* | 0.79[a] | 5 |
| Rabbit *Oryctolagus cuniculus* | 0.35 | 6 |
| Ship rat *Rattus rattus* | 0.76 | 4 |
| Laboratory rat *Rattus norvegicus* | 1.71 | 4 |
| Norway rat (wild) *Rattus norvegicus* | 0.22-3.0 | 7 |
| Bennett's wallaby *Macropus rufogriseus* | 0.21 | 8 |
| Dama wallaby *Macropus eugenii* | 0.27 | 6; 8 |

[a] Ambient temperature may affect the acute toxicity of 1080 to possums, with increased toxicity at low temperatures (Veltman & Pinder 2001).

1 Eason & Frampton(1991); 2 Rammell & Fleming (1978); 3 Tucker & Crabtree (1970); 4 McIlroy (1982); 5 Bell (1972); 6 McIlroy (1981); 7 Chenoweth (1949); 8 Munday (1978).

### 6.2.2 How much bait does the target pest have to ingest in order to be poisoned, within what timeframe?

Target pests would have to eat at least the amounts given in Table 34 in one feeding session (at least three hours) to be likely to receive an acute lethal dose.

TABLE 34. AMOUNT OF BAIT A TARGET PEST NEEDS TO INGEST TO RESULT IN DEATH BASED ON $LD_{50}$.

| SPECIES | $LD_{50}$ (mg $kg^{-1}$) | AV. WEIGHT FEMALE (g) | AMOUNT OF 0.2g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.4g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.6g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 0.8g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 1.5g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 2.0g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 50g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ | AMOUNT OF 100g $kg^{-1}$ BAIT (g) FOR $LD_{50}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bennetts wallaby | 0.21 | 11000 | | - | | - | - | 1.5 | 1.2 | 0.05 | 0.02 |
| Cat | 0.28 | 2500 | | - | | - | 0.7 | - | - | - | - |
| Dama wallaby | 0.27 | 4300 | | - | | - | - | 0.8 | 0.6 | 0.02 | 0.01 |
| House Mouse | 8.30 | 20 | | | | 0.21 | | 0.1 | | | |
| Norway rat (wild) | 0.22 | 220 | | - | | 0.06 | - | 0.03 | - | - | - |
| Possum | 0.8 | 3000 | | - | 4.0 | 3.0 | - | 1.6 | - | - | - |
| Rabbit | 0.35 | 800 | 1.4 | 0.7 | 0.47 | - | - | - | - | - | - |
| Red deer | 0.5 | 80000 | | - | | - | - | 26.67 | - | - | 0.4 |
| Ship rat | 0.76 | 140 | | | | 0.13 | | 0.07 | - | - | - |

*Palatability*

Palatability of a bait will also influence the whether the target pest will ingest a lethal dose.

**Possums**

For possums, Morgan (2004) reported that under field conditions No Possums® 1080 gel blocks have a 20% decline in palatability after 36.4 months. In the same study, double wax coated 1080 pellets left in Philproof bait stations had a 20% decline in palatability after 4 months.

**Mice**

Wild caught mice demonstrate marked avoidance of baits containing 1080 in pen studies (Morriss et al. 2008; Fisher et al. 2009). In paired choice tests (using toxic pellets and non-toxic rodent pellets), only 8% of mice died when offered 0.15% 1080 baits. Pellet type (Wanganui #7 or RS5), the presence or absence of green dye, the presence or absence of 0.3% cinnamon and bait size (2g and 12g) did not have any effect on the amount of toxic bait eaten by mice (Morriss et al. 2008). In similar paired choice tests, Fisher et al. (2009) reported that mice had a low acceptance of 0.08% and 0.15% 1080 pellets and mortality rates were similar (25%) for both concentrations of 1080. The authors also found that pre-feeding with non-toxic pellets did not improve the acceptance of 0.15% 1080 pellets by mice.

Based on the marked avoidance of 1080 by mice, O'Connor et al. (2005) recommended that 1080 should not be used for mouse control operations until new methods are developed to improve 1080 bait acceptance by mice.

*Other factors*

Parkes (1991) noted that the when 10% 1080 gel with a carbopol carrier was applied to mahoe leaves, the baits had a maximum life of about 60 days because phytotoxicity caused most leaves to absciss within 46 days. When mahoe leaves were smeared with 10% 1080 gel in a petrolatum carrier, the baits could remain effective as baits for at least 110 days, after which time most leaves had abscissed. However, abscissed leaves could remain toxic to animals that eat leaf-fall for at least 300 days.

### 6.2.3 What is the latent period between bait ingestion and onset of symptoms?

The latent period is hours. Possums receiving a sub-lethal dose of 1080 have been known to develop bait shyness (O'Connor & Matthews 1999; Ogilvie et al. 2000) and this can persist for at least three years (O'Connor & Matthews 1999). Conditioned food aversion to diets containing 1080 has been reported in rats (Nachman & Hartley 1975).

Note: A short latent period increases the likelihood of the target pest developing poison shyness.

### 6.2.4 What field evidence is there that this pesticide use causes a population decline of the target pest species at sites where it is used?

**Possums**

*Aerially distributed 1080 cereal pellets*

The percentage kills obtained during aerial operations using 0.08% 1080 cereal pellets are presented in Table 35. For non-prefed aerial operations using 0.08% cereal pellets the mean kill was 69.1% (n=10). The mean kill for prefed aerial operations using 0.08% cereal pellets was 91.1% (n=2).

The percentage kills obtained during aerial operations using 0.15% 1080 cereal pellets are presented in Tables 36. Based on this data, the mean possum kill for prefed operations is 93.2% (n=38), operation where cause of failure known excluded) and for non prefed operations 80.0% (N=21).

TABLE 35. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 0.08% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg $ha^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 100% | Station Creek A Trial, Jul 2006 | - | 5 ( #7 12 g pellets) | 1 |
| 82.2% | Station Creek B Trial, Jul 2006 | 2 (12 g pellets) | 5 (12g #7 pellets, 7 days later) | 1 |
| 0% | Mapara, October 1992 | - | 8 | 2 |
| 89% | Isolated Hill SR Nelson August 1992 | - | 4 | 2 |
| 96% | Titirangi Reserve Wanganui June 1992 | - | 5 | 2 |
| 50% | Puketi Forest Northland March 1992 | - | 5 | 2 |
| 32% | Mapara October 1991 | - | 5 | 2 |
| 91% | Whitecliffs Wanganui July 1991 | - | 6 | 2 |
| 61% | Waipapa EA June 1991 | - | 10 | 2 |
| 79% | Mapara September 1990 | - | 8 | 2 |
| 93% | Rangitoto Island October 1990 | - | 12 | 2 |

1 Josh Kemp per comm.; 2 Spurr (1993)

TABLE 36. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 0.15% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 100% | Blue Mountains, June-July 2008 | 2 (12g #7 baits) | 3 (12g #7 pellets coated with deer repellent, 21 days later) | 1 |
| 91.3% | Manawatu Gorge, 20-25/7/2007 | 2 | 3 (5 days later) | 2 |
| 100% | Parapara 07A Trial, May 2007 | 3 (6g pellets) | 3 (12g RS5 pellets, 25 days later) | 3 |
| 100% | Parapara 07C Trial, May 2007 | - | 3 (12g RS5 pellets) | 3 |
| 100% | Hukarere A May 2007 | 2 (12g pellets) | 2.5 (12g #7 pellets, 25 days later) | 3 |
| 100% | Hukarere B May 2007 | 2 (12g pellets) | 2.5 (12g #7 pellets, orange lure, 25 days later) | 3 |
| 100% | Hukarere C May 2007 | 2 (12g pellets) | 2.5 (6g RS5 pellets, 25 days later) | 3 |
| 87.3% | Thomas River, 12-15/01/2007 | 1 (6g pellets) | 3.5 (12g pellets, 3 days later) | 4 |
| 89.4% | Mataketake, 12-15/01/2007 | 1 (6g pellets) | 3.5 (12g pellets, 3 days later) | 5 |
| 91.1% | Otaki Bio Site, 12/09-14/12/2006 | 2.11 (6g pellets) | 2.11 (6g pellets, 93 days later) | 6 |
| 100% | Otaki Core, 12/09-14/12/2006 | 2.11 (6g pellets) | 2.11 (6g pellets, 93 days later) | 6 |
| 100% | Wangapeka, Oct 2006 | 0.8 (12g pellets) | 5 (12g RS5 pellets, 14 days later) | 3 |
| 81.1% | Hawdon Valley, 12-28/9/2006 | 2 (6g pellets) | 5 (6g pellets, 16 days later) | 7 |
| 89.4% | Poulter Valley,12-28/9/2006 | 2 (6g pellets) | 5 (6g pellets, 14 days later) | 7 |
| 100% | Whenuakite, Aug 2006 | 2 (6g pellets) | 3 (12g #7 pellets, 13 days later) | 3 |
| 100% | Station Creek C Trial, Jul 2006 | 2 (12g pellets) | 5 (12g #7 pellets, 7 days later) | 3 |

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 78.4% | Waiohine/Tauherenikau, 29/08/2005 | - | 3 ( #7 pellets) | 8 |
| 90.2% | Pembroke - Block 1A, 25/01/2005 | - | 3 ( #7 pellets) | 9 |
| 84.6% | Matemateaonga Stage 1, 19/11/04, 11/1/05 | - | 4 ( #7 pellets) | 10 |
| 100% | St Andrews 11/11/2004 – 21/02/2005 | 2 | 3 (#7 pellets, 102 days later) | 11 |
| 85.3% | Waiotauru, 7-8/09/2004 | - | 3 ( #7 pellets) | 12 |
| 75.9% | Mt Karioi, 20/05/2004 – 09/06/2004 | 2 | 4 (12g #7 pellets, 20 days later) | 13 |
| 96.6% | Copeland River, 18-19/10/2003 | 2 | 3 (12g pellets) | 14 |
| 28.1% | Copeland River, 18-19/10/2003 | - | 3 (12 g pellets) | 14 |
| 87.6% | Kahurangi Point, 10/9/2003 | - | 3 (12 g pellets) | 15 |
| 94.7% | Gouland Downs, 29/8/2003 | - | 3 (12 g pellets) | 16 |
| 98% | Hutt River, 28/7/03 | 2 | 2 (12g pellets, 5 days later) | 17 |
| 85.7% | Featherston / Waiorongomai Block 1 retreatment, 02/03 (GWRC op) | 1.5 | 1.5 (10g pellets) | 18 |
| 93% | Mt Pirongia, 27/8/2002 | 2 | 4 (12g pellets) | 19 |
| 100% | Hampden, North Otago, 28/6/2002 | 2 | 2 (12g pellets) | 20 |
| 89.7% | Featherston / Waiorongomai Block 3, Dec 01-Feb 02 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 95.5% | Featherston / Waiorongomai Block 2, Dec 01-Feb 02 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 38.2%[a] | Featherston / Waiorongomai Block 1, Dec 01-Feb 02 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 94.2% | Mt Bruce / Miki Miki, 01/02 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 90.4% | Mt Bruce / Miki Miki, 01/02 (GWRC op) | 2 | 1 (10g pellets) | 18 |
| 88.1% | Akatarawa valley, 01/02 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 84.7 | Owhanga, 01/02 (GWRC op) | 2 | 2 (10g pellets) | 18 |

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 89.2% | Castlehill/Bideford, 01/02 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 77.3% | Otaki, 2001 | - | 3 (12 g pellets) | 18 |
| 81.1% | Upper Waingawa, 2001 | - | 3 (12 g pellets) | 18 |
| 88.3% | Marapara EA, 5/10/2001 | 2 | 3 (12g pellets) | 21 |
| 97.7% | Tongariro Forest CA, 19/9/2001 | 2 | 3 (12g pellets) | 22 |
| 82.9% | Ohau/Mangahao, 8/9/2001 | - | 3 (12 g pellets) | 23 |
| 97.2% | Leslie/Karamea, 27/8/2001 | - | 4 (12 g pellets) | 24 |
| 81.1% | Blue Mountains, 22/8/2001 | 1 | 2 (RS5 pellets) | 25 |
| 57.6 % | Hackett, 31/5/2001 | - | 3 (12 g pellets) | 26 |
| 94.0% | Featherston, 00/01 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 92.2% | Whakatikei, 00/01 (GWRC op) | 1 | 1 (10g pellets) | 18 |
| 93.2% | Otaki Crown, Jan 01 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 97.6% | Tinui, 00/01 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 81.5% | Moeatoa, 6/8/2000 | - | 5 (6 g pellets) | 27 |
| 81.5% | Whareorino, 6/8/2000 | - | 5 (6 g pellets) | 28 |
| 100% | Bideford, 99/00 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 97.9% | Pukunui, 99/00 (GWRC op) | 1.2 | 2 (10g pellets) | 18 |
| 95.5% | Owhanga, 99/00 (GWRC op) | 2 | 2 (10g pellets) | 18 |
| 94.0% | Wainuiomata, 98/99 (GWRC op) | 3 | 3 (10g pellets) | 18 |
| 87.0% | Arawhata, 26/4/1999 | - | 3.1 (6 g pellets) | 29 |
| 18.3% | Okura, 24/4/1999 | - | 2.6 (6 g pellets) | 30 |
| 84.0% | NE Tararua, 1999 | - | 4 (8 g pellets) | 18 |
| 92.8% | Tauherenikau, 1998 | - | 4 (8 g pellets) | 18 |
| 94.2% | Landsborough, 30/6/1998 | - | 4 (6 g pellets) | 31 |
| 95.8% | Landsborough, 30/6/98 | - | 2 (6 g pellets) | 31 |

[a] heavy thunderstorms on the evening treatment occurred damaged the bait.

1 Morriss & Nugent (2008); 2 Pestlink:0708PNT18; 3 J Kemp per comm.; 4 Pestlink:0708SWS07; 5 Pestlink:0708SWS06; 6 Pestlink:0708KAP16; 7 Pestlink:0607WMK02; 8 Pestlink:0607WRP02; 9 Pestlink:0506TEA01; 10 Pestlink:0506WHA01; 11 Pestlink:0405BUL15; 12 Pestlink:0405KAP21; 13

Pestlink:0304WAI22; 14 Pestlink:0304SWS27; 15 Pestlink:0304GDB05; 16 Pestlink:0203GDB13; 17 Wright (2004); 18 Brown & Urlich (2005); 19 Pestlink:0203WAI05; 20 Lorigan et al. (2002); 21 Pestlink:0203MPT03; 22 Pestlink:0203RUA06; 23 Pestlink: 0304KAP12; 24 Pestlink: 0203MOT19; 25 Nugent & Yockney (2001); 26 Pestlink: 0203SWS32; 27 Pestlink: 0203MPT36; 28 Pestlink: 0203MPT04; 29 Pestlink:0203SWS17; 30 Pestlink:0203SWS18; 31 Pestlink:0304SWS05.

*Aerially distributed 1080 carrots*

The mean percentage possum kill for operations using 0.8 g $kg^{-1}$ 1080 carrots (Table 37) is 91.1% (n=7).

Table 38 lists aerial operations using 1.5 g $kg^{-1}$ 1080 carrots where the percentage kill could be calculated. The mean kill for these operations was 93.7% (n=4).

TABLE 37. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 0.8 g $kg^{-1}$ 1080 CARROT.

| KILL | LOCATION | SOWING RATE (kg $ha^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 93.4% | Te Kopia SR, 11-25/7/2006 | 2 (6g baits) | 5 (6g baits, 12 days later) | 1 |
| 91.8% | Whirinaki Rata Block 30/8-8/9/2005 | 3 | 5 (8 days later) | 2 |
| 87.8% | Hunua Ranges, 7-8/9/2001 | 5 | 5 | 3 |
| 86% | Otupaka EA, 17-18/05/2000 | 5 | 10 (6g baits) | 4 |
| 96.0% | Paeroa Range, 18/08/1999 | 5 | 10-15 (6g baits) | 5 |
| 88.4% | Marokopa/Tawerau, 5/7/1998 | 5 | 5 (6g baits) | 6 |
| 94.2% | Marokopa/Tawerau, 5/7/1998 | 5 | 10 (6g baits) | 7 |

1 Pestlink:0607ROT01; 2 Pestlink: 0506RAN01; 3 Pestlink: 0203AKD13; 4 Pestlink: 0304RAN08; 5 Pestlink: 0304ROT05; 6 Pestlink: 0203MPT08; 7 Pestlink: 0203MPT08.

TABLE 38. THE PERCENTAGE POSSUM KILL FOR AERIAL OPERATIONS USING 1.5 g $kg^{-1}$ 1080 CARROT.

| KILL | LOCATION | SOWING RATE (kg $ha^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 98.1% | Matakuhia, Tataraakina, July 2003 | 5 | 5 (6g baits) | 1 |
| 96.3% | Wakeman's Block, Tataraakina, July 2003 | 5 | 5 (6g baits with deer repellent) | 1 |
| 86.6-100% | Hampden, North Otago, 28/6/2002 | 2 | 2 (6g baits) | 2 |
| 92.5% | Lake Okataina SR, 27/7/1999 | 5 | 12 (6g baits) | |

1 Nugent et al. (2004); 2 Lorigan et al. (2002); 3 Pestlink: 0304ROT04.

*1080 cereal pellets in bait stations*

Table 39 contains the percentage possum kills for bait station operations using 0.15% 1080 cereal pellets. The mean kill for these operations was 93.3% (N=8).

TABLE 39. THE PERCENTAGE POSSUM KILL FOR 0.15% 1080 CEREAL PELLETS IN BAIT STATIONS

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 83.7% | Opuiaki, Sept-Oct 2009 | 100 x 100 m grid, 2 prefeeds (600g per bait station), 1 toxic fill (300 g bait per station) | 1 |
| 95% | Fox Valley, April-May 2008 | 100 x 200 m grid, 2 prefeeds (460 g per bait station), 1 toxic fill (460 g bait per station) | 2 |
| 88.9% | Fox Valley, July 2007 | 100 x 200 m grid, 2 prefeeds (500 g per bait station), 1 toxic fill (500 g bait per station) | 2 |
| 97.1% | Rotoehu EA, Oct-Nov 2007 | 1 bait station/ha, 2 prefeeds (1500 g per bait station), 1 toxic fill (700 g bait per station) | 3 |
| 96.2% | Mokaihaha EA, October 2001 | 1 bait station/ha, 3 prefeeds, 1 toxic fill (1500 g bait per station) | 4 |
| 94.8% | Minganui Faces, Oct 1999 | 0.53 bait stations/ha, 3 prefeeds, 1 toxic fill (750 g bait per station) | 5 |
| 100% | Kaharoa CA, Jan 1997 | 0.25 bait stations/ha, 3 prefeeds, 1 toxic fill (1000 g bait per station) | 6 |
| 90.6% | Minganui Faces, Nov 1996 | 0.53 bait stations/ha, 3 prefeeds, 1 toxic fill | 7 |

1 Pestlink: 0800TAU01; 2 Pestlink: 0809SWS04; 3 Pestlink 0708ROT03; 4 Pestlink: 0304ROT06; 5 Pestlink: 0304RAN12; 6 Pestlink: 0304ROT09; 7 Pestlink: 0304RAN13.

*No Possums® 1080 gel (1.5 g* $kg^{-1}$ *1080) in bait stations*

The mean percentage possum kill for the operations using No Possums® 1080 gel block in Table 40 is 78.4% (N=2).

TABLE 40. THE PERCENTAGE POSSUM KILL DURING BAIT STATION OPERATIONS USING NO POSSUMS® 1080 GEL BLOCK.

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 65.6% | Whareorino, August 2003 | 2 bait stations/ha, 1 prefeeds, 1 toxic fill (250 g bait per station) | 1 |
| 91.3% | Leslie Karamea, Jan-April 2002 | 0.24 bait stations/ha, 1 toxic fill (500 g bait per station), used in conjunction with feracol | 2 |

1 Pestlink: 0304MPT03; 2 Pestlink: 0203MOT19.

*Handlaid 1080 cereal pellets*

The mean percentage possum kill for operations using handlaid 0.15% 1080 cereal pellets (Table 41) is 88.8% (n=6).

TABLE 41. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING HANDLAID 0.15% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg $ha^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 91.7% | Stewart Island, Dec 07 – Jan 2008 | | Not specified, but not prefed | 1 |
| 100% | Colenso Basin, Ruahines, Sept-Oct 2007 | 2 (6 g pellets) | 1.5 (12 g pellets, 31 days later) | 2 |
| 66.7% | Awarua, 3/3/2000 | | 0.4 (8 g pellets, traps and Feratox also used) | 3 |
| 90.6% | Fox Valley, 23/9/1999 | | 0.5 (8 g pellets, traps also used) | 4 |
| 94.6% | Abbey Rocks B, 2/6/1999 | | 0.5 (6 g pellets, traps also used) | 5 |
| 89.3% | Abbey Rocks C, 3/6/1999 | | 0.5 (6 g pellets, traps also used) | 5 |

1 Pestlink: 0809SIS02; 2 Pestlink: 0708PNT17; 3 Pestlink: 0203SWS30; 4 Pestlink: 0203SWS34; 5 Pestlink: 0203SWS28.

*1080 cereal pellets in bait bags*

The percentage kills obtained following the use of 1080 cereal pellets in bait bags are presented in Table 42. The mean is 82.9%.

TABLE 42. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING 0.15% 1080 CEREAL PELLETS IN BAIT BAGS.

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 96% | Stewart Island, Oct-Nov 2008 | 20 x 100 m grid (not prefed) | 1 |
| 97.6% | Pegasus/Tin Range Oct-Nov 2004 | Grid (not prefed) | 2 |
| 85% (Range: 68.8%-100%) | Paterson Inlet Blocks, Oct 2003 | Bags put on recent sign (not prefed) | 3 |
| ~92.6% | Mt Anglem/Hananui, Oct-Nov 2003 | 4.3-5.3 bait bags/ha, 1 prefeed, 2 toxic bag placements (6 g baits). | 4 |
| 53.1-73.2% | Warawara Forest Blocks, Mar-Jun 2003 | Bags put on recent sign (not prefed) | 5 |

1 Pestlink: 0809SIS03; 2 Pestlink: 0405SIS04; 3 Pestlink: 0304SIS19; 4 Pestlink: 0304SIS20; 5 Pestlink: 0203KAI12.

*1080 paste in bait bags*

See Table 43 for the percentage kill during operations using 0.15% 1080 paste in bait bags.

TABLE 43. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING 0.15% 1080 PASTE IN BAIT BAGS.

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 56.4% | Minganui Faces, Sept-Oct 2000 | Bags placed on a 75m x 10m grid, not prefed. | 1 |

1 Pestlink: 0304RAN09.

*Handlaid 1080 paste*

The mean percentage possum kill for operations using handlaid 0.15% 1080 paste under good weather conditions is 83.1% (n=5) (Table 44).

TABLE 44. THE PERCENTAGE POSSUM KILL FOR OPERATIONS USING HANDLAID 0.15% 1080 PASTE.

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| ~84% | Rangitikei Snail Area, Kaimanawa FP, 2000-2002 | Prefed, set on recent sign. | 1 |
| 86.6% | Mortens, Canterbury | Spits 5-6 m apart around forest edge, not prefed | 2 |
| 84.7% | Steventon, Canterbury | Spits 5-6 m apart around forest edge, not prefed | 2 |
| 84% (Range: 50-96%) | 9 sites around NZ (1996-98) – good weather conditions | Spits 5 m apart around forest edge, prefed | 3 |
| 34% (Range: 0-59%) | 4 sites (1997) - where rain washed out baits or hot weather dried out the baits | Spits 5 m apart around forest edge, prefed | 3 |
| 76% (Range: 68-93%) | 9 sites around NZ (1996-98) – good weather conditions | Spits 5 m apart around forest edge, not prefed | 3 |
| 30% (Range: 11-46%) | 4 sites (1997) where rain washed out baits or hot weather dried out baits. | Spits 5 m apart around forest edge, not prefed | 3 |

1 Pestlink: 0304RAN09; 2 Ross & Henderson (2003); 3 Thomas & Morgan (1998)

**Rats**

*Aerially distributed 1080 cereal pellets*

The percentage rat kill for the aerial operations using 0.08% cereal pellets is presented in Table 45.

The percentage rat kills obtained during aerial operations using 0.15% 1080 cereal pellets are presented in Tables 46. Based on this data, the mean kill for prefed operations is 98.7% (n=30).

TABLE 45. THE PERCENTAGE RAT KILL FOR AERIAL OPERATIONS USING 0.08% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 100% | Whakapohai E, Jan 2007 | 5 (6g baits) | 2 (12g #7 pellets, 5 days later) | 1 |
| 1.2% | Station Creek A Trial, Jul 2006 | - | 5 (12g #7 pellets, 5 days later) | 1 |
| 96.3% | Station Creek B Trial, Jul 2006 | 2 (12g pellets) | 5 (12g #7 pellets, 7 days later) | 1 |
| <70% | Mapara, Oct 1992 | - | 8 | 2 |
| 80% | Mapara, Oct 1991 | - | 8 | 2 |
| 100% | Mapara, Sept 1990 | - | 8 | 2 |

1 J Kemp per comm.; 2 Bradfield. (1993).

TABLE 46. THE PERCENTAGE RAT KILL FOR AERIAL OPERATIONS USING 0.15% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 100% | Kia Wharite – Matemateaonga, Nov-Dec 2008 | 1 (6g pellets) | 2 (12g #7 pellets, 27 days later) | 1 |
| 100% | Poulter Valley, Oct 2008 | 1 (6g pellets) | 2 (6g #7 pellets, 17 days later) | 2 |
| 44.1% | Heaphy Coast A, Nov 2007 | - | 2 (6g #7 pellets) | 3 |
| 72.7% | Heaphy Coast B, Nov 2007 | - | 2 (6g RS5 pellets) | 3 |
| 100% | Heaphy Coast C, Nov 2007 | 1 (12g pellets) | 2 (6g RS5 pellets, 12 days later) | 3 |
| 100% | Heaphy Coast D, Nov 2007 | 2 (12g pellets) | 2 (6g RS5 pellets, 12 days later) | 3 |
| 100% | Pihanga, Nov 07 | 2 (12g pellets) | 2 (12g #7 pellets, 8 days later) | 4 |
| 100% | Catlins, Aug 2007 | 2 (12g pellets) | 3 (12 g RS5 pellets, 29 days later) | 4 |
| 100% | Parapara 07A Trial, May 2007 | 3 (6g pellets) | 3 (12g RS5 pellets, 43 days later) | 4 |
| 100% | Parapara 07B Trial, May 2007 | 3 (6g pellets) | 3 (12g #7 pellets, 43 days later) | 4 |
| 90.6% | Parapara 07C Trial, May 2007 | - | 3 (12g RS5 pellets) | 4 |
| 0% | Parapara 07D Trial, May 2007 | - | 3 (12g #7 pellets) | 4 |
| 100% | Hukarere A May 2007 | 2 (12g pellets) | 2.5 (12g #7 pellets, 25 days later) | 4 |
| 100% | Hukarere B May 2007 | 2 (12g pellets) | 2.5 (12g RS5 pellets, 25 days later) | 4 |
| 100% | Hukarere C May 2007 | 2 (12g pellets) | 2.5 (12g #7 pellets, 25 days later) | 4 |
| 98.1% | Whakapohai A, Jan 2007 | 5 (6g pellets) | 2 (12g #7 pellets, 5 days later) | 4 |
| 100% | Whakapohai B, Jan 2007 | 2 (6g pellets) | 2.5 (12g #7 pellets, 5 days later) | 4 |
| 100% | Whakapohai C, Jan 2007 | 2 (6g pellets) | 2.5 (12g #7 pellets, 5 days later) | 4 |

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 100% | Whakapohai D, Jan 2007 | 1 (6g pellets) | 2.5 (12g #7 pellets, 5 days later) | 4 |
| 98.4% | Dart/Caples, 25-30/10/2006 | 2 | 2 (6g RS5 pellets, 5 days later) | 5 |
| 100% | Otaki Bio Site, 12/09-14/12/2006 | 2.11 (6g pellets) | 2.11 (6g #7 pellets, 93 days later) | 6 |
| 98.9% | Otaki Core, 12/09-14/12/2006 | 2.11 (6g pellets) | 2.11 (6g #7 pellets, 93 days later) | 6 |
| 100% | Wangapeka, Oct 2006 | 0.8 (12g pellets) | 2.5 (12g RS% pellets, 14 days later) | 4 |
| 100% | Hawdon Valley, 12-28/9/2006 | 2 (6g pellets) | 5 (6g pellets, 16 days later) | 7 |
| 100% | Poulter Valley,12-28/9/2006 | 2 (6g pellets) | 5 (6g pellets, 14 days later) | 7 |
| 100% | South Branch Hurunui Valley, 14/9-6/10/2006 | 2 (6g pellets) | 5 (6g pellets, 22 days later) | 7 |
| 98.7% | Tongariro Forest, 30/8-15/09/2006 | 2 | 4 (12g #7 pellets, 5 days later) | 8 |
| 100% | Opuiaki, 18-28/8/2006 | 2 | 3 (12g #7 pellets, 5 days later) | 9 |
| 94.9% | Central Coromandel, Aug 2006 | 2 (6g pellets) | 3 (12g #7 pellets, 13 days later) | 4 |
| 96.1% | Whenuakite, Aug 2006 | 2 (6g pellets) | 3 (12g #7 pellets, 13 days later) | 4 |
| 98.8% | Station Creek C Trial, Jul 2006 | 2 (12g pellets) | 5 (12g #7 pellets, 7 days later) | 4 |
| 98.0% | Waipoua Forest, 24/09 – 12/10/2005 | 2 | 3 (12g #7 pellets, 16 days later) | 10 |
| 80.2% | Waipapa East, Waipapa EA, Sept 2001 | 2 | 2 | 11 |
| 97.8% | Waipapa North, Waipapa EA, Sept 2001 | 2 | 2 | 11 |
| 100% | Kaharoa, Oct 1990 | 2 | 18 | 12 |
| 92.1% | Makino Forest, August 1989 | - | 9 | 13 |

1 Pestlink:0809WHA01; 2 Pestlink:0809WMK06; 3 Pestlink:0809BUL06; 4 J Kemp per comm.; 5

Pestlink:0708WAK04; 6 Pestlink:0708KAP16; 7 Pestlink:0607WMK02; 8 Pestlink:0708RUA01; 9 Pestlink:0607TAU05; 10 Pestlink:0506KAU09; 11 Styche et al. (2004); 12 Innes et al. (1995); 13 Warburton (1989).

*Handlaid 1080 cereal pellets*

A 61% rat kill was achieved at Beam Head, Northland, in October 2008 when 0.08% 1080 rodent pellets were laid in clusters 50 metres apart along an existing track system. The operational area was prefed at a rate of 1 kg $ha^{-1}$ and 30 days later the toxic bait was laid at a rate of 0.8 kg $ha^{-1}$ (Pestlink reference: 0809WNG05).

*1080 cereal pellets in bait stations*

Table 47 contains the percentage rat kills for bait station operations using 0.15% 1080 cereal pellets.

TABLE 47. THE PERCENTAGE RAT KILL FOR 0.15% 1080 CEREAL PELLETS IN BAIT STATIONS

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 97.0% | Opuiaki, Sept-Oct 2009 | 100 x 100 m bait station grid, 2 prefeeds (600g per bait station), 1 toxic fill (300 g bait per station) | 1 |
| 91.2% | Waipapa East, Waipapa EA, Aug 2000 | 150 x 150 m bait station grid, 2 prefeeds, 1 toxic fill | 2 |
| 87.7% | Waipapa North, Waipapa EA, Aug 2000 | 150 x 150 m bait station grid, 2 prefeeds, 1 toxic fill | 2 |
| 85.5% | Waipapa South, Waipapa EA, Aug 2000 | 150 x 150 m bait station grid, 2 prefeeds, 1 toxic fill | 2 |
| 100% | Trounson Kauri Park, Nov 1996 | 100 x 100 m bait station grid, 4 prefeeds, 1 toxic fill | 3 |

1 Pestlink: 0800TAU01; 2 Matthew et al. (2004); 3 Gillies et al. (2003).

**Mice**

*Aerially distributed 1080 cereal pellets*

The percentage mouse kill for the aerial operations using 0.08% cereal pellets is presented in Table 48. The percentage rat kills obtained during aerial operations using 0.15% 1080 cereal pellets are presented in Tables 49. Based on this data, the mean kill for prefed operations is 90.0% (n=12).

TABLE 48. THE PERCENTAGE MOUSE KILL FOR AERIAL OPERATIONS USING 0.08% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 58% | Whakapohai E, Jan 2007 | 5 (6g pellets) | 2 (12g #7 pellets, 5 days later) | 1 |

1 J Kemp per comm.

TABLE 49. THE PERCENTAGE MOUSE KILL FOR AERIAL OPERATIONS USING 0.15% 1080 CEREAL PELLETS.

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 93.4% | Poulter Valley, Oct 2008 | 1 (6g pellets) | 2 (6g #7 pellets, 17 days later) | 1 |
| 100% | Pihanga, Nov 07 | 2 (12g pellets) | 2 (12g #7 pellets, 8 days later) | 1 |
| 86.2% | Parapara 07C Trial, May 2007 | - | 3 (12g RS5 pellets) | 1 |
| 37.3% | Parapara 07D Trial, May 2007 | - | 3 (12g #7 pellets) | 1 |
| 97.0% | Parapara 07A Trial, May 2007 | 3 (6g pellets) | 3 (12g RS5 pellets, 43 days later) | 1 |
| 92.0% | Parapara 07B Trial, May 2007 | 3 (6g pellets) | 3 (12g #7 pellets, 43 days later) | 1 |
| 100% | Whakapohai A, Jan 2007 | 5 (6g pellets) | 2 (12g #7 pellets, 5 days later) | 1 |
| 66.7% | Whakapohai B, Jan 2007 | 2 (6g pellets) | 2.5 (12g #7 pellets, 5 days later) | 1 |
| 96.4% | Whakapohai C, Jan 2007 | 2 (6g pellets) | 2.5 (12g #7 pellets, 5 days later) | 1 |
| 86.0% | Whakapohai D, Jan 2007 | 1 (6g pellets) | 2.5 (12g #7 pellets, 5 days later) | 1 |

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 50.0% | Dart/Caples, 25-30/10/2006 | 2 | 2 (6g RS5 pellets, 5 days later) | 2 |
| 100% | Otaki Bio Site, 12/09-14/12/2006 | 2.11 (6g pellets) | 2.11 (6g #7 pellets, 93 days later) | 1 |
| 100% | Wangapeka, Oct 2006 | 0.8 (12g Pellets) | 2.5 (12g RS5 pellets, 14 days later) | 1 |
| 100% | Tongariro Forest, 30/8-15/09/2006 | 2 | 4 (12g #7 pellets, 5 days later) | 1 |

1 J Kemp per comm.; 2 Pestlink: 0708WAK04.

*1080 cereal pellets in bait stations*

Table 50 contains the percentage mouse kills for bait station operations using 0.15% 1080 cereal pellets.

TABLE 50. THE PERCENTAGE MOUSE KILL FOR 0.15% 1080 CEREAL PELLETS IN BAIT STATIONS

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 94% | Trounson Kauri Park, Nov 1996 | 100 x 100 m bait station grid, 4 prefeeds, 1 toxic fill | 1 |

1 Gillies et al. (2003).

**Wallabies**

The percentage kill of wallabies using aerially distributed 1.5 g kg$^{-1}$ 1080 carrot is presented in Table 51 and in Table 52 for handlaid 5% and 10% 1080 gels.

TABLE 51. THE PERCENTAGE WALLABY KILL FOR AERIALLY DISTRIBUTED 1.5 g kg$^{-1}$ 1080 CARROTS

| KILL | LOCATION | SOWING RATE (kg ha$^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 93.1% | Okataina SR, 1999 (Dama wallabies) | 5 | 12 | 1 |

1. PESTLINK: 0304 ROT04

TABLE 52. THE PERCENTAGE WALLABY KILL FOR HANDLAID 5% AND 10% 1080 GEL

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 86.2% | Okataina SR, 1988 (Dama wallabies) | 5-10 m x 50-100 m transects, 5 baited leaves/branch (5% 1080 gel) | 1 |
| 91.3% | Tasman Smith SR, Hunter hills, 1983 (Bennett's wallabies) | 10 branches/ha, 25 baited leaves/branch (10% 1080 gel) | 1 |

1. Warburton (1990)

**Deer**

The percentage kill of deer is presented in Table 53 for aerially distributed 1.5 g $kg^{-1}$ 1080 carrot is and in Table 54 for handlaid 10% 1080 gel.

TABLE 53. THE PERCENTAGE DEER KILL FOR AERIALLY DISTRIBUTED 1.5 g $kg^{-1}$ 1080 CARROTS

| KILL | LOCATION | SOWING RATE (kg $ha^{-1}$) | | REF. |
|---|---|---|---|---|
| | | Prefeed | Toxic | |
| 92% | Titiraupunga, 1997 | 5 | 15 | 1 |
| 34% | Pureora, 1994 | 5 | 15 | 2 |
| 42% | Pureora, 1994 | 15 | 15 | 2 |

1 Fraser & Sweetapple (2000); 2 Fraser et al. (1995)

TABLE 54. THE PERCENTAGE DEER KILL FOR HANDLAID 10% 1080 GEL

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 79% | Hauhangaroa Range, 1997 | 2 branches/ha, 10 baited leaves/branch | 1 |
| 80%+ | Stewart Island, 1981 | 2.5 branches/ha, 20 baited leaves/branch | 2 |
| 100% | Stewart Island, 1981 | 5 branches/ha, 20 baited leaves/branch | 2 |

1 Sweetapple (1997); 2 Nugent (1990).

**Goats**

*10% 1080 gel (100 g* $kg^{-1}$ *1080), handlaid*

The percentage kill of goats using handlaid 10% 1080 gel is presented in Table 55.

TABLE 55. THE PERCENTAGE KILL OF GOATS FOLLOWING THE USE OF HANDLAID 10% 1080 GEL

| KILL | LOCATION | METHOD | REF. |
|---|---|---|---|
| 88% | Whitecliffs, Buller River, Jul 2007 | 2.2 branch/ha in preferred habitat, 10 - 20 baited leaves/branch | 1 |
| 87% | Motu River, Jan 1986 | 1 branch/ha in preferred habitat, 20 baited leaves/branch | 2 |
| 97% | Motu River, March 1982 | 2.5 branches/ha, 20 baited leaves/branch | 3 |

1 Anderson (2008) Docdm-231336; 2 Veltman & Parkes (2002); 3 Parkes (1983)

# 7. Glossary of Terms

**µg** $kg^{-1}$**, µg** $l^{-1}$

See ppb.

**µg** $g^{-1}$**, µg** $ml^{-1}$

See ppm.

**Absciss**

Part of a plant breaking off naturally (e.g. leaves dying)

**Aconitase**

An enzyme occurring in many animal and plant tissues that accelerates the conversion of citric acid first into aconitic acid and then into isocitric acid.

**Biological Exposure Index (BEI)**

A reference value below which exposure to a substance will not create an unreasonable risk of disease or injury. BEIs are set by the American Conference of Governmental Industrial Hygienists (ACGIH).

**Biosynthesis**

The production of a chemical compound by a living organism.

**bw**

Body weight

**Carcinogenic**

The ability of a substance to cause cancer.

**Citrate**

A salt or ester of citric acid.

**Cyanosis**

Blueness of the skin and mucous membrane due to insufficient oxygen in the blood.

**Defluorination**

To remove fluorine

**Endocardium**

The lining of the interior surface of the heart chambers. The endocardium consists of a layer of endothelial cells and an underlying layer of connective tissue. a thin serous membrane lining the cavities of the heart.

**Epicardium**

The inner layer of the pericardium, a conical sac of fibrous tissue that surrounds the heart and the roots of the great blood vessels./ the visceral part of the pericardium that closely envelops the heart

**Epiglottis**

The flap that covers the trachea during swallowing so that food does not enter the lungs.

**Fluorocitrate**

The toxic metabolite of fluoroacetate that causes inhibition of aconitase.

**Gastrointestinal tract**

The stomach and intestine as a functional unit

**Glial cells**

A supportive cell in the central nervous system. Glial cells do not conduct electrical impulses (as opposed to neurons, which do). The glial cells surround neurons and provide support for them and insulation between them.

**Half-life**

During each half life (t½ or elimination half-life) 50% of the pesticide in the body at the beginning of that half-life is eliminated. The half-life is established in laboratory trials, and is used to predict the rate of elimination of a single dose of pesticide from the body and to estimate how long the disappearance of cumulative intakes of a pesticide from the body would take.

**Hypotension**

Abnormally low pressure of the blood -- called also low blood pressure

**Intravenous**

Administered into a vein.

**$LC_{50}$**

Lethal Concentration 50%. The calculated concentration of a gas/liquid that kills 50% of the test organisms

$LD_{50}$

Lethal Dose 50%. The estimated dose that kills 50% of the test organisms.

**LOEL**

Least Observable Effect Level. The lowest dose in a study in which there was an observed toxic or adverse effect

**Mitochondrial aconitate hydratase**

An iron-dependent enzyme that catalyzes conversion of citrate to cis-aconitate in the tricarboxylic acid cycle within the mitochondrion.

**Metabolites**

The breakdown of compounds resulting from the metabolism of a parent compound.

**mg** $kg^{-1}$**, mg** $l^{-1}$

See ppm.

**mmol (, mM)**

millimole: a unit of metric measurement that is equal to one thousandth (10-3) of a mole. It is the amount of a substance that corresponds to its formula mass in milligrams. [mol $l^{-1}$]x[mL] = mmol.

**Mutagenic**

The ability of a substance to cause damage to DNA and produce alterations or loss of genes or chromasomes

**NOEL**

No Observable Effect Level. A dosage of a toxicant that fails to produce any discernable signs of toxicosis, which may include a lack of morphological, biochemical, or physiological change

**Non-saponifiable lipids**

Non-polar compounds that cannot be broken down by a simple hydrolytic reaction. They include steroids and hormones.

**Oral**

Given or taken through or by way of the mouth, as in an oral solution.

**Phosphofructokinase**

An enzyme that functions in carbohydrate metabolism and especially in glycolysis by catalyzing the transfer of a second phosphate to fructose.

**ppb**

parts per billion. This concentration unit is equivalent to 1 $\mu g\ l^{-1}$ in water (solution) or air and 1 $\mu g\ kg^{-1}$ in solid samples (soil/sediments/biological tissue).

**ppm**

parts per million. This concentration unit is equivalent to 1 $mg\ l^{-1}$ (or $\mu g\ ml^{-1}$) in water (i.e. solutions) or air and 1 $mg\ kg^{-1}$ (or $\mu g\ g^{-1}$) in solid samples (i.e. soil/sediments/biological tissue).

**Succinate dehydrogenase**

An iron-containing flavoprotein enzyme that catalyzes, often reversibly, the dehydrogenation of succinic acid to fumaric acid in the presence of a hydrogen acceptor and that is widely distributed especially in animal tissues, bacteria, and yeast -- called also succinic dehydrogenase.

**Subepicardial**

Under the serious membrane which covers the heart situated or occurring beneath the epicardium or between the epicardium and myocardium.

**Teratogen**

A compound that causes birth defects in a developing foetus.

**Toxicosis**

A pathological condition caused by the action of a poison or toxin.

**Toxin**

A natural occurring poison, e.g. 1080, cyanide.

**Toxicant**

A synthetic man-made poison, e.g. brodifacoum.

**Trachea**

The tube-like portion of the respiratory tract that connects the "voice box" (larynx) with the bronchial parts of the lungs. called also windpipe.

**Tricarboxylic acid cycle**

A sequence of reactions in the living organism in which oxidation of acetic acid or acetyl equivalent provides energy for storage in phosphate bonds - called also citric acid cycle, Kreb cycle.

**Threshold Limit Values (TLV)**

Recommended values for the highest level of exposure to airborne chemical concentrations in the workplace that does not produce adverse health effects. They are set by the American Conference of Governmental Industrial Hygienists (ACGIH).

**Viscera**

Body organs.

**VPRD**

Vertebrate Pesticide Residue Database. (DOCDM-32812)

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