Review of Rabbit Management Initiatives

Addressing the rabbit problem in the Otago region

Image: Otago Regional Council

Manaaki Whenua
Landcare Research

Otago Regional Council

Version: 1.0
Status: Final
Date: 21.07.2022

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Executive Summary

Otago Regional Council (ORC) biosecurity staff have commissioned this report to explore novel scientific and social science tools that could assist in strengthening rabbit management within the Otago region.

Following a comprehensive review of international rabbit management programmes, tools, research programmes, and recent literature, it was found that there are no novel scientific tools being utilised overseas that have not already been (at least) trialled by ORC. CSIRO in Australia has an active biocontrol research programme for rabbit management, although nothing is ready for immediate implementation.

Despite there being no new control tools available, the review provides several recommendations that could considerably strengthen existing rabbit management. The recommendations have been grouped into national and regional initiatives for easy reference and have been prioritised to assist with planning and implementation:

National level recommendations	Potential lead agency	Priority
Business Case		
Assess support amongst other Regional Councils for developing a National Business Case for Rabbit Management similar to that undertaken for Wallabies. A key component of the business case should be ensuring adequate funding for research to direct effective rabbit control efforts. This could be led by ORC.	ORC with support from other regional councils, MPI, DOC, LINZ and Manaaki Whenua	High
Research & Relationships		
Establish/strengthen the research relationship with Australian counterparts to ensure NZ biosecurity staff keep abreast of latest developments in rabbit management.	Manaaki Whenua	Med
Undertake further research to increase knowledge of the new RHDV2 strain, including its rate of spread and impacts.	Manaaki Whenua	High
Tools		
Explore the update or re-release of a rabbit management smartphone app similar to RabbitScan or Rabbit Tracker. This needs to be coupled with funding to allow sufficient publicity of the app to ensure its uptake.	MPI	Med

Regional recommendations	Lead	Priority
Oversight		
Establish a rabbit management programme within the Council which oversees the implementation of the following recommendations (including BAU).	ORC Biosecurity Team Leader & Manager Environmental Implementation	High
Funding and Resourcing		
Ensure the operational impacts of climate change on rabbit numbers and management are taken into consideration during annual and long term plan funding rounds. A reduced control window due to climate change may have significant operational impacts with scheduled control not able to be completed. To ensure all scheduled control can take place in a shortened time frame, increased investment in more staff, training and equipment (e.g. planes modified for rabbit control) will likely be required	ORC Biosecurity Team Leader	High
Consider establishing a dedicated role within the ORC biosecurity team to solely focus on rabbit management.	ORC Biosecurity Team Leader & Manager Environmental Implementation	Med
Advocacy		
Follow up with Sherman Smith of the Ministry for Primary Industries who is part of the NZRCG, and continue to advocate for the implementation of recommendations from the RHDV1-K5 Importation Lessons Learned paper.	ORC Biosecurity Team Leader	Med
Operations		
Consider adopting aerial strip sowing of 1080 across large areas of uniform terrain as best practice.	ORC Biosecurity Delivery Leads & Performance and Delivery Specialist	High
Develop a regional monitoring and surveillance programme which incorporates serum testing and fly trap monitoring to increase the effectiveness of targeted biocidal RHDV1-K5	ORC Biosecurity Delivery Leads & Performance	High

releases in semi rural and difficult to control local rabbit populations. This will also help inform research into anomalies such as Moeraki.	and Delivery Specialist	
Research		
Assess with Manaaki Whenua the feasibility and potential advantages/disadvantages of re-releasing the 95 MacKenzie Basin strain of RHDV, including the relevant approval process that would need to be followed.	ORC Biosecurity Delivery Leads	Low
Investigate the cause of low level of rabbit population knockdown in Moeraki and potential immunity to RHDV1-K5.	ORC Biosecurity Performance and Delivery Specialist	High
The impact of climate change on control tools, baiting strategies and resourcing for the Otago region, as well as on upcoming rabbit hotspots.	ORC Biosecurity Performance and Delivery Specialist	High
Research new methods for assessing rabbit densities (outside of MMS) in peri-urban and urban areas, and review RPMP rules and operational plan targets in relation to these areas. In the next iteration of the RPMP, inclusion of a rule around rabbit warrens could also be considered.	ORC Biosecurity Delivery Leads	Low
Data		
Update the rabbit proneness heatmap to take into account the effects of climate change in the region and to guide conversations around management decisions.	ORC Biosecurity Performance and Delivery Specialist	High
Policy		
Meet with ORC policy staff who work with the Resource Management Act 1991 (RMA) to: - Ensure that implications of RMA policy on biosecurity are taken into account when providing submissions and feedback on these processes. - Review the recently released draft Waitaki District Plan and formulate a position for submission on this plan. - Get assistance in establishing a regular forum with regional and district RMA planners to raise awareness of biosecurity and discuss challenges	ORC Biosecurity Team Leader ORC Biosecurity Principal Environmental Implementation	Med

and opportunities relating to rabbit management. - Work up a standard set of resource consent conditions in relation to rabbit management that could be applied to subdivision consents, and share these with District Council planners in the region.		
Communication and engagement		
Revise communication and engagement strategies to take account of latest developments in behaviour change research, and as outlined in this report. Also ensure that operational plan targets, the rationale for the RPMP programme, and how well the region is progressing towards rabbit management targets is communicated to and understood by the public. In addition, if adopting strip sowing of aerial 1080 as best practice, communication and engagement strategies should consider addressing reasons for low uptake by landholders and operators.	ORC Biosecurity Community Education Partnership Lead	High

Surveys, interviews and workshops with ORC biosecurity staff have ensured the thorough testing of these recommendations. It is suggested that as a next step, a plan to deliver on the key recommendations of this report, including consideration of budget and resourcing requirements for successful implementation is prepared.

1. Introduction

1.1. Purpose

In response to the ongoing rabbit problem in the Otago region, Otago Regional Council (ORC) is seeking recommendations to better manage feral rabbit populations in both rural and semi-rural areas of the Otago region.

The purpose of this report is to:

- Undertake a review of current scientific and social science tools used in Australia (and other relevant environs) to manage feral rabbit populations; and
- Outline recommendations for further investigation and potential implementation within the Otago region, with a view to widening the range of management methods that may be able to be used.

Note that the terms feral rabbit, wild rabbit and rabbit are used interchangeably throughout this report, but in all instances it is feral/wild rabbits that are the subject of findings and recommendations.

1.2. Scope

In addition to the above, ORC is particularly interested in potential biocontrol options for controlling rabbit populations in rural and semi-rural environments as well as exploring social/behaviour change responses to rabbit management. This review focuses on these options as well as others which are being utilised primarily in Australia.

1.3. Structure of the report

This report provides:

- A brief overview of the rabbit issue in Otago and the impacts rabbits are causing;
- Key findings from the review of literature, surveys and workshops, identifying where rabbit management in the Otago region could be strengthened;
- Recommendations on management initiatives that warrant further investigation;
- Next steps for ORC.

1.4. Methodology

To arrive at the recommendations presented in this report, the following steps were undertaken:

- A review of the following information sources to establish the most recent innovations in the field of rabbit management:

    - recent journal articles on rabbit management techniques and behaviour change programmes, and
    - research programmes led by CSIRO and Manaaki Whenua - Landcare Research.
    - General internet searches to pick up any innovative rabbit management tools that have not been documented in journal articles and/or formal research (see Bibliography).
- ORC biosecurity staff were invited to respond to a survey exploring the current rabbit management programme in the Otago region and any challenges/potential opportunities moving forward. A copy of the survey questions is contained in Appendix A.
- Two virtual workshops were held with key ORC biosecurity staff, and Janine Duckworth of Manaaki Whenua - Landcare Research. These workshops covered the following:
    - **Workshop 1:** Understanding the rabbit problem in Otago, locations of hot spots within the region, potential factors influencing population numbers and what methods/tools have been tried already and to what level of success, helping to inform recommendations for potential new methods.
    - **Workshop 2:** Presentation and testing the findings of the literature review on rabbit management initiatives to inform final recommendations.
- In addition to the above, the RHDV1-K5 importation lessons learned paper produced by Place Group on behalf of the New Zealand Rabbit Coordination Group (NZRCG) following the release of RHDV1-K5 has been reviewed to inform recommendations in relation to improving national resourcing and coordination. Contact was also made with biosecurity staff from Environment Canterbury to discuss key contacts within the NZRCG to help progress initiatives, and input regarding RHDV strains and RHDV monitoring and surveillance protocols was sought from Manaaki Whenua.

This report has also been peer reviewed by Janine Duckworth of Manaaki Whenua who has extensive research experience in biocontrol for rabbits.

2. Overview of the rabbit issue

2.1. A brief timeline of the rabbit problem

ORC have declared European rabbits (*Oryctolagus cuniculus*) as the number one pest in the Otago region. Imported in the 1800s as game, and as a meat and fur source, the European rabbit was one of the earliest mammalian pests to be introduced to New Zealand (Norbury and Duckworth, 2021; Department of Conservation, n.d).

Native to southern Europe and North Africa, European rabbits favour a dryland semi-arid climate, which the Otago region is well suited for. With favourable climatic conditions including grassland habitat at low altitudes, ample sun and low rainfall, and a lack of natural predators, Otago (Central Otago in particular) provides the perfect breeding ground for rabbits (Otago Regional Council, 2022).

The following excerpt from Te Ara[1] briefly outlines the rise of the rabbit population to plague proportions following introduction to New Zealand:

> *"A population of rabbits became established in the coastal sandhills between Invercargill and Riverton in the 1860s. In the early 1870s rabbits from this area began moving up the banks of the nearby rivers onto the inland plains. By 1875 they were established in Central Otago. By the early 1880s rabbits had spread to all parts of Otago and Southland and had begun to invade Canterbury. In the 1890s they overran the Mackenzie Country.*
>
> *In the South Island the first rabbit plague had peaked by 1895. After this, rabbit numbers remained high in the semi-arid region of Central Otago, but dropped markedly in other areas."*

Following importation, initially the establishment of wild rabbit populations was limited by lack of suitable habitat. However, the subsequent increase in pastoral farming over the years assisted spread and growth in numbers (DOC. n.d).

Internet searches have confirmed that Otago's rabbit problem still remains highly topical, with a multitude of news articles expressing landowner frustration at the destruction the pest wreaks across the landscape.

2.2. Impacts of rabbits

Regarded as primarily an agricultural pest, five main impacts can be attributed to rabbit infestation (DOC, n.d.), (ORC, 2022):

- **Competition for pasture** - 7 to 10 rabbits eat as much pasture as 1 ewe, affecting pastoral production, lambing rates, and livestock mortality.
- **Assisted spread of bovine tuberculosis** - rabbits provide a stable food source for mammalian predators carrying bovine tuberculosis.
- **Increased erosion** - burrows and scrapes cause extensive damage on erosion-prone soils, so much so that agricultural land can be rendered useless.
- **Threat to ecological values** - browsing on vulnerable native plant communities has meant that some areas once well covered with tussock, grasses and small shrubs – now have very little vegetation cover leaving them prone to soil erosion from wind and rain and invasion by weeds. Rabbits also provide a year-round food source to mammalian predators which are contributing to the extinction of many New Zealand native birds and animals.
- **Destruction of gardens and planting** - rabbits readily destroy gardens and eat tree seedlings and vegetables.

With the ability to breed from five months of age, a single female rabbit (doe) is able to produce 20-50 offspring in a year, with a litter of four or five kittens every six weeks. This means that if a female rabbit is born in early spring, it can be expected that she will produce young within the same breeding season (DOC, n.d). Such a high reproductive potential sees

[1] Peden, R. (2008) *'Rabbits - The spread of rabbits in New Zealand',* Te Ara - the Encyclopedia of New Zealand, http://www.TeAra.govt.nz/en/rabbits/page-1 (accessed 29 April 2022).

rabbit populations commonly increasing eight-to tenfold in one season (Peden, 2008). Does are also capable of adjusting litter sizes to food supply meaning that rabbit populations are capable of rebounding quickly from natural disasters or control pressures (DOC n.d).

3. Key findings - survey, literature review and workshops

The following sections outline the key findings from survey responses, our review of literature and feedback from the workshops. The survey was designed to guide the direction of the literature review by exploring the current rabbit programme, opportunities and challenges for rabbit management. The workshops provided an opportunity to test findings and further explore areas of interest that had been identified with ORC biosecurity staff.

3.1. Survey Responses

Survey participants had differing levels of biosecurity knowledge and understanding of rabbit management

To better understand feral rabbit management in the Otago region, a survey was sent to key biosecurity staff from the ORC Environmental Implementation team. Responses to survey questions highlighted differing views and knowledge/understanding of rabbit management amongst staff - likely due to varying roles/responsibilities within the team and level of experience with biosecurity.

Participants included:

- Manager Environmental Implementation - managerial role
- Team Leader of the Biosecurity Team - managerial role
- Delivery Lead Central Biosecurity - operational/field role
- Delivery Lead Coastal Biosecurity - operational/field role
- Principal Environmental Implementation - strategy role
- Community Education Partnership Lead - education role
- Performance and Deliver Specialist - data analyst role

It is important to note that rabbit management forms part of the wider biosecurity programme at ORC and at present there is no FTE dedicated solely to rabbit management within the council.

Rabbit hotspots

Central Otago and Wanaka have long been strongholds for high rabbit population densities. In recent years, biosecurity staff have identified what appears to be a number of new emerging hotspots outside of these areas. These new areas are primarily coastal and include spots within:

- Coastal Otago - down to just south of Dunedin

- Otago peninsula
- Moeraki
- Catlins
- Millers Flat
- Milton/Waihola
- Waikouaiti (inland, and previous hotspot)
- Shag Valley/Pig Route (near to Macraes, and previous hotspot)

Factors identified (outside of environmental and climatic factors) that could potentially be influencing the upswell in rabbit numbers at these locations include:

- Lack of previous control/management action from both land occupiers and ORC.
- Land use change - many large farms have been subdivided into smaller lifestyle blocks resulting in more landowners to coordinate to undertake rabbit control, an increase in social and economic barriers, and a limitation of control tools due to urbanisation.
- Management efforts being hindered/compromised by neighbouring occupiers/landowners who aren't undertaking control.
- Reluctance/inability to use vertebrate toxic agents (VTAs), or shoot rabbits.
- Community perception issues around safety of VTAs and night shooting that need addressing.
- Cost of control vs the lack of economic value associated with controlling rabbits (particularly in peri-urban areas).
- Lack of awareness in relation to when control should be undertaken and coordination in timing of effort.
- Perception that ORC alone should be managing rabbits.
- Land blocks that have multiple owners or trustees, complicating management/control initiatives.

Rabbit management tools

The following rabbit management tools have been used within the Otago Region. The relative success of each tool/method is dependent on the context in which it is used.

- Fumigation of burrows using Magtoxin
- Vertebrate toxic agents - 1080 and Pindone
- Biocontrol release - RHDV1-K5
- Rabbit stops (like small cattle stops - used at the Pisa Moorings subdivision)
- Rabbit proof fencing
- Ferreting
- Dogging
- Shooting
- Long netting
- Trapping
- Warren ripping
- Hand digging or blocking up burrows
- Rules within the ORC Regional Pest Management Plan

- Advocating for conditions on subdivision consents
- Community engagement

The above list has helped to direct our search of literature for novel rabbit management tools/methods, and to refine with ORC biosecurity staff where refinements to current practices could be made to improve rabbit management within the region.

Use of RPMP rules and RHDV1-K5 in achieving MMS 3

The Regional Pest Management Plan (RPMP) for Otago lists feral rabbits as a sustained control pest. Rules under this programme set the requirement to ensure rabbit populations do not exceed level 3 on the Modified McLean Scale (MMS)[2] and place the responsibility for control with the land occupier. ORC facilitates this programme by inspecting properties, undertaking advocacy and education, and enforcing rabbit control where appropriate. The 2021-2022 Operational Plan, which accompanies the RPMP, sets out ORC's role in more detail with an emphasis on monitoring feral rabbit trends, responding to complaints, and facilitating community-led action.

The RPMP became operative shortly after the first release of RHDV1-K5. Survey results show that the ORC Biosecurity team now believe reliance on the RPMP programme as it stands, coupled with strategic release of RHDV1-K5 is not enough to achieve the objective of maintaining feral rabbits at MMS 3 across the region. This indicates that some level of change, either within or outside of the RPMP, is likely required to achieve this objective.

It was also raised within the survey that additional tools to measure rabbit population densities in urban areas may be required, as the MMS was developed for broad-scale (i.e. rural) areas and is therefore not as well suited to estimating rabbit densities on peri-urban and urban landholdings.

Responsibility for rabbit control

The responsibility for rabbit management in Otago has changed numerous times over the decades from Rabbit Control Boards, to ORC, to land occupier responsibility, and some confusion remains over who is now responsible for control. Whilst community engagement programmes are addressing this confusion, there still appears to be a misconception amongst occupiers of smaller landholdings that ORC is responsible for rabbit control. This also appears to be true for people who have moved into the region and are unaware of the rabbit problem.

Survey results show that ORC biosecurity staff feel that this range of views could potentially be due to targets within the ORC Operational Plan not being effectively communicated or understood, and confusion for the layperson over which pests ORC undertakes direct control of, as this differs on a pest by pest basis in the RPMP. Staff, in their engagement with communities also see instances of people being unaware of RPMP rules and the obligations these place on them.

[2] See Appendix B for the Modified McLean Scale.

Whilst these observations are anecdotal, they highlight that effective communication and dissemination of information is still required on an ongoing basis to support rabbit management within the region.

Community engagement and barriers to effective rabbit management

ORC has considerably increased its efforts in community engagement to assist and educate land occupiers and community groups on rabbit management over the last 3 years. Despite this ramped up effort, there are still disparate community views over what successful rabbit management entails.

Of those communities that have been engaged with, ORC staff have noticed that often groups seek different outcomes in regards to rabbit management. Some desire eradication of rabbits across the region and for work to be undertaken by ORC, and others seek sustained control to MMS level 3 and just need a little support to fulfil their responsibilities under the RPMP. Views often vary depending on people's values and how they are being affected by rabbits. For example a station owner will likely experience a large financial loss if rabbits are left unchecked, whereas rabbits for a lifestyle block owner are more likely to be merely a nuisance. This indicates that the target audience is made up of segments, each of which have different capabilities, opportunities and motivations to undertake rabbit management.

Engagement methods employed by ORC to assist in behaviour change by increasing people's understanding of the issue and ability to undertake control include:

- Information on the ORC website
- Public meetings, drop-in sessions, social media and media releases
- One-on-one meetings between land occupiers and biosecurity staff
- Facilitation of community led programmes
- Letter drops
- Online surveys

Ahikā Consulting were contracted by ORC to provide programme design, stakeholder engagement and project implementation services for community-led pest control (rabbits) initiatives in Otago. Whilst a robust engagement plan was produced, a review of this plan in light of the most up to date international developments in community engagement, has identified opportunities to further strengthen the rollout of this plan by incorporating methods founded in behavioural psychology.

One component of successful engagement is the identification of barriers that prevent people from undertaking pest control. Potential barriers for land occupiers identified by ORC staff include the cost of control/access to control tools and not having the knowledge to plan a successful rabbit management programme for their landholding, or to recognise a growing rabbit problem. Other barriers include individual beliefs on the safety of control methods, and contractor capacity to assist with control operations. These will need to be addressed to effect behavioural change.

In answering the survey questions, ORC staff also identified several other barriers to achieving MMS 3 across the region. These included:

- District planning tools not being utilised to full effect in regards to managing land use change.
- Changes to the monitoring and surveillance programme to make it more robust.
- Inadequate funding for research at a national level to support direct control efforts.
- The inability for landholders to work together collectively to resolve a pest issue in an area made up of multiple landholdings.

3.2. Review of current scientific and social science tools for rabbit management

Survey results helped to refine the literature review by directing our search towards determining any novel control methods not yet tried by ORC, exploring tools being used overseas to implement behaviour change programmes specific to pest management, and identifying future research needs to strengthen rabbit management in the region. The following outlines our key findings of the literature review as well as discussion on these findings explored through the workshops where relevant.

3.2.1. Research and control tools

In reviewing literature on rabbit control tools, it was found that there are no novel methods being utilised overseas that have not already been (at least) trialled by ORC. Lots of research into potential new biocontrol tools is being undertaken, however nothing is ready for immediate implementation. Australian researchers are the most active in this area with the CSIRO biocontrol research programme encompassing:

- Understanding the fundamental biology of rabbit caliciviruses, how viral proteins interact with cellular proteins, and how host cells respond to infection (Urakova et al, 2017).
- Diagnostics and surveillance of rabbit caliciviruses and myxoma virus in Australia, understanding which viruses are active, when and where in Australia and how they interact with each other (Hall et al, 2018).
- Investigation of how different caliciviruses in Australia can be applied in a more strategic manner to maximise the outcome of rabbit biocontrol operations and further reduce rabbit impacts to agriculture and the environment (CSIRO, n.d.).
- Understanding the evolution of rabbit caliciviruses through time (Mahar et al, 2021).
- Understanding how RHDV2 infection differs from RHDV1 infection and looking at disease progression and welfare impacts (Hall et al, 2021).
- Development of a platform technology to accelerate and direct the natural evolution of RHDV. This is being done through the investigation of rabbit organoid systems (3D cell culture systems that mimic miniature organs) for growing and studying rabbit caliciviruses in vivo. The ultimate goal of this project is to be able to repeatedly select

tailored virus strains for subsequent virus releases, giving the virus the cutting edge to stay ahead in the co-evolutionary arms race with its host (Kardia et al, 2021).

- Pathogen profiling by metatranscriptomic sequencing to identify any potential new pathogens that could be explored in the context of wild rabbit management. This study did not elicit any new pathogens, however it did provide a validated approach to explore future mortality events of lagomorphs that may identify candidate novel biocontrols (Jenckel et al, 2022).
- Investigation of blowflies as a suitable surveillance method for rabbit (and potentially other livestock and human) viruses (Hall et al, 2019).

Whilst there are no new rabbit control tools on the immediate horizon, our review of literature did reveal new developments in the way some existing control tools can be applied.

A paper by Latham et al (2016) recommends refinement of sowing methods for aerial 1080 to control rabbits on agricultural land by using strip-sowing techniques instead of broadcast sowing. Whilst strip sewing is not new and has been in practice for many years, previously variable and often wider spacing has been used between strips (e.g. 150m) and this has resulted in variable efficacy (Duckworth, J., pers comm, 13 July 2022). The Latham et al paper clarifies the effective baited swath width for fixed-wing aircraft (24m - 12m either side of flight line) and helicopters (13m) to ensure access to baits by a high proportion of rabbits, and also recommends a reduction in sowing rates to 10-15kg/ha (down from 20-35kg/ha under broadcast sowing) (Latham et al, 2016).

This method does not result in any loss of efficacy over large areas of uniform terrain and could also result in potential medium-high cost savings over a 20 year farm management plan due to a reduction in sowing rates (10kg - 15kg vs 20 - 35kg per hectare) (Latham et al, 2016). Latham et al do note however that caution in applying strip-sowing control is recommended in areas where it may be difficult to align strips sufficiently to ensure all rabbits are able to encounter sufficient bait (i.e. to ensure that there are no gaps between baited areas of more than ~50 m) (Latham et al, 2016). This might be of particular concern in areas that are comparatively small (<100 ha), irregularly shaped, and/or where the terrain is broken and rugged (Latham et al, 2016).

The ongoing availability of 1080 for pest control is important because, in the post-RHD environment in New Zealand where population resistance to the disease is high, there are currently few other high-efficacy broad-scale tools for reducing high density rabbit populations (Latham et al, 2016). This new operational practice responds to the 2011 review of 1080 use in NZ by the Parliamentary Commissioner for the Environment which called for optimising the use of 1080 to minimise potential risks associated with the toxin (Parliamentary Commissioner for the Environment, 2011). Increased cost savings, and a reduction in sowing rates is likely to make the use of 1080 more socially acceptable (Latham et al, 2016).

However despite the above, the rate of adoption of the strip-sowing technique has been low. Potential barriers appear to be that operators are unwilling to change from what they know and are concerned that landowners may try to cut corners and not follow the recommended amounts and bait strip spacings (Duckworth, J., pers comm, 13 July 2022). It is

recommended that these barriers are addressed as part of any behaviour change programme.

3.2.2. Climate change

With climate change trending towards warmer winter periods, food availability for mammalian pests is becoming less scarce due to longer growing seasons. When food is not limited, susceptibility to anthropogenic control methods is reduced (Latham et al, 2015).

The optimal time to poison rabbits is outside of their main breeding season (which occurs in spring through to early summer) (Latham et al, 2015). In temperate regions, food availability is typically limited by low winter temperatures, and rabbit populations during this time are at their lowest. Consumption of baits during winter is high, achieving high kill rates (Latham et al, 2015). As winters warm and rainfall increases, if higher temperatures do not cause a moisture deficit grass continues to grow, resulting in increased food availability and a population of rabbits that are less likely to consume poison baits (Latham et al, 2015). The optimal control period therefore becomes restricted resulting in poor kill rates, and continued environmental and economic impacts as rabbit populations quickly rebound (Latham et al, 2015).

A reduced control window due to climate change may have significant operational impacts with scheduled control not able to be completed. To ensure all scheduled control can take place in a shortened time frame, increased investment in more staff, training and equipment (e.g. planes modified for rabbit control) will likely be required (Latham et al, 2015).

3.2.3. RHDV1-K5

Biocontrol agent RHDV1-K5 was released in 2018 and thought to be a potentially significant biological control tool for pest rabbits in New Zealand (Manaaki Whenua, n.d.). Following its release it was expected there would be improved knockdown in those areas where the current strain of RHDV is less effective. However, whilst initial knockdowns in rabbit populations did occur, subsequent knockdowns have not. This outcome has likely been due to a number of reasons and research is ongoing to determine a definitive cause.

Current unpublished research has shown that there are a number of strains of RHDV circulating in New Zealand rabbit populations including RHDV1-Czech, RHDV2 and the benign RCV-NZ1 (Duckworth, J., pers comm, 1 June 2022). This means that those rabbits that have had prior exposure to these virus strains and have survived, now have antibodies protective against RHDV and are immune to subsequent RHDV infections.

RHDV2 kills off young rabbits, but may be killing all ages of naive rabbits at a lower rate meaning that a bigger proportion of the population becomes immune to RHDV2 and survives to breed. Further research to increase knowledge of the new RHDV2 strain, including its rate of spread and impacts is needed (Duckworth, J., pers comm, 1 June 2022). One thing that is known is that the RHDV2 strain in New Zealand is not the same as the RHDV2 circulating in Australia.

Rabbits acquire immunity due to (Norbury and Duckworth, 2021):

- Exposure to RHDV1-Czech at a young age (rabbits <8-9 weeks survive exposure)
- Maternal antibodies in utero or via lactation (protect up to ~8-10 weeks)
- Surviving infection with normally lethal dose (<1-5%)
- Cross-protection from antibodies following infection with benign, non-pathogenic rabbit calicivirus (eg. RCV–NZ1)
- Genetic changes in the virus or the rabbit

In addition to the above, there is anecdotal evidence that the benign RCV-NZ1 strain may have affected the efficacy of RHDV1-K5 (Duckworth, J., pers comm, 1 June 2022). Initially it was thought that RCV-NZ1 would act in a similar manner to the Australian version of the benign calicivirus (RCV-A1) and therefore RHDV1-K5 would be more effective than the RHDV1-Czech strain. However when rabbits were challenged with RHDV1-K5 and RHDV1 Czech strains, the following results were recorded:

	Percentage of rabbits surviving RHDV challenge	
	RHDV1 K5	RHDV1 Czech
Naïve Rabbits	0% (0 of 7)	0% (0 of 7)
Prior exposure to benign RCV-NZ	100% (7 of 7)	57% (4 of 7)
Australian Trial Results: Prior exposure to benign RCV-A1	25%	50%

The New Zealand benign RCV strain (RCV-NZ1) provided partial cross-protection against RHDV1 Czech and, unexpectedly, was completely protective against RHDV1 K5. This may explain why RHDV1 K5 failed to compete against RHDV1 Czech and did not persist, leaving RHDV2, and RHDV1 Czech as the lethal strains circulating in wild rabbit populations. RCV-A1 is not present in New Zealand (Duckworth, J., pers comm, 1 June 2022). This challenge study was undertaken on a small scale, and further monitoring is needed to verify results, however it provides an insight as to why RHDV1-K5 may not be working as expected, and can help guide management decisions about the future application of RHDV1-K5 as a biocide.

The success of RHDV-based rabbit biocontrol depends on a number of factors including:

- Population density and season
- Susceptibility due to age
- Immunity due to prior exposure to lethal rabbit calicivirus strains (RHDV1 Czech/K5 or the new RHDV2 strain)
- Partial immunity due to benign rabbit calicivirus (RCV-NZ1)

To help increase the effectiveness of targeted RHDV1-K5 releases, development of a regional monitoring and surveillance programme incorporating serum testing and fly trap

monitoring was discussed with workshop participants. Sampling of carrion flies through fly trap monitoring provides an effective surveillance field tool for monitoring lagovirus spread and circulation at a landscape scale, which in turn can help to guide more effective rabbit management programs (Hall et al, 2019). Manaaki Whenua can undertake multiplex assays to detect various RHDV strains in the liver of dead rabbits and circulating in carrion flies and provide information on which RHDV viruses are present or absent in an area. Once this information is known, serum testing of rabbits for RHDV antibodies can further inform a potential response by helping determine the proportion of rabbits susceptible to a RHDV biocide operation or a natural outbreak e.g. the proportion of naive rabbits.[3] It is possible that RHDV1-K5 could be introduced at key times in populations where immunity to RHDV is low, to strategically suppress rabbit populations.

It was noted in the workshops that Moeraki and some peri-urban areas have experienced low levels of kills despite baits laced with RHDV1-K5 being eaten. Moeraki has never had a fly trap monitoring network (Stevenson, S., pers comm. 20th May 2022). Serum testing for antibodies and fly trap monitoring could help inform research in these areas to determine the potential cause of this anomaly. Running multiplex assays is expensive with four samples costing approximately $1200, however if monitoring on a regular basis with a larger throughput of samples, there is potential to automate some of the process which would assist with bringing costs down. At present, Manaaki Whenua are equipped to run 8-10 samples at a time (Duckworth, J., pers comm, 1 June 2022).

95 MacKenzie Basin Strain of RHDV

Research undertaken in 2012 to determine lethality of RHDV strains, showed that the '95 MacKenzie Basin' strain of RHDV was the most lethal strain in New Zealand (at that point in time). This strain killed 100% in an average time to death of 39.9 hours. The aim of the research was to find a strain that killed "quickly and humanely" (Price, 2015). While more than 24 wild strains of RHDV1 Czech had been detected by Manaaki Whenua, only nine were tested because of resource limitations (Price, 2015).

The MacKenzie Basin strain could be locally released again, however approval from the Environmental Protection Authority may be required, and this is something that would need to be investigated (Duckworth, J. pers comm, 1 June 2022).

[3] AgResearch is currently the only organisation running RHDV antibody assays as a commercial service. This service is currently on hold as AgResearch has run out of reagents. Importation of test kits has not been possible for the last 2 years due to a lack of international flights to bring frozen freight on dry ice from Italy to New Zealand. International freight may soon be possible, but freight costs have skyrocketed to ~$6000 per shipment. This is a problem worldwide. As the reagent kits expire after a couple of years, it would be extremely useful for AgResearch to have a reliable estimate of the number of samples the councils wish to have tested each year to determine if there is sufficient demand for testing so that the service would be cost effective. To date, AgResearch testing has used RHDV1 antibody kits which may cross-react and also detect RHDV2 antibodies. This would have to be confirmed. There are also now specific RHDV2 antibody reagents available from the Italian manufacturer. Manaaki Whenua Landcare Research's most recent results indicate that RHDV1 Czech and RHDV2 seem to be the main strains circulating (Duckworth, J. Pers Comm, 21 June 2022).

3.2.4. Monitoring and surveillance for RHDV strains - digital tools

The review also revealed a variety of tools such as the app RabbitScan - a free resource for landholders, landcare groups, community groups, local councils, professional pest controllers and biosecurity groups (FeralScan, n.d.) to assist with citizen science in Australia.

The app helps users to:

- Develop a property or local area map of rabbit activity to guide control efforts.
- Work together with neighbours to undertake coordinated control.
- Notify local community or landholder groups about rabbit activity and disease presence.
- Send alerts to nominated people, such as neighbours or biosecurity authorities

The app which is part of the Australian FeralScan programme supported by Centre for Invasive Species Solutions, Australian Wool Innovation Ltd, NSW Department of Primary Industries, FeralScan and PestSmart, also helps communities track the spread of RHDV1-K5 by:

- Prompting users to record details of dead rabbits including uploading images of rabbits affected by virus and disease for easy ID.
- People can also submit tissue samples from dead rabbits with suspected RHDV. Users click a sample button and are sent a free postage-paid sampling kit with full instructions for sampling and sending. Once samples are confirmed a digital map is updated, and the person who sent the sample is notified with accurate information of what virus is affecting rabbits in their area or control site, which is valuable information for management planning.

RabbitScan was looked into some time ago for potential rollout within New Zealand, however the cost for the app at the time was estimated at approximately $3 million, and didn't receive sufficient buy-in. A New Zealand version of the app called Rabbit Tracker was created, and was used at the time of the RHDV1 K5 release. However it had relatively limited functionality and didn't take off due to insufficient funding for publicity and lack of training resources like those developed for Australian land managers (Duckworth, J., pers comm, 1 June 2022).

The use of GIS to produce heatmaps identifying rabbit prone land within the region was also discussed in the workshops. Murray Boardman noted that the current heatmap for Otago was done some time ago and requires updating, particularly to take account of the potential impacts of climate change and land use changes (irrigation, vineyards and subdivision). Manaaki Whenua could assist ORC with this project as they have the GIS layers available, but would need data from ORC on rabbit densities on different land types (Duckworth, J. pers comm, 1 June 2022). Once the heatmap is updated, it could be used as part of the monitoring and surveillance programme informing conversations and management decisions around potential hotspots, district planning levers, and the next iteration of the RPMP.

3.2.5. District plan levers for rabbit management

Several levers exist within the District Planning under the Resource Management Act 1991 (RMA) which may complement regional rabbit management efforts under the Biosecurity Act 1993 (BSA). Survey responses highlighted that ORC has previously tried to advocate (unsuccessfully) for consent conditions to be placed on a large subdivision consents in Wanaka to curb increases in the rabbit population that inevitably follow the urbanisation of pastoral land.

Other options beyond requesting specific consent conditions that could be explored under the RMA to support rabbit management include:

- Developing a set of consistent rules that could be inserted into District Plans through the plan review or private plan change process. Zoning could also be explored based on identification of rabbit prone land and appropriate land uses.
- Establishment of a regular biosecurity forum with District Planners (and ORC policy planners) to discuss challenges and opportunities for biosecurity and how different land uses impact on biosecurity objectives. This may also increase information sharing regarding opportunities to participate in impending District Plan reviews that the ORC Biosecurity Team may not otherwise be aware of.

District Plans are legally required to undergo a review every 10 years. The table below highlights which plans within the region are coming up for review:

District Council	**District plan due for review?**
Queenstown-Lakes	Has gone through review process, part way through appeals
Central Otago	Operative in 2008, overdue for review
Clutha	Operative in 1998, overdue for review
Dunedin City	Has gone through review process, part way through appeals
Waitaki	In the process of review, notification of informal draft **1 June 2022**

The Waitaki District Plan is currently in the process of being reviewed, and this represents an opportunity for ORC Policy and Biosecurity staff to be involved. If ORC wishes to request changes to the other district plans outside of their respective review cycles, private plan changes would need to be initiated, and costs borne by ORC rather than the district councils.

Hines et al (2019) also note that amending legislation to promote desired behaviours and prohibit undesired behaviours, and working towards achieving legislative consistency across all areas that influence the performance of the desired behaviour is an important component of pest management.

3.2.6. Behaviour change programmes - engagement tools

Workshops with ORC biosecurity staff highlighted that there are still some perception issues within communities regarding rabbit management that require addressing. The council is receiving political pressure from the non-rural sector to manage the rabbit problem, and barriers to participating in rabbit management remain for some segments of the target audience. Occasionally ORC also has to deal with misinformation regarding rabbit issues and/or control.

Our review of literature revealed that there are several ways to help strengthen communication and engagement programmes to overcome these issues, based on techniques used in behavioural psychology. Most of the information, strategies and tools provided below are drawn from Australian resources and can be used to inform engagement strategies moving forward.

It is important to keep in mind that when implementing behaviour change programmes, placing top down pressure on communities to take action should be avoided unless supporting resources to enable and empower communities to carry out the desired action are provided. Doing so risks feelings of antagonism and can have negative implications for community/government relationships (Howard et al, 2016).

Behaviour selection framework

With limited budget and resources, it is important to ensure that energy invested into engagement is going to have the desired end result. Most behaviour change interventions fall down by trying to change the wrong behaviours or too many behaviours at once (Hines et al, 2019). Keeping communication goals clear, specific and framed as concrete behavioural outcomes will help shape interventions and provide a base for programme evaluation (Hines et al, 2019). An example of a communication goal could be to "Increase the number of rural landholders undertaking rabbit control in Central Otago by 2024". Once the goal has been identified, working out where to focus effort and funding to effect the most change is an important next step. McKenzie-Mohr (2011) provides a useful tool called the 'behaviour selection framework' which can help with this prioritisation process.

The behaviour selection framework requires different behaviours to be rated based on the **impact** of the behaviour on tangible ecological, economic, social and public health outcomes, the **probability of adoption**, and the proportion of the target population currently engaged in the behaviour **(penetration)**. This information is then used to calculate the projected effectiveness of each behaviour by multiplying: *impact x adoption probability x (1 - penetration)* (Hines et al, 2019).

A general rule of thumb is to design engagement interventions that target high impact behaviours that have a reasonably high probability of being adopted, and are not already being undertaken by most of the target audience (Hines et al, 2015).

Target audience segmentation

The threat of pests to the environment, biodiversity and people's livelihoods is often well publicised and well known by target audiences. However, despite this, it remains difficult to get 100% land occupier participation in pest control activities recommended by experts (Mcleod et al, 2019). A recent case study which surveyed 731 rural landholders in rural western Australia and their participation in control activities to manage invasive mammals, found that over half of the respondents had not participated in any activities over the previous 12 months (McLeod et al, 2019). The study found a range of reasons for non-participation and highlighted that within the target audience existed six subgroups, each with distinctive psycho-graphic profiles:

- *Unaware, unskilled and unmotivated*
- *Aware but unskilled and doubtful*
- *Unskilled and time poor*
- *Disinterested*
- *Skilled but dismissive*
- *Capable but unmotivated*

These results, obtained using latent profile analysis, demonstrate that engagement specialists should not treat non-participating landholders as a single homogeneous group (McLeod et al, 2019). Non-participators differ considerably in terms of their capabilities, opportunities, and motivations, and require targeted engagement strategies informed by these differences (McLeod, 2019). The key reason for undertaking target audience segmentation is to help better allocate available resources, focus strategies and messages and increase the likelihood of influencing permanent behaviour change (Slater, 2006), thereby increasing the success of rabbit management.

It is important to acknowledge that trying to change human behaviour is a complex process, and learning which engagement methods work best for different audience segments will be iterative (McLeod et al, 2019). There are several good starting points for understanding attributes which can be used for undertaking audience segmentation, including the COM–B method (Michie et al, 2014), and segmentation based on stages of change - or the *'Transtheoretical Model'* (Prochaska et al, 1992) (as cited in McLeod et al, 2019).

The COM-B method is founded on understanding the causes that lead landholders to engaging in desirable behaviours (drivers), in this case pest management, or those that prevent them engaging in the activity (barriers) (Hine et al, 2019). Drivers and barriers can be grouped into three main types:

"Capability - Do landholders have the relevant knowledge, skills and physical capacity to engage in the target behaviour? Do they know the best management strategies? Are they physically able to hunt, trap and bait?

Opportunity - Are situational conditions present to support the behaviour? Are relevant laws and other support structures in place? Are appropriate control technologies such as baits, ejectors and viruses readily available?

Motivation - Are landholders sufficiently motivated to take action? Are they aware a problem with invasive animals exists in their region? Do they possess the right combination of values, attitudes and beliefs to inspire action?" (Hine et al, 2019, p. 12).

The Transtheoretical Model of behaviour change recognises that change is gradual, and as people change their behaviour they progress through five distinct stages (Hines et al, 2019, pg. 13):

1. *Pre-contemplation – where they are not considering change.*
2. *Contemplation – where they are beginning to think about change.*
3. *Preparation – where they make a personal or public commitment to change in the near future.*
4. *Action – where they are actually changing their behaviour.*
5. *Maintenance – where they are maintaining the changed behaviour.*

Each stage requires a different goal, and therefore different intervention strategies. Hines et al, (2019) provide a good overview of intervention/engagement strategies for people at different stages of the Transtheoretical Model, or those with different drivers and barriers to engaging in the target behaviour. The table below has been adapted from Hines et al (2019) providing examples of engagement goals for people at each of the five stages.

Stage	**Engagement goals**
1. Pre-contemplation (Not ready)	Engage interest in rabbit issue and increase awareness and knowledge of problem.
2. Contemplation (Getting ready)	Requires further motivation to engage in behaviour. Could be achieved by highlighting pros and cons, or giving feedback from community members already responding to rabbit issue.
3. Preparation (Ready)	Focus on increasing confidence and self efficacy. Use engagement strategies that reinforce beliefs that change is possible, and that enhance knowledge and skills related to rabbit management.
4. Action (Making change)	Provide real-time support and advice, consider mentorships, training days, community champions.
5. Maintenance (Keeping up change)	Provide feedback on progress, acknowledgement of achievements, constructive advice for continuous improvements. Get commitment from landholders to engage in a specified behaviour. Commitments work best when they are voluntary, written down, publicised (with permission), and followed up to see if any further assistance can be provided. A good resource can be found here:

	https://www.toolsofchange.com/en/tools-of-change/obtaining-a-commitment/ Follow up with reminders and prompts to ensure timely performance of desired behaviours. These should be specific e.g. push notifications stating 'remember to lay pindone in paddock 6 tomorrow'. A good resource can be found here: https://www.toolsofchange.com/en/tools-of-change/prompts/

Undertaking quantitative target audience segmentation involves statistical analysis, however there are options for using qualitative approaches (depending on project goals) that may be more cost effective. Slater (2006) in their paper on health audience segmentation, describes how to undertake segmentation on a shoestring budget. They note that a well designed survey, gleaning information from published literature on the issue, speaking with key people who are active within the community to gain personal insight into drivers and barriers for different groups, and listening to target audiences are easy ways to undertake effective segmentation at low cost (Slater, 2006).

There is no one correct way to undertake audience segmentation, and the approach will depend on available expertise, goals, financial resources and time constraints (Hines et al, 2019), however the benefits of doing so will always outweigh the costs (Slater, 2006).

Delivering key messages

When disseminating information as part of an engagement programme, it is important to consider how messages will be framed for maximum impact, who is best to deliver the messages so they don't fall flat, and what communication tools to use and when in the process to use them to encourage the behaviour you want to see. Each of these factors is briefly discussed below, with further detail contained in Hines et al (2015).

Communication tools	**Key points**
Framing messages	Message framing involves presenting an issue in a way that achieves a desired interpretation and results in the message being noticed, processed and acted upon. Before selecting a frame it is important to know your audience so you can choose a frame that matches audience values and concerns. ● Different frames might be needed for different target audience segments. ● The most relevant frames to pest animal management are: ○ Consequence frames

	■ Highlighting consequences of not taking action - match these to values e.g. financial loss, potential impacts on mental health, environmental loss. The converse can also be used. ○ Locally relevant frames ■ Frame as a local issue happening within the community to increase the audience's sense of connection to the issue. ○ Now vs future frames ■ Present the problem as 'happening now' and highlight short term consequences of inaction to overcome the psychological phenomenon of 'temporal discounting'. ○ Fear appeals ■ Fear can be an important driver of behaviour change. Strong fear appeals lead to greatest behavioural change when coupled with concrete advice about how to avoid, reduce or eliminate the threat. ■ If fear appeal is not coupled with tangible things people can do to address the issue, risk creating defensive responses such as denial and disengagement - two outcomes best avoided.
Choosing messengers wisely	Audience trust is integral to getting people to take messages on board. In the absence of trust, key messages relating to pest management will be dismissed or ignored. Choosing the right messenger is one way to foster trust. Apply the following key principles in selecting messengers: ● Make sure the messenger is 'likeable', people are put off by messages delivered in an arrogant, cocky or indifferent manner. ● Choose someone who can easily communicate complicated technical information in terms familiar to the layperson. ● Select someone who is similar in demographic to the target audience and who shares similar behavioural characteristics. Avoid messengers who might be perceived as outsiders. ● Choose messengers who are engaged, have a concern for managing wild rabbits and are genuinely committed to solving the problem.

	• Messengers should display honesty and integrity - avoid telling audiences what they want to hear, acknowledge complexity and uncertainty and avoid over-promising. This builds trust. • Different messengers may be required for different audience segments.
Using intrinsic and extrinsic values in communication through deep framing	There are two competing types of values relevant to social and environmental issues - 'intrinsic values' and 'extrinsic values'. • Intrinsic values focus on care and cooperation for the greater good. • Extrinsic values focus on activities and outcomes related to power and achievement. • Deep framing involves developing messages that operate at the level of values, priming values we want to promote. • Draw audience attention to intrinsic values. Emphasise themes like community, cooperation and helping in key messages. Avoid priming extrinsic values. • Avoid mention of extrinsic values related to wealth, personal status and self-interest. In conversation, reframe responses to promote intrinsic values and ignore others.
Using descriptive and injunctive social norms to encourage desirable behaviours	Social norms influence behaviour based on how others behave. They help people determine what is normal, expected or correct. Descriptive norms describe how others behave. Injunctive norms describe what others *should* be doing. • Most people follow the crowd. Use descriptive norms to encourage others to follow suit. E.g. If you want more landholders to bait at a certain time, suggest that most farmers in the area are baiting at this time. • Only use descriptive norms if most people are actually carrying out the desired behaviour, as if not - seeing that most others are not acting creates normative pressure towards inaction. • Use injunctive norms to emphasise what is valued. E.g. praising a landholder for their efforts in rabbit management in a local community newsletter is a good example of an injunctive norm. A case study demonstrating the use of social norms to improve rabbit management is outlined below: *"The Granite Creeks Project group in Victoria has used several methods to gently apply peer pressure and establish new social norms to improve rabbit management. A degree of peer pressure*

	has been used to drive the message, *"rabbit management is a community issue and it needs to be dealt with at a community level".* *Associated with this message is a new norm that government officers work with community and, vice versa, community actively engage with government officers. 'Relationship' is now a central factor for obtaining effective rabbit management.* *A new norm has also developed in the community that people deserve to be fined if they don't engage with their community in rabbit management. This pressures those who don't comply to lift their game or suffer the consequences of production and biodiversity loss, and potential litigation."*
Engaging audiences using narratives	Narratives can be an effective way of reframing scientific knowledge in a way that draws an audience in by tapping into their values and beliefs. The narrative approach allows communicators to unleash their creative instincts and emotionally engage their audiences through compelling characters and storylines. Stories that match personal values and pre-existing beliefs often resonate with people. Recent neuroscience indicates that people's brains react similarly when reading about an experience and actually living the experience (Mar, 2011). This suggests that stories can engage audiences in a fundamentally deeper way than standard scientific writing. ● Ensure narratives are presented in story format with a beginning, middle and end. ● Match storylines to audience values (see target audience segmentation). ● Use a single metaphor to emphasise a point and keep things simple. ● Do not use extended metaphors. ● Metaphors are most effective when used early in the engagement process as this affords the opportunity to shape subsequent engagement. ● Use familiar language.
Encouraging rational thinking	There are two types of systems thinking when it comes to decision-making, system 1 - which is automatic and subconscious, often based on gut feel; and system 2 which is

	rational, analytic, slow, largely free of emotion and logical. Situational factors can prompt people towards system 1 or 2 types of thinking. Understanding how these systems work and how they influence decision-making is critical to crafting persuasive messaging. ● System 1 thinking is often employed when audiences are uninterested or distracted. Here, people use cognitive shortcuts to make decisions and often base these on how much they like the person delivering the message, whether they're perceived as credible, what others think of the message, and how the message makes them feel. ● Wherever possible encourage system 2 thinking through strong, credible and reasoned arguments for change. System 2 thinking promotes long term behaviour change. ● Understanding audience motivation, and selecting message frames which resonate with the target audience will also assist with system 2 thinking. ● Avoid solely relying on system 1 strategies (e.g. emotionally engaging messaging that is intellectually empty). System 1 strategies such as choosing likeable messengers and eliciting positive emotions are recommended, however these should be incorporated with system 2 strategies which encourage longer term behaviour change.
Debunking myths and misinformation	In pest management, deeply entrenched (and often misguided) views are sometimes encountered. Accurate information is required to debunk myths and misinformation, and it is important to understand how people process new information, how existing knowledge is modified, and how current worldviews and beliefs can undermine rational, clear thinking. Below are some key pointers for ensuring that the right information gets through to target audiences: ● Do not repeat myths in messaging. When myths are repeated they become more familiar and are more likely to be believed. It is recommended to avoid the myth entirely. If this cannot be done, only acknowledge the myth <u>after</u> the correct information has been provided. ● If directly acknowledging a myth, be very clear about why the information is incorrect. ● In debunking myths, keep messaging concise, engaging and easy to understand. Less is more. Use images

	liberally to emphasise core facts and arguments. • Beware of pre-existing worldviews and confirmation bias. People often seek out information that aligns with their worldview, and spend significant time composing counter arguments. For those who hold deeply entrenched views, it may be impossible to change their mind. Effort (and money) may be better spent focussing on engaging target audience segments that are undecided or hold moderate views. This again highlights the importance of target audience segmentation. • If deeply entrenched groups must be engaged, select message frames that match with their pre-existing world views and beliefs.

Getting information into the community - how are others doing it?

Several methods for distributing information have been mentioned in this review. However, below is a brief list of key ways biosecurity teams in Australia are getting information out to target audiences, and coordinating community led rabbit management. It should be noted that methods need to be matched to engagement interventions and target audience segments as part of an engagement programme.

Method	**Further information**
Technology • Push notifications • Smartphone Apps • Videos/YouTube clips • Website • E-mail • Phone • Online management toolkit • Social media • Virtual Extension Officer	Short video clips can be an effective way to demonstrate how to bait or undertake other control methods. Smartphone apps can help with mapping rabbit densities, damage, and track knockdowns - an important citizen science tool. Online management toolkits are a way to provide all information in one place, including videos, field guides, factsheets and who to contact for further assistance. A good example can be found here: https://pestsmart.org.au/toolkits/european-rabbits/ Social media can quickly extend the reach of information and create two-way dialogue. However, beware of the platform becoming an echo chamber.

	The Victorian Rabbit Action Network (VRAN) has set up a Virtual Extension Officer - a new interactive tool designed to help landholders manage 3 of Victoria's worst invasive species – gorse, serrated tussock and rabbits. More information can be found here: https://vran.com.au/resources/
Print media • Glovebox guides • Adverts • Newsletters • Articles • Fridge magnets • Window stickers • Pledge cards • Fact sheets	Fridge magnets, window stickers and pledge cards can act as reminders and commitments for people to carry out an action.
In person • Practical field/demonstration days • Community champions • Mentoring programmes • Consultative services • Pint of Science events • Drop in sessions • Workshops/open days • Local community action groups facilitated by Council	These methods primarily focus on upskilling people and building capacity. VRAN offers consultative services to assist individuals, organisations or groups to ensure people are getting the most out of their rabbit management program. Services available include: • Strategic support in the development of rabbit management strategies or integrated best practice rabbit management plans. • Facilitation and presentation services at community workshops or demonstration days. • Onsite training in specific rabbit management control methods. Pint of Science events aim to deliver interesting and relevant talks on the latest science research to the public – in cafes, pubs and bars. The events provide a platform which allows people to discuss research with the people who carry it out, no prior knowledge of the subject is required. Further information can be found here: https://pintofscience.nz/about/

	Community champions are those who are knowledgeable in the subject area, reside within the community of interest, and have the trust of both the community and council as providing credible information and assistance.
Other • Bait delivery and subsidisation schemes • Competitions • Incentive schemes • Victorian Rabbit Action Network (VRAN Cooperative governance model)	Bait delivery and subsidisation schemes can be used to break down barriers for those who are motivated to undertake control but are limited by time and financial resources. Competitions between catchments/districts/towns etc can be used to incentivise communities to take action/participate in rabbit management programmes. However, beware of behaviour returning to status quo once the competition ends (Hines et al, 2019). Incentive schemes can promote rapid behaviour change, and are useful if resources are available. However beware that incentives rarely change intrinsic motivation and behaviour can revert when the incentive runs out. Generous incentive schemes may also result in high uptake quickly exhausting funding, and therefore require careful planning and management (Hines et al, 2019). <u>VRAN</u> The Victorian Rabbit Action Network (VRAN) was established in 2014 as a vehicle to reframe the collective thinking about the Rabbit problem and how it can be managed. A one-stop shop for all things rabbits, VRAN is a facilitating entity founded on the belief that rabbit management can only be improved by bringing everyone together - citizens, institutes, organisations, and government (Woolnough et al, 2020). Everyone has something to bring to the table, whether it be different experiences, knowledge, expertise and insights - bringing together those who do not normally work together promotes learning, creativity and innovation for individuals

	and across the group. VRAN facilitates this process by providing the strategic mechanism to bring community voices and experiences into the design and development of programmes, ensuring that objectives spanning all domains (economic, environmental, social, cultural) are considered (Woolnough et al, 2020). Communities are empowered through enabling more integrated, inclusive and constructive politics among the spectrum of those involved. In addition, resilience and effectiveness of rabbit management programmes are enhanced by building social capacity, bringing local knowledge and experience to bear, changing institutional structures and processes, and shifting to shared decision making (Woolnough et al, 2020).

Evaluation of behaviour change programmes

It is important to incorporate evaluation into behaviour change programmes to determine the effectiveness and cost-effectiveness (ROI) of interventions. This step should be budgeted for upfront in communication and engagement strategies, and involve the use of rigorous methods to determine whether the program works, including: treatment and control groups, random assignment, and statistical tests to rule out chance as an explanation for results (Hines et al, 2019).

Assessing the impact of communications on behaviour (not just awareness or attitudes), and where possible linking behaviour change to environmental impacts is also an important component of evaluation. By adopting a scientific mindset, the results of evaluation contribute to a loop of continuous learning and improvement (Hines et al, 2019).

Monitoring and evaluating the impact of social media campaigns can also be easily incorporated into an overall evaluation strategy. Many free online evaluation tools are available to organisations to assist with this, such as Google for Nonprofits, including Google Analytics, Facebook Insights, Twitter Analytics, Twitalyzer, Cool Social, and Bitly (Alter et al, 2017).

3.3. National and regional resourcing and coordination

At the national level, the NZRCG appears to have lost momentum. Following the successful importation and release of RHDV1-K5, a lessons learned paper was prepared for the NZRCG highlighting recommendations for taking rabbit management forward at a national level. Immediate next steps identified in this paper, included:

- To establish a clear mandate and identify and define the roles and responsibilities within the group.
- Establish formal and ongoing funding streams for the management of the NZRCG and its projects.
- Identify key stakeholders and their representatives and implement an ongoing communication programme focused on rabbit management.
- Report on the outcomes of RHDV1 K5 introduction and potential implications of RHDV2.
- Identify future projects and a programme of work to improve rabbit control nationally.
- Identify consultants and contractors to support and deliver the programme as required.

These recommendations were discussed with workshop participants from ORC and it was noted that staff had recently followed up with MPI on the above actions and were yet to receive an update on progress. In addition to the above, ORC staff highlighted that maintaining relationships with Australian counterparts will be important to ensure New Zealand biosecurity staff are across latest research developments, and that increased funding of New Zealand based research will be integral to the success of rabbit management. These issues need to be addressed at a national level and options for doing so could be explored through a national business case. To start this process, it is recommended that Otago Regional Council contacts other regional councils facing similar rabbit issues to understand the level of interest in progressing a national business case.

At a regional level, to strengthen the ORC rabbit management programme, the idea of a dedicated staff member to solely focus on rabbit management and drive innovation was raised by workshop participants. This role would incorporate a large field component, and potential responsibilities could include:

- Developing a regional monitoring and surveillance programme incorporating serum testing and fly traps
- Experimenting with new technology and methods e.g. thermal equipment, night counts and drones to develop best practice guidance
- Investigating additional tools outside of MMS to assist with enforcement under the RPMP
- Investigating trapping in urban areas - there is anecdotal evidence that a community member traps for harvest and is getting good rabbit numbers (Bowman, R. pers comm, 20th May 2022).
- Running community demonstration days to share developments in new technologies or best practice.

3.4. Regional research priorities

The following regional research priorities for ORC were identified in the workshops:

- Investigating the cause of low level of rabbit population knockdown in Moeraki and potential immunity to RHDV1-K5.

- The impact of climate change on control tools, baiting strategies and resourcing for the Otago region, as well as on upcoming rabbit hotspots.

If budget is not available within current funding levels, these priorities should be considered in the next Long Term Plan funding round.

4. Recommendations

The following recommendations have been made on the basis of the information contained in this report to strengthen rabbit management on both national and regional fronts. It is anticipated that any developments from the implementation of recommended actions will be shared across councils and agencies (where relevant) to encourage advancements in best practice.

Recommendations have been grouped for easy reference:

National level recommendations	Potential lead agency	Priority
Business Case		
Assess support amongst other Regional Councils for developing a National Business Case for Rabbit Management similar to that undertaken for Wallabies. A key component of the business case should be ensuring adequate funding for research to direct effective rabbit control efforts. This could be led by ORC.	ORC with support from other regional councils, MPI, DOC, LINZ and Manaaki Whenua	High
Research & Relationships		
Establish/strengthen the research relationship with Australian counterparts to ensure NZ biosecurity staff keep abreast of latest developments in rabbit management.	Manaaki Whenua	Med
Undertake further research to increase knowledge of the new RHDV2 strain, including its rate of spread and impacts.	Manaaki Whenua	High
Tools		
Explore the update or re-release of a rabbit management smartphone app similar to RabbitScan or Rabbit Tracker. This needs to be coupled with funding to allow sufficient publicity of the app to ensure its uptake.	MPI	Med

Regional recommendations	Lead	Priority
Oversight		
Establish a rabbit management programme within the Council which oversees the implementation of the following recommendations (including BAU).	ORC Biosecurity Team Leader & Manager Environmental Implementation	High
Funding and Resourcing		
Ensure the operational impacts of climate change on rabbit numbers and management are taken into consideration during annual and long term plan funding rounds. A reduced control window due to climate change may have significant operational impacts with scheduled control not able to be completed. To ensure all scheduled control can take place in a shortened time frame, increased investment in more staff, training and equipment (e.g. planes modified for rabbit control) will likely be required	ORC Biosecurity Team Leader	High
Consider establishing a dedicated role within the ORC biosecurity team to solely focus on rabbit management.	ORC Biosecurity Team Leader & Manager Environmental Implementation	Med
Advocacy		
Follow up with Sherman Smith of the Ministry for Primary Industries who is part of the NZRCG, and continue to advocate for the implementation of recommendations from the RHDV1-K5 Importation Lessons Learned paper.	ORC Biosecurity Team Leader	Med
Operations		
Consider adopting aerial strip sowing of 1080 across large areas of uniform terrain as best practice.	ORC Biosecurity Delivery Leads & Performance and Delivery Specialist	High
Develop a regional monitoring and surveillance programme which incorporates serum testing and fly trap monitoring to increase the effectiveness of targeted biocidal RHDV1-K5 releases in semi rural and difficult to control local rabbit	ORC Biosecurity Delivery Leads & Performance and Delivery	High

populations. This will also help inform research into anomalies such as Moeraki.	Specialist	
Research		
Assess with Manaaki Whenua the feasibility and potential advantages/disadvantages of re-releasing the 95 MacKenzie Basin strain of RHDV, including the relevant approval process that would need to be followed.	ORC Biosecurity Delivery Leads	Low
Investigate the cause of low level of rabbit population knockdown in Moeraki and potential immunity to RHDV1-K5.	ORC Biosecurity Performance and Delivery Specialist	High
The impact of climate change on control tools, baiting strategies and resourcing for the Otago region, as well as on upcoming rabbit hotspots.	ORC Biosecurity Performance and Delivery Specialist	High
Research new methods for assessing rabbit densities (outside of MMS) in peri-urban and urban areas, and review RPMP rules and operational plan targets in relation to these areas. In the next iteration of the RPMP, inclusion of a rule around rabbit warrens could also be considered.	ORC Biosecurity Delivery Leads	Low
Data		
Update the rabbit proneness heatmap to take into account the effects of climate change in the region and to guide conversations around management decisions.	ORC Biosecurity Performance and Delivery Specialist	High
Policy		
Meet with ORC policy staff to: - Ensure that implications of RMA policy on biosecurity are taken into account when providing submissions and feedback on these processes. - Review the recently released draft Waitaki District Plan and formulate a position for submission on this plan. - Get assistance in establishing a regular forum with regional and district RMA planners to raise awareness of biosecurity and discuss challenges and opportunities relating to rabbit management. - Work up a standard set of resource consent	ORC Biosecurity Team Leader ORC Biosecurity Principal Environmental Implementation	Med

conditions in relation to rabbit management that could be applied to subdivision consents, and share these with District Council planners in the region.		
Communication and engagement		
Revise communication and engagement strategies to take account of latest developments in behaviour change research, and as outlined in this report. Also ensure that operational plan targets, the rationale for the RPMP programme, and how well the region is progressing towards rabbit management targets is communicated to and understood by the public. In addition, if adopting strip sowing of aerial 1080 as best practice, communication and engagement strategies should consider addressing reasons for low uptake by landholders and operators.	ORC Biosecurity Community Education Partnership Lead	High

5. Next Steps

To strengthen rabbit management within the Otago region the following next steps are recommended:

- Preparation of a plan to deliver on the key recommendations of this report, including consideration of budget and resourcing requirements for successful implementation.

Place Group Ltd are happy to assist with the above, and our staff have a broad range of expertise in the biosecurity field including:

- Navigating legislative change and approval processes under the Hazardous Substances and New Organisms, Biosecurity, and Resource Management Acts
- Biosecurity and resource management policy development
- Development of national business cases using the Better Business Case framework
- Development and delivery of community engagement strategies.
- Project management services.
- ToP trained facilitators.

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CSIRO

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Invasives action tool

https://actiontool.invasives.com.au/dashboard/

Victorian Rabbit Action Network

https://vran.com.au/resources/

8. Appendix A - Survey Questions

9. Appendix B - Modified McLean Scale

Modified McLean Scale

The Modified McLean Scale (MMS) is a scale used by councils to determine rabbit levels. It helps with regulation to make sure landowners are managing rabbit numbers to a level set in the Pest Plan. Otago's Pest Plan has set the scale for Otago at a maximum of level 3.

As a rule of thumb, if you see groups of rabbit droppings less than 10 metres apart, there's a problem and you need to take action.

Scale	Rabbit infestation
1	No sign found. No rabbits seen.
2	Very infrequent sign present. Unlikely to see rabbits.
3	Pellet heaps spaced 10m or more apart on average. Odd rabbits seen; sign and some pellet heaps showing up.
4	Pellet heaps spaced between 5m and 10m apart on average. Pockets of rabbits; sign and fresh burrows very noticeable.
5	Pellet heaps spaced 5m or less apart on average. Infestation spreading out from heavy pockets.
6	Sign very frequent with pellet heaps often less than 5m apart over the whole area. Rabbits may be seen over the whole area.
7	Sign very frequent with 2-3 pellet heaps often less than 5m apart over the whole area. Rabbits may be seen in large numbers over the whole area.
8	Sign very frequent with 3 or more pellet heaps often less than 5m apart over the whole area. Rabbits likely to be seen in large numbers over the whole area.