THE POSSUM PROBLEM IN THE MANAWATU-WANGANUI REGION

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TABLE OF CONTENTS

CHAPTER 3

NONMARKET VALUATION

CHAPTER FOUR

THE MANAWATU-WANGANUI CASE STUDY

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

Since their introduction to the Manawatu-Wanganui region possums have increased dramatically in number and are now causing problems in both rural and urban areas. They are responsible for the destruction of indigenous forests and the spread of bovine tuberculosis, a disease that threatens the access of dairy, meat and several other animal products into a number of key overseas markets. The study addresses this by looking at the problems associated with possums and the value that the region places on their control. This was done via two contingent valuation surveys, one in the form of a dichotomous choice question and the other in the form of an open ended question. It was found that 97.8 percent of respondents were aware that possums were causing problems in New Zealand. The region placed a value of between $1.5 million and $7.0 million per year on possum control. Farmers' valuation of possum control was approximately twice that of nonfarmers, possibly reflecting the adverse effect that possums could have on farmers' income stream.

CHAPTER 1

BACKGROUND AND MOTIVATION

1.1 INTRODUCTION

The possum was first introduced into New Zealand from Australia over 150 years ago. It has since spread to cover most of the country. Although considered an asset to the country when first introduced as a means of starting a fur industry, controversy surrounded the possum for the next 120 years. During this period, Government played a variety of roles in the control of possum populations, ranging from protection to killing operations.

This animal is now considered to be a major pest, both in its ability to destroy indigenous forest and as a vector of bovine tuberculosis (Tb) (Manawatu-Wanganui Regional Council, N.D.#2), a disease which threatens the access of our dairy and beef exports to several overseas markets. Possums are also responsible for damage to exotic forests, pastures, orchards, nurseries, catchment plantings and domestic gardens.

Although possums are a problem throughout most of New Zealand, this study focuses on the Manawatu-Wanganui region (Figure 1.1). The Manawatu-Wanganui region covers an area of 22,179 km^2 (Manawatu-Wanganui Regional Council, N.D.#3) or 10 percent of New Zealand's land area. With a population of 223,039 (Manawatu-Wanganui Regional Council, N.D.#3), it is the fifth most populated region in the country. The region contains a diverse range of land use, ranging from a city with a population of approximately 70,000 persons to both extensive and intensive agricultural practices. There are now several tuberculosis endemic areas in the Manawatu-Wanganui region.

In the past, control has been carried out by a variety of organisations, often with little liaison between them. Although the cost of pest control in the region is projected to be over $3.4 million for the 1992/93 financial year (Manawatu-Wanganui Regional Council, N.D.#1), little is known about the benefits people of the region derive from it. Approximately 80 percent of this money will be spent on possum control.

Possums are mobile animals which know few boundaries. This poses a problem if they are to be controlled. It raises the question 'who should control possums ?' Possums belong to no-one and hence no-one takes responsibility for their control. Control however does benefit all, irrespective of whether people contribute to the cost of control or not. Clearly this public good characteristic of the problem calls for Government intervention. This raises questions as to the way this intervention should proceed, the costs and benefits involved and how payment for control should be obtained.

1.2 OBJECTIVES OF THE PROJECT

The overall objective of this study is to ascertain what possum control is currently being carried out in the Manawatu-Wanganui region. This will be compared to the control wanted by residents of the region both in an organisational sense and in a monetary sense. From this it will be possible to decide if the allocation of funds is effective and efficient in relation to the benefits derived from them.

Specific objectives of the study are:

To summarise much of the information currently available on possums.

To ascertain the value that the public places upon possum control.

To measure any differences in the perceptions of the problem and the values placed on possum control between different sectors of society, especially urban versus rural dwellers.

To identify the roles of organisations currently involved in possum control.

To identify the benefits gained from possum control in the Manawatu-Wanganui region.

To ascertain the way that Government and other organisations should be involved in possum control in the region.

1.3 OUTLINE OF THE THESIS.

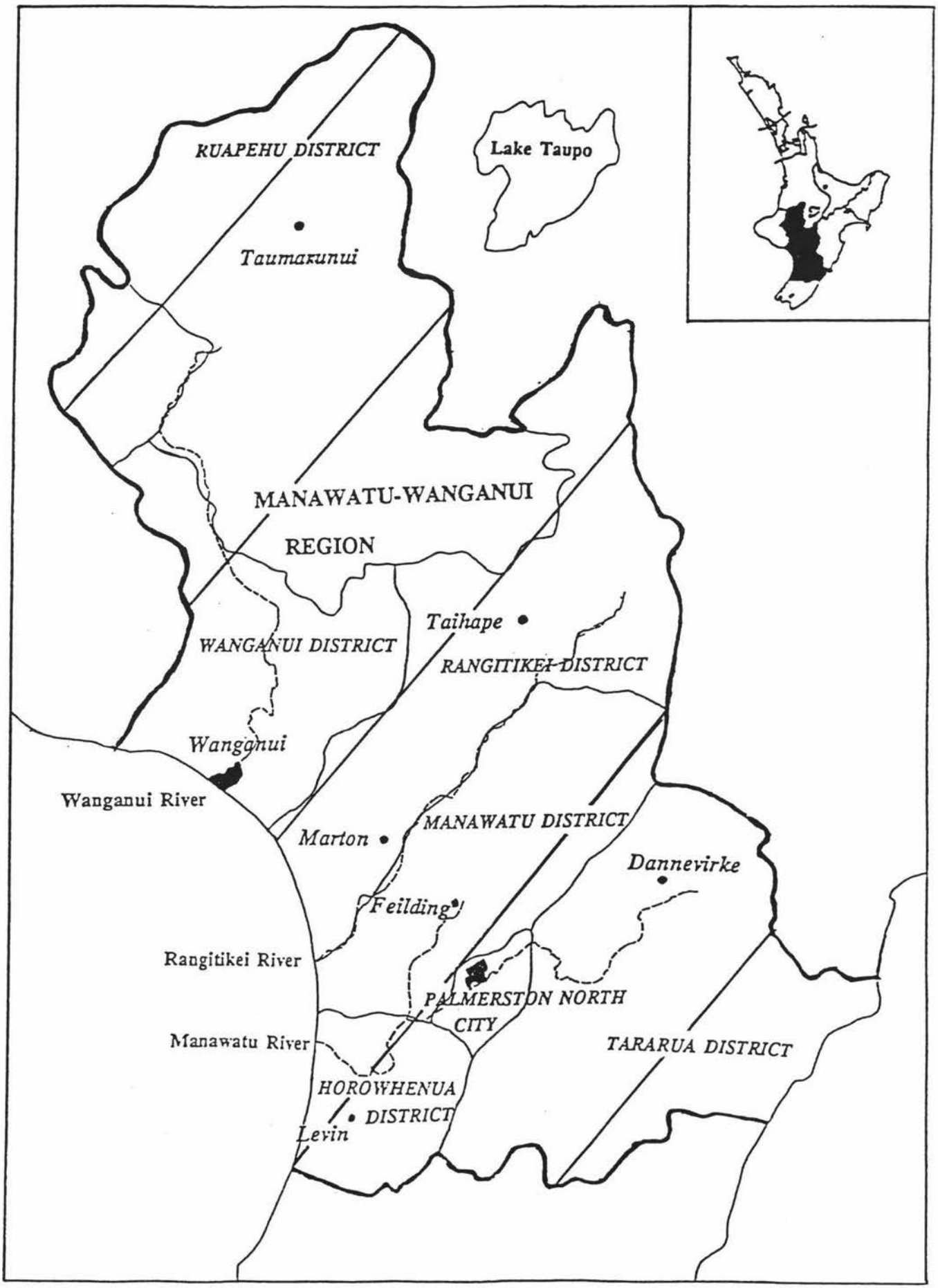
Chapter Two gives an in-depth overview of the possum including history, habits, damage and methods of possum control. This chapter goes on to look at the role of Government and other organisations in the control of possums and the need to measure the benefits and costs of control.

Chapter Three contains a discussion of the techniques used to measure the benefits and costs of possum control including the contingent valuation method (C.V.M.), the logit model and the survey methods used.

Chapter Four presents the methodology used to obtain the economic measures of the benefits and costs of possum control. It continues by discussing the results derived from the survey and presents them from a regional viewpoint with particular reference to the value that the Manawatu-Wanganui places on possum control.

Chapter Five concludes the project by discussing the results and giving recommendations based upon them, with particular reference to the Government's role in the control of possums. It also looks at the ability of the thesis to fulfil its objectives.

Figure 1.1 The Manawatu-Wanganui Region



CHAPTER TWO

BACKGROUND ON POSSUMS AND POSSUM CONTROL

2.1 INTRODUCTION

Although New Zealand lacked native terrestrial mammals, except for two species of bat, over 50 species of mammals have been introduced and become established since the late eighteenth century. The unforeseen consequences of these introductions are well summarised by Veblen and Stewart (1982, pp372-373).

> "The absence of native terrestrial mammalian herbivores permitted evolution of a flora highly vulnerable to browsing and grazing.
>
> The populations of wild animals (especially deer) that were introduced mainly during the latter half of the nineteenth century grew explosively because of the lack of competitors and predators.
>
> Browsing and grazing by the introduced wild animals have had a devastating impact on the native vegetation, often resulting in severe depletion of the plant cover and accelerated erosion"

The acclimatisation of animals and birds was sanctioned by early legislation, the intention of Acts passed in 1861 being to

> "...encourage the importation of... ...animals and birds not native to New Zealand which would contribute to the pleasure and profit of inhabitants when they became acclimitised and were spread over the country in sufficient numbers" (Johns and McGibbons, 1986 ,p7).

It was not until 1895 that consent of the Government was required for the introduction of any animal or bird (Johns and McGibbons, 1986).

2.2 HISTORY OF POSSUMS IN NEW ZEALAND.

Possums were primarily introduced to establish a fur industry with those imported as pets having only a minor influence on the rate of establishment and spread. The artificial dispersion of New Zealand bred progeny (both legally and illegally) by private individuals and Acclimatisation Societies had by far the greatest impact on their spread and overall distribution.

Information tends to indicate that the first possums were released in the vicinity of Riverton prior to 1840 by Captain John Howell. After a first introductory phase importation was sanctioned by legislation under the Protection of Certain Animals Act 1861 and by the Animal Protection Act 1880 and its amendments (Pracy, 1962). From 1915 to 1924 importations were restricted to incidental pets with no further entries known after 1924.

Prior to 1922, 31 consignments of possums, mainly from Tasmania, were introduced to New Zealand by private individuals and Acclimatisation Societies (Figure 2.1). These animals and their progeny were liberated at at least 464 places in New Zealand (Pracy, 1962), principally by private individuals (1837 to 1861) and Acclimatisation Societies (1870 to 1930) (Cowan, 1991). It is thought that illegal liberations are still occurring (Batcheler, 1990).

From 1890 to 1900 both the importation and artificial dispersion of New Zealand bred stock peaked, although importations tapered off between 1900 and 1910 as the result of a recession. This coincided with the main phase of liberations of New Zealand bred stock by Acclimatisation Societies (Figure 2.2). These were predominantly Tasmanian Black possums which were much sought after by the fur industry (Pracy, 1962).

The Government played an active part in the acclimatisation of possums from 1895 to 1906, with the predominance of releases occurring in the Westland, Grey and Buller districts. These were near or within the constituency of the Rt. Hon. R.J.Seddon, Premier of New Zealand from to 1890 to 1906, who was very interested in the liberation of possums.

Figure 2.1 Importation of Possums into New Zealand from 1830 to 1930

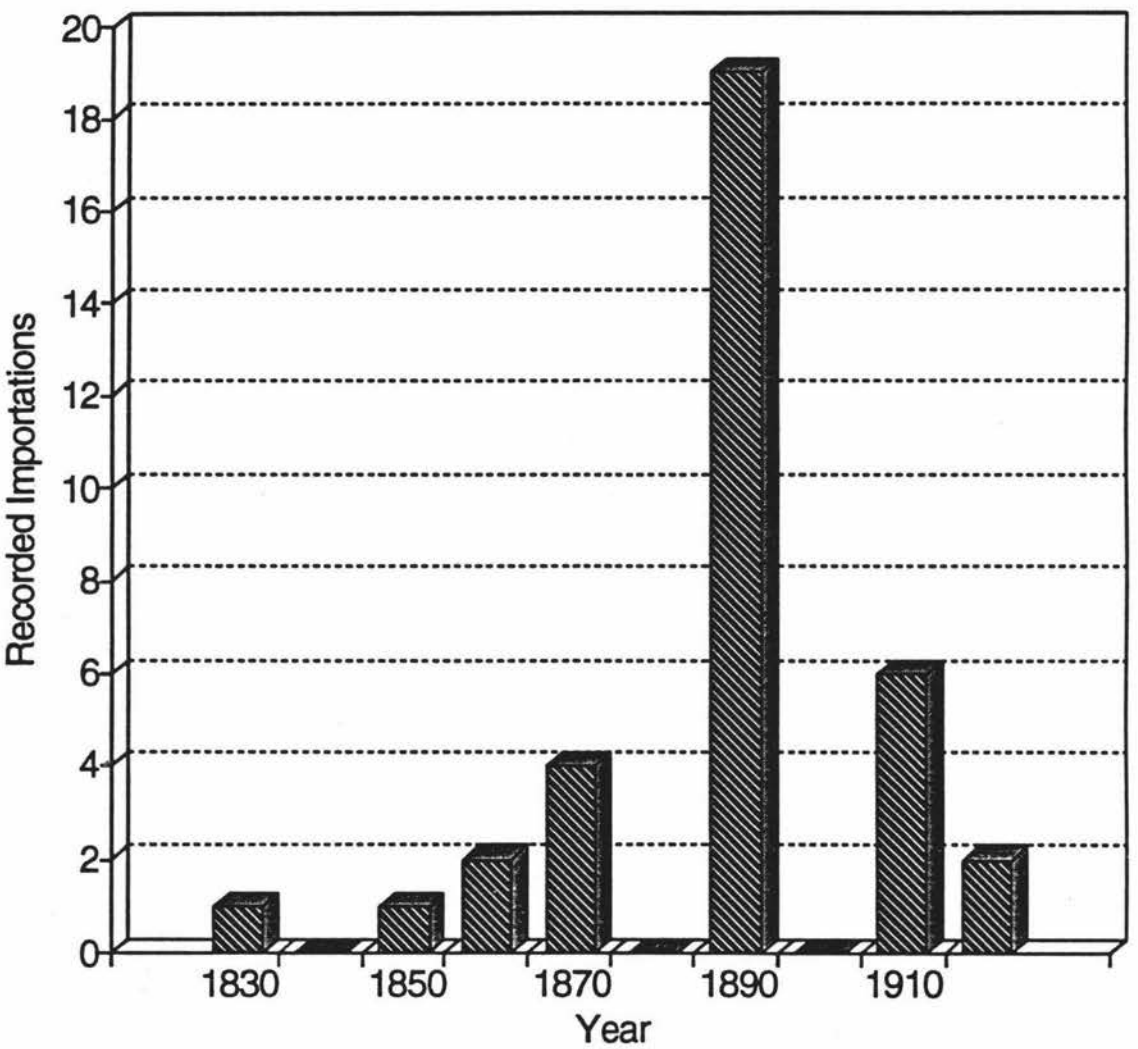
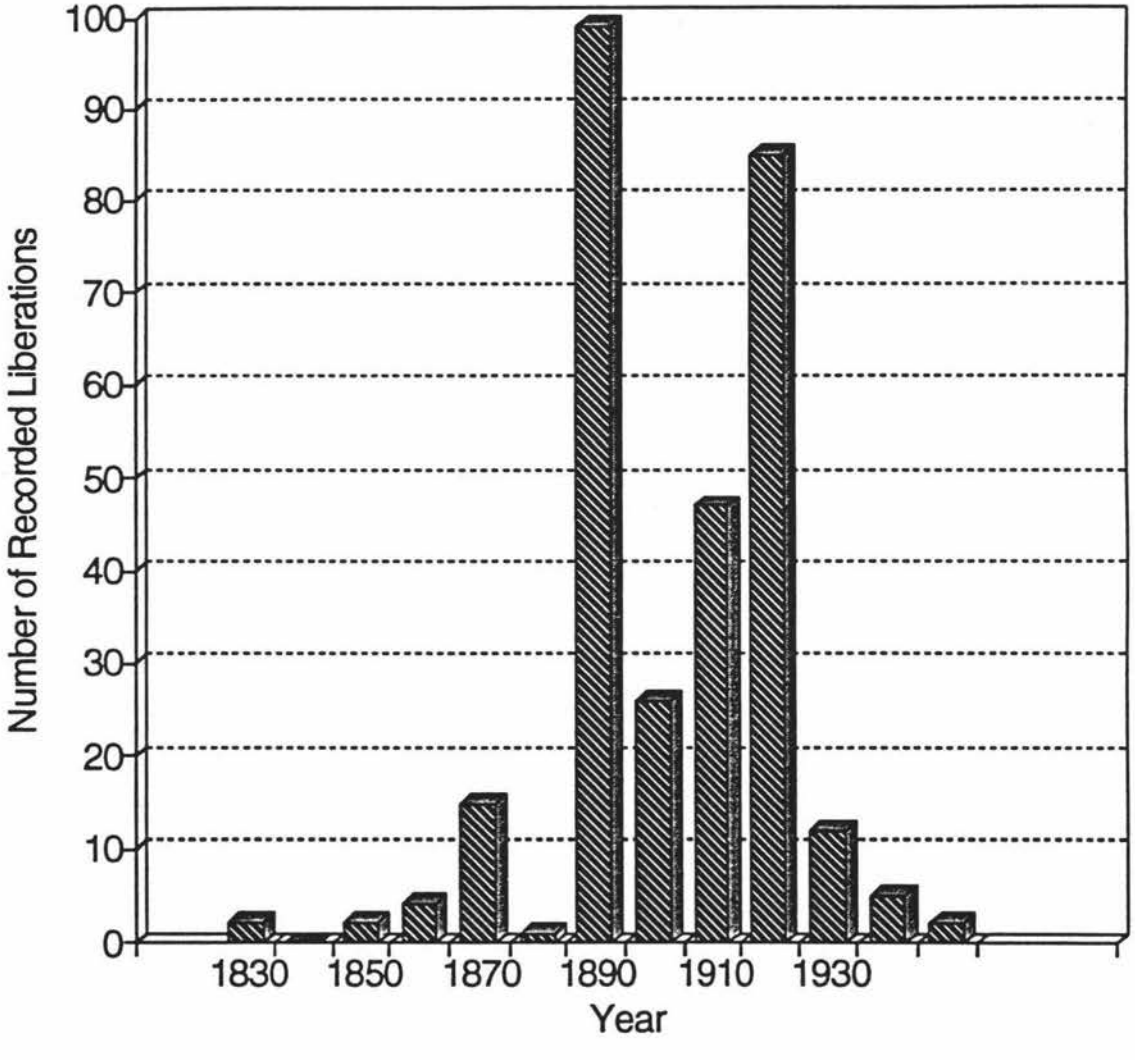


Figure 2.2 Liberation of Possums in New Zealand from 1830 to 1950



Generally the legislation aided and abetted the acclimatisation of animals from 1846 to 1912, although the Government was influenced by public opinion. Public opinion was mixed from the start as represented by the following extracts:

> "We shall be doing a great service to the country in stocking these large areas (of rough bush hills) with this valuable and harmless animal " (Annual Report of the Auckland Acclimatisation Society 1916-1917, in Pracy, 1962, p6).

The British Journal *Nature* made the following statement on what it regarded as the 'silly mania of acclimatisation', which it said was at the time being

> " ... so warmly fostered by many well meaning but ill advised persons, and nowhere more so than in New Zealand. In a reckless way, animals of extremely doubtful advantage have been transported to the Antipodes and, unaccompanied by any of the checks which keep natural fauna balanced, the importations will inevitably become the greatest of nuisances. Among the pilgrim fathers of New Zealand who will ultimately obtain the apotheosis, the members of their various Acclimatisation Societies will, we suspect, scarcely be reckoned." (Pracy, 1962, p6).

1910 to 1920 was a time of much debate with representations to the Government by both pro-possum groups (mainly Acclimatisation Societies) and protests by anti-possum groups, particularly the New Zealand Fruit Growers' Federation Ltd and farmer organisations. Due to the increasing destruction of possums in certain areas, Acclimatisation Societies put pressure on the Government to protect them. This resulted in an Order of the Council in 1911 declaring the possum to be imported game under the Animals Protection Act 1908, making it illegal to trap or kill them. At this time possum trapping was extremely profitable. Trappers and settlers made representations to Parliament citing damage to crops and orchards as reasons for removing these restrictions. In 1912 all protection was removed. This legislation produced an immediate outcry from the Acclimatisation Societies such that the Government reconsidered its decision and in 1913 another Order was issued declaring possums to be protected in specific counties (Pracy, 1962).

At this stage there was a need for more information on possums, so in 1916 the Department of Internal Affairs sent a circular to all Acclimatisation Societies, the Department of Tourist and Health Resorts and the Department of Agriculture questioning them on any possum damage they knew of and the desirability of further liberations. Press coverage of this lead to strong protests by numerous fruit growers' associations including the New Zealand Fruit Growers' Federation Ltd, County and Borough Councils and private individuals. Stemming from these representations, the Government began to have grave doubts as to the prudence of indiscriminate possum releases.

The Government, through the New Zealand Institute requested that Professor H.B. Kirk undertake a comprehensive investigation of the possum. Kirk came up with the following conclusions from his 1920 study:

> "The damage to New Zealand forests is negligible and is far outweighed by the advantages that already accrue to the community. That advantage might be enormously greater. On the other hand, the damage to orchards and gardens is indisputable; much annoyance and a loss statable at hundreds of pounds is caused. But the volume of the present trade in skins is in the thousands and the loss is born by one sector of the community while the gain made from skin trade is made by another.... ...Possums may in my opinion, with advantage be liberated in all forest districts except where the forest is fringed by orchards or has plantations of imported trees in the neighbourhood ." (Pracy, 1962, p9).

He concluded that an open trapping season from May to July should occur, with a license fee of a pound plus a royalty of 1 shilling per skin being payable to the Crown (Pracy, 1962). Leonard Cockayne, the most distinguished forest ecologist of the day, endorsed Kirks' assessment (Batcheler and Cowan, 1988).

5 May 1921, saw regulations being laid down for the taking of possums and prohibiting the harbouring or liberation of possums without consent from the Department of Internal Affairs. The restrictions on their liberation were relaxed later that year when eight authorities for releases were granted. In 1922 all authorities were cancelled and from then on, the Department of Internal Affairs

took a firm stand and declined further requests for permission to liberate possums (Pracy, 1962).

Although illegal liberations had taken place earlier, 1922 to 1940 was characterised by a large number of illegal liberations, particularly by trappers and private individuals as well as by some Acclimatisation Societies. The greatest number of these liberations took place between 1920 and 1929. Controversy over the liberation of possums continued with Cockayne stating

> "...these tree dwellers stand, economically in a class by themselves.... ...at any rate, if it is proved eventually - which is most unlikely - that possums are a menace to forests, their skins are so valuable that any time the animals can be reduced in numbers to the extent desired without cost..." (Pracy, 1962, p10).

Opposition to the possum increased throughout the 1920s with the Forest and Bird Protection Society commencing its continuous campaign in 1924. The volume of protests was balanced by the proposals for further liberations, but the increasing evidence of damage to orchards and exotic tree species, together with the probable competition with native birds for food, had considerable influence on Government policy.

Prior to 1946, possum destruction, with the exception of intensive control on Kapiti Island, was conducted under the authority of the Lands and Survey Department. 1916 to 1943 was characterised by short seasonal operations by licenced commercial trappers. Proceeds of the licencing and royalties were allocated through the Department of Internal Affairs to the Forest Service, Acclimatisation Societies and a consolidated fund for the policing and administration of trapping blocks (Pracy, 1980).

A Department of Internal Affairs resolution "that the present regulations are not an adequate means of controlling possum populations" (in Pracy, 1962, p12) led to new regulations in 1946 which retained the licence system for taking and killing, but discarded the licensing of brokers, the stamping of skins and the payment of royalties to the Crown. Amendments to the possum regulations in 1947 cancelled all restrictions on the taking of possums and made harbouring and liberating subject to harsher penalties. Poisoning was legalised in certain areas.

Being uncertain that removal of restrictions would result in adequate control, the Department of Internal Affairs embarked on a programme of field research followed by a nationwide survey on the distribution, damage and effects of possums on forests. The survey showed that possum control was required in certain areas.

As the Department of Internal Affairs was not capable of undertaking the necessary control operations immediately, an interim measure of placing a bounty of 2s 6d (Pracy,1962) on the production of the ears, backskin and attached neck of the possum was set. This destroyed the commercial value of the skin (Batcheler and Cowan, 1988). A Government subsidy of up to 2s 9d on every skin sold on the market was also payable to ensure that after the deduction of brokerage, trappers would receive a minimum of 2s 6d per skin (Pracy, 1980). The bounty scheme began in 1951 and ran for 9 years. By 1961, $23.8 million had been paid out for 8.2 million tokens (Batcheler and Cowan, 1988). The scheme was abandoned when analysis indicated that most tokens were coming from 'nuisance' possums in prosperous farming and semi-urban areas, or from possums killed on country roads rather than from areas where they critically affected production, watershed protection and wildlife values (Batcheler and Cowan, 1988). The bounty scheme did not restrict the further natural dispersion of possums into unoccupied habitats in many parts of New Zealand (Pracy, 1980) and evidence suggests that the scheme resulted in a renewal of liberations by trappers and token hunters (Pracy, 1962).

From the early 1950s, the Rabbit Destruction Council sought involvement in possum control on ratable land. In 1961 Rabbit Boards were enabled to impose a separate possum control rate where possums were recognised as 'Pests of Local Importance', however by 1967, more than a third of Rabbit Boards declared that they had no interest in possum control (Batcheler and Cowan, 1988). In 1956, noxious animal control and its research was transferred from the Department of Internal Affairs to the New Zealand Forest Service.

The 1950s saw the first trials with aerially distributed 1080 cereal pellet baits, with possum kills estimated at between 50 and 98 percent. In the 1960s and early 1970s, large scale control programmes ran to protect down river farmlands from the effects of erosion if the watershed forests were destroyed. The 1970s also saw the involvement of New Zealand Forest Service (NZFS) and the Agricultural Pest

Destruction Board (through the Agricultural Pests Destruction Council (APDC)) in extensive poisoning operations as agents of the Animal Health Division of the Ministry of Agriculture and Fisheries. Their prime objective was to eradicate tuberculosis (Tb) from possums. By 1980 it became clear that their objective was not attainable, thus their policy changed to that of cost effective control (Batcheler and Cowan, 1988).

By the late 1970s, private hunters were placing increasing pressure on possum populations in accessible areas as skin prices improved. At the same time, some scientists began to question if the possum was the primary culprit for the widespread death of forests. Due to these doubts and the increasing hunter pressure on numbers, a steady decline in the amount of aerial poisoning on state-owned and administered lands occurred.

Since the drop in value of furs on the world market in the mid to late 1980s, due to the anti-fur lobby, the share market crash and an oversupply of European farmed furs, possum numbers have been on the increase. Trapping pressure, which at its height only removed 3 million possums per year, has in the most part been removed.

Many organisations are now involved in research on possums, the control of possums and the control of bovine tuberculosis. These include the Animal Health Board (AHB) and other divisions of the Ministry of Agriculture and Fisheries (MAF), Regional and District Councils, Universities, the Department of Scientific and Industrial Research (DSIR) and farmer and trapper organisations. The role of these organisations will be discussed in section 2.8.

2.3 DESCRIPTION OF POSSUMS AND THEIR HABITAT

2.3.1 Description of Possums

The possum is indigenous to Australia, where it is a partially protected species. The only country that it has been introduced into is New Zealand. It is a highly variable animal (Green, 1973) which is classified into some eight subspecies which interbreed (Kean and Pracy, 1953). In New Zealand, the stock is mixed and varies from place to place. It includes black, grey and red animals.

The possum is a nocturnal and mainly arboreal animal, spending between 6 and 20 percent of its time on the ground (Agricultural Pest Destruction Council, N.D.). Its weight, which varies with the season, locality and reproductive condition, is generally between 2.5 and 4 kilograms (Johns and McGibbons, 1986). Juveniles generally weigh less than 2 kilograms. Possums den mainly on the ground, on hillsides and sides of gulleys where suitable cover is available (Pfeiffer et al, 1991).

From samples taken on Kapiti Island, Orongorongo Valley, Waverley and the Hokitika River, the average life expectancy ranges from 2.5 to 3.5 years with only 1 in 500 possums reaching an age of 13 years (Agricultural Pest Destruction Council, N.D.). On average, females live longer than males.

2.3.2 Distribution of Possums

The distribution of possums up to the 1940s was not recorded, however it is estimated that 54 percent of New Zealand was occupied by possums by 1948-50. This increased to 84 percent by 1961-63, 90 percent by 1974 and 91 percent by 1980 (Batcheler and Cowan, 1988). The populations are now increasing and spreading only in the northern tips of Northland and the Coromandel Peninsula, the southern Kaimai and northern Mamaku Ranges, central portions of the Raukumara Range east of Opotiki, a small part of the west Taupo-Taranaki forest tract, part of north west Nelson centred on the Gouland Downs, South Westland, the upper reaches of some Canterbury rivers, south east Fiordland and the southern tip of Stewart Island (Cowan, 1991). The population is now estimated to be between 60 and 70 million (Batcheler, 1990), of which 40 million are estimated to live in scrub land habitats (Batcheler and Cowan, 1988). They are

now distributed throughout almost all of mainland New Zealand and the following islands

Kawau Island	-Hauraki Gulf
Rangitoto Island	-Auckland
Motutapu Island	-Auckland
Whanganui Island	-Coromandel
Rangipukea Island	-Coromandel
Tarakaipa Island	-Marlborough Sounds
Stewart Island and the adjacent islands of Codfish, Native, Tommy and Bravo	
Chatham Islands	(Pracy, 1980)

Possums can tolerate a wide variety of climates, varying from rainfalls of 350 millimetres to more than 8500 millimetres per year and altitudes from sea level to 1800 metres and 2400 metres in the South Island and North Island respectively (Cowan, 1991). They are known to live in forests, montane scrubland, tussock grassland, pasture, exotic forests, shelter belts, orchards, cropping areas, thermal regions, swamp and pakihi country, sand dunes and both rural and urban areas (Cowan, 1991).

2.3.3 Population Dynamics

Any consideration of the possum, either as a pest or as a harvestable resource, must consider population dynamics since the intensity of browsing, the yield of skins and the potential to transmit diseases are all dependent upon the density of the populations (Efford, 1988).

Several models exist that predict the population dynamics in newly colonised areas, however, the 'eruptive fluctuation model' has generally been favoured as an explanation of this. It was derived from work on ungulates by Caughley (1970). Pracy (see Batcheler and Cowan, 1988), provides a concise description of the population dynamics following colonisation. This closely follows the eruptive fluctuation model.

> "Following the liberation of possums or the colonisation by dispersion into unoccupied territory there is a well marked series of changes in population levels... ...Initially there is a slow but steady increase in the populations, followed by a relatively short eruptive period to peak population levels... ... The period of peak population is generally of short duration followed by a sharp and often drastic decline in numbers brought about by malnutrition or exposure through the lack of adequate nesting sites... ...The initial sharp decline is arrested after a relatively short period and is followed by a slow but steady decrease in the populations, with minor fluctuations often occurring"

Peak populations are generally associated with an increase in signs of possums such as defoliation and depletion of palatable species. The increase to peak populations generally takes about 20 years (Agricultural Pest Destruction Council, N.D.), although this varies with the type and condition of habitat, topography, climate and geological structure of the country. Only juvenile possums disperse into unoccupied territories.

2.3.4 Reproduction

Possums are largely solitary animals with no strong pair bonding or social grouping. Pairing is usually a transient phase with sexual activities leading to copulation rather to the establishment of a lasting bond.

The main breeding season is April to June, with a second peak occurring in September to November during which up to 80 percent of females may give birth for a second time (Efford, 1988). Young however, can be born at any time of the year. The gestation period is 17 to 18 days and with rare exception only one young is born at a time. In pouch mortality appears to be low (Efford, 1988) and is correlated to the body weight of the dam in autumn (Bell, 1981).

The young possum leaves the pouch at around 6 months of age, although it does not generally breed until two years of age. In good environments, about a third of yearling females may bear young, whilst males reach sexual maturity at approximately 16 months of age. (Pfeiffer et al, 1991) The intensity of spring breeding and the proportion of one year olds breeding generally reflects the relative condition of the population (Efford, 1988).

The possum has an undefended home range. This consists of a system of runways along the ground and on trees (Kean and Pracy, 1953). Green and Coleman (1984) give an average range size in New Zealand of 1.9 ha for males and 1.3 ha for females, however much larger ranges have been recorded (Green and Coleman, 1986; Brockie et al, 1987; Brockie, 1991). Once an animal has established a home range, it is unlikely to abandon the ground, either to avoid death, exploit a nearby food supply or to fill an empty niche. Simultaneous den sharing is uncommon (Pfeiffer et al, 1991) although Brockie (1991), recorded 9 animals in a single den at one time.

2.3.5 Mortality

Mortality is strongly seasonal (Efford, 1988; 1991), with most deaths occurring in the winter months. Annual mortality is low in the first four years (age 2 to 6 years) of adult life, being 10 percent for females and 16 percent for males. This increased rapidly to reach 50 percent for 9 year old males whilst females did not reach a 50 percent annual mortality rate until they reached 12 years of age (Efford, 1988). Efford (1991) recorded a maximum longevity of 13.6 years.

2.3.6 Population Density

The density of possums in New Zealand is estimated to be two to twenty times that of possums in their native Australia (Cowan, 1991). Of New Zealand's estimated 60 to 70 million possums, 66 percent live in the North Island and 34 percent live in South Island. The average density of North Island possums at 4 per hectare is 2.7 times the average density of possums in the South Island (Batcheler and Cowan, 1988). Scrub supports more than half of the New Zealand possum population (Brockie, 1991).

Maximum population densities of 25.4 per hectare for broadleaf podocarp forests and 8.5 per hectare for farmland have been recorded (Batcheler and Cowan, 1988), however these both refer to areas where possums routinely move out to forage on pasture. Cowan (1991) recorded average possum densities of 10 to 20 per hectare in podocarp/broadleaf forests, 1 to 3 per hectare in pine plantations, 0.5 per hectare in beech forests and 1 per hectare in scrubby farmland reaching 10 per hectare in scrub filled swamp. Possum density is generally lower at higher altitudes (Batcheler and Cowan, 1988).

2.4 THE POSSUM PROBLEM

Although a protected species in Australia, the possum is now a major pest in New Zealand. It causes a variety of damage, the most significant being the modification and destruction of indigenous forests and the spread of the disease bovine tuberculosis (Tb). As well as damage to indigenous forests, possums may cause a reduction in the numbers of many native fauna. Possums are also responsible for damage to exotic forests, crops, domestic gardens, pasture and fixtures such as buildings and telephone lines.

To better understand the damage that possums cause in their eating of plants it is important to understand their feeding habits.

2.4.1 Feeding Habits of Possums

The possum is largely an arboreal animal, spending less than 20 percent of its time on the ground (Pracy, 1980). Its diet tends to be composed predominantly of leaves, although it does also eat flowers, bark and other foods. Its feeding pattern is distinctive and is determined mainly by the size of the animal, the position it assumes when feeding and the practice of holding its food in its forepaws whilst eating (Batcheler and Cowan, 1988). Feeding patterns of the possum are characterised by the relative defoliation of different parts of the tree and the outline of leaf fragments left. Typically this is an entire petiole bearing a small basal portion of blade with protruding midrib (Kean and Pracy, 1953). Other feeding patterns exist less commonly.

In forests, research and field investigations have shown that no one tree species can meet the nutritional requirements of the possum. The possum has a high dietary requirement and cannot thrive on foods of low nutritional value because the gut cannot hold sufficient bulk. It has a simple stomach which does not utilise microbial digestion of cellulose in the caecum (Agricultural Pest Destruction Council, N.D.). The critical period for possums is winter, particularly in areas where they have reached high numbers and depleted food resources (Pracy, 1980).

2.4.2 Indigenous Forests

Despite warnings from the 1890s onwards, the impact of the possum on indigenous forests was not generally recognised until the 1940s. This coincided with an exponential increase in the founder colonies and an increase in numbers to peak densities. By the 1950s, the effects were often disastrous. Surveys of this period and subsequent detailed research has shown the following generalisations:

> Beech forests are the least vulnerable forests, with podocarp and mixed hardwood forests being most vulnerable, particularly those with kamahi, rata and/or pohutukawa (Cowan, 1991).
>
> More than half of North Island indigenous forests can be considered vulnerable to extensive modification by possums (Batcheler and Cowan, 1988).
>
> More than a quarter of South Island indigenous forests can be considered vulnerable to extensive modification by possums (Batcheler and Cowan, 1988).

Blaschke et al (1981), further classified the susceptibility of indigenous forest in the North Island and South Island as 18 percent and 9 percent respectively with an exotic plantation element, 27 percent and 65 percent with a beech element and 55 percent and 26 percent without a beech element.

Where there is little undergrowth due to stock, deer or goat grazing, the area always carries a relatively high number of possums (Innes, 1990), the reason for this being that possums can get wet and still remain warm as long as their fur is not brushed flat. If their fur is brushed flat in winter they often succumb to pneumonia and die. The coexistence of ungulates with possums, as well as being a precursor to higher possum numbers, results in severe forest undergrowth damage (Innes and Seitzer, 1990).

Depending on the possum density, the length of occupation and the site which the possum inhabits, they may affect the surrounding forests in one of two ways:

> The canopy may collapse completely where it is composed predominantly of preferred food species.

The forest may be severely modified.

The most severe cases of forest collapse occur on steep mountains, where high canopied palatable forests occur in a mosaic with shrublands dominated by fuchsia, wineberry or other palatable seral species. The mosaic provides ideally interspersed resources of summer food, especially fuchsia and winter food, especially rata. The high forest mosaic usually occurs near fault zones where the landscape is vulnerable to any disturbance (Batcheler and Cowan, 1988; Batcheler, 1990).

On more stable terrain or where the dominant vegetation is not preferred by possums e.g. beeches and podocarps, possums seldom reach high enough density to destroy forest structure. They may, however, eliminate many minor species such as mistletoes, fivefingers, titoki and mamaku fern (Batcheler and Cowan, 1988; Batcheler, 1990). As the length of possum occupation in an area increases, the severity of foliage loss and the incidence of possum browsing may increase (Leutert, 1988).

Leaves provide the bulk food for possums. Commonly, mature leaves are eaten, but in some cases buds, young leaves or petioles are taken. Over 70 indigenous tree species are listed as food as well as a number of species of fern, epiphyte, vine, grass and sedge. Strong preferences are shown for definite species, but differences in order of palatability are found from district to district (Johns and McGibbons, 1986). This can not be adequately explained although it is probably due to the need to balance different food combinations.

The most preferred species are eaten first and when there is none of these left, possums move on to eating the next most preferred species. The persistent defoliation of a tree by possums may result in its death.

Although 16 species of flowers have been recorded as eaten by possums in field observations, few are found in their stomach contents, probably due to the shortness of the flowering season. Fruits are of importance in the possums' diet from the middle of summer to late autumn when they are almost as important as leaves. As many fruits are taken while green and incompletely developed, frequently only part of the fruit is eaten. In addition to the wastage due to

partially eaten fruit, undamaged berries are knocked from trees in large quantities (Kean and Pracy, 1953).

Some 70 tree species have been recorded as being subjected to bark biting. Owing to the ease of observation, bark biting is often overestimated. Bark tends to be a winter feed which is eaten when other foods are in short supply. The baring of wood may facilitate the entry of boring insects and fungi, however the extent of this problem is difficult to evaluate.

2.4.3 Current Damage to North Island Indigenous Forests

The North Island contains a variety of indigenous forest types, with varying susceptibility to possum damage. The distribution of these forest types is shown on Figure 2.3.

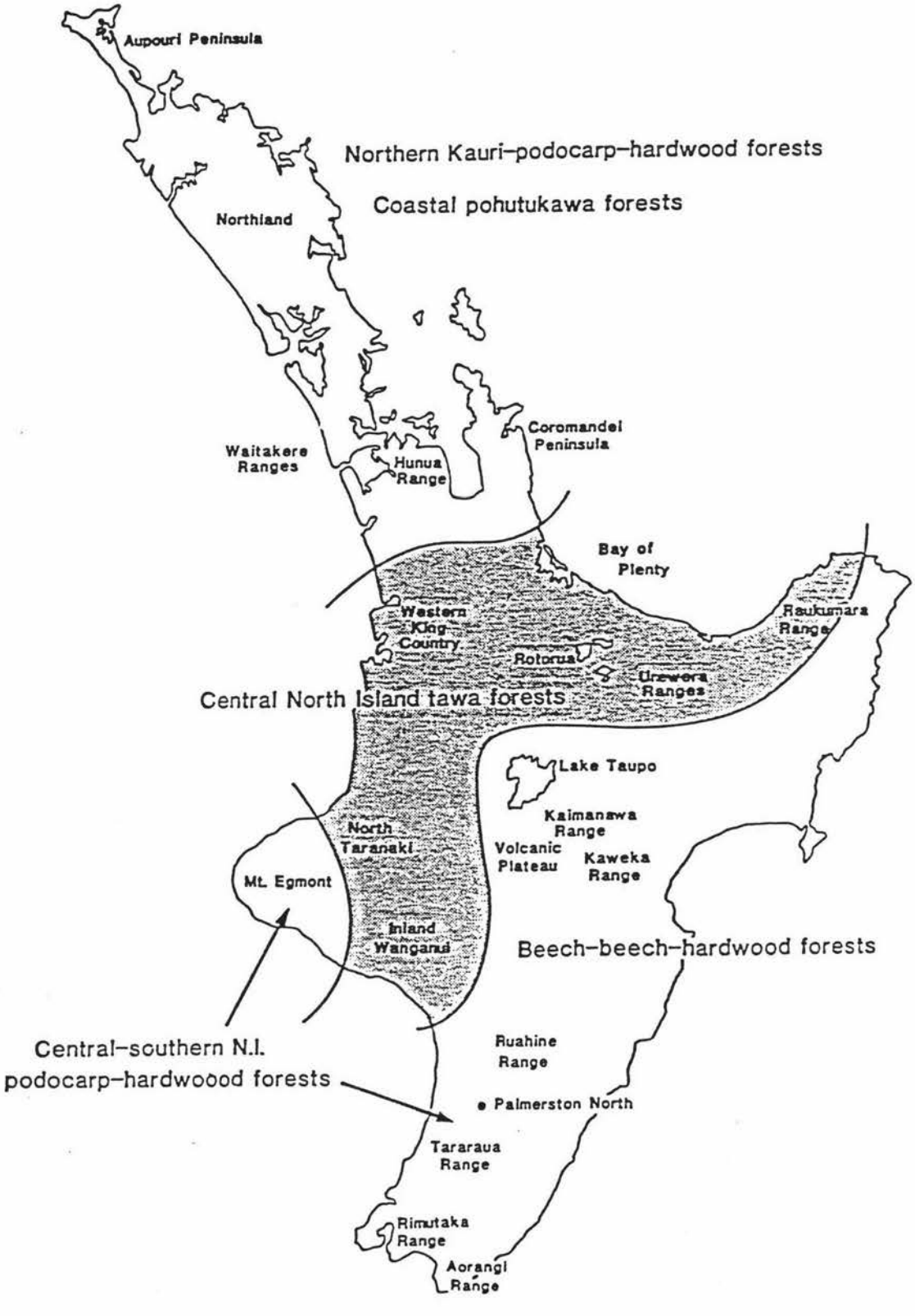
Northern Kauri-Podocarp-Hardwood Forests

This includes forest types in which kauri is present, together with lowland hardwood associations of the Northland, Auckland and Coromandel regions. Although a wide range of species are browsed by possums, the most conspicuous damage is the severe defoliation and death of emergent northern rata *(Metrosideros robusta)* and kohekohe *(Dysoxylum spectabile)*. In some areas, shrub hardwoods such as five-finger, *(Pseudopanax arboreus)*, fuschia *(Fuchsia excorticata)*, pate *(Schefflera digitata)* and the mamaku tree fern *(Sphaeropteris medullaris)* are also reported to be severely defoliated and killed (Batcheler and Cowan, 1988).

Coastal Pohutukawa Forests

Pohutukawa *(Metrosideros excelsa)* dominated forests are a feature of the Northland and Coromandel coastlines. These extend south towards New Plymouth on the west coast and towards Gisborne on the east coast. Damage appears to be most severe to trees in the Northland area (Batcheler and Cowan, 1988; Hosking, 1990). Possums frequently browse and kill one or a few trees while ignoring other nearby pohutukawa trees. Damage appears to be most severe in areas which are farmed or otherwise developed (e.g. picnic areas and camping grounds).

Figure 2.3 Distribution of North Island Indigenous Forest Types (Source: Batcheler and Cowan, 1988)



Central North Island Tawa Forests

Tawa are regarded as a good food for possums. Apart from the defoliation and eventual death of the scattered emergent rata, forest canopies on ridges and hill slopes are not greatly modified by possum browsing. The most change occurs in the valleys where fuchsia, mahoe *(Melicytus ramiflorus)*, pate, kamahi *(Weinmannia racemosa)*, wineberry *(Aristotelia serrata)* and raukawa *(Pseudopanax edgerleyi)* are heavily browsed. The estimated rata mortality in the inland Wanganui forests ranges from 10 to 15 percent (Batcheler and Cowan, 1988).

Central-Southern North Island Podocarp-Hardwood Forests

South and east of the central tawa belt, kamahi replaces the tawa as the main canopy species in hardwood and podocarp-hardwood forests. Damage of these forests appears to be most severe in areas which contain a high proportion of seral vegetation or emergent northern rata.

Massive collapse of the mixed hardwood forests (rata, kamahi) coincided with the buildup of possum, deer and goat populations in the southern Ruahine Ranges. Although there was little evidence of possum damage in the southern Ruahine Range prior to 1940, 19 shrub and tree species were being defoliated by 1948. By 1955, canopy defoliation was becoming conspicuous from the plains, while by 1965 possums had almost completely defoliated large areas of forest (Elder, 1965). The former rata/kamahi forests generally collapsed, leaving only scattered species of trees not preferred by possums (James, 1973). The Manawatu Hill country suffered a similar fate (Batcheler and Cowan, 1988).

Batcheler (1983), assessed the overall effect of possums in the Pohangina Valley from aerial photographs and found that the high forest cover declined from 74 percent in 1946 to 6 percent in 1978. In the Hihitahi forest sanctuary south of Waiouru, high altitude kaikawaka *(Libocedrus bidwillii)* and totara *(Podocarpus hallii)* have been extensively damaged by possums and deer.

Beech/Beech-Hardwood Forests

Major areas of beech and beech-hardwood forest occur in the Raukumara, southern Urewera, Kaweka and Kaimanawa Ranges, the west of Mount Ruapehu and over a large area of the southern North Island ranges. Possums feed on the leaves and bark of beech species, however as it is not a preferred species, damage

to the trees is usually minimal. Most damage is to seral and subcanopy vegetation (Cowan, 1991) and is difficult to differentiate from ungulate grazing (Batcheler and Cowan, 1988).

The general conclusion reached from studies in many areas is that possums progressively browse and kill out many species of plants including fuchsia and aristotelia. There is no evidence that possums have attained an ecological balance with vegetation in any indigenous forest types (Cowan, 1991), but result in a gradual change in forest composition (Meads, 1976; Fitzgerald, 1976; Coleman et al, 1985). Secondary damage from possums is less obvious, however this includes canopies that are weakened by browsing being more susceptible to windthrow, salt damage, pathogens, insects and climatic extremes (Green and Coleman, 1984; Payton, 1988).

2.4.4 The Effects of Possums on Native Fauna

Concern over the effects of possums on native animals is longstanding, with the Royal Forest and Bird Protection Society opposing the liberation of possums as early as 1924, due to their presumed competition with native birds (Pracy, 1962).

It is difficult to assess the effects of possums on mainland bird populations due to the combined effects of possums and other predators including cats, stoats and weasels. On islands which are free of these predators it is much easier to assess the effects of possum control on bird populations. The eradication of possums from Kapiti Island between 1980 and 1986 led to a steady increase in bird populations (Cowan, 1991).

Forest modification and a decrease in diversity due to the browsing of possums and other ungulates has been reported frequently (Mason, 1958; Brockie, 1982; Campbell, 1984). Reducing forest diversity is likely to reduce the number and diversity of forest dwelling native animals. The most serious effect on bird life from possums comes from the competition for food - either directly through the use and/or wastage of flowers and fruit or indirectly through the destruction and depauperisation of trees through defoliation (Kean and Pracy, 1953; Cowan, 1991). Nectivorous and frugivorous birds such as the silvereye, bellbird, tui, saddleback, kokako, kaka and the native pigeon are most severely affected by this (Batcheler and Cowan, 1988).

Occasional traces of fledglings and eggs have been found in the stomach contents of possums although it does not appear that these are a sought after form of food (Kean and Pracy, 1953).

2.4.5 The Role of Possums in the Transmission of Disease

Possums are responsible for the transmission of a number of diseases, however the main one of concern is bovine tuberculosis.

2.4.5.1 Bovine Tuberculosis

Bovine tuberculosis is an ancient disease which is thought to have travelled to Australasia from Europe in the course of the colonisation, probably with the first cattle around 1840 (Hickling, 1991). It soon became widespread throughout the cattle populations in these countries, although it will infect virtually any mammal (Ryan, 1990).

Two forms of tuberculosis, human tuberculosis *(Mycobacterium tuberculosis)* and bovine tuberculosis *(Mycobacterium bovis)*, which are similarly pathogenic to humans, have been public health issues for many decades. Control of these diseases began with the pasteurisation of milk in the 1920s. This was followed by the immunisation of children against tuberculosis, beginning in the 1940s. Control of bovine tuberculosis in cattle began in 1940, with the voluntary testing of town supply dairy herds. All cattle which reacted to the disease were slaughtered.

Bovine tuberculosis in New Zealand's cattle herds threatens many of our animal exports. All animal products imported into the U.S.A. and E.E.C. are subject to stringent regulations in relation to diseases including bovine tuberculosis. If the incidence of the disease increases this could be used as a nontariff barrier to New Zealand exports of beef, live cattle, semen and dairy products. The total closure of the US market for one year would result in a possible net market loss of $484 million (Forbes, 1989).

In Westland the introduction of testing in cattle in 1956 resulted in a progressive reduction in the incidence of the disease until the reactor and tuberculosis rates

suddenly increased dramatically for no known reason. Some herds were showing more than 50 percent reactors (Batcheler, 1990). In 1967, bovine tuberculosis was first identified by a Ministry of Agriculture and Fisheries Livestock Officer, on a Westport farm with a history of continuing infections in the cattle herd (Davidson, 1991). Within 5 years tuberculosis had been identified in possum populations in the Wairarapa, the western bays of Lake Taupo, the central North Island as well as many parts of Westland.

The testing programme was gradually extended until by 1977 all cattle except for young beef cattle were tested. The programme was successful in eliminating almost all clinical cases and by 1979-80, the incidence in dairy and beef herds had been reduced from 8.6 percent to 0.05 percent and 0.8 percent to 0.01 percent respectively (Batcheler and Cowan, 1988).

By 1987 tuberculosis had been identified in at least 20 areas from north of Auckland to the south eastern corner of the South Island. It is still unknown in Australian possum populations. The reason for this is unknown although several possible reasons such as the lower possum density in Australia (Green and Coleman, 1984), or the dryer climate except for Western Tasmania have been put forward.

When control of tuberculosis began, two major philosophies influenced the decision making. These were the pre-eminent place of agriculture and livestock farming in the New Zealand economy and the thought that eradication was realistic because the disease and causative organisms were confined primarily to cattle. Government set rules, provided eradication programmes and funded them. These philosophies have changed dramatically with Government no longer assuming responsibility for the total financial support of the programmes. Investment in agriculture must now be based on market returns. Also, tuberculosis in possum populations is now self sustaining (Ministry of Agriculture and Fisheries, 1986).

Tuberculosis is considered endemic in an area on the finding of tuberculosis infected wild or feral animals or their presence being known based on epidemiological evidence from cattle and deer testing (Livingstone, 1991#1). In the central North Island, the area mapped as 'endemically infected' increased at a constant rate of 10 percent per annum between 1975 and 1987. Nationwide the

extent increased from 2.51 percent to 13.65 percent in the North Island and 2.86 percent to 12.03 percent in the South Island (Batcheler, 1990). By 1991 approximately 25 percent of New Zealand was tuberculosis endemic (Figure 2.4) (Hickling, 1991).

The current failure to check the rate of spread of tuberculosis suggests that if the same process occurs in future decades, all of the North Island and South Island possum populations will be infected by 2024 and 2031 AD respectively (Batcheler and Cowan, 1988; Batcheler, 1990). Extrapolating the experience of possum control over the past 20 years, whereas the 1990 cost of possum control was approximately $15 million, the national bill in 2030 AD could exceed $80 million (1990 dollars) which is approximately 2 percent of the export earnings of the cattle industry (Batcheler, 1990).

New endemic areas are still being identified, some of these having existed as unrecognised tuberculous possum areas. Others have arisen from the movement of infected feral animals through large tracts of conservation estate or infected farmed deer and possibly pigs infecting possum and other feral animal populations (Livingstone, 1991#1). Prevalence of the disease in forests decreases with increasing distance from the forest margin, however some infected possums have been found up to 3 km from the forest margin (Hickling, 1991). Barlow (1991), estimated that in the absence of possum control, the rate of spread of tuberculosis through possum to possum contact and possum dispersal is 1.6 to 2.6 kilometres per year.

For tuberculosis management purposes, New Zealand is now divided into two types of areas, Special Tuberculosis Control Areas (STCA) where tuberculosis is endemic and Surveillance Areas where tuberculosis not endemic. A Special Tuberculosis Control Area is a geographically defined area containing a central endemic area, surrounded by a fringe area and a nonendemic area. Outside of this is the Surveillance Area (Figure 2.5). Unless possums are controlled, Special Tuberculosis Control Areas will continue to expand due to outward migration of infected juvenile possums (Hickling, 1991; Livingstone, 1991#1) and other wild/feral animals (Livingstone, 1991#1).

Figure 2.4 Location of Endemic and Special Tuberculosis Control Area at September 1991 (Source: Livingstone, 1992)

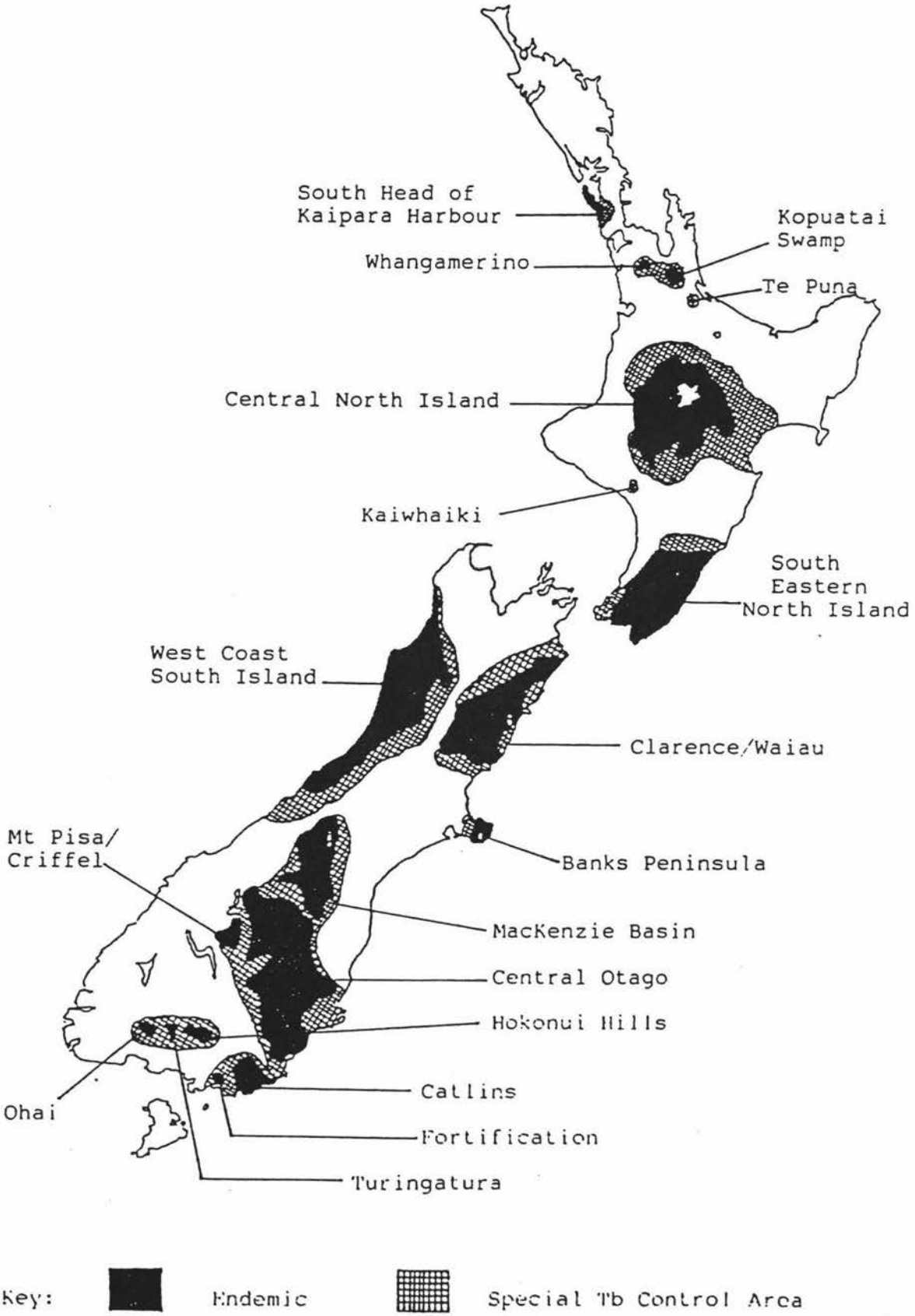
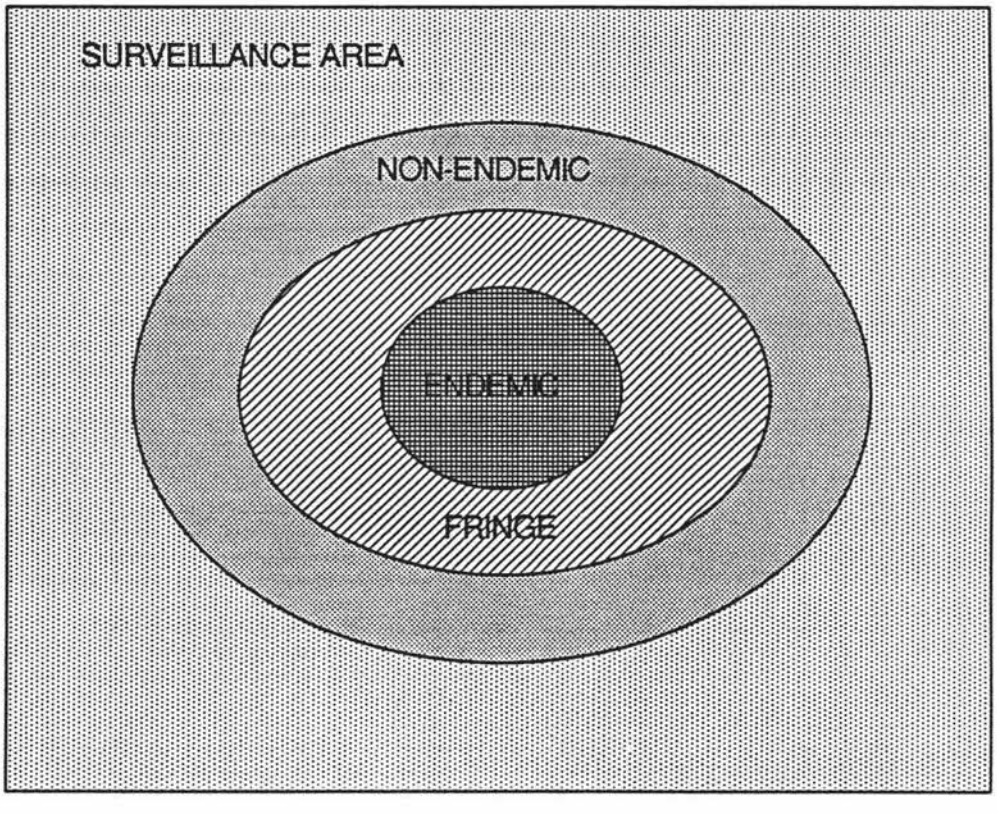


Figure 2.5 Special Tuberculosis Control Area
(Source: Livingstone, 1991#1)



Bovine tuberculosis was first recognised in feral deer in 1970 and farmed deer in 1978. Since then, the deer industry has implemented various options for control as the diagnostic technologies have changed. In August 1985, a voluntary accreditation scheme was introduced for deer herds. This culminated with the January 1990 introduction of a compulsory control programme for all deer herds (Carter, 1991).

The reactor rate in cattle ranged from 0.208 to 0.256 percent between 1984 and 1989, with cattle in Special Tuberculosis Control Areas being on average 5 to 13 times more likely to be slaughtered as tuberculosis reactors than animals in Surveillance Areas (Livingstone, 1991#1).

Although the prevalence of tuberculosis amongst the national possum population is less than 1 percent (Hickling, 1991), possums are effective vectors of bovine tuberculosis. Reasons for this include the fact that their immune response is poor, therefore they become highly infectious; they are abundant on farm margins; and they browse extensively on pastures thus coming into close contact with cattle (Hickling, 1991). The relationships between these and other reasons are shown in figure 2.6.

Species other than possums, deer and cattle that have been found to carry *Mycobacterium bovis* infections are the pig, cat, ferret, stoat, weasel, goat, rabbit, dog, sheep, fitch and horse. These are thought to contribute little in the transmission of the disease, although the feral pig, feral cat and feral ferret may make a significant contribution in certain areas of New Zealand. However, on a national basis this contribution is small compared to the overriding influence of the possum (Allen, 1991).

It is possible to eradicate tuberculosis from infected herds using conventional test and slaughter methods, however reinfection due to contact with tuberculous possums is common (Livingstone, 1991#1). Control methods aimed at both tuberculosis infected herds and possums are now known to obtain the best results (Figure 2.7). Basic epidemiology predicts that there is a threshold population density below which the disease will fail to persist, however possum populations probably exceed this hypothetical threshold soon after survivors of a control operation breed and juvenile immigrants move in (Hickling, 1991).

The estimated cost of eradicating tuberculosis from the New Zealand possum population is more than $700 million spent over a 20 year period. This is not likely to proceed due to the low probability of achieving the desired results and the probable public concern over the amount of 1080 poison which would be required (Livingstone, 1991#1).

Figure 2.6 Factors Influencing Transmission of Tuberculosis among Possums (Source: Pfeiffer et al, 1991#1)

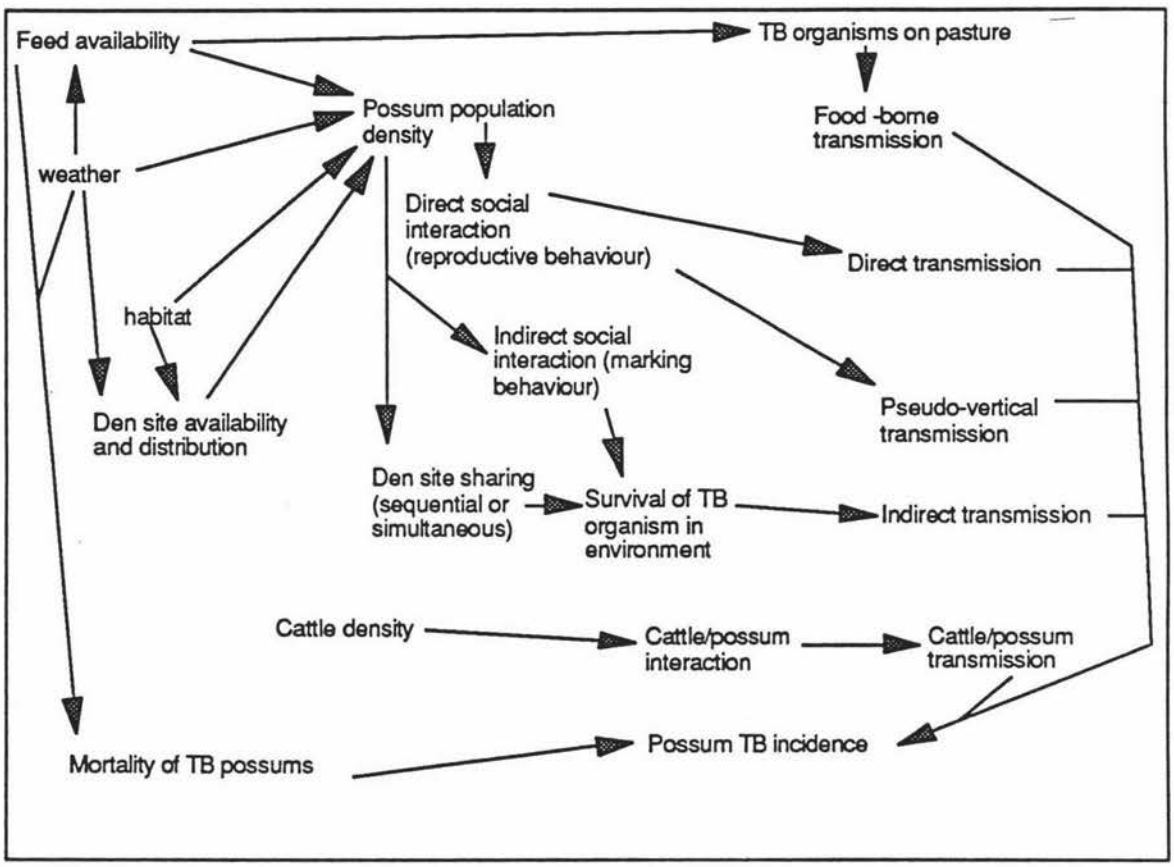
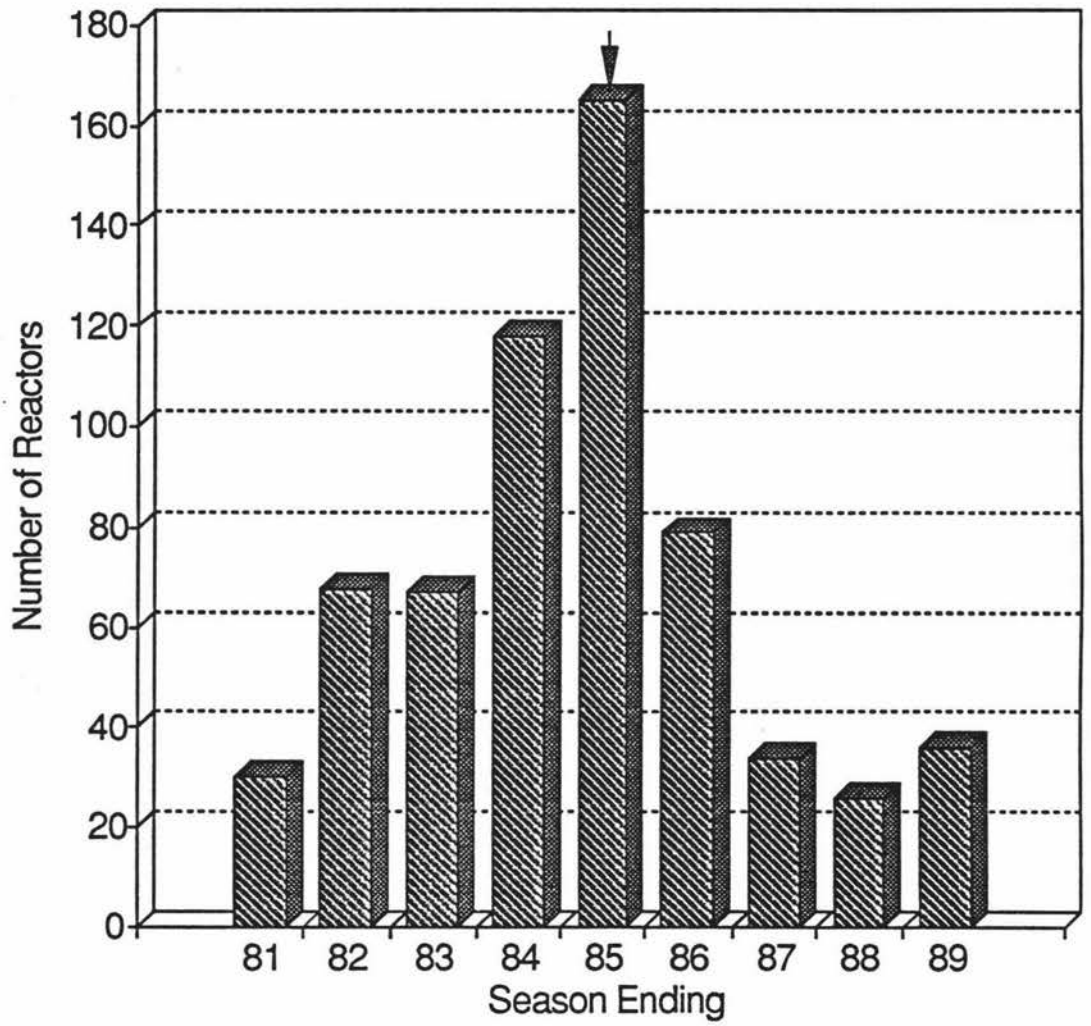


Figure 2.7 Effects of a Localised Possum Control Operation on the Number of Tuberculosis Reactors Slaughtered per Season (Source: Livingstone, 1991#1)
(↓ indicates timing of the control operation)



2.4.5.2 Other Diseases

Although tuberculosis is by far the most serious disease associated with possums, they also act as a vector for several other diseases and parasites of farm animals. These include liver fluke *(Fasciola hepatica)*, a nematode parasite of sheep *(Trichostrongylus colubriformis)* and other nematodes of domestic animals including *T. axei, T. retortaeformis* and *T. vitrinus.* It is not known how important possums are in the infection and maintenance of these parasites in domestic animals (Cowan, 1991).

Recently, possums in the Hawkes Bay and Wellington areas have been found to be infected with *Giardia intestinalis*, a water borne protozoa which causes severe diarrhoea in people (Cowan, 1991).

Infections with *Leptospira interrogans* serovar *balcanica* is common and widespread among possums in the North Island (up to 80 percent of animals). Occasionally cross infection of cattle may occur, however *balcanica* is not readily transmitted to humans. Infection of possums with other serovars is rare (Cowan, 1991).

2.4.6 Damage to Exotic Forests

As of March 31 1985, New Zealand had 1,095,000 hectares of exotic forest comprising of 89 percent Pinus radiata, 5 percent Douglas fir *(Pseudoxsuga menziesii)*, 1 percent hardwood and the rest of mixed species. This comprised of 566,000 hectares of State Forests and 529,000 hectares of privately owned forests (Department of Statistics, 1990#1). Of these, 40 percent of the State Forests and 50 percent of the privately owned forests were less than 10 years of age.

Damage has been recorded on at least 12 species of Pinus as well as a number of other exotic species. Possums cause 4 types of damage in exotic forests:

Browsing of terminal shoots of newly planted seedlings for the first one to two years after planting.

Bark stripping and chewing of cambial tissue, both basal and around the top whorls of laterals on trees of all ages, but mostly of those less than 10 years of age.

Breakage of leaders and top whorls of laterals mostly on trees of 5 to 10 years of age.

Cone loss from seed stands after trees mature from 8 years onwards.

Because browsing and bark stripping are mainly problems of young stands, there is a large scope for minimising losses by thinning (Batcheler and Cowan, 1988). Studies in the 1970s established that the loss due to possums was 1 to 2 percent of the final crop at rotation in the worst case and that in most cases, the costs of traditional control (blanket aerial poisoning, blanket roadside poisoning and spot poisoning) exceeded the benefits derived from it (Batcheler and Cowan, 1988).

Contrary to these findings, the National Opossum Survey (Pracy, 1980) showed that significant damage does occur in some exotic forests. This tends to be linked with the species of tree, its age and adjacent cover. High possum populations were not always associated with significant damage. It was found that low density possum populations which were in good condition were the most difficult to eradicate and tended to cause the most problems (Pracy, 1980).

Cowan (1991), estimated that even if losses were as low as 1 to 2 percent at rotation this could account for an annual loss of between $7 million and $9 million.

2.4.7 Damage to Pasture

There is much difference in opinion on the damage that possums do to pastures, however severe damage has been recorded in the presence of high possum populations. Damage tends to be most severe on newly sown pasture adjacent to cover or forest. Noticeable damage can extend up to 40 metres from the forest margin. Within pasture, leaves, flowers and fruits of clovers, grasses and weeds are eaten by possums.

Pastures generally provide only a supplementary feed (Pracy, 1980), as possums' teeth are unsuited to mastication of grass and their simple stomach unable to digest fibre or cellulose. The caecum, although able to do this, acts too slowly to be efficient (Pracy, 1980). In general, 20 to 60 percent of the diet of possums on

farmland comprises of pasture species (Harvie, 1973; Cowan, 1991). Harvie (1973), calculated that in the absence of possums, stocking rates on a farm in Waverley could be increased by 1.3 sheep per hectare.

Pasture is most commonly eaten from late summer to early winter (Gilmore, 1967; Harvie, 1973; Coleman et al, 1985). Possums whose diet is composed predominantly of pasture species tend to be in poor condition.

2.4.8 Damage to Crops

An adequate assessment of possum damage is hard to obtain as often no distinctions are made between damage caused by possums and that caused by other animals and there is usually no measure of actual losses and no assessment of the cost effectiveness of control. The relative importance of possum damage to crops is dependent on several factors including type and value of the crop, the stage of the crop and the type of damage done. Damage appears to be seasonal.

A 1980 survey by the Agricultural Pests Destruction Board (APDC) concluded that although crop damage occurred, damage to pasture, crops, orchards, gardens and vineyards was not significant in terms of overall productivity, however locally severe damage did occur. Damage was most severe near forest margins, remnants of forests and other cover (Pracy, 1980).

2.4.9 Damage to Catchment Protection Plantings

Browsing of plantings of poplars and willows became common in the 1940s, at the same time as possum populations increased in many districts. Young plantings were particularly vulnerable. More recent reports of possum damage on a number of experimental plots ranges from about 10 to 87 percent, with mortality in the vicinity of 2 to 20 percent (Thomas et al, 1984; Cowan and Mooed, 1987; Batcheler and Cowan, 1988).

Possums damage poplar and willow poles by browsing the foliage, removing the bark and breaking leaders and branches (Cowan and Mooed, 1987). Foliage browsing during the first three years after planting often results in reduced growth rates and poor root establishment (Cowan, 1991). Most browsing occurs in spring and early summer. Although poles often recover foliage later in the season, they

are weakened by the browsing and become more susceptible to other mortality factors. Bark biting usually occurs in winter and ring barking of branches or leaders is often fatal. Breakage of leaders and branches occurs at all ages and results in malformed trees with an impaired ability to protect catchments.

Research at the Soil Conservation Centre at Aokautere has lead to the development of possum resistant poplar clones, however these still suffer from the breakage of branches by possums. None of the currently used tree willows are possum resistant.

2.4.10 Other Damage Caused by Possums

Possums are responsible for other forms of damage which appear to be localised in their existence. Damage to domestic gardens occurs both in rural and urban areas, with possums damaging both vegetable and flower gardens.

Possums cause damage to both the outside and inside of buildings, including houses, if they gain entry. Damage includes fouling in buildings, knocking objects over and scratching paintwork. In addition possums can cause serious damage to electricity and telephone connections by causing short circuits and occasionally fires. Most power poles have a metal sheath to prevent access by possums.

Wodzicki (1950), recorded that commercial production of honey from trees appeared to have been affected as possums spread and increased in numbers in Westland. This has probably continued with the increased damage to Westland rata forests (Batcheler, 1983).

2.5 CONTROL OF THE POSSUM

Although it would be desirable to eradicate possums from New Zealand it is not presently a feasible option due to the cost and lack of available means to do so. The best alternative is to work out desirable population levels based on the area in question. At one end of the management spectrum are such places as Kapiti Island and Codfish Island bird sanctuaries where the desirable possum density is zero. In between there are certain crops, conservation plantings and commercial plantations which can withstand some positive level of possum population. At the far end of the spectrum are nonsensitive habitats although it is now debatable whether these exist. The most difficult habitats to evaluate for control are noncommercial forests and scrublands where there is no market to measure the value of protecting these areas. The cost of failing to control possum damage in these areas may include the loss of indigenous plant and animal species, the modification of communities, the loss of honey supplies for bee keepers and the loss or change of landscape values.

2.5.1 Methods of Possum Control

No matter what device is used in the reduction of possum numbers, many people will regard the practice as ethically offensive and unacceptable. Apart from the ethical dilemma, the issues of the efficiency and humaneness of the techniques being used also arise. The control method must also be environmentally acceptable and safe to wildlife (Nelson, 1990).

Methods of possum control currently employed include poisoning, trapping, snaring, shooting, repellents and protective devices (Nelson, 1985). Gin traps, cyanide and 1080 are by far the most widely used methods. New methods of controlling possums and the spread of bovine tuberculosis by possums are currently being researched.

2.5.2 Chemical Methods

Three toxins are available and suitable for possum control. These are 1080 (sodium monofluoroacetate), cyanide and phosphorus.

2.5.2.1 Sodium Monofluoroacetate (1080)

1080 has been widely used as a poison since the early 1960s and is now the most commonly used poison for possum control in New Zealand (Nelson, 1990). It is considered by the Forest Research Institute (FRI) and other pest control agencies to be the most cost effective toxin available for the widespread control of possums (Livingstone, 1991#1). Between 1.1 and 1.4 tonnes of 1080 are used annually in New Zealand (Coleman, 1991).

Possums can smell and taste 1080. This problem can be overcome by flavouring the baits (Morgan, 1990). Baits are coloured with lissamine green dye at 0.02 percent weight for weight to repel birds (Coleman, N.D.).

The success rates of poisoning operations vary greatly (Coleman, N.D.; Morgan, 1990), with only 40 percent of operations killing more than 80 percent of the target population (Coleman, N.D.). The kill rate is based on pre-poison and post-poison drop faecal counts. The difference in kill rate is mostly dependent upon the weather, the bait quality and ground cover (Morgan, 1990), although possums also vary regionally and seasonally in their susceptibility to 1080 poison (McIlroy, 1983). Control operations are generally most successful in late winter when possums are expected to be in poor condition (Morgan, 1982) due to a reduction in the availability of suitable food sources.

1080 is favoured as a poison due to its:

Modest cost.
Molecular simplicity.
Toxicity to possums.
Humane action in many animals.
Conversion to nontoxic metabolites by microorganisms, plants and animals receiving sublethal doses.
Being noncumulative in the environment and sublethally poisoned animals.
Water soluble therefore lacks persistence in baits after rain.
Limited taste and odour
(Coleman, 1991).

Two major problems exist with the use of 1080 as a poison. These are the build up of resistance to the poison in possum populations and the secondary poisoning of dogs if they obtain access to poisoned possum carcasses (Nelson, 1990; Mitchell, pers. comm., 1991). Other problems are its indiscriminate toxicity to many animals, the lack of an effective antidote, adverse public perceptions of its action and persistence and the endangerment it places on foreign meat markets (Coleman, 1991).

2.5.2.2 Phosphorus

There have been several moves to ban phosphorus as a poison, however as it is the only viable alternative to 1080 in many situations it has not been banned. It is illegal to use phosphorus within 500 metres of a beehive or 250 metres of a river, road or house (Nelson, 1990).

2.5.2.3 Cyanide

Cyanide has the advantage that it is quick and easy to apply. The major problem with the use of cyanide is that possums quickly become 'bait shy'. To use this poison effectively, a bait station must be used and at least three prefeeds must be given before the poison.

2.5.3 Trapping

The effect and intensity of commercial hunting is very difficult to assess with the differing population trends which occur due to factors such as the length of colonisation and habitat.

Despite a long history of possum exploitation, commercial poisoning and trapping has not restricted the dispersion and consequent colonisation of new habitats. The buoyant skin prices of the late 1970s with their increased trapping and poisoning pressure failed to halt the spread of possums into unoccupied habitats. The results of research work leads to the opinion that commercial hunting with its lowering of the population density may serve to stimulate the reproductive cycle of possums (Pracy, 1980).

Trapping is very labour intensive and is carried out predominantly by full time operators. It has advantages over poisoning in the following situations:

At sites where poisoning has recently occurred but it is necessary to carry out further possum destruction.

To ascertain the level of possum infestation in a particular area.

Where there is evidence of bait shyness.

Where poisoning cannot be carried out due to heavy rainfall.

There is much debate over whether trapping can be as successful as blanket poisoning operations in the control of possum populations. Much of the problem lies in the fact that trappers will often want to maintain their income flow over the future years, thus tend to harvest possums on a sustainable basis (Mitchell, pers. comm., 1991). Research in an easily accessible area of the Orongorongo Valley, Wellington, showed that trappers were keeping the population at between 49 percent and 63 percent of the full carrying capacity (Brockie, 1982).

Traps available for possum control fall into two categories: the kill trap which is designed to kill a possum by capturing it around its neck as it is taking a bait and the leg hold trap.

2.5.4 Other Control Methods

A number of methods of controlling the breeding of possums and its ability to spread the disease bovine tuberculosis are currently being researched. If viable, it may still be many years before any of these methods will be available for use.

2.5.4.1 Vaccination of Possums against Tuberculosis

Vaccinations, if developed, will have an effect on the control of bovine tuberculosis but not on the actual possum population. This would be less effective than other methods of controlling tuberculosis. This is partly because the proportion of animals immunised is significantly lower than that which would be killed by an equivalent bait density and the vaccination has no adverse effect

on the possum itself (Barlow, 1991). A further problem with this method of controlling the disease is that the development of a vaccine may not be feasible. If it is feasible it will take considerable time and research expenditure (Livingstone, 1991#2).

2.5.4.2 Control of Reproduction

It may be possible to develop a chemosterilant which when delivered on a bait will permanently sterilise female possums. This would be less effective than the equivalent percentage kill due to a lag time before the population declines (Barlow, 1991).

If vaccination poses problems (cost and lack of effect) and widespread poisoning is environmentally unacceptable in the long term, then in spite of its cost, control of reproduction may be the only future alternative in areas where trapping is impracticable (Barlow, 1991).

2.5.5 Target Specificity of Control Operations

No trap or poison is possum specific in its catch or kill, however with care the risk to other species can be reduced. Trap sites should be carefully selected and prepared, with traps being set up off the ground or shielded at the sides with rocks or sticks to minimise the risk of capture of inquisitive birds such as wekas (Warburton, 1981).

Only a few birds (mainly introduced species) were reported dead during the first 20 years of 1080 use in New Zealand, however 158 birds, including more than 40 native ones were found dead after a poisoning operation in Kaioi in 1976. These included the rifleman, whitehead, grey warbler, pied tit and silvereye. Similar kills were recorded at Kaingaroa in 1977. A study by the Forest Research Institute, the Department of Conservation and the New Zealand Forest Service on the effects of 1080 operations on the kokako found a slight but acceptable risk (Spurr, 1990). Reducing the toxic loading of baits will not reduce the risks to birds as virtually all fragments are likely to be lethal to small birds at any toxic loading which is effective for possums (McIlroy, 1983).

Invertebrates are susceptible to both primary and secondary 1080 poisoning. Furthermore, poisoned invertebrates are commonly eaten by other invertebrates,

birds and animals. Information on the pathways of 1080 through the invertebrate food web and the effects of the poison on invertebrate populations and communities is lacking. 1080 was first registered as an insecticide, however was subsequently withdrawn due to its toxicity and lack of specificity (Hutcheson, 1990).

There is little information on the effect of 1080 control operations on other nontarget populations, however deer populations were reduced by 40 percent in two operations at Stonewall catchment (1961) and Pureora (1988) (Hickling, 1990). Dogs are very susceptible to both primary and secondary poisoning. Cattle, sheep, pigs, deer and goats will also succumb to the poison unless adequately protected from it. Secondary poisoning has also been recorded to affect cats, stoats, weasels and ferrets (Hickling, 1990).

2.5.6 Recovery Rate After Control

The response of possum populations after control is very important as this dictates the length of time between control operations. Rates of recovery vary with kill, habitat, condition and population history. Estimates show that following a 70 percent kill, populations can recover to 90 percent of their former levels within 10 years, however large variations exist (Pekelharing, 1979; Green and Coleman, 1984).

The increase of a population after a lowering of its density implies either an increase in per capita recruitment from breeding and/or immigration or a decrease in per capita losses from death and/or emigration, or both. Initial recolonisation of depopulated areas is mostly by immigration when there are adequate sources nearby. This is generally the case when a small part of a large tract of forest has been cleared of possums. Young males (0 to 1 years) are the predominant dispersers and typically populations reestablished by dispersal contain a high number of males from the year class preceding the control operation.

2.6 THE FUR INDUSTRY

Possums were first introduced to New Zealand as a means of starting a fur trade. At first trapping was very profitable, however prices never again reached their 1927-28 peak. Records of total exports have been kept since 1921. These show that from 1921 to 1985, 43.7 million skins worth $527.5 million in 1987 dollars were exported (Batcheler and Cowan, 1988).

The total annual harvest fell into three characteristic levels associated with three different management phases: 0.2 million during the licenced trapping period (1921 to 1946), 0.4 million from 1946 to the end of the bounty period in 1961, an erratic increase to a peak of 3.2 million in 1980 followed by a fall to 1.5 to 2 million in 1987 (Batcheler and Cowan, 1988). Since the share market crash in 1987 and the pressure of the anti-fur lobby, the demand for skins and thus the export numbers and prices of skins have remained low.

Real values for possums skins reached a peak in 1927-28, decreased until the mid 1950s, stabilised for about ten years, peaking again in 1978 to 1980 and have declined steadily ever since. High prices in the 1920s were influenced by the fact that virtually all possums were from pre-peak populations, thus the furs were in prime condition. Since the 1940s most populations have peaked and fur quality has deteriorated (Batcheler and Cowan, 1988).

From year to year the number of possums trapped and therefore number of skins exported is closely related in movements in the average price. When trapping was controlled by licences, the number of licences declined in the year after prices dropped. Possum skins are currently worth between $1 and $3 each, with top quality skins reaching up to $10 each.

New Zealand possum furs have been traded at auction overseas since before 1920. New Zealand is the only major supplier of possum fur with Australia, the only other producer of possum furs, supplying about 200,000 furs per year.

The main centres of world fur trade are North America and the Far East (Japan, Korea and China). Over the last decade Korea's share of the market has increased dramatically from 10 percent in 1980 (Department of Statistics, 1980) to 76 percent in 1990 (Department of Statistics, 1990#2) as manufacturers took

advantage of the low labour costs there. Although most exports are of low quality furs for linings and trimmings, a garment industry for high quality furs is developing.

Before 1970 most skins were sold at auction either in London or New York or sold to exporters and overseas brokers. Few were auctioned in New Zealand. Most skins were used for coats or trimmings or in the United States and United Kingdom mill trade to prevent thread breakage on the looms in cotton and silk mills. Since 1970 all possum furs have been used in the fashion industry. Possum furs are towards the bottom end of the fur market with a predominance of low grade and damaged pelts.

At the moment the fur trade in New Zealand has, apart from some export of possum skins, virtually ceased to exist. This resulted in the major possum auction 'Kiwi Furs' closing in late 1989 and the only other company, 'New Zealand Fur Auctions' closing in mid 1990. This leaves a few private collectors to deal in possum furs. The market for large quantities of furs (full container loads) is very limited as no more than 100 companies worldwide are prepared to produce possum trims or garments. It is much more profitable to use mink or fox which are more acceptable to consumers (Tosh, pers. comm., 1990).

Very few possum skins are used in New Zealand. There are a few small toy manufacturers (mainly cottage industries) and one or two minor garment manufacturers but with the current limited demand for furs these concentrate more on leather and other materials (Chiles, pers. comm., 1990).

2.7 THE NEED FOR RESEARCH ON THE BENEFITS AND COSTS OF CONTROL

Current research shows that the New Zealand public considers that not enough is being done to control possums (Sheppard and Urquhart, 1991). However, it is not enough to allocate money to possum control without analysing its effects.

> "...The question of benefit analysis of control programmes needs to be raised. Benefits need to be proven against costs to enable funding for control programmes..." (Farnsworth, 1990)

Although this is referring to individual possum control programmes, these are an integral part of possum control on a national basis.

Possums belong to no-one and hence no-one takes responsibility for their control, yet all New Zealanders benefit from possum control. This could be directly such as a farmer in a tuberculosis endemic area, or indirectly through the reduced risk to export earnings from reducing the incidence of tuberculosis in bovine herds. Another major factor in the public good nature of possum control is that nonuse values (section 3.3) may also be important to people in relation to the native bush that possums modify. Clearly this public good characteristic of the problem calls for Government intervention. This raises questions as to the way intervention should proceed, the costs and benefits involved and how payment for control should be obtained.

2.8 THE CURRENT ROLE OF ORGANISATIONS IN POSSUM CONTROL

A number of groups are involved with the possum problem in the Manawatu-Wanganui region. These include farmers, farmer organisations, the Ministry of Agriculture (MAF-Policy), the Animal Health Board (AHB), the Department of Conservation (DOC) and Regional and District Councils (Figure 2.8).

The Manawatu-Wanganui Regional Council.

The Manawatu-Wanganui Council is responsible for undertaking the ground work involved in possum control. This work is jointly funded by the Regional Council, Department of Conservation and the Animal Health Board. Initial control operations are 100 percent funded by the Animal Health Board, whilst maintenance operation costs are split with the Regional Council being responsible for 53 percent of the costs and the Animal Health Board being responsible for 47 percent of the costs. All monies for possum control on Department of Conservation land are now directed through the Animal Health Board, thus their share of the region's costs increased from 34 percent to 47 percent on July 1, 1991 (Nicholls, pers.comm., 1992).

The main objective of pest control operations is to prevent the spread of tuberculous vector possums from endemic areas within or outside the region to nonendemic areas. Other objectives are to protect primary production, environmental and aesthetic values (Manawatu-Wanganui Regional Council, 1991#1).

The Animal Health Board.

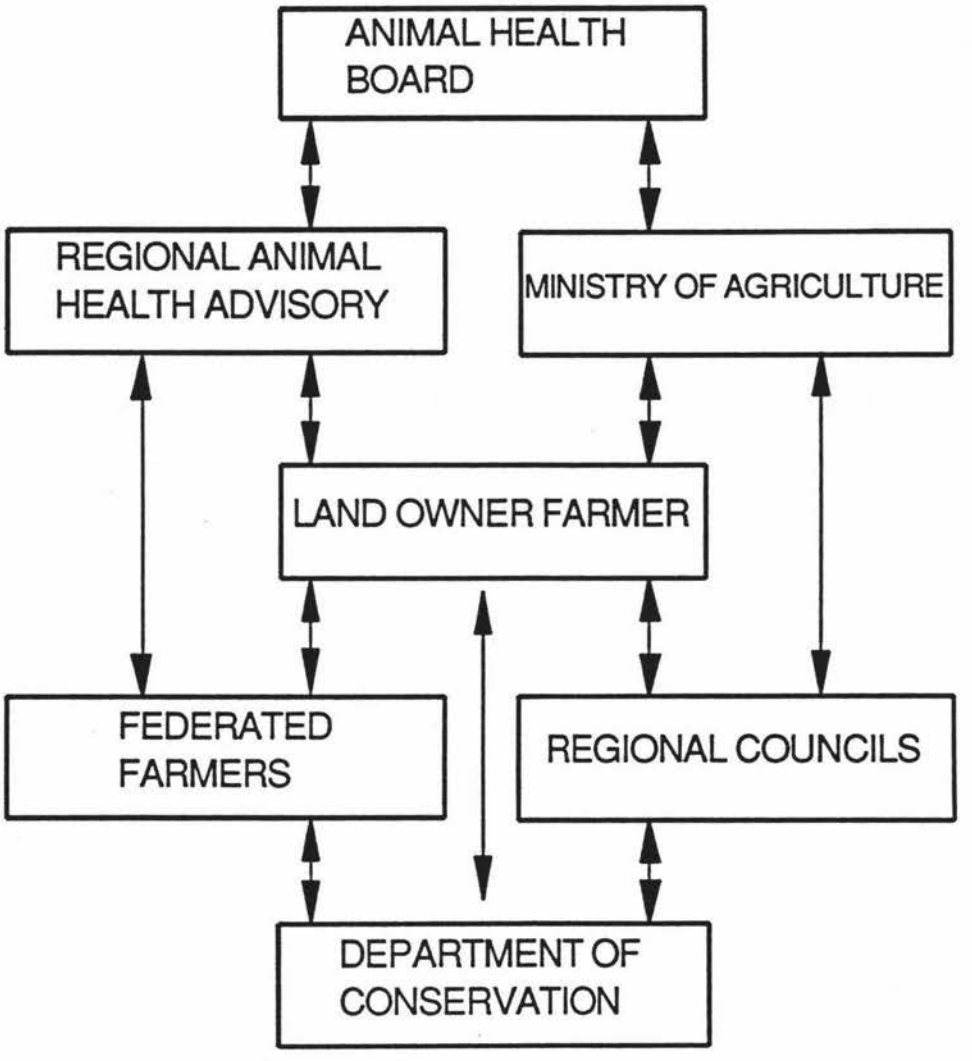
The Animal Health Board manages the current tuberculosis scheme and is responsible for the allocation of funds, levy payments and operational matters. It comprises of two appointees from Government, two from the Meat Industry, two from the Dairy Industry, one from the Regional Councils and one from the Deer Industry (Isbister, 1991). The primary role of the organisation is as a policy making body. It also coordinates the expenditure of monies collected from farmers who are levied on cattle slaughtered.

The tuberculosis scheme is funded from two major sources, cattle farmers via a levy of $5.70 per animal slaughtered and by the Government (Livingstone,

1991#1). Approximately 70 percent of the funding now comes from farmers, an increase from less than 50 percent in 1989 and almost nothing five years ago (Isbister, 1991). The 1991/92 budget for the Animal Health Board is $18 million of which $550,000 will be spent in the Manawatu-Wanganui region.

Task Force Green plays a minor role in possum control in the Manawatu-Wanganui region. Whilst it does not occur in the Manwatu-Wanganui region, in some regions possum control is being carried out with corporate sponsorship. Villa Maria Wines is assisting with possum control on Rangitoto Island, Auckland (Bellingham, 1990).

Figure 2.8 Network of Possum Control in the Manawatu-Wanganui Region (Source: Manawatu-Wanganui Regional Council, N.D.#2)



2.9 CONTROL OF POSSUMS IN THE MANAWATU-WANGANUI REGION

Possums were first liberated in the Manawatu-Wanganui region in 1892 (Pracy, 1962) and soon spread to cover the entire region. They are now a major pest to both rural and urban residents of the region.

In the Rangitikei region a number of conservation planting areas were severely damaged before control operations were undertaken (Mitchell, pers. comm., 1991). Damage to native forests is severe in several areas. In the Pohangina Valley high forest cover declined from 74 percent in 1946 to 6 percent in 1978 (Batcheler, 1983). The Manawatu hill country suffered a similar fate. In other parts of the region, damage to seral vegetation has been severe. Bovine tuberculosis is endemic in the Ruapehu region and has been found in other regions. Although there is no dollar record of the damage caused by possums in the Manawatu-Wanganui region they are causing a significant amount of damage.

The Manawatu-Wanganui region currently has 100,831 hectares of exotic forestry (McIntyre and Bills, 1991). This is nearly 10 percent of all exotic forestry grown in New Zealand. Based on Cowan's (1991) estimated forestry losses to New Zealand of $7 million to $9 million per year, one would expect the annual losses in this region to be in the vicinity of $0.7 million to $0.9 million.

The only available data on money spent on possum control in the Manawatu-Wanganui region is that which is spent by the Regional Council, Animal Health Board and Department of Conservation. For the 1991/92 year these organisations have budgeted to spend $1,414,000 on control and maintenance operations. The Regional Council projects to spend a further $1,116,000 on corporate overheads related to pest control (Manawatu-Wanganui Regional Council, N.D.#1). Approximately 80 percent of this could be attributed to possum control.

2.10 COSTS OF NATIONAL POSSUM CONTROL

Cowan (1991) assessed that the national annual costs of possum control and damage are likely to exceed $35 million.

Damage to poplars and willows planted to alleviate soil erosion was estimated at $300 000 to $800 000 (Batcheler and Cowan, 1988). This did not include the costs of Regional Council control operations and the funding of research into the development of varieties of poplars and willows unpalatable to possums.

New Zealand currently has around 1.1 million hectares of Pinus radiata exotic forests. If damage is taken at 1 to 2 percent of the crop at rotation, this accounts for a loss of around $200 per hectare at current prices. With one rotation of the current crop of 1.1 million hectares, the cost of losses to possums would be approximately $220 million or $7 million to $9 million per year (Cowan, 1991).

There are no estimates of losses attributable to possums from the horticultural sectors, however if losses were as low as 0.1 percent this would represent an annual loss of more than $1 million (Cowan, 1991).

Cowan (1991) estimated that the replacement cost of excluders on power and telephone poles would exceed $2 million. Other costs include the exclusion of possums from generating stations and the costs of power losses to consumers.

New Zealand's sheep industry farms on about 6 million hectares of pasture land. Cowan (1991), assumed an average reduction in production due to possums of 0.05 sheep per hectare. This would have resulted in a loss in export earnings from sheep meat and wool of $12 million in 1987 (Cowan, 1991).

During the 1990 calendar year, the deer industry earned $101 million in export earnings, yet the control of tuberculosis cost the industry $3.63 million. This comprised of $2.1 million for the testing of deer herds (Carter, 1991), $0.4 million as the estimated loss to farmers through reactors, $0.5 million as administration costs for the Ministry of Agriculture and Fisheries and $0.63 million as the industry's share of the Animal Health Board's expenditure on possum control (Carter, 1991).

Research on the impacts of possums and improvements in their management currently costs between $2 million and $3 million per year. This is conducted mainly by the Ministry of Agriculture and Fisheries, Department of Scientific and Industrial Research and the Forest Research Institute. It is predominantly funded by the Crown and Animal Health Board (Cowan, 1991).

CHAPTER THREE

NONMARKET VALUATION

3.1 INTRODUCTION

Possums belong to no-one and hence no-one takes full responsibility for their control. Control however, benefits all, irrespective of whether they contribute to the control. Thus the problem shows characteristics of a public good. Because no defined markets exist measuring the value of possum control, nonmarket valuation techniques must be used to derive a measure of this. Value information is necessary to determine efficient levels of control from the point of view of efficient allocation of funds.

This chapter describes the theory of benefit estimation which underlies the various types of nonmarket valuation techniques available. Nonmarket valuation has been used in New Zealand for less than 20 years, with Gluck (1975), a visiting Australian, producing one of the first attempts in New Zealand when evaluating the Rakaia River recreation fishery. Since then, other researchers have used nonmarket valuation methods to place values on a number of different types of nonmarket goods in New Zealand (Harris and Meister, 1981; Kerr, 1985; Kerr et al, 1986; Kirkland, 1988; Greer and Sheppard, 1990; Lynch, 1992).

The major part of this chapter will be spent examining the nonmarket valuation technique to used in this project, the contingent valuation method. This will include a description of the strengths and weaknesses of the method. It will also look at the model to be used with the dichotomous choice data, specifically the logit model.

3.2 CONSUMER SURPLUS HISTORY

As no markets exist from which the value of possum control can be elicited, other methods must be used to do this. These methods arise from the concept of consumer surplus.

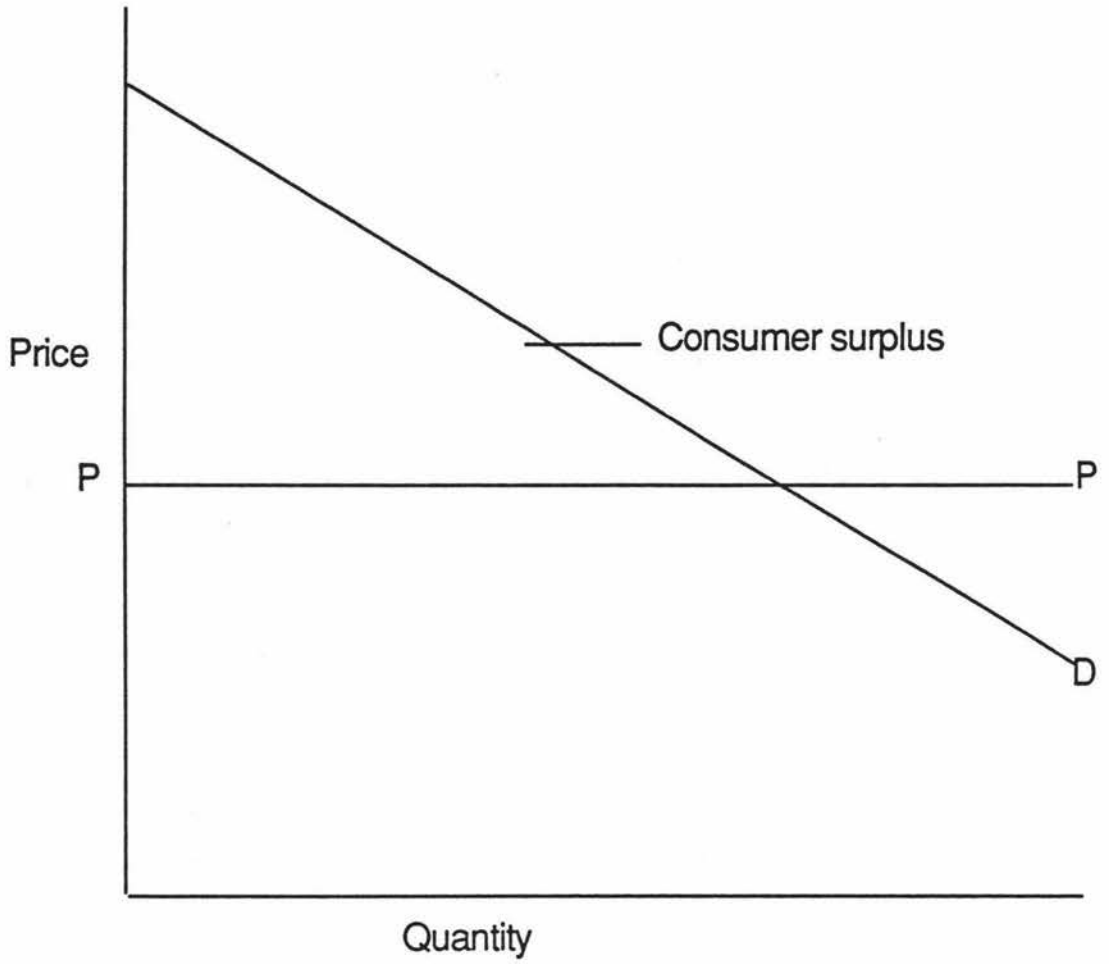
The history of consumer surplus since its development by Dupuit in 1844, has been stormy. In his classic paper on the utility of public works, Dupuit tried to determine criteria for the social value of collective goods such as roads, canals and bridges. He claimed that a buyer may receive a surplus from a transaction.

Dupuit was closely followed by Marshall who considered consumer surplus to be the utility gained from a purchase, defining it as 'the total utility afforded by the consumption of a commodity over the utility foregone on other commodities' (Currie et al, 1971). This was called the 'extra expenditure' and it measured the net benefits derived from consuming a good rather than going without it. Thus, changes in net benefits due to an increase or decrease in price or quantity were taken to reflect changes in consumer welfare.

The difficulty with this is that a price change has two effects. Firstly, the consumer can substitute towards cheaper goods and secondly, the change in real income resulting from the transaction shifts the consumer to an alternative welfare level.

Since utility is not directly measurable, a money measurement of welfare change is the only reasonable approach for most applied economic welfare problems (Just et al, 1982). To obtain an acceptable cardinal measure of utility requires two relationships, a unique relationship is required between the changes in price and surplus and between the change in surplus and utility. The former relationship requires a zero income effect whilst the latter relationship requires that the marginal utility of money (M.U.M.) be constant. For this to be so, the price elasticity of demand (P.E.D.) must be unity, and the marginal utilities of other goods be unaffected by changes in the consumption of that commodity. This occurs with commodities on which expenditure is a small fraction of the total expenditure (Currie et al, 1971), thus leaving the marginal utility of the consumer's income constant. This in practice turned out to be very restrictive.

Figure 3.1 The Marshallian Measure of Consumer Surplus



Consumer surplus was largely forgotten until the 1940s, when Hicks redefined it using an ordinal system of indifference curves to overcome the objection to the measurability of utility (Currie et al, 1971). He redefined consumer surplus as the amount of income variation which would leave a consumer on their original indifference curve following the introduction of the commodity at a particular price (Currie et al, 1971). Subsequently, Henderson demonstrated that the Dupuit and Marshallian measures constrained consumers to buying a certain quantity, whereas the Hicksian measure did not (Currie et al, 1971). He also noted that the relevant compensating variation in income depended upon whether the consumer had to pay to buy a new good or was compensated for not being able to purchase this good.

Hicks responded by defining four measures of the change in consumer surplus (Figure 3.2) resulting from an actual or proposed change in price. These were:

Compensating Variation

This is the amount of compensation paid or received, that will leave the consumer in their initial welfare position following the change in price, if they are free to buy any amount of the commodity at the new price.

Equivalent Variation

This is the amount of compensation paid or received, that will leave the consumer in their subsequent welfare position in the absence of the price change, if they are free to buy any quantity of the commodity at the old price.

Compensating Surplus

This is the amount of compensation paid or received, that will leave the consumer in their initial welfare position following a price change, if they are constrained to buy at the new price the quantity they would have purchased in the absence of compensation.

Equivalent Surplus

This is the amount of compensation paid or received, that will leave the consumer in their subsequent welfare position in the absence of a price change, if they are constrained to buy at the old price, the quantity they would have bought at that price in the absence of compensation.

Consider a consumer with an income OY_0. The initial price for a commodity X is given by the slope P_0 and falls to P_1. Compensating variation, the maximum amount of money that a consumer would be prepared to pay for the privilege of buying the commodity at the lower price in whatever quantity they wish, is Y_0Y_1. Equivalent variation, the minimum amount of money that a consumer would be prepared to accept to relinquish the privilege of buying any quantity desired at the lower price, is Y_0Y_2. Compensating surplus, the maximum amount of money that a consumer would be prepared to pay for the privilege of buying at the lower price the amount that they would have bought in the absence of this compensation in income, is BC. Finally, equivalent surplus, the minimum amount of money that a consumer would be prepared to accept as compensation to forego the lower price if they had to buy the quantity they would have bought at the original price, is AD (Currie et al, 1971).

None of these four measures were conceptually identical to the Marshallian measure. Variations differ from surpluses in that variations are carried out after the consumer has made optimising adjustments in their consumption set (Table 3.1). Surpluses do not permit such adjustments (Randall and Stoll, 1980). In general, variations are used, however situations do arise in which optimising adjustments are prohibited. For instance, once a project's specifications are determined, the individual must take these as given. Similarly, if the services under consideration are indivisible in production or nonrival in consumption, individual quantity adjustments are impossible, thus in some circumstances Hicksian surpluses are appropriate.

Figure 3.2 Alternative Measures of the Welfare Effect of a Price Change

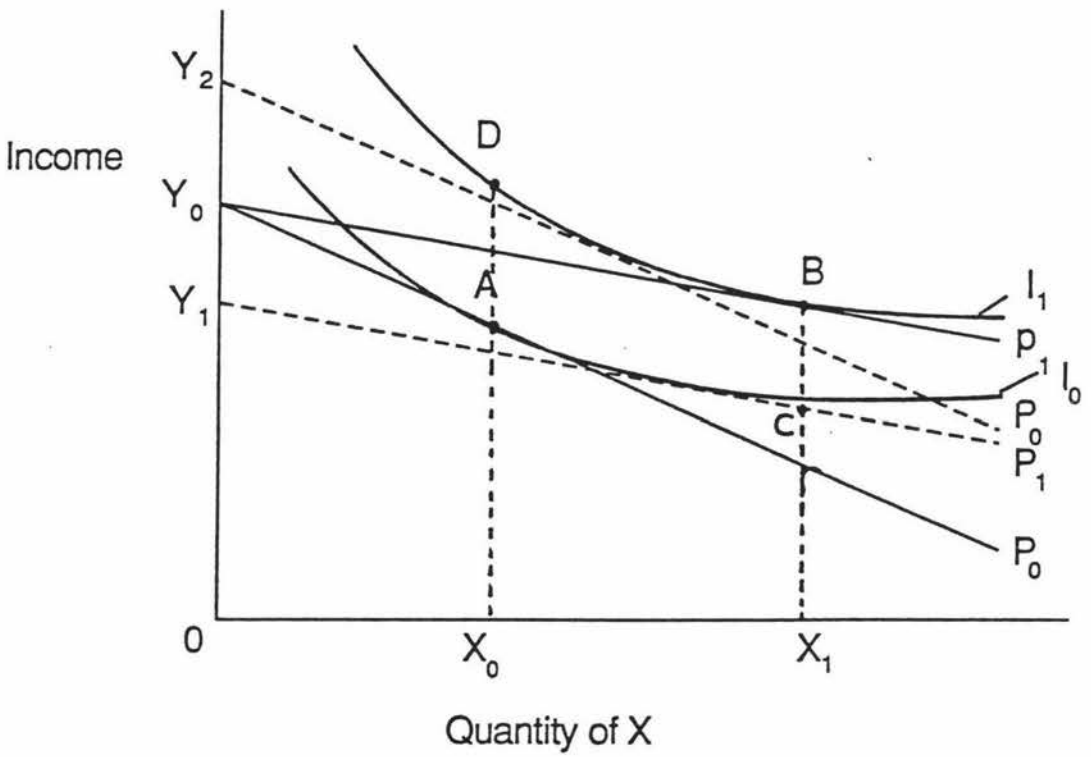


Table 3.1 The Appropriate Choice between the Four Concepts of Consumer Surplus.

Nature of the market	Change in Price	
	Price Fall	Price Rise
Consumer is free to purchase any quantity at the given price	compensating variation	equivalent variation
Consumer must take a given quantity but is free to offer any price	equivalent surplus	compensating surplus

Only the variation measures allow the consumer freedom of choice in responding to a changing environment. Since the vast majority of policy decisions allow consumer adjustments, attention will be focussed on these two measures. Hicks has given a unique relationship between compensating variation (and equivalent variation) and utility, however the information required to obtain exact measures of compensating variation or equivalent variation is very demanding. Three possible approaches to measuring these values should be mentioned.

One approach is to rationalize the difference between the Marshallian (uncompensated) and Hicksian (compensated) demand curves using the Willig (1976) conditions on income elasticity and expenditure. The Willig conditions can be used to calculate error bounds on consumer surplus as an approximation of either the compensating or equivalent measures of welfare quantity. This allows the use of the consumer surplus measured under an ordinary demand curve as an acceptable approximation of the Hicksian variation measures (Just et al, 1982). Other more direct approaches use duality theory to compute the compensated demand function directly from the ordinary demand function. Unfortunately doing this is far from easy. A final approach is to estimate compensating variation or equivalent variation using direct questioning techniques. The first and the third approaches are used in the nonmarket valuation techniques to be

discussed later. The second approach is not developed enough to be useful for applied research.

3.3 VALUE

So far only use value, the value that people directly or indirectly derive from the active or passive use of a resource, has been discussed. However, there are other values associated with resource use. To efficiently allocate resources the resource manager needs to know all the values that society places upon the resource in question. These values must be measured in a common unit, so as to allow direct comparisons to be made (Kerr, 1986).

The value of a resource reflects the total benefits or satisfaction that a person derives from it. As most decisions on how to 'use' a resource are based upon an uncertain future, several different types of value exist. Another factor affecting the decision making is irreversibility. If we use a resource now it may not be possible to use it in the future. For instance if we log a forest then it may not be possible to use it for recreation purposes in the future. Because uncertainty and irreversibility affect our decision making, we can derive values for resources other than from immediate use. These values include option, existence and quasi-option values. Pearce and Turner (1990), give total economic value as the sum of the actual use value, option value and existence value. These values will be further discussed below.

3.3.1 Use Value

This is the economic value derived from present and future use. It reflects the satisfaction derived from the goods and services, either directly as raw materials or indirectly through recreational pursuits or through aesthetic appreciation (Meister, 1988). The use value is often derived using the capital value of the resource (R). This is given as the net present value of its stream of services in each time period, S_t, where t=0,1,2,3....infinity and the present time period is defined as t=0. Thus

$$PV(R) = \sum_{t=0}^{\infty} \frac{V(S_t)}{(1+r)^t} \qquad (3.1)$$

where (S_t) = the net value at time t, of the bundle of services produced by the resource in time t

r = the discount rate (Randall and Stoll, 1980).

3.3.2 Option Value

An individual who is not currently consuming a particular commodity or amenity may place some value upon the option to use it in the future (Randall, 1981). Because of uncertainty, an individual may be willing to pay more than their expected consumer surplus in order to ensure that they can use a good in the future. This is a risk premium over and above future use value to secure a guarantee that the resource will be available in the future (Sharp, 1985; Meister, 1988). The total willingness to pay is the 'option price'. It consists of the expected consumer surplus E(CS) and an extra payment, the option value (OV), to ensure future availability of the resource.

$$OP = E(CS) + OV \qquad (3.2)$$

3.3.3 Quasi-Option Value

Quasi-option value is the value of preserving options given the expectation of growth in knowledge. New knowledge may result in new uses for a resource. If the resource is destroyed or irreversibly changed, options for its use with new knowledge may no longer exist (Meister, 1988). Conrad (1980) demonstrated that the quasi-option value was equivalent to the expected value of information.

While the quasi-option value is definable, it is not possible to identify it as future information is unknown. This identifies a potential error. As the quasi-option value is not measured, the future benefits of preserving are likely to be greater than estimated.

3.3.4 Existence Value

This is the value enjoyed from knowing that something exists. It is independent of current use, expected future use, and the avoidance of risk related to future use. Existence value is derived from some form of altruism, and may take several forms. These are:

PHILANTHROPIC - because ones contemporaries may want to use it.
BEQUEST - because future generations may want to use it.
INTRINSIC - because we care about the nonhuman component of the ecosystem.

Pearce and Turner (1990) suggested that as beneficiaries of a bequest may make use of it in the future, the distinction between option value and existence value is often unclear.

3.4 MARKET DEMAND AND SUPPLY OF GOODS

For many resources a market exists which gives it a price or value, however in some cases, commodities affected by an action are not traded on markets. One motivation for public sector involvement is the lack of availability of these commodities through private means (Smith, 1986). Nonmarket goods commonly occur either when the production of a good impacts upon people other than those buying or selling the good i.e. an externality, or when some form of social organisation has evolved as a means for guiding decision making. The fact that a market price does not accompany the use of a resource does not necessarily imply that a zero valuation is attached to it (Sharp, 1985).

Efficient provision of a good is dependent upon whether or not a good is excludable, i.e. whether or not some mechanism exists whereby consumption can be rationed or controlled so that someone cannot consume without paying a price. Without exclusion no property rights exist for a good and it is impossible to ration it efficiently. Goods with such characteristics are often called public goods. The distinguishing feature of a public good is that everyone can consume it without detracting from its value to other users. Public goods are nonexcludable meaning that it is not possible to prevent other persons from using them. For instance one person is able to listen to a radio station without stopping another from also listening. Each individual may be willing to pay a given amount for a good if assured that everyone else will pay a fair share, but in a large economy where an individual does not perceive that their own actions influence the overall amount of the good, a natural inducement exists to enjoy the good without paying for it. People who gain benefit from the provision of a good but fail to pay towards its provision are called free riders. The opposite may also occur in that if the individual considers that their response will not affect their tax burden, then they may overstate their valuation of the good (Meister, 1988).

Because it not possible to exclude people from a public good once it is supplied, the market frequently fails to provide the good. In this case the free competitive economy fails to reach social optimality. Because of this problem some form of Government intervention is necessary. Commonly the Government plays the role of the producer, thus deciding upon the quantity of the good to provide (Just et al, 1982). In determining the point of social optimality, the Government is faced with the problem of determining marginal social benefits and equating them with

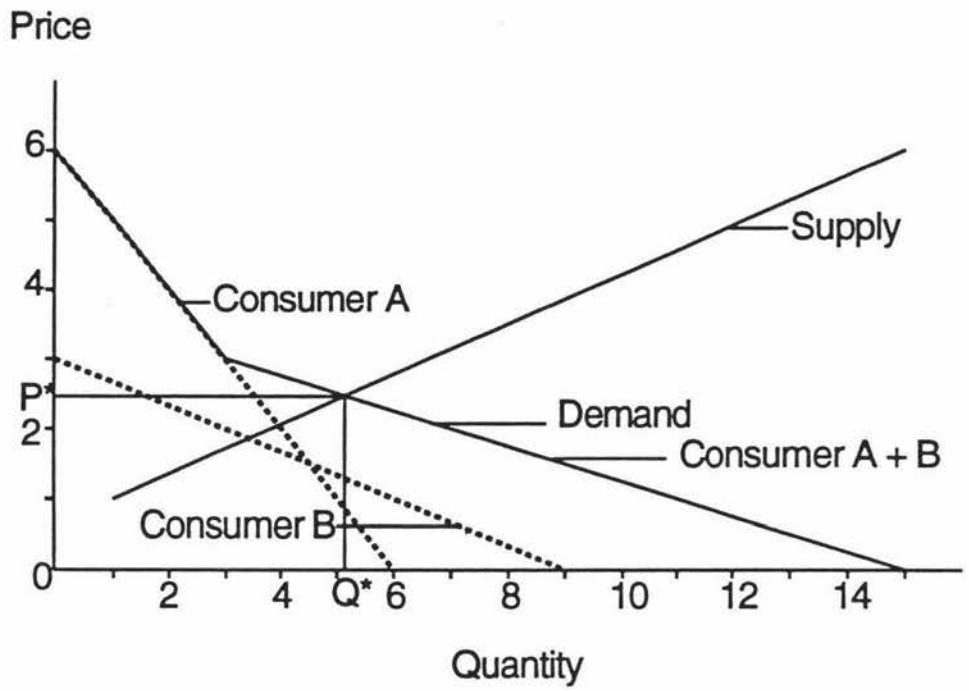
the cost of production. Therefore, the willingness to pay of individuals must be determined even though the equilibrium market prices may not be observable, or may not adequately indicate willingness to pay. Because of the freerider problem the Government cannot simply set a price on the use of the good and see how much is taken by individual consumers (Just et al, 1982).

Private goods are able to confer benefits to a single user who is able to exclude others from its use. There is a spectrum of goods between public and private goods which show characteristics of both. For example, a recreational fishery may be owned publicly with use open to all, but the use of the fishery by one person does affect its value to others by reducing the catch rate (Kerr, 1986).

3.4.1 Private Goods

With a private good, the market system should work efficiently to allocate the good at an optimal level to all consumers. Everyone is faced with the same price per unit, however consumers are free to consume differing quantities. Market demand for a private good is the horizontal summation of the individual demand (willingness to pay) curves (Figure 3.3). At equilibrium, the marginal cost will equal the marginal benefits and Q^* will be produced at a cost of P^* per unit. If the good is produced by a perfectly competitive industry, it will be produced at a level where the price and marginal costs are equal (P=MC).

Figure 3.3 Market Demand for a Private Good



3.4.2 Public Goods

With a public good, everyone consumes the same quantity, however differences in preferences can be accounted for by individuals paying differing prices.

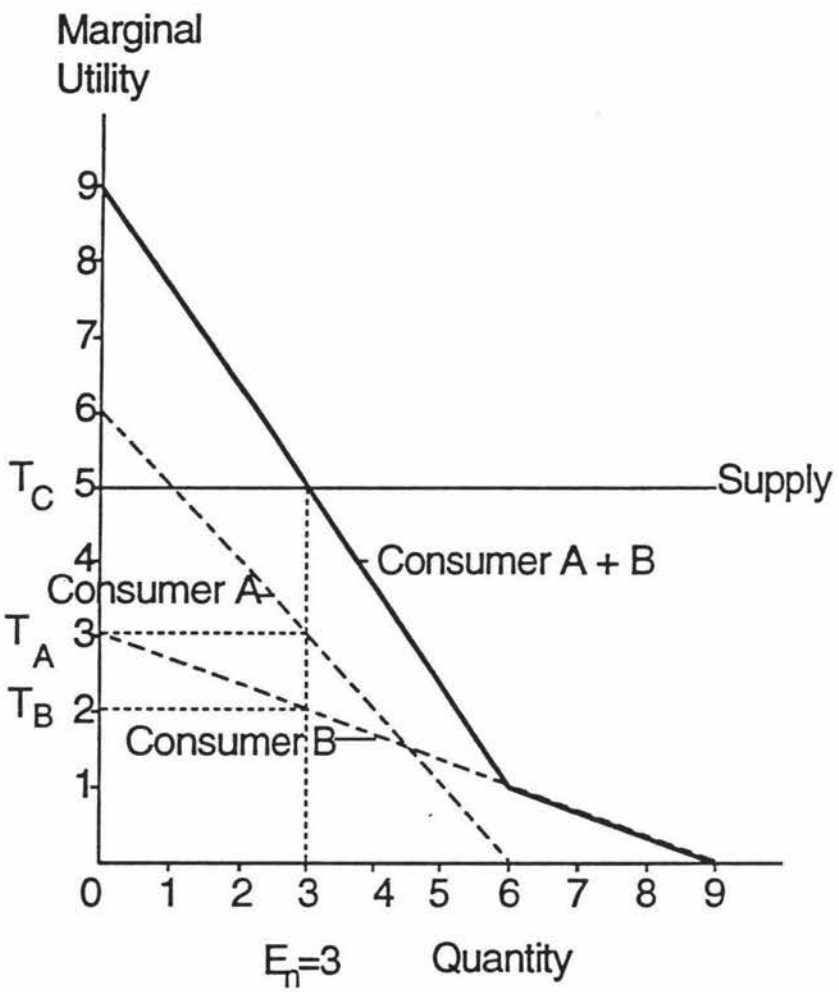
Market demand for a public good is the vertical summation of individual demand (willingness to pay) curves (Figure 3.4). At equilibrium, the sum of the marginal benefits is the marginal cost. Assuming that the supply curve is SS, the equilibrium level of environmental provision is OE_n. At that level of output, each individual will be in equilibrium only if they are charged a per unit price equal to their valuation of the good.

A pays or taxed OT_A/unit

B pays or taxed OT_B/unit

Problems arise with the pricing of public goods. If we charged A and B OT/2, then A would prefer to see less environmental quality provided and B would prefer to see more environmental quality provided, thus we must charge each individual at a price reflecting their demand for the environmental quality. Output will adjust to a level at which the price and marginal cost are equal (P=MC).

Figure 3.4 Market Demand for a Public Good



3.5 WILLINGNESS TO PAY AND WILLINGNESS TO ACCEPT

The compensating variation and equivalent variation discussed in section 3.2 are, respectively, the willingness to pay for an increment and the willingness to accept compensation for a decrement of the good in question. Economic theory states that these two values should not differ significantly, yet studies suggest some quite major disparities. Willingness to pay (W.T.P.) and willingness to accept (W.T.A.) are based upon a total value curve (Figure 3.5). This is an indifference curve between the consumer's income and the quantity of a particular good, service or amenity they choose to consume (Randall, 1981).

Consider an individual who enjoys some specified quantity of a good or service (Q). In addition, they also enjoy some given quantity of the Hicksian 'all other goods' numeraire (Y). This can be thought of as their income, thus giving the consumer's level of utility (U) as

$$U = U (Q, Y) \tag{3.3}$$

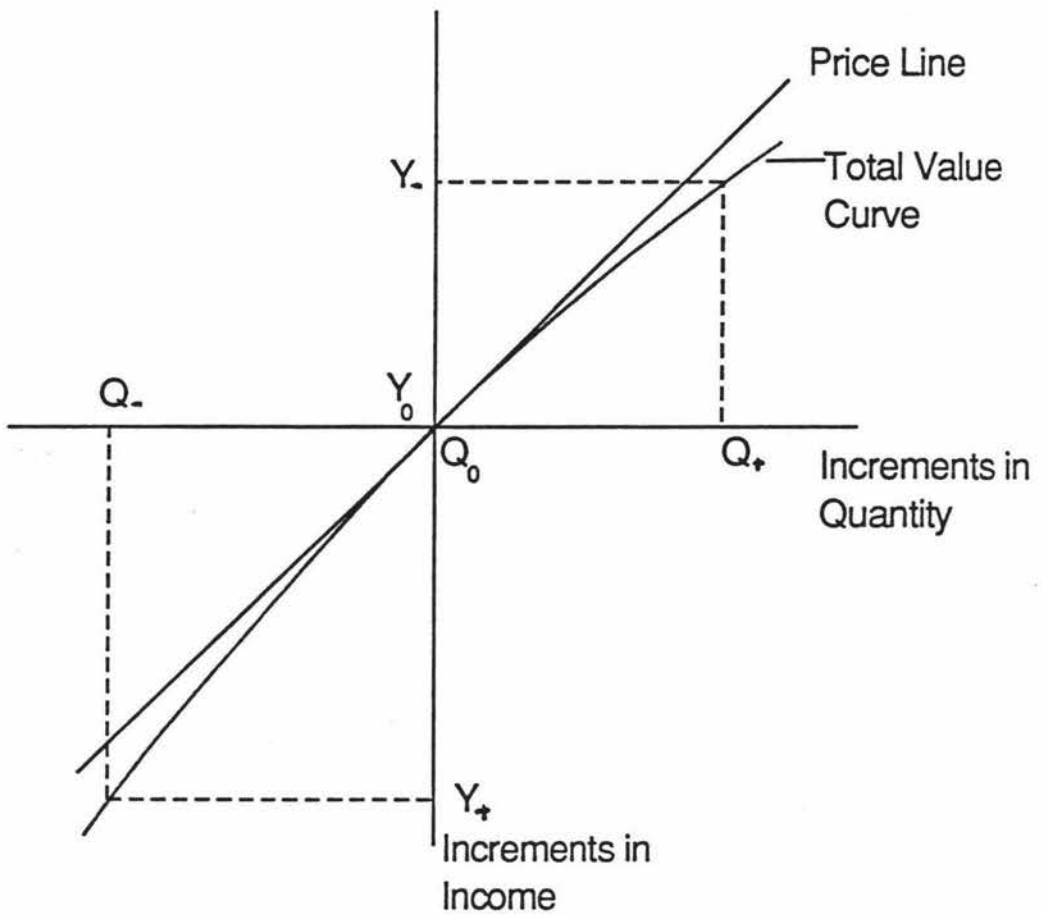
Thus the individual is at the origin which defines their level of welfare in the 'without project' situation. The total value curve, also known as the 'bid curve', is of positive slope, given that the individual is not satiated in the range under consideration. Thus the 'total value curve' is an indifference curve passing through the individuals initial welfare state, that is

$$U (Q, Y) = U (Q_{-}, Y_{+}) = U (Q_{+}, Y_{-}) \tag{3.4}$$

The northeast quadrant indicates that the consumer is willing to pay positive amounts of money in order to obtain an increment in Q, whereas the southwest quadrant indicates that the consumer is willing to accept positive amounts of money concurrent with a decrease in Q (Randall, 1981). Starting at the origin, (Y_0Y_-) is the individual's willingness to pay to obtain an increment in the level of provision of the service from Q_0 to Q_+. Willingness to accept (Y_+Y_0), is the amount of money which would induce the individual to accept voluntarily a decrease in the level of provision of the service from Q_0 to Q_- (Randall and Stoll, 1980).

Given an empirical estimate of the total value curve, the total value to an individual of an increase or decrease in the quantity of the good, service or amenity provided can be readily estimated in a form consistent with the 'Potential Pareto Improvement Criterion'. From any proposed change in output, individual total values may be aggregated across relevant populations. For a small change in Q relative to the total Q exchanged in a competitive market with low transaction costs, the price line is tangent to the total value curve (Randall, 1981). Thus in this situation, the price line provides a reliable estimate of the total value of a good, service or amenity.

Figure 3.5 The Total Value Curve for an Individual Consumer



3.6 NONMARKET VALUATION TECHNIQUES

To measure all the benefits that people gain from a nonmarket good, the Hicksian measure of compensating variation or equivalent variation must be calculated. These estimate respectively, the willingness to pay for an increment or willingness to accept compensation for a decrement in the good in question. A number of methods exist to do this. These include surrogate market approaches such as the hedonic pricing method and travel cost method, where the price of substitute or complimentary goods are used to value an unpriced environmental good. Another way of valuing a nonmarket good is through the use of survey based methods. This approach includes trade-off games, costless choice, priority evaluation, Delphi techniques and contingent valuation/bidding games (Mitchell and Carson, 1989). All these attempt to measure the concept of 'consumer surplus', the total amount people are willing to pay or are willing to be paid for a given quantity of goods over and above their costs, rather than go without it.

3.6.1 The Contingent Valuation Method

The contingent valuation method has been commonly used to derive estimates of the benefits attributable to public or other nonmarket (open access) goods (Kneese, 1983; Grandstaff and Dixon, 1986; Sellar et al, 1986; Cameron, 1988; Boyle and Bishop, 1988; Greer and Sheppard, 1990; Stone, 1991; Lynch, 1992). It creates a hypothetical market for a nonmarket good and then asks people to state the amount that they would be willing to pay or willing to accept as compensation for the suggested change in supply or quality of the good (Kerr, 1986).

Cummings et al (1986) give two behavioural assumptions that the contingent valuation method is based upon. These are:

> Subjects can and have the incentive to determine their preference orderings between the good in question and all other relevant goods and services, i.e. they behave as they would in real market transactions and maximise their utility subject to their income.
>
> Subjects will not behave strategically.

The procedural steps followed with the contingent valuation method are as follows:

Design of the survey instrument (questionnaire) which includes the following key steps;

- a cogent explanation of the survey and its purposes,
- a description of the public good which is to be valued,
- a request for the subjects income and expenditure patterns,
- a willingness to pay (or willingness to accept compensation) question which includes a description of the payment vehicle,
- a request for demographics (age, sex, income) and attitudinal data.

A pilot study carried out as a pretest of the survey instrument.

Choice of the final sampling design and survey area.

Implementation of the survey.

The questions used in contingent valuation surveys can take a number of forms, however only the open ended and dichotomous choice questions are considered in this study.

Open ended questions are the simplest form of questioning, thus they are often used in mail questionnaires. They ask the respondent to put a value on the item in question. The question used in this study was:

"What is the maximum amount your household is willing to pay each year for possum control?

$\_\_\_\_$/year "

Respondents often find it difficult to put a dollar value on nonmarket goods, primarily because they have never before considered doing so, thus other methods of eliciting the respondents' valuations are frequently used.

Dichotomous Choice. To make the valuation process similar to a market type approach, Bishop and Heberlein (1979) pioneered a 'take it or leave it' or referendum approach. Since then a number of experiments have been undertaken with discrete responses both in New Zealand and overseas (Sellar et al, 1986; Cameron, 1988; Boyle and Bishop, 1988; Greer and Sheppard, 1990; Lynch, 1992). The question asks whether a good is worth more or less than a certain amount. If it is worth more, then the good will be purchased, if not, it will not be purchased. For example in purchasing a meal there is a given price (P) which the consumer can take or leave. If the consumer is unwilling to pay the price, the benefits of the meal are foregone.

The theoretical advantage of dichotomous choice over other forms of questioning used in contingent valuation method studies is that it is very like the markets we use in most of our purchases, thus it simplifies the response process. The method also has the advantage that it can be used in mail surveys as well as telephone and personal interview surveys. The main disadvantage of the method is that the analysis of the data derived requires a more sophisticated procedure than with open ended questions.

The dichotomous choice question takes the following form:

"Is your household willing to pay $X each year for possum control?

1 YES

2 NO "

where X is the bid price offered

The bid price is varied amongst questionnaires. Data is frequently analysed using the logit method whereby the area under the probability of paying versus bid price curve is calculated. From the responses it is possible to predict the maximum willingness to pay for any person of given characteristics. The logit model is further discussed in Section 3.7.

Loomis (1990) compared the reliability of both the open ended and dichotomous choice questions in deriving the total willingness to pay for the preservation of natural resources. He found that both were good predictors of the long run value people placed on resources.

3.6.1.1 Strengths

Although the contingent valuation method is subject to a number of weaknesses it has several major advantages that warrant its use in this study. The method is most flexible as it can be used in recreation and urban areas, can obtain estimates for current and potential future impacts and can estimate both use and nonuse values (Rowe and Chestnut, 1983). In this study we wish to capture both use and nonuse values (option, existence and quasi-option) for possum control (see section 3.3). The contingent valuation method has the advantage that it can be readily used in a postal form, thus reducing the costs associated with the study.

Although the contingent valuation method has a number of drawbacks, particularly its susceptibility to biases, this method offers the best opportunity to derive the value that the region places on possum control. With careful design of the survey instrument it is possible to reduce the potential for bias.

3.6.1.2 Weaknesses

The major criticism of the contingent valuation method is the potential for biases to arise with its use. Biases and undesired influences upon responses occur due to aspects of the survey design such as starting bids, payment vehicle, information given (amount and type), question framing and subject-interviewer interactions. These are especially apt to raise problems when the respondents are unsure of their 'true' value.

Hypothetical Bias

A number of studies have reported that potential error is induced by not confronting the individual with the actual situation (Schulze et al, 1981). People often do not act in the hypothetical situation as they would in the real situation if they lack the incentive to do so (Kerr, 1986). To limit this, the situation must be made believable and be fully understood by the respondent. The problem can be exacerbated in instances where the subjects are unfamiliar with the public good in

question, thus it is important that the respondents are presented with a credible simulated market (Kirkland, 1988). Individuals must believe that the change may occur and that their response will affect both the possibility and magnitude of the environmental attribute or quality change (Schulze et al 1981; Kerr, 1986).

A test for hypothetical bias would require that the proposed situation occur and then the respondents' actual reactions be compared to their actions in the hypothetical situation. Richard Bishop used simulated markets for environmental goods and compared these the hypothetical markets (see Carson, 1991), however most often this is not possible.

Mitchell and Carson (1989) consider that the hypothetical nature of the study does not bias the results in any particular way, but represents instead a reliability problem.

Strategic Bias

Individuals who maximise their own welfare have incentives for misrepresenting their preferences. If a respondent believes that everyone must pay the mean bid, then those who are willing to pay more than the mean bid may overstate their value (Kerr, 1986). This is an attempt to impose their true preferences on others (Schulze et al, 1981). For an environmentalist where environmental preservation is an issue, infinity may be the upper bound of their bid, while for a 'developer' the relevant bid may be zero.

Given the assumption that true bids are distributed normally, the Brookshire test for strategic bias involves the inspection of the actual bid distribution. The greater the occurrence of strategic bids, the flatter the distribution of bids.

Freeman (1979), described two methods of solving strategic bias. These are:

> Attempt to measure the bias and adjust the actual responses according to the measured degree of bias.
>
> Structure the questions so as to eliminate incentives for strategic bias. Individuals could be left uncertain as to how, if at all, their responses may affect their liability to pay e.g. the question could be worded 'if the willingness to pay for a 'desirable' project is greater than the

construction costs then the plant will be constructed. You may be called upon to pay exactly the amount you stated or an amount proportional to this. Furthermore, it is possible that the costs of the plant will be partly or completely financed by the Government.' This gives no clear advantage for a person to either overstate or understate their willingness to pay (Freeman, 1979).

Strategic bias can be reduced by emphasizing the hypothetical nature of the survey, however this will increase the hypothetical bias. Empirical studies for strategic bias have not found it to be a major problem (Schulze et al, 1981; Hufschmidt et al, 1983).

Instrument Bias

This is bias introduced by the procedure or process employed to discover the survey respondents' preferences. This includes biases from the vehicle for payment and the starting point for bidding.

Vehicle Bias

If a subject has an aversion to taxes, they may understate their willingness to pay for an environmental commodity if such payment must be made through higher taxes (Cummings et al, 1986). From economic theory, a bid should differ if the price to the respondent of the commodity changes with the payment vehicle. When a payment vehicle allows substitution over a wider range of commodities purchased, the bid should be higher or the compensation lower than when the range is smaller (Schulze et al, 1981; Kerr,1986). Evidence at present supports the vehicle bias proposition (Cummings et al, 1981).

Starting Point Bias

The starting point, when iterative questions are used to extract a respondent's willingness to pay, can affect their maximum bid in two ways. The respondent may alter their bid to please the interviewer if they consider that the starting point suggests the appropriate bid range (Schulze et al, 1981). If the starting point is far from the respondent's bid, the respondent may tire of the process and state a lower willingness to pay than their true one to finish the process (Schulze et al, 1981; Kerr, 1986). This may be worsened if the respondent values their time highly (Schulze et al, 1981).

> While some studies show that starting point biases may be of minimal importance in the application of the contingent valuation method, results from a number of other studies show otherwise. Boyle and others (see Kirkland, 1988), found that starting point bias was evident in three contingent valuation studies that they examined, whilst Cummings et al (1986), stated that the latest consensus was that the reduction of starting point bias was possible through proper payment card design. Starting point bias is not a problem with dichotomous choice and open ended questions.

Information Bias

With surveys, the information that the respondent receives is often different to the information that they would receive if the project were to occur in reality. The respondent's behaviour may be affected by giving them information as to how other respondents behaved, whether in aggregate their bids are sufficient to achieve the goal and the alternative sequencing of questions.

Nonresponse Bias

This results in the loss of valid responses from those originally chosen as recipients of the survey. It is virtually impossible to carry out a survey without some nonresponse bias (Mitchell and Carson, 1989). Researchers have found that this form of bias is associated with a lack of interest in the survey topic. The bias arises as it is thought that those who are less interested in the topic probably have different values to those who are interested in the topic. To determine whether or not nonresponse in a survey results in bias, two questions must be asked. These are:

> Do differential response rates from identifiable household categories exist?
>
> Are there systematic differences between those within a particular group who did and did not answer a certain question (Mitchell and Carson, 1989)?

The extent of the difference between respondents and nonrespondents can seldom be determined. The higher the response rate in a survey, the lower the potential for response bias.

There are two types of nonresponse bias.

Unit Nonresponse Bias

This occurs when those who are surveyed fail to respond to the entire survey. It is virtually impossible to eliminate this form of bias, however it can be significantly reduced by simplifying the response process and including incentives for the respondent to reply.

Item Nonresponse Bias

This occurs when respondents answer some or most of the questions in the survey, but fail to answer a particular question of interest. In general 3 to 8 percent of items on a questionnaire are left blank (Craig and McCann, 1978). Item nonresponse can be divided into four categories- (a) don't knows, (b) refusals, (c) protest bids and (d) responses that fail to meet an edit for minimal consistency. In well designed surveys, the bulk fall into categories (a), (b) or (c). It is possible to influence the distribution across the four categories through survey design.

Craig and McCann (1978), in their study of six surveys, found that item nonresponse was independent of questionnaire length, but varied systematically with age and education. Older respondents tended to have a higher rate of item nonresponse. Variables such as income, occupation and sex had little or no effect.

Although there are many biases which can arise with the use of the contingent valuation method, well designed questionnaires can reduce or overcome them. Therefore for a well understood problem such as possum control, this technique offers a flexible way to determine willingness to pay.

3.6.2 Other Methods

A number of other methods have been used to derive the value of goods for which markets do not exist. These include surrogate market approaches such as the hedonic pricing method and travel cost method where the price of substitute or complimentary goods are used to value an unpriced environmental good and survey based methods such as trade-off games, costless choice, priority evaluation, Delphi techniques (Mitchell and Carson, 1989). The two most commonly used approaches are the hedonic pricing method and travel cost method.

3.6.2.1 Hedonic Pricing Method

The hedonic pricing method (H.P.M.) for valuing public, nonmarket goods involves efforts to impute public good values from observed market prices (Cummings et al, 1986). It involves the identification of the attributes associated with a market commodity and the decomposition of the commodity's market price into values relating to each of the attributes (Cummings et al, 1986).

The method recognises that individuals are willing to pay different amounts for goods with different characteristics. Many goods that we purchase are composed of a bundle of characteristics e.g. housing characteristics include - number of bedrooms, section size, construction materials, type of heating, garaging facilities, age, distance from shops and air quality (Kerr, 1986). If the level of a nonmarket good e.g. air quality, varies geographically, then the level of the good at different locations may be reflected in local housing prices (Cummings et al, 1986). The major assumption underlying the hedonic pricing model is that individuals are cognizant of and optimise across the attributes of the market commodity (Cummings et al, 1986).

The strength of the hedonic pricing method lies in the fact that it yields the market equilibrium value of the public good, however a major problem with its application exists in that adequate data acquisition may be quite expensive or the data may simply not be available. This is particularly so in small countries such as New Zealand. The weaknesses of the technique lie in the unresolved theoretical and econometric issues (Palmquist, 1991). Some of these have been resolved but have not yet been completely implemented. It is not clear that the

market value imputed to a public good from the study of one market, for example property values for houses, captures the full value of the public good. Clean air for example affects people at work as well at home, thus maybe wage differentials should also be considered.

Being market based the hedonic pricing method is often better than the contingent valuation method if data is available. It is applicable for localised populations, however the method has limited applications for many nonmarket goods in that the required data often does not exist or would be very expensive to collect.

3.6.2.2 Travel Cost Method

The travel cost method (T.C.M.) was initially developed to value the benefits to consumers from their use of an environmental good, specifically from the use of an urban park. It is based upon the assumptions that a visit to a site will only be taken if the benefits derived from it are at least equal to the costs associated with the visit (Cummings et al 1986; Kerr, 1986) and that the number of visits to a site is inversely related to the costs of getting there (Kerr, 1986).

Users of many recreational goods pay nothing or a very minimal fee for their enjoyment. Even if revenue is collected for the use of a site, it generally is not a good indicator of the value of the site.

The travel cost method assumes that users come from various places to spend time at the site. Even if no fee is charged for a site, the demand for it is not infinite as there is a cost involved in getting to and from the site. This is the travel cost. Those living closer to the site are expected to use it more often (demand more) as its implicit price is lower, thus the users receive a greater consumer surplus (Hufschmidt et al, 1983). The travel cost method derives how the number of site visits change in response to a change in price per visit.

This method of deriving the value people place upon a good is based upon the assumptions of single purpose trips, equality of substitutes and zero valuation of travel and on site time. Cesario (1976), however, found that incorporating travel time valuations in recreational benefit analysis was vastly superior to excluding it on both practical and theoretical grounds.

Several problems arise with the application of data derived from the travel cost method. These are listed below:

Estimates of the value from the analysis are site specific. These results can not be applied to other sites (Hufschmidt et al, 1983; Cummings et al, 1986).

Benefit estimates derived apply to the site per se, not the joint outputs of the site e.g. specific recreation experiences. The method says nothing about the value of any part of the site or the value of altering characteristics pertaining to the site.

The method does not measure any nonuser values associated with the amenity.

3.7 THE CHOICE OF MODEL FOR USE WITH DICHOTOMOUS CHOICE QUESTIONS

In response to a dichotomous choice question, the respondent states whether or not they are willing to pay a given bid price. From the pattern of yes and no (taken as 1 and 0 respectively) given in response to this question, the maximum willingness to pay for the commodity in question must be inferred. The inference works by comparing the probabilities at different bid values. A number of models exist for the estimation of dichotomous data, the most common being logit and probit. The logit model was chosen to be used in this thesis as it is consistent with consumer utility maximisation theory (Hanemann, 1984). As it was not possible to assume that the error terms were normally distributed the probit model could not be used. While the logit model is used more frequently in research than the probit model, the logistic and normal cumulative distribution curves are very similar and hence they yield similar predicted probabilities (Loomis, 1988). The logit model has been used previously in New Zealand and overseas (Sellar et al, 1986; Cameron, 1988; Boyle and Bishop, 1988; Greer and Sheppard, 1990; Lynch, 1992). By calculating the area under the probability versus bid price curve a measure of the maximum willingness to pay can be calculated.

3.7.1 Estimation of the Logit Function

To estimate the willingness to pay, an equation must be estimated to fit a curve to the responses. The first step is to estimate a function that allows the 0s and 1s to be translated into a range of probabilities that vary with the dollar amount specified. This is in the form:

$$Y = f(X) \tag{3.5}$$

where Y is the response, equalling 1 if the respondent is willing to pay the specified amount and 0 if not,

X is the dollar amount that the respondents were asked to pay.

In this case it has been assumed that bid price is the only independent variable, however in reality demand theory and the sign of the coefficients may indicate that more than one independent variable exists.

Whilst it may be tempting to use ordinary least squares regression (OLS) to fit the calculated data to the equation, this is incorrect as ordinary least squares belongs to a class of linear statistical models. Loomis (1988), lists several disadvantages in using a linear model where the dependent variable is qualitative. These are:

> The mathematical expectation of a qualitative variable is a nonlinear function of its independent variables, therefore linear probability models represent an incorrect specification of the probabilities.
>
> Whilst under some circumstances the coefficients are unbiased, the estimates are not efficient in the sense of having the smallest variance.
>
> It is possible for the predicted probabilities to have values of greater than 1 and less than 0. Whilst weighted least squares regression can account for heteroscedacity and provide minimum variance, predicted probabilities may still lie outside of the range 0 to 1.

As mathematical expectations of probabilities are inherently nonlinear, they are best estimated using a nonlinear model such as the logit model.

Given that the utility that respondent gains from a nonmarket good is greater than or equal to the bid price if they accept the price, a utility difference model can be formalised that relates the probability of a yes to the utility difference of the unimproved and improved situations.

For the model

$$P_i = E\,(\,Y=1 \mid X_i) = \beta_1 + \beta_2 X_i \qquad (3.6)$$

where P_i = probability of saying yes to the bid price,

β_1, β_2 = the parameter estimates for the intercept and dependent variables.

Mathematically, the logit can be written as

$$P_i = \frac{1}{1+e^{-z_i}} \tag{3.7}$$

where e is the natural logarithm,

z_i is a function of the variables which are hypothesised to predict the respondent's response to the question. In this example, $z_i = \beta_1 + \beta_2 X_i$

As the yes and no responses are mutually exclusive events, if P_i is the probability of the respondent saying yes to the bid price then $(1 - P_i)$ will be the probability of the respondent saying no to the bid price. Thus the probability of the respondent answering no can be written as

$$(1 - P_i) = \frac{1}{1+e^{z_i}} \tag{3.8}$$

and the odds in favour of paying the offered price can be written as

$$\frac{P_i}{(1-P_i)} = \frac{(1+e^{z_i})}{(1+e^{-z_i})} = e^{z_i} \tag{3.9}$$

If P_i is 0.75 then the odds in favour of saying yes to the bid price are 3 to 1.

By taking the natural log of equation 3.6, L_i the logit is obtained

$$L_i = \ln \frac{(P_i)}{(1-P_i)} = z_i = \beta_1 + \beta_2 X_i \tag{3.10}$$

This is called the log odds ratio and is linear in X and the parameters (βs).

Gujarati (1988) gives the following features of the logit model which make it well suited to modelling discrete choices:

> As P goes from 0 to 1, the logit varies from -∞ to +∞. That is, although the probabilities lie between 0 and 1, the logit is unbounded.

Although L is linear in X, the probabilities themselves are not.

By plotting the predicted probabilities derived from the logistic regression function in equation 3.10, the inverse cumulative regression function is gained. The area under this curve is the expected maximum willingness to pay for those in the sample. Mathematically, the expected value is the integral of the cumulative distribution function.

$$W.T.P. = \int_{1}^{\bar{} } [1 - \frac{1}{1+e^{x}}] \, dX \tag{3.11}$$

A difficulty exists with estimating the willingness to pay as data on bid prices does not exist over the range from zero to infinity. The tail of the estimated distribution is determined by the bid range offered. It is impossible to determine how the tail approaches the axis beyond the highest data point. Because of this Duffield and Patterson (1991) argue that the overall mean is inconsistent with basic consumption theory. The plausible upper limit to the distribution should not be infinity, but something less than income.

The motivation behind the use of the overall mean as a welfare measure is that it can be aggregated to give a measure of total value for a population. As distributions are commonly skewed to the right, the overall mean has a tendency to overestimate the willingness to pay. It is also very sensitive to the model chosen, for example logit versus probit (Patterson, 1990; in Duffield and Patterson, 1991).

The median value (where 50 percent of the respondents will say yes to the bid price) is consistent with theoretical constraints since it is not influenced by the upper tail of the distribution (Duffield and Patterson, 1991). Although a number of researchers argue that it can not be aggregated to provide a measure of Pareto efficient outcomes (Johansson et al, 1989; Duffield and Patterson, 1991), it has been aggregated by a number of other researchers (Hanemann, 1984; Lynch, 1992).

A third method of estimating the value is by truncating the range of integration at the highest bid value (Bishop and Heberlein, 1979) or at a fixed percentile (Boyle and Bishop, 1988; Duffield and Patterson, 1991). Boyle and Bishop (1988) chose

the 90th percentile of the logit function as the truncation point. The truncation point should be less than income and less than the highest bid price (Duffield and Patterson, 1991).

The researcher must make a value judgement on which of these three approaches to follow. In this thesis all three approaches are used to demonstrate the differences between results obtained from each approach.

3.8 MODEL STATISTICS

A number of statistics will be used in this thesis to test the significance of the derived answers. These will be described in the following sections.

3.8.1 Chi-square Statistic

The Chi-square statistic will be used to measure the likelihood that outcomes from cross tabulations occur purely by chance. It will be presented with a statistic describing the probability of obtaining a Chi-square value as large as the one obtained by chance alone. The Chi-square statistic is calculated as

$$X^2=\sum_{i=1}^{n} \frac{[(O_i-E_i)^2]}{E_i} \qquad (3.12)$$

where O_i is the observed outcome from a cell

E_i is the expected outcome from the corresponding cell (Mendenhall and Ott, 1980)

The Chi-square statistic is of questionable value in logit analysis as logit is based upon maximum likelihood estimators as compared to the ordinary least square regression. Statistics calculated in logit are pseudostatistics, thus it is better to use a statistic such as the McFadden's R^2.

3.8.2 McFadden's R^2

The McFadden's R^2 is calculated as

$$R^2=1-\frac{(\log\beta_{m_l})}{(\log L_c)} \qquad (3.13)$$

where $\log \beta^{ml}$ is the sum of the parameter estimates (βs) for the entire model,

$\log L^0$ is the parameter estimate (β) for the intercept.

The McFadden's R^2 is interpreted in a similar fashion to the correlation of determination r^2, thus it describes the proportion of variation in the dependent variables that can be described by the explanatory variables.

3.8.3 C Table

Another method of estimating the overall fit of a model is by checking how well the modelled data fits the observed data. This can be done with a c table, a 2x2 frequency table of observed and predicted responses. With the observed data an event is considered to occur when the respondent says yes to the question (in the case of this survey when the respondent is willing to pay the bid price). For the predicted data, an event is considered to occur when the probability of the respondent saying yes to the question is at least 50 percent (SAS Institute Inc., N.D.). This table gives the percent of outcomes correctly predicted by the model.

3.8.4 Correlation Coefficient

A commonly used statistic used to show whether a relationship exists between two variables is the Pearson's Correlation Coefficient (R). It is a number between -1 and +1 which indicates how one variable changes as the other in the relationship changes. A positive correlation coefficient tells us that as one variable increases, so too will the other variable increase, whereas a low or zero correlation coefficient tells us that little relationship exists between the two variables. A negative coefficient indicates that as one variable increases the other will decrease. To show whether two variables are correlated, the probability associated with the correlation coefficient should be considered. This gives the probability of obtaining a sample correlation coefficient as large or larger than the one obtained, by chance alone, i.e. the variables actually have no correlation.

The significance of the correlation coefficient is a function of sample size and the magnitude of the correlation coefficient. Even a small coefficient can be significant with a large data sample, e.g. 0.195 is significant at the 5 percent level for a sample with 100 data points (Cody and Smith,1985).

One of the best ways of interpreting r is to look at the r^2, the sample coefficient of determination. This is best interpreted as the proportion of variance in one of the variables that can be explained by variation in the other variable, thus $(1-r^2)$ gives the proportion of variance due to other factors (Cody and Smith, 1985; Gujarati, 1988).

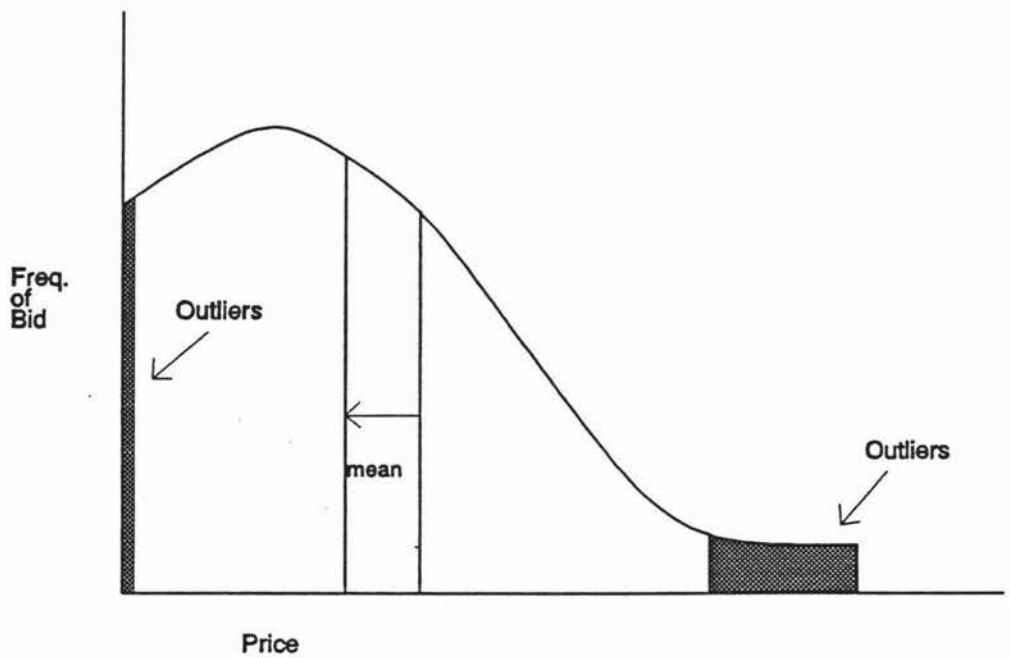
3.8.5 Robust Statistics

A few outliers if genuinely invalid can significantly distort an estimate. Even a sufficiently large sample size cannot solve the problems presented by outliers, which tend to be a constant percentage of the sample regardless of its size (Mitchell and Carson, 1989). This is a particular problem in contingent valuation surveys where a few very large bids may dominate the mean willingness to pay. The median is often pre♠ferred in locating the centre of a skewed distribution (Mendenhall and Ott,1980), however a number of other methods are frequently used.

The domination of the mean willingness to pay by one or more very high bid values can be overcome by their removal, raising the problem of how this should be done. One approach is to delete outliers on an adhoc basis, however this has the flaw of leaving researchers open to the criticism that they have engaged in selective deletion to gain the results that they desire. A defensible way to compensate for the effect of outliers is through the use of robust statistical estimators (Mitchell and Carson, 1989). Although a number of such estimators exist (Mosteller and Tukey, 1977; Huber,1981), the α-trimmed mean has been used in this case.

The family of α-trimmed means are commonly used estimators. The median is the α-trimmed mean with alpha equal to 0.50, whilst the mean is the α-trimmed mean with alpha equal to 0.00. Bickell and Doksum (1977) recommend that a range $0.10 \leq \alpha \leq 0.20$ seems to yield estimates that provide adequate protection against the proportions of gross errors expected in practice and yet perform reasonably well when the sampling is from a normal distribution. Whilst others advocate a larger range for alpha (Mitchell and Carson, 1989), Stigler (1977) has shown an alpha value of 0.10 to give the best results. Following the recommendations of Stigler (1977), an alpha level of 10 percent has been used in this thesis. This results in the highest 10 percent and lowest 10 percent of bids being deleted and the mean being recalculated (Figure 3.7).

Figure 3.6 The Effect of Trimming the Mean



By ordering the bids from the smallest X_1 to the largest X_n, the α-trimmed mean is defined as

$$\overline{X}_{\alpha} = \frac{X_{([n\alpha]+1)} + \ldots + X_{(n-[n\alpha])}}{(n-2[n\alpha])} \tag{3.14}$$

for $0.00 \leq \alpha \leq 0.50$
where $[n\alpha]$ is the largest integer $\leq n\alpha$.

The trimmed mean can be coupled with estimates of its asymptotic variance to yield confidence boundaries and intervals for μ. An operational estimator of the variance of the α-trimmed mean, the Winsorized sample variance (Bickell and Doksum, 1977) is given by

$$\sigma^2_{\alpha} = \sum_{i=([n\alpha]+1)}^{(n-[n\alpha])} \frac{(X_i - \overline{X}_{\alpha})^2 + [n\alpha] * [(X_{([n\alpha]+1)} - \overline{X}_{\alpha})^2 + (X_{(n-[n\alpha])} - \overline{X}_{\alpha})^2}{(1-2\alpha)^2 n} \tag{3.15}$$

where $X_{[n\alpha]+1}$ and $X_{n-[n\alpha]}$ are the empirical order statistics.

If we assume that the X_i are from a symmetric unimodal distribution, then assymptotically the random variable is given by

$$T = \sqrt[2]{n}\frac{(\overline{X}_{\alpha} - \mu)}{\partial_{\alpha}} \tag{3.16}$$

where μ is the population mean which has approximately standard normal distribution (Z). Confidence intervals can be formed in the following manner:

$$\overline{X}_{\alpha} \pm \frac{Z(1-0.5\alpha)\,\partial_{\alpha}}{\sqrt[2]{n}} \tag{3.17}$$

CHAPTER FOUR

THE MANAWATU-WANGANUI CASE STUDY

The contingent valuation method (C.V.M.) was described in detail in Chapter 3, therefore this chapter will focus on the application of the method to derive the region's willingness to pay for possum control. The value derived will be an aggregate of both use and nonuse values, however it will not be possible to distinguish between the two.

The chapter begins by looking at the methodology of applying the contingent valuation method. It continues by analysing household perceptions of the possum problem followed by a description of the costs and problems imposed by possums on the respondent households. The value that households place on possum control is ascertained using nonmarket valuation techniques, specifically the dichotomous choice and the open ended contingent valuation methods. These values are then aggregated under several scenarios. Finally the chapter concludes with a discussion on the values derived.

4.1 METHODOLOGY

Randomly sampled households were asked to place their value on possum control, either via an open ended question or a dichotomous choice (yes/no) question. Their answers were contingent on the following hypothetical situation (see Appendix 1B and 1C):

> '...all households... ... will be expected to pay into this fund annually... ...all expenses on possum control will be covered by this fund. You will no longer be charged rates or taxes for possum control and it will not be necessary to spend any money on privately funded possum control...'

By stating this strict criteria, it was hoped that households would give their true valuation of possum control i.e. the total amount of possum control they considered should be carried out. The willingness to pay for possum control

reported was assumed to correspond to that point of indifference between having the stated amount of income and the utility gained from that amount of possum control.

The willingness to pay question was asked twice, once for payment on a regional basis with all money being spent in the region and once for payment on a national basis. Any difference in bid price between the two scenarios should indicate how the respondent felt about the distribution of funds.

The hypothetical situation was designed to be as realistic as possible (Randall et al, 1974; Bennett, 1984). A fund was chosen as the best method to collect the bids that the respondents offered. This was considered to be a relatively neutral collection method as compared to other possible methods such as taxes or rates (Kirkland, 1988). Taxes and rates have been found to be emotive and low responses have been recorded with their use as a collection vehicle (Kirkland, pers. comm., 1990).

Respondents who were unwilling to pay into the fund for possum control (either for the regional scenario, national scenario, or both) were asked to explain their reasons for this. This was to identify genuine zero bids as compared to protest bids. Protests were most commonly directed towards the collection method or the survey game.

The individual bids were aggregated to give the mean willingness to pay for the regional and national scenarios under a number of different assumptions. By multiplying these willingness to pay values by the number of households in the region, the total value for possum control in the Manawatu-Wanganui region was calculated.

Demographic data on the respondent households was gathered in order to examine the relationship between such variables as age, sex, occupation, household income and membership of various organisations; and willingness to pay for possum control. Information on the respondent household's perceptions of the problem and the effect that possums were having on their property was collected to examine its impact upon willingness to pay for possum control. In the case of the dichotomous choice model, a number of these variables were required to derive a demand function for possum control. This function was then used in the logit model.

The principle objective of the survey was to derive the value that the region puts on possum control. The simplest way to ascertain this given the constraints of time and money, was through the use of a mail survey. As households may derive benefits from possum control other than use value (e.g. option and existence values for native forest), the contingent valuation method was considered to be the best method of eliciting an aggregate of these benefits. Two commonly used methods of eliciting values are the open ended question approach (Kirkland, 1988; Stone, 1991) and the dichotomous choice question approach (Greer and Sheppard, 1990; Lynch, 1992). It was decided to use both approaches so that a comparison could be made of the values derived from each. As dichotomous choice surveys require a larger number of respondents, two thirds of the surveys were sent in this form and one third in the open ended form.

4.1.1 Questionnaire Design

Dillman's 'Total Design Approach' was called upon in the design of the survey. Some of the key features of this are listed below.

The ordering of questions in descending order of usefulness, the grouping of similar questions and the use of a simple question as a lead in to the questionnaire.

The laying out of the survey in an appealing and simple to follow format.

The provision of simple directions on how to answer the questions.

The thorough pretesting of the survey.

By calling upon similar research (Kerr, 1985; Kirkland, 1988) a pilot survey was drawn up along with its covering letter (Appendix 1A). The covering letter was designed to motivate recipients of the survey into responding by explaining the aims of the survey. The letter also contained information on the confidentiality of the survey. Following the pilot survey, a number of changes were made to the questionnaire, however these will be discussed in section 4.1.5.

4.1.2 Sampling Frame

An integral part of the survey implementation process was the identification of a suitable sampling frame and the use of it to select the required sample. A number of different sampling frames were considered including electoral rolls, telephone directories and valuation indices. The first two were ruled out as they did not differentiate respondents into the desired regions (District and City Councils of the Manawatu-Wanganui region). The possibility of asking survey respondents to identify which region they resided in was considered, however it was decided that due to recent boundary changes a large number of respondents may not have been aware of the Council area they resided in. This left valuation indices as the only viable option. This sampling frame suffered from a number of problems, the major one being the duplicity of properties. In areas with street numbers it was possible to account for this by sending the survey to the occupier of the residence. If the owner of the property was also the occupier (this was taken to occur when the address given for the rates assessment to be sent to coincided with that of the property), the survey was addressed to the owner in person, however if this was not so, the survey was addressed to "The Householder". In rural areas it was not possible to account for this problem beyond deleting any obvious multiplication of names from the sampling population.

4.1.3 Sampling Procedure

To collect a random sample of households in the Manawatu-Wanganui region, an estimate of the number of households in each area was first gathered, followed by an estimate of the number of ratable properties in the area. It was decided to collect 1700 addresses. This figure was based upon monetary constraints and by the desire to receive responses from at least 1 percent (780) of the households in the survey region. The number of respondents required from each region was calculated. These were randomly selected off of the appropriate valuation index.

Table 4.1 Number of Households and Ratable Properties in the Manawatu-Wanganui Region.

Council Area	Number of Households	Percentage of Households (1)	Number of Ratable Properties	Percentage of Ratable Properties (1)
Ruapehu District	5441	7.0	19500	8.7
Wanganui District	16316	20.9	44000	19.7
Rangitikei District	5664	7.3	17700	7.9
Manawatu District	9199	11.8	25800	11.6
Palmerston North City	23924	30.7	67239	30.1
Tararua District	6761	8.7	19900	8.9
Horowhenua District	10657	13.7	28900	13.0
TOTAL	77962	100.1	223039	99.9

(1) does not add to 100.0% due to rounding errors

Once the sample listings had been identified, the addresses (either under "The Householder" or the name of the resident household) were loaded into a computer and printed onto labels. This allowed for the efficient multiplication of labels.

4.1.4 Survey Implementation

1652 surveys with covering letters were posted out between June 10 and June 13, 1991, with nearly 70 percent being posted on June 10. To increase the credibility of the survey, the covering letter was on Massey University letterhead paper and the envelopes used were embossed with the Massey University crest. A stamped return envelope was included with the survey. Responses were received within 3 days of posting with a final survey being received over 11 months after it was posted out. 42.5 percent of the usable responses were returned within 10 days of posting whilst 11.1 percent of usable responses were returned more than 30 days after posting (Table 4.2).

Table 4.2 Time Taken to Return a Usable Survey

Time Taken to Return a Usable Survey (Days)	Percentage of Usable Responses
1 - 10	42.5
11 - 20	22.4
21 - 30	24.0
31 - 40	4.1
41 - 50	5.3
51 - 60	0.7
61 - 70	0.6
More than 70	0.4
	100.0

10 days after the initial posting a reminder letter was sent out to all who had failed to respond to the survey. This resulted in an increased number of responses per day. A further reminder letter was posted 25 days after the initial posting of the survey. In total, 1033 first reminder letters and 788 second reminder letters were posted. Responses to these included a number of phone calls and letters requesting the posting of another survey to replace the original which had been misplaced.

A number of methods have been used by researchers to increase response rates including a second copy of the survey being posted out with the second reminder letter (Kirkland, 1988), the use of a registered letter with a replacement survey or the use of follow up phone calls to nonrespondents (Dillman, 1978). The use of prepaid monetary incentives (Yu and Cooper, 1983; McGuiness, pers. comm., 1991) has been found to increase the response rate in surveys to the extent that they more than pay for themselves. Unfortunately monetary constraints dictated that none of these approaches could be followed.

In total 1652 surveys were posted out however 215 (13.0 percent) were returned 'person unknown'. It was assumed that the remainder (1437) reached the desired households. Of those receiving a survey, 818 responded in some form giving a response rate of 56.9 percent. Given the monetary constraints limiting the amount and methods of nonrespondent follow up, this response rate was acceptable. It is comparable with that gained in recent similar work (Kirkland, 1988; Greer and Sheppard, 1990). Of those responding to the survey, 106 refused to 'play the game', giving 712 usable responses (Table 4.3). This accounts for 49.5 percent of those contacted in the survey. The percentage of respondents replying from each region was similar to the number of households in the region, although the usable response rate from the predominantly urban areas (taken to be the Palmerston North, Wanganui and Manawatu regions) was lower than that of the other regions. The aggregate response rate of the former regions was 46 percent compared to 54 percent for the latter regions.

Table 4.3 Response Rate to Surveys Sent to Persons in the Manawatu-Wanganui Region.

Region	Number Sent	Not Found	Refusals	Number of Usable Returns	Percent Usable
Horowhenua	217	42	15	79	11.1
Manawatu	195	42	13	76	10.7
Palmerston North	472	29	37	208	29.2
Rangitikei	143	13	11	85	11.9
Ruapehu	164	31	5	68	9.6
Tararua	148	22	6	74	10.4
Wanganui	313	34	15	119	16.7
Area Undefined		2	4	3	0.4
Total	1652	215	106	712	100.0

4.1.5 Pretest

Pretesting is especially important for mail questionnaires as there are no interviewers to report defects and inadequacies in the survey to the researcher. It is designed to test the questionnaire as well as the questions, thus general impressions of the questionnaire are as important as comments relating to specific questions.

Because of this, Dillman (1978) designed a specific set of procedures, the 'Total Design Method' for pretesting of mail surveys. The method is based on the recognition that any pretest of a mail survey must answer several questions:

> Is each question measuring what it is intended to measure?
> Are all the words understood?
> Are questions interpreted similarly by all respondents?
> Does each question have an answer that applies to each respondent?
> Does the questionnaire create a positive impression, one that motivates people to answer it?
> Are the questions answered correctly?
> Does any aspect of the questionnaire suggest bias on the part of the researcher?

The survey should be submitted to the scrutiny of the following three groups of people.

> Similarly trained professionals who understand the study's purpose, including the hypothesis being tested. This group of people should evaluate the study in terms of whether it will accomplish its objectives or not.
>
> The second group should comprise of persons who are potential users of the data. The primary objective is to find people with a substantial knowledge of the topic who may find flaws in the facts contained in the survey.
>
> The third group of persons who should be consulted in the pretest are a sample drawn from the general public.

The third group are often the only group consulted in pretests, however it is important to consult all three groups. They should be given a survey and covering letter in the presence of the researcher. Verbal and nonverbal feedback such as hesitating before answering a question or erasing an answer provide important information to the researcher.

It is desirable to carry out a small scale survey to complete the pretesting phase of a survey as this will give an estimate of the response rate to expect with the final survey.

Pretesting of the survey was carried out in April and May 1991. As specified by Dillman (1978), it comprised of checking the survey with professionals trained in the area of nonmarket valuation, those who were knowledgeable on the topic of possums (Department of Conservation and Regional Council employees) and the general public. This was followed by a small scale survey whereby 20 surveys were sent out to a sample of persons in the Manawatu-Wanganui region. As it was not possible to use the valuation indices for the region at that time, names of recipients for the pretest were selected from the relevant telephone directories. There were two major functions of the pretest, the first to test the survey and ascertain that all questions were answered in the required way and the second to obtain an indication of the range of bids which would be expected in the final survey. This information was required to set an appropriate range of bids in the dichotomous choice question.

Although no follow up letters were posted out to nonrespondents, 55 percent of the surveys were returned. Bids offered in both the pretest survey and by others shown the survey ranged from $0 to $200 per annum.

A number of changes to the survey were carried out after the pretest. These comprised mainly of minor wording changes and minor changes in the survey format. The more major changes which occurred following the pretest include the deletion of questions 22 and 25 of the pretest questionnaire (Appendix 1A). The former asked for the household's main type of farming whilst the latter asked for the respondent's property size. The latter question was substituted for a question on the type of area the respondent resided in, i.e. a rural area, a community of less than 500 residents or an urban area of greater than 500 residents. The willingness

to pay on a national basis question was altered from a question asking 'would you pay? (yes/no)' to 'how much would you pay? ($ amount)' This change was made as a number of respondents indicated that their willingness to pay would change if the payment method was altered from a regional to a national basis.

Based on the range of bids offered in the pilot survey, a bid range from $5 to $500 was used with the dichotomous choice question. This was to allow for an expected increase in bid range with the larger sample size being used. A limited amount of information was available on the choice of bid values for the dichotomous choice question, thus it was decided to select a variety of bids which covered the upper tail less densely. Bid values chosen were:

$5, $10, $20, $40, $60, $80, $100, $120, $140, $160, $180, $200, $300, $400, $500.

One of these bids was randomly assigned to each of the dichotomous choice surveys so that the question read as

> "... Is your household willing to pay $X into this fund annually for possum control..."
>
> where X was one of the bid prices listed above.

In the final post out of the surveys, 66.6 percent or 1100 were sent in the dichotomous choice format and 33.4 percent or 652 were sent in the open ended format.

4.2 REPRESENTATIVENESS OF THE SURVEY

The demographic data from the survey was compared with the corresponding regional data to check that the survey was representative of the region. In several instances data for the region from the 1991 census was unavailable, thus either 1986 census data or national data was used to compare the survey data to.

Although the survey respondents are reasonably representative of the region (Table 4.4), a number of discrepancies do occur:

Approximately equal percentages of males and females were included in the survey when all members of each respondent household were summed, however of those who physically filled in the survey only 22.7 percent were females.

The survey underestimates the number of respondents in the 20 to 30 years and 60 and over age brackets and overestimates those in the 40 to 60 year age bracket. This combination of overestimating those who are likely to be in the higher income earning bracket and underestimating those who are likely to be in the lower income bracket may lead to an overestimation of the willingness to pay.

Although only 7.3 percent of those in the region over the age of 15 years are classified as farmers, 18.6 percent and 15.3 percent of respondents of the open ended and dichotomous choice questions respectively, classified themselves as farmers. Farmers would be expected to have a higher valuation of possum control than nonfarmers due to the direct benefits that they gain from possum control. Other sectors to be over represented in the survey were professional, technical, managerial and administrative workers. Economic theory dictates that the latter four groups would have a higher than average willingness to pay for possum control due to their higher expected earning capacity. Those groups under represented in the survey include labourers, the unemployed and beneficiaries. In particular, only 1.8 percent and 3.3 percent of respondents of the open ended and dichotomous choice questions respectively, classified themselves as unemployed or beneficiaries, yet unemployed persons make up 11.1

percent of the region's population. No data was available on the number of beneficiaries in the region. These groups are generally less educated and of lower income thus would be expected to have a lower valuation of possum control.

Recent regional data on household income was unavailable. In the 1986 census the distribution of household incomes was similar on a national and regional basis (Department of Statistics, 1986#5; 1986#6). This similarity between data would be expected to remain constant. The national average household income was $39,780 at March 1990 (Department of Statistics, 1991#3), however this declined by 2.1 percent over the next 1.25 years (Department of Statistics, 1991#2) giving an average national household income of $38,944 in June 1991. The average household income of survey respondents (taking the midpoint of each income category) was $33,176. These household incomes can be considered similar due to the inaccuracies of the measuring method.

Table 4.4 Household Demographic Statistics.

Characteristic	Percentage of Respondents		Regional Percentage
	Open Ended Question	Dichotomous Choice	(1)
Household Size (1,2)			
1	12.0	11.7	19.4
2	40.4	34.7	30.5
3	17.2	17.6	17.1
4	17.2	20.0	17.7
5	7.5	11.3	9.4
6	3.1	3.1	3.6
7 or more	0.7	1.7	2.3
Sex (3)			
Female	50.8	48.7	50.6
Male	49.2	51.3	49.4
Age (4)			
Under 15	24.3	23.2	24.8
15 - 19	10.5	9.3	9.6
20 - 29	12.5	14.1	17.1
30 - 39	15.5	13.0	13.8
40 - 49	14.7	15.4	10.1
50 - 59	10.3	13.0	8.7
60 and over	12.3	11.9	15.9
Occupation			
Professional & Technical	14.2	13.0	6.8
Administrative & Managerial	2.8	4.1	1.9
Clerical	3.6	5.1	7.1
Sales & Service	7.2	6.4	9.2
Agriculture & Fisheries	18.6	15.3	7.3
Labourer	9.3	7.0	15.5
Studying	14.2	13.8	5.6(2)
Retired	13.7	13.4	16.7(2)
Unemployed/ Beneficiary	1.8	3.3	11.1(5,6)
At home	11.3	13.4	9.7(2)
Others / Not specified	3.3	1.0	4.8(2)

(1) Department of Statistics (1990#1).
(2) National data used as no regional data was available.
(3) Department of Statistics (1991#1).
(4) As the regional boundaries have altered since the 1986 census, this data is based on an estimate derived from combining the data from the Manawatu Local Body region and Wanganui Local Body region (Department of Statistics, 1986#1), Taumarunui County and Borough (Department of Statistics, 1986#2), Horowhenua County, Levin and Otaki Boroughs (Department of Statistics, 1986#3) and the Eketahuna County (Department of Statistics, 1986#4).
(5) Department of Statistics (1991#4).
(6) Does not include beneficiaries, only unemployed.

4.3 THE POSSUM PROBLEM

4.3.1 Household Perceptions of the Possum Problem

As was expected following recent media attention on possums, most respondents were aware that possums were causing problems in New Zealand. 2.3 percent of respondents were unaware of the problem, all of these being urban residents. Another 2.0 percent of respondents were unsure if a problem existed or not. Possibly a greater proportion of those who failed to reply to the survey were unaware of the problem.

The most significant possum problems as perceived by respondents were damage to native forests and wildlife and the spread of the disease bovine tuberculosis (Tb) with 85.0 percent and 71.3 percent of respondents rating these as a bad or severe problem (Table 4.5). Damage to soil conservation plantings, damage to exotic forests and damage by eating pasture, crops, shrubs, flowers and vegetables were considered bad or severe by over 40 percent of respondents. Surprisingly the problem rated least highly was damage by eating pasture, crops, shrubs, flowers and vegetables, yet this category made up over 50 percent of all possum problems faced by respondents (Table 4.7).

Table 4.5 Respondents' Perceptions of the Possum Problem

Possum Problem	Rating of the Possum Problem				
	No Problem	Slight Problem	Moderate Problem	Bad Problem	Severe Problem
Spread of Tb	3.3	6.6	18.9	30.0	41.0
Damage to Native Forests and Wildlife	0.8	1.6	12.5	31.0	54.0
Damage to Exotic Forests	6.2	13.6	26.4	23.6	30.2
Damage by Eating Pasture, Crops, Shrubs,Flowers and Vegetables	7.7	23.9	25.5	21.5	21.5
Damage to Soil Conservation Plantings	3.0	13.3	27.9	28.3	27.5

There was a significant positive correlation between respondents' ratings of the possum problems at the 0.01 percent level (N= 625 to 661). This indicates that those who were aware of one type of possum damage were also aware of others.

4.3.2 Reported Possum Damage and Associated Costs

Although possums are a problem in both rural and urban areas, a greater proportion of rural respondents reported a possum problem on their property. Whilst 50.9 percent of rural inhabitants reported a possum problem on their property, only 5.9 percent of urban dwellers did so (Table 4.6). As possum densities are higher in rural areas than in urban areas, a greater amount of damage would be expected in rural areas.

Table 4.6 Percentage of Households with a Possum Problem, by Locality

Possum Problem	Locality		
	Rural	Township (1)	Urban
Yes	50.9	14.9	5.9
No	49.1	85.1	94.1
Total	100.0	100.0	100.0

N=670, X^2=171.8, p=0.000

(1) Township is defined as a settlement with less than 500 households

Possums caused damage on 20.9 percent of respondents' properties. Damage was diverse, ranging from the distracting of dogs to the damage of buildings. The most commonly reported problems were damage to gardens, fruit trees and other noncommercial exotic plants, with 34.3 percent of all damage reports relating to household gardens. 59.7 percent of respondents reporting a possum problem on their property recorded more than one form of damage or nuisance.

Table 4.7 Reported Damage Caused by Possums

Possum Problem/ Damage	Number of Complaints	Percentage of Total Complaints
Damage to Native Vegetation and Wildlife	34	11.8
Damage to Household Gardens	99	34.3
Possible Source of Tb Infection/ Extra Work from Tb Testing	47	16.3
Noise at Night time	10	3.5
Damage to Undefined Trees and Vegetation	21	7.3
Damage to Buildings/Fixtures	14	4.8
Eat Stockfood/Crops/Grass	26	9.0
Damage to Soil Conservation Plantings	12	4.2
Damage to Forestry	3	1.0
Tb in Respondent's Cattle/Deer	13	4.5
Reduced Capital Value of Farms in Tb Endemic Areas	1	0.3
Problem on Road	1	0.3
Damage to Shelter Belts	2	0.7
Spread Diseases to Humans	2	0.7
Distract Dogs	4	1.4
	289	100.1

Most respondents were unable to place a monetary estimate on the damage caused by possums on their property, however 71 respondents did so. Their valuations ranged from $2 to $10,000 with 20.2 percent reporting annual damage of more than $1000. 80.0 percent of those estimating that possums cost their household more than $1000 per annum were affected by the disease bovine tuberculosis and/or by possums destroying stockfeed on their property. Both of these forms of damage have the potential to adversely affect the income of farming households. Of those with more than $1000 worth of possum damage occurring on their property in 1990, 80 percent suffered from more than one form of possum damage.

Table 4.8 Monetary Estimate of the Damage Caused by Possums on Respondents' Properties

Amount of Damage ($)	Number of Households Reporting Dollar Value of Damage	Percentage of Damage Reports
1 - 20	10	14.1
21 - 50	12	16.9
51 - 100	7	9.9
101 - 200	5	7.0
201 - 500	13	18.3
501 - 1000	9	12.7
1001 - 4000	9	12.7
4001 - 10000	6	8.5
Total	71	100.1

4.3.3 Control Carried out on Respondents' Properties

25.4 percent of respondents carried out some form of possum control on their property in 1990, ranging from the setting of a single trap around their house to massive control operations on farms in tuberculosis endemic areas. 29.2 percent of respondents reported carrying out control on their property prior to 1990. The difference of 3.7 percent may in part be accounted for by the longer time period involved with control prior to 1990.

187 households reporting to have killed at least one possum on their property during 1990 (Table 4.9). Of these, 70 killed more than 50 possums. All of these households were located in a rural area. It is estimated that residents of the Manawatu-Wanganui region are responsible for the annual destruction of between 1 and 3 million possums.

Table 4.9 Number of Possums Killed in 1990 per Household

Number Killed	Number of Households	Percentage of Possums Killed
1 - 50	117	62.6
51 - 100	36	19.3
101 - 500	24	12.8
More than 500	10	5.3
Total	187	100.0

Of those spending money on possum control in 1990, 58.6 percent spent less than $50 per annum (Table 4.10). The dominant form of possum damage reported by respondents was damage to household gardens (Table 4.7). Although in aggregate this problem may result in damage of a significant dollar value, the damage on an individual basis would most likely not warrant costly forms of possum control.

Only 4.3 percent of respondents spent more than $500 on possum control in 1990. All respondents spending more than $50 on possum control were rural residents, whilst all spending more than $100 on possum control were farmers. Farmers are most likely to suffer from a loss in income if affected by tuberculosis or possums eating pasture. It is estimated that between $1 million and $3 million is spent on possum control by residents of the Manawatu-Wanganui region annually.

Table 4.10 Money Spent on Possum Control in 1990.

Amount Spent ($)	Number of Respondents	Percentage of Respondents
1 - 50	82	58.6
51 -200	35	25.0
201 - 500	17	12.1
501 - 1500	5	3.6
More than 1500	1	0.7
Total	140	100.0

Nearly 70 percent of possum control was carried out by members of the respondent's household with a further 8.3 percent carried out by friends, neighbours, relatives and farm workers. Government organisations such as the Ministry of Agriculture and Fisheries (MAF), Department of Conservation (DOC) and Regional Councils played a smaller role in possum control on private properties.

39 households reported that the skins from the possums killed on their property in 1990 were sold. This represents only 20.8 percent of the households reporting to have killed possums during this period. A further 10 households were unsure if the skins from possums killed on their property were sold.

4.3.4 Allocation of Funds Desired by the Respondents

By far the most popular method of funds distribution was on a national basis according to where control was most urgent, with 64.9 percent of respondents wanting the money allocated in this way (Table 4.11). Other methods of funds allocation suggested were predominantly various aggregates of the national, regional and district methods. Those respondents with a possum problem on their property were more likely to want possum control to be funded on a regional basis compared to those who did not suffer from a possum problem. This could indicate that they may feel more secure in obtaining possum control if it was funded on a regional basis.

Table 4.11 Respondents' Desired Form of Funds Allocation, by Possum Problem

Method of Funds Allocation	Possum Problem		Total
	Yes	No	
District/Region	42.6	29.0	31.7
National	51.1	69.4	64.8
Other	6.4	1.6	3.5
Total	100.1	100.0	100.0

N=651, X^2=21.8, p=0.000 with DF=2

4.3.5 Control Carried out by Organisations

The organisations which were most recognised as being involved in possum control were the Ministry of Agriculture and Fisheries (MAF) and the Department of Conservation (DOC) with 69.1 percent and 79.5 percent of the respondents being aware of their involvement (Table 4.12). Between 25.2 and 40.5 percent of respondents were aware of the role that Regional and District Councils, Universities, Forest Research Institute (FRI) and the Department of Scientific and Industrial Research (DSIR) played in possum control. Respondents cited another 16 organisations which they considered to be involved in active possum control and/or research into possum control. The most commonly cited were Federated Farmers (N=7) and Pest Destruction Boards (N=8), although the latter became defunct in October 1989. All pest control operations which were carried out exclusively by local Pest Destruction Boards are now the responsibility of Regional Councils with District Councils having minor involvement (Harrison, 1990).

Table 4.12 Awareness of Organisations Involved in Active or Researching Possum Control

Organisation	Percentage Aware
Ministry of Agriculture and Fisheries	69.1
Regional Council	38.2
District Council	25.2
Department of Conservation	79.5
Universities	31.8
Forest Research Institute	40.5
Department of Scientific and Industrial Research	35.7

4.4 FACTORS INFLUENCING RESPONDENTS' WILLINGNESS TO PAY VALUES

4.4.1 Correlation Analysis

In order to ascertain the factors that influence a household's willingness to pay for possum control, correlation coefficients were calculated for the open ended willingness to pay question. With reference to table 4.13 it can be seen that although r is always small, in some cases it is significant at the 5 percent level by virtue of the sample size.

Factors influencing both models at the 5 percent level of significance were income from cattle or deer farming, membership of an outdoor recreation group and membership of an animal rights organisation. Membership of an environmental organisation had a significant effect on the regional willingness to pay only. Factors which were expected to have a significant correlation at the 5 percent level but failed to, were household income and whether or not the respondent was a farmer, rural dweller or member of a farming organisation. There was found to be a slight negative but highly insignificant correlation between household income and willingness to pay ($r=-0.0029$ $p=0.9752$ for the regional model and $r=-0.0107$ $p=0.9069$ for the national model). Membership of a farming organisation and the occupation of farming were significantly correlated to the willingness to pay at the 10 percent and 20 percent levels of significance for the regional and national models respectively.

Table 4.13 Correlation Analysis on Factors Thought to Influence Willingness to Pay for Possum Control (Open Ended Question)

Factor Affecting Correlation Coefficient	Regional Level r	Regional Level p	National Level r	National Level p
Days to Return Survey	.0662	.3929	.0762	.3262
Spread of Bovine Tb (3)	.1454	.0528	.1372	.0695
Damage to Native Forests & Wildlife (3)	.0602	.4209	.0564	.4521
Damage to Exotic Forests (3)	-.0443	.5583	-.0438	.5646
Damage by Eating Pasture, Crops, Shrubs, Flowers & Vegetables	.0023	.9759	-.0093	.9020
Damage to Soil Conservation Plantings (3)	.1404	.0647	.1195	.3262
Possum Problem on Own Property (1)	.1175	.1083	.0796	.2816
Annual Dollar Damage on Own Property	.1454	.5406	-.0996	.6676
Control done on Own Property in 1990 (1)	.0661	.3677	.0533	.4711
Money Spent on Possum Control (4)	.1228	.3005	.1081	.3731
Number of Possums Killed on own Property Annually (4)	-.0574	.6420	.0561	.6570
Reside in Tb Endemic Area (1)	.1020	.1639	.0971	.1887
Household Size	.0433	.5575	.0608	.4125
Children (1)	.1223	.0945	.1412	.0553
Respondent's Age	-.1021	.1918	-.1048	.1803
Over 60 Years (1)	-.0860	.2405	-.0816	.2695
Respondent's Sex (2)	-.0509	.4877	-.0641	.3856
Farmer (1)	.1384	.0582	.1038	.1596
Income from Cattle or Deer (4)	.2953	.0257 *	.3436	.0095 *
Household Income (4)	-.0029	.9752	-.0107	.9069
Rural Dweller (1)	.0907	.2158	.0639	.3876
Member of Environmental Organisation (1)	.1601	.0282 *	.1331	.0708
Member of Outdoor Recreation Club (1)	.1728	.0177	.1631	.0260
Member of Farming Organisation (1)	.1327	.0694	.0999	.1759
Member of Animal Rights Group (1)	.2153	.0030 *	.2299	.0016 *

* indicates significance at the 5 percent level

(1) coded as yes =1 no =0

(2) coded as male =1 female =0

(3) coded as 1 to 5 with 1 indicating no problem and 5 indicating a severe problem

(4) coded by taking the midpoint of each category used in the survey

4.4.2 Cross Tabulation Analysis of the Open Ended Willingness to Pay Question

To further check the influence that demographic and other data had on the open ended willingness to pay question, data was categorised and cross tabulations were carried out. Membership of an animal rights organisation, environmental organisation and outdoor recreation club using the bush had no significant effect on the household's bid however membership of a farming organisation did. (N=491 X^2= 8.4 p=0.039). This agrees with other findings that farmers have a significantly higher mean willingness to pay than nonfarmers.

With reference to Table 4.14 it can be seen that households with a possum problem were willing to pay a significantly greater amount than those households unaffected by possums. 34.2 percent of respondents with a possum problem on their property were willing to pay more than $100 per annum compared to 10.6 percent of those without a possum problem. This could possibly be explained by the fact that those suffering from a possum problem on their property gain greater utility from possum control. 75.3 percent of those households who did not suffer from a possum problem on their property were willing to make a bid of at least $1 per annum. This indicates that these respondents gain some value from possum control other than use value i.e. reducing the possum problem on their property.

31.9 percent of rural residents had a bid of over $100 per annum as compared to 4.6 percent of urban and township residents. In part this may be accounted for by the proportion of respondents with a possum problem being far higher for rural residents.

Respondents considered damage to native bush and the spread of bovine tuberculosis to be the worst problems associated with possums. Those who considered these problems to be bad to severe had a significantly higher bid than those who considered the problems to be moderate or less.

Table 4.14 Factors Affecting Willingness to Pay for Possum Control.

Factor Affecting Willingness to Pay	Annual Household Willingness to Pay ($)			
	0	1 to 50	51 to 100	more than 100
Possum Problem (1)				
Yes	4.9	29.3	31.7	34.2
No	24.7	50.7	14.1	10.6
Locality (2)				
Urban/Township	24.1	58.3	13.0	4.6
Rural	15.3	26.4	26.4	31.9
Perceptions of Tb. problem (3)				
Moderate or Less	27.5	52.9	11.8	7.8
Bad to Severe	16.7	42.9	20.6	19.8
Perceptions of Damage to Native Forests and Wildlife (4)				
Moderate or Less	34.5	41.4	3.5	20.7
Bad to Severe	16.6	47.0	21.2	15.2

(1) N=183, X^2=26.0, p=0.000 with DF=3

(2) N=180, X^2=36.3, p=0.000 with DF=3

(3) N=177, X^2=7.7, p=0.052 with DF=3

(4) N=180, X^2=8.8, p=0.032 with DF=3

A number of demographic variables were examined to ascertain their effect on willingness to pay (Table 4.15). For the data on age, sex and occupation, the respondent was taken to be the person who filled in the survey, however the data on income reflected the entire household.

As expected from economic theory an increase in income resulted in a corresponding increase in bid price. Whilst 38.0 percent of those earning less than $20,000 placed a zero valuation on possum control, only 7.8 percent of those earning greater than $40,000 had a valid zero bid. This may be because a person on a higher income has more discretionary income.

Only 17.9 percent of respondents aged 60 years and over were prepared to pay more than $50 per annum, compared to over 40 percent for the rest of the population. This could be a factor of income. 17.9 percent of respondents aged 60 years and over came from a household with an annual income of more than $30,000 compared to 57.4 percent in the 30 to 59 years age bracket and 40.0 percent in the 15 to 30 years age bracket. There was no significant difference between the willingness to pay of males and females.

Occupation had a significant effect upon the household willingness to pay. Of those respondents involved in agriculture, forestry and related industries, 69.1 percent had an annual household bid of greater than $50. Farmers are in the situation that possums may adversely affect their income if they spread tuberculosis and eat pasture. 40 percent or less of respondents from the other occupation categories placed bids of $50 per annum or greater.

Table 4.15 Effect of Demographic Data on Willingness to Pay for Possum Control.

Demographic Characteristic	Willingness to Pay ($) 0	1 to 50	Greater than 50
Household Income (1)			
20 000 and less	38.0	30.0	32.0
20 001 to 40 000	10.7	55.4	33.9
More than 40 000	4.1	34.3	39.7
Age (2)			
Less than 30	22.7	36.4	40.9
31 to 59	14.6	44.7	40.8
60 and over	35.7	46.4	17.9
Sex (3)			
Male	16.1	43.8	40.2
Female	26.7	46.7	26.7
Occupation (4)			
Sales & Service	18.2	59.1	22.7
Professional & Managerial	12.5	56.3	31.3
~~Clerical~~ farming	14.3	16.7	69.1
Studying	20.0	50.0	30.0
Retired	43.5	52.2	4.4
At Home	10.0	50.0	40.0
Labourer	20.8	58.3	20.8

(1) N = 158, X^2=24.4, p=0.000 with DF=4

(2) N = 153, X^2=8.8, p=0.067 with DF=4

(3) N = 157, X^2=3.6, p=0.169 with DF=2

(4) N = 180, X^2=36.3, p=0.000 with DF=3

4.5 WILLINGNESS TO PAY FOR POSSUM CONTROL ON A REGIONAL LEVEL: THE OPEN ENDED QUESTION

This section analyses the responses to the willingness to pay question. Specifically the question asks respondents to contribute into a fund annually for the control of possums. Two funds were set up, one for payment on a regional basis, the other for payment on a national basis. A fund was chosen as the vehicle to collect bids as it was considered to be realistic to the respondent, yet be less emotive than collection vehicles such as taxes and rates.

The reasons given for refusing to pay into the fund are presented below in Table 4.16. In some cases the respondent indicated more than one reason for not paying into the fund. When this occurred the first reason given was taken to be the predominant reason.

For the regional scenario 66 protests to the open ended willingness to pay question were received. The most commonly given protests were that it would be more suitable to pay on a national basis (N=17) and possum control should be paid for by the Government and/or Regional Bodies (N=13). 48 nonprotest comments were made following this question, the most common being that the respondent could not afford to pay (N=22) and that possums were not a problem on the respondent's property (N=15).

55 protest bids were returned for the national scenario open ended willingness to pay question. Again the most commonly given reasons were that it would be more suitable to pay on a regional basis (N=8) and possum control should be paid for by the Government and/or Regional Bodies (N=10). 31 nonprotest comments were made following this question, the most common being that the respondent could not afford to pay (N=18) and that possums were not a problem on the respondent's property (N=8).

Table 4.16 Reasons Given for Failing to Pay into the Fund for Possum Control

Reason Given For Refusing to Pay	Number of Respondents	
	Regional Scenario	National Scenario
PROTEST REASONS		
More Suitable to Pay on a National Basis	17	0
More Suitable to Pay on a Regional Basis	0	8
Too many Inefficiencies in System/Too much Bureaucracy	2	4
Get Nothing for What They are Paying Now	6	3
Should be User Pays	3	3
Should be Paid for by Government/Regional Bodies	13	10
Need more Information	6	6
Already Paying Too Much	9	7
Disagree with System	4	4
Prefer a Levy on Rates/Taxes	2	2
Other	4	8
TOTAL	66	55
NONPROTEST REASONS		
Can't Afford to Pay	22	18
Possums not a Problem here	15	8
Control Themselves	5	1
More Important Problems	1	1
Others	4	3
TOTAL	47	31

Respondents returned 188 valid bids for the open ended willingness to pay question on a regional basis. A further 66 bids were considered invalid due to some form of protest. All bids over $1000 per annum were checked and found to be valid with 64.7 percent coming from households who derived part of their income from dairy, beef or deer farming. The other respondents were considered to have offered valid bids on the basis of their perceptions of the possum problem and their income i.e. they could afford to pay their bid. The top bid ($5000) came from a household involved in possum control (personal communication with the relevant household).

Valid bids ranged from $0 to $5000 with 21.8 percent of respondents placing no value on possum control (Appendix 3). 13.8 percent of respondents had bids of $200/household/year or greater. As commonly found with open ended willingness to pay questions, respondents valuations tended to be clustered around 'popular' bid values such as $10, $20, $50, $100 and $200. This suggests that when respondents are faced with an unfamiliar or difficult evaluation situation, they revert to familiar lump sum amounts (Kirkland, 1988).

The mean bid was $107.22 per year with a standard deviation of $393.45, the large standard deviation indicating a wide distribution of bids. The distribution of bids was skewed heavily to the right being influenced by a number of high bid values. The median bid was $23.00.

For the national scenario valid bids ranged from $0 to $5000 with 17.3 percent of respondents placing no value on possum control. 10.8 percent of respondents offered a bid of $200 or greater. The mean bid was $96.42 with a standard deviation of $394.12. Again this reflects the large spread of the bids. The median bid was $20.00. The difference between the mean and the median indicates that the distribution is skewed to the right.

The mean bid is very sensitive to outliers. This problem can not be solved by enlarging the sample size as outliers are generally a constant percentage of the sample regardless of its size. A few outliers if genuinely invalid can significantly distort an estimate. A defensible approach to compensate for the effect of outliers is through the use of robust statistical estimators (Mitchell and Carson, 1989). In this thesis the α-trimmed mean approach, with an alpha level of 0.10 was used (see Section 3.8.5). This gave a 10 percent trimmed mean value of $48.40 for the regional scenario and $38.85 for the national scenario.

Table 4.17 α-trimmed Means for the Regional Willingness to Pay Question

α (1)	Xα	N	var	sd	t
0.00	107.22	188	154801	393.45	
0.05	57.39	170	13287	115.27	-5.93
0.10	48.40	151	7472	86.44	-9.33
0.15	41.34	133	6183	78.63	-11.49
0.20	39.38	114	4948	70.35	-13.14
0.25	37.41	95	6337	79.61	-12.02
0.50	23.00	1			

(1) α=0.00 refers to the mean value, whilst α=0.50 refers to the median value

Table 4.18 α-trimmed Means for the National Willingness to Pay Question

α (1)	Xα	N	var	sd	t
0.00	96.42	185	155330	394.12	
0.05	46.93	167	8044	89.69	-7.50
0.10	38.85	148	6475	80.47	-9.73
0.15	34.87	130	3263	57.13	-14.65
0.20	32.06	111	4090	63.96	-13.69
0.25	28.11	93	6232	78.94	-11.77
0.50	20.00	1			

(1) α=0.00 refers to the mean value, whilst α=0.50 refers to the median value

4.6 THE DICHOTOMOUS CHOICE METHOD

With the dichotomous choice method, respondents were asked if they were willing to pay a given price. These prices were varied between surveys, with the prices chosen to cover the expected range of bids. The logit model was then used to transform the responses (yes or no) to the bid prices into a function. From this it was possible to calculate the mean willingness to pay by integrating under the function.

The logit model may contain a number of variables which are found to influence the probability of a respondent accepting a bid price. The parameter estimates for these should be theoretically consistent. For example, economic theory states that bid price coefficients should be negative and income coefficients should be positive. The model should also have a goodness of fit. This should explain as much of the variation in the dependent variable as possible through the explanatory variables, that is, the goodness of fit statistic should be as high as possible. Rejection of variables should be based on a combination of the sign of the coefficients, the Chi-square of the coefficients, the overall goodness of fit of the model and its ability to correctly predict outcomes.

The Chi-square is of questionable value in logit as logit is based upon maximum likelihood as compared to ordinary least square regression. Statistics calculated in logit are pseudostatistics. Thus the McFadden's R^2 which gives a better estimate of the goodness of fit of a model has been used. This is calculated as

$$R^2 = 1 - \frac{(\log \beta_{m_1})}{(\log L_0)} \qquad (4.1)$$

where $\log \beta_{ml}$ is the sum of the parameter estimates (β's) for the entire model

$\log L_o$ is the parameter estimate (β) for the intercept

The McFadden's R^2 is interpreted in a similar fashion to the coefficient of determination r^2, thus it describes the proportion of variation in the dependent variable that can be described by the explanatory variables.

In this thesis, two logit models are derived, one calculating the willingness to pay on a regional level, the other calculating the willingness to pay on a national level. A variety of variables were tested to check the effect they had on the models. Those considered included the respondents' perceptions of the spread of bovine tuberculosis and damage to native forests and wildlife, how respondents wished the funds to be allocated and whether or not they had a possum problem on their property. Demographic details such as the household size, whether or not it contained children, household income, percentage of income derived from cattle or deer farming, respondent's age, sex and occupation, whether the household was situated in an urban, township or rural area and household membership of an environmental organisation, tramping/hunting or other outdoor recreation club, farming organisation or animal rights organisation were also considered. Several of these variables were categorised in a number of forms to estimate their effect upon the logit equation.

4.6.1 Protests to the Survey Method

The reasons given for refusing to pay into the fund are presented in Table 4.19. For the regional scenario 108 protest bids were received. The most commonly given protests were that it would be more suitable to pay on a national basis (N=26) and that possum control should be paid for by the Government and/or Regional Bodies (N=20). 166 nonprotest comments were made following this question, the most common being that the respondent could not afford to pay (N=72), that possum were not a problem on the respondent's property (N=33) and that the bid price offered was too high (N=35).

90 protest bids were returned for the national scenario. The most commonly given reasons were that there was too much inefficiency and bureaucracy in the system (N=16) and that possum control should be paid for by the Government and/or Regional Bodies (N=14). 141 nonprotest comments were made following this question, the most common being that the respondent could not afford to pay (N=61), the bid price offered was too high (N=35) and that possums were not a problem on the respondent's property (N=18).

Table 4.19 Reasons for Failing to Pay for Possum Control: the Dichotomous Choice Models

Reason Given for Refusing to Pay	Number of Respondents	
	Regional Scenario	National Scenario
PROTEST REASONS		
More Suitable to Pay on a National Basis	26	10
Too many Inefficiencies in System/Too Much Bureaucracy	10	16
Get Nothing for what they are Paying Now	9	6
Should be User Pays	4	6
Should be Paid for by Government/Regional Bodies	20	14
Need more Information	8	7
Already Paying too Much	11	9
Disagree with System	3	6
Prefer a Levy on Rates/Taxes	11	10
Other	6	6
TOTAL	108	90
NONPROTEST REASONS		
Can't Afford to Pay	72	61
Possums not a Problem here	33	18
Too Much	35	35
Use Umemployed	6	4
Control Themselves	8	7
Others	12	16
TOTAL	166	141

4.6.2 Calculation of Dichotomous Choice Models

A number of models were derived for the national and regional scenario, some of which are shown below in Tables 4.20 and 4.21.

Table 4.20 Dichotomous Choice Models for Willingness to Pay for Possum Control on a Regional Basis

INT	P	F	X	IM	IH	A	McF	Percent Correct
0.1451	-0.0102	2.2772	0.8231	1.1664	1.1673		.329	73.0
1.2242	-0.0092						.173	70.5
0.9237	-0.0104	1.9716	0.8837				.300	75.4
0.6185	-0.0092			1.1162	1.0759		.211	70.2
1.0400	-0.0106	2.2700					.285	77.9
0.606	-0.0093					0.9491	.205	71.5

Table 4.21 Dichotomous Choice Models for Willingness to Pay for Possum Control on a National Basis

INT	P	F	X	IM	IH	A	McF	Percent Correct
0.4555	-0.00883	1.4287	1.1597	0.8590	1.0510		:278	77.4
1.3228	-0.00788						.154	69.2
1.2042	-0.00894	1.8052					.234	73.8
1.1208	-0.00907	1.3024	1.1564				.255	76.0
0.7090	-0.00780			1.0058	1.556		.185	72.6

where INT = intercept
P = bid price offered
A = age, coded as 1 if respondent is over 60 years, else coded as 0
F = farmer, coded as 1 if respondent is a farmer, else coded as 0
X = possum problem, coded as 1 if respondent has possum problem on their property, else coded as 0
IM = income, coded as 1 if household income from $20,001 to $40,000 per annum, else coded as 0
IH = income, coded as 1 if the household income was over $40,000 per annum, else coded as 0
McF = McFadden's R^2

Based on the overall fit of the model given by the McFadden's R^2, the best model for the regional scenario was found to be:

$$L = 0.1451 - 0.0102P + 2.2272F + 0.8231X + 1.1664IM + 1.1673IH \quad (4.2)$$

Another method of estimating the overall fit of a model is by checking how well the modelled data fits the observed data. For this a 2x2 frequency table of observed and predicted responses was calculated. With the observed data, an event was considered to occur when the respondent was willing to pay the bid price, whilst with the predicted data, an event occurred when the predicted probability of the respondent being willing to pay the bid price was ≥ 0.50.

Table 4.22 Ability of the Regional Willingness to Pay Model to Correctly Predict Events

		PREDICTED		
		EVENT	NO EVENT	TOTAL
OBSERVED	EVENT	100	37	137
	NO EVENT	40	81	121
	TOTAL	140	118	258

The regional model correctly predicted 70.2 percent of the observed outcomes. It correctly predicted 73.0 percent of events as event and correctly predicted 66.9 percent of no events as no event.

The best model for the national scenario was found to be

$$L = 0.4555 - 0.00883P + 1.4287F + 1.1597X + 0.8590IM + 1.0510IH \quad (4.3)$$

A 2x2 frequency table of observed and predicted responses was also calculated for the national model (Table 4.23). It correctly predicted 77.4 percent of the observed outcomes. It correctly predicted 86.1 percent of events as events and correctly predicted 65.2 percent of no events as no event.

Table 4.23 Ability of the National Willingness to Pay Model to Correctly Predict Events

		PREDICTED		
		EVENT	NO EVENT	TOTAL
OBSERVED	EVENT	136	22	158
	NO EVENT	39	73	112
	TOTAL	175	95	270

A mean willingness to pay was calculated by integrating under the logit curve from zero dollars to infinity. This was calculated as $184.06 per household per annum for the regional model and $222.24 per household per annum for the national model. The Simpson method of integration was used to integrate under the logit curve. Truncating the mean at the 90th percentile (this corresponds to where the probability of the respondent saying yes to the bid price is 10 percent), resulted in annual household payments of $173.73 and $210.31 for the regional and national models respectively. The median willingness to pay, representing the point where 50 percent of households would be willing to pay into the fund was $116.11 for the regional model and $143.74 for the national model (Table 4.24).

Table 4.24 Annual Willingness to Pay for Possum Control per Household

Payment Basis	Dichotomous Choice Mean	Dichotomous Choice Truncated Mean	Dichotomous Choice Median
Regional Scenario	184.06	173.73	116.11
National Scenario	222.24	210.31	143.74

4.7 AGGREGATION OF WILLINGNESS TO PAY

To aggregate the willingness to pay for possum control the number of households in the Manawatu-Wanganui region was multiplied by the individual willingness to pay amounts. From the 1991 census, there were 78,076 occupied dwellings in the Manawatu-Wanganui region (Department of Statistics, 1991#1). This was taken to represent the number of households in the region.

In aggregating the results, assumptions were made with respect to the number of households who declined to take part in the study. Two scenarios have been considered with respect to this:

1. The views expressed by the respondents were representative of the entire population of the region.

2. The views expressed by the respondents were not representative of the entire population of the region. Those who did not respond to the survey placed no value on possum control and were therefore not willing to fund it.

In reality it is likely that nonrespondents' values on possum control falls somewhere between these two boundaries, i.e. nonrespondents are likely to place some value on possum control, but at a lower level than respondents. Because it would be difficult to assess the value that nonrespondents place on possum control, we can consider scenario 1 as the upper bound and scenario 2 as the lower bound of the range of values that the region places upon possum control.

Farmers were over represented in both the regional and national dichotomous choice models with 25.0 percent and 23.5 percent of respondents respectively being farmers. 7.3 percent of the region's population specify their occupation as farming (Department of Statistics, 1991#1). There was a significant difference between the mean willingness to pay of farmers and nonfarmers as calculated from zero dollars to infinity (Table 4.25). For the regional model, farmers were found to have a mean bid of $308.06 compared to the nonfarmers' value of $147.84. For the national model the mean bids were $329.89 and $192.42 for farmers and nonfarmers respectively.

Table 4.25 Mean Annual Household Bids for Possum Control by Farmers and Nonfarmers.

Occupation	Mean Annual Household Bid	
	Regional Model	National Model
Farmer	344.68	333.47
Nonfarmer	144.09	189.16

As farmers were over represented in the model and their mean bid was significantly higher than nonfarmers, this resulted in an overestimation of the willingness to pay for possum control. By adjusting the model to include only 7.3 percent of farmers a reduction in the mean, truncated mean and median of approximately $27.20 for the regional model and $23.40 for the national model occurred (Table 4.26).

Table 4.26 The Effect of Weighting the Number of Farmers in the Logit Model

Payment Basis	Dichotomous Choice Mean	Dichotomous Choice Truncated Mean	Dichotomous Choice Median
ADJUSTED FOR FARMERS			
Regional	156.87	146.54	88.91
National	198.84	186.90	120.34
NOT ADJUSTED FOR FARMERS			
Regional	184.06	173.73	116.11
National	222.24	210.31	143.74

Table 4.27 Aggregation of the Willingness to Pay for Possum Control for the Regional and National Scenarios.

	Household Value		Aggregated Value ($ million per Annum)	
	Regional Scenario	National Scenario	Regional Scenario	National Scenario
DICHOTOMOUS CHOICE - SCENARIO 1				
Mean	184.06	222.24	14.37	17.35
Truncated Mean	173.73	210.31	13.56	16.42
Median	116.11	143.74	9.07	11.22
DICHOTOMOUS CHOICE - SCENARIO 2				
Mean	70.31	80.90	5.49	6.32
Truncated Mean	66.36	76.55	5.18	5.98
Median	44.35	52.32	3.46	4.09
DICHOTOMOUS CHOICE - ADJUSTED FOR FARMERS - SCENARIO 1				
Mean	156.87	198.84	12.25	15.52
Truncated Mean	146.54	186.90	11.44	14.59
Median	88.91	120.34	6.94	9.40
DICHOTOMOUS CHOICE - ADJUSTED FOR FARMERS - SCENARIO 2				
Mean	59.92	75.96	4.68	5.93
Truncated Mean	55.98	71.40	4.37	5.57
Median	33.96	45.97	2.65	3.59
OPEN ENDED QUESTION - SCENARIO 1				
Mean	107.22	96.42	8.37	7.53
Truncated Mean	48.40	38.85	3.78	3.03
Median	23.00	20.00	1.80	1.56
OPEN ENDED QUESTION - SCENARIO 2				
Mean	47.39	40.88	3.70	3.19
Truncated Mean	21.39	16.47	1.67	1.29
Median	10.17	8.48	0.79	0.66

Depending upon the assumptions made, the aggregate willingness to pay ranged from $0.79 million to $14.37 million for the regional payment scenario and $0.66 million to $17.35 for the national payment scenario. The large range of these bid values reflects the imprecise nature of the contingent valuation method. Differing assumptions can markedly affect the final outcome. The values derived appear to be consistent with the possible actions of respondents. For example, farmers and rural dwellers who are more likely to be adversely affected by possums placed a higher value on possum control than nonfarmers and urban dwellers. Values for payment on a national and regional basis were similar, however for the open ended questions the bid value was higher for the regional scenario, yet for the dichotomous choice questions the bid value was higher for the national scenario.

Scenario 2 gave the lower bound, whereby all who refused to reply to the survey were considered to have a zero valuation of possum control, whereas scenario 1 produced the upper bound by assuming those who replied to the survey were representative of nonrespondents. Realistically, one would expect the nonrespondent population to fall somewhere between these two bounds.

The dichotomous choice survey produced willingness to pay values of approximately twice the magnitude of the open ended question. This could be in part because some respondents may have wanted to demonstrate that they placed a positive value on possum control. Thus if faced with a bid value higher than they would have offered in an open ended question, they may have replied yes to indicate that they placed some positive value on possum control.

By deleting scenario combinations which could overestimate the aggregate values, (combinations that consider nonrespondents to have similar valuations to respondents, over represent farmers and use the mean value), and combinations which may underestimate the aggregate value (the use of the median value in combination with the assumption that nonrespondents placed a zero value on possum control) it was found that 80 percent of the region's values for possum control lay between $1.5 million and $7 million. This could be taken as a better indicator of the regions value of possum control.

Both the open ended and dichotomous choice approaches resulted in skewed distributions of prices. This suggests that a small number of respondents placed a very high value on possum control. The problem is how to reflect these when

aggregating the values. If we ignore this problem we will use the mean value, however this may not reflect the valuation that the majority of the population places on possum control. The median has the advantage that it represents the largest amount that 50 percent of the population would pay. The trimmed mean has the advantage that it can adjust for outliers yet still reflect the proportion of the population that places a high value on possum control. In this thesis a 10 percent trimmed mean has been used, however if we increase the percentage of bids trimmed, the trimmed mean value will decrease until it becomes the median value.

4.8 BIASES ARISING IN THE SURVEY METHOD

Although overall a degree of bias occurred, the results obtained in the surveys are still considered valid. The contingent valuation method gives the best opportunity to assess the value that the region places on possum control.

4.8.1 Hypothetical Bias

The only way to test for hypothetical bias is to set up a fund for possum control and elicit real payments. These should be checked to ascertain if respondents are willing to pay into the fund the same amount as they bid. As this was not feasible, it was not possible to test for hypothetical bias. For a well publicised and understood topic such as possum control, hypothetical bias is considered to be minimal.

4.8.2 Strategic Bias

Empirical studies (Schulze et al, 1981; Hufschmidt et al, 1983) have shown that this is not generally a major problem.

4.8.3 Vehicle Bias

To reduce the incidence of vehicle bias in the survey a fund was used as the collection method rather than such methods as rates or taxes which have been found to induce vehicle bias. Although it was not possible to measure the degree of vehicle bias with the fund collection method, a number of respondents questioned the validity of the collection method, whether or not it was causing more bureaucracy. This indicates that some degree of vehicle bias occurred in the survey. The use of a fund may have increased the hypothetical nature of the survey.

4.8.4 Unit Nonresponse Bias

50 percent of the households that received a survey form failed to respond to the survey. If these nonrespondents had different characteristics to the respondents this would induce a bias in the survey. Monetary and time constraints dictated that it was not possible to contact any of the nonrespondents.

4.8.5 Item Nonresponse Bias

Analysing those questions that all respondents were expected to answer it was found that all questions suffered from some degree of nonresponse. On average 7.0 percent of respondents failed to answer each of the questions in the desired manner. This ranged from 2.1 percent to 20.8 percent depending on the question. Item nonresponse was highest with the personal data questions such as age, sex, occupation and household income. In a number of cases where respondents refused to answer these questions, they commented that they failed to see any relationship between the question asked and the possum problem. Item nonresponse was lowest for simple yes/no questions such as 'do you believe that possums are causing problems in New Zealand?' and 'are possums a problem on your property?'

Most nonresponse occurred when no answer was given to the question, however some also occurred when the respondents made comments such as 'data not available', 'unsure' or a qualifying statement such that their response could not be categorised with the bulk of the data.

Item nonresponse was far higher for the open ended willingness to pay question than its dichotomous choice counterpart. 16.4 percent and 20.8 percent of respondents refused to 'play the game' for the regional and national open ended willingness to pay questions whilst only 3.6 percent and 5.4 percent did so with the dichotomous choice willingness to pay question. This difference could be caused by a number of factors the most important being that the dichotomous choice format provides the recipient of the questionnaire with a market like situation which is much easier to answer. A second reason for this difference is that based on reasons given for refusing to pay into the fund, a number of respondents failed to write an answer when they had a zero bid. In future this problem could be overcome by adding a statement such as 'please write zero if your bid is zero', although this could possibly induce bias in implying to the respondent that a zero bid is acceptable.

It should be noted that the nonresponse was higher for the national scenario than the regional scenario. This is thought to be caused by some respondents incorrectly thinking that the same question was being repeated and others thinking that their comments for the regional question would automatically follow through to the national question.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

The main focus of this dissertation was on the possum problem in the Manawatu-Wanganui region. The study addressed a number of questions, namely the value that people in the region placed on possum control, whether or not groups with differing characteristics placed differing values on possum control and what control was currently being undertaken. Its main objectives, however, were to ascertain the current level of possum control occurring in the Manawatu-Wanganui region and to compare this to the level of possum control desired by residents of the region. From this it was possible to decide if the current allocation of funds is efficient and effective in relation to the benefits derived from them. A review of the available literature on possums and possum control showed that possums, from being an introduced protected animal, became an undesirable pest. Their impact in terms of spreading bovine tuberculosis and destruction of indigenous forests and other vegetation is large and places a great cost on society. There is no evidence that possums have attained an ecological balance with vegetation in indigenous forest types, but result in a gradual change in forest composition. Failure to control possums is likely to be disastrous. Possum control in the region is currently being undertaken by a number of organisations, the main ones being the Department of Conservation, the Manawatu-Wanganui Regional Council and the Animal Health Board.

Decision makers need information on the benefits and costs of possum control, hence methods were discussed that could be used to discover peoples' strength of preference to differing levels and types of possum control. Because of its ability to measure nonuse as well as use values, it was decided to base the empirical part of the study upon a contingent valuation survey of the Manawatu-Wanganui region.

Contingent valuation surveys were sent to a random sample of residents in the region. 712 (49.5 percent) of those receiving the survey returned a usable form. The survey collected information on perceptions of the problem, the regional valuation of possum control and demographic details about the respondent and

their household. The results of the contingent valuation survey showed a high degree of awareness about the possum problem among the respondents and a significant willingness to pay for possum control.

5.2 CONCLUSIONS

Results from the contingent valuation survey show that 97.8 percent of respondents were aware that a possum problem exists in the region. The most severe problems they associated with possums were damage to native forests and wildlife and the spread of the disease bovine tuberculosis. Although possum problems occurred in rural, urban and township areas, over 50 percent of rural respondents suffered from a possum problem compared to less than 15 percent of other respondents. Approximately 80 percent of respondents placed some value on possum control. Farmers and rural residents placed a higher value on possum control than urban and township dwellers.

The region placed an annual value of between $0.66 million and $17.35 million on possum control. The large range indicates the sensitivity of the valuation methods to the assumptions made by the researcher. Assumptions made by the researcher were grouped into scenarios. Deleting those scenarios considered to be unrealistic narrowed the valuation range substantially. Those scenarios deleted consisted of the following assumptions:

> Scenario combinations which were considered to underestimate the value of possum control were those in which respondents were assumed to place a zero value on possum control and the median value was used.
>
> Scenario combinations which were considered to overestimate the value of possum control were those which contained at least two of the following characteristics - nonrespondents were assumed to have similar valuations to respondents, farmers were over represented in the sample and the mean was used to calculate the final result.

Elimination of the scenarios considered to be unrealistic narrowed the value range such that 80 percent of the bids were between $1.5 million and $7 million. This represents a better indicator of the regional valuation of possum control.

Currently $1.4 million is being spent by the Manawatu-Wanganui Regional Council, Department of Conservation and the Ministry of Agriculture and Fisheries on possum control operations annually. On top of this another $1.0 million is spent by the Regional Council on corporate overheads and related

expenses for possum control. The region also benefits from the research carried out by institutes such as the Department of Scientific and Industrial Research and Universities. As the benefits from research are distributed throughout the country, it is difficult to know how much of this cost to apportion to the region. Control is also carried out by residents of the region particularly those in rural areas. It is estimated that between $1 million and $3 million is spent by residents annually on possum control, a majority of it being spent by farmers. This accounts for the destruction of an estimated 1 to 3 million possums per year. Thus, one would expect the annual expenditure on possums in the region to be in the vicinity of $3.4 million to $5.4 million.

The current regional expenditure falls within the value range for possum control obtained by the contingent valuation surveys. This indicates that the current level of expenditure may be sufficient given the perceived benefits gained from possum control.

Results of the surveys showed that farmers placed a value on possum control that was approximately two times greater than that of nonfarmers, indicating that they derive a greater benefit from possum control. This could be due in part to the fact that bovine tuberculosis threatens the livelihood of cattle and deer farmers. Rural nonfarming households placed a value on possum control that was approximately 25 percent higher than urban and township residents. This is possibly a reflection of the greater incidence of possums in rural regions. Unlike farming households, the income stream of these households is not likely to be adversely affected by possums. Although a majority of respondents did not suffer from a possum problem on their property many still valued possum control. This demonstrates that residents of the region derive benefits from possum control beyond use value. These may include option, existence and quasi-option values.

Currently a mixture of both private and Government possum control exists. Within the Manawatu-Wanganui region, the Regional Council coordinates all control operations, with the Ministry of Agriculture and Fisheries and the Department of Conservation primarily being involved in the funding of these operations. Problems with control on a regional basis arise as possum control is a nonexcludable resource. It is impossible for one region to control possums without benefitting other regions. For example the creation of buffer zones in the eastern Manawatu-Wanganui region may help to reduce the spread of tuberculosis

into the Hawkes Bay region. If all regions carried out equivalent levels of control, this would not be a problem, however in reality this does not occur. Because of these externalities arising from possum control, there is a role for central government to play in the control of possums. This could be either through the coordination of control or the provision of control. This however raises a new issue on how the central body should obtain its funding. Objectives of government intervention should be to:

Provide least cost control by minimising externalities

Provide an equitable funding basis

This could be done through either the current taxation or rating system. Although some problems exist with these systems, such as the cost of transactions, it is preferable to the low level of possum control which is likely to be supplied in a free market system.

The results of the contingent valuation survey showed a high degree of awareness about the possum problem among the respondents and a significant willingness to pay for possum control. This must be encouraging to decision makers as it serves as a justification for the work done on possum control from the view of those who ultimately fund it (in this case residents of the Manawatu-Wanganui region). The magnitude of the willingness to pay may also be helpful in the prioritising of funds.

5.3 POLICY IMPLICATIONS

From the conclusion drawn in section 4.2 a number of policy implications can be drawn. These are:

There is a regional benefit from possum control, thus it is appropriate for the region to fund this activity.

Over 80 percent of residents of the Manawatu-Wanganui region place some value on possum control thus under the current system both rural and urban residents should be rated for possum control.

Benefits within the region vary significantly between farmers and nonfarmers. Funds for the regional cost of possum control should be levied on two groups: farmers and nonfarmers. Farmers' assessment could be on a per hectare basis.

Some benefits of possum control are national, thus the region should work to ensure that the central government continues to pay a share of control costs.

The region needs to push central government for a more coordinated control system, so that the region's externalities (benefits for others) can be minimised.

The current level of expenditure on research into possum control, particularly that pertaining to the prevention of breeding and the spread of tuberculosis should be increased.

5.4 LIMITATIONS

A number of limitations exist with this research. These are predominantly related to weaknesses in the research methods used. It should be noted that although the methods still have weaknesses, they are well understood and the direction of biases in the answers can be determined. The weaknesses do not invalidate the methodology which is still one of the few that can provide results of this nature. The researcher however, should be aware of these weaknesses when interpreting the results of the research.

One of the major limitations of this study is that it is applicable only to the Manawatu-Wanganui region. It is not possible to extrapolate the results to fit the nation. By doing this we have set a boundary on the region in which possum control will occur, yet the possum is a mobile animal which is not affected by these boundaries. In part this was addressed by asking if households were willing to pay a differing amount if control was to be on a national basis.

The methods used gave a large range of values for possum control depending on the assumptions made by the researcher. This indicates the limitations of the data derived in the survey. This problem could be overcome in part by the collection of data on nonrespondents. The results obtained by the researcher should be used only as a guideline in the framework of other research.

A large number of protest bids were obtained in response to the willingness to pay questions, particularly with the open ended question. Careful survey design should be used to attempt to reduce this problem.

An overall usable response rate of 49.5 percent was obtained. Although we addressed the problem of nonrepresentativeness in part by giving a range of aggregate willingness to pay values, it would been better to have attempted to measure the degree to which the demographic characteristics, perceptions of the problem and willingness to pay of nonrespondents differed from respondents. Monetary and time constraints dictated that this was not possible, thus the results given are dependent upon the assumptions made by the researcher.

The willingness to pay value calculated comprised of both use and nonuse (option, existence and quasi-option) values. From this survey it was not possible to address the degree to which each of these values were represented.

5.5 FURTHER RESEARCH

Further research on this topic is required to address some of the limitations discussed in Section 5.4. This falls into two categories - research to address problems with the elicitation methods used and research to address problems associated with possum control.

5.5.1 Further Research into the Elicitation Methods Used

Further work is required with the contingent valuation method on how to reflect the divergent views of respondents. In this study, results given for the mean, median and 10 percent trim mean values varied by up to 480 percent. Arguments exist over whether the mean value, with its upper limit of infinity, is consistent with basic economic theory (Duffield and Patterson, 1991) and whether or not the median value can be aggregated to provide a measure of Pareto optimal outcomes (Johansson et al, 1989). The median measure also fails to reflect the views of respondents with high bids. If we elect to use a truncated mean as a measure of benefits then the question arises over whether to truncate at a fixed percentage (Boyle and Bishop, 1988; Duffield and Patterson, 1991) or at the highest bid value offered (Bishop and Heberlein, 1979).

The results obtained from the dichotomous choice survey showed a valuation of possum control approximately twice that of the open ended survey. Further work is required to address this issue, with particular reference to recent work by Hanemann et al (1991), showing that by using two dichotomous choice questions the willingness to pay bid is significantly lower.

5.5.2 Further Research into Possum Control and its Effects

From this study it is not possible to differentiate between the different use and nonuse values that respondents place on possum control. Knowing this would help in the allocation of monies to different areas of control.

The results of this study show that the current level of money spent on possum control in the region is similar to the value that the region places upon possum control.

Further work is required to address the potential effects that tuberculosis may have on the access of New Zealand's overseas exports and how this should be addressed when interpreting the results of this study.

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APPENDIX 1

MANAWATU-WANGANUI RESIDENT SURVEY ON POSSUM CONTROL

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AND BUSINESS

APPENDIX 1(A) PILOT RESIDENT SURVEY

2 May 1991

Dear Respondent,

Possum Survey

I am undertaking a study looking at the funding of possum control. One aim of the study is to assess whether people feel the amount of money that is being spent on control is enough. I am studying the Manawatu-Wanganui region. This is the shaded area on the map on page 2.

The study is part of my thesis for a Masters of Agricultural Science. It is being supervised by Professor Anton Meister of the Department of Agricultural Economics and Business, Massey University.

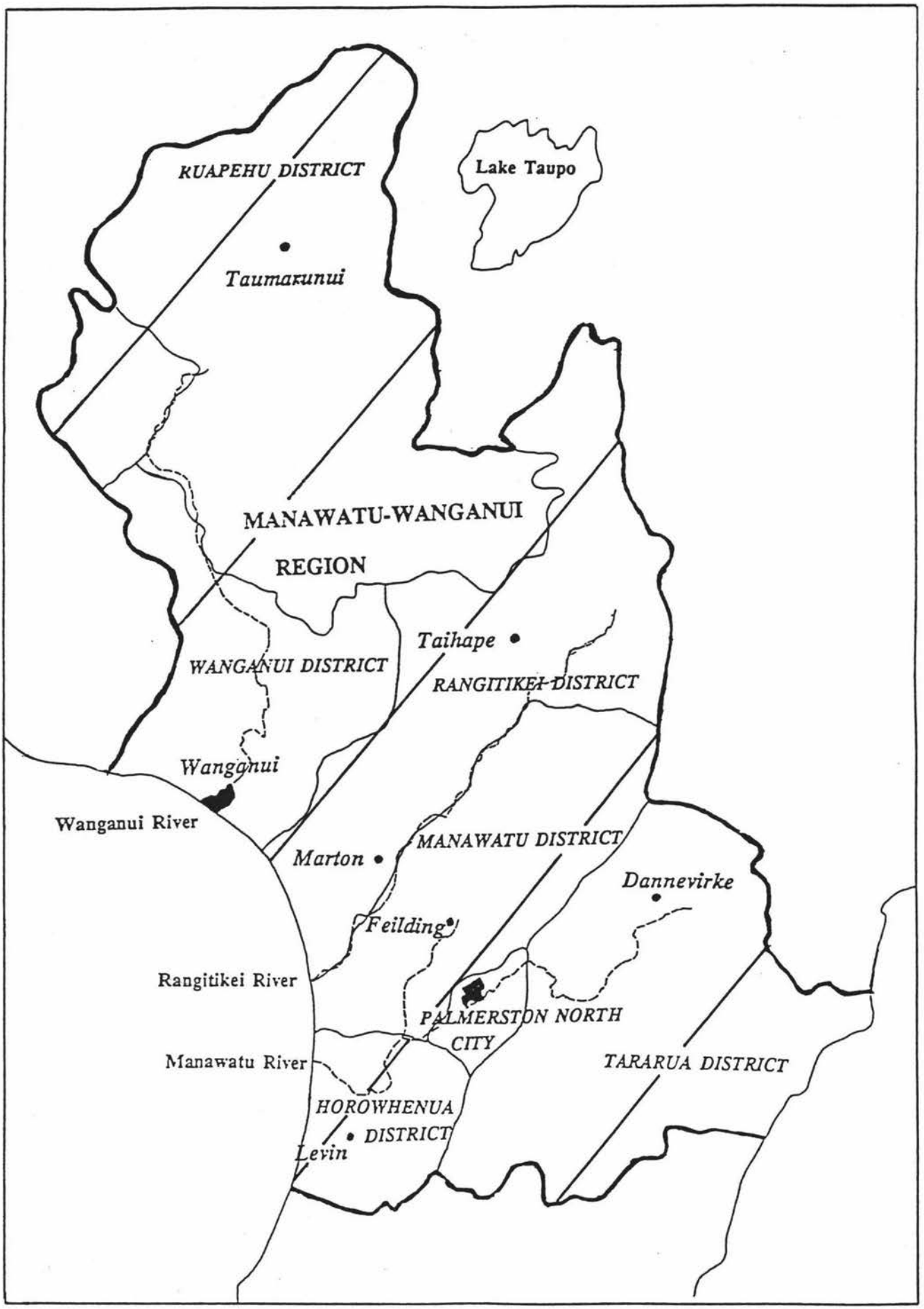
All information given will be treated in the strictest of confidence and you and your responses will not be identifiable. The questionnaire has an identification number for mailing purposes only. This is so that we may check your name off of the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire.

Thank you for your assistance. I look forward to receiving your completed questionnaire as soon as possible.

Yours sincerely,

Glenda Lock

Encl.


KUAPEHU DISTRICT
Lake Taupo
Taumarunui
MANAWATU-WANGANUI
REGION
Taihape
WANGANUI DISTRICT
RANGITIKEI DISTRICT
Wanganui
Wanganui River
Marton
MANAWATU DISTRICT
Dannevirke
Feilding
Rangitikei River
PALMERSTON NORTH
CITY
Manawatu River
TARARUA DISTRICT
HOROWHENUA
DISTRICT
Levin

Thank you for reading so far. Would you now please answer all the questions that apply to your household. If you are unsure of a question, please explain your difficulty with it by writing in the side margin.

1. Do you believe that possums are causing problems in New Zealand? **[CIRCLE NUMBER PLEASE]**

   1 YES

   2 NO **If no please go to question 3**

2. If you answered yes to question 1, please rate how severe you consider the problem to be (1=no problem, 2=slight problem, 3=moderate problem, 4=bad problem, 5=severe problem). **[CIRCLE NUMBERS PLEASE]**

1	SPREAD OF THE DISEASE BOVINE TUBERCULOSIS	1 2 3 4 5
2	DAMAGE TO NATIVE FORESTS	1 2 3 4 5
3	DAMAGE TO EXOTIC FORESTS	1 2 3 4 5
4	DAMAGE BY EATING PASTURE/CROPS/SHRUBS/ FLOWERS/VEGETABLES	1 2 3 4 5
5	DAMAGE TO SOIL CONSERVATION PLANTINGS	1 2 3 4 5
6	OTHERS (PLEASE SPECIFY) _____	1 2 3 4 5
	_____	1 2 3 4 5

3. Which of the following organisations do you believe are <u>currently</u> involved in active possum control or researching possum control? **[CIRCLE NUMBER OR NUMBERS PLEASE]**

   1 MINISTRY OF AGRICULTURE AND FISHERIES (MAF)

   2 REGIONAL COUNCILS

   3 DISTRICT COUNCILS

   4 DEPARTMENT OF CONSERVATION (DOC)

   5 UNIVERSITIES

   6 FOREST RESEARCH INSTITUTE (FRI)

   7 DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (DSIR)

   8 OTHERS (PLEASE SPECIFY) _____

   _____

4. How should the funds for possum control be allocated between: **[GIVE PERCENTAGES PLEASE]**

1	CONTROL BY AERIAL POISONING	_____
2	CONTROL BY TRAPPERS (e.g. TRAPPING, SHOOTING AND POISONING)	_____
3	RESEARCH INTO PREVENTING POSSUMS FROM SPREADING TUBERCULOSIS (TB) AND PREVENTING POSSUMS FROM BREEDING	_____
4	OTHERS (PLEASE SPECIFY) _____	_____
	_____	_____
		100%

5. The following question is designed to measure how strongly you value possum control.

Suppose a special fund is to be set up to control possums in the Manawatu-Wanganui region. All households in this region will be expected to pay into this fund annually.

Assume that all expenses on possum control will be covered by this fund. You will no longer be charged rates for possum control and it will not be necessary to spend any money on privately funded possum control.

What is the maximum amount you would be willing to pay into the fund each year for possum control?

$_____per year

6. If your household is not willing to pay into this fund, please explain why.

_____

_____

_____

7. Suppose that instead of setting up a fund for possum control in the Manawatu- Wanganui region, all New Zealanders will be expected to pay additional taxes for possum control on national level.

Would your household be willing to pay additional taxes for possum control? [CIRCLE NUMBER PLEASE]

1 YES

2 NO

8. If your household is not willing to pay additional taxes for possum control on a national level, please explain why.

_____

_____

_____

9. Should the funds for possum control be spent on control within **[CIRCLE NUMBER PLEASE]**

1 THE DISTRICT IN WHICH THEY ARE COLLECTED (i.e. THE RANGITIKEI DISTRICT)

2 THE REGION IN WHICH THEY ARE COLLECTED (i.e. THE MANAWATU-WANGANUI REGION)

3 USED ON A NATIONAL BASIS ACCORDING TO WHERE CONTROL IS MOST URGENT

10. Are possums a problem on your property? **[CIRCLE NUMBER PLEASE]**

1 YES **If no go to Q13**

2 NO

11. If yes, please explain why possums are a problem on your property

_____

_____

_____

_____

12. If possible could you put a dollar value on the damage possums are causing on your property on an annual basis.

$_____/year

13. Was any possum control done on your property(s) during 1990? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO **If yes go to question 14 otherwise go to question 18.**

3 UNSURE

14. How much money are you currently spending on possum control annually? **[CIRCLE NUMBER PLEASE]**

1 $0

2 BETWEEN $0 AND $50

3 BETWEEN $50 AND $200

4 BETWEEN $200 AND $500

5 BETWEEN $500 AND $1500

6 MORE THAN $1500

15. Who carried out this control on your property in 1990? **[CIRCLE NUMBER OR NUMBERS PLEASE]**

1 MEMBERS OF YOUR HOUSEHOLD

2 PRIVATE CONTRACTOR

3 OTHERS PLEASE SPECIFY _____

_____

16. Approximately how many possums have been killed on your property during 1990? **[CIRCLE NUMBER PLEASE]**

1 0

2 1-50

3 51-100

4 101-500

5 MORE THAN 500

6 UNSURE

17. Were the skins of the possums killed on your property in 1990 sold? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO

3 UNSURE

18. Prior to 1990, was any possum control carried out on your property(s)? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO

3 UNSURE

The following information is required to make sure we have surveyed a representative sample of the Manawatu-Wanganui region.

19. How many people are there in your household? _____

20. How many of these are children under the age of 15?_____

Please fill in the following table for each member of your household over the age of 15.

21.

HOUSEHOLD MEMBER		SEX	AGE	OCCUPATION
e.g.		male	45	science technician
YOURSELF	1			
AND OTHER	2			
MEMBERS IN	3			
HOUSEHOLD	4			
	5			
	6			

22. If any member of your household specified farming as their occupation, what are their main types of farming? **[CIRCLE NUMBER PLEASE]**

1 DAIRY

2 BEEF

3 CROP

4 SHEEP

5 DEER

6 OTHER (PLEASE SPECIFY)_____

_____

23. What percentage of your gross farm income is derived from cattle (dairy or beef) or deer? **[CIRCLE NUMBER PLEASE]**

1 0%

2 1-20%

3 21-50%

4 51-80%

5 MORE THAN 80%

24. What is your annual <u>household</u> income this year? (before tax) **[CIRCLE NUMBER PLEASE]**

1 LESS THAN $10 000

2 $10 001 TO $20 000

3 $20 001 TO $30 000

4 $30 001 TO $40 000

5 $40 001 TO $50 000

6 $50 001 to $60 000

7 MORE THAN $60 000

25. How large is your property **[CIRCLE NUMBER PLEASE]**

1 LESS THAN 1 HECTARE

2 1-10 HECTARES

3 10-50 HECTARES

4 50-100 HECTARES

5 100-500 HECTARES

6 MORE THAN 500 HECTARES

26. Do you or any members of your household belong to **[CIRCLE NUMBER OR NUMBERS PLEASE]**

1 AN ENVIRONMENTAL ORGANISATION (e.g.GREENPEACE/MARUIA/ FOREST AND BIRD

2 A TRAMPING CLUB

3 A FARMING ORGANISATION (e.g. FEDERATED FARMERS, DEER FARMERS ASSOCIATION)

4 ANOTHER CLUB INVOLVED IN BUSHCRAFT (PLEASE SPECIFY)

_____

_____

27. Do you have any further comments on possum control and possum damage?

_____

_____

_____

Thankyou very much for completing this survey. Please return it as soon as possible in the envelope provided.

APPENDIX 1(B) OPEN ENDED RESIDENT SURVEY

MASSEY
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FACULTY OF
AGRICULTURAL
AND
HORTICULTURAL
SCIENCES

DEPARTMENT OF
AGRICULTURAL
ECONOMICS
AND BUSINESS

7 June 1991

Dear Sir/Madam

I am undertaking a study looking at the funding of possum control. One objective of the study is to assess whether people feel the amount of money that is being spent on control is enough. The area that I am studying is the Manawatu-Wanganui region. This is the shaded area on the map.

The study is part of my thesis for a Masters of Agricultural Science. It is being supervised by Professor Anton Meister of the Department of Agricultural Economics and Business, Massey University.

All information you give will be treated in the strictest of confidence. You and your responses will not be identifiable. The questionnaire has an identification number for mailing purposes only. This is so that we may check your name off the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire.

Thank you for your assistance. I look forward to receiving your completed questionnaire as soon as possible.

Yours sincerely,

Glenda Lock

Please answer all the questions that apply to your household. If you don't understand a question, please explain your answer by writing in the side margin.

1. Do you believe that possums are causing problems in New Zealand? **[CIRCLE NUMBER PLEASE]**

   1 YES

   2 NO **If no please go to question 3**

2. If you answered yes to question 1, please rate how severe you consider the problem to be for each of the situations below (1=no problem, 2=slight problem, 3=moderate problem, 4=bad problem, 5=severe problem).

[CIRCLE NUMBERS PLEASE]

1	SPREAD OF THE DISEASE BOVINE TUBERCULOSIS (TB)	1	2	3	4	5
2	DAMAGE TO NATIVE FORESTS AND WILDLIFE	1	2	3	4	5
3	DAMAGE TO EXOTIC FORESTS	1	2	3	4	5
4	DAMAGE BY EATING PASTURE/CROPS/SHRUBS/ FLOWERS/VEGETABLES	1	2	3	4	5
5	DAMAGE TO SOIL CONSERVATION PLANTINGS	1	2	3	4	5
6	OTHERS (PLEASE SPECIFY) _____	1	2	3	4	5
	_____	1	2	3	4	5

3. Which of the following organisations do you believe are <u>currently</u> involved in active possum control or researching possum control? **[CIRCLE NUMBER OR NUMBERS PLEASE]**

   1 MINISTRY OF AGRICULTURE AND FISHERIES (MAF)

   2 REGIONAL COUNCILS

   3 DISTRICT COUNCILS

   4 DEPARTMENT OF CONSERVATION (DOC)

   5 UNIVERSITIES

   6 FOREST RESEARCH INSTITUTE (FRI)

   7 DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (DSIR)

   8 OTHERS (PLEASE SPECIFY) _____

   _____

4. How should the funds for possum control be allocated between: **[GIVE PERCENTAGES PLEASE]**

1	CONTROL BY AERIAL POISONING	_____
2	CONTROL BY TRAPPERS (e.g. TRAPPING, SHOOTING AND POISONING)	_____
3	RESEARCH INTO PREVENTING POSSUMS FROM SPREADING TUBERCULOSIS (TB) AND PREVENTING POSSUMS FROM BREEDING	_____
4	OTHERS (PLEASE SPECIFY) _____	_____
	_____	_____
		100%

5. The following question is designed to measure how strongly you value possum control.

Suppose a special fund is to be set up to control possums in the Manawatu-Wanganui region. All households in this region will be expected to pay into this fund annually.

Assume that all expenses on possum control will be covered by this fund. You will no longer be charged rates or taxes for possum control and it will not be necessary to spend any money on privately funded possum control.

What is the maximum amount your household is willing to pay into the fund each year for possum control at a regional level?

$_____per year

6. If your household is not willing to pay into this fund , please explain why.

_____

_____

_____

7. Suppose that instead of setting up a fund for possum control in the Manawatu- Wanganui region, all New Zealanders will be expected to pay into a fund for possum control at a national level

Assume that all expenses on possum control will be covered by this fund. You will no longer be charged rates or taxes for possum control and it will not be necessary to spend any money on privately funded possum control.

What is the maximum amount your household is willing to pay into this fund annually for possum control at a national level?

$_____per year

8. If your household is not willing to pay into this fund for possum control on a national level, please explain why.

_____

_____

_____

9. Should the funds for possum control be spent on control within **[CIRCLE NUMBER PLEASE]**

1 THE DISTRICT IN WHICH THEY ARE COLLECTED
(i.e. THE RANGITIKEI DISTRICT)

2 THE REGION IN WHICH THEY ARE COLLECTED
(i.e. THE MANAWATU-WANGANUI REGION)

3 USED ON A NATIONAL BASIS ACCORDING TO WHERE CONTROL IS MOST URGENT

10. Are possums a problem on your property? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO **If no go to Q13**

11. If yes, please explain why possums are a problem on your property

_____

_____

_____

_____

12. If possible could you put a dollar value on the damage possums are causing on your property on an annual basis.

$_____/year

13. Was any possum control done on your property(s) during 1990? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO **If yes go to question 14 otherwise go to question 18.**

3 UNSURE

14. How much money are you currently spending on possum control annually? **[CIRCLE NUMBER PLEASE]**

1 $0

2 BETWEEN $0 AND $50

3 BETWEEN $50 AND $200

4 BETWEEN $200 AND $500

5 BETWEEN $500 AND $1500

6 MORE THAN $1500

15. Who carried out this control on your property in 1990? **[CIRCLE NUMBER OR NUMBERS PLEASE]**

1 MEMBERS OF YOUR HOUSEHOLD

2 PRIVATE CONTRACTOR

3 OTHERS PLEASE SPECIFY _____

_____

16. Approximately how many possums have been killed on your property during 1990? **[CIRCLE NUMBER PLEASE]**

1 0

2 1-50

3 51-100

4 101-500

5 MORE THAN 500

6 UNSURE

17. Were the skins of the possums killed on your property in 1990 sold? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO

3 UNSURE

18. Prior to 1990, was any possum control carried out on your property(s)? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO

3 UNSURE

The following information is required to make sure we have surveyed a representative sample of the Manawatu-Wanganui region.

19. How many people are there in your household? _____

20. How many of these are children under the age of 15?_____

Please fill in the following table for each member of your household over the age of 15.

21.

HOUSEHOLD MEMBER		SEX	AGE	OCCUPATION
e.g.		male	45	science technician
YOURSELF	1			
AND OTHER	2			
MEMBERS IN	3			
YOUR	4			
HOUSEHOLD	5			
	6			

If any member of your household specified farming as their occupation, please go to question 22 otherwise go to question 23.

22. What percentage of your gross farm income is derived from cattle (dairy or beef) or deer? **[CIRCLE NUMBER PLEASE]**

1 0%

2 1-20%

3 21-50%

4 51-80%

5 MORE THAN 80%

23. What was your annual <u>household</u> income before tax last year?(1990/91) **[CIRCLE NUMBER PLEASE]**

1 LESS THAN $10 000

2 $10 001 TO $20 000

3 $20 001 TO $30 000

4 $30 001 TO $40 000

5 $40 001 TO $50 000

6 $50 001 to $60 000

7 MORE THAN $60 000

24. Which of the following best describes where you live? **[CIRCLE NUMBER PLEASE]**

1 AN URBAN AREA i.e. GREATER THAN 500 HOUSEHOLDS

2 A COMMUNITY OF LESS THAN 500 HOUSEHOLDS

3 A RURAL AREA

25. Which of the following organisations do members of your household belong to **[CIRCLE NUMBER OR NUMBERS PLEASE]**

1 AN ENVIRONMENTAL ORGANISATION (e.g.GREENPEACE/MARUIA/ FOREST AND BIRD

2 A TRAMPING/HUNTING OR OTHER OUTDOOR RECREATION CLUB THAT USES BUSH

3 A FARMING ORGANISATION (e.g. FEDERATED FARMERS, DEER FARMERS ASSOCIATION)

4 AN ANIMAL RIGHTS ORGANISATION

5 NONE OF THE ABOVE

26. Do you have any further comments on possum control and possum damage?

_____

_____

_____

Thank you very much for completing this survey. Please return it as soon as possible in the envelope provided.

APPENDIX 1 (C) DICHOTOMOUS CHOICE RESIDENT SURVEY
(includes only pages which differ from the open ended survey)

4. **How should the funds for possum control be allocated between: [GIVE PERCENTAGES PLEASE]**

1 CONTROL BY AERIAL POISONING _____

2 CONTROL BY TRAPPERS (e.g. TRAPPING, SHOOTING AND POISONING) _____

3 RESEARCH INTO PREVENTING POSSUMS FROM SPREADING TUBERCULOSIS (TB) AND PREVENTING POSSUMS FROM BREEDING _____

4 OTHERS (PLEASE SPECIFY) _____ _____

_____ _____

100%

5. The following question is designed to measure how strongly you value possum control.

Suppose a special fund is to be set up to control possums in the Manawatu-Wanganui region. All households in this region will be expected to pay into this fund annually.

Assume that all expenses on possum control will be covered by this fund. You will no longer be charged rates or taxes for possum control and it will not be necessary to spend any money on privately funded possum control.

Is your household willing to pay _____ into this fund each year for possum control at a regional level?

1 YES

2 NO

6. If your household is not willing to pay into this fund , please explain why.

_____

_____

_____

7. Suppose that instead of setting up a fund for possum control in the Manawatu- Wanganui region, all New Zealanders will be expected to pay into a fund for possum control at a national level

Assume that all expenses on possum control will be covered by this fund. You will no longer be charged rates or taxes for possum control and it will not be necessary to spend any money on privately funded possum control.

Is your household willing to pay _____ into this fund annually for possum control at a national level?

1 YES

2 NO

8. If your household is not willing to pay into this fund for possum control on a national level, please explain why.

_____

_____

_____

9. Should the funds for possum control be spent on control within **[CIRCLE NUMBER PLEASE]**

1 THE DISTRICT IN WHICH THEY ARE COLLECTED
(i.e. THE RANGITIKEI DISTRICT)

2 THE REGION IN WHICH THEY ARE COLLECTED
(i.e. THE MANAWATU-WANGANUI REGION)

3 USED ON A NATIONAL BASIS ACCORDING TO WHERE CONTROL IS MOST URGENT

10. Are possums a problem on your property? **[CIRCLE NUMBER PLEASE]**

1 YES

2 NO **If no go to Q13**

11. If yes, please explain why possums are a problem on your property

_____

_____

_____

APPENDIX 1 (D)
REMINDER LETTERS FOR RESIDENT SURVEY

FIRST REMINDER LETTER

MASSEY
UNIVERSITY

Private Bag
Palmerston North
New Zealand
Telephone 0-6-356 9099
Facsimile 0-6-350 5642

FACULTY OF
AGRICULTURAL
AND
HORTICULTURAL
SCIENCES

DEPARTMENT OF
AGRICULTURAL
ECONOMICS
AND BUSINESS

21 June 1991

Dear Madam/Sir

Approximately 10 days ago you should have received a copy of a survey in regard to my study of possum control. To date I have not received any reply from you. This letter is to urge you to fill in the survey and return it in the postage paid envelope as soon as possible.

Although you may consider that possums have no direct effect on your household, you are indirectly involved in possum control through taxes and rates. Rates have an effect on the price of rental accommodation.

Your response is very important to the success of my survey and degree. I am interested in responses from both people who value possum control and people who do not value possum control.

If you have already returned your survey, please ignore this letter.

Thank you

Yours sincerely

Glenda M Lock

MASSEY
UNIVERSITY

Private Bag
Palmerston North
New Zealand
Telephone 0-6-356 9099
Facsimile 0-6-350 5642

FACULTY OF
AGRICULTURAL
AND
HORTICULTURAL
SCIENCES

DEPARTMENT OF
AGRICULTURAL
ECONOMICS
AND BUSINESS

SECOND REMINDER LETTER

8 July 1991

Dear Madam/Sir

Recently you should have received a copy of a survey in regard to my study of possum control. To date I have not received any reply from you. This letter is to urge you to fill in the survey and return it in the postage paid envelope as soon as possible.

Although you may consider that possums have no direct effect on your household, you are indirectly involved in possum control through taxes and rates.

Your response is very important to the success of my survey and degree. I am interested in responses from both people who value possum control and people who do not value possum control.

If you have already returned your survey or contacted me please ignore this letter.

Thank you

Yours sincerely

Glenda M Lock

APPENDIX 2

FURTHER COMMENTS MADE BY RESPONDENTS

Table A2.1 Further Comments Made By Respondents

COMMENT	NUMBER RESPONDING	PERCENTAGE OF COMMENTS
Encourage fur industry/market as environmentally friendly	23	6.3
Not troubled by possums	8	2.2
Lost animals with 1080/against aerial 1080 poisoning	14	3.8
National problem/fund nationally/national importance	13	3.6
Object to some questions/ whole survey	27	7.4
Against some organisations	4	1.1
Abolish tax on skins	7	1.9
Reintroduce bounty scheme/ subsidy on control	62	16.9
Study more applicable to rural areas/not a town problem	9	2.5
Matter is urgent/control is important/not enough done at present	24	6.6
Eradicate possums	21	5.7
Worried about Tb problem	13	3.6
Worried about damage to forests /ecology	16	4.4
Humane control required/ against trapping	4	1.1
Follow up is important/lacks	3	0.8
Too much bureaucracy/ administration	10	2.7
Anti-fur lobby causing problems	7	1.9
Rabbits a problem	6	1.6
Many farmers doing own eradication/can control possums themselves	3	0.8
Survey cost too much/ waste of money	2	0.6
Use unemployed	17	4.6
More research into biological control required	16	4.4
Have limited knowledge/ not aware of problem	7	1.9
More education/PR required	10	2.7
Make landowners responsible for own possum control	2	0.6
Current Tb eradication scheme not working/low farmer support	2	0.6
Control done better by private enterprise	3	0.8
Use skins and meat	8	2.2
Threat to exports	8	2.2
User pays	2	0.6
Govt/treasury responsible for payment/allocate taxes	5	1.4
Other	10	2.7

APPENDIX 3
BIDS OFFERED IN THE OPEN ENDED WILLINGNESS TO PAY QUESTION

Table A3.1 Bids Offered in the Open Ended Willingness to Pay Question on a Regional Basis.

Bid	Frequency	Percentage of Bids	Cumulative Frequency	Cumulative Percentage
0	41	21.8	41	21.8
1	1	0.5	42	22.3
2	2	1.1	44	23.4
5	9	4.8	53	28.2
10	17	9.0	70	37.2
15	1	0.5	71	37.7
20	22	11.7	93	49.4
21	1	0.5	94	49.9
25	8	4.3	102	54.2
30	1	0.5	103	54.7
31	1	0.5	104	55.2
50	22	11.7	126	66.9
80	1	0.5	127	67.4
100	32	17.0	159	84.4
120	1	0.5	160	84.9
150	2	1.1	162	86.0
200	10	5.3	172	91.3
250	4	2.1	176	93.4
300	2	1.1	178	94.5
400	2	1.1	180	95.6
500	5	2.7	185	98.3
1000	1	0.5	186	98.8
1500	1	0.5	187	99.3
5000	1	0.5	188	99.8

Table A3.2 Bids Offered in the Open Ended Willingness to Pay Question on a National Basis.

Bid	Frequency of Bids	Percentage of Bids	Cumulative Frequency	Cumulative Percentage
0	32	17.3	32	17.3
1	1	0.5	33	17.8
2	4	2.2	37	20.0
5	14	7.6	51	27.6
10	24	13.0	75	40.6
13	1	0.5	76	41.1
15	3	1.6	79	42.7
20	17	9.2	96	51.9
21	1	0.5	97	52.4
25	10	5.4	107	57.8
30	2	1.1	109	58.9
40	3	1.6	112	60.5
50	24	13.0	136	73.5
100	26	14.1	162	87.6
120	1	0.5	163	88.1
150	2	1.1	165	89.2
200	7	3.8	172	93.0
250	3	1.6	175	94.6
300	3	1.6	178	96.2
400	1	0.5	179	96.7
500	3	1.6	182	98.3
1000	1	0.5	183	98.8
1500	1	0.5	184	99.3
5000	1	0.5	185	99.8