# The Introduction, Classification and Management of Marsupial Species (*Trichosurus vulpecula* and *Marcropus eugenii*) in the Bay of Plenty to December 2015.

by

Mawera Gina-Marie Karetai
Otago Polytechnic Student number: 1000025583

Submitted: 17 October 2016
Academic Mentor: Malcolm Macpherson
Facilitator: John Gualter

A thesis submitted in conformity with the requirements for the degree of:

## Master of Professional Practice with a special focus on Environmental Management



**Mō tātou, ā, mō kā uri, ā muri ake nei!**
*For us and our children after us!*

**DECLARATION**

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of an institution of higher learning.

Mawera Gina-Marie Karetai
03/10/2016

# The Introduction, Classification and Management of Marsupial Species (*Trichosurus vulpecula* and *Marcropus eugenii*) in the Bay of Plenty to December 2015.

Mawera Karetai

Master of Professional Practice with a special focus on Environmental Management
Otago Polytechnic

2016

# Executive Summary

The Bay of Plenty on the North Island of New Zealand is a place where almost everything that survives, thrives. Endemic, native and introduced species of flora and fauna all live in the same environment, all vying for the space and resources necessary for survival; this includes humans. Perhaps in time, if left to do so, nature would find a balance where all species could live in harmony – but perhaps not. Australian Brushtail Possum (*Trichosurus vulpecula*) and Dama (also known as Tammar) Wallaby (*Marcropus eugenii*) are two introduced species which have made a home and an impact on the Bay of Plenty environment.

The Brushtail Possum was introduced to New Zealand between 1890 and 1930. The Dama Wallaby was one of twelve wallaby species introduced to New Zealand between 1858 and 1870[1]. Both species were repeatedly introduced to different parts of New Zealand in several installations. With no natural predators, both species thrived in their new habitat and are now on the Bay of Plenty Regional Council pest list[2].

Because of the impact both species have had on the environment, there have been considerable resources used in an effort to control them. Various control methods have been utilised, including trapping, shooting and poisoning them as a means of reducing the population. Of these three methods, the one that has been most effective on a cost per head basis appears to have been poison, but the only cost measured is in the number of target species deaths. There are six poisons commonly used for the control of marsupials (usually possums)[3]: *Sodium Fluoroacetate (1080), Phosphorus, Cholecalciferol, Cyanide* and anticoagulants – *Brodifacoum* and *Pindon*e. While these six poisons are different in the active ingredient and the way they are applied, there is one thing they all have in common; they are indiscriminant killers of every animal that ingests them, including the species we want to protect.

Research for this project has come from books, journals, articles and firsthand knowledge. There are no conclusions reached in this work and that is by design. One of the main goals

[1] (Wodzicki)

[2] (Bay of Plenty Regional Council, 2011)

[3] (Department of Conservation)

of the work was to present the information as facts only and not to allow personal views to influence the reader/learner.

## Learning Outcomes

1. An in-depth understanding of the facts of marsupial origin and spread in the Eastern Bay of Plenty.
2. An in-depth understanding of past and current pest control methods used in the control of marsupials in the Eastern Bay of Plenty and their impact on the population.
3. A foundation document to be the basis of PhD research into alternative methods of pest control and in environmental education.

# Acknowledgments

This work is dedicated to my dad, Dave Karetai, the hardest working man I know. My dad, a farmer, a coal miner, a truck driver, a shearer, a hunter, a fisherman, a courier driver, a handyman (and so many other things) has always done what was necessary to survive. He taught me to be resilient, to be capable and to have a wide open mind. He believes in me and so I have always believed in myself.

I would like to acknowledge my long-suffering husband, Dave Barrett for supporting and encouraging me on this journey and for enabling me to do this instead of getting "a real job". I also acknowledge our kids David, Beau, Alexi and Jack for being amazing and for giving me the space to write when I needed it.

My thanks to two people who laid the foundation for this in my early years; my cornet teacher, Paul Mayhew and then my first husband, and good friend, Tony Key. Both of you have contributed to all the successes in my life and I thank you for it.

Many thanks to my support team at Otago Polytechnic: John Gualter, Malcolm Macpherson and Glenys Ker for getting me through the tough times and for being so available to me. Special thanks to my Aunty Professor Emeritus Dr Khyla Russell, who paved the way for a generation of women from the Kaik to academic achievement.

Last, I would like to acknowledge David Paine, of the Bay of Plenty Regional Council. David, it was your challenge to me that started this. I know a thing or two about wallabies now! Thank you for challenging me!

# Table of Contents

## Contents

# List of Plates and Tables

## Plates



## Tables

# Chapter 1 Effectiveness of Brodifacoum Pre-human Aotearoa New Zealand

## 1 Before there was a name

In a time before the end of the Cretaceous period of the Mesozoic Era, 65 million years ago (or so), a small sliver split from the supercontinent, Gondwanaland and began its journey to the East to become the land we now know as Aotearoa, New Zealand.[4]

Pre-human Aoteaora flora and fauna was vaguely representative of the flora and fauna of Gondwanaland. As the ages passed, species present at the time the small sliver split away evolved independently of the family they came from, their evolution influenced by the ever changing environment of a constantly moving land mass. Those species become the endemic species we acknowledge today.

Endemic species are those that are unique to the country they are found in. This should not be confused with native, which is the term given to a species that arrives in a new home naturally. Species of that are native can be native to more than one country. Pukeko is an excellent example of a native species – it is called a Purple Swamphen in its other native home, Australia.

Before the arrival of humans, Aotearoa was home to over 2500 species of native conifers, flowering plants and ferns, 80% of which are endemic to here. There were 245 species of bird ad 71% of them were endemic. It is estimated that there were around 70 000 animal species in Aotearoa, many of which have still not been named or classified. Some of the 70 000 animal species included:

- 6,000 beetles
- 5,800 fungi
- 2,500 higher plants
- 2,000 moths and butterflies
- 1,100 spiders
- 1,000 land snails
- 550 mosses
- 500 liverworts and hornworts
- 170 earthworms

[4] (King, 1990)

- 85 millipedes
- 91 birds that breed and feed on land
- 80 skinks and geckos
- 38 freshwater fish
- seven frogs
- three bats
- two tuatara.[5]

When humans arrived in Aoteaora, they found a country covered in forests and teeming with life. All but the highest peaks were covered in indigenous forest, wetlands and clean inland waterways. Figure 1, below shows us the estimated land cover of pre-human Aotearoa. Most of the land is covered with indigenous forest, untouched for millions of years.

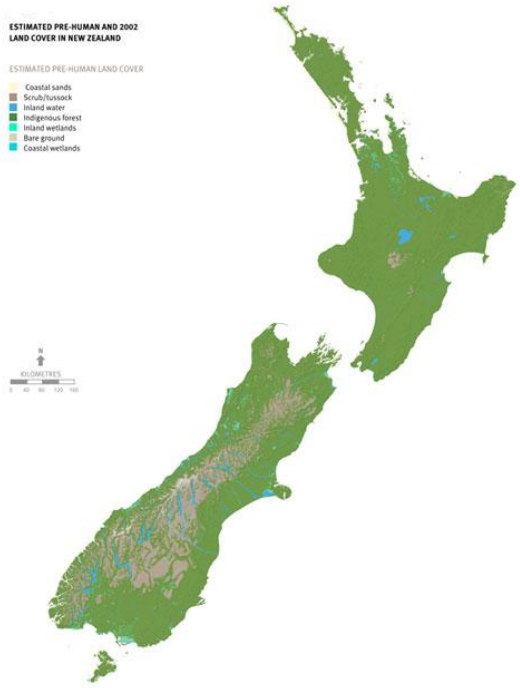



**Figure 1**[6]

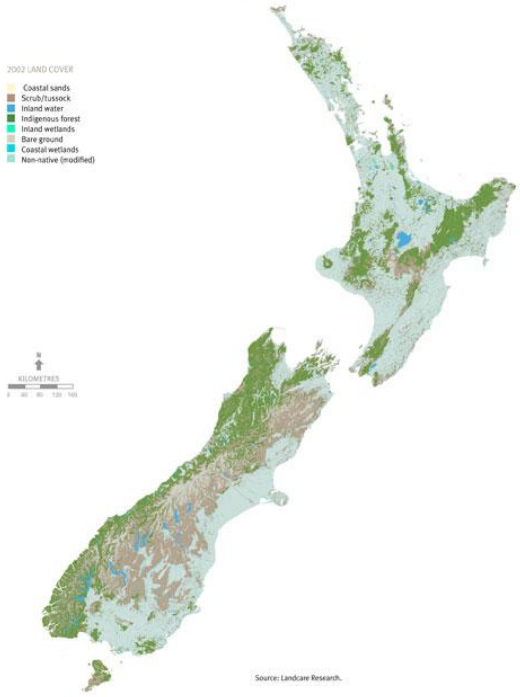



**Figure 2**

## 1.1 Where are we now?

Fast forward nearly 1000 years and the picture, as shown in Figure 2 above, loses its luster. Much of endemic forest that once covered the land from coast to coast, has long been felled or burned to make way for humans. Once pristine waterways have had their courses altered, have dried up or have become so contaminated by our existence that they bear no

[5] (Brockie, 2007)

[6] Environment New Zealand 2007 (Ministry for the Environment, 2007)

resemblance to what they once were. Inland and coastal wetlands across the country have been drained so land can be used for human endeavors and where there should be native forest, we too often now see pine, commercial orchards, eucalyptus and paddocks. Over the last 1000 years, we have lost 40-50% of our bird species, up to 50% of our frog species and more species of insect, fish and reptile life than we could ever know existed.[7]

Some of the worst threats to our native species, according to Forest and Bird have been mammalian pests – stoats, possums, rats and deer[8]. We need to add humans to that list. Together, we introduced species have devastated the environment and wrecked ecological havoc on this land we all now call home.

It is too late to bring back what we have lost; it is not too late to save what we have left. Sometimes to plan for a future, we need to understand the past.

## 1.2 Acclimatisation Societies

The ability of Europeans to move around and colonise the world resulted in the movement of flora and fauna by man. Immigrants settling new lands brought with them the plants and animals they were familiar with. Europeans settling in New Zealand desired to make life more like home and so liberated hedgehogs, rabbits, stoats, gorse and broom, to create familiar surroundings[9].

For many settlers the ability to introduce animals opened up a new opportunity for them that had previously been denied. Species such as deer, grouse, pheasants, hares, partridges, rabbits, and salmon that were restricted in England to the wealthy classes could be liberated in New Zealand with no restrictions[10]. Hunting and fishing became a past time for everyone, instead of just those who were born to the wealthy classes. While a great number of our mammalian imports came from England, there were many species that came from other countries across the world.

---

[7] (Holdaway R. , 1989)

[8] (Forest and Bird)

[9] (Bompas, 1885)

[10] (McLintock, 1966)

| Countries of Origin of Introduced Mammals and Birds | | | | |
|---|---|---|---|---|
| | Number of Species | | | |
| | Liberated | | Established | |
| Country of Origin | Mammals | Birds | Mammals | Birds |
| Europe and England | 20 | 48 | 19 | 17 |
| Australia | 13 | 33 | 4 | 8 |
| Polynesia | 2 | 2 | 2 | - |
| North America | 7 | 16 | 4 | 3 |
| South America | 4 | 1 | - | - |
| Asia | 5 | 19 | 5 | 3 |
| Africa | 2 | 6 | - | - |
| **Total** | **53** | **128** | **34** | **31** |

**Table 1**

With Europeans to New Zealand came not only many new species of flora and fauna, but also the ability to accurately record information on existing native species and their habitat as it was at that time; this work was done by purposely created Acclimatisation Societies.

Acclimatisation societies were formed throughout Europe, the Americas and Australasia. In New Zealand, each region had its own society charged with the responsibility of recording the facts of each species it liberated. With this information we have been able to see where the newly liberated species have come from and also the effects of pest species on our environment.[11] While the societies existed for the same purpose, each operated independently of the other. This certainly made for interesting reports where one region would promote the benefits of possum for the value of skins to their local economy, while the neighboring region would call them a pest for the destruction of orchards and new trees planted. This reporting became and basis for animal control legislation.

While flora and fauna were first deliberately introduced to Aotearoa with the arrival of the first humans, most of the liberations that occurred in here were between 1773 and 1900. The period between1860 and 1880 was most prolific with 22 mammal and 90 bird species liberated[12]. It is through that period Aotearoa saw the liberation of two species that have had an impact on the ecology of the Bay of Plenty - brushtail possums and dama wallabies. The next two chapters of this work will deal specifically with those two species; their introduction, liberation, spread and population management.

[11] (Thomson, 1922)

[12] (Wodzicki)

# Chapter 2
# Dama Wallaby

**Figure 5**

## 2 Dama Wallaby in New Zealand

Dama or tammar wallaby, a native of Australia, were first introduced to New Zealand by Sir George Grey around 1870.[13] One of at least seven, but possibly as many as twelve[14] wallaby species introduced here, they are now one of only five remaining species.

A nocturnal marsupial, standing only up to 50cm at full height, the dama is one of the smallest in the wallaby species. They have a grey/brown upper body, a light grey underbelly and a reddish colouring on the shoulder. The tapered tail is the same grey as the upper back. Dama wallaby doe are sexually mature at 12-months. Birthing usually occurs in January or February, after 28 days gestation. Young will stay in the pouch for around 250 days.[15]

Dama were initially released on Kawau Island, in the Hauraki Gulf, off the coast of Auckland. The dama, along with other wallabies embraced their new home and the

[13] (King, 1990)

[14] (Thomson, 1922)

[15] (Department of Conservation)

population increased quickly. Commentators of that time write about numbers of wallaby exploding in an "incredible manner".[16]

From Kawau Island, dama wallaby are said to have spread by human intervention to other islands and to various mainland locations. They successfully adapted to life in the Bay of Plenty, after being liberated near Lake Ōkareka in 1912.[17]

Wallabies adapted so well to New Zealand that they became listed under the Noxious Animals Act 1956 and since then there has been some effort put into controlling the population and spread. This change in classification meant that wallaby were then "owned" by the Crown and could not be kept as a pet, or captured and relocated. Legislation provided access for the Government to enter any property to investigate the effects of the animal on the land, to catch the animal alive or dead and to bring any equipment or erect any structures as was deemed necessary. The management of wallabies was moved from the Noxious Animals Act into the Wild Animals Control Act 1977. A review of overlapping pest management in legislation then saw wallaby moved to the Biosecurity Act 1993. Wallaby and possum were both specified in the new legislation as an unwanted organism under the Act. An "unwanted organism" is defined in the Biosecurity[18] Act 1993 as:

> Any organism a Chief Technical Officer (CTO) believes capable of causing unwanted harm to any natural and physical resources or human health.
> It is an offence under the Biosecurity Act 1993 to breed, knowingly communicate, exhibit, multiply, propagate, release, and sell or offer for sale unwanted organisms. If you wish to carry out any of these activities for a specific purpose e.g.:
> - you are a Crown Research Institute or university wishing to undertake research on an unwanted organism, or
> - a regional council wishing to exhibit an unwanted organism at the Field Days, or
> - you are wishing to make a commercial benefit from an unwanted organism

The Biosecurity Act takes ownership of pest management, taking into account legislation from the Wild Animal Control Act 1977, Wildlife Act 1953, Conservation Act 1987 and Resource Management Act 199. It is designed to improve and simplify the development and

[16] (Thomson, 1922)

[17] (Bay of Plenty Regional Council)

[18] (Ministry for Primary Industrustries, 2015)

implementation of national pest management strategies. Currently there is no overarching strategy in place that deals with directly reducing the number of wallaby in the wild.

## 2.1 Dama Wallaby in the Bay of Plenty

Introduced in 1912, to the Lake Ōkareka area, dama thrived from the outset. Larger than those found on Kawau Island, in a new environment, with no population pressure, they were able to reach their potential height and weight due to an abundance of food. Excellent health, with optimal conditions made for successful breeding and the dama wallaby quickly spread. By the 1940s[19] there were reports of their population increase and concern about their spread. At that time they inhabited an area of around 0.6km².

Dama wallabies are nocturnal grazers[20] with a preference for "edge habitats"[21]. An edge habitat is where pasture meets dense vegetation or bush. The bush provides an ideal cover for wallaby as they rest during the day, and easy access to pasture for nighttime grazing.

Since the release of the first dama wallabies near Lake Ōkareka in 1912, little has been done to manage the population. Gazetting the dama under various Acts of legislation, as an unwanted pest species, has really only meant that the animal can be controlled if there is the need to do so. Other than some aerial 1080 drops in high population areas, and some use of shooting, there has been no consistent effort out into managing the population. In fact the easiest way to control the species by shooting is made difficult by extremely limited across to the land which is home to the main population.

Dama wallaby are considered a "legacy pest"[22] and classified a containment pest by the Bay of Plenty Regional Council, in their Biosecurity Operational Plan Annual report - 2013/2014. Legacy because it a pest long established with no consistent effort put into controlling it, and containment because that is the management objective for the pest[23]. The dama population has impacted on native flora, and on farming and forestry operations as numbers have increased.[24] The Ministry for Primary Industries estimates the gross annual benefit of avoiding the ecological impact of the dama wallaby in the Bay of Plenty area to be around

[19] (King, 1990)

[20] (Lentle, 1998)

[21] (King, 1990)

[22] (Murray, 2014)

[23] (Bay of Plenty Regional Council, 2011)

[24] (Lentle, 1998)

$4.2 million. If they continue to spread at the same rate, with no management plan implemented, that figure increases to $16.5m per annum over the next ten years.[25]

Without a clear multi-agency plan for management of the pest[26] and with so few studies done in recent times, there is little to prevent further expansion of the population. As a result the first few animals introduced to the Bay of Plenty some 104-years-ago have expanded their range to cover 1800 km² (180 000 hectares²). The distribution figure estimated by the Bay of Plenty Regional Council is considerably lower than the Ministry for Primary Industries (MPI) estimate of 4126 km². Continuing to spread at the same rate, MPI predict the range of Dama wallaby could increase to an area as large as 40 579 km², which equates to one third of the North Island.[27]

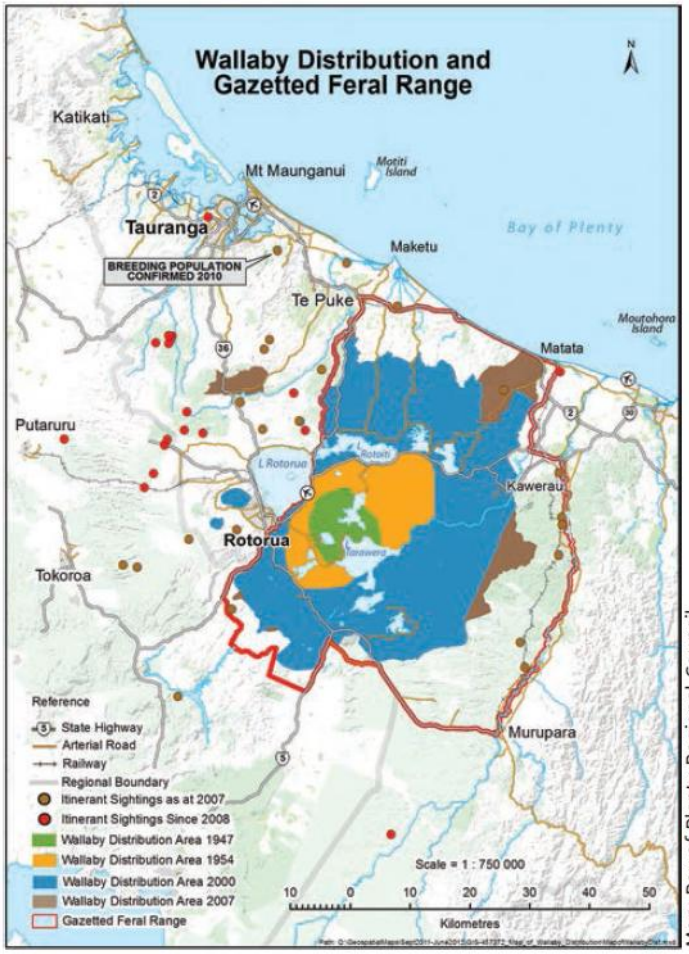



**Figure 2**[28]

[25] (Ministry for Primary Industries, 2016)

[26] (Lee Shapiro, 2011)

[27] (Ministry for Primary Industries, 2016)

[28] (Bay of Plenty Regional Council)

The “Unwanted Organism” status of a dama wallaby expires on the 16th September 2016. Leading up to this date there was some media by the Bay of Plenty Regional Council requesting sightings of dama, so they could better understand the current distribution. Their distribution and impact have been assessed and a decision in pending as to the ongoing classification and the future management of them.

# Chapter 3
# Brushtail Possums

**Figure 6**

## 3 Possums in New Zealand

Possum, like the dama wallaby, are a nocturnal native of Australia. There are several conflicting stories as to when and where the first possums were introduced to New Zealand and all of them seem plausible; the earliest date given is 1837[29], although actual evidence of this has been difficult to find. A Wellington Acclimatisation Society report from 1892 states, "These animals were first liberated in the bush behind South Riverton in 1858 by Mr Basstian. Some years after, one of two opossums (presumably Australian Grey Opossums) escaped from confinement in the same neighborhood."[30]

The subspecies of possum first introduced to New Zealand were distinguishable from each other due to being two clearly different colors - black and grey. The grey possum was brought from the Australian mainland and the black possum from Tasmania.[31] Grey pelt coloring in mammals is associated with concealment in open forest environments. Black

[29] (Hutching, 2008)

[30] (Thomson, 1922)

[31] (King, 1990)

colouring, or melanistic provides concealment in dense vegetation [32] In their home environment black possums were more suited to high humidity environments, in particular swampy areas in high temperature climates, and grey possums were suited to cooler, drier climates.[33]

As was quite acceptable in the early years of colonisation, possums were introduced by private individuals before they were introduced by Aclimatisation Societies. They were originally introduced to New Zealand in an effort to develop a fur trade. Australia had an established fur trade and it was hoped that possum would provide the same sort of trade for New Zealand.[34] On arrival in New Zealand, the two subspecies of possum freely interbreed. As a result, new the black and grey colours began to give way to some new mixed colouring in the pelts. The fur industry classifies nine different colours of possum fur in New Zealand; grey, pale, black, light slate, dark slate, red brown, dark brown, red neck and rusty.[35]

Since their arrival, possums have spread to cover almost all of mainland New Zealand. There is very little information available about the early spread across the country, however records show there were only 200-300[36] of them liberated, at different times and in different locations.

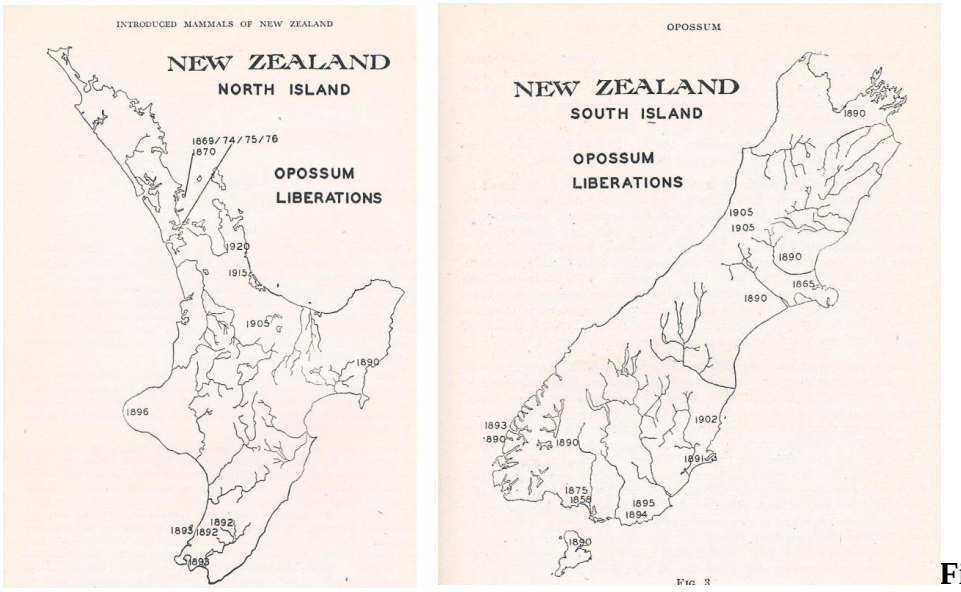



**Figure 4**[37]

[32] (Kean R. , 1971)

[33] (Kean R. I., 1967)

[34] (King, 1990)

[35] (Goergous Creatures, 2016)

[36] (Pracy, 1974)

[37] (Wodzicki)

Most if the possum liberations were by Regional Aclimatisation Societies. Some of the original stock imported from Australia was used in a breeding program in New Zealand. Once the breeding stock was released, the Australian-born possums accounted for only 8% of the total liberated possums around the country. The effort to populate New Zealand with possums was both sanctioned and non-sanctioned. The Aclimatisation Societies released around half of the population, as per their role, and the other half was "illegal" liberations by private individuals. Illegal liberations were common between 1920 and 1940[38]

With so much effort put into increasing the possum population, the number of animals started to cause a problem. Settlers started to become aware that the possums were actually impacting on the environment in an increasingly negative way. By the late 1890s possum fur was so valuable that the trappers were impacting on numbers in some areas, and so the Aclimatisation Societies lobbied the government to bring possums under the Protection of Animals Act 1880. But complaints from settlers of fruit trees, gardens and field crops being decimated prompted the government to remove that protection so trapping could resume. On and on it went, with possums in and out of legislated protection until 1946-47[39] when it was recognized that an ever increasing possum population was having a significant impact on the environment and very strict controls were implemented.

The controls put in place in 1946-1947 are very similar to the controls in place now and so that legislation became the foundation for what we use today. After the legislation changed to allow for renewed trapping and introducing poison, the Department of Internal Affairs (DIA) was responsible for managing pests. Not set up for a mass pest management project, they embarked on a massive survey to determine the extent of the problem. Numbers continued to increase[40] and in 1956, under the Noxious Animals Act 1956, the New Zealand Forest Service became the agency in charge of managing the pest[41].

Since 1956 there has been a war on possums that has seen the development and use of poisons as a means of controlling the pest. Countless millions of dollars have been and will be spent in an attempt to control an animal that is well entrenched in our environment, from one end of New Zealand to the other. In the latest effort to control the pest, the Department of Conservation has launched the "Predator Free New Zealand 2050" program.

---

[38] (Pracy, 1974)

[39] (Wodzicki)

[40] (Pracy, 1974)

[41] (King, 1990)

The Predator Free New Zealand 2050 program will see a multi-agency approach to rid New Zealand of stoats, rats and possums across the country that currently cost New Zealanders $70 million dollars each year to manage[42]. The project will see a significant investment in research and technology. It will require work and dedication from the entire community.

[42] (Department of Conservation, 2016)

Chapter 4

# 4 Poisons used in pest control

Since the change to the Opossum Regulations on the 23rd of April 1946,[43] regulations around the control of the species for the first time included the use of poisons as a means of control; this had previously been illegal. Licenses and permits were abolished and it then became illegal to import possum, to keep them in captivity and to relocate them. Trapping and shooting, which had previously been used to provide for the fur industry, were now being used as a means of population control. With poisoning of the pests also came primary and secondary poisoning of native and endemic species, and concerns over the suffering of the animals that ingest it.

Each poison in this chapter will be accompanied by a table summarising it and table showing the welfare impact of it.

Note: Poisons used in the control of dama wallaby will not be studied in this work because there is insufficient data available to evaluate any of the poisons currently used.

[43] (Wodzicki)

## 4.1 Brodifacoum

New Zealand brand name[44]: Talon and Pestoff

Target Species: Brushtail possum, rabbit and rat

Application: Brodifacoum is spread in target areas as cereal bait and is also used in bait stations. Each pallet is blue/green and around 2cm long[45]. This product is also available in supermarkets and hardware stores as bait for rodent control, often in wax blocks. It has been used in the control of possums and rodents since the 1970s and registered for use in New Zealand in the 1990s.

Clinical effects: Brodifacoum is an anticoagulant. By suppressing the normal synthesis of vitamin K blood clotting factors in the liver[46], the toxin alters the amount of time it takes for blood to clot and leads to hemorrhaging. Absorption is through the intestines and though skin contact. Death is slow, with animals that have ingested a lethal dose taking up to three weeks to die[47], all the while feeding on more bait. Mortality rates are high with only a single feed required to cause death, with between 90 and 100% mortality in rats after a single dose[48]. A lethal dose of Brodifacoum for a possum is around 20mgs, but a possum can eat up to a kilogram of the bait before it dies[49].

Effects on non-target species: There is considerable evidence to show that non-target species will consume baits directly and will also consume the carcasses of deceased animals. Non-target species see the baits as food and will consume them as readily as target species. Once an animal has consumed Brodifacoum, any poison that is not metabolised can stay in the liver and muscle tissue of the animal for months. Scavenging animals who ingest the tissue are then at risk of death through secondary poison. For this reason, Brodifacoum should not be used for the control of pest species where wild pigs are present and could be hunted for. This includes the Department of Conservation Estate.[50]

---

[44] (Inter-organization Programme for the Sound Management of Chemicals, 1996)

[45] (Departmet of Conservation, 2007)

[46] (Fisher, 2010)

[47] (C. T Eason, 1999)

[48] (R. T. Meister, 1984)

[49] (C. T Eason, 1999)

[50] (Departmet of Conservation, 2007)

| Effectiveness of Brodifacoum[51] | |
|---|---|
| Advantages | Disadvantages |
| Generally available. No licence required | High risk of secondary poisoning of non-target species |
| Effective against possums that have developed | Persistent (>9months) in liver of vertebrates |
| poison/bait shyness | (can enter food chain and put meat for human consumption at risk) |
| Effective for rodent control | |
| Antidote available | Although an antidote (vitamin k) is available, long-term treatment is needed |
| | Expensive compared to 1080 |
| | Possums can eat excessive amounts of bait |
| | (increase costs) |
| | Possums take 2-4 weeks to die |

**Table 2**

| Relative Welfare Impact of VTA (Vertebrate Toxic Agent)[52] | | | | |
|---|---|---|---|---|
| Agent | Effect | Overall Impact | Approx time until death | Overall Grade |
| Brodifacoum | Breathlessness | Severe-Extreme | Days-Weeks | 7-8 |
| | Weakness | | | |
| | Pain | | | |
| **Table 8** | Sickness | | | |
| | Breathlessness | | | |

**Note: The overall grade for welfare impact is scored from 1-8. 8 is high impact.**

[51] (Wickstrom, 2001)

[52] (Ministry of Agriculture and Fisheries, 2010)

## 4.2 Cholecalciferol

New Zealand brand name: Feracol and Decal

Target Species: Possum

Application: Cholecalciferol comes in the form of serial bait, distributed by bait station, a peanut butter paste and in gel form[53].

Clinical effects: Cholecalciferol provides a lethal dose of vitamin D. Once ingested the toxin removes calcium from the bones and moves it into the blood stream and decreases the amount of calcium the body can process through the kidneys. The raised levels of calcium in the blood can result in calcifications in throughout the body, including the heart, stomach kidneys, muscles and blood stream. A lethal dose will kill an animal in four to seven days. Death will occur from hypocalcaemia, tissue calcification and renal or cardiac failure[54].

Effects on non-target species: There is considerable evidence to show that non-target species will consume baits directly and will also consume the carcasses of deceased animals. Non-target species see the baits as food and will consume them as readily as target species. Cholecalciferol breaks down in the body very quickly and as a result, fatal secondary poisoning of scavenging animals that ingest the tissue is unlikely due to a reduced bioavailability of the toxin. However, a non-lethal dose of the toxin can remain in the body of a living animal and therefore, hunters should be made aware of Cholecalciferol use in areas where there are wild pigs.[55]

[53] (Wickstrom, 2001)

[54] (S.E Jolly, 1995)

[55] (Wickstrom, 2001)

| Effectiveness of Cholecalciferol[56] | |
|---|---|
| Advantages | Disadvantages |
| Available to general public | Expensive compared to 1080 and Cyanide |
| Can rapidly reduce possum numbers (an acute toxin) | Not registered for aerial application |
| Low risk secondary poison | Use of secure bait stations is essential |
| Less toxic to birds than 1080 | |
| A useful single dose alternative to 1080 | |
| Not long-term residue risks in sub-lethally exposed animals | |

**Table 3**

| Relative Welfare Impact of VTA (Vertebrate Toxic Agent)[57] | | | | |
|---|---|---|---|---|
| Agent | Effect | Overall Impact | Approx time until death | Overall Grade |
| Cholecalciferol | Nausea | Severe-Extreme | Days | 7-8 |
| | Weakness | | | |
| | Pain | | | |
| | Sickness | | | |
| | Breathlessness | | | |

**Table 9**

**Note: The overall grade for welfare impact is scored from 1-8. 8 is high impact.**

[56] (Wickstrom, 2001)

[57] (Ministry of Agriculture and Fisheries, 2010)

## 4.3 Cyanide

New Zealand brand name: Feratox

Target Species: Possum

Application: Paste and pallet. Pea-sized pieces of paste are place with a mix of flour and jam, or flour and icing sugar in areas where possums are common. Pallets are used in bait stations with feed pallets or mixed in a peanut butter paste[58].

Clinical effects: Cyanide is a fast-acting, very effective asphyxiant, causing death within minutes. Providing the cyanide is reasonably fresh, as soon as the toxin in enters the body through inhalation or ingestion, the animal will experience muscle tremors and other central nervous system reactions. Shortly after the animal will become unconscious and likely convulse through lack of oxygen. It is widely regarded as the most humane of all poisons used, because it works so quickly and causes the least amount of distress to the animal[59].

Effects on non-target species: Many studies have been done on the effect of cyanide on the environment and the impact on non-target species. There is evidence to show that non-target species will consume baits directly but in large numbers. Non-target species see the baits as food and will consume them as readily as target species. However, research has shown this is not a common occurrence. Cyanide breaks down in the body and in the environment very quickly. As a result, fatal secondary poisoning of scavenging animals that ingest the tissue is unlikely due to a reduced bioavailability of the toxin[60].

[58] (Wickstrom, 2001)

[59] (N.G Gregory, 1998)

[60] (Environmental Protection Authority, 2012)

| Effectiveness of Cyanide[61] | |
|---|---|
| Advantages | Disadvantages |
| Cheap (1-2c per bait) | Hazardous to users |
| Humane (very rapid action) | Toxicity of paste deteriorates rapidly in wet weather |
| Suitable for skin/carcass recovery | Paste can result in very poor kills if possums are cyanide-shy, hence not favoured by pest-control agencies |
| Low risk of secondary poisoning | Can induce poison aversion |
| Achieves moderate to high kills (70-90%) | Antidotes are available but controversial |
| Encapsulated cyanide does not produce HCN gas so is safer for hunters to use and is suitable for cyanide shy possums | |
| Encapsulate cyanide pallets can be recovered and reused | |
| Encapsulated cyanide is not adversely affected by wet weather | |
| Biodegradable in the environment. | |

**Table 4**

| Relative Welfare Impact of VTA (Vertebrate Toxic Agent)[62] | | | | |
|---|---|---|---|---|
| Agent | Effect | Overall Impact | Approx time until death | Overall Grade |
| Cyanide | Nausea | Mild - Moderate | Minutes | 3.5-4 |
| | Weakness | | | |
| **Table 10** | Sickness | | | |
| | Breathlessness | | | |
| | Dizziness | | | |
| | Anxiety/Fear | | | |
| | Headache | | | |

**Note: The overall grade for welfare impact is scored from 1-8. 8 is high impact.**

[61] (Wickstrom, 2001)

[62] (Ministry of Agriculture and Fisheries, 2010)

## 4.4 Pindone

New Zealand brand name: Pindone

Target Species: Used around the world to control rats, mice, rabbits, possum and wallaby. Pindone is registered in New Zealand for the control of rabbits and possums.

Application: Serial bait delivered in bait stations

Clinical effects: Like Brodifacoum is an anticoagulant. By suppressing the normal synthesis of vitamin K blood clotting factors in the liver[63], the toxin alters the amount of time it takes for blood to clot and leads to hemorrhaging. It can take up to 5 days for the animal to die, if it is going to and it is a painful death[64]. Pindone is a first generation anticoagulant and is not as effective as second-generation, higher potency compounds. Possums have been found to be resistant to Pindone in low doses.[65] To be effective, large amounts must be consumed – over 100mg per kg in a single dose is required to achieve mortality.

Effects on non-target species: There is some evidence to show that non-target species will consume baits directly and will also consume the carcasses of deceased animals. Birds in particular seem to be susceptible to secondary poisoning by Pindone[66]. Non-target species see the baits as food and will consume them as readily as target species. Once an animal has consumed Pindone, any poison that is not metabolised can stay in the liver and muscle tissue of the animal for months. Scavenging animals who ingest the tissue are then at risk of death through secondary poison. For this reason, Pindone should not be used for the control of pest species where wild pigs are present and could be hunted for. This includes the Department of Conservation Estate.[67]

---

[63] (Fisher, 2010)

[64] (Department of Conservation)

[65] (Ministry of Agriculture and Fisheries, 2010)

[66] (Wickstrom, 2001)

[67] (Departmet of Conservation, 2007)

| Effectiveness of Pindone[68] | |
|---|---|
| Advantages | Disadvantages |
| No licence required | Not as potent as second-generation anticoagulant poisons such as 1080, cholecal-ciferol, or cyanide |
| Effective for rodent control | Not potent for possum control |
| Antidote | |
| Less persistent than Brodifacoum | |

**Table 5**

| Relative Welfare Impact of VTA (Vertebrate Toxic Agent)[69] | | | | |
|---|---|---|---|---|
| Agent | Effect | Overall Impact | Approx time until death | Overall Grade |
| Pindone | Sickness | Moderate - Extreme | Days – weeks | 7-8 |
| | Weakness | | | |
| | Nausea | | | |
| **Table 11** | Hunger/Thirst | | | |

**Note: The overall grade for welfare impact is scored from 1-8. 8 is high impact.**

[68] (Wickstrom, 2001)

[69] (Ministry of Agriculture and Fisheries, 2010)

## 4.5 Phosphorus

New Zealand brand name: Phosphorus (Limited use in New Zealand as of December 2015)

Target Species: Rabbits and possums

Application: Pallets and paste

Clinical effects: How phosphorus works is not really clear in any literature.[70] What is clear is that that death may occur in 1-2 days, but can take as long as three weeks. Phosphorus is a systemic poison that somehow causes the cells of internal organs to die. The organs become starved of oxygen, which ultimately leads to the death of the animal.

Effects on non-target species: There is very little data available on phosphorus was a possum management poison. There is some evidence to show that non-target species will consume baits directly and will also consume the carcasses of deceased animals. Scavenging animals who ingest the tissue are then at risk of death through secondary poison. For this reason, Brodifacoum should not be used for the control of pest species where wild pigs are present and could be hunted for. For this reason, phosphorus is no longer used by the Department of Conservation.[71]

[70] (Wickstrom, 2001)

[71] (Departmet of Conservation, 2007)

| Effectiveness of Phosphorus[72] | |
|---|---|
| Advantages | Disadvantages |
| Effective (kills of >90% achieved | Has some animal welfare concerns |
| Less public opposition than with 1080 | Secondary poisoning risk to dogs and birds |
| | Risk of fire |
| | Antidotes of limited Value |

**Table 6**

| Relative Welfare Impact of VTA (Vertebrate Toxic Agent)[73] | | | | |
|---|---|---|---|---|
| Agent | Effect | Overall Impact | Approx time until death | Overall Grade |
| Phosphorus | Nausea | Moderate - Severe | Hours – Days | 5-7 |
| | Weakness | | | |
| | Pain | | | |
| **Table 12** | Sickness | | | |
| | Anxiety/Fear | | | |

**Note: The overall grade for welfare impact is scored from 1-8. 8 is high impact.**

[72] (Wickstrom, 2001)

[73] (Ministry of Agriculture and Fisheries, 2010)

## 4.6 Sodium Fluoroacetate (1080)

New Zealand brand name: 1080

Target Species: 1080 is used around the world in the management of many different pests. In New Zealand it is formulated specifically for use in control of possums.

Application: Carrot, cereal, paste and gel baits. 1080 carrot and cereal baits are usually applied by aerial drop over large areas of land. Paste and gel baits are applied to specific areas

Clinical effects: A lethal dose of 1080 interferes with the body's Krebs Cycle; the ability to provide energy for cells to function. The citrate component of 1080 may inhibit the production of acetylcholine, which allows communication between muscles and nerves. These results in seizures often associate with 1080 poisoning. Once the body has been depleted of energy from cell death, death will usually occur within 5-196 hours[74] from organ failure – usually respiratory or heart failure.[75]

Effects on non-target species: There is considerable evidence to show that non-target species will consume baits directly and will also consume the carcasses of deceased animals. Non-target species see the baits as food and will consume them as readily as target species. A lethal dose of 1080 in a carcass breaks down in the very slowly, particularly in cold temperatures[76]. As a result, fatal secondary poisoning of scavenging animals that ingest the tissue is likely. Hunters should be made aware of 1080 use in areas where there are wild pigs.

[74] (Ministry of Agriculture and Fisheries, 2010)

[75] (Wickstrom, 2001)

[76] (Department of Conservation)

| Effectiveness of Sodium Fluoroacetate (1080)[77] | |
|---|---|
| Advantages | Disadvantages |
| Highly effective for achieving rapid reduction in possum numbers | Controversial, especially aerial operations |
| The only poison available for aerial application | Secondary-poisoning risk from carcasses (especially to dogs) |
| Cheap compared to most other poisons | No effective antidote |
| Biodegradable in the environment | Generates bait shyness if target animal gets sub-lethal dose |
| Can achieve consistently high kills | Poor-quality bait causes bird deaths |
| High-quality efficacy data and extensive field experience underpin both aerial and ground-baiting techniques | |

**Table 7**

| Relative Welfare Impact of VTA (Vertebrate Toxic Agent)[78] | | | | |
|---|---|---|---|---|
| Agent | Effect | Overall Impact | Approx time until death | Overall Grade |
| 1080 | Nausea | Moderate - Extreme | Hours | 5-7 |
| | Weakness | | | |
| **Table 13** | Pain | | | |
| | Sickness | | | |
| | Breathlessness | | | |
| | Dizziness | | | |
| | Anxiety/Fear | | | |

**Note: The overall grade for welfare impact is scored from 1-8. 8 is high impact.**

[77] (Wickstrom, 2001)

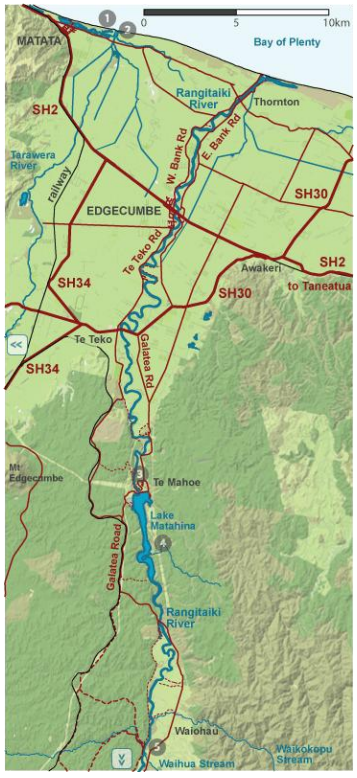
[78] (Ministry of Agriculture and Fisheries, 2010)

# Chapter 5
# Critical Commentary

## 5 My Masters Journey

In trying to find a metaphor for what this Masters journey has done for me, I thought of a butterfly emerging from its chrysalis – cliché, I know. But it was not enough. I realised as I thought back over the last couple of years that I have not just transformed from an immature form of myself to another, I have actually started a whole new life. The end of my Masters represents a new life – the beginning of something profoundly beautiful – a complete metamorphosis. In a sense my Bachelor of Applied Management transformed me from a caterpillar to a butterfly. Completion of my Masters is like the laying of an egg from that butterfly. My children were right all along - I am an egg!

[79]After I completed my BAM I told my husband I wanted to complete a Masters. He said, "You don't need a Masters to do what you want to do - I forbid you." I said ok then, and enrolled. When I first enrolled in the MPP program I was excited to have the opportunity to embark on a fresh-water research project. I wanted to compare invertebrate life at the confluence of farm filtered and forest filtered streams where they met the Rangitaiki River.




The Rangitaiki is our home river for our fishing guide business and is where we hunt and fish for a lot of our food. I have long been curious about whether farming operations are actually impacting on invertebrate life directly and if, so, how much? The idea for this research started forming as I wrote a paper for my BAM called "Sustainability on the Rangitaiki River" (this can be found at the end of my document in the appendices.) A while after that, while I was working on Course One and Two, a friend came to visit and asked how my Masters was going. Dave asked, "What Masters?" I laughed. He asked about my subject and said there

[79] (nzfishing.com)

were plenty of others looking at that already, and I should focus on wallabies and 1080. And so it began…

The beginning of my MPP was a challenge for me. I had come straight out of a very supported and nurtured process, completing my Bachelor of Applied Management, ably facilitated by John Gualter. John was available and encouraging. My first MPP mentor was more interested in me doing what he thought I should do, than what I wanted to do. Shortly after, he left his role and I was assigned a new mentor. My second mentor was a good man and when we spoke it was great – but I found it difficult to make contact with him and I could feel my motivation starting to wane. In the past this would have been enough to let me walk away – but my BAM opened a new door in my mind – it is a one-way door and quitting-because-it-is-hard is no longer an option for me. So I went back in my mind to where I was last happy in my learning and called John Gualter. John put me in touch with Glenys and we worked through the process of changing mentors – enter Malcolm Macpherson. Malcolm became my academic mentor, and John was allowed to continue to work with me as my facilitator. I was set!

From the beginning I knew that Malcolm understood where I wanted to be and he was encouraging. I got my Course One in and then started on Course Two. Malcolm warned me that my project for my MPP was unconventional. I knew it was, but that is why I chose to study with Otago Polytechnic – what I wanted to do did not fit anywhere else. I sent Malcolm an outline of what I wanted to achieve and he came back suggesting I needed to broaden my view a little and look at what has been happening in the rest of the world. That turned out to be a game changer for me.

Malcolm led me to “The Land Ethic” by Aldo Leopold. It was a life defining read for me and it completely changed the way I think about how we engage with the land we stand on. Leopold was an American environmentalist in the early 1900s – a long time before it was cool to care. Leopold believed we needed to have a branch of ethics devoted to our relationship to land and those ethics should not be human-focused, but should be ecologically based; land-focused. Leopold gave me a lot to think about: What is land ownership? When a person who has no connection to a piece of land that they are making decisions for, how is that ethical and how does it fit with their personal ethics? How do municipal authorities engage with indigenous land owners where there are multiple owners and who makes the decisions for everyone? How does all of that work with the Resource Management Act? There was so much going through my mind, so I started with the RMA and enrolled in the training to become a Commissioner.

The Resource Management Act 1991 – or RMA – is a reasonably new piece of legislation that governs how we interact with, and manage the environment. It provides a direction for decision making and in theory keeps the environment safe from us. I am not convinced it does that, but that is a story for another day. A commissioner's role is to sit on a panel to decide on applications under the Act for resource consents and other applications for change. The decision to become a commissioner was based on my wanting a deeper understanding of pest management practice and planning in legislation. I soon turned my mind to our local council and realised it would also make me a useful councillor, so I decided to stand – for the second time. While I started thinking about a Council campaign, I also had to get Course Two finished.

Course Two was amazing. As I wrote about what I wanted to achieve I was excited by the challenge it presented. How was I, the woman with an opinion on everything, and an undying passion for everything I believe in, going to be able to write an unbiased work that presented facts only and left people to make up their own minds? That was the challenge I set myself and what a challenge! I completed the work and submitted it, with a gentle reminder from Malcolm that my work was pushing the MPP boundaries. Some people like it when others push boundaries, but not the people who assessed my work. They did not get it. At the time I saw it as an attack, but now in reflection, I see it as I did not explain myself properly – I could have done better. But so could they. There is no such thing is a door that can't be broken down and for some reason when I received my assessment, even though I knew it was pushing boundaries, it hit me hard. The newly build-one way door in my mind was at risk because the assessment was like a sledgehammer I could use to smash it down. I wanted to quit. There was a lot going on in my life and it was all getting too much. Instead of quitting, I just stopped – I figured it was better to do nothing than to do something I would later regret – this was very much outside of my character and as I reflect on it I am still pretty happy with myself.

While I stopped writing and thinking specifically about my MPP, I kept reading. Reading and learning are two of my favorite things. Soon after I found out that my dad had been diagnosed with terminal cancer. Every time I called him, the first thing he asked was how my Masters was coming along. I started to get back to work on it. I now had a very powerful reason to finish this journey – the pride of my dad. In reflection I can see why I so happily switched to possums and wallabies – my dad. My dad hunted red necked wallabies in the South Island. To our family they were food. Now, here I am a grown woman with my own family, hunting dama wallaby for food. Life does not really change, it just goes round and round in ever-

changing circles. This circle I call my MPP is about to come back around on itself as it comes to its end. And immedialy it ends, there is a new beginning. Around eight weeks ago, Waikato University approached me with an offer that has blown me away. I had been talking to a friend who works there about Leopold and the questions his work raised in my mind. My friend shared that conversation with one of the heads of the university and they were excited by the potential of that. They invited me to come for meeting and offered me an LLD starting in 2017 though the Māori department within the Law School. They want me to answer those questions I asked myself. They want to know the answers, too.

As I think back over these last months, about the trials and tribulations, there is a lot of have learned about possums and wallabies, and also about myself. One thing that I am so proud of is that I have achieved my main objective – there now exists a document that teaches people about brushtail possums and dama wallabies. It gives the history of their introduction, their population spread, changes in classification, and efforts to contain them. It does all of that in an unbiased, factual way and I did not know if I would be able to do that. I think I have. This new skill I have developed will be very beneficial throughout the rest of my life as I learn to contain my enthusiasm in sharing information. I have learned through this process that it is better to bring someone to a place where they can make their own decisions, armed with all the facts. Another thing I have learned about is the reality of using poison to control animals. While I have always been opposed to the use of poison, I did not have the facts to back up my position – now I do.

This year I was appointed to the Department of Conservation Board and also the Te Taputoru a Toi Board. I have come onto these two Boards as a staunch and vocal opponent of 1080 for control of possums. That they would have me on the Board, knowing my position means that they want something different. I want to be the difference.

My thanks and gratitude to John, Malcolm and Glenys for the support and encouragement you have all so freely given.

Ehara taku toa, he takitahi, he toa takitini

*My success should not be bestowed onto me alone, as it was not individual success but success of a collective*

# 6 Bibliography

Bay of Plenty Regional Council. (n.d.). *Bay of Plenty Regonal Council*. Retrieved August 23, 2016, from Dama Wallaby: https://www.boprc.govt.nz/media/448365/pa16-dama-wallaby-web.pdf

Bay of Plenty Regional Council. (2011). *Pests of the Bay of Plenty.* Whakatane: Bay of Plenty Regional Council.

Bompas, G. (1885). *Life of Frank Buckland.* London: Smith, Eder and Co.

Brockie, B. (2007, September 24). *Native plants and animals – overview - Species unique to New Zealand*. Retrieved August 12, 2016, from Te Ara - the Encyclopedia of New Zealand: http://www.TeAra.govt.nz/en/native-plants-and-animals-overview/page-1

C. T Eason, L. M. (1999). *Secondary and Tertiary Poisoning Risks Associated With Brodifacoum.* Lincoln: Landcare Research.

Department of Conservation. (n.d.). *Alternative Poisons*. Retrieved September 18, 2016, from Nature: http://www.doc.govt.nz/nature/pests-and-threats/animal-pests/methods-of-control/1080-poison-for-pest-control/the-use-of-1080-for-pest-control/6-other-control-options/6_3-alternative-poisons/

Department of Conservation. (n.d.). *Key Facts about 1080*. Retrieved September 20, 2016, from Department of Conservation: http://www.doc.govt.nz/nature/pests-and-threats/animal-pests/methods-of-control/1080-poison-for-pest-control/the-use-of-1080-for-pest-control/4-information-about-1080/4_1-key-facts/

Department of Conservation. (2016). *Predator Free New Zealand 2050*. Retrieved October 6, 2016, from Department of Conservation: http://www.doc.govt.nz/our-work/predator-free-new-zealand-2050/

Department of Conservation. (n.d.). *Wallabies.* Retrieved September 18, 2016, from Parks and recration: http://www.doc.govt.nz/parks-and-recreation/things-to-do/hunting/what-to-hunt/wallabies/

Departmet of Conservation. (2007, October). *Brodifacoum factsheet.* Retrieved September 16, 2016, from Department of Conservation: http://www.doc.govt.nz/Documents/conservation/threats-and-impacts/animal-pests/northland/brodifacoum-factsheet.pdf

DOC. (2010). *Ngāi Tahu whakapapa – genealogical origins and creation*. Retrieved April 15, 2016, from Department of Conservation: http://www.doc.govt.nz/about-us/our-policies-and-plans/conservation-management-strategies/west-coast/ngai-tahu-whakapapa-genealogical-origins-and-creation/

Environmental Protection Authority. (2012, January). *Questions and Answers on Sodium Nitrate.* Retrieved August 12, 2016, from Environmental Protection Authority: http://www.epa.govt.nz/search-databases/HSNO%20Application%20Register%20Documents/ERMA200570_QA%20sodium%20nitrite.pdf

Fisher, P. (2010). *Environmental fate and residual persistence of broadifacoum in wildlife.* Lincoln: Landcare Research.

Forest and Bird. (n.d.). *Threats and Impacts*. Retrieved September 29, 2016, from Forest and Bird: http://www.forestandbird.org.nz/saving-our-environment/threats-and-impacts

Goergous Creatures. (2016). *NZ Possum Fur*. Retrieved October 2, 2016, from Gorgeous Creatures: http://www.gorgeouscreatures.com.au/NZ+Possum+Fur.html

Holdaway, R. (2007). *Extinctions - New Zealand extinctions since human arrival.* Wellington: e Ara - the Encyclopedia of New Zealand.

Holdaway, R. (1989). New Zealand's pre-human avifauna and its vulnerability. *NEW ZEALAND JOURNAL OF ECOLOGY, VOL 12* , Supplement.

Hutching, G. (2008, November 24). *Story: Possums*. Retrieved August 2nd, 2016, from Te Ara: http://www.teara.govt.nz/en/possums

Inter-organization Programme for the Sound Management of Chemicals. (1996). *Brodifacoum*. Retrieved April 16, 2016, from INCHEM: http://www.inchem.org/documents/pims/chemical/pim077.htm#SectionTitle:1.1 Substance

Kean, R. I. (1967). Behaviour and territorialism in Trichosurus vulpecula (Marsupupialia). *New Zealand Ecological Society* , 71-78.

Kean, R. (1971). Selection for melanism and for low reproductive tate in Trichorsurus Vulpecula (Marsupialia). *New Zealand Ecological Society, Vol. 18* , 42-48.

King, C. M. (1990). *The Handbook of New Zealand Mammals.* Auckland, New Zealand: Oxford University Press.

Lee Shapiro, J. R. (2011). Effectivness of cyanide pellets for control of dama wallabies (Macropus eugenii). *New Zealand Ecological Society* , 287-290.

Lentle, R. (1998). *Feeding strategies of the tammar wallaby ((Macropus eugenii Desmarest).* Palmerston North: Massey University .

Marchand, P. (2013). *Life in the Cold: An Introduction to Winter Ecology, fourth edition.* Lebanon: University Press of New England.

McLintock, A. H. (1966). Acclimatisation Societies and their Activities. In *The Encyclopedia of New Zealand.* The Encyclopedia of New Zealand.

Ministry for Primary Industries. (2016). *Review of current and future predicted distributions and impacts of Bennett's and dama wallabies in mainland New Zealand.* Wellington: Ministry for Primary Industries.

Ministry for Primary Industrustries. (2015, 11 30). *Unwated Organisms Permission*. Retrieved 09 23, 2016, from Biosecurity in New Zealand: http://www.biosecurity.govt.nz/biosec/pol/statements/unwanted-organisms-permission

Ministry for the Environment. (2007). *Environment New Zealand 2007.* Wellington: Ministry for the Environment.

Ministry of Agriculture and Fisheries. (2010). *How humane are our pest control tools?* Lincoln: Ministry of Agriculture and Fisheries.

Murray, W. (2014). *Biosecurity Operational Plan Annual report - 2013/2014.* Tauranga: Bay of Plenty Regional Council.

N.G Gregory, L. M. (1998). Effect of potassium cyanide on behaviour and time of death in possums. *New Zealand Veterinary Journal 46* , 60-64.

nzfishing.com. (n.d.). *Lower Rangitaiki River/Lake Matahina Toopographic Map*. Retrieved October 10, 2016, from nzfishing.com: http://www.nzfishing.com/FishingWaters/Eastern/ERMaps/Rangitaiki_lowerTopo.htm

Pracy, L. (1974). Introduction and liberation of the opposum ( Trichosurus vulpecula) into New Zealand. *NZ Forest Service Infromation Series No. 45* .

R. T. Meister, G. L. (1984). *Farm Chemicals Handbook, 70th ed.* Willoughby: Meister.

S.E Jolly, R. J. (1995). Cholecalciferol Toxicity and Its Enhancement by Calcium Carbonate in the Common Brushtail Possum. *Wildlife Research* , 22.

Thomson, G. M. (1922). *The Naturalisation of Animals and Plants in New Zealand.* Cambridge: Cambridge University Press.

Wickstrom, C. E. (2001). *Vertebrate pesticide toxicoology manual (poisons).* 2001: New Zealand Department of Conservation.

# Appendices

A. Sustainability on the Rangitaiki River
B. Final Learning Agreement Course Two
C. Review of Learning from BAM
D. CV Sept 2016