Bio-Protection & Ecology Division

Uptake of 1080 by Watercress and Puha – Culturally-Important Plants Used for Food

by

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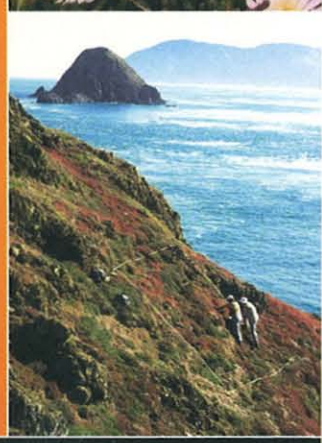

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Uptake of 1080 by Watercress and Puha – Culturally-Important Plants Used for Food

Final Report

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Prepared For:

Animal Health Board, PO Box 3412, Wellington
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Executive Summary

1.1 Project and client

Research was undertaken for the Animal Health Board Inc. (AHB) under Contract R-80694 "Uptake of 1080 by Watercress and Puha" by Lincoln University. This report comprises the findings of that research.

This research was aimed at examining the uptake and persistence of 1080 in two plants of cultural importance, puha, (*Sonchus* spp.) and watercress (*Nasturtium microphyllum/officinale*). The work was carried out between September 2007 and March 2009.

1.2 Objectives

- Undertake appropriate consultation with local Maori at the potential study sites to obtain the necessary consent to carry out research that involves the addition of 1080 to a food source site
- Complete applications to the Medical Officer of Health for each site and receive approval for field use of 1080
- Undertake fieldwork to measure the uptake and elimination of 1080 in puha and watercress using simulated aerial application of 1080 cereal baits
- Complete 1080 laboratory sample analyses
- Add the findings of this work to the 1080 database (R-80667-01)
- Report the research findings on 1080 in puha and watercress to members of the collaborative Maori community, and nationally through established networks and interested individuals
- Publish findings in a peer-reviewed journal.
- Complete a final report on the findings of this research (this document is that report).

1.3 Methods

- Consultation was undertaken with Ngai Tuhoe at Tuai. It was agreed that puha (*Sonchus* spp., used for food) was an appropriate plant to study at this site.
- Consultation took place with Ngati Kuri of Ngai Tahu at Kaikoura, where it was agreed to conduct the watercress (*Nasturtium microphyllum/officinale*) component of this research.
- A field site on the shores of Lake Waikaremoana was identified for the puha research (E28693.29 N62572.25); a field site on private farm land in Kaikoura was identified for the watercress research (E25506.10, N58673.00).
- Instrumentation was deployed to monitor rainfall, air and litter temperature, and soil moisture during the field work for puha. Instrumentation to measure air temperature, water temperature and pH was deployed at the watercress field site. Water velocity was measured. Rain fall was recorded by the farmer.
- Ten individual puha plants were randomly selected, and caged to prevent herbivore grazing.
- A single Wanganui No. 7 bait (0.15% 1080) was placed in a small cage at the base of eight puha plants. Two non-toxic baits were placed at the base of two plants (control plants).

- Five gram tissue samples were collected from each of the puha plants at Day 0, 3, 7, 14, 28 and 38 days after the baits were deployed, and snap-frozen on dry ice, then transported to the laboratory for analysis.
- At the Kaikoura field site, a 100 m section of stream was selected based on watercress abundance, and divided into 10 m sections. It was then fenced off to exclude stock.
- A single Wanganui No. 7 bait (0.15% 1080) was dropped into a cylindrical wire mesh cage within a stand of watercress in seven sections of stream (treatment sections). Three non-toxic baits were dropped into cages within watercress stands in the three upstream sections (control sections).
- Five gram watercress plant tissue samples were collected at time 0 and 30 minutes, 1 hour, and 1, 3, 7, 10 and 17 days, and snap frozen on dry ice, before being transported to the laboratory for analysis.
- Water samples from each of the 10 sections in the stream were collected at time 0, 15 and 30 minutes, 1, 2 7 and 14 hours, frozen on dry ice and transported to the laboratory for analysis.
- The 1080 concentration in each of the plant tissue samples and water samples was measured using gas chromatography.
- Results from the puha research were reported to the Lake Waikaremoana Hapu Restoration Trust (Ngai Tuhoe), Tuhoe Tuawhenua Trust (Ngai Tuhoe), and Department of Conservation representatives on November 14th 2008; and were presented at the NPCA conference, November 26-27th 2008.
- Results from the watercress research were reported to the entire research team (including Tuhoe and Ngati Kuri of Ngai Tahu) at Tuai on the 7th April 2009.

1.4 Results

Puha

- Average leaf litter temperature (where baits were positioned) ranged from 11 – 19 ºC, while average daily air temperature ranged from 9 – 23 ºC over the 38 days.
- Soil moisture fluctuated from 0.382 - 0.717 m^3/m^3, but after Day 7 remained greater than 0.5 m^3/m^3.
- There were three major rain events, with a maximum of 16.7 mm of rain recorded in one day; a total rainfall of 72.9 mm recorded over the duration of the study, with a mean daily rainfall of 1.66 mm recorded.
- Measurable levels of 1080 were detected in 9 of the 10 puha plants sampled.
- The one plant that never showed measurable 1080 was not a control plant.
- The highest 1080 concentration was seen on Day 3, at 15 ppb, from a single sample.
- By Day 38, the 1080 concentration had decreased below the Method Detection Limit (MDL) for all plants.
- When the MDL was removed from the raw data, very low concentrations of 1080 were observed in 59 of the 60 plant tissue samples taken, including samples taken on Day 0, prior to the addition of toxic baits.

Watercress

- Mean daily air temperature ranged from 11.95 – 20.31˚C; mean daily water temperature ranged from 13.82 – 14.83˚C.
- Stream water pH ranged from 7.27 – 8.25, with a gradual, slow increase observed over the duration of the study.

- Rain fell on three occasions throughout the study duration, on Days 1, 4 and 9. Maximum rain fall recorded in one event was 11 mm; total rainfall over the duration was 21 mm.
- Mean water velocity in the 100 m length of stream ranged from 0.042 – 0.044 L/sec.
- Mean water velocity for each section showed section 8 to have the slowest water flow at 0.013 L/sec, and section 6 to have the fastest water flow at 0.094 L/sec.
- No 1080 was ever detected from any of the three control sections for either water samples or plant tissue samples.
- 1080 was detected in only three of 56 treatment watercress samples.
- 1080 first appeared in a single watercress sample after 30 minutes at 17 ppb; 1080 first appeared in water samples after 15 minutes at 3 ppb.
- The maximum 1080 concentration detected in watercress was 63 ppb from section 8, on Day 7; maximum 1080 concentration detected from water samples was 7 ppb at 1 hour, also from section 8.
- For watercress samples, 1080 concentrations were below MDL on the last 2 sampling days (Days 10 and 17); for water samples, 1080 was detected in only a single sample at 14 hours equivalent to the MDL (0.1 ppb).

1.5 Conclusions

- Based on data collected here, it appears that 1080 occurs naturally in puha.
- The highest 1080 concentration measured was 15 ppb in puha leaf material 3 Days after bait placement; therefore all concentrations detected from puha were very low.
- Watercress appears able to take up and eliminate 1080 introduced from toxic baits.
- The highest 1080 concentration seen in watercress tissue samples was 63 ppb, from a single sample on Day 7. All other 1080 concentrations detected were lower than this.
- 1080 did not persist at levels above the MDL for either plant species.
- At the highest measured 1080 concentration seen from puha of 15 ppb, a 70 kg person would have to eat 9.3 tonnes of affected plant material to receive an LD_{50}
- With the highest 1080 concentration seen from watercress of 63 ppb, a 70 kg person would have to consume 2.2 tonnes of affected plant material to receive an LD_{50}
- Therefore, there is a negligible risk of secondary poisoning to humans who consume either puha or watercress plant material that have taken up 1080 from baits after an aerial 1080 operation.

1.6 Recommendations

- The poisoning of humans via consumption of puha and watercress after an aerial 1080 operation should not be considered a significant threat.
- However a withholding period of 30 - 38 days should be observed after any aerial 1080 operation in an area where puha will be affected; a withholding period of 10 days should be observed before collecting watercress after an aerial 1080 operation in the area.
- Water should not be consumed for 12 – 24 hours after an aerial 1080 operation where it is suspected 1080 baits have landed in the water.
- Consideration should be given to conduct further research to ascertain whether 1080 occurs naturally in puha, and if so, at what levels over time and under differing conditions i.e. weather/season/grazing pressure. This research should also be expanded to include a survey of 1080 in other NZ plant species.

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Introduction

Sodium fluoroacetate (Compound 1080) is a key tool in the control of possums, and the most extensively used vertebrate pesticide in New Zealand (Livingstone 1994; Morgan 1994a, b; Thomas 1994; Gillies and Pierce 1999; Powlesland et al. 1999; Sherley et al. 1999; Styche and Speed 2002). The most common method of control using this pesticide is via aerial application of cereal or carrot baits containing 1080 (Eason et al. 2000). This is a cost-effective means of reducing possum populations by more than 90% (Eason et al. 1994, Veltman and Pinder 2001).

Despite the efficiency of aerial 1080 application for reducing possum population numbers, support amongst Maori is mixed. In general, Maori oppose the use of toxins in the environment, despite the benefits to be had through the control of pests. In particular, there is much opposition around the aerial use of 1080 (Ogilvie et al. *in press*). Para (1999) documented concerns of Maori regarding the fate of 1080 in wild harvested kai (food) species. The risk of secondary poisoning of people using kai resources has previously been identified as key research by the Animal Health Board (AHB), Environmental Risk Management Authority (ERMA) and Maori.

During aerial application of 1080 baits, there is the possibility that 1080 may leach from baits and be taken up by nearby plants (Atzert 1971; Rammel and Fleming 1978). More recent laboratory research has shown that 1080 can be taken up by terrestrial and aquatic plants, including *Myriophyllum triphyllum*, a native aquatic New Zealand plant (Ogilvie et al. 1995); *Elodea canadensis*, an introduced aquatic species (Ogilvie et al. 1996); and broadleaf and ryegrass, both terrestrial species (Ogilvie et al. 1998). In a field setting where a simulated aerial 1080 operation has been conducted, low concentrations of 1080 were found in *Coprosma robusta*, or karamuramu, a native species used as medicine by Maori; however no 1080 was found in *Asplenium bulbiferum*, or pikopiko, a native species commonly consumed by Maori (Ogilvie et al. 2006).

This report is part of a research programme conducted to investigate the uptake and persistence of 1080 in puha and watercress. This report focuses on data generated from research carried out at two separate study sites, one for each plant species.

Puha is a plant species of particular cultural significance to Maori as a kai (food) resource, and to Ngai Tuhoe. Ngai Tuhoe are a Maori tribe of the eastern central North Island. The Urewera National Park lies within the rohe (area) of Ngai Tuhoe, and here, the incidence of Tb is thought to be increasing. Consequently, the use of 1080 in this area to control possum numbers and therefore Tb is important; however wild growing kai species are often harvested in this area, such as puha. This component of the research was undertaken between September 2007 and November 2008.

Watercress is one of the most important wild-sourced food plant species to Maori, a key reason why this research is to be done. The AHB had also requested research proposals for watercress based on feedback received during the recent reassessment of 1080 under the HSNO Act (1996). The watercress component of this research was conducted from January 2008 to December 2008.

Objectives

1. Undertake appropriate consultation with local Maori at the study sites to obtain consent to carry out the research that involves the addition of 1080 to a food source site.
2. Complete applications to the Medical Officer of Health and receive approval for field use of 1080.
3. To measure the uptake and elimination of 1080 in puha and watercress using simulated aerial application of 1080 cereal baits.
4. Add the findings of this work to the 1080 database (R-80667-01).
5. Report the research findings on 1080 in puha and watercress to members of the collaborative Maori community, and nationally through established networks and interested individuals.
6. Publish findings in a peer-reviewed journal.
7. Complete a report on the findings of this research (this report is that document).

Methods

Consultation with local Maori - Puha

A strong working relationship with Lake Waikaremoana Hapu Restoration Trust (LWHRT – Ngai Tuhoe) and Tuhoe Tuawhenua Trust (TTT – Ngai Tuhoe) existed from previous research carried out by this research team. An initial hui at Tuai, on the south side of Lake Waikaremoana, was held during September 2007 to discuss any issues surrounding this work, and the use of 1080 in a food source, with members of LWHRT, TTT and local Department of Conservation (DoC) representatives present. Puha (*Sonchus* spp.) was selected as a plant of particular cultural significance in this area, due to the regular harvesting of wild stock of this species for human consumption. It was also discussed a number of times in submissions during the ERMA 1080 reassessment process recently conducted.

Following this, site visits were conducted on September 13th – 14th 2007 with members of LWHRT, TTT, DoC and the research team, to determine whether suitable sites were available. A number of potential sites were present. Due to the use of 1080 in this research, sites were then narrowed down by selecting areas with low or no public access, or a means of blocking public access; no access by stock, dogs or other non-target species; somewhere accessible for the research team carrying the required equipment; an area with large puha plants present; and a site that was not currently being used by local people for puha harvesting. A site on the shore of Lake Waikaremoana was eventually chosen for use (Fig. 1. E28693.29 N62572.25). This site was on DoC administered land. Public access was able to be restricted, and highly visible signage was erected.

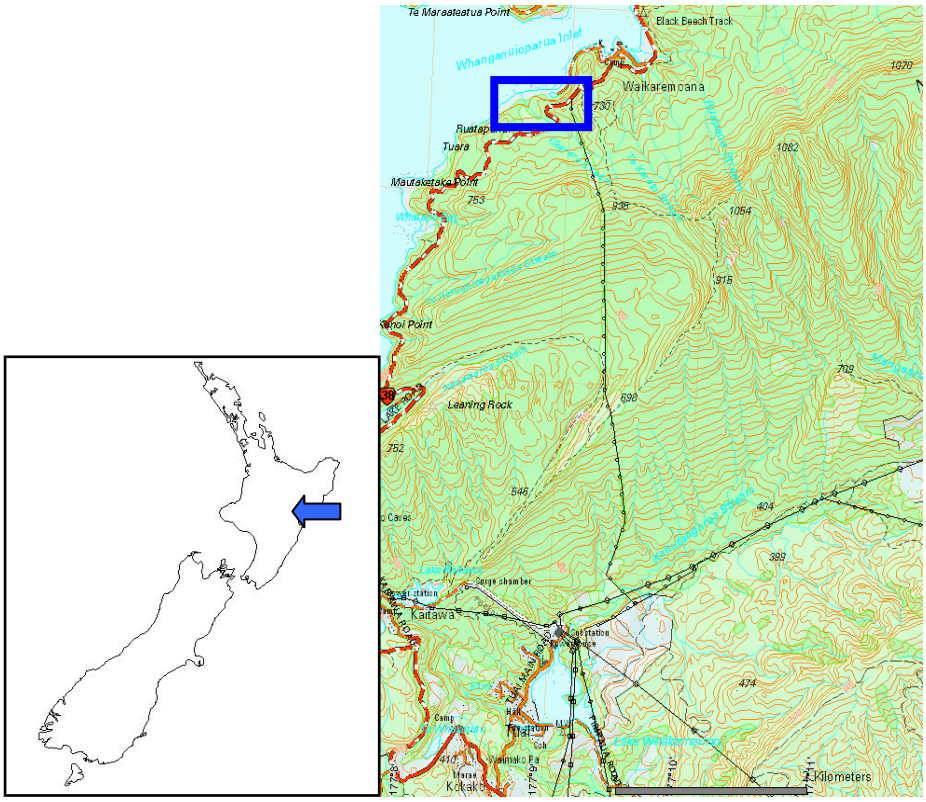

Figure 1. (Inset) New Zealand. Blue arrow indicates location of Lake Waikaremoana. Figure to the right shows the edge of Lake Waikaremoana. Blue rectangle represents puha study site (E28693.29 N62572.25).

Consultation with local Maori - Watercress

A good working relationship has been established through this research with Ngati Kuri – Ngai Tahu iwi based in Kaikoura. Initial hui were held with local iwi and Department of Conservation (DoC) representatives to discuss this work in January of 2008. Watercress (*Nasturtium microphyllum/officinale*) was the species chosen for use at this site, as earlier attempts to carry out this work at Lake Waikaremoana were hindered due to unforeseen circumstances.

Site visits were conducted in January 2008. A number of potential sites were visited; however, due to the use of 1080 in this research, sites were narrowed down by selecting areas with no human consumption of water from proposed site; low or no public access; no access by stock, dogs or other non-target species; accessibility for the research team; an area with a good abundance of watercress plants present; and a site that was not currently being used by local people for harvesting watercress. A site on privately owned farm land was eventually chosen (Fig. 2). At the site, stock were excluded using electric fencing. The stream selected was spring-fed. Road access to the property was blocked with a closed gate. The paddock containing the stream was blocked with a padlocked gate. Warning signs were erected at various obvious vantage points, to notify people approaching from any direction.

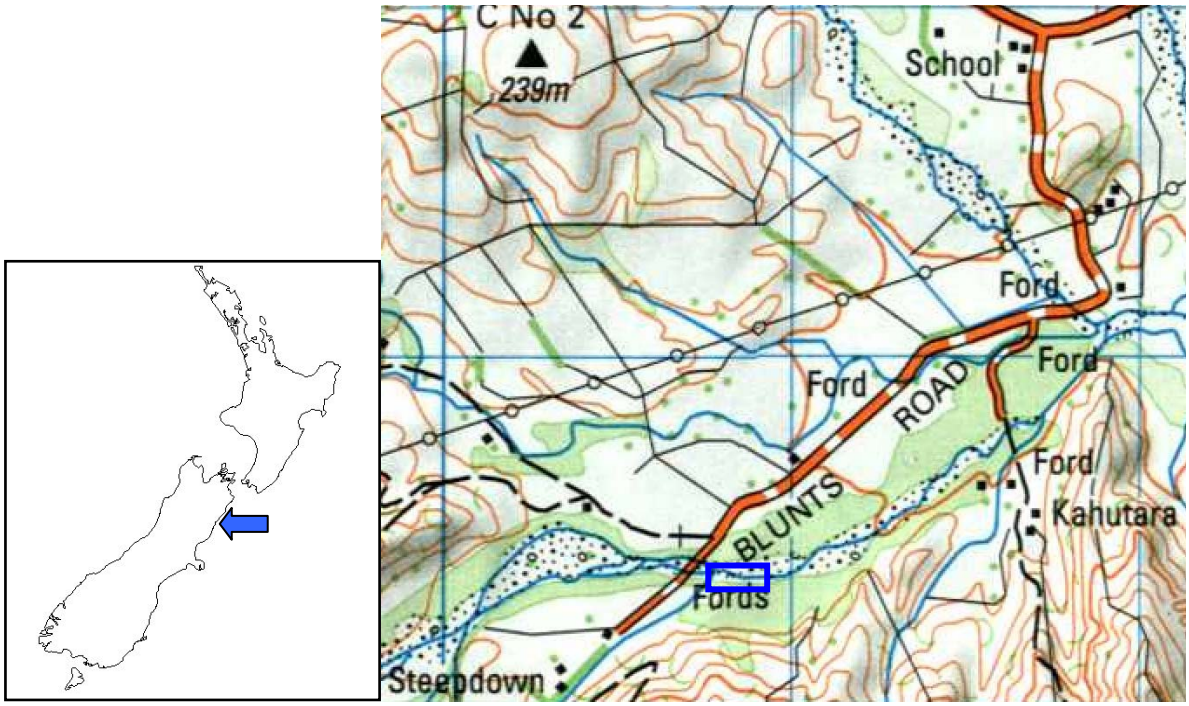

Figure 2. (Inset) New Zealand. Blue arrow indicates the location of Kaikoura. Figure to the right shows the study site, located inland from Kaikoura township on privately owned farm land. Blue rectangle represents the study site (E2550610, N5867300).

Medical Officer of Health Approval

Obtaining the Medical Officer of Health permit required an "Application for Medical Officer of Health Permission for the use of Controlled Pesticide(s)" to be filled out and filed with the appropriate District Health Boards – for puha, the Hawkes Bay District Health Board; for watercress, the Canterbury District Health Board. These applications involved providing background to the project; information about the selected site; GPS co-ordinates and maps of the site (Fig. 1, 2); information about the toxin (1080) to be used and method of use; proximity of sites to schools, camping grounds, public access, roads, water ways, dwellings, and tramping tracks/huts and bivvies; copies of warning notices to be posted; listing all places (i.e. local doctors, veterinary clinics, local DoC office) who were to be notified of the research, and providing copies of these letters. The permits were issued approximately one week (puha) and two weeks (watercress) after submission (Appendices 1 & 2). Permission was also sought, and granted, to carry out the puha research on DoC administered land, and in the case of the watercress, permission was sought and granted from adjacent land owners.

Measuring the uptake and elimination of 1080 in Watercress and Puha

This research investigated the uptake of 1080 under a simulated aerial operation in field conditions. In previous research (R-80620), simulated field conditions enabled our team to replicate a 'worst-case' scenario of bait landing at the base of plants – a situation that may not actually occur in an aerial operation. The same "worst-case scenario" approach was used here.

Toxic (1080) and non-toxic cereal baits (Wanganui No. 7) with a nominal 1080 concentration of 0.15% were obtained from Animal Control Products, Wanganui. The concentration of 1080 in the toxic baits was quantitatively analysed at Landcare Research by gas chromatography, as described below.

Puha

Ten puha plants were selected at the study site. Each plant was enclosed in a wire-mesh cage, constructed of ''Weldfab'' (Fig. 3) (1 mm diameter wire, with 25 mm mesh size) to prevent grazing by wild animals such as deer, pigs, goats and possums. Each plant was a minimum of 600 mm distance from the neighboring plant. A single toxic bait was placed in a smaller wire cage (10 mm mesh size) at the base of eight of the plants (Fig. 4), while a single non-toxic bait was placed at the base of two plants (control plants). Five-gram samples of leaf material were harvested from each of the ten plants at Days 0, 3, 7, 14, 28 and 38 after bait deployment. Each plant sample was triple bagged in water-proof ziplock bags. Five toxic baits were enclosed in a wire cage (Fig. 5) and left in the study site area. A single one of these baits was taken on each of the subsequent sampling days (3, 7, 14, 28 and 38 days) to determine the percentage of leached 1080 over the duration of the study. Bait samples were always taken after the plant tissue samples had been handled and bagged. Baits were triple bagged in water-proof ziplock bags. Plant and bait samples were snap frozen in dry ice and stored at -20°C prior to analysis at Landcare Research.

Figure 3. Setting up wire mesh cages around puha plants with member of LWHRT.

Fine copper-constantan thermocouples covered by a radiation shield located 1.25 m above the ground logged air temperature every 30 seconds using a data logger (21X, Campbell Scientific, Logan, UT, USA), and averaged every 30 min. An automatic rain tipper gauge monitored rainfall events and volume. Volumetric soil water content at a depth of 50 mm was measured daily (ThetaProbe (Delta-T, UK)), calibrated to moisture measured manually from soil samples.

Figure 4. Caged puha plant with 1080 bait in cage at base of plant (indicated by red arrow).

Figure 5. 1080 baits within cage for sampling over the study duration.

Watercress

The stream used for this research was spring-fed. A 100 m length of the stream was selected, based on presence and abundance of watercress. The 100 m was then divided into ten sections of 10 m each (Fig. 6). The start point of each section was marked with string anchored perpendicular to the stream. The three upper most stream sections were used as control sections (non-toxic bait added). The seven downstream sections were treatment sections (toxic bait added). To prevent baits deployed in the water from floating downstream, plastic-coated wire mesh cages were made (1 mm diameter wire, 10 mm^2 mesh, 1 m length cylindrical shaped cages). The cages were inserted into a watercress stand, and a bamboo pole of approximately 1 m height with a pink plastic ribbon tied to the end was secured down the inside of the cage (Fig. 7), into the sediment on the bottom, to clearly mark where bait was deployed. In the control sections, a single non-toxic RS5 cereal bait was dropped into the cage; in the treatment sections, a single toxic RS5 cereal bait was added to the cage. Samples of both toxic and non-toxic baits used were sent to the Landcare Laboratory for 1080 analysis.

Figure 6. 100 m section of stream selected for watercress research, divided into ten equal sections of 10 m.

Figure 7. Water sample collection immediately downstream from bait. Bait was secured within a cylindrical wire mesh cage, and position marked with a bamboo pole and pink ribbon.

Water temperature and pH were measured every half hour at the site using a YSI sonde field logger, deployed in section five (mid-way along the 100 m section). Water velocity was measured in each section of the stream once on each sampling day (1, 3, 7, 10 and 17), using a water velocity meter. Calculations were carried out to convert these measurements to litres per second (L/sec) velocity. Air temperature was measured every half hour for the study duration using a Hobo (Fig. 8), set up next to a stand of bulrushes positioned approximately 4 m away from the stream, at the beginning of section one. An effort was made to position the Hobo where it was not excessively sheltered or exposed to sunshine, to prevent inaccurate readings.

Figure 8. Instrumentation deployed to measure air temperature during the study.

Water and watercress tissue samples were taken at varying times over a 17 day period, from December 1st 2008 to December 17th 2008. Water samples were taken at time 0, 15 and 30 minutes, and 1, 2, 7 and 14 hours. Plastic 250 ml bottles were used. In each section, prior to collecting a water sample, the bottle was rinsed three times with stream water. The water sample was then collected from approximately 10 – 20 cm under the water surface, depending upon depth of the stream at the collection point. The bottles were filled to around 2/3rd of their capacity, to allow room for expansion of the water upon freezing. The water samples were collected immediately downstream from where the bait had been positioned. The upstream, non-toxic sections were always sampled first, followed by the seven downstream toxic sections. Each bottle was nestled in dry ice inside a cooler bin until delivered to the Landcare Research laboratory. Samples from the non-toxic sections (both water and watercress tissue samples) were placed in a separate cooler bin to samples taken from toxic sections. Condition of the bait was recorded at these times also, i.e. colour, swelling and general decomposition of the bait in the water.

Watercress tissue samples were taken at time 0 and 30 minutes, 1 hour, and 1, 3, 7, 10 and 17 days after bait deployment into the watercress stands (Fig. 9). At each of these times, 5 g of harvest quality leaf and stem from above the water line was removed from a plant within a watercress stand immediately downstream of the bait. Tissue samples were placed into plastic zip lock bags labelled with date, sampling day and stream section, and sealed within a further two plastic zip lock bags (triple bagged). These samples were immediately snap frozen on dry ice and stored in the appropriate cooler bin. Samples were delivered as soon as possible to the Landcare Research laboratory, usually within 6 hours, and there were kept at -20º until analysis was carried out.

Figure 9. Watercress growing within the study stream. Note the string marking the start point of a section.

The 1080 concentration contained in all samples (both watercress tissue material and water samples) was quantified by gas chromatography, using methods modified from those developed by Ozawa and Tsukioka (1987). Each sample was homogenised in an alcohol/water mixture, deproteinised, centrifuged, filtered, and passed through an ion-exchange column. The eluent was acidified with hydrochloric acid and converted to the dichloraniline derivative, using dicyclohexylcarbodiimide and 2,4-dichloraniline. The derivative was extracted with ethyl acetate, cleaned with a silica column, and quantified by gas chromatography using electron capture detection. The Method Detection Limit (MDL) in plant material is 3 ppb, and in water samples is 0.1 ppb.

Results

Puha

Quality assurance of the baits used for this field work showed a starting 1080 concentration of 0.15%, the same as that normally found in baits used for aerial operations. This 1080 concentration decreased over time (Fig. 10), until no 1080 was detected above the MDL by Day 38, the final day of sampling. This equates to > 99% of the 1080 leaching from the baits (Table 1). Physical appearance of baits deteriorated; while still intact, they appeared weathered, cracked and the presence of the green dye faded considerably over this period.

Table 1: Concentration of 1080 in baits after 0 and 38 Days

	1080 Concentration in bait (% of total weight)		
	Day 0	Day 38	% 1080 gone from bait by Day 38
Cereal Bait	0.15	<MDL	> 99%

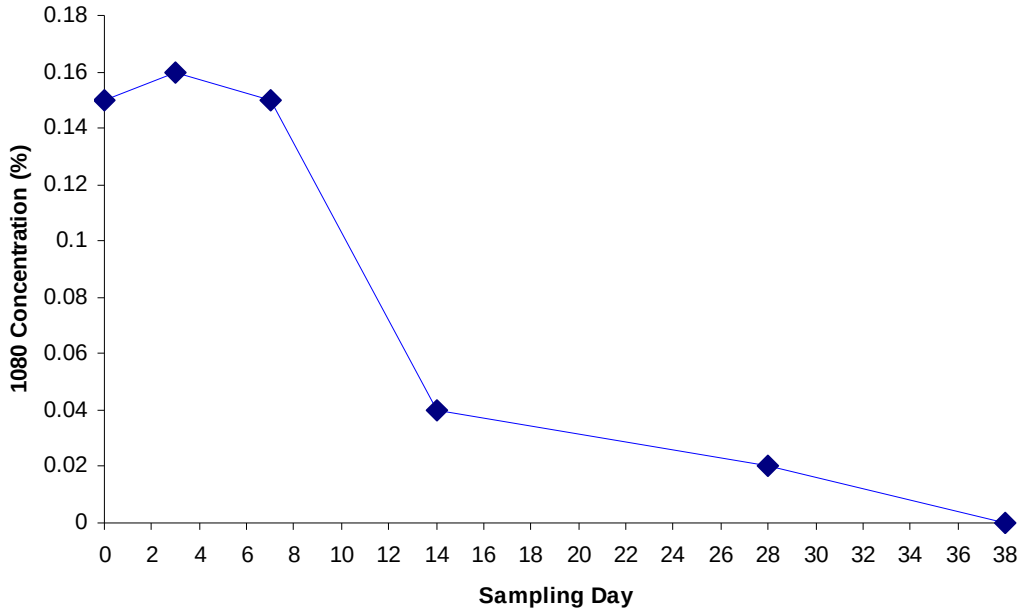

Figure 10. Concentration of 1080 from toxic baits over study duration.

Over the 38 day duration of this component of the study, average daily air temperature ranged from 9 - 23ºC; average litter temperature from 11 - 19ºC; rainfall from 0.0 – 16.7 mm/day (Fig. 11); and soil moisture from 0.382 – 0.717m^3/m^3. Maximum rainfall was 16.7 mm/day, and the mean rainfall was 1.66 mm/day. Three major rainfall events occurred. No discernable patterns are apparent from this environmental data; however average daily air and litter temperature showed similar fluctuations (Fig. 11).

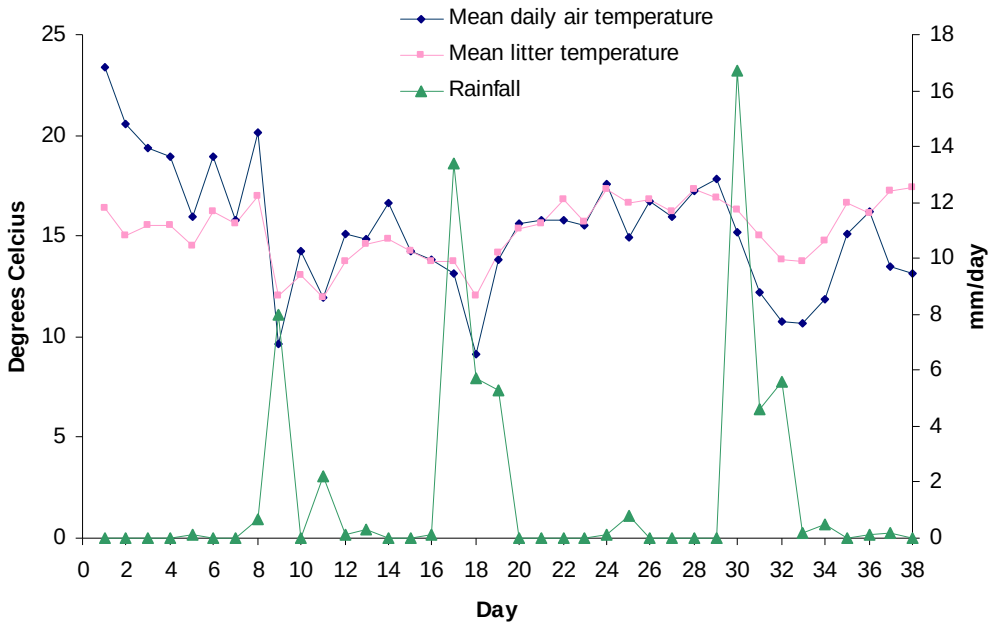

Figure 11. Mean daily air temperature, mean litter temperature (°C), and rain fall (mm/day) over the study duration.

Of the 60 plant tissue samples collected (10 plants at six sampling days), 14 showed measurable concentrations of 1080 i.e. 14 samples were above the Method Detection Level (MDL) of 3 ppb (Table 2). Maximum 1080 concentration recorded in plant tissue was 15 ppb from a single sample on Day 3. One plant (plant 3) never showed 1080 concentrations above the MDL. This was not a control plant. Both control plants showed levels of 1080 above the MDL at varying time points, although this was not consistent across all days, only occurring once in one plant, and twice in the other control plant.

Curiously enough, with the MDL removed, 1080 appeared at very low concentrations (minimum 0.1 ppb) in ***59 of 60*** plant tissue samples, including on Day 0, before the addition of toxic baits (Table 2). This is comparable to levels of 1080 seen in common brands of tea leaves, i.e. Bell Tea, Tiger Tea, PG Tea etc., where the concentration of 1080 detected ranged from 0.2 – 1.2 ppb (Eason et al. 1995). However, as mentioned earlier, accuracy decreases at these low concentrations.

Table 2: Concentrations of 1080 (ppb) detected in plant tissue samples (raw data) with the Method Detection Limit (MDL) removed. Numbers in RED indicate 1080 concentrations above the MDL (3 ppb).

	Plant 1					Plant 6				
Day	Control	Plant2	Plant 3	Plant 4	Plant5	Control	Plant 7	Plant 8	Plant 9	Plant 10
0	0.7	0.2	0.2	0.2	0.1	0.2	0	0.4	1.6	0.2
3	**11.2**	1.8	0.5	0.8	0.6	0.5	**8.9**	1.2	**15.4**	0.8
7	1.5	1.5	2	0.9	0.6	0.6	1.1	0.8	0.5	0.4
14	0.5	**9.2**	0.3	0.5	**5.8**	0.4	1.3	0.8	**3.9**	1
28	**3.5**	**4.9**	2.5	**4.7**	2.9	**3.3**	**5.1**	**3.2**	**4.3**	**3.1**
38	0.3	0.6	0.3	0.3	0.3	0.3	0.2	0.2	0.4	0.3

Anomalies occurred with this data - a standard decay curve was not seen (Fig. 12). With the MDL in place, no 1080 appeared on Day 7 or Day 38; with the MDL removed, 1080 was detected on both of these days at very low concentrations (Table 2). All levels of 1080

detected, regardless of plant or sample day, were at very low concentrations.

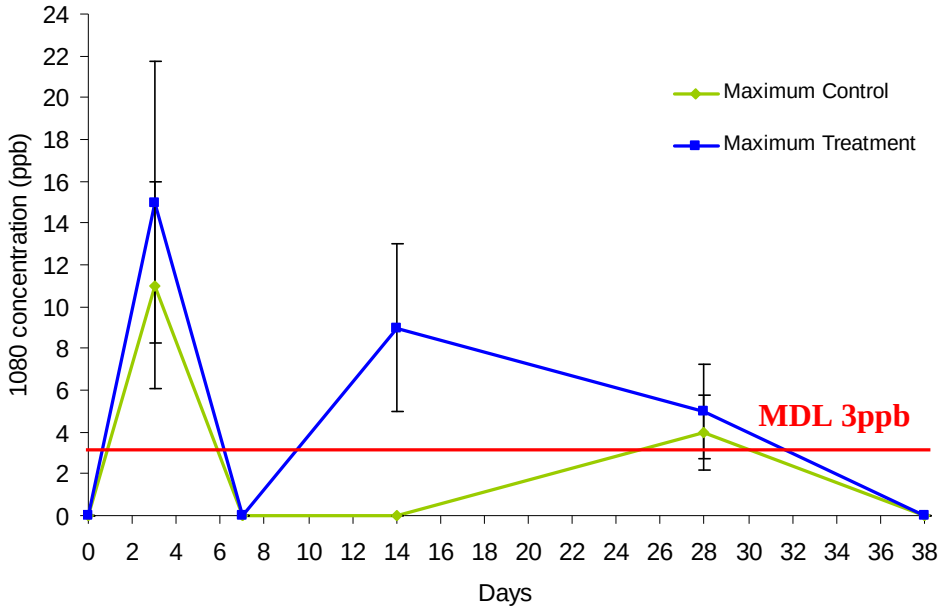

Figure 12. Maximum 1080 concentrations (ppb) seen from puha tissue samples over study duration.

When maximum 1080 concentration from puha samples was graphed with rainfall (Fig. 13) (mm/day) no pattern was observed, as the rainfall events occurred after sampling. However, plant tissue samples were not collected every day, and had daily sampling occurred a pattern may have been observed.

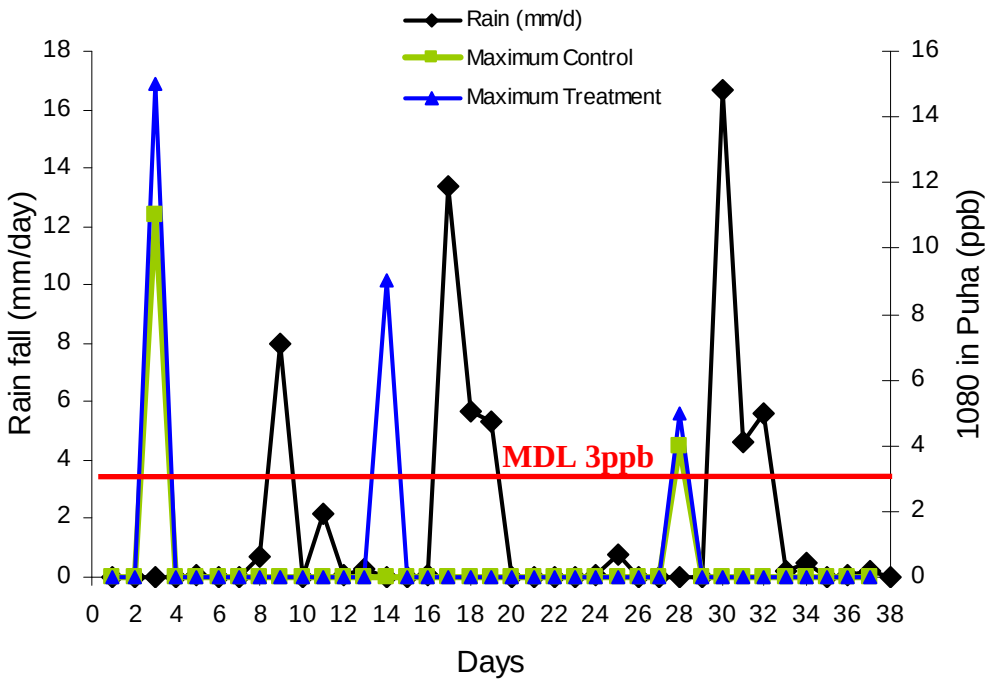

Figure 13. Maximum 1080 concentrations (ppb) from puha tissue samples, and rainfall (mm/day) over study duration.

Mean daily air and litter temperatures (ºC) also appeared to have no affect on the maximum 1080 concentrations recorded from puha samples (Fig. 14).

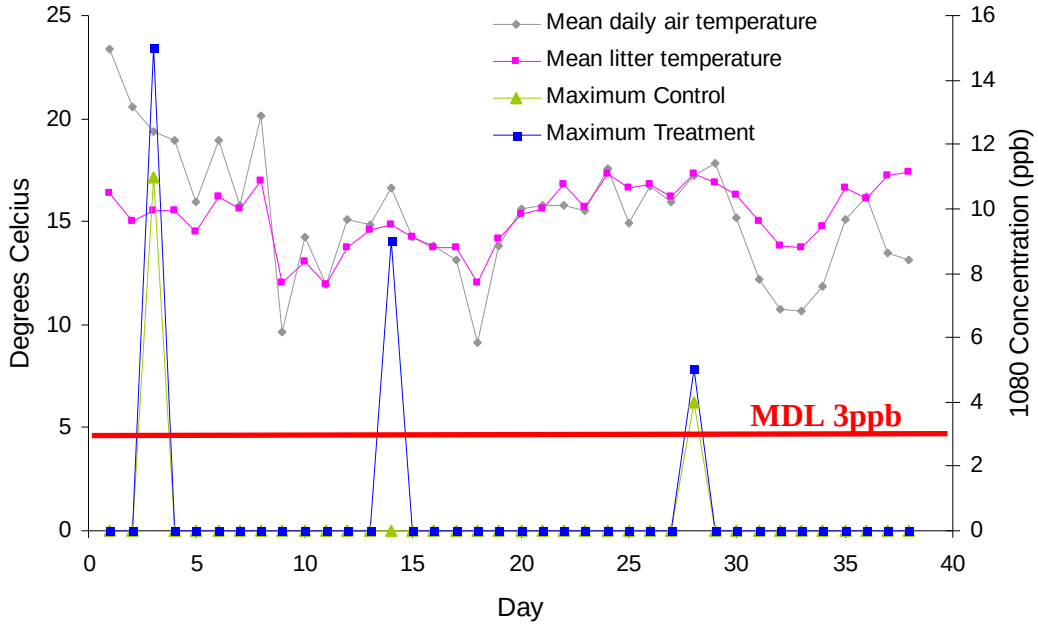

Figure 14. Maximum 1080 concentrations (ppb) from puha tissue samples, mean daily air temperature and mean litter temperature (°C) over study duration.

Watercress

Quality assurance of the baits used for this component of the research showed a 1080 starting concentration of 0.17%, slightly higher than the nominal 1080 concentration in baits used for aerial operations, of 0.15%. Non-toxic baits were tested to ensure they did not contain any measurable levels of 1080. Laboratory results showed they were below the Method Detection Limit (MDL) for 1080, and therefore non-toxic. Baits were not sampled over time, as was done with the puha research, as baits submerged in flowing water rapidly break down.

Visual observations showed baits were swelling after two hours in the stream and were severely cracking and breaking when checked at 14 hours. Twenty-four hours after placing toxic baits in the stream, all green dye had disappeared, baits had all but broken down and only a few crumb-sized pieces could be seen in places. Subsequent visual checks showed baits were no longer visible after the 24 hour check; however this does not mean 1080 was no longer present, just that baits had deteriorated to a point where they were too difficult to detect visually.

Over the 17 day duration of this component of the research, mean daily air temperature ranged from 11.94 – 20.31˚C; mean water temperature ranged from 13.76 – 14.85˚C; and mean daily pH 7.3 – 8.2 (Fig. 15). Mean daily air temperature fluctuated somewhat, and would have been influenced by overnight temperatures being included in the daily average temperature. Mean water temperature fluctuated very little, varying by little more than 1˚C over the 17 days. Mean pH showed a gradual increase over time. The lowest mean pH reading was taken on the first day of the study (pH 7.3) and constantly and gradually increased over the following 17 days, to pH 8.2. Rain fall was recorded on only three of the 17 days – Day 1 (11 mm), Day 4 (1 mm) and Day 9 (9 mm).

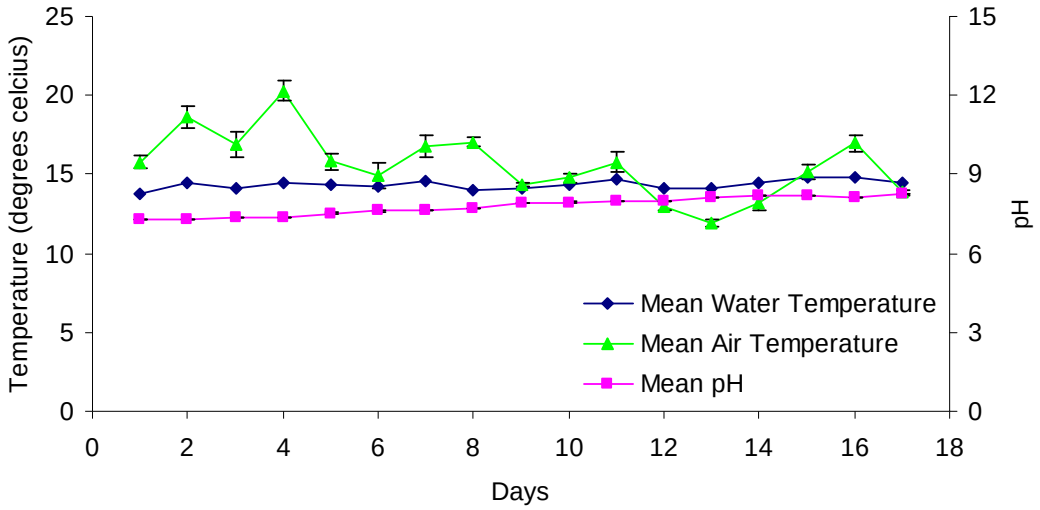

Figure 15. Mean daily air and water temperature (˚C) and mean pH, with standard error bars.

The stream this research was conducted in was spring-fed, and overhung by exotic vegetation, primarily willows (Genus *Salix*), with broken branches of these trees lying in the stream. Long grass and other plant species not identified here were also present at varying points and in varying density along the stream. The stream itself was not straight but had a number of curves and boggy sections. Width and depth of the stream varied. The widest point of the selected 100 m of stream was at section 10 (3.2 m); the narrowest point was at section 8 (1.1 m). The deepest point occurred in section 6 (0.48 m); the shallowest point occurred in section 8 (0.19 m).

Water velocity was measured in each of the ten sections of the stream on each sampling day (1, 3, 7, 10, 17) of the study. When water velocity in each of the ten sections was averaged across the 17 days of the study, section 8 had the slowest water flow (0.013 L/sec), while section 6 had the fastest water flow (0.095 L/sec) (Fig. 16). The second widest point in the stream occurred at section 6 (2.7 m).

The average water velocity over the study duration across the whole length of stream used for this research ranged from 0.042 – 0.044 L/sec, showing it was almost constant. Rain fall events did not create any noticeable increases in water velocity (Fig. 17). This would have been largely due to two factors – 1) the stream was spring-fed, and 2) two of the three rain fall events recorded occurred after water velocity was measured. However, in the one instance where rain fall was recorded prior to a sampling day (rain fall on Day 9, 9 mm, water velocity measured on Day 10), no increase in water velocity was observed.

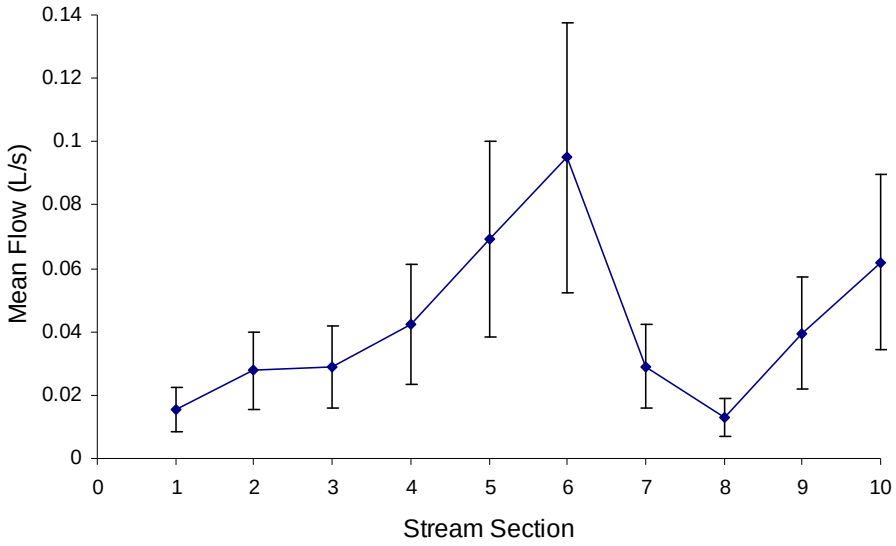

Figure 16. Mean water velocity (L/sec) in each section of stream over study duration, with standard error bars.

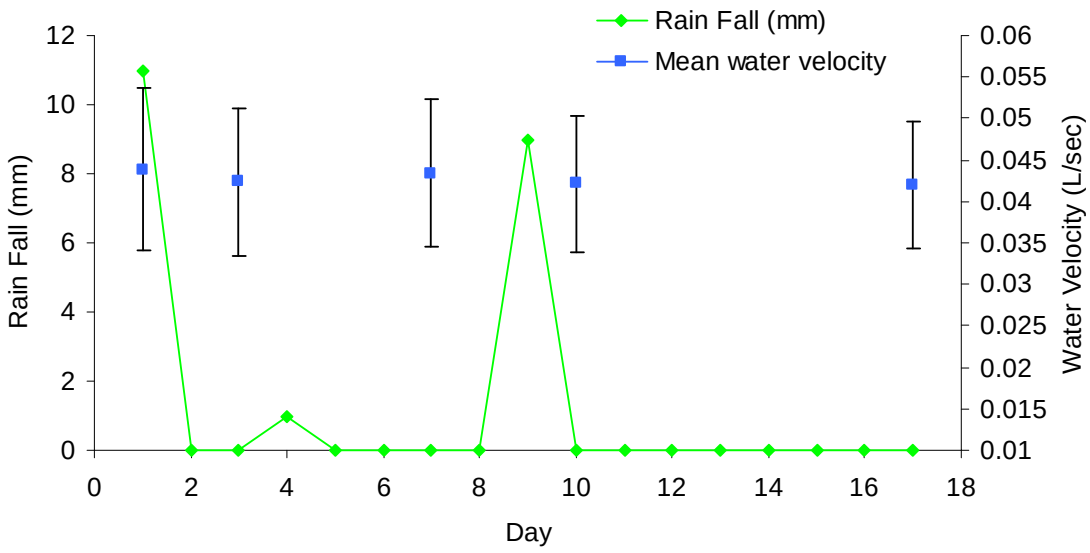

Figure 17. Mean water velocity (L/sec) over the length of stream, with standard error bars, and corresponding rain fall events.

Water from each of the ten sections was tested for 1080 concentration at seven time periods within 14 hours of bait placement, giving a total of 70 samples. Twenty one samples came from upstream, in the three treatment (non-toxic) sections. None of these 21 samples showed any measurable 1080 concentrations. Of the 49 remaining water samples from the treatment sections, 18 samples showed measurable levels of 1080, meaning 31 did not show detectable levels of 1080. The minimum 1080 concentration detected was 0.1 ppb at 14 hours. This is equivalent to the MDL. The maximum 1080 concentration detected was 7 ppb at 1 hour (Fig. 18). 1080 was first detected 15 minutes after bait deployment (3 ppb). After the maximum 1080 was detected 1 hour after bait deployment, 1080 concentration decreased until at 14 hours (840 minutes) the concentration of 1080 detected was equivalent to the MDL (0.1 ppb).

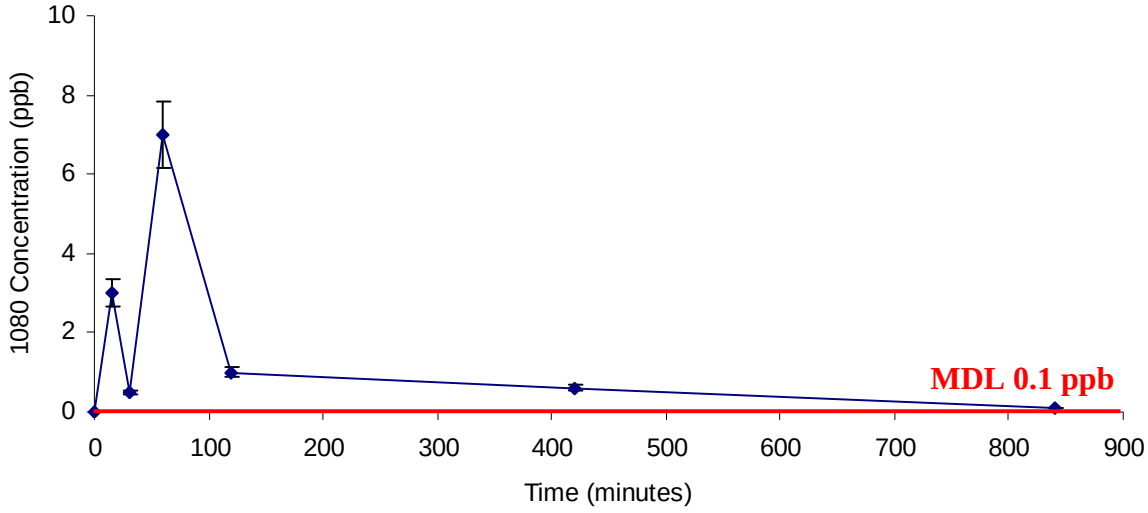

Figure 18. Maximum 1080 concentration (ppb) seen in water samples from time 0 minute to 14 hours, with a 95% confidence interval of ±12%.

Mean daily air and water temperature did not overlap with the water sampling times, as they were averaged for a daily reading, while all water samples were collected within the first 14 hours of the research. As such, no graph is presented of this data as there were no patterns to be observed due to this lack of overlap.

When the maximum 1080 concentration seen from each section was plotted with the mean water velocity (L/sec) from each section (Fig. 19), it was apparent that the mean velocity in each section may have influenced the maximum 1080 concentrations. Section 8, with the slowest mean flow of 0.013 L/sec, corresponded to where the maximum 1080 concentration was detected, 7 ppb. Conversely, section 6 with the fastest mean flow of 0.095 L/sec, corresponded to where the lowest maximum 1080 concentration was detected within the treatment sections, being below the MDL. Treatment sections did not show any detectable 1080 concentrations.

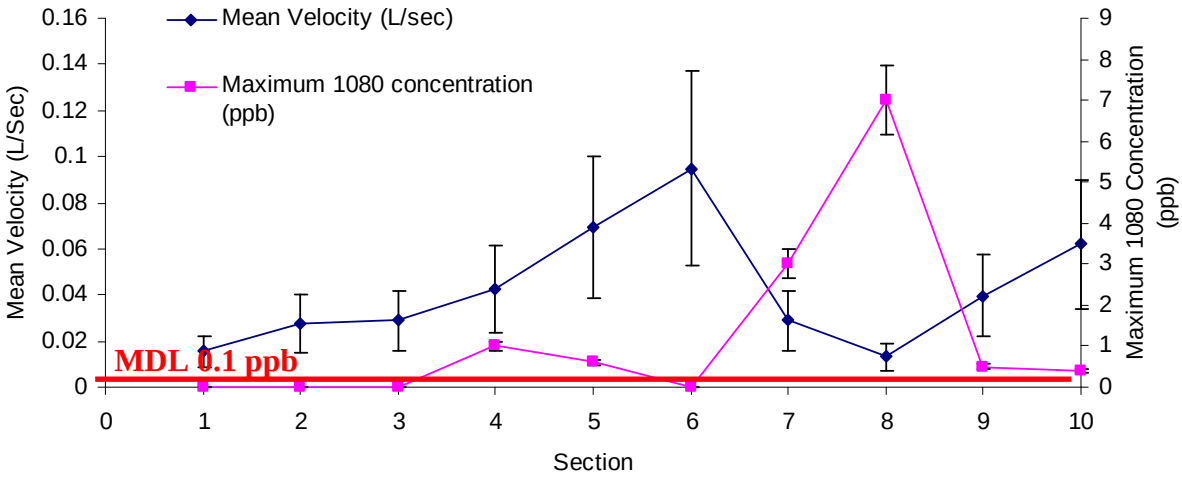

Figure 19. Mean water velocity (L/sec) in each section of stream, with standard error bars, and maximum 1080 concentration (ppb) from water in each stream section, with 95% confidence interval of ±12%.

Plant tissue samples from watercress stands within each of the ten stream sections were taken at eight time periods, giving a total of 80 samples over the 17 day duration. No 1080 was detected from any of the 24 samples taken in the three control sections. 1080 was detected in only three samples from within the remaining 56 treatment samples, meaning 53 samples did not contain detectable levels of 1080. A low concentration of 1080 was detected 30 minutes after bait deployment, at 17 ppb from a single sample in section 9. 1080 was again detected on Day 3, at 8 ppb from section 10. The maximum 1080 concentration was detected on Day 7, at 63 ppb, from section 8. All readings after this were below the MDL, showing that 1080 had broken down after this time (Fig. 20).

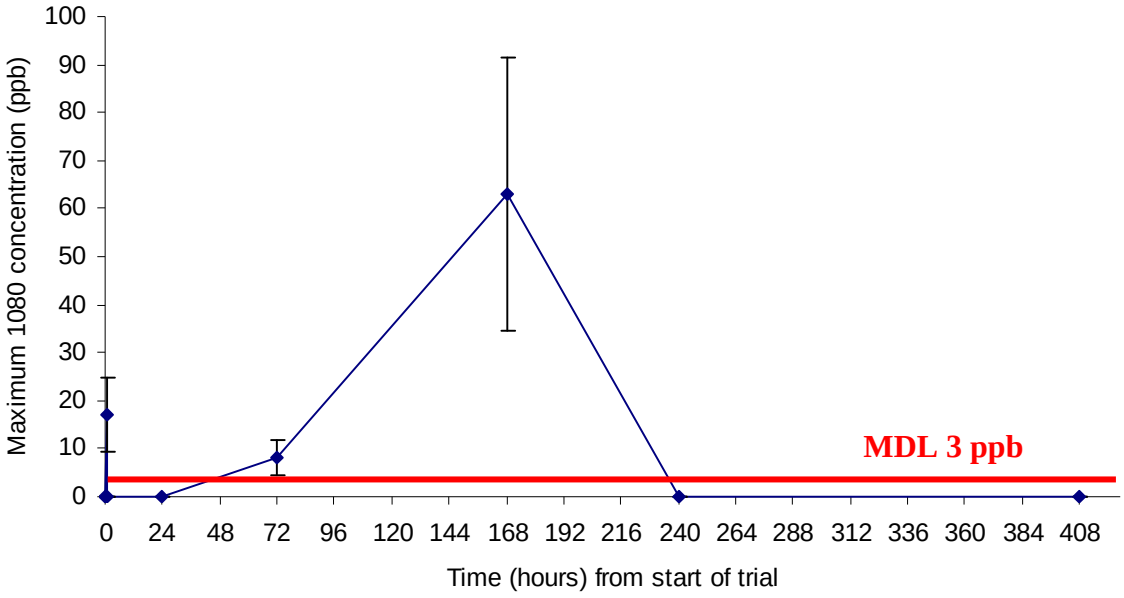

Figure 20. Maximum 1080 concentration (ppb) seen from watercress tissue samples over study duration, with a 95% confidence interval of ±45%.

When the maximum 1080 concentration from the watercress tissue samples for each section were graphed with the mean water velocity (L/sec) in each section (Fig. 21), it was apparent that the mean velocity influenced where the maximum 1080 concentrations were detected. As per the water samples (Fig. 20), maximum 1080 concentration detected came from section 8, which also had the slowest water flow of 0.013 L/sec. No watercress tissue samples from sections upstream of section 8 had any 1080 detected in them, with the three samples where 1080 was detected being in section 8 on Day 7, section 9 at 30 minutes after bait deployment and section 10 on Day 3. This indicates that 1080 was being washed downstream from the upstream treatment sections, and being slowed by water velocity in section 8, where the watercress then had an opportunity to take up the 1080.

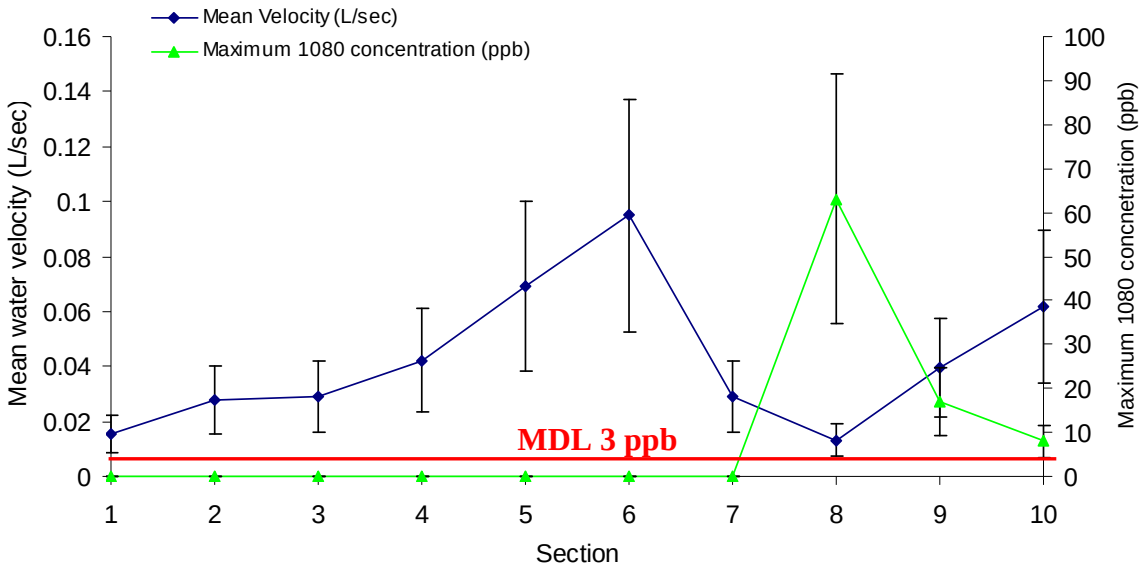

Figure 21. Mean water velocity (L/sec) in each section of stream, with standard error bars, and maximum 1080 concentration (ppb) from watercress in each stream section, with a 95% confidence interval of 45%.

When mean daily air and water temperatures are plotted with the maximum 1080 concentrations seen from the watercress tissue samples, no obvious pattern emerges (Fig. 22). Neither mean daily air, nor mean water temperature appears to have influenced the 1080 concentrations detected.

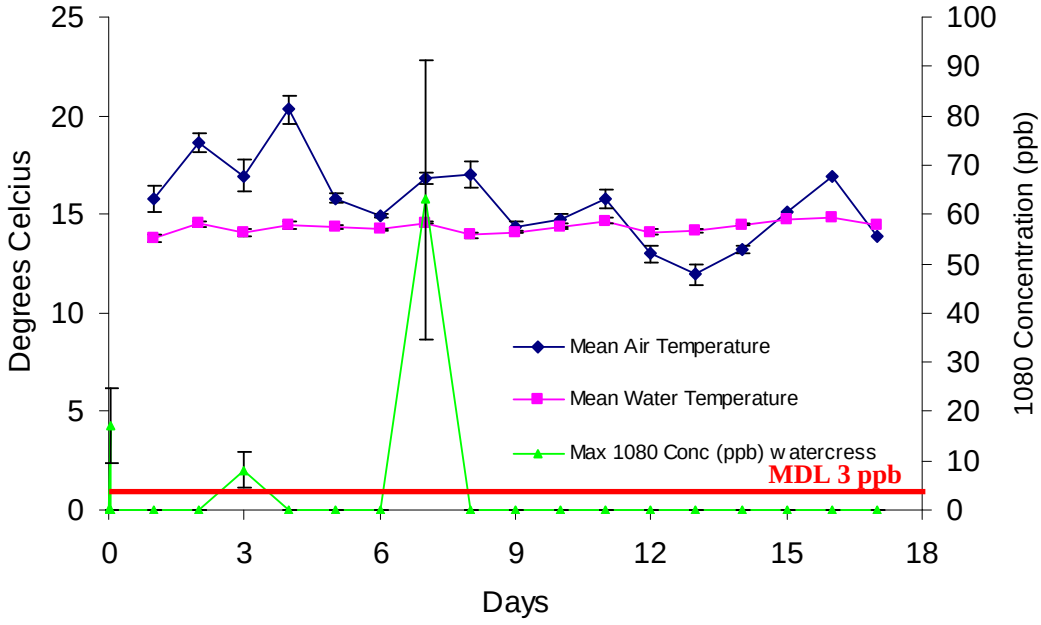

Figure 22. Mean daily air and water temperature, with standard error bars, and maximum 1080 concentration (ppb) from watercress tissue samples.

Adding the findings to the 1080 database

The new information from this study has been added to the 'Plants' section of the 1080 database, at www.lincoln.ac.nz/1080.

Reporting research findings to the collaborative Maori community and nationally

On 14th November 2008 members of the research team gave a presentation of these findings to members of LWHRT, TTT and local DoC representatives from the Lake Waikaremoana area. The results generated much discussion. When this data was compared with previous findings of 1080 concentrations in common tea brands, it gave perspective to the levels of 1080 being detected.

A presentation of this research was made at the National Pest Control Agency (NPCA) conference in Wellington, 26th – 27th November 2008.

A final meeting of representatives from LWHRT, TTT, DoC and Kaikoura Runanga was held on 7th April 2009. The team were especially interested in further exploration of the idea that 1080 could be naturally present in puha. It was thought that this should be followed up, with a more substantial survey of puha, and with a survey of other New Zealand plant species that may also contain 1080.

A popular article reporting the results of this study has been accepted for publication in *Te Putara*, a publication of the Environmental Risk Management Authority (ERMA). *Te Putara* is disseminated to Maori environmental managers, kaitiaki, and iwi authorities throughout New Zealand.

Publishing findings in a peer-reviewed journal

The results presented in this final report have been converted into a manuscript and submitted for publication in *Ecotoxicology* -an international peer-reviewed scientific journal.

Discussion

Bait and Environmental Conditions - Puha

As expected, the concentration of 1080 contained within the baits used for this component of the study started at the same concentration as that normally found in baits used for 1080 aerial possum operations, 0.15%. As such, the bait was appropriate for the objectives of this research.

Over time, 1080 concentration in the baits decreased, until no 1080 was detectable at Day 38. These baits were subject to the same environmental conditions as those in the field study, i.e. they were left at the study site covered only by a wire mesh cage. It is likely that 1080 leached from the baits at the point of contact with the ground, where soil micro-organisms such as *Psuedomonas* and *Fusarium* species, which have been reported as being able to break down 1080, would have been in direct contact with the baits (King et al. 1994).

Highest 1080 concentration from the baits was recorded prior to the first major rainfall event. It is most likely that this rainfall event promoted the leaching of 1080; however this event occurred on Day 8, bait was sampled on Day 7 and then not sampled again until Day 14; therefore any toxin leaching immediately after this rainfall event was missed due to the sampling regime.

Over the duration of the study, little rainfall occurred, with an average daily rainfall of 1.66 mm/day. Soil moisture content increased somewhat after this first rainfall event on Day 8, but remained relatively constant for the duration, remaining above 0.5 m^3/m^3 and below 0.65 m^3/m^3. Mean daily air temperature and mean litter temperature showed slight decreases after the rainfall events.

1080 Concentration - Puha

The concentration of 1080 detected in the puha tissue samples did not follow a normal decay curve, and a number of anomalies were seen that are difficult to explain.

The first and most obvious of these anomalies was the appearance of measurable 1080 levels in both control plants. The maximum 1080 concentration observed in a control plant was 11 ppb, not much lower than the maximum 1080 concentration seen in plants treated with toxic baits, of 15 ppb. 1080 was not detected in every sample from the two control plants, but low concentrations were seen twice from one plant and once from the other control plant.

Initial analyses of the data indicated possible contamination, either during handling or analyses, but as contamination events tend to be represented by extremely high levels of toxin (P. Fairbrother *pers. comm.*), stringent handling and laboratory procedures were followed, and the amounts of 1080 being detected were barely above the MDL, this was unlikely and was ruled out. The only plant that did not show any 1080 present in concentrations above the MDL was treated with toxic bait.

One suggestion made that may partially explain the occurrence of 1080 in the control plants, was that the non-toxic baits may have invariably contained 1080 (M. Thomas *pers. comm.*). Here, the concentration of 1080 in the non-toxic baits was not tested, so this remains unknown. It does not, however, explain the occurrence of 1080 at low concentrations in the

Day 0 plant samples, prior to any baits being used on site.

The second anomaly seen was that no 1080 was detected above the MDL in any plant on Day 7, yet on Day 14, three of the plants again showed detectable levels of 1080, and on Day 28, 8 of the plants, including both control plants, also showed very low concentrations of 1080; however these levels were barely above the MDL of 3 ppb. There is no apparent explanation for this irregularity.

Previous work done by the research team investigated the uptake and persistence of 1080 in pikopiko (*Asplenium bulbiferum*, a plant species used for food) and karamuramu (*Coprosma robusta*, a medicinal plant) under field conditions (Ogilvie et al. 2004). 1080 was never detected in pikopiko, and minimal quantities were recorded from karamuramu. Concentrations of 1080 in karamuramu peaked at Day 7, at 5 ppb, and by Day 28, no detectable levels of 1080 were measured (Ogilvie et al. 2004). Here the maximum 1080 concentration of 15 ppb was seen on Day 3, no 1080 was detected in any plants on Day 7, 1080 was again detected on Day 14 and low concentrations were seen on Day 28, but no 1080 was present above the MDL on Day 38. The 1080 did therefore decrease to levels below the MDL by the end of the study, and when present, were only in very low concentrations.

The maximum 1080 concentration recorded here is comparable to that seen in karamuramu (5 ppb, Ogilvie et al. 2004), but is lower than 1080 concentrations recorded from ryegrass (80 ppb after 3 days) and broadleaf (60 ppb after 10 days) (Ogilvie et al. 1998). However, research on ryegrass and broadleaf used RS5 compared to the Wanganui #7 baits used here, and was also conducted under controlled laboratory conditions, not in the field, as with the karamuramu and puha results obtained here, making these studies difficult to compare directly.

Removal of the MDL

A further anomaly became apparent when the MDL was removed from the raw data. Standard laboratory procedures impose an MDL at 3 ppb, as below this, the confidence of accuracy in any 1080 detected decreases (±45% CI above 3 ppb, becoming greater below 3 ppb); therefore with the 3 ppb MDL in place, all readings below this are reported as "Below MDL". However, due to the unusual nature of the data, it was decided to investigate the data with the MDL removed.

With no MDL imposed, ***59 of 60*** samples showed 1080, including tissue samples taken on Day 0 – *prior* to the addition of toxic 1080 baits. Where previously "Below MDL" had been recorded, levels from 0.1 ppb – 2.9 ppb were recorded, although again, these are all extremely low concentrations. As already mentioned, these levels are comparable to levels of 1080 seen in common brands of tea leaves, i.e. Bell Tea, Tiger Tea, PG Tea, where the concentration of 1080 detected ranged from 0.2 – 1.2 ppb (Eason et al. 1995). What this indicates is that 1080 could naturally occur in puha.

Bait, Environmental Conditions, and Water Velocity – Watercress

Unlike results seen from the puha component of this research, toxic baits submitted for 1080 analysis for this section of the research came back showing slightly elevated concentrations of 1080 (0.17%) compared to that normally found in baits used in 1080 operations (0.15%).

However, by the time laboratory results were known, field work had already been carried out using these baits. With a 95% confidence of ±45% on all solid (i.e. non-water sample) 1080 analyses from the laboratory, the research team do not consider the toxin loading in these baits to be unusually high, or that it would falsely elevate 1080 concentrations from samples in any way.

Visual inspections of the baits, while not quantifiable, gave an indication of the rate of deterioration in flowing stream water. As was expected, bait swelled rapidly, cracked and began breaking apart, and after 24 hours, only crumbs remained to be seen. At subsequent checks, no bait could be seen; however one cannot rule out the possibility that small fragments of the baits may have sunk in the water column or become covered by sediments. 1080 is known to be highly water soluble (Eason et al. 1992; Meenken & Eason 1995; Booth et al. 1999). A study by Suren (2006) examined the fate of 1080 baits in a controlled laboratory flow tank, and found 50% of the 1080 leached after 5 hours submerged in the water, and >90% leached after 24 hours, thus being very rapid. While the flow rate used in Suren's (2006) controlled experiment was faster than the flow rates recorded here (0.2 L/sec as opposed to an overall stream flow of 0.042 – 0.044 L/sec in this research), it still indicates the rapid deterioration and leaching of 1080 from baits submerged in flowing water. However, micro organisms, bacteria and plants present in the spring-fed stream would have facilitated 1080 leaching.

Mean daily water temperatures recorded from the stream did not vary greatly, with little more than 1˚C difference seen between the minimum and maximum readings. As this stream is spring-fed, external environmental conditions, such as air temperature/daylight hours, would have had only a small effect on water temperature; however the stream is relatively shallow (maximum depth 48 cm in the experimental area), but also shaded by overhanging willow trees and vegetation, reducing direct UV exposure. Rainfall events occurred only three times over the study duration, with maximum rainfall recorded at 11 mm. Again, due to the stream being spring-fed, rather than relying on rainfall, no change in water velocity or mean water temperature was observed.

The pH of the stream water showed a small but gradual increase over the duration of the study. The pH of the stream water started at pH 7.3, which is relatively neutral, and increased to pH 8.2, meaning it became more basic (i.e. less acidic). Water temperature can influence pH – as temperature increases, pH decreases (becomes more acidic) to try and absorb the extra heat (www.lentech.com ©2008). This is opposite to what was observed here, with only a very small increase in water temperature, (Fig. 15), which may have had some influence on the small increase in pH recorded here.

Water velocity (L/sec) in the stream was relatively constant when looked at across the 100 m stretch of stream used. Because this is a spring-fed stream, water velocity would not have been much influenced by rainfall events, and would rely primarily on the amount of water coming from the spring. However, when water velocity in each of the ten sections of the stream was investigated individually, it was found that section 6 had the highest water flow, and section 8 the slowest flow. This relates directly to the size of the stream at each of these points. Section 8 was the shallowest and narrowest point in the study stream, whereas section 6 was the deepest and second widest section. Section 8 occurred on a bend in the stream; section 6 occurred in a straight section between bends. The depth, width and curves in the stream would all have contributed to affecting water velocity, as would aquatic vegetation growth, submerged branches (Figueiro et al. 2008) and water flow around rocks (Eymann

1993). Gradient of the stream bed and type of substrate would also affect water velocity; however these factors were not investigated here, but would all contribute to influence water flow velocity.

1080 Concentration – Water and Watercress

The concentration of 1080 was measured both for water from the stream, and watercress tissue samples. For both the water samples and the watercress tissue samples, no 1080 was detected from any of the control sections, indicating 1080 does not naturally occur in watercress, as was expected.

Of the water samples, 18 of the 49 treatment samples contained detectable levels of 1080 although all levels were very low. 1080 was first detected 15 minutes after the addition of toxic baits, and peaked 1 hour later, in section 8. As already mentioned, section 8 had the slowest water velocity due to a number of physical factors such as stream width, depth and gradient, many of which were not investigated in this research. The presence of large volumes of aquatic plants, such as the watercress being studied here, would also slow water velocity, leading to 1080 being present for longer, before degrading. There is also the possibility that 1080 from faster flowing upstream sections was washed into section 8, contributing to an elevated 1080 concentration in comparison to the other sections. It is therefore no surprise that the maximum 1080 concentration was detected in section 8. By contrast, no 1080 was detected in water samples from section 6, where water velocity was at its greatest.

Levels of 1080 decreased after the maximum peak seen at 1 hour. At 14 hours, 1080 was still detected, at a level equivalent to the MDL (0.1 ppb). It was also only detected in a single water sample at this time point, thus no further testing of water samples was done, as a standard decay curve was observed. As already noted, 1080 is known to be highly water soluble (Eason et al. 1992; Meenken & Eason 1995; Booth et al. 1999). Suren (2006) showed that 50% of 1080 leached from baits in a controlled laboratory flow tank after 5 hours submerged in the water, and >90% had leached after 24 hours. Studies investigating 1080 concentrations in water ways after aerial 1080 operations tend to sample from pre-determined sites, and usually detect no, or only minimal amounts of 1080 (Eason et al. 1992; Hamilton & Eason 1994; Meenken & Eason 1995). Here, we sampled water directly downstream from where we knew toxic baits had been placed, which would have increased the chances of detecting 1080.

Studies by Ogilvie et al. (1995, 1996) showed that temperature significantly affects the rate at which 1080 is degraded in water, with higher temperatures resulting in faster degradation, and 1080 degrading faster in stream water than ionised water (Ogilvie et al. 1996). Water temperature in this study was relatively constant, and could even be considered warm, at 13.76 – 14.85˚C. Temperature and the presence of micro-organisms in the water would therefore have played a role in the relatively quick degradation of 1080. The findings of Ogilvie et al. (1995, 1996) substantiate what was seen here, that 1080 rapidly degrades in flowing water, and supports our findings, that after 14 hours only minimal traces of 1080 were detectable in steam water samples.

Of the watercress tissue samples from the seven treatment stream sections, 53 of the 56 samples did not contain any measurable level of 1080; therefore only three tissue samples

showed 1080 at detectable levels (above 3 ppb). These samples came from sections 9 (17 ppb), 10 (8 ppb) and 8 (63 ppb) respectively, all downstream sections. Section 8 was also where 1080 concentration peaked in the water samples. As already noted, section 8 had the slowest water flow of the 10 stream sections, meaning fragments of baits from other upstream sections could have accumulated in section 8 and sat there degrading, exposing watercress tissue in this section to greater levels of 1080 than plants in other sections.

1080 was detected in watercress tissue samples on Day 7, and was not detected again from plants on any subsequent sampling days; therefore a standard decay curve was seen. Concentration of 1080 detected within this research was comparable to that seen in experiments investigating the uptake of 1080 in the native aquatic plant *Myriophyllus triphyllum*, (25 ppb) (Ogilvie et al. 1995), and the non-native aquatic plant *Elodea Canadensis* (80 ppb) (Ogilvie et al. 1996). Both of these studies were conducted under controlled laboratory conditions, whereas the research here was conducted under field conditions. These levels are, nevertheless, still low.

All watercress samples taken here were from harvestable plant tissue above the water line, from an area immediately down stream and as close as possible to where bait was placed. Therefore, before any 1080 could be detected in these samples, it first had to enter the plant below the water line where the 1080 was present, and move through the plant to the upper harvested tissue. This would contribute to the lag time seen between 1080 in the water samples, and appearing some days later in the watercress tissue samples. Temperature as well as the presence of micro-organisms capable of degrading 1080 would have also contributed to the degradation of 1080.

The 1080 detected in watercress tissue samples are likely to have been affected by differences between plant uptake rates. Once a plant was harvested for sampling, the same plant could not be harvested again as it had been removed through sampling, although a plant from within the same stand or a nearby stand of watercress was harvested at subsequent times. It is possible that small fragments of bait which were not detected visually may have sunk into the sediment where 1080 leaching would have occurred at a slower rate, exposing the plants to 1080 after the majority of the toxin had degraded, thus explaining the peak in 1080 seen on Day 7. This seems unlikely though, due to the rapid detection of 1080 in the water samples, and the final sample at 14 hours being equivalent to the MDL.

As with previous studies investigating the uptake and persistence of 1080 in plants (Ogilvie et al. 2006), here it was seen that watercress can take up 1080; it occurs at levels comparable to previous studies on aquatic plant species, such as *M. triphyllum* (25 ppb) (Ogilvie et al. 1995) and *E. canadensis* (80 ppb) (Ogilvie et al. 1996); and it also rapidly eliminates 1080, with 1080 no longer detected from any watercress samples from Day 10 onwards.

An assessment of toxicity risk to humans

The maximum concentration of 1080 seen in puha in this study was 15 ppb, or 0.000015 mg/g. The LD_{50} (dose considered lethal to 50% of individuals of a given population) for humans is 2 mg/kg (Rammell & Fleming 1978). For a 70 kg person this is equivalent to a dose of 140 mg. The amount of puha that would contain 140 mg of 1080 is:

$$\frac{140 \text{ mg}}{0.000015 \text{ mg/g}} = 9, 333, 333 \text{ g}$$

Therefore a 70 kg person would need to consume 9.3 tonnes (9, 333, 333 g) of puha containing the maximum 1080 concentration of 15 ppb recorded here, in a single sitting, to receive an LD_{50} and therefore have a 50% chance of dying.

The maximum concentration of 1080 seen in watercress in this study was 63 ppb, or 0.000063 mg/g. An LD_{50} equates to:

$$\frac{140 \text{ mg}}{0.000063 \text{ mg/g}} = 2, 222, 222 \text{ g}$$

Therefore a 70 kg person would need to eat 2.2 tonnes of watercress containing 1080 at the maximum concentration detected here, of 63 ppb, in a single sitting, to have a 50% chance of dying. Due to the large volume of plant matter needing to be eaten for both of these species, we believe there is a negligible risk of humans being poisoned by 1080 through the consumption of puha or watercress after an aerial 1080 operation.

Conclusions

Puha

- 1080 can leach from baits under field conditions.
- 1080 was detected at very low concentrations (maximum 15 ppb in leaf material on Day 7) in puha.
- 1080 was also detected at very low concentrations in both control plants, but not consistently.
- After the 38 days duration of the study, no 1080 was detected above the MDL.
- When the MDL was removed, 1080 was apparent in 59 of the 60 plant tissue samples taken.
- Based on data collected here, it appears that 1080 occurs naturally in puha.
- However, even at the maximum concentration of 1080 recorded (15 ppb), a 70 kg person would need to eat 9.3 tonnes of puha in a single sitting, to receive an LD_{50}; therefore based on this risk profile, we would conclude that there is a negligible risk to humans of 1080 poisoning after an aerial 1080 operation.

Watercress

- 1080 rapidly leaches from baits when in flowing stream water, and 1080 concentration in water samples was equivalent to the MDL after 14 hours (0.1 ppb).
- No 1080 was detected from any water or plant control sections.
- 1080 was detected in only 3 of 56 watercress tissue samples, with a maximum concentration of 63 ppb seen in a single sample at Day 7.
- No 1080 was detected from watercress tissue samples after Day 10.
- Based on this data, it appears watercress can take up and eliminate 1080.
- From the risk assessment analysis, we conclude there is a minimal risk to humans of secondary poisoning from consuming 1080-affected watercress after an aerial 1080 operation.

Recommendations

- The poisoning of humans by the consumption of puha or watercress after an aerial 1080 operation should not be considered as a significant threat to human health.
- Consideration could be given to observe a 30-38 day withholding period on harvesting wild grown puha immediately after an aerial 1080 operation in the area; a withholding period of 10 days for watercress should be observed.
- Further research to confirm whether 1080 does occur naturally in puha would be of great interest to Maori communities, Pest Control Operators, and the wider public. This research should also be expanded to include a survey of 1080 in other NZ plant species.

Acknowledgements

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Appendix 1. MoH Permit for Puha Study

HAWKE'S BAY DistrictHealth Board

MINISTRY OF HEALTH
MANATŪ HAUORA

PERMIT FOR USE OF VERTEBRATE TOXIC AGENT(S)

Pursuant to section 95A of the Hazardous Substances and New Organisms Act 1996

To: Dr. Shaun Ogilvie

Of: Bio-Protection and Ecology Division, LINCOLN UNIVERSITY

Application Identification Code: **LINCOLN(Tuai Study)11-2007:2.4ha approx.**

Purpose of Application: **Research on 1080 uptake in plants of cultural importance**

Application Location: **Tuai, Lake Waikaremoana, Northern Hawke's Bay**

Start Date: **19th November 2007**

Finish Date: **18th January 2008**

I, Noel Watson, a person acting under powers delegated by the Environmental Risk Management Authority (the Authority), GRANT PERMISSION for the use of the following vertebrate toxic agent(s):

Sodium Monofluoroacetate (0.15%w/w): Cereal Pellet

This permission issued on the 7th November 2007, is subject to the CONDITIONS set out in SCHEDULE 1 attached hereto.

Signed

Name: **Noel Watson**

Title: **Health Protection Officer/HSNO Enforcement Officer**

Date: **7th November 2007**

Appeals: Section 125 (1A) of the Hazardous Substances and New Organisms (HSNO) Act: A person may appeal to the District Court against a decision of the Authority, under section 95A about the terms and conditions of a permission held by the person.

Notice of appeal: Section 127 of the HSNO Act: Before or immediately after the filing and service of a notice of appeal, the appellant shall serve a copy of the notice on The Authority, and every other party to the proceedings, and any other person who made a submission to the Authority.

SCHEDULE 1- PERMIT CONDITIONS

Application Identification Code: **LINCOLN(Tuai Study)11-2007**

Application Location: **Tuai, Lake Waikaremoana, Northern Hawke's Bay**

In addition to the requirements specified under the Hazardous Substances and New Organisms Act and its regulations, including the Hazardous Substances (Vertebrate Toxic Agents) Transfer Notice 2004 the following conditions shall apply:

Copies of the Transfer Notices can be found on the ERMANZ web-site at www.ermanz.govt.nz/hs/transfer-docs/
Please ensure you are complying with all aspects of this legislation.

1. **All statements of intended action that the applicant makes in the application form dated the 29th October 2007 (including documented Public Health Unit/applicant communication) in answers to each section shall be complied with as a self-imposed condition. If there is a discrepancy between the applicants self-imposed, and the conditions in this approval then the more stringent condition shall be applicable**

2. All complaints relating to the operation that may impact on public health shall be documented and notified to the Public Health Unit, (excluding lost, spilt, or unintended application of vertebrate toxic agent(s) as these are required under HSNO. See condition 3). Please contact Noel Watson on (06)834-1815 or (027)279-3892, or the On-Call Health Protection Officer on either (06)834-1815 or (06)878-8109, particularly if Noel Watson's office voice mail advises that he is away.

3. The applicant shall be aware of the notification requirements in case of lost, spilt, or unintended application of vertebrate toxic agent(s). These are contained within the Hazardous Substances (Vertebrate Toxic Agents) Transfer Notice 2004, or the controls relating to this/these specific VTA(s) on the ERMA web-site. Copies of Transfer Notices can be found on the ERMANZ web-site at www.ermanz.govt.nz/hs/transfer-docs/
It is the applicant's responsibility to ensure they are familiar with these legal requirements.

4. Any work vehicle used to transport vertebrate toxic agent(s) or its wastes shall be operated according to statutory requirements and kept locked when the applicant is away from the vehicle.

5. If any circumstances relating to the application or the operation change, the Public Health Unit shall be informed immediately and retains the right to withdraw permission.

11. **No ground baits shall be laid within 20 metres of human drinking water intakes and feeder water sources. Water sources include springs, streams, rivers, lakes, ponds, and reservoirs.**

12. Persons who take drinking water from immediately downstream of the operational zone (i.e. water supplies with intakes inside the operational area or on adjoining properties) shall be notified of the operation and its duration.

13. **No baits shall be laid within 150 metres of dwellings unless the occupier agrees in writing with the applicant to a lesser distance.**

14. **The applicant shall send information on the types of Vertebrate Toxic Agents being used, operational area's involved, time period of application, and contact details for the applicant through to the following local health and medical services:**
    - **Wairoa Health Centre, Kitchener St., Wairoa.**

    The applicant shall send a copy of this letter to Noel Watson, Public Health Unit, PO Box 447, NAPIER.

15. Residents and landowners adjacent to the operational area shall be identified by the applicant and shall be provided with information on safety and precautions with respect to the vertebrate toxic agent being used.

16. **The following educational institution shall be provided with information on the operation and the VTA being used before the operation begins. The information is for distribution from the institution to parents/caregivers of children who may gain access to the operational area, therefore the information provided shall state in writing this to be its purpose.**
    - **Te Kura O Waikaremoana School**
    - **Waikaremoana Te Kohanga Reo, Waimako Pa, Tuai**

    The applicant shall send a copy of this information to Noel Watson, Public Health Unit, PO Box 447, NAPIER.

17. This approval shall expire on the 18th January 2008. If the applicant wishes to continue the operation outside these dates, under the same conditions, they should re-submit it with a covering letter to this effect, at least a month before the expiry date.

Note:

The requirements under HSNO are minimum requirements and stricter conditions may be imposed by a person acting under a delegation from the Authority. The delegation includes the power under section 95A of the HSNO Act:

A.I.W.

(i) to decide an application for a permission; and/or
(ii) to add, delete or otherwise vary any condition on a permission; and/or
(iii) to revoke a permission

for the use of vertebrate toxic agents in a catchment area from which water is drawn for human consumption or in any other area where a risk to public health may be created if the substance is applied or used where such a control has been set under section 95A of the HSNO Act.

Conditions in the permission form may be modified or waived with the agreement in writing of the person acting under a delegation from the Authority unless they relate to other regulatory requirements.

Appendix 2. MoH Permit for Watercress Study

PERMISSION FOR USE OF VERTEBRATE TOXIC AGENT(S)

Pursuant to section 95A of the Hazardous Substances and New Organisms Act 1996

To:	Dr Shaun Ogilvie	**Of:**	Bio-Protection and Ecology Division Lincoln University
Application Identification Code:	**2008VTA - 274**	**Operation Name / Locality:**	Blunts Rd. KAIKOURA
Start Date:	24 November 2008	**Finish Date:**	24 December 2008

I, Braden Leonard, a person acting under powers delegated by the Environmental Risk Management Authority (the Authority), GRANT PERMISSION for the use of the following Vertebrate Toxic Agent(s):

- Cereal based pellets containing 0.15g sodium fluoroacetate /kg

This permission is subject to:

- **the requirements specified in the application form, and**
- **the CONDITIONS set out in SCHEDULE 1 attached hereto.**

Signed: **Name:** **Title:** **Date:**	 Braden Leonard Enforcement Officer, Hazardous Substances & New Organisms Act 11 November 2008	**Contact Person:**	Lew Graham Phone: (03) 3799480 ext 740 Fax: 03 3796 125 Email: lew.graham@cdhb.govt.nz Community & Public Health 76 Chester St East PO Box 1475. CHRISTCHURCH

Notice: Section 125 (1A): A person may appeal to the District Court against a decision of the Authority, under section 95A about the terms and conditions of a permission held by the person.

Section 127 Notice of appeal: Before or immediately after the filing and service of a notice of appeal, the appellant shall serve a copy of the notice on The Authority, and every other party to the proceedings, and any other person who made a submission to the Authority.

ORIGINAL COPY.

SCHEDULE 1

CONDITIONS
PERMISSION FOR USE OF VERTEBRATE TOXIC AGENT(S)
HAZARDOUS SUBSTANCES AND NEW ORGANISMS ACT 1996

Application Identification Code: 2008VTA – 274 Blunts Rd Kaikoura

NOTE: In addition to the requirements specified under the Hazardous Substances and New Organisms Act and its Regulations, Hazardous Substances (Vertebrate Toxic Agents) Transfer Notice 2004 and the Hazardous Substances (Sodium Fluoroacetate) Transfer Notice 2005, the approved operator or person in charge must ensure that all staff are aware that the following conditions must also be met:

PART A. For ground-baiting operations using Vertebrate Toxic Agents

All complaints relating to the operation that may impact on public health shall be documented and notified to the contact person (see page 1).

NOTE: Lost, spilt, or unintended application of Vertebrate Toxic Agent(s) are separately required to be notified under HSNO (see Controls in VTA Transfer Notices).

1. If any circumstances relating to the application or the operation change, including any changes to start or finish dates, the contact person (see page 1) shall be informed immediately. The permission may be changed or withdrawn as a result of any change in circumstances.

2. Adjacent residents and landowners shall be identified by the applicant and shall be provided with information on safety and precautions with respect to the Vertebrate Toxic Agent(s) being used.

   NOTE: Regulation 28 Hazardous Substances (Classes 6, 8 and 9 Controls) Regulations 2001, has a variation to controls that requires, among other things, that warning signs must remain until the Vertebrate Toxic Agent has been retrieved from the place, or has disintegrated, or has been destroyed, or is no longer toxic, but not less than 2 months after the last application of the Vertebrate Toxic Agent.

3. Warning notices shall be in a fixed position, be checked at regular intervals, and must be repaired/replaced within 24 hours of discovery or notification of damage or theft. Notices positioned at distance from the operational zone shall have posted with them a map indicating the operational zone in relation to the signs located.

4. Vertebrate toxic agent(s) shall not be applied within 20 metres of waterways that are drinking water sources, including intakes and feeder water sources. Waterways include springs, streams, rivers, lakes, ponds and reservoirs.

5. Persons who have piped or pumped drinking water supplies in the area being poisoned or within 3km downstream of the area shall be notified of the planned operation and its duration.

6. All necessary and practicable steps shall be taken to prevent contamination with the vertebrate toxic agent(s) of all areas within 150 metres (or within a distance mutually agreed in writing with occupiers) of the dwellings.

7. Where Vertebrate Toxic Agent is applied by hand, the bait is not to be laid within sight of walking tracks, roads, lay-bys, parks etc or other areas used by the public