# Effective Rabbit Management in a Post RHD Environment in New Zealand

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# Abstract


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Developing effective rabbit management in the post RHD environment in New Zealand is of paramount importance to land managers and government agencies. Historically rabbit management has lacked clear objectives and faced conflicting interests from various stakeholders.

With the advent of RHD, rabbits at some sites were reduced by up to 90% (Cooke, 2002). However, the ad-hoc style of release meant there was no coordinated approach or collective action to maintain these gains through secondary control such as shooting and fumigation to remove surviving rabbits. Soon rabbits again reached high levels in many areas that necessitated a return to primary control using toxin application. Many landholders are locked in a model of periodic reactive control, still with no clear objective to permanently reduced rabbit numbers.

A model of strategic sustained management (SSM) offers an alternative solution for effective rabbit management in the post RHD environment. SSM has a clear objective to permanently reduce rabbit numbers. It is one of the best methods to ensure the efficacy of RHD is maintained by removing immune survivors, thereby mitigating the potential of heritable immunity. It is anticipated under a model of SSM, that regular repetition of secondary control methods will reduce rabbit numbers and lead to declining efforts and costs concurrently. Striking the correct balance between costs and repeat applications is important and this will largely depend on the rabbits reproductive capacity at a site, RHD dynamics and environmental parameters.

Landholders frequently implement wasteful rabbit control practices because they rely heavily on one technique, often inefficiently, and fail to follow up with maintenance control that may have sustained the initial level of control achieved (Cooke, 1981). This represents a model of crisis management which lacks a clear long term objective. Implementing a program of strategic sustained management will avoid this pitfall. A thorough knowledge of factors that impede a rabbit’s chance of survival is needed to enable the manager to systematically create an environment that is non-

conducive to the rabbit's success. Combined with secondary control, this will create systematic sustained management and long-term benefits with reduced long term costs.

Landholders need to take ownership of the rabbit problem but landholder and community attitudes to rabbit management is complex. There is often a lack of technical rigour and best practice is poorly understood in many cases. Government agencies have a regulatory compliance role which often lacks a strategic approach and is more of a command and control model than being supportive of long term objectives.

Maniototo Pest Management Ltd (MPM) based in Otago has successfully implemented a model of SSM and operates an audited self-management program. It has successfully maintained rabbits at low levels and has shown that frequency of treatment can be extended once low levels of rabbit infestation are achieved . Ownership of the rabbit problem while divested in the pest management company is still squarely with the landholders who hold shares in MPM. This model has proven successful and holds merit for other areas wishing to implement a program of strategic sustained management and maintain the efficacy of RHD.

**Keywords:** Oryctolagus cuniculus, Rabbit control, Strategic sustained management, Rabbit haemoragic disease, Periodic reactive control, Integrated pest management, Monitoring, Biosecurity, Regional Pest Management Strategy, Extension services, Rabbit biology, Rabbit distribution, RHD immunity.

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# Chapter 1 Introduction

Developing effective rabbit management in the post RHD environment is of paramount importance to land managers in the semi-arid lands of New Zealand. Rabbits continue to pose a considerable financial and environmental burden in areas of Hawkes Bay, Marlborough, North Canterbury, Otago and some areas in Southland. Effective tools to manage rabbits have developed over a long period of time and without these simple tools used today such as bait containing sodium fluroacetate (1080) or Pindone™, New Zealand would be facing rabbit populations in plague proportions in many areas.

In 1997 the illegal introduction of rabbit haemorrhagic disease (RHD) (O'Hara, 1997), formerly known as rabbit calicivirus disease (RCD), has had a profound impact on rabbit populations in most areas resulting in a breakthrough in rabbit management in New Zealand, despite its dubious and illegal method of introduction. However, the efficacy of this biological control agent appears to be diminishing in many regions due to a range of factors, some of which can be manipulated through management techniques to reduce this occurrence.

Developing a management strategy with a long term goal of permanently reducing rabbit populations has a two-fold advantage. Firstly, it will aid in the reduction of any heritable immunity from the population given the reduced pool of survivors from which this can occur and secondly, it will avoid a crisis management model, which has thus far proven ineffectual and costly to land managers. A model of strategic sustained management (SSM) represents an alternative to the current model being implemented at many sites. SSM has a clear goal to permanently reduce rabbit populations with evidence indicating this model will be cheaper to implement over the long term and includes the added benefits of reducing RHD immunity.

There have been waves of rabbit plagues in New Zealand from the mid 1800's with the most recent occurring in 1980 (Te Ara, 2013). Various control techniques have managed these plagues, such as the establishment of the rabbit boards in 1947 which coincided with the de-commercialisation of rabbit carcases, followed by the aerial application of the toxin compound 1080 in 1953 (Lough, 2009).

Today, controlling rabbits falls into two broad categories of primary control and secondary control. Primary control usually involves the application of toxins to target large populations that have bourgeoned out of control. The biological control agent RHD, has provided an additional primary control tool to reduce rabbit populations and after its initial introduction, populations in some areas were reduced by up to 90% (Cooke, 2002). Secondary control involves the implementation of a management strategy to maintain rabbit populations at low levels following primary control. Secondary control is an ongoing process of strategic sustained management that systematically targets survivors in an effort to ensure the population does not increase at a rate greater than the control mechanism is able to reduce it. It involves ground-based methods such as shooting and the use of fumigants applied to burrows to kill the remaining survivors, as well as habitat manipulation. All these efforts aim to mitigate the necessity of returning to primary control tools. The combination of these control strategies needs careful consideration to ensure the best use is made of available resources.

Within the New Zealand context there are various levels of primary and secondary control being implemented with varying levels of success. These programs range from a crisis management model of periodic reactive primary control efforts on a rotational basis to meet compliance requirements of an area's Regional Pest Management Strategy, to that of ongoing strategic sustained management with successful control efforts voiding the need for primary control efforts all together. Maniototo Pest Management Ltd, which operates in the heart of Otago, has for some time implemented a model of SSM which has helped to reduce the need for primary control efforts, with initial findings showing this method to be a very effectual management model.

The Rabbit Coordination Group (RCG) was established in 2007 to strengthen approaches to rabbit management in New Zealand and allow key stakeholders to share information and collectively address the rabbit issue. The RCG draws on the knowledge and experience as detailed in the Lough Report (2009), and identifies issues, options and recommendations for the future. The RCG has developed a set of priorities based on the Lough Report (2009) which is believed will provide the greatest benefit with available resources (Rabbit Coordination Group, 2010).

The RCG identified the following key issues and needs:

- Best practice needs to be developed and adhered to.
- Training and skills retention is a real issue facing the industry given the short seasonal nature of the rabbit control season.
- Collective action is required to ensure a coordinated approach is taken.
- Communication is best facilitated through the RCG to ensure stakeholder awareness.
- Appropriate industry tools need to be retained and complimented with the advent of RHD.

Within the issues and needs identified there are multiple levels of complexity that have the potential to form impediments to the effective management of rabbits within the New Zealand context. Without satisfactory removal of the impediments, rabbit management in New Zealand risks repeating the same errors that have historically plagued the rabbit issue in New Zealand. Without clear objectives and collective action, rabbit management will not progress. Methodologies that have failed in the past should not be repeated. RPMS rules and strategic direction need to focus on creating some real long-term gains and results. Ownership of the rabbit problem needs to be clearly linked to land management and practices of land management need to made within that context. Knowledge and decisions based on good science will be keys that unlock the solution to the rabbit problem.

The Regional Pest Management Strategy rules of councils do not support a model of collective action so this must be approached from an underlying strategic direction such as is supported through the RCG. Best practice is often poorly understood by landholders. Training and essential skills are often lost as people leave the industry. The RCG aims to address these issues, however, caution needs to be exercised over the approach of what may be perceived as vesting rabbit management in an external agency such as the RCG or regional councils, thereby removing the individual responsibility and ownership of the problem. Pest liaison committees may be an appropriate stakeholder forum to address this situation and have been shown to work well in some regions.

Unfortunately, many semi-arid lands have already been forced to return to primary control as a method to manage bourgeoning rabbit populations in the post RHD environment. However, this could be prevented if correct management practices are implemented in a timely and effective manner. Evidence exists to support a claim that correct management in the form of strategic, sustained control can not only avoid a model of crisis management necessitating primary control, but can also be beneficial in maintaining the efficacy of RHD and that this management regime is the most cost effective long term model (Williams, 1995).

The cost and benefits of various management regimes needs careful consideration, as does the complexity that underpins attitudes to pest control and the political and legislative environment within which it operates. Developing an effective rabbit management model is a long term process (>10yr). In terms of the longevity of an optimum control model, it was considered that the Rabbit and Land Management Program introduced was too short in its five year duration but rather a 10-15 year time frame may have been more realistic to enable the full scope of the program to be realised (Mulcock, 1993).

One of the most important lessons to have been learned from rabbit management in New Zealand over the last 40 years is the need for stakeholders to understand each other's needs (Williams, 1991) Rabbit Management is only one small aspect of a very complex system which includes social, economic and biophysical components. Developing a successful rabbit control strategy requires an understanding of all the interacting components.

## 1.1 History

The historical records of rabbit introductions are somewhat unclear, possibly due to the unpopularity of what soon became a pest animal in New Zealand. However, it is an established fact that the European rabbit (*Oryctolagos cuniculus*) was introduced to New Zealand in the mid 1800's for food and sport but once established, in the absence of any effective management or predation, the population soon reached plague proportions.

Numerous private liberations were carried out and even as late as the 1870s passengers on incoming ships were bringing rabbits with them in the expectation of a profit, since they could be sold to settlers at high prices. Gold prospectors carried them into the Otago region and released them in large numbers around the goldfields as a food resource.

By 1876, the whole of Southland was infested and North and Central Otago were fast approaching the same situation. By 1887 rabbits were swarming on the Canterbury Plains, joining the hordes that were descending south from Marlborough (Druett, 1983).

With jobs becoming hard to find and in the face a fading gold rush a new occupation of the full-time rabbiter was born. In 1919, revenue from the sale of skins was reported to be four shillings for a good winter pelt. Carcasses were also sold and the total value of rabbit exports rose from £196,545 in 1900 to nearly one million pounds in 1919, and in 1946 approached one and a half million pounds. One report indicates gangs of rabbiters taking 60,000 rabbits off one block in a season of six months with over 20 million skins exported in 1919 (Druett, 1983). This gives some indication of the enormity of the new industry and scale of the emerging rabbit problem in New Zealand.

## 1.2 Historical Management

The historical management of rabbits was initially not so much a case of pest management but more one of acclimatisation. Rabbits initially proved hard to acclimatise and numerous attempts failed, but by the 1870s success of the early attempts was evident and the full enormity of the increase of the rabbit population was beginning to dawn on farmers.

Initial control campaigns in the late 1800's and early 1900's were less than ideal, being focussed on the recovery of pelts and meat, which was less about control and more about commercialisation of a steadily growing pest problem. With farmers struggling to maintain feed for livestock the rabbit nuisance was becoming evident. The rabbiter was making a prosperous business out of the farmers' rabbit-induced misery, which soon became so profitable that rabbiters were paying property-owners for the privilege of cleaning out their properties. It became evident that commercial recovery of rabbits for pelts or meat was not going to control this new pest and various new means were required to change the tide of the rabbit plagues.

Effective control solutions were being sought for vast tracts of land and soon owners of some stations began paying their men a bounty system of tokens for rabbits killed. Some landholders paid for pairs of ears, however, enterprising rabbiters thought nothing of reaching into burrows, snipping off the ears and putting the rabbits back alive to continue breeding. The sight of earless rabbits in traps or on poison lines was quite common in the early days (Druett, 1983). Some landholders paid for tails and once again enterprising rabbbiters used to meet in secret at the boundaries of properties, swapping ears for tails. Bounty systems were thwart with skulduggery requiring the use of other means of effective rabbit control.

By the early 1900’s landholders were experimenting with alternative methods of rabbit control with poisoning becoming very popular. The rabbiters were persuaded on many properties, to poison rabbits and recover skins alone. It soon became evident that poisoning was an effective means of controlling rabbits over large tracts of land. By 1876 the 'Rabbit Nuisance Act' had been passed and this gave Government inspectors powers to instruct landowners to destroy all rabbits on their land. The Act was revised year after year, giving rabbit inspectors’ greater powers and yet rabbit numbers continued to increase in many areas (Druett, 1983).

Rabbit boards were soon to be developed with the first rabbit board being formed in Hawkes Bay in 1887. The boards could undertake rabbit control themselves on private land that had high levels of rabbit infestation, but their work was hindered by slow establishment due to rabbiting still proving so commercially profitable in many areas.

In 1947 the Rabbit Destruction Council was formed and the “killer policy” was developed (Godfrey, 1974) having an initial intention of eradication. This was problematic in the environment where landholders and private interests were making substantial financial gains from retaining rabbits on their land. A change in policy was required and in 1955 legislation was being amended to completely devalue rabbit products thereby removing any incentive to retain rabbits on a property. The amended legislation resulted in the Rabbit Amendment Act 1956 (Cotton, 1994) which happened to coincide with better quality toxic baits and improved delivery mechanisms. Fixed-wing aircraft were beginning to be used and 1080 (sodium fluoroacetate) was proving to be spectacular at controlling rabbits over vast tracts of land. Thus, the focus changed from commercial harvesting to an eradication policy and talk of destroying the “last rabbit” was common among landholders (Godfrey, 1974).

The Agricultural Pest Destruction Council (APDC) was formed in 1968 after the passing of the Agricultural Pest Destruction Act 1967 and a new era dawned on rabbit control in New Zealand. The APDC introduced a policy of sustained control in 1972 rather than eradication, as it was becoming evident that eradication was not viable and acceptance of the current situation was set to continue for some time into the future (Godfrey, 1974).

A policy of sustained control was followed, largely unchanged within differing methodologies, but always with a heavy reliance on toxin application combined with some follow-up secondary control. In some areas an annual program of shooting was in place but it was later shown to be ineffective, as some populations were self-regulating with natural predators, thus efforts and resources were being largely wasted in these areas (Robson, 1993).

By the late 1970’s and early 1980’s a new emphasis on the actual costs and benefits of rabbit control emerged as the predominant focus. The 1980’s saw progressive removal of agricultural subsidies for farmers. Previously government contributions amounted to between 50-85% of actual control costs (Williams, 1993). With the progressive removal of subsidies during the 1980’s and therefore shifting of costs to those directly benefiting from rabbit control, the full cost burden of rabbit control became painfully evident. It was clearly uneconomic for many farms to control rabbits to the same levels as those funded by subsidies, resulting in the proposal for the introduction of the myxomatosis virus as a solution (Williams 1993). The Parliamentary Commissioner for the Environment (PCE) was lobbied for the introduction of myxomatosis, however, the PCE recommended a more holistic approach to rabbit management rather than introduction of another control technology. This in turn led to the governmental proposal for the introduction of the five year Rabbit and Land Management Program (R&LMP) and the Rabbit and Land Management Task Force (Rabbit & Land Management Task Force, 1988) which started in 1989. The R&LMP was the culmination of a 10-year political debate over who should pay and an attempt was made to unravel the whole land use, land management and ecological and environmental complexity surrounding rabbit management in New Zealand.

Up until 1989 a lack of clear goals and objectives around effective rabbit management drew much criticism. In 1959, the killer policy was translated into an eradication policy that was retained until 1971. Eradication as an objective was technically unachievable. In 1971, the Pest Destruction Boards then had an objective of maximising the control effort using the most effective methods to prevent an upsurge in infestation of rabbit-prone land. This lacked an objective measure of success with little thought given to a long term objective and the reality was that this approach became more a case of, spend as much as possible to control rabbits through subsidies and farmer inputs, with the belief that any rabbit killed achieved the overall objective.

The lack of clear objectives resulted from farmers developing policies and practices through their heavy involvement in Pest Destruction Boards while the Government carried most of the costs without measurable accountability of success. Pest board staff became increasingly isolated from farming management. In turn, farming goals were alienated from pest management and a holistic approach was lacking. The R&LMP sought to solve this disconnection of the two.

The Rabbit and Land Management Program was largely built on four broad principles:

1. An advisory committee was established to shape and develop the program based on previous knowledge and experience.
2. A subsidised rabbit control and land management program was developed around a whole farm plan with the aim to integrate rabbit management into overall farm management. This facilitated a transition away from a subsidised system in the future by identifying an integrated management approach.
3. A consistent monitoring program was established to determine the outcomes of the program on the biophysical, economic, social and institutional components. Monitoring contained an extension component to report findings back to all stakeholders.
4. Research was conducted on a "whole system" approach incorporating aspects of predator/prey dynamics, farm systems, regional planning and information transfer. Research was designed to find methods around limitations to farming in rabbit prone lands. Some of these methods looked at alternative land use. This was extended to identify societal attitudes to pest control methods, institutional impediments to alternative land use, effectiveness of resource protection legislation and the economic outlook for rabbit prone lands (Williams, 1993).

With the devolution of the Agricultural Pest Destruction Council to regional councils and the systematic removal of governmental financial subsidies, it was recognised that Central Otago and parts of inland Canterbury and Marlborough still had a severe rabbit problem. It was also recognised that there should still be government support for controlling rabbits, which the Rabbit and Land Management Programme fulfilled until 1994. Unfortunately, the R&LMP only addressed the rabbit problem on some properties. In Otago for example, only 57 properties were included and this represented only 111,000ha of some 300,000ha of land needing extensive rabbit management initiatives. This created a situation of the "have and have not" resentment between farmers. The program was successful in developing a sense of ownership of the problem for many of those included, but it failed to generate the same response for those not included. It was suggested that the five year timeframe was very ambitious and a 10-15 year timeframe may have been more meaningful and realistic (Mulcock, 1993).

## 1.3 Distribution

The current distribution of rabbits (*Oryctolagos cuniculus*) throughout New Zealand is described in terms of proneness of land to rabbit infestation, being based on historical evidence of rabbit infestations. These areas have remained largely unchanged with the exception of areas that have had major habitat modification through means such as irrigation and/or land-use change.

Areas most highly prone to rabbit infestation are areas of Marlborough including the Awatere Valley, Wairau Valley and coastal areas of Cape Campbell and Ward while areas in the Canterbury region are located in Kaikoura and North Canterbury with larger areas in the Mackenzie Basin in the Canterbury high country. Areas in Otago are widespread but located predominately in Central Otago. Some areas of Southland are also considered to be rabbit prone, but are relatively minor in scale. Some areas in the North Island have historically experienced rabbit infestations - these areas being primarily coastal with free draining, sandy soils ideally suited to rabbits.

A striking feature of all rabbit prone land is the relationship between elevation, rainfall and soil type. Almost without exception, rabbits thrive in low rainfall areas and up to an elevation of 900m ASL and in free draining soils, which are commonly described as semi-arid lands (Kerr et al, 1987).

## 1.4 Biology

Maximising the efficacy of any rabbit control operation requires a thorough knowledge of rabbit reproduction and natural regulation. This will ensure that control efforts are integrated with natural population cycles. Given that rabbit control is most effective outside the breeding season (Poole, 1963; Rowley, 1968), correct timing of operations is imperative. This will also ensure that behavioural and territorial effects do not interfere with an individual’s ability to encounter toxic bait (Fraser, 1988) which can be limited to an area of only 0.5 ha when alternative food is abundant. Territorial limits will expand with less food supply and is larger with males than females (Williams & Robson, 1985).

The breeding season of rabbits in New Zealand differs between regions. In Central Otago there is a marked breeding season between September and April (Fraser, 1988) reflecting the extreme environmental conditions of that region. Frequent heavy frosts from May to August limit pasture growth which is an important factor in successful breeding (Myers & Poole, 1962). Elsewhere in the country such as North Canterbury, Wanganui and the Wairarapa, monthly pregnancies rarely fall below 20% (Gibb et al, 1985; Williams & Robson, 1985). During the breeding season, pregnancy rates across rabbit prone regions in New Zealand appear to be very similar (Gibb et al, 1985; Williams & Robson, 1985) with highest rates of pregnancy between September and February.

Age of sexual maturity is approximately six months. The implications of this for breeding in Central Otago are that very few rabbits are breeding in their season of birth. In other regions, more females can become pregnant due to a less restrictive and the longer breeding period.

Male fertility follows a distinct annual cycle in Otago of maximum activity through the period September to February while other regions fertility rarely falls below 40% (Williams & Robson, 1985). Male fertility has been shown to be closely correlated with weather conditions and food availability (King et al, 1983).

Maximum female fertility appears to be between 12-17 months of age. Fertility is positively correlated with carcass weight. Individuals in the 12-17 month age group also have the lowest prenatal mortality indicating this group of individuals had a greater reproductive potential (Fraser 1985) and is therefore making the biggest contribution to maintaining populations of rabbits.

Gestation takes 28-30 days with young suckled for approximately 21 days. Young are fed once every 24 hrs with feeding being very short in duration (only a few minutes) and occurring in the early evening. Litter size is variable dependent on female age but ranges from 3-4 for young females to 5-8 for adults (Williams & Robson, 1985). In terms of productivity, which is an expression of the number of young per adult female per year, New Zealand has been shown to have some of the highest levels of rabbit productivity in the world with an average of 47.6 young per adult rabbit (Williams & Robson, 1985) under ideal conditions such as the Wanganui Coast and the Central Plateau. Productivity however, has little bearing in terms of rabbit management because it is the subsequent survival rates from birth to 2-3 months that is an important factor.

Accordingly, control efforts will have greatest success in the March to August period when a lack of breeding reduces the territorial and social hierarchy impediments to individuals encountering toxic baits. Furthermore, control efforts must be timed to ensure that a good bait take is achieved through limited alternative food supplies being available. It must be noted that control efforts or control strategies are indiscriminate in the age or sex of rabbits killed. It is not possible to target a particular sex or age group for control.

## 1.5 Chapter One - Key Points

- In 1997 RHD was introduced (illegally) to New Zealand as a tool to manage bourgeoning rabbit populations. This biological agent now appears to be diminishing in its efficacy in many regions.

- Rabbit management must have a long-term goal to permanently reduce rabbit populations. Many rabbit management programs represent a form of crisis management with no long-term goals or objectives. An alternative program of strategic sustained management has been shown to be an effective method of achieving this goal. Strategic sustained management uses primary control initially to bring a population into control but then relies heavily on secondary control techniques to maintain those gains.

- Collective action is imperative to achieving a program of strategic sustained management. One of the most important lessons learned from the past is that stakeholders need to understand each other's needs. Ownership of the rabbit problem must remain the responsibility of land managers and land management decisions must be made with consideration of the effects they will have on overall rabbit management.

- Developing an effective rabbit management strategy is a long-term program. Such a program needs >10 yrs to be given a chance to yield any real results.

- Rabbits are distributed in areas of low rainfall and free draining soils. These areas are described as being "Rabbit Prone".

- Primary control efforts will have their greatest success when a lack of breeding reduces rabbit's ability to encounter toxic baits through territorial behaviour. Timing is important to ensure bait is taken in sufficient quantities. This timing must coincide with limited alternative food supplied being available. March to August represents the ideal rabbit control timing for primary control efforts.

## 1.6 Research Summary

Rabbits are continuing to be a problem in New Zealand. There is a long history of research on rabbits, which is valuable to land owners and management agencies. Much of this information is scattered widely through various research papers. It is the overall aim of this dissertation to pull together much of this information and to provide not only the writer, but also land managers, biosecurity staff and Regional Councils the opportunity to have this information in one document to help them better understand the topic of effective rabbit management in New Zealand in the post RHD environment.

The aim of this dissertation is to assess the literature on this topic and critically review our current practices. Examples of programs that are having clear successes have been covered to try to ascertain what made the difference in those situations and where possible, what can be duplicated at other sites or regions. Much of this was restricted to the Otago context to fit within the scope of this dissertation's academic parameters and the writer's resource and time constraints.

A more effective and alternative management approach was sought given that the current approach as widely adopted, appeared in many instances to have done little to solve the rabbit problem or reduce the financial burden it imposes. To this end the following chapters look at a range of topics that are of value to effective rabbit management.

The information contained within this dissertation is as far as possible drawn from literature within the New Zealand setting to maintain relevance to the target audience. Much of the information is sourced from key personnel involved in rabbit management both currently and historically. This material was compiled using the writer's experiential knowledge and observations while engaged in first hand rabbit management in Otago.

# Chapter 2

# Natural Population Dynamics in a Post RHD Environment

## 2.1 RHD Effects and Trends

With the introduction of RHD in 1997, rabbit populations were decimated in Otago and other regions and a great success was hailed, but it soon became apparent that RHD was not the “silver bullet” many farmers had hoped it would be. An understanding of the viral epidemiology of RHD in relation to rabbit age at exposure will make this situation clearer.

Rabbits have four possible responses to a RHD epidemic:

### 2.1.1 Juvenile Immunity

Juveniles are not fully susceptible to RHD up to approximately six weeks of age. If exposed to the disease within the first six weeks they will generally overcome the disease and exhibit lifelong immunity. RHD has been shown to bind histo-blood group antigens (HBGA) and non-secretor individuals lacking ABH antigens in epithelia have been found to be resistant to infection (Cooke, 2002; Nyström et al 2011). The antigens in the mucosal cells of the juvenile rabbit’s gut and upper respiratory tract only become fully functional when the rabbits reach approximately six weeks of age. Prior to this age RHD virus is prevented from binding (Cooke, 2002).

### 2.1.2 Juvenile Passive Immunity

Juveniles in the 10-15 week age group appear to have sufficient transitory, acquired or passive immunity from maternal antibodies to enable them to mount a successful immune response and survive. Young rabbits acquire maternal antibodies across the placenta which occurs in the last few days of pregnancy by active transport across the yolk sack. It has been demonstrated that young rabbits retain these RHD maternal antibodies for up to 12 weeks of age (Cooke et al, 2000).

### 2.1.3 Adult Passive Immunity

Adults previously exposed to virulent strains of RHD as juveniles are usually able to mount a successful antibody response. If rabbits recover from RHD exposure the antibody titres rapidly peak within two weeks then decline. There is now good evidence that rabbits are readily re-infected which has been demonstrated by high antibody titres throughout the year (Cooke et al, 2000).

### 2.1.4 Adult Non-immunity

Death will be the result when susceptible adult rabbits are exposed to a virulent strain of RHD and are unable to mount a successful immune response.

Determining the best management option will be dependent on how successful the RHD epidemic was at reducing the population. If after an epidemic a large population is still present it may necessitate the implementation of a primary control program involving toxin application. As the efficacy of RHD diminishes within the population, the need to increase secondary control measures will become more important to minimise the number of survivors. Such survivors will have the capacity to breed and create a population with heritable factors that diminish the efficacy of RHD.

All effort must be made to minimise the levels of RHD immunity in the rabbit population to ensure epidemics are able to have the greatest effect on the remaining population to duplicate the successes that were recorded with initial RHD releases. The population which most closely resembles the naïve pre RHD state will gain the best results from future epidemics. It is also vitally important to maintain predator populations as these have a strong impact on residual rabbit populations and removal of RHD resistant rabbits (Reddiex et al, 2002).

**Benign Rabbit Calicivirus Disease (b-CV) – Implications for Bio-control agent RHD.**

Results of tests conducted by the Rabbit Calicivirus Disease (RCD) Application Group (RCD being the disease, rabbit calicivirus commonly referred to as rabbit haemoragic disease [RHD] due to its mode of action) revealed that at least one strain (probably more) of rabbit calicivirus was widespread in New Zealand prior to the illegal introduction of the virus in 1997 (Lough, 1998). A benign virus (b-CV) has the potential to influence the efficacy of the virulent strains. Tests conducted in Great Britain have indicated that all wild rabbits carrying antibodies to RHD, have survived when challenged with the virulent strain of RHD (Cooke, 2002). This has the potential of a b-CV providing protection against the virulent strain which has been confirmed by field testing in various locations (Mutze et al, 2010). Evidence confirms that antibodies produced against b-CVs do indeed provide significant protection against RHD outbreaks in field populations of rabbits. The implications of this, is that b-CVs can greatly reduce the impact of RHD on wild-rabbit populations, and RHD epidemics in the presence of b-CVs are likely to have minor or inconsistent benefit for controlling rabbit numbers. The influence of such viruses indicate a possible explanation for the seasonal and geographical variability in mortality that was noted in the initial spread of RHD through the Australian rabbit population (Henzel et al, 2002).

**RHD - Implications for Conventional Control**

Legal obligations of landholders to control rabbits under a Regional Pest Management Strategy (RPMS) are based on an index of rabbit abundance determined by the Modified McLean Scale. This is underpinned by the knowledge that if rabbits reach the compliance trigger level, initiating a control program is justified because the predicted damage caused by rabbits would outweigh the economic costs of the control operation. However, this logic has now become heavily blurred and is dependent on whether RHD works at a site and/or to what degree. This is largely influenced by levels of immunity and a suite of environmental factors that impact on the field epidemiology of the disease. It may be that rabbits are kept in check by RHD to the extent that implementing a rabbit control program involving primary control would no longer make economic sense or the level of rabbit infestation is no longer in breach of the RPMS.

## 2.2 Natural Mortality and Disease

High levels of natural mortality in lowland improved and semi-improved pastures are capable of creating a stable rabbit population in the absence of control efforts. This is largely due to high juvenile mortality, disease and predation acting on the population in this environment (Williams & Robson, 1985). Prior to the introduction of RHD, natural mortality from drowning as a result of the combined factors of rainfall and soil type can be a major contributor to juvenile rabbit deaths at some sites. This, combined with predation can result in as little as 13% of litters being weaned successfully in lowland improved pastures (Robson, 1993).

Parasitic infection from liver coccidiosis is a natural cause of disease among rabbits and while it could contribute to mortality, its incidence is rare in semi-arid regions (King, 1990; Robson, 1993). Even in lowland, higher rainfall environments more suited to the disease, it has been shown (Henning et al 2008; Robson, 1993) that the disease is rarely evident and that disease from factors other than RHD are insignificant as a mortality agent with most young dying before they are susceptible to coccidosis (Thompson & King, 1994). Though diseases other than RHD are able to reduce rabbit populations it is only an important factor when populations are dense and conditions damp (Robson, 1993).

## 2.3 Predation

In areas of improved-lowland pastures, populations of rabbits are maintained to a large degree by both predation and natural mortality both before and after they emerge from nests (Robson, 1993). In semi-arid areas pre RHD, it has been shown that predation merely limits and does not regulate the population (Gibb & Williams, 1990) due to the decoupling effect of rapid pulses in rabbit seasonal breeding that cannot be matched by predator abundance. In the post RHD environment this situation is altered to one where the combination of RHD and predation are capable of reducing the population to a level more within the range of densities at which natural predation is able to regulate the population (Reddiex et al, 2002).

Predators play a key role in maintaining the overall efficacy of RHD by removing surviving immune rabbits in an area. Areas that conduct predator control (i.e. ferrets) such as for reduction in the transmission of bovine tuberculosis, run the risk of affecting the efficacy of predation by reducing densities to a level where they are not able to make a real impact on the rabbit population. This will result in enhancing the recovery rate of rabbits between epidemics and result in higher levels of immunity within populations.

Predation comes from a host of species including ferrets (*Mustela putorius furo*), cats (*Felis catus*) and the harrier hawk (*Circus approximans*). Of these species, cats have the greatest impact on adult rabbit populations while ferrets appear to have the greatest impact for juvenile rabbits due to their ability to dig out the breeding stops (Henning et al, 2008). Hawks do not appear to have a great impact due to their poor success, specifically in catching adult or reproductive rabbits (Gibb et al, 1978).

One study (Henning et al, 2008) has indicated that 40% of mortality was from predation. Deaths from RHD and other natural causes accounted for similar rates (20% and 19% respectively). This indicates predation has the potential to be comparable to RHD and natural mortality in the scale of effect and that predation should not be underestimated as a relevant mechanism of control. Predation is therefore most specifically relevant in maintaining low-density populations at stable low levels in the presence of RHD.

## 2.4 RHD Field Epidemiology

With RHD now playing an important role in regulating rabbit populations, a thorough understanding of the field epidemiology of RHD is essential for effective rabbit management. There are a variety of factors that have to be present in order to ignite a large-scale RHD epidemic such as: 1) a susceptible rabbit population of such density that will create sufficient contact to facilitate viral spread. 2) the abundance of non-rabbit vectors (flies, *Calliphora spp*) that also have the ability to spread the disease, and 3) suitable environmental conditions and yearly timing. The combination of these factors will affect the temporal and geographic spread of RHD.

It is difficult to precisely observe epidemics of RHD because rabbits do not show any outward appearance or behavioural changes until approximately 12 hours before death. Rabbits have been shown in experimental trials, (Cooke, 2002) to be eating grass until shortly before their death with some even having fresh grass in their mouth, indicating death is sudden. Experimental trials also indicated that 75% of rabbits died underground in burrows (Cooke, 2002) making field observations problematic.

The initial spread of RHD in New Zealand was in Otago. This was by deliberate release in 1997 and the New Zealand Ministry of Agriculture officially confirmed the presence of RHD on at least one farm on 23 August 1997 (Thompson & Clark 1997). This occurred despite a government decision not to allow the disease to be imported or released as a bio-control agent for rabbits (O'Hara, 1997). Initial indications were that the disease was a success and populations in some areas reduced by up to 90% (Cooke, 2002). However, the manner of release meant it was not well coordinated and follow up treatments not planned in a coordinated manner. Subsequently, rabbit populations in some areas have steadily expanded. Levels of immunity have increased resulting in the need to return to conventional control measures in many areas.

After RHD epidemics, where mortality levels are low, it is essential to remove immune survivors before there is potential for these individuals to breed. This will allow a two-fold effect of retarding the potential for the population to increase due to a reduced overall population size and the efficacy of the next epidemic will be enhanced due to less passive or acquired immunity within that population.

For the first three years of RHD epidemics in Otago there was evidence that the virus had two clear peaks of activity in one year; one in early summer and the other in autumn. It is important to note that at very low densities RHD epidemics could easily occur unreported or even unnoticed. Evidence now indicates that RHD epidemics are unpredictable, irregular and intermittent at annual or biannual intervals (Parkes et al, 2002). This further complicates the ability of land managers to effectively plan rabbit control operations and in some instances such control operations could be killing rabbits that would have died already from an RHD epidemic. This is especially relevant where an epidemic occurred in late autumn when control operations were well into the planning phase.

The virus is spread between rabbits by oral, nasal or parental transmission and is also excreted in urine and faeces. Rabbits can remain infectious for up to four weeks if they are able to survive that long (Cooke & Fenner, 2002).

Insect vectors have been shown to be an important means of virus transmission with blowflies (*Calliphora spp.)* playing a key role. A total of eight blowfly species have been identified as potential vectors of the RHD virus (Henning et al, 2005). The virus has been detected in flies up to nine days after they were fed infected liver. Fly faeces (fly spots) play an important role in virus transmission. Fly spots can contain 2-3 times the lethal dose ($LD_{50}$) of RHD virus for a rabbit. The method of transmission is mechanical as it has been shown that maggots feeding on RHD infected rabbits and the subsequent flies that developed from those maggots, did not contain the virus (Asgari et al, 1998).

Fly activity is closely related to season, temperature and environmental conditions and may help to further explain the field epidemiology of RHD which follows the same pattern. In Australia, flies have been implicated with the initial spread of RHD. The rate of spread shows a seasonal pattern, being over 50 km/week in the spring and autumn, but somewhat slower in the summer and winter (Kovaliski, 1998). Similar results have been observed in New Zealand (Henning et al, 2005) and analysis of climate at this time (Smyth et al, 1997) also suggests that the virus spreads most rapidly when maximum daytime temperatures are between 15°C and 32°C (optimum 24°C) coinciding with peak fly activity (Norris, 1966).

The high rates of spread recorded and the thoroughness of spread in uninhabited areas of arid inland Australia implied common winged vectors were the source of spread, which was also similar to results obtained in New Zealand (Heath, 1999). Flies disperse widely whereas rabbits are relatively sedentary and territorial. Transmission by rabbit-to-rabbit contact cannot explain the observed rate of spread of the virus. Some observers have described the spread of the disease as being, “like it spread on the wind” which is consistent with insect vectors movements.

Environmental conditions in spring and autumn coincide with warm, damp conditions which may enable the persistence of the virus in fly spots. There is also possibility of the more random spread being associated with rain events and suitable environmental conditions. There is also the possibility that conditions may not all be present at the right time at a location meaning an epidemic may not occur, making epidemic prediction problematic.

Relative fly abundance may influence RHD virus transmission and it appears that peaks in fly abundance do correspond to the occurrence of RHD epidemics in the New Zealand context. Dynamics in fly populations are complex but evidence exists to link field epidemiology of RHD to flies, however, this needs to be viewed within a geographic and climactic context. There is also evidence that the combined factors that are required to be present to ignite a large-scale RHD epidemic may not occur in a given season. If this was the case, and is combined with ideal rabbit breeding conditions and decreased mortality throughout the winter period, it could lead to a situation where a population that was stable under a predation/RHD/natural mortality model could soon become a population requiring conventional control mechanism of toxin application to bring the population back into a stable state.

### 2.4.1 RHD Effects on Rabbit Rates of Population Recovery

Timing of RHD epidemics is important to rates of population recovery among rabbits. At some sites (most notably Central Otago and the Mackenzie Basin, Canterbury) rabbits do not breed continuously, but breeding is associated with periods of pasture growth associated with spring and autumn. The consequence of this is that susceptible rabbits reach highest numbers in the spring months. This picture becomes complicated when a RHD epidemic coincides with the spring population explosions (as it often does) because this facilitates a large population under the six week threshold where young rabbits lack the receptors to facilitate lethal infection to RHD (Guillon et al, 2009; Nyström et al, 2011). While these rabbits may not breed in the first season due to age of sexual maturity being approximately 6 months, there is scope for breeding to occur in the following season or for breeding to occur if there is a mild or slow onset to winter.

These rabbits will be immune to RHD and this presents a management problem. Not only is there a large population that is immune to RHD in the subsequent breeding season, but there is also the ability of those immune parents to pass passive immunity over the placenta to create a population with immunity and that will have immunity boosted by subsequent exposure to RHD when epidemics do occur (Cooke et al, 2000). This may explain to some degree why populations in some central Otago locations are now reaching high levels of immunity in the 70-100% range. The implications for management are obvious when age-specific immunity is considered. The effect of RHD on the population is reduced because sufficient numbers of young rabbits survive to maintain a breeding population and the rate of population recovery will be greatly increased which will be exacerbated by favourable environmental conditions.

In a study conducted to establish if conventional control could reset the effect of RHD by reducing the number of immune survivors to initial RHD levels (Parkes, 2009), the results indicated that conventional control does not have a significant effect in resetting RHD in immune populations. In fact the percentage of immune surviving rabbits was shown to be twice that of initial RHD epidemic levels where conventional control was conducted and the percentage of adult rabbits with immunity remained high among the survivors of the poisoning event. The observed fall in juvenile immunity levels was not due to transmission from mothers because the percentage remained unchanged. However, this lower level of immunity in juvenile rabbits is better explained by a lower prevalence of the virus in the environment, resulting in lower incidence of infection in the juvenile population.

### 2.4.2 RHD Implications for Management Decisions

If no RHD epidemic is experienced in a given season or geographic area it is assumed (within natural mortality and predation parameters) that such a population would be expected to increase in the absence of conventional control. The situation where no epidemic occurs is unlikely, as it has been shown (Parkes et al, 2000) that all populations tested throughout New Zealand have antibodies to RHD virus indicating some level of exposure has been encountered in the past and that this is potentially able to be repeated.

A more likely situation is the possibility that an RHD epidemic is encountered and that the RHD epidemic only limits the population growth. In this situation it would be expected that population declines are experienced where previously increases would have been seen, or that increases are markedly slower than was experienced in the past. It must be noted that human-induced control on top of the effects of the biological effects of RHD may not result in any real gains. This has been shown to be the case in Earnscleugh station (Parkes et al, 2000) which had this situation of no population increases even in the absence of human induced control such as sustained secondary control. This situation needs to be viewed with caution and all factors need careful evaluation. The outcome is most probably explained by the holistic approach to rabbit and land management practices and the influence this has had on rabbit populations at this site.

The correct management approach in terms of the effects of RHD leaves the land manger with only two management approaches: Firstly, a proactive approach could be employed in initiating control strategies, however, this risks killing rabbits that would have died naturally as a result of RHD and so potentially wastes financial resources. Secondly, a reactive approach could be employed, but this risks facing severe damage caused by a rabbit population explosion and a larger potential problem as the population spreads out from most favourable sites which would cost more to control in the long run.

Possibly the optimal approach is one of monitoring the population carefully and being ready to implement population control if a certain threshold is breached irrespective of the RHD status. Any control effort will never be totally wasted because a population sitting on the brink of a critical threshold of population explosion is unlikely to revert to one of a very low density even in the face of RHD. It's not so much a matter of *if*, but *when* the population will require controlling. It is the difference in the cost of the means of that control that needs to be addressed on a site-by-site/case-by-case manner.

Another potential scenario may also be present. This situation is one where rabbits are increasing despite the presence of RHD epidemics. This comes through a variety of potential causes, such as high levels of immunity and/or favourable environmental conditions (mild winters and unseasonal grass growth in mid-summer dry periods). Favourable seasonal conditions may result in RHD killing rabbits but the recruitment rate then outweighs the mortality and other factors such as predation cannot respond fast enough to the situation. Clearly this situation will require conventional control strategies of either primary or secondary control to be implemented.

In consideration of the above, the failure of RHD to regulate rabbit populations and making a decision on when to activate a control strategy is a complex problem. There are a variety of factors acting to create this situation. A site may have a unique environmental predisposition that is not suited to RHD epidemics. RHD may still occur but in a limited capacity resulting from levels of immunity due to pre-existing viruses (Mutze et al, 2010). Differences in route of infection may also play a key role and is potentially density dependent. Each site needs to be evaluated on its own merit and historical information will help predict the correct management approach to take.

## 2.5 Seasonal Population Dynamics

Rabbit’s exhibit seasonal population dynamics closely linked to seasonal breeding episodes and food availability, both of which are closely linked to environmental conditions. The rabbit's basic reproductive strategy is best described as opportunistic, taking advantage of favourable environmental conditions. The ultimate size of a rabbit population then becomes a function of productivity and survival rates.

Not all geographic areas exhibit the same population dynamics given the differential environmental conditions between sites in New Zealand. In Central Otago, one female rabbit will produce approximately 25 young during the breeding season (Fraser, 1985) with a marked breeding season being evident between September and April (Fraser, 1988). Frequent heavy frosts from May to August in Otago limit pasture growth, which is an important factor in successful breeding (Myers & Poole, 1962). In contrast, a female rabbit in lowland, wetter habitats produce 45-50 young/adult females over an eight to nine month breeding season (Gibb et al, 1985; Williams & Robson 1985). In some areas such as North Canterbury, Wanganui and Wairarapa, monthly pregnancy has been shown to rarely fall below 20% (Gibb et al, 1985; Williams & Robson, 1985).

Survival rates differ markedly with lowland areas having very high juvenile mortality rates and populations in these areas being generally stable, compared to rabbits in Central Otago, which have much lower mortality rates.

The seasonal population dynamics and the rabbit's reproductive pattern is determined by the timing of the main breeding season which is ultimately determined by the availability of adequate food (Gibb et al, 1985; Williams & Robson, 1985). Variations in aspects such as the onset, duration, and productivity of the breeding season are produced by a complex set of environmental factors, acting differently in different environments. An increasingly longer breeding season is becoming evident as a result of milder winter conditions. Winter mortality has also decreased as a result of milder environmental conditions creating a twofold population phenomenon from increased breeding leading to increased productivity.

## 2.6 Dispersal

Rabbits have high rates of natural dispersal which also creates a potential problem for control operations. Areas that are subject to primary control can create a vacant niche for adjacent areas containing high populations that are readily dispersing. The resulting vacant warrens provide an ideal area for repopulation.

Rabbit-proof fences can mitigate this to some degree but invariably rabbit fences only act as a control barrier to work to with control operations, but not as a complete rabbit proof barrier as these barriers are often breached. Rabbits under pressure will inevitably find a way through, over or under a rabbit barrier. In fact, the terminology "rabbit-proof fence" is somewhat misleading to those familiar with rabbit's tenacious efforts and abilities to breach these barriers. Effective rabbit control is therefore problematic in an area with high adjacent rabbit densities. Geographic boundaries such as rivers make for more long-lasting barriers in many cases.

Dispersal is thought to be a population regulation mechanism (Henderson, 1981). It has been shown that a population density in an enclosure increases much more than one outside an enclosure even when predation was acting equally on both sites (Gibb et al, 1969). Rabbits will disperse from warrens with high rabbit density to areas of lower density and from an area of high juvenile production to areas of lower production (Henderson, 1981). Most dispersal is to adjacent social systems but movements >20km by individuals have been recorded (Douglas, 1969). Between 36–72% of males and 8–30% of females breed in warrens that they were not born in (Mykytowycz & Gambale, 1965), indicating dispersal is a strong mechanism acting on a rabbit population.

Core ranges and home ranges are factors influencing dispersal. The home range is an area that is habitually used but not necessarily defended and may overlap between individuals. Within the home range there may be a core range that generally no other individual uses. The home ranges often overlap while the core range is more exclusive. Core ranges of 0.54 ha for males and 0.57 ha for female surface-dwelling rabbits have been calculated (White et al, 2003). Core range areas are larger for males than females in winter when mating activity begins. Home ranges will increase when resources become scarce. Significant differences in home-range size between sexes has been observed with males increasing their movements towards females during breeding periods (Henning 2003).

Home ranges have been recorded between 2.6 ha (minimum) with largest being 6.5 ha for males and 4.5ha for females. Home range size is heavily influenced by habitat and distribution of available food (Gibb, 1993) and will be expected to fluctuate seasonally.

The impact of dispersal must not be overlooked in developing effective management plans for rabbits. Control operations should be coordinated and timed to ensure the effects of long distance dispersal is minimised and to ensure areas controlled are not readily repopulated. In most instances a rabbit barrier such as a rabbit fence will be the only mechanism to minimise repopulation of an area. This will be particularly important in summer months when food resources become scarce on rabbit infested neighbouring properties.

Dispersal may also be an important mechanism for RHD transmission. Surface dwelling, subordinate and dispersing juveniles are susceptible to predation and their carcases are readily available for mechanical transmission of RHD.

## 2.7 Habitat Modification

Ideal conditions for rabbits will favour their increase and the converse is also true. Habitat modification can be an effective means of reducing rabbit density. It has been historically noted (Howard, 1958) that post-poison pasture management of lowered stock grazing resulted in a lengthened grass sward that was not conducive to rabbit population recovery. It is also noted that habitat management has become the most common successful technique in restoring rabbit populations in Mediterranean ecosystems (Ferreira & Alves, 2009) so the converse techniques are obviously worthy of consideration where rabbit numbers are needing to be reduced.

Rabbits are known to be ecosystem engineers (Gálves et al, 2009) capable of creating and sustaining an environment conducive to their success (Ferreira & Alves, 2009). Once rabbits reach peak abundance they are capable of producing modifications to the landscape structure by themselves, by maintaining a network of warrens and maintaining a short grass sward near the warren that best suits their needs.

Availability of food and shelter combine to influence rabbit abundance, but the pattern of activity and aggregation will have a bearing on the survival probability.

### 2.7.1 Surface Harbour Clearance

Surface harbour of scrub, briar *(Rosa rubiginosa)*, rocks and timber debris will allow rabbits to remain above ground and makes some forms of rabbit control such as fumigation and warren ripping problematic as a management technique. Surface harbour removal will eliminate this habitat option. It will also increase predation by allowing predators' easy access to rabbits. It will expose rabbit populations to inclement environmental conditions and enables land managers to use rabbit control techniques with greater success by ensuring baits are readily delivered to the target species.

Scrubland on its own often presents a situation of low foliage abundance and quality. Conversely, grassland has the potential to reduce protective cover, but allows high quality and quantity food resources. It has been demonstrated that rabbits reach their highest abundance where there is a combination of both adequate cover and ideal quality forage material which is able to be maintained in a modified state of short sward by rabbit density and browsing pressure (Lombardi et al, 2003). Limiting the shelter and food possibilities of rabbits will ultimately reduce the success of rabbits to re-colonise areas that have had control treatments applied. This may systematically reduce their abundance and distribution over time in an area.

Removal of surface harbour may also mean rabbits are not as widely spread over an area, but become aggregated into larger warrens. This sort of aggregation has been implicated in facilitating the spread of diseases and viral epidemics such as RHD (Lombardi et al, 2003).

### 2.7.2 Irrigation and Development

Habitat modification can be implemented in improved high production lands where alternative land uses are available. The development of dairy farming and vineyards on properties in Central Otago have turned historically rabbit-prone lands containing short tussock and native scrub, into high-producing environments not suited to rabbits and economically able to sustain ongoing intensive rabbit control programs when necessary. Habitat modification is an alternative to ongoing rabbit control programs and is often a twofold gain, by reducing suitable habitat and by increasing productivity at the same time.

Dairy farming and dairy support has increased the number of properties that are able to develop intensive irrigation systems that create an environment similar to lowland environments that see higher levels of mortality, predation and disease.

Habitat modification through development is only possible in areas that are not being maintained for conservation or biodiversity purposes and so may be a limited option for many protected natural areas, riparian zones and urban sustainability areas or where the natural ecosystems are being maintained intact for their ecosystem services and/or amenity values.

## 2.8 Chapter Two - Key Points

- After its illegal introduction 1997 it soon became apparent that RHD was not the silver bullet many land managers though it would be. Levels of immunity became apparent with some juveniles acquiring lifelong immunity to RHD while other individuals developed degrees of immunity that were able to be passed on to juveniles (across the placenta from females to young) and bolstered up in the adult population by continued exposure.

- Effective rabbit management must ensure levels of RHD immunity are kept at a minimum within the population to ensure that when future epidemics do occur, the population is as close as possible to the naïve population prior to the introduction of RHD.

- If benign rabbit calicivirus disease (b-CV) is found in New Zealand this will have a major negative impact on the ability of RHD to control rabbit populations in the future. Epidemics in the presence of b-CVs are likely to have minor or inconsistent benefits for controlling rabbit populations.

- RHD has complicated conventional rabbit control programs that are using primary control through toxin application. This comes about through RHD potentially reducing the population to a level that no longer necessitates primary control. RHD therefore makes planning rabbit control programs (something that takes a long period of time if carrot is required to be grown) problematic.

- Historically natural mortality through disease and predation has struggled to maintain rabbit population levels at acceptable limits. In the post RHD environment this situation is now capable of maintaining rabbit populations at low levels, negating the need to implement control strategies in some cases. Predation coupled with RHD are the key factors in this equation.

- The field epidemiological factors of RHD needed to initiate an epidemic include a susceptible population, abundance of vectors (mainly flies, *Calliphora spp*) and suitable environmental conditions/annual timing. RHD is spread between rabbits by oral, nasal or parental transmission. It is also excreted in urine and faeces. Insect vectors are the most important non-rabbit vectors and fly spots are a key component of activity. Fly activity is heavily influenced by seasonal environmental conditions.

- The optimal approach to rabbit management in the post RHD environment is one where populations are monitored carefully and a control program is ready if a population breaches a determined threshold. This avoids initiating a program of control where rabbits would have died naturally as a result of RHD which wastes resources, or not being ready to react quick enough and having to deal with a potentially larger population which is readily dispersing

- Rabbits generally exhibit seasonal population dynamics. These dynamics need to be understood for any specific control area to ensure monitoring and rabbit control efforts are timed correctly.

- Rabbits readily disperse when in high population densities. While dispersal is an important mechanism of RHD transmission, populations need to be kept at low levels to prevent dispersal and the exacerbation of the rabbit problem to neighbouring areas.

- Habitat modification is an effective mechanism of reducing rabbit's chances of success for survival and reproduction. Where possible, the clearance of surface cover will aid in limiting rabbit's success by exposing them to the environment and predation. Land intensification through irrigation has a twofold gain by increasing productivity while reducing suitable habitat and environmental conditions.

# Chapter 3

# Management & Control Options

## 3.1 Current Management Options

Various rabbit management options have been used throughout New Zealand. With some areas of land, particularly in Otago having inherently low productivity, developing cost effective rabbit control is often questionable from an economic perspective (Kerr et al, 1993).

Dependent on the desired level of rabbit control and in a post-RHD environment, land managers are realistically faced with only four options on their land: 1) local eradication which is difficult and expensive to achieve; 2) periodic reactive control which lacks a long term objective to reduce rabbits and maintain those gains; 3) strategic sustained control which has a clear objective of sustained reduction of rabbit infestations or 4) doing nothing, which in some sites may be viable but won't be applicable in rabbit prone areas as rabbit levels will soon exceed levels in regional pest management strategy rules.

Best practice needs to be taken into consideration for each option along with a thorough evaluation of the ability of the method to meet the objective of reducing and maintaining rabbits at low levels.

### 3.1.1 Eradication

Eradication has thus far proven to be unachievable on a regional or national scale. The Rabbit Destruction Council, operating under the Rabbit Nuisance Amendment Act of 1947, historically implemented a program to eradicate rabbits almost regardless of cost, but the program was shown to be flawed and the government of the day moved away from this approach. Equity issues arise around criteria for public funding of programmes on private land (Working Party on Sustainable Land Management, 1994).

Efficiency is generally best achieved by targeting costs to those closest to a particular set of works (Environment Canterbury, 2008). This means the decision maker pays for the results of their action or inaction and shifts the power of ownership. Individual ownership of the rabbit problem will achieve good localised rabbit management, but does not facilitate regional or national eradication as it lacks a regionally or national coordinated approach. The need for collective actions and differing levels of commitment of various landholders makes eradication on anything bigger than an individual property problematic. Having high levels of rabbits on one side of a property boundary and low or free levels on the other, it will generally be a matter of time before infestation to free areas occurs. This makes eradication at a regional or national scale problematic. Eradication does have a clear objective to permanently remove rabbit infestation but the costs of such a program may exceed the benefits if re-invasion risk is high and gains cannot be maintained.

### 3.1.2 Periodic Reactive Control

Periodic reactive control will see the land manager allowing rabbits to reach a point where intervention is required at periodic intervals dependent upon rabbit numbers. The level of intervention will most often be in the form of primary control, using toxins to reduce high levels of rabbits in order to become compliant with rules set out in existing Regional Pest Management Strategies developed by the regional councils. It is a reactive management approach and does not demonstrate good pest management. It also has negative implications for the efficacy of RHD as a biological control mechanism by allowing a large population of rabbits, which has potential to select a RHD genetic resistant population much more likely. This control option is expensive to implement, as the control frequency is high. It could also lead to rabbits demonstrating neophobic behaviour where they develop avoidance to taking the toxic baits due to the frequent intervals of toxic bait application. This situation must be avoided as it has been shown that some rabbits are able to detect a poison bait event though 1080 is reported to be a colourless, odourless and tasteless toxin (Bell 1991).

### 3.1.3 Strategic Sustained Management

Strategic sustained management is a control strategy where heavy reliance is placed on on-going monitoring and control. It may require an initial primary control treatment to reduce rabbits to a very low level and then uses secondary control techniques to maintain these gains. The program has a clear objective to reduce and maintain rabbits at low levels and represents best practice for rabbit control. Additionally, a sustained program has the potential to have reduced input costs over time as rabbit numbers are constantly being reduced. The implications for RHD are good as the disease is still present in the population, but the population is not able to select for genetic resistance from a large pool of survivors with the numbers being continually reduced.

This approach allows the rabbit program to move away from such heavy reliance on primary control measures using toxins, associated negative social implications and reduces the risk of neophobic behaviour by rabbits that are repeatedly poisoned. Each year the rabbit population can be monitored and an appropriate level of control implemented. If the population is not systematically reducing to a very low level then the inputs need to be increased. Full advantage needs to be taken of natural mortality and RHD epidemics. Control efforts need to coincide with a low and stable rabbit population in winter, which also reduces the cost of this approach.

### 3.1.4 Do nothing - Population Self-Regulation

Doing nothing is not an option in rabbit-prone areas as these properties will rapidly become non-compliant with the rules set out in the Regional Pest Management Strategies (RPMS) developed by the regional councils. This may however, be an option for properties that have little or no risk from rabbit infestation. In many areas rabbit populations are self-regulating and natural mortality and predation will ensure rabbit numbers do not exceed acceptable levels (Robson, 1993). Due to this, not all areas in New Zealand have a rabbit problem (are rabbit prone) or require any level of intervention.

Farmers in some areas have taken the “do nothing” approach to the rabbit problem where low productivity of land means there is little economic sense in controlling rabbits. However, with rabbits having high rates of dispersal, there is a risk with this approach causing neighbouring properties to become infested. While this approach may make economic sense, it does not represent best practice and will fail any test of a RPMS. The large pool of rabbits that are not being controlled also promotes the potential for selection of RHD resistance.

## 3.2 Control Techniques

The aim of any effective rabbit management program is to permanently reduce rabbit density and to minimise damage caused by rabbits in a strategic, sustained manner. Habitat modification has positive benefits for reducing rabbit’s ability to succeed as well as in some situations creating productivity gains. The use of various control techniques, both primary control using toxins as well as secondary control to keep rabbit numbers at low levels are all part of a systematic program to reduce the impact of rabbits.

Rabbit control must also be viewed in the holistic context of land management so that appropriate land management practices can be adopted to reduce rabbit infestation. The integration of multiple rabbit control techniques will improve the overall effectiveness of the whole program (Cooke, 1981). There is no silver bullet for the rabbit problem. It requires all tools in the box to be employed to ensure the outcome is a sustained reduction in rabbit infestation over time and to avoid repeating of any of the steps that have already yielded gains.

### 3.2.1 Evaluate The Objectives

Clear objectives are required to ensure the approach taken for rabbit management is robust from all technical, practical and economic viewpoints. The major criticism of rabbit management in the 40 years up until the Rabbit and Land Management Program (RLMP) was that there were no definite goals and objectives for rabbit management in New Zealand. Additionally, there was no means to measure the success of programs that were being implemented (Williams, 1991). Any approach taken must be able to be proven to meet the long-term objectives of creating a sustained reduction in rabbit infestation. Any approach short of this risks leaving a landholder with a rabbit problem that carries considerable financial burden into perpetuity. The long-term cost of that sort of program will not be sustainable for most landholders and fails to meet best practice, humaneness or the best interests in reducing the resistance to RHD and avoiding neophobic bait avoidance.

### 3.2.2 An Integrated Approach

Integrated pest management (IPM) takes this process one step further and looks at an approach with four key aspects; biological controls, cultural controls, mechanical controls and chemical controls. IPM identifies three key foundational aspects; 1) Identification of the pest problem, 2) monitoring that problem and 3) identifying the economic thresholds. Economic thresholds may not be the same as the RMPS threshold, which can cause a conflict between objectives of the landholder and the regulatory authority.

An integrated approach aims to ensure the best use is made of various methods within a thorough knowledge of the efficacy of the methodology and the biology and ecology of the pest.

### 3.2.3 Timing

For rabbit control to be effective it is all about timing and monitoring. Rabbits need to be monitored to evaluate population increases and the status of RHD immunity. If the results of surveys indicate high levels of RHD immunity in areas historically prone to rabbits and poison application is required, this needs to be timed to gain the maximum efficacy of that method.

Treating rabbit populations when density is lowest will greatly improve the effectiveness of the operation. It will also, reduce costs in terms of product required and be more humane as aggregate suffering is minimised (Williams et al, 1995). Timing must therefore coincide with the correct seasonally low population dynamic of winter. This is when quantity and quality of food resources is low and rabbits will readily take bait. This will also ensure any poisoning will be most effective as rabbits are not readily dispersing and are less territorial as they are not breeding. This all means more rabbits will be likely to find and eat poisoned bait. However, with the shorter and warmer winters being experienced in some locations, especially the McKenzie Basin Canterbury and Central Otago, successful winter baiting is becoming more difficult to achieve.

### 3.2.4 Assessing Options

Site location will govern the availability of the tools available. It may not be possible to use the most effective method due to some social constraint such as the risk to pets and people. Knowledge of rabbit biology and ecology will ensure the right method is used at the right time of the year. Cereal baits applied to rabbits, which are no longer cereal feeding will have limited success, as will applying a carrot bait when food resources are still readily available and of high nutritional value.

The cost-benefit ratio will also need to be considered in terms of the benefits derived versus the costs of various control strategies. The conflict here is that the RPMS is not always consistent with the economics of a pest control program. Once the different options have been assessed there may be various mechanisms to deliver an effective program. Within those mechanisms there will be advantages and disadvantages that need to be further evaluated.

## 3.3 Mechanisms to Deliver Effective Rabbbit Management

The mechanisms employed will need to reflect the objectives being undertaken. For example, an eradication program will have a vastly different approach, delivery and use different mechanisms to that of a strategic sustained management program. The objectives need to be carefully considered to ensure they are achievable within the available resources at the disposal of the landholder or manager. The mechanisms will be different dependent on the level of rabbit infestation and the objectives of the control program. Underlying any delivery of rabbit control is the need to ensure the gains equal or exceed the expenditure over the long term. This will be very hard to justify in many cases and will often be dictated by the RPMS rules rather than an economic model of cost benefit.

The delivery of the rabbit control program will need to be monitored to ensure the mechanisms are achieving the desired long-term goals and objectives. This will enable the rabbit control program to assess what mechanism to employ at what time through the control program and prevent repeat control effort or wasted resources.

### 3.3.1 Primary Control - Poison Application

Poison application is a commonly-used rabbit management technique with heavy reliance having been placed on this method historically. While poison is a very good (and practically the only) method of reducing a heavy rabbit infestation it is not the total solution to the rabbit problem. Invariably some rabbits will not take bait, resulting in a residual population that if not controlled, will return to infestation levels. Despite this, some landholders and government agencies continue to use poison application in a crisis management manner of periodic reactive control as the standard management mechanism.

Poisoning is usually referred to as primary control as it is the primary mechanism used to gain control of the rabbit problem in an area. If no further action is taken then the gains will be relatively short lived (Williams & Moore, 1995). The resources such as warrens and habitat remain available for recolonization following a poison program. A secondary follow up program will be required to complete the control program.

Any discussion around poisoning would not be complete without giving heed to the public opposition to this method of control (especially the use of 1080). Much of the public's opposition may be the result of being poorly informed, but this is still a major consideration. Potential kills of non-target animals is always a concern, as is the potential animal welfare concerns that go hand in hand with poisoning of wildlife and potentially pets or domestic stock. There is also the concern about bait shyness and poison aversion or neophobic behaviour of rabbits that prevent successful kills (Fraser, 1985).

## Poisons – Sodium Fluoroacetate (1080) and Pindone®

Sodium Fluoroacetate (1080) poison was first used in New Zealand in the 1950's with much of the success of early rabbit control campaigns being attributed to this poison. The combined effect of a poison that was relatively cheap and the advent of aerial application, totally revolutionised the rabbit control scene in the 1950's. Sodium Fluoroacetate (1080) was clearly a "game changer" for the pest control industry in New Zealand. Pindone poison was later used and became another valuable tool for pest managers and landholders.

Sodium Fluoroacetate (1080) is an acute metabolic poison that inhibits cellular energy production (Twigg & Parker, 2010). Signs of 1080 poisoning usually become evident within three hours of being exposed to a lethal dose and death usually occurs within 24 hours (McIlroy, 1982). Sodium Fluoroacetate (1080) has a broad-spectrum of toxicity to mammals, birds and invertebrates (Eisler, 2000), however, animals that are sub-lethally exposed are able to metabolise and excrete 1080 over a few days (Eason, et al. 1997). This means that there is a negligible risk to people who consume meat that have been treated with 1080 after adequate withholding periods are observed. It has been shown (Eason, 1992), that 1080 is readily degraded by bacteria and fungi into non-toxic compounds. There is no antidote for 1080 poisoning which does create considerable risk to susceptible non-target species, particularly domestic dogs.

Pindone is a chronic anticoagulant that acts by inhibiting the formation of blood clotting factors in the liver, with lethal exposures eventually causing death through haemorrhage (World Health Organisation, 1970). Pindone has a delayed onset of action, and poisoning may not be evident for some days after ingestion of a lethal dose. In rabbits, the first signs of illness after Pindone bait ingestion occur on average 8.5 days, and death at 10 to 12 days. Rate of death will vary as the level of toxicity of different baits vary (cereal vs liquid concentrate on cut carrot). Pindones' oral toxicity is substantially increased when repeated doses are ingested (Fisher, 2013) with less Pindone required for a lethal dose when oral exposure occurs over a number of days. Pindone has high acute toxicity to mammals and to birds (Fisher, 2013). There is an effective treatment (administration of Vitamin K1) for accidental poisoning (Shlosberg & Booth, 2004).

### 3.3.2 The Effective Use of Poisons

Poison application is only effective if it results in substantially reducing the rabbit population to a level that can then be economically controlled with secondary control techniques. If the percentage kill from a poison campaign was reduced from 95% to 85%, the effectiveness of the poison campaign will be substantially reduced due to rabbit's high reproductive potential (Williams et al, 1995). Effective rabbit control with the use of poisons requires high kill rates (above 95%) to be effective. This also reduces the costs required for secondary control by reducing the size of the residual population that requires control.

If used alone, poisoning is an expensive method of rabbit control because the treated areas can be readily recolonized (Williams et al, 1995). Poisoning is a primary control mechanism that is part of a larger program, which must include a sustained secondary control program involving methods such as shooting or gassing of warrens. Additionally, the risks from repeated poisoning episodes could lead to the creation of a neophobic population as was the case in the 1980s (Fraser, 1995).

Timing is critical to successful baiting campaigns. To be truly effective baiting must coincide with low levels of natural food availability and a stable rabbit population. The population must not be actively breeding as the territorial behaviour reduces the chances of encountering adequate bait. If supplies of high quality natural food resources are available, then achieving high rates of bait acceptance is going to be problematic. Additionally dense swards of grass make baits hard to find. There must be low densities of young rabbits as these individuals do not have large range sizes and may not encounter sufficient bait. In New Zealand, the ideal timing to meet this criteria is winter, although success may be achieved in summer baiting programs where food resources become scarce and populations become stable.

### 3.3.3 Fencing

Rabbits are tenacious creatures and will find their way over, under or through a rabbit fence. However, rabbit fencing is a good method of achieving land parcel consignment into management units that are then able to be managed within the rabbit control program to avoid recolonization of areas already treated. Rabbit fences create a buffer between properties that are at different stages of their control program or implementing different control strategies.

To be effective, rabbit fences must be constantly maintained as return on investment is potentially low if rabbit control is not being applied to the same level and standard on both sides of the fence.

Rabbits will pressure a fence if the population on one side is high with resulting low food resources and food resources on the other side are plentiful. In such a situation rabbits will inevitably make a way towards the more favourable areas by breaching the rabbit fence.

Some Regional Pest Management Strategies, such as Otago require that where there is no rabbit barrier between properties, control programs must be compatible or jointly undertaken. This situation ensures collective action where lack of rabbit barrier exists in order to avoid wasted resources from the potential reinvasion of rabbits onto areas that have been poisoned.

### 3.3.4 Shooting

Shooting rabbits is considered the most humane method of rabbit control (Henning et al, 2005). It is an effective method of secondary control, however if high levels of rabbit infestation are present, shooting will have little effect. At some lowland sites shooting will actually only be killing rabbits that would have succumbed to natural mortality (Robson, 1993). Historically much effort has been expended in rabbit control using shooting at considerable cost to the tax payer with little or no return (Williams, 1991).

Shooting is, one of the best methods of secondary control. With the aid of aerial shooting facilitated by relatively inexpensive two seat helicopters such as the Robinson R22, landholders have been enabled to access areas previously inaccessible and uneconomic to shoot. One of the biggest advantages of shooting is that unlike poison applications shooting does not require land to be destocked, there is no withholding period and limited disruption to farming practices. While the cost of shooting may be quite high in some instances the advantages it offers over poison applications make it an attractive option. Maniototo Pest Management Ltd use this method extensively (not exclusively) to limit the need for toxin application. The Maniototo Pest Management Company thought there must be a better way to controlling rabbits over the long term so shooting has developed as the preferred method given the advantages it offers (Ossie Brown, Maniototo Pest Management Company Ltd, 2014 pers comm).

### 3.3.5 Traditional Ground Based Methods.

**Dog & Gun, Ferrets & Nets and Fumigation.**

The traditional methods of pest control using dog & gun and ferrets & nets has all but vanished as a skill within the rabbit control industry. This is because of the high costs and limited success gained with these methods. Dog & gun has the potential to move rabbits and force dispersal - an undesirable outcome. Where dogs do have a place is for putting rabbits to ground. This needs to be done in a systematic manner to allow follow up net & ferret or MagToxin® fumigant application to burrows and warren systems. In isolated sites and where toxin application is not an option, then the implementation of these traditional methods by a skilled operator provide another control mechanism. These methods need to be maintained in the rabbit control industry as a viable tool for semi-urban environments and on properties of small scale with organic status.

The efficacy of traditional methods such as dog & gun must be considered. High rabbit tallies don't necessarily equate to effective control. Some lifestyle property owners may be duped into believing a constant high tally is showing the program is successful. Without control of surrounding properties and/or rabbit fences, any effort will certainly create a vacuum that rabbits with a high rate of dispersal will quickly fill.

## 3.4 Monitoring

Any rabbit control program needs to be monitored to evaluate the success of various methodologies employed. This needs to be both pre- operative and post-operative monitoring to enable a kill rate to be accurately assessed. Long-term trend data is essential to give a good picture of the overall rabbit situation. Historically night count lines have enabled rabbit managers to gauge the pre-and-post kills, but this practice has largely dropped off due to the costs and the resources required for completing the task. Some areas still have annual night count lines, but these are heavily influenced by the current control activities occurring on them.

Compliance monitoring currently uses dung heap spacing as a reliable way to assess an index of rabbit infestation. This avoids the influence of weather or time of day that impact on actual rabbits seen. The method, now known as the Modified McLean Scale has been widely used and was derived from two assessment techniques: One was developed by Harry McLean of the Wairarapa Pest Destruction Board, and the other by DSIR scientist John Gibb. This method was further refined by Landcare Research for Environment Canterbury (McGlinchy, 1996). The method has been adopted by the Rabbit Coordination Group as the standard measure of rabbit infestation (RCG 2007) and is listed on the National Pest Control Agency website (NPCA, 2014) and further work is being undertaken to develop a protocol for this method.

RHD monitoring is also very important as this allows an assessment to be made of the efficacy of the disease. RHD immunity levels will be heavily dependent on epidemics and one should expect high levels of RHD immunity post RHD epidemic as non-immune individuals should have died, however, if the population has a low level of immunity (in the absence of secondary control) this may indicate the disease is not working well in that area for some environmental or population reason. RHD monitoring will also allow tracking of the genetic strains of the disease within the population and identify any genetic resistance.

## 3.5 Chapter Three – Key Points

- Developing cost effective rabbit control programs on low productivity land is often questionable from an economic perspective. However, rabbits will still need to remain within acceptable compliance levels detailed in an areas RPMS rule.

- Land managers are faced with various options including local eradication, periodic reactive control, strategic sustained management or simply doing nothing. Eradication has thus far proved unachievable on a regional or national scale. Periodic reactive control does not demonstrate good practice, is expensive to implement and has the potential to select for RHD resistance. Strategic sustained management has a good long term objective, is able to have reduced costs and frequency concurrently, is socially acceptable, doesn't risk killing valuable predator populations and does not risk moving towards RHD immunity at the genetic or population level. Doing nothing may be applicable in some areas where populations will self-regulate but this not an option in semi-arid lands.

- There is no "silver bullet" to the rabbit problem. A combination of actions and efforts will be needed. All efforts will need clear objectives and measurement of success of the program through monitoring. Timing will be an important aspect of both control efforts and monitoring. Cost-benefit analysis will be needed to assess if the correct control strategy is being employed. The mechanism of delivery will be dependent on the level of infestation and the desired objective or goal at a site.

- Control efforts broadly fall into two categories: 1) Primary control which relies heavily on toxin application; 2) Secondary control is used to maintain populations at low levels after primary control. Many land managers and government agencies rely heavily on primary control alone in a cyclic manner and do not implement secondary control to maintain their gains. This represents a crisis management model which is expensive to implement and does not represent best practice. Additionally a program with a heavy reliance on toxins will inevitably face public opposition.

- Shooting is one of the best methods of secondary control. Unlike primary control using toxins shooting doesn't require land to be destocked, there is no withholding period, limited disruption to farming practices and it doesn't eliminate valuable predator populations.

- Any rabbit control program requires monitoring to ensure the goals and objectives are being met and maintained. RHD monitoring is also important to assess the disease status within the population.

# Chapter 4

# Community and Landholder Attitudes to Rabbit Management

Community and landholder attitudes can make or break the effectiveness of any rabbit management program. Often landholders are poorly informed and risk wasting valuable resources on efforts that are poorly timed and ineffective. The Rabbit Coordination Group has highlighted two key areas of concern on this topic: The need for collective action and communication of information (Rabbit Coordination Group, 2007).

Landholders readily share information informally between themselves; however, this information may lack technical rigour or robust rationale. Such was the case when landholders thought biociding of RHD on carrot drops would provide an effective mechanism of the disease transmission when they were in some cases inadvertently spreading a dead virus to the rabbit population and thereby inoculating the population against RHD.

New Zealanders and particularly the rural community have a “can do” attitude and when faced with frustrating politics often decide to get on with the job at hand. This became evident through the frustration of not being given authority to import the RHD virus to New Zealand (O’Hara, 1997). The consequence of this action lead to an uncontrolled and uncoordinated release of RHD, which lacked a strategic approach to follow up with secondary control techniques. Despite this many landholders still maintain that the RHD release was a success (Henning et al, 2005) and given that RHD is continuing to have an impact on rabbit populations it is easy to see how this conclusion has been popularised.

The initial successes achieved with RHD have created a change in attitudes with many landholders becoming complacent about the need for continuing with conventional control techniques, which involve the use of primary and secondary control. The “super bug” mentality that has been adopted has led some landholders to move away from any conventional primary or secondary control, instead relying on some future biological control agent that will eventually solve all their problems. This is an error of judgement and a dangerous outlook. Any new technological or biological mechanism will not replace, but rather compliment conventional control. The challenge moving forward is to use conventional control to take full advantage of lowered rabbit densities. This challenge has failed as is evident from the situation that has arisen in New Zealand after the release of RHD and also the Australian situation following the release of Myxomatosis in that country (Williams et al, 1995).

## 4.1 Landholder Responsibilities

Private landholders are required by law, to abide within the rules of a council's Regional Pest Management Strategy (RPMS). It is the landholder's responsibility to meet the rules in the RPMS and in most cases this is through a user pays system, where the costs of the rabbit control program lies squarely with the beneficiary, the landholder. This situation becomes more complex where a property is leased, as in most instances the responsibility lies with the occupier of the land. This requirement may be explicit within the terms of a lease agreement or may be apportioned between the lessee and lessor.

Most regional councils have a maximum allowable level of rabbit infestation. In the particularly rabbit prone lands of Canterbury, Otago and Southland this is set to level three (on a scale of 1-7) on the Modified McLean Scale. This is also the case in Marlborough with the exception of Upper Awatere / Clarence, which is set to level four. The Modified McLean Scale is the standardised measure of rabbit infestation that primarily uses buck heaps or faecal pellet heap distance as a standard measure (McGlinchy, 1996).

Landholders in Otago have the added responsibility for adjoining properties and are required to have a rabbit control program, which is compatible or jointly undertaken with their neighbours where a lack of rabbit barriers exist (Otogo Regional Council, 2009). This stipulation ensures a coordinated program is implemented and mitigates the effects of re-infestation to adjoining properties. It also allows the Otago Regional Council to reject a program that fails to meet those criteria, facilitating the issuing of a notice of direction if not complied with. This gives the council greater powers of enforcement where adjoining properties have differing ideas on how the program should proceed.

## 4.2 Landholder Attitudes

Many landholders still live in the "pest board" days, a legacy of rabbits being taken care of by someone else. Some have taken hold of the responsibility of the rabbit problem and have robust programs in place while others still largely ignore the rabbit problem until an enforcement officer identifies them to have breached the maximum allowable level in the RPMS.

Some landholders have programs in place which appear to meet the requirements of the RPMS and have been ongoing for many years. However, the ongoing cost of such program needs to be evaluated against developing an approach that reduces rabbit densities to low levels and maintains them at that level. Often their programs lack a clear objective to reduce levels of rabbit infestation to low levels over time and so continue to be a substantial financial burden to them.

The view taken by many landholders is to live with the rabbit problem because developing a long-term solution has thus far eluded them. The view is held that rabbits have natural population fluctuations and as long as harsh environmental conditions prevail, which control rabbits to low levels, it is seen that financial resources would be expended to control rabbits that would have naturally died anyway. This results in a reluctance to do anything apart from merely hoping for a harsh winter. This view has been exacerbated by the effects of RHD with some landholders holding off control efforts in the hope that RHD will solve the problem and in some cases it does to an extent. However, the reality is that harsh winters are becoming fewer and shorter in duration and RHD immunity levels are increasing in many areas as a result of not implementing effective secondary control. Many landholders are therefore, locked into a crisis management model and only act when the problem is clearly out of control or an enforcement agency compels them to act.

Without a coordinated control program, it can be argued that landholders are wasting their time controlling rabbits while adjacent properties do nothing. This highlights the need for collective action along with a program that operates at a wide geographical context and in a coordinated manner. Trying to get all land requiring control into an appropriate control regime is fittingly likened to herding cats. Not all land can be made available because of farming activities and the need for areas for livestock grazing, or in some instances, the requirements of such a program would exceed landholders financial capacity.

In some instances, the rabbit problem has become so vast that it has defied any attempts to overcome it. Certainly, the New Zealand historical account supports this. The problem has become psychologically intimidating and now forms an acceptable nuisance to many people. Many people with good and noble intentions may be beaten back by the sheer scale and logistical implications of the problem.

Lifestyle property owners (which appear to be in ever growing numbers) exacerbate the problem by not seeing the need to control rabbits. In fact some people actually enjoy having a few rabbits to shoot and take little or no thought to the exacerbation effect they cause by retaining rabbits. This severely undermines any attempt to piece together the complex jigsaw puzzle of a coordinated approach. Such properties are often non-productive and as such, there is no production incentive to control rabbits from an economic perspective. The situation does not fully manifest itself until the extent of the problem starts to interfere with amenity plantings and landscaping where rabbits burrow and generally wreak havoc.

Privately-run pest control activities of some landholders are not adequate due to the lack of sufficient skill, but represent something more attuned to sustained yield than control. Such attempts at pest control will fail to meet the objective of reducing rabbits to compliance levels in the RPMS.

## 4.3 Community Attitudes

Some people view any form of rabbit control as inhumane. They have been beguiled by likeable images of rabbits from children's literature like Beatrix Potter and Watership Down, which have anthropomorphised rabbits into the subconscious mind where rabbits portray human values and feelings. These ingrained images do not easily dissipate. The true nature of rabbits as destructive vermin is seldom brought to the light.

People are seldom informed about the economic and environmental damage caused by rabbits. The true environmental implications of rabbits at modifying plant communities is poorly understood (Lough, 2009). People might be persuaded to advocate for rabbit control from an ecological perspective if better information was available. Unfortunately, the insidious nature of change in plant communities is such that it is scarcely perceived and is not promoted as rationale for rabbit control programs. While it has been documented that rabbits will alter plant communities in Australia (Cooke, 1988), it is difficult to link changes to plant communities to rabbits alone due to other factors, such as livestock grazing, stocking rates and climate (Working Party on Sustainable Land Management, 1994). These variables make this rational for rabbit control problematic.

Animal welfare is a strong influence in a community's thinking and logic around rabbit control. Historical methods of rabbit control were viewed as barbaric in the modern public eye. For example, long-spring traps with toothed jaws are still evident in the rural communities, but more as interest pieces than control tools in modern times where stricter animal welfare regulations have long since banned the use of such tools. Of more importance now is the inhumanness and suffering of allowing rabbit numbers reach plague proportions that necessitate the use of poisons. It is very unlikely that any wild rabbit will quietly succumb to old age and die peacefully in its burrow. Predation is a cruel and ruthless process that culls out the old, weak and sick rabbits, not to mention the slow death resulting from disease and in some cases starvation or hypothermia.

Human-induced rabbit population control campaigns (primary and secondary pest control activities) cause suffering and pain to rabbits, which is to some people still unacceptable. Poisoning is never going to be a nice way to die for a rabbit, but if the rabbit problem is prevented from occurring in the first place, it decreases the need for action that requires such measures. Interestingly, secondary control through shooting was perceived by landholders and the public as the most humane method of rabbit control (Henning et al, 2005) and it is also one of the most effective in the secondary control campaigns. Such aggregated suffering can be prevented by maintaining rabbit numbers at low levels permanently. This requires the primary control measures to be sufficiently robust to be non-repetitive or little is achieved from this animal welfare viewpoint. A crisis management model that employs a cyclic pattern of poisoning when populations exceed acceptable levels does not meet these criteria but represents an inhumane management style.

## 4.4 Commercialisation of Rabbits - Implications for Effective Control

Although rabbits represent a significant agricultural pest, a change in legislation has seen a shift from the Rabbit Amendment Act 1956, which completely devalued rabbit products and removed any incentive to retain rabbits on a property (Cotton, 1994). This legislation was in place to ensure there was no incentive to retain rabbits and remove the conflict of interest with pest control, which conflicted with the killer policy of the 1940's and the subsequent control policies of the 1970's.

The Agricultural Pests Destruction Act of 1967 and Section 121 of that Act had stated:

***121. Sale or export of rabbit skins and carcasses prohibited*** *- No person shall -*
*(a) Sell or offer for sale; or*
*(b) Export from New Zealand for sale, -*
*any rabbit skin or rabbit carcass produced in New Zealand.*

On October 1st, 1993 the Biosecurity Act repealed the Agricultural Pests Destruction Act of 1967. This change of legislation lacked any equivalent restrictions for the sale and export of feral rabbit products.

The Biosecurity Act also amended the Meat Act of 1981 to include feral rabbits in the definition of game (s.2(1)(b). This represented significant change, resulting in the initiation of a whole new industry that supplies not only pet food, but also a growing human consumption market. This situation represents a clear conflict of interest with pest control initiatives. It views rabbits as a resource rather than a pest and sends the message of sustained yield harvesting rather one of eradication. This conflicting message is being conveyed to land managers, resulting in an opportunistic pest control industry that requires rabbits to exceed the maximum allowable level of a Regional Council Pest Management Strategy (RPMS) in order to be commercially viable for harvest.

The implications for effective rabbit control, is that many landholders will try to use services that recover rabbits for pet food or human consumption. Such services will often be free of charge or if charged, the rate will be dramatically reduced due to the recovery of animals for sale. The efficacy of such operations in the actual reduction of rabbits needs to be questioned. Rabbits shot for recovery are shot in a very different manner to those shot to waste for pest control. Recovered animals need to be shot cleanly forward of the diaphragm or preferably head shot for maximum value. Juvenile rabbits will often be left, as there is little or no commercial value for these rabbits. The requirement to gut as you go will slow any shooting down dramatically and many rabbits will simply go to ground and avoid the spotlight.

Furthermore, any efforts to coerce farmers into undertaking a poison program where recovery operations are taking place, have to compete with the farmer's risk of losing the free services of recovery rabbit control. Under a poison program, the property will have a withholding period and neighbouring blocks will not be able to shot for some time following poison application. High tallies from recovery operations risk being confused with good outcomes and best practice is compromised through perceived effective control by shooting.

Strong relationships forged between farmers and their shooters may be hard to break and while commercial shooting is needed as an effective secondary control mechanism, it is not normally appropriate or best practice as a primary control mechanism where rabbits have exceeded maximum allowable levels under compliance in the RPMS. The dilemma is how to convince farmers that a shooter who achieves very low kills on a sustained basis represents better management and is a more cost effective control mechanism than that of a shooter who boasts large tallies on a regular basis. Any such program indicates that the shooter is in fact having little of no effect on the population and represents a waste of landholder's resources. It also lacks a clear objective of reducing rabbit infestations.

Where rabbit control has exceeded compliance levels, primary control will need to be followed by a quality shooting program which needs to be carried out on a regular basis when the population is low and stable. However, without recovery shooting there is in many instances, no way to sustain good shooters in the market place for this service. One compromise to this situation is that properties planning a poison operation can allow a shooter to do recovery shooting up until three months prior to poisoning. Three months allows the population to settle before poisoning occurs. The shooter can again be engaged, at a commercially viable hourly rate after the poisoning, to mop up any survivors. This represents best practice and could be a viable solution to retaining quality shooters in the marketplace.

## 4.5 Extension Services & Technical Advice

It has been identified by the Rabbit Coordination Group that communication of information is a vital component of effective rabbit management (Rabbit Coordination Group, 2007). Extension services is a form of technical advice that is generally provided by a governing body such as the regional council in its efforts to promote best practice and help landholders meet their obligations of council's strategy rules and objectives. Landholders and the community need good quality information that is up to date and represents current best practice. There needs to be a range of information to suit the range of different landholder situations. Information applicable to large farms may not be applicable to small lifestyle or semi-urban situations. It has been shown that good quality information will lead to changed attitudes and adoption of quality rabbit control techniques. A study of the use of extension effort to dissimilate information and promotion of adoption of rabbit control practices that are based on research, has the potential to induce considerable change in behaviour, opinion, attitude and aspirations regarding effective rabbit management (Presser & Russell, 1965). It was concluded from this study that well organised campaigns using all possible means of persuasion such as communication of aspects such as research results, social implications, economics and legal obligations can achieve major changes in programs and attitudes.

Extension services need to be actively engaged in the community to be effective. Pest liaison committees are an ideal vehicle for the delivery of extension services.

### 4.5.1 Training, contribution to extension services

To enable effective extension services there is a need to ensure current research findings and past knowledge is transferred to pest management staff at all levels. There needs to be a continuous transfer of information to those who use and benefit from that information. In New Zealand the Agricultural Pest Destruction Council trainee scheme was set in motion to equip field staff in their roles and to bring them up to speed with best practice. Currently no such scheme runs in New Zealand and the only training is from Primary Industry Training Organisation (Primary ITO) in the form of a National Certificate in Pest Management with optional strands, one of which includes rabbits. This training is largely geared to field operations and lacks technical rigour and the depth of knowledge required for extension services.

There will need to be a change in training direction and industry commitment in New Zealand if young people are going to be attracted to and retained in the vertebrate pest control industry. Currently the industry is transient with no clear career path or industry body promoting the various options for progression within the industry. Some pest management staff come into the industry at higher levels after completing relevant university degrees but these people need to be fully aware that landholders with lifetimes and multiple generations of experience with rabbit control will be very hard to liaise with. There is a need for a thorough knowledge of the historical and contemporary situation and all of the economic, social and legal implications of various actions. Also, rabbit management needs to be understood within the wider land management context so that land management decisions can be understood for their influence and effects on the wider rabbit management situation.

It is not hard to find a rabbit expert in any rural community where rabbit have historically been a problem. Convincing them that the methodology they employ may not be appropriate or needs more effort may be met with stiff opposition, even when fully schooled on best practice and current research results.

## 4.6 Chapter Four – Key Points

- Community and landholder attitudes are an important consideration in developing effective rabbit management programs. People are often poorly informed and the information they have may not represent best practice or be scientifically robust.

- Initial success with RHD has led to some land mangers becoming complacent about rabbit management. They have developed the "super bug" mentality and are waiting for a new strain of RHD to solve all their problems without understanding that any new biological control agent will be at best a complement to conventional control.

- Many land mangers still live in the "pest board" mentality and think someone else will solve the rabbit problem. They have not yet taken ownership of the problem themselves. Where they have implemented a rabbit control program, the ongoing costs of that program, which often lack clear objectives to permanently reduce rabbit infestation, represents a waste of resources in an ongoing manner creating considerable financial burden.

- In some instances lack of technical skill and scientific rigour is impeding attempts to implement effective rabbit control. Extension services from Regional Councils are needed to aid private individuals and land managers to make the best choices within the resources available. However, there is no system of training currently in place to allow Regional Council staff to achieve this.

- Community attitudes are complex. Many people do not see the need to control rabbits. They are unaware of the economic and environmental damage they cause and think rabbit control is cruel and inhumane. These perceptions are founded on poor information and lack of communication between pest managers and the community.

- The change of legislation that came into effect with the Biosecurity Act 1993, brought with it an amendment to the Meat Act of 1981 and included feral rabbits as game. This created a clear conflict of interest in attempts to develop effective rabbit management. There is now an incentive to retain rabbits as a resource. The level of rabbits needed to be harvested in an economically viable manner contravenes the acceptable level required in the RPMS of Council rules.

# Chapter 5

# Governance and Rabbit Management

## 5.1 Historical Governance

Historically public governance of rabbits in New Zealand occurred because of ineffectual private individual action.

The first legislation relating to rabbit control in New Zealand was the 1876 'Rabbit Nuisance Act', which was passed by the Government. This legislation gave inspectors powers to instruct landowners to destroy all rabbits on their land and was revised year after year to give rabbit inspectors' greater powers (Druett, 1983).

Rabbit boards were soon to arrive on the scene. A rabbit board could be established if a petition was sent to the Minister of Agriculture by a majority of farmers in an area of land not less than 8,000 ha in extent. The first rabbit board was formed in the North Island in the Hawkes Bay in 1887. Each rabbit board had a board of trustees elected by the ratepayers, and this board had the power to levy rates on all land in the district. The Government met this revenue with a pound for pound subsidy, paid out of the Consolidated Fund.

Rabbit boards continued to be formed throughout the country, peaking at 208 Boards in 1969, but were systematically amalgamated to produce less boards and more efficiency. The Rabbit Destruction Council was formed in 1947 and the "killer policy" was developed (Godfrey, 1974).

In 1955 legislation was amended to completely devalue rabbit products and remove any incentive to retain rabbits on a property which resulted in the Rabbit Amendment Act 1956 (Cotton, 1994).

The Agricultural Pest Destruction Council (APDC) was formed in 1968 after the passing of the Agricultural Pest Destruction Act 1967. This introduced a policy of control rather than extermination in 1972 (Godfrey 1974).

In 1983, the Pest Destruction Review Committee recommended that government funding for pest management be stopped. Farmers were to deal with the 'rabbit problem' as part of their own land management objectives (Nightingale, 1992). Up to this point of time, the Government had heavily subsidised rabbit control in acknowledgement of the rabbit problem and the economic burden and implications for productivity.

Regional councils took over the responsibilities of the Agricultural Pest Destruction Council in 1989, based on the belief that these organisations would be more "cost-effective" and sensitive to local needs. It was acknowledged there were still severe rabbit problems in parts of New Zealand so the Rabbit and Land Management Programme was initiated and ran until 1994. This had the approach that rabbit management is an integral part of land use management (Rabbit and Land Management Taskforce, 1988).

## 5.2 The Biosecurity Act 1993

The Biosecurity Act enables anyone to take action against pests if it is in their interest to do so. The Act allows coercive powers to be exercised as required by entities to protect their property rights and interests. In the case of rabbits, ratepayers represent that interest and the rural community have a huge interest in their control for economic reasons. While no public agency is required to engage in pest control under the Act, it is the intention of the Act to enable agencies such as regional councils to protect its constituent's interests and property rights.

The Biosecurity Act gives regional councils the ability to regulate and force landholders to take action against established pests such as rabbits. The attraction of the Act is that a Regional Pest Management Strategy prepared under the Act has broad regulatory powers, and therefore Regional Councils have voluntarily engaged in preparation of their RPMS through the Act for the powers it facilitates.

The Crown, however, cannot be bound by a RPMS developed under the Act. This creates a complex dual pest management scenario when crown land is involved. The Department of Conservation is not subject to the rules in a Regional Council's RPMS. While good neighbour principles apply, there is no jurisdiction for regional government to use in compelling central government and Department of Conservation to conform to a region's RPMS.

Generally good neighbour principles, goodwill and common sense apply, however, complexities do arise when it comes to coordinating rabbit control programs that contain Department of Conservation land. The Department may not apply best practice, correct toxic products or timing in its programs and there is little or nothing a regional council can do about his situation. The implications for developing a coordinated pest control program can be that it undermines the efforts of private landholders and area-wide programs.

Historical pest management under the legislation that preceded the Biosecurity Act was rooted in rabbit and weed control with a focus on managing risks to primary production. This created a model of individual pest management with a landholder as the client. This situation has changed dramatically now with a landscape ecology approach to biodiversity. This new approach is more conducive to effective rabbit management as it takes a holistic approach to the problem, incorporating the multiplicity of interacting factors.

## 5.3 Regional Councils

Regional councils were developed as part of a comprehensive reform of New Zealand's local government. Regional councils manage a range of environmental roles and responsibilities, to form primary environmental policy and to operate as environmental agencies. Within this portfolio the regional councils undertake the role of rabbit management.

In 1993, the Biosecurity Act came into effect and rabbit management was now covered by new legislation. Regional councils have the responsibility to prepare and implement a Regional Pest Management Strategy (RPMS) and to administer this strategy within its legislative requirements. This requires regional councils with rabbit pests to develop a detailed set of rules in relation to rabbit control in their region.

New Zealand is divided into sixteen regions for local government. Eleven are administered by regional councils (the top tier of local government) and five are administered by unitary authorities, which are territorial authorities (the second tier of local government) that also perform the functions of regional councils. These sixteen regions of government have Regional Pest Management Strategies having various methods of dealing with a variety of pests. Most regions list rabbits as an animal pest, but largely the rabbit problem is restricted to Hawkes Bay, Marlborough, North Canterbury, Otago and some areas in Southland.

Generally, the rules with RPMS in relation to rabbits require a measurement of the levels of infestation. Most regional councils with rabbit problems have a maximum allowable level of rabbit density, which is set between level 3 and 4 on the Modified McLean Scale.

### 5.3.1 RPMS and a Strategic Approach to Rabbit Control

Within a policy context, a strategy provides for a consistent approach to an issue across an organisation or between organisations. It creates a framework for action that is centred around short and long term goals of the organisation(s) and its employees. In this context a strategy creates unity of commitment between key stakeholders and interest groups with a common goal (Enfocus Ltd, 2008).

RPMS's however, fail in most instances to create the desired outcome from a strategic perspective and are more of a regulatory code of conduct, which fail to create unity of approach and often lack consistency. This is largely a result of the narrow brief and prescription set out in the Biosecurity Act.

The RPMS is generally very narrow in its view, having a pest specific focus. It lacks a strategic approach to dealing with pests at the landscape level or on a sustained basis. It is not site-based, but comes from a species-specific approach. With its regulatory code of conduct style of approach, it aims for a level of compliance but does not necessarily promote best practice. In relation to the rabbit problem in New Zealand, best practice is of high importance, also the program has a long-term focus rather than just meeting a level of compliance. Only two of the regional councils (South Island only) have additional rules relating to the frequency of toxin application and only one (Otago) appears to have rules relating to control programmes for adjoining properties - which must be compatible or jointly undertaken where a lack of rabbit barriers exist. None of the rules and requirements for rabbit management appear to take a strategic approach to the problem.

Furthermore, rabbits are dealt with on an occupier basis with each occupier being treated as a separate entity (although neighbours have been combined in Otago where lack of natural rabbit barriers exists). This further exacerbates the non-coordinated approach taken with the RPMS and does not support collective action.

This is not to say that the RPMS can't be applied in a strategic manner and in some cases this may be taking place. For example, in Canterbury there is heavy reliance on pest liaison committees. Canterbury is divided into 11 pest districts with 11 pest liaison committees. This creates an advisory and reporting forum with a two-way flow of information and aspirations. The pest liaison committees meet biannually and discuss targets and objectives including how rated monies are being spent. The program still relies heavily on individual landholder contact, but this form of implementation ensures a constant involvement of land occupiers. It is more of an audited self-management model as opposed to the 'command-and-control' regulatory approach taken by some councils. It is still backed by a strong regulatory approach and individual landholders are required to submit staged rabbit control programs that protect and safeguard neighbouring properties (Brent Glentworth, Canterbury Regional Council, 2014 Pers Comm).

Maniototo Pest Management Ltd (MPM), based in Otago, has an alternative approach to rabbit management than that proposed by the Otago Regional Council. MPM uses a land rate system and retains a delivery of service model. This model came out of the disestablishment of the Maniototo Pest Management Rabbit Board in 1989 with local farmers wanting to retain the best interests of pest management in their area. Individual landholders have a property account where rates are collected to form shares in MPM with rates being evaluated based on the historical needs of individual properties. MPM's model works very well and represents an effective form of audited self-management, with the Otago Regional Council retaining the compliance and monitoring roles of the

RPMS in the area while MPM implements effective rabbit management on behalf of its landholders/shareholders.

This model does, however, run the risk that the individual landholder no longer takes ownership of the rabbit problem and on farm decisions no longer include a “rabbit-based” way of thinking. Rabbits become the problem of MPM and farming decisions could risk being made without thorough consideration of the impacts to the rabbit problem.

One of the biggest advances of the Rabbit & Land Management Program was the change in attitude of many landholders and their taking ownership of the rabbit problem on their land (Lough, 2009). This is important in the light of one successful rabbit control campaign on Earnscleugh Station, where the run holder Alister Campbell is quoted as saying that the turning point came when “we took ownership of the operation ourselves” (Lough 2009) This differs markedly from the rabbit board days when it was largely someone else’s problem.

The Maniototo Pest Management Ltd model (to their credit) seems to have avoided the pitfalls of not taking individual ownership of the problem. This is largely because ownership is still present but on a larger scale, now within MPM as a whole and within the community it represents as opposed to individual landholders. This approach represents one of the best management models for effective rabbit management. A middle ground between regional councils and their RPMS with their lack of strategic approach on one hand and the rabbit board days (delivery of service) of over subsidised and ineffective delivery models on the other hand.

### 5.3.2 RPMS and Best Practice

Rabbit control in most instances is still a user-pays system of delivery, which creates some concerns for regional council biosecurity staff. Landholders are not necessarily applying industry best practice as this is often seen as being too expensive. Individuals are prone to take shortcuts such as patch poisoning to meet compliance levels. The RPMS does not usually stipulate that best practice or a strategic approach should be applied. Landholders are only required to meet compliance levels and this level is not necessarily the best long-term approach to effective rabbit management. For example, in Canterbury landholders have been noted as applying measures that only meet the level 3 on the Modified McLean Scale. Ideally, for long-term cost effective control level 2 is the desired outcome (Brent Glentworth, 2014 Pers Comm). This minimum compliance approach may result in more frequent toxin application risking neophobia and potentially wasted resources in the long term.

Best practice is always going to be hard to regulate and particularly hard in an open market, user-pays environment where contractors are prone to take measures that may seem on the surface to be saving money, but which long term will leave the landholder with an ongoing problem and higher costs. Given that rabbit control on the whole, rarely makes any money for a farming venture, lowest cost solutions will be common. The most rabbit-prone land is often the least viable from a farming perspective and simply represents a compliance burden. It is common for landholders to fence off unproductive rabbit prone areas and let rabbits do what rabbits do, all the while hoping that regional council compliance officers will not come to enforce compliance. This represents effective rabbit management from a farming perspective, but does nothing for a long-term strategic approach or for RHD immunity levels, which have the potential to reach high levels in these areas.

Best practice comes about by:

1. Using technical best practice in primary and secondary control

2. Developing a coordinated approach of collective action with a sustained methodology

3. Having clear objectives and monitoring the program against those objectives

Regional councils have the potential to develop a coordinated approach and sustained methodology through the requirement of landholders to develop rabbit control programs (RCP's) that are consistent with best practice. Otago Regional Council has such an approach (Otago Regional Council 2009) and Canterbury Regional Council has a similar approach.

Ensuring technical best practice is applied is only possible with a thorough understanding of what works best and this is best dissimilated through extension services of councils and pest liaison committees. Maintaining a committed pool of experienced contractors is also a prerequisite to best practice, but without correct performance measures there is always the risk of poor quality work and shortcuts. Best practice requires more than just meeting the compliance level set in a RPMS.

Clear objectives need to be set that are achievable within the resources available and it is important to monitor the success or otherwise of the program against the objectives to ensure resources are being expended in a way that yields the best long-term returns.

One of the biggest concerns facing effective rabbit control is the effects of conflict of interest and its ability to undermine an effective rabbit control program. The existence of commercial rabbit control within the regulatory agency of a regional council forms this sort of situation. This situation cannot avoid an emphasis on commercial viability and profitability above promoting best practice. For a regulatory authority having a commercial rabbit control wing within its organisation, it is always going to be hard to promote best practice where this direction will undermine the profitability of that regulatory agency's commercial rabbit control business. A program that relies heavily on primary control of toxin application in a crisis management model is well set to maintain its interests in the market and limit access to new entrants who may undermine this position. Furthermore, this situation does not promote a model of strategic sustained management with the objective of permanently reducing rabbit populations. It is for this reason most regional councils have divorced themselves from this conflict of interest in the interests of maintaining transparency and compliance integrity within their regulatory scope.

Similar arguments can also be made against some privately-owned pest control companies whose commercial interests outweigh their use of industry best practice. Some may provide poor advice to landholders on the most appropriate methodology or strategy in order to keep the rabbit problem running in a continual cycle rather than promoting an objective that permanently reduces rabbit infestation and therefore costs to the landholder. Therefore, it is important for landholders to ensure the person monitoring the rabbit control programs success is different from those benefiting from the continuity of that program. Best advice will be independently sought to avoid any vested interest in methods that have poor objectives.

## 5.4 Chapter Five – Key Points

- Public governance of rabbits in New Zealand occurred because historically private governance was ineffective. Rabbit boards were the first on the scene with the Agricultural Pest Destruction Council following. Regional Councils currently hold the public governance of rabbits under the Biosecurity Act 1993, with their regional pest management strategies and associated rules.

- The Crown is not able to be bound by a Regional Council's RPMS rules. However, generally good neighbour principles apply.

- Historically rabbits were controlled for managing risks to primary production. This situation has somewhat changed to include landscape ecology and biodiversity which takes a more holistic approach.

- RPMS rules stipulate what level of rabbit infestation is acceptable or not. Landholders are subject to compliance inspections using the Modified McLean Scale to measure levels of infestation.

- RPMS's in most instances fail to create a strategic or sustained approach. They do not promote collective action and in most instances act as a regulatory code of conduct. Landholders are treated as separate entities. RPMS's do not promote best practice but more often aim at a compliance level approach with no long term objective. This is a result of the narrow brief set out in the Biosecurity Act.

- The Maniototo Pest management Company Ltd has taken an alternative approach to rabbit management by retaining to some extent, the rated system rooted in the rabbit board days where rabbit control was by delivery of service. The Maniototo model has maintained the "ownership" of the rabbit problem with the landholder, but now at the larger scale within the company, which operates at the community level. The model is very successful and demonstrates strategic sustained management in action through their rabbit management approach.

- Technical best practice is important to any effective rabbit control program. This comes through using the best technical approach, developing a coordinated approach and having clear objectives with monitoring in place to assess the program's success

- As far as possible regulatory agencies must remain separate from operational and commercial rabbit control activities and retain their regulatory brief. This removes any conflict of interest which undermines the regulatory function. It enables the regulatory agency to freely promote best practice and be involved in extension services.

# Chapter 6

# Future Direction – Cost-Effective Rabbit Management

## 6.1 Economics of Rabbit Management

An economic framework is required to enable landholders to assess the relative value of alternative strategies towards rabbit management. Within this framework is a need to clearly identify the problem, develop a set of clear objectives and assess the costs and benefits of various methods in achieving those objectives. Impediments to achieving those objectives also need to be identified. An economically-efficient rabbit control program is where the incremental cost of control is at least equal to the incremental benefits or savings derived as a result of that control.

There are many factors to be considered when attempting to assess the economic costs and benefits of various rabbit control programs. Increased productivity that will arise from rabbit control will be closely linked to commodity prices. Proneness of a location will be a key factor in determining the intrinsic rate of rabbit population increase. Not all sites generate population increases to the same extent. Predation and environmental factors will be key determinants. There is no secret solution and every site should be assessed on its own merits. There is little quantitative information available to reliably demonstrate the relationship between rabbit density and the impacts to base a good case of cost-benefit modelling on. Historically, cost-benefit assessment for rabbit management has proven to be difficult and unreliable (Williams, et al, 1995).

It is known that after a relatively expensive initial primary control program, using toxin application, repeated secondary maintenance treatments will achieve higher and higher levels of control and thus costs can be expected to decline to a low plateau after 4-5 maintenance treatments (Williams, et al, 1995). It makes sense that the landholder will therefore receive greatest return on investment if the maintenance treatment is continued indefinitely and becomes part of the wider land management program. This has certainly been borne out in the case of some properties in Otago such as Earnscleugh Station where rabbit control costs have remained stable since 1997 (Lough, 2009).

It is important to note that control mechanisms that are expensive initially, may be more cost effective in the long run and vice versa (Williams et al, 1995). A focus on costs alone is a poor indicator of cost effectiveness. A model that looks long term at costs and benefits will more accurately reveal the true costs and benefits of a program. Short-term analysis will be of little value as figures will be skewed by high initial costs that may yield benefits for many years beyond the short period of analysis.

Cost-benefit analysis may be negated in many cases where the RPMS has a maximum allowable level for rabbit infestation. If this level is breached it will not matter if the costs of control outweigh the benefits derived. The compliance levels in the RPMS will require the population to be reduced and maintained at or below the compliance level. This creates a lot of frustration for farmers who have areas with high levels of rabbit infestation and very low productive potential as RPMS's do not have different maximum allowable levels for different productive types of land. This is mostly due to the high dispersal potential of rabbits to infest neighbouring properties and the risk this presents.

## 6.2 Strategic Sustained Management

The relative costs and benefits of rabbit control are poorly known with little quantitative information available to reliably demonstrate cost-benefit modelling (Williams et al, 1995). However, it is agreed by experienced personnel that strategic sustained management is the most practical way to control rabbits in most circumstances.

Strategic sustained management (SSM) is a method of rabbit management that aims to reduce rabbit infestation to a low level (as low as possible) by an initial control campaign (primary control) and then to maintain that low level of rabbit infestation by frequent maintenance control (secondary control). It is anticipated under SSM, that regular repetition of secondary control will reduce rabbit numbers and lead to declining efforts and costs concurrently. Striking the correct balance between repetition and the corresponding cost will be a key determinant. This will largely depend on the rabbit's reproductive capacity at the site, disease dynamics and environmental parameters. The important point is to ensure the rabbit population is not allowed to increase to a level that cannot then be managed by secondary control.

The choice of control technique is important, as is timing. To be effective the rabbit population needs to be stable and readily accepting of toxic bait. The degree of success will have implications on the frequency, intensity and costs of the secondary control campaign and it must be noted that different bait types, delivery mechanisms and time of application will have a bearing on the success. The worst case scenario is that the primary control has such a poor outcome, it may be better to abandon the secondary control campaign in favour of another primary control campaign, which may not be able to be implemented until following years. This is thwart with risk if the failure is due to neophobic bait aversion. In this case, a high intensity secondary control program with associated high costs will be the only way to break out of this cycle.

## 6.3 Implimenting a Program of Strategic Sustained Management.

Landholders frequently implement wasteful rabbit control practices because they rely heavily on one technique, often inefficiently and fail to follow up with maintenance control that may have sustained the initial level of control achieved (Cooke, 1981). Implementing a program of strategic sustained management will avoid this pitfall. A thorough knowledge of factors that impede a rabbit's chance of survival is needed to enable the manager to systematically create an environment that is non-conducive to the rabbit's success. Combined with secondary control, this will create systematic sustained management and long-term sustained benefits with reduced overall long-term costs.

The additional costs associated with SSM that come from the need for secondary control after the initial primary control campaign, may be offset by the reduced costs of the alternative, which will require regularly repeated primary control campaigns. If primary control is the only control method used, the interval may need to be repeated on a two-yearly cycle in the absence of secondary control. This represents an expensive rabbit control methodology given the high direct costs of primary control. In selecting the most appropriate strategy, it is important to compare the alternative of a less frequent repetition of primary control using toxin or to apply secondary control. Other factors such as maintenance of RHD and reduction of immune survivors are also considerations that need to be taken into account. However, a method that relies heavily on primary control is thwart with risk.

It is evident from experimental analysis (Williams & Moore, 1995) that effort and costs declined with subsequent secondary control applications. Costs have been shown to reduce to approximately half for successive maintenance applications and the maintenance intervals can be approximately doubled to the point where the fifth application sees the maximum cost benefit being achieved. This is becoming evident with Maniototo Pest Management Ltd where the low levels of rabbits present on some blocks, now means that areas are only being treated biannually (Ossie Brown, Maniototo Pest Management Ltd, 2014 Pers Comm). This situation supports the evidence of experimental analysis and advocates for the strategic sustained management approach to effectively manage rabbits.

Key factors in implementing strategic sustained management are:

- Removal of surface harbour
- Maintenance of the predator population
- Restriction of rabbits ability to modify the habitat
- Maintenance of a very low population that has low levels of RHD resistance
- Monitoring the population to ensure efforts match population increases.

Once secondary control is able to maintain the population at low levels at one particular site, resources will be available to extend the area being controlled.

Strategic sustained management also has positive benefits for the predator population. Predators can be maintained in an area, as these predators are not subject to control methods such as poisoning. Any rabbit control mechanism that concurrently kills rabbits as well as predators will be counterproductive to that program.

Most secondary control methods such as shooting will directly remove rabbits while leaving the predators unaffected. This creates a twofold gain and further accelerates the strategic sustained model in a direction that meets the overarching objectives of permanently reducing the rabbit population.

## 6.4 Maintaining the Gains and Efficacy of RHD

In order to maintain the gains from RHD it is important to remove those young rabbits that have immunity through exposure in the first six week period when they lack the receptors for viral infection, but generate an antibody response. It is also important to ensure there is a reduced ability for passive immunity, either through the adults surviving and passing resistance to young, or for adults to retain immunity via re-exposure. While it is difficult to completely eliminate the re-exposure or continuance of passive immunity, ideally the population needs to be in a similar state to when RHD was first released into New Zealand and the population was somewhat naïve to it. In order to achieve this, the population needs to be maintained at a very low level so as to remove as many immune survivors as possible.

Strategic sustained management has the best potential to enable a RHD naïve population to be maintained. While it is not possible to selectively target immune survivors within the remaining population, it is most likely that any survivors after a RHD epidemic will be immune (otherwise they would have succumbed to the virus). Reducing this population size is of paramount importance to rabbit management if the full positive effects of population reduction from RHD are to be achieved.

Any program that allows immunity to be maintained within a rabbit population by not controlling survivors, runs the risk of deleting the efficacy of any RHD epidemics. Further to this, there is potential to have a shift in population genetics towards rabbits that carry heritable characteristics of RHD immunity. Strategic sustained management is the only management program that offers a solution to maintenance of the efficacy of RHD within the rabbit population and is therefore, the best overall management strategy to be employed. It has also been shown to be cost effective over the long term and has potential to allow resources reallocated to expand the area being treated.

## 6.5 Recommendations for Effective Rabbit Management

Effective rabbit management is a complex set of environmental, political and societal aspects all working together to create a range of impediments to gaining a long-term clear objective of permanently reducing rabbit populations. Within these constraints there is a lot of scope to share information, promote best practice, help landholders take ownership of the rabbit problem, equip regional councils to take a more strategic approach, create collective action and ensure good quality outcomes.

### 6.5.1 Recommendations for Land Managers

Land managers need to ensure the resources they commit to a rabbit management program are well spent and meet their long-term objectives. It will be important to decide on the scale of the management units to be treated and to ensure these are fenced to limit reinvasion. Having an objective to permanently reduce rabbit populations and maintain those gains will enable the land manager to free up resources and extend the scale of their program in a strategic sustained manner. There is no silver bullet to the rabbit problem but a combination of methods will ensure success.

Key points for land managers are:

- Aim for a level of control that exceeds the current RPMS rules.
- Develop a strategic sustained program that has a long term objective to permanently reduce rabbit numbers.
- Ensure resources are sufficient for the scale of the management units.
- Prioritise which management units and methods will be used to meet the long term objectives.
- Identify the best control mechanism for the site. This will often require a combination of methods at different times to yield the best results.
- Evaluate and monitor the program to ensure the effort is achieving the objectives and matching or exceeding population increase. Monitoring will identify any impediments in the methodology or mechanisms employed.
- Seek technical advice and extension services where these are available to ensure best practice is employed.

Land managers who employ ad-hoc programs without best practice will inevitably be wasting resources on a program that lacks clear objectives and will often fail to meet even the compliance levels in a council's RPMS. It is also important to ensure competent staff or contractors are used to ensure there are no conflicts of interest between the monitoring of the program and the delivery of pest control services.

### 6.5.2 Recommendations for Regional Councils

Regional councils will be able to reduce the compliance burden from rabbit management if some key points are considered. It is important to ensure landholders take ownership of the rabbit problem, are correctly informed on the best practice and that the long term objectives of the RPMS are achieved with minimal default action being required.

Experienced and trained staff will be the first point of contact and it is important to forge long-term, positive relationships with landholders. The compliance aspect is potentially confrontational, but with good quality liaison, this can be made a positive experience. It is often only a few landholders that are letting rabbits run out of control so education and persuasion can often help remedy that situation.

Some key points that need to be considered by regional councils are:

- Provide good quality extension services that promote best practice and provide a two-way channel of communication and training. Pest liaison committees will be a good vehicle to achieve this and regular newsletters will keep land managers well informed as well as keeping the rabbit problem before them.

- Promote best practice and collective action that has long-term objectives to permanently reduce rabbits. This is represented in a program of strategic sustained management.

- Provide support to identify the most cost effective methods at a particular site and promote cost effective rabbit management by providing case study examples of success stories for validity.

- Ensure a dedicated pool of contactors, staff and managers are available who are skilled and understand how to promote best practice and effective rabbit management. Retaining skills is a key consideration given the long period of time required to gain the depth of skill required to address this problem.

- Ensure conflicts of interest are avoided and ensure regulatory and compliance roles don't become blurred with delivery of services.

- Ensure landholders take ownership of the rabbit problem.

- Lobby for de-commercialisation of rabbit products to remove the incentives for retaining rabbits on land.

- Ensure programs are coordinated to promote collective action and that good neighbour principles are promoted and applied, especially by Crown agencies who boarder private land.

Regional councils have the option to take a proactive approach to effective rabbit management that will have a long-term goal of reducing the compliance burdens. This will result in a shift from a command-and-control model to one of education and support, which is more attuned to audited self-management. The councils role is to ensure programs are running well and landholders are well informed and supported in meeting or exceeding the compliance levels in the RPMS.

## 6.6 Future Research Needs

Continued research is essential to effective rabbit management as it has the capacity to develop new technologies, new methodologies and ensure best practice is understood and employed by people involved in rabbit management. While a lot of good work has been undertaken, there is always scope to gain a better understanding of some of the complexities that underpin effective rabbit management. The recent occurrence of RHD has required this new aspect to also be incorporated into research.

It is essential that research be aimed at increasing the efficacy of current technologies and maintaining the gains already made. In particular, it is essential that RHD is understood more fully and that RHD remains a viable biological control mechanism well into the future. It is important that research is conveyed to the field ensuring pest liaison and extension service staff are aware of recent developments.

There is little quantitative information available to reliably demonstrate the relationship between rabbit density and the impacts to base a good case of cost-benefit modelling on. Costs and benefits of various methodologies are poorly understood and a program of strategic sustained management – which has anecdotal evidence of being the best methodology – needs to be researched in such a way that some definitive conclusions can be reached to validate this programs approach. Various case studies are coming to light such as Maniototo Pest Management Ltd's program, which support this approach and so from a practical perspective this approach has merit, however, this needs to be backed by more technically rigorous research. A holistic research approach is needed to ensure that

SSM does actually give the best long-term outcomes for RHD maintenance and is the most cost effective model.

Alternative control tools are often the focus of research. This is important but there are only so many ways you can kill a rabbit. However said it is important to ensure maximum efficacy is being achieved at the lowest cost from current technologies and methodologies.

Ecological implications of rabbits and the damage they do to native plant communities appears to be poorly understood so this area of rabbit management could prove an advocate for rabbit management for people who are averse to rabbit control. Often the people who are anti-pest control are also pro-ecosystem so there is potential to leverage effective rabbit management on the native ecosystem argument. This area needs a better understanding of whether rabbits are indeed altering the structure of native plant communities as is thought.

RHD research, while now becoming a well-studied topic and providing a wealth of knowledge is still unable to generate a RHD epidemic prediction model that is reliable. An RHD epidemic is a complex set of environmental, population level and insect vector parameters that are hard to model, however one large gap in knowledge is the ability of rabbit control programs to predict the need to implement a control program in the presence of RHD. A lot of forward planning is required to implement a large-scale rabbit control program and resources may be wasted planning to kill rabbits that would die from RHD anyway. This situation makes current pest control planning very difficult. The use of key indicator sites may provide a two-fold result of helping to understand RHD epidemics while also giving good baseline data to evaluate the efficacy of the disease over time. Ongoing monitoring is required to better understand what is happening with RHD at the field level and why.

All research needs to be focused on developing effective rabbit management in the post RHD environment, with the long-term objective being to permanently reduce rabbit infestations.

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