Boffa Miskell

Wild Animal Management Plan, Upper Rangitata River Catchment

Strategy and Operational Priorities for Management of Wild Animals
Prepared for the Upper Rangitata Gorge Landcare Group and Environment Canterbury

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Executive Summary

The Wild Animal Management Plan (referred to as the Plan in this document) provides direction for the management of wild animal species within the upper Rangitata River catchment. The preparation of this plan included consultation with key agencies and landholders, field surveys within key areas of the catchment, and provides recommendations for the management of wallabies and feral pigs. The upper Rangitata River catchment (henceforth 'upper Rangitata'), above the Rangitata Gorge, has high cultural, biodiversity, agricultural and recreational values. The extensive braided river system provides habitat for indigenous flora and fauna, including threatened braided river bird species. Compared with surrounding areas and adjacent river systems, the upper Rangitata has relatively low abundance of many invasive animal species. Abundant populations of invasive animal species in adjoining catchments is resulting in dispersal into the upper Rangitata. Bennett's wallabies and feral pigs are two invasive species currently dispersing into the upper Rangitata. Both species are successful at invading New Zealand landscapes, but have not yet established high densities within this catchment. Wallabies are extremely cryptic, and feral pigs can reproduce quickly, making them difficult to control effectively. Wallabies browse on a wide range of indigenous and exotic vegetation. Feral pigs are omnivores, and will consume almost anything, including the roots of vegetation and a range of animal species. These behaviours cause damage to biodiversity and agriculture. To effectively manage wallabies and feral pigs at low densities, a coordinated, landscape-scale control programme is required. In the upper Rangitata there are numerous land tenures, and many agencies involved with managing various aspects of the catchment. To date, control of these species has been largely managed and funded by several landholders in the catchment. All landholders and key agencies are supportive of a landscape-scale programme to manage wallabies and feral pigs at low densities. Sufficient funding is necessary to carry out an effective management programme, particularly in remote areas such as the upper Rangitata. Without this funding, it is likely that wallabies and feral pigs will continue to increase in abundance and distribution, resulting in serious, long-term damage to cultural, biodiversity and agricultural values.

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Appendices

1.0 Introduction

This Wild Animal Management Plan (henceforth Plan) has been prepared for the Upper Rangitata Gorge Landcare Group (URGLG) and Environment Canterbury (ECan) to direct the future management of wallabies and feral pigs in the upper Rangitata River catchment. This area is of high importance to Environment Canterbury, the Department of Conservation (DOC) and Land Information New Zealand (LINZ), due to the significant indigenous biodiversity values within the riverbed and surrounding hill country. Several documents guide the programmes of work relating to protecting braided river biodiversity in this area, however these programmes lack any coordinated methodology for the control of wallabies and feral pigs at landscape-scale. The Plan focuses on the Rangitata River catchment upstream of the Rangitata Gorge and includes information on wallaby and feral pig abundance, distribution, and priority surveillance and control options across the catchment.

The upper Rangitata River catchment (henceforth upper Rangitata), located between the Lake Tekapo and Rakaia/Ashburton River catchments, is a 145,000 hectare area above the Rangitata Gorge. The upper Rangitata River ranges from subalpine riverbeds through to a braided river up to 4km wide in some areas. The catchment includes a range of high country habitat types and includes numerous, smaller sub-catchments including the Havelock River, Clyde River, Potts River and Forest Creek.

Wallabies and feral pigs are known to have adverse effects on indigenous biodiversity, economic impacts on agriculture, and pose serious biosecurity risks through the potential transmission of diseases, including bovine tuberculosis. Currently, both these invasive species are at low densities throughout the upper Rangitata, with some areas not yet having any established populations present. However, increasing numbers of both wallabies and feral pigs are immigrating into this catchment, particularly from the Opuha and Orari River catchments to the south. The Rangitata River is the northern boundary of ECan's wallaby containment area. Wallabies are not known to have established on the northern (true-left) side of the Rangitata River, although there have been a few reports of wallabies being detected here. A landscape-scale approach is required to manage invasive large mammal species, as they often travel across land tenures. This ensures areas of controlled lands are not immediately reinvaded by dispersing individuals from adjoining properties and provides a long period of time for vegetation regeneration before reinvasion occurs. Landscape-scale control methodologies for invasive large mammals are not well developed in New Zealand, as they require good communication and aligned priorities from multiple stakeholders and land managers.

The upper Rangitata has long had consistent and coordinated weed management, which has included significant funding from relevant agencies. Management of large mammals, including wallabies and feral pigs, has been largely overlooked, with most control to date being funded and carried out by individual landholders. This control has gone above and beyond what is required by any regional or local strategy or plan, in an effort to prevent wallabies and pigs from establishing significant populations. This control has been somewhat coordinated but has not been comprehensive enough to limit dispersal and increasing abundance. Landholders have no obligations to control wallabies or feral pigs at low densities, nor the funds to achieve this.

There are several key parties involved in protecting the upper Rangitata, including Te Rūnaka o Arowhenua, local and central government agencies and the Upper Rangitata Gorge Landcare Group (URGLG). The group is made up of landholders from throughout the catchment and was established in 1992 following the disbandment of the local Rabbit Board. This group has been,

and continues to be, fundamental to the management of weeds and pest animals throughout the catchment, and whose vision statement is:

"To protect the indigenous flora and fauna and to enhance the natural environment of the Upper Rangitata River in a societal, environmental and economically sustainable way"

Regular URGLG meetings are held to discuss management of the upper Rangitata, and are attended by key agencies, including the Department of Conservation (DOC), Environment Canterbury (ECan), Land Information New Zealand (LINZ) and the Central South Island Fish and Game Council (F&G). These meetings allow information sharing on weed distribution and previous and planned control works, with invasive animal management becoming more commonly discussed at these meetings. Consultation with these key stakeholders has been vital in understanding wild animal distribution and to set appropriate priorities and objectives for the catchment.

2.0 Biodiversity

The vegetation communities in the upper Rangitata are influenced by the topography and varied altitudinal range, from 2875m (Mt D'Archiac) down to approximately 400 metres in the riverbed upstream of the gorge. This catchment contains extensive, unmodified alpine and subalpine flora. This includes herbfields, tall tussock grasslands and shrublands occurring on stable slopes and valley floors at higher altitudes, including into the lower reaches of the Forbes River catchment. Montane forest of mountain beech (*Fuscospora cliffortioides*) occurs in patches on hillslopes, along with associated forest and forest-edge species including broadleaf (*Griselinia littoralis*), kowhai (*Sophora* spp.), Hall's totara (*Podocarpus laetus*), mountain toatoa (*Phyllocladus alpinus*) and mountain lacebark (*Hoheria* spp.) in valleys and gullies.

The upper catchment shrublands of *Dracophyllum* spp., spaniards (*Aciphylla* spp.) and hebe (*Veronica* spp.) include subalpine herbs such as Mt Cook buttercup (*Ranunculus lyallii*) (including in the Forbes River) and mountain daisies (*Celmisia* spp.). Further east the shrublands are dominated by matagouri (*Discaria toumatou*) and mingimingi (*Coprosma propinqua*) and the tall tussock grasslands (snow tussock, *Chionochloa rigida*, and red tussock, *Chionochloa rubra*) give way to short tussock and exotic grasslands.

In the floodplain of the upper catchment rivers, relatively stable islands include indigenous dominated communities of woolly moss (*Racomitrium lanuginosum*), and gravel fields with mat daisies/scabweeds (generally *Raoulia* spp.), creeping pohuehue (*Muehlenbeckia axillaris*), silver tussock (*Poa cita*), indigenous common broom (*Carmichaelia* spp.) and scattered matagouri (*D. toumatou*). The exotic species increase in abundance further downstream with grasses (browntop, *Agrostis capillaris*; sweet vernal, *Anthoxanthum odoratum*; and yorkshire fog, *Holcus lanatus*), clovers (*Trifolium* spp.), hawkweeds (*Hieracium* spp. and *Pilosella* spp.) and other herbs common. Wetlands adjacent to the riverbed include red tussock (*C. rubra*), bog rush (*Schoenus pauciflorus*), tussock sedge (*Carex stricta*) and other indigenous sedges (Carex spp.) and are increasingly dominated by exotic rushes and grasses further east.

The Rangitata River is of very high value for braided river birds. It has high species diversity, abundant potential feeding and breeding habitat (due to the lack of weeds) and supports important populations of nationally threatened and at-risk species, including wrybill

(*Anarhynchus frontalis*), black-fronted tern (*Chlidonias albostriatus*), black-billed gulls (*Chroicocephalus bulleri*), banded dotterel (*Charadrius bicinctus*) and South Island pied oystercatcher (*Haematopus finschi*). Other threatened and at-risk fauna reported in the catchment include scree skink (*Oligosoma waimatense*) and jewelled gecko (*Naultinus gemmeus*).

3.0 Wild Animal Species

Bennett's wallabies and feral pigs are considered the two most important invasive large animal species for immediate management in the upper Rangitata. This is due to their currently low, but increasing, densities in the catchment, the challenges associated with their control, and the adverse effects they have on biodiversity and agriculture. Bennett's wallabies and feral pigs are both hardy species, and the upper Rangitata provides excellent habitat for them to establish in.

The distributions and biology of wallabies and feral pigs are summarised below, with further details described in Appendix 1.

3.1 Bennett's wallaby

Bennett's wallabies are a cryptic, kangaroo-like marsupial, introduced to New Zealand in 1870 from Tasmania (King, 1998). They are a very mobile species, can hide well in forest, low scrub or tussock cover, are largely nocturnal/crepuscular and have a camouflaged brown/grey pelage. This makes wallabies difficult to detect in a range of habitats, particularly at low densities. At medium and high densities, wallabies begin to inflict noticeable damage on indigenous biodiversity and agriculture, as they browse on a wide range of plant species (Latham, Latham, & Warburton, 2018). Wallabies are capable of embryonic diapause, whereby they can delay embryo development in unfavourable conditions, thus making them profound breeders. Approximately three wallabies are equivalent to one stock unit in terms of grazing pressure (ORC, 2018).

The Rangitata River is the northernmost Wallaby Containment Area boundary, and will slow, but not prevent wallaby dispersal further north. Wallabies are currently at very low densities in the catchment but appear to be increasing in abundance and distribution. The higher-density populations to the south are undoubtedly dispersing into the upper Rangitata, most likely moving through the Two Thumb, Ben McLeod and Tara Haoa Ranges.

3.2 Feral pig

Feral pigs are a robust, medium-sized ungulate that consume a very wide range of foods, including roots, carrion, ground-nesting birds, eggs, invertebrates, amphibians, lizards and livestock, including new-born lambs (King, 1998). They cause considerable damage through rooting (digging up soil) for food, adversely affecting numerous indigenous species and agricultural farmland. Feral pigs are also a vector for bovine tuberculosis (NPCA(a), 2018). They are generally gregarious, although mature boars (males) often travel separately. Feral pigs are intelligent, mobile and can reproduce rapidly, making it difficult to reduce abundance effectively across a landscape once they are established (King, 1998).

Feral pigs are at low densities in the upper Rangitata but are well established in nearby catchments. The general feral pig distribution is higher densities southeast of Forest Creek and Potts River, and lower densities to the northwest. The key cause for concern in the upper Rangitata is the potential for increasing abundance and dispersal arising from the feral pig population in the Orari River catchment, particularly the Hewson River. Feral pigs were very rarely seen on the Ben McLeod/Tara Haoa Range in the upper Rangitata River catchment until approximately 2015. Dispersal and population establishment in the area is now likely, despite landholders' conscientious efforts to prevent this from occurring.

Feral pigs are also disbursing north-westward from the lower Potts River into the Lawrence River, likely using the riverbed and lower hill country as a corridor. Populations of feral pigs in the Harper Range and Ashburton Lakes area will likely be contributing to the dispersal into the upper Rangitata. Control operations have been carried out by landholders over several years to maintain low feral pig densities, but abundance and distribution is continuing to increase in some areas. Feral pigs have not yet properly established in the forestry at Forest Creek, although there may be low numbers throughout this area. Feral pigs are not known to be present in the upper Bush Stream and upper Forest Creek catchments but are likely to be present in all other operational areas (Figure 1) in varying abundances.

3.3 Other wild animal species

Although wallabies and feral pigs are the focus of this management plan, other wild animal species could be added to this plan for future management. Decisions on the desired objectives for each species would consider the views of all key stakeholders, including landholders and agencies. These objectives may include maintaining populations to pre-defined abundances, after weighing up economic and recreational value against adverse impacts. These additional wild animal species may include (but are not limited to):

- Himalayan tahr
- Red deer
- Chamois
- Fallow deer
- Feral goats
- Feral cats

4.0 Research, Consultation and Survey Method

Preliminary search and control of wallabies began in 2016, jointly between Mesopotamia Station and Boffa Miskell Ltd. Numerous search and control operations through to February 2020 resulted in eight wallabies being shot, with ECan and DOC contributing personnel and some funding for aerial transport. Although this work resulted in more data on wallaby presence, there is still much that is unknown about densities and dispersal of wallabies in the upper Rangitata. Fieldwork was undertaken throughout all seasons, with most occurring in 2019.

A meeting was held in February 2020 to discuss wallaby management in the upper Rangitata, involving discussions with DOC, URGLG and ECan to better understand the priorities from each group. There is unanimous support for a proactive wallaby and feral pig programme in this area, with a higher importance placed on wallaby control by some landholders.

Te Rūnaka o Arowhenua were engaged to discuss cultural impacts arising from this proposed programme. There was agreement that the proposed programme will be of benefit to indigenous biodiversity, as kaitiakitanga is of utmost importance to Rūnaka. Furthermore, it is expected that mahika kai will play a role in the control programme. In some areas, it is viable for meat from feral pigs and wallabies to be utilised, so coordinating this with Rūnaka in advance will benefit all involved.

Research undertaken by Boffa Miskell Ltd in 2019 has attempted to understand distribution of wallabies at very low densities through the comparison of differing ground-based detection methods. This has provided valuable information on the most reliable and cost-effective methods for detecting and controlling wallabies. Furthermore, it has provided data to map some areas of known wallaby distribution and to delimit the wallaby population (with relative, but not absolute, confidence) from some upper tributaries. It should be noted however, that this research was not comprehensive enough to categorically map presence/absence of wallabies throughout the entire catchment.

The information on feral pig distribution and abundance is based on discussions with landholders and DOC. No feral pigs or pig sign was observed during the fieldwork carried out for wallaby surveillance in the upper Rangitata (on the true-right). However, based on feral pig behaviour in other areas of New Zealand, it is expected that feral pigs will increase in density within the upper Rangitata, particularly as they move into the area from the Opuha and Orari River catchments (NPCA(a), 2018).

The key stakeholders who support the programme to target wallabies and feral pigs in the upper Rangitata include:

- Te Rūnaka o Arowhenua,
- Environment Canterbury,
- Department of Conservation,
- Land Information New Zealand,
- Forest and Bird,
- Fish and Game (Central South Island branch),
- All landholders within the upper Rangitata (Mesopotamia Station, Forest Creek Station, Ben McLeod Station, Rata Peaks Station, Stew Point Station, Whiterock Station, Tenehaun Station, Erewhon Station, Mt Potts Station and Mt Possession Station).

Control will only be carried out on a property once permission has been granted. Continued communication with rūnaka, landholders and agencies will be vital to maintaining good relationships and achieving a successful programme.

5.0 Protecting values

Wild animal control is required to protect biodiversity values in the upper Rangitata. Both wallabies and feral pigs forage on indigenous flora and disturb ecological processes such as plant regeneration and nutrient cycling (King, 1998). Numerous indigenous biodiversity values are present across the upper Rangitata River landscape, and in areas beyond this catchment where wallabies have not yet established.

This Plan aims to maintain very low densities of wallabies and feral pigs within the catchment, and completely exclude these species where possible. Landholders have no responsibility to maintain these low densities and it is not practicable without a coordinated approach. Wallabies will have adverse effects on biodiversity and agriculture while still at levels compliant with the CRPMP. Feral pigs can have more localised and more significant adverse effects on indigenous biodiversity and agricultural values. Of particular concern is their impacts on wetland areas, braided river bird nests and on farm stock, particularly their predation on newly born lambs.

6.0 Wild Animal Strategy

The goals and objectives set out below seek to achieve greater effectiveness for invasive wild animal management within the upper Rangitata. The management of invasive wild animals in this area to date has been somewhat coordinated, but not comprehensive. Through achieving the objectives below, resources will be increased and optimised, ensuring appropriate control is implemented to progressively reduce wallaby and feral pig abundance and distribution throughout the catchment.

6.1 Monitoring and control plan

6.1.1 Monitoring

Figure 1 shows the upper Rangitata River catchment broken into operational areas. The breakdown into operational areas allows for consistent reporting and information transfer between stakeholders. It also allows for different outcomes/programmes to be determined in each area, depending on the density and proximity to areas of high wallaby and/or feral pig abundance. Wallaby reports have not been mapped where they are within operational areas where wallabies have been shot. Feral pig distribution has not been mapped due to their ability to move great distances across the landscape.

Table 1 outlines management outcomes (programmes) for each operational area. This information has been developed to be consistent with the National Policy Direction for Pest Management 2015 (MPI, 2015). Operational areas have been assigned a management outcome based on current information on animal densities: ‘exclusion’, ‘eradication’, ‘progressive containment’, ‘sustained control’ or ‘protecting values in places’ (Table 1). These outcomes provide a basis for prioritisation of control throughout the area and an understanding of what is achievable. Where either wallabies or feral pigs have not been detected in an

operational area, the management outcome for that area is “exclusion”. Currently, there are no ‘eradication’ management outcomes assigned to an operational area. The absence of ‘eradication’ outcomes is due to insufficient funding to adequately monitor operational areas as immigration with current control tools cannot be prevented. This results in the three essential criteria for eradication not being met, as immigration cannot be prevented. The three essential eradication criteria are that (1) the rate of removal exceeds rate of increase at all population densities, (2) immigration is zero, and (3) all reproductive individuals must be put at risk (Bomford & O’Brien, 1995). The ‘progressive containment’ management outcomes for the upper Rangitata operational areas are generally acting on very low-density populations and, consequently, the control activities closely resemble those employed in an eradication programme. The control activities in some operational areas may result in temporary eradication but until landscape-scale, comprehensive control and monitoring is undertaken, immigration back into these areas is highly likely.

The management outcomes and priorities are based on information up to and including March 2020 (Table 1). Operational area outcomes for each species are subject to change as new information is obtained, particularly if wallabies are detected in ’exclusion programme’ operational areas, which would then regress to ’progressive containment’ and become highest priority. The operational area boundaries should remain static, as they are based on topographic features and provide clear direction to the outcomes and actions required for each area. The minimum search frequency for each operational area is:

- At least once per annum in all operational areas
- At least twice per annum where wallabies or feral pigs have been previously identified through a verified sighting or kill in the previous year

The search frequencies are essential to ensure any remaining individuals do not establish populations and disperse further. This monitoring regime will only be possible once sufficient funding is obtained. Some operational areas do not need detailed search (e.g. Clyde, Lawrence) until individuals or sign have been found. The return times for follow-up control after detections are detailed in Table 1. The timing for control is based on this Plan becoming operational by mid May 2020, but search and control can be undertaken throughout all months of the year (Table 1). Search effort must be balanced against available budget, time constraints, and time since wallabies or feral pigs were last detected in that area. The cost of effective search throughout this type of terrain is approximately $2 per hectare. This figure can be used for both ground-based contractors (with or without trained wallaby dogs) and aerial search with thermal imagery. The cost per hectare for aerial search can be more easily reduced, however, this will also reduce the probability of detection.

Feral pigs and their field sign are generally easier to detect than wallabies. For this reason, detection effort generally focuses on wallabies, with feral pig detections being recorded and follow-up control carried out when required. For example, search for pig sign (rooting) can be carried out during aerial transport for ground control operations, and feral pigs will be more easily detected by thermal imaging equipment when searching for wallabies. Comprehensive search in each operational area isn’t required on a species where it is unlikely for them to occur. For example, wallabies have not been detected in the Clyde operational area, so searching the upper reaches is not a high priority until there is reason to suggest wallabies are nearing that area. Further information on control and monitoring tools for wallabies and feral pigs can be found in Appendix 1.

6.1.2 Control

All wallabies and feral pigs found should be despatched as and when they are found. If there is no capacity for effective control, animals should not be disturbed, and the location recorded for efficient follow up control. This information should always be recorded and given to appropriate landholders, allowing for quicker follow up control if the landholder has the resources for this. In some situations, animals may be purposely disturbed to move them in the direction of more accessible terrain or reduced cover. The method of follow up control depends on where the animals were found (e.g. how remote, the terrain, vegetation cover) and how many were found. Successful monitoring and control will require a systematic and dynamic approach, using multiple control methods, as animals learn to avoid control techniques over time. For example, if animals have become wary of helicopters and dogs, the thermal imaging equipment may be used.

Aerial search is planned to take place after ground search for two reasons. Firstly, the information on wallaby sign from ground search can focus the aerial search, which reduces cost. However, aerial search can still take place over wider areas, particularly those that have not been ground searched thoroughly. Secondly, aerial control may have a small window for most effective control after a significant snow event. More data on wallaby distribution can direct aerial control to these locations more efficiently to capitalise on this control window. If sufficient budget is allocated to this programme, aerial search and control may be carried out first to provide guidance to ground hunters. Ground hunters will ideally be available for aerial transport while aerial search is underway. If a wallaby is lost into cover during these operations, the ground hunters can be deployed to find and despatch all wallabies found. Ground hunters with trained wallaby dogs are the most effective option for this work. However, with so few trained wallaby dogs available this is not always possible.

Toxins and traps are not planned for widespread use in this programme. Feratox (potassium cyanide) may be required in some areas to control pockets of wallabies and/or those that are more difficult to control by aerial and ground hunting due to the remote/steep terrain or vegetation. Similarly, traps may be utilised for feral pig control where effective control is not possible due to thick vegetation and/or steep terrain. The use of widespread poison (e.g. 1080) is not planned for wallaby (or feral pig) control in this catchment at current population densities. This programme seeks to maintain low abundance of both species, ensuring that the widespread use of toxins is not required at any stage.

6.2 Key goals

1. **Coordinate management and control operations**

   It is vital that there is continued communication between all stakeholders to ensure the successful delivery of control operations. The regular URGLG meetings, involving relevant agencies, are an efficient way to share information and coordinate control operations. Specific individuals/groups can be selected to deliver control operations to ensure efficient use of funds and resources to achieve effective control over all land tenures.

   Objectives

   1.1 Continue regular URGLG meetings to ensure all stakeholders have a common understanding of objectives and progress toward these

   1.2 Increase URGLG meeting attendance from landholders on northern side of Rangitata River

1.3 Use local aerial operators where practicable to increase cost-effectiveness and utilise local knowledge.

1.4 Data on wallaby and feral pig distribution to be managed and collated in one central database, to provide a collective and accurate reporting system

1.5 Select a single project manager to be responsible for planning and coordinating search/control operations

2. Progressively reduce wallaby and feral pig abundance and distribution

To effectively manage invasive wild animal species, they must be controlled systematically across the landscape. This requires an objective (programme) and plan for all operational areas, and sufficient funding for comprehensive search and control. The current funding levels are insufficient to comprehensively monitor and control wallabies and feral pigs throughout the upper Rangitata, demonstrated by the increase in reported sightings and kills over the past few years. Further information gained on wallaby and feral pig distribution will allow for an accurate understanding of the budget required. Until now, landholders have carried out most control on these species and have been required to bear these costs. This Plan is aligned with relevant plans and strategies, which increases the likelihood that the funding required for sufficient control can be obtained.

Progressive containment is the appropriate programme for areas where wallabies and feral pigs are present, to reduce adverse effects and limit dispersal into new areas. With sufficient funding, as well as management programmes being undertaken in surrounding areas, progressive containment programmes may eventually be recategorised to eradication programmes.

Objectives

2.1 Increase annual funding to $135,000 by July 2021, to provide sufficient funding for search, control, and management of wallabies and feral pigs over all operational areas within the catchment (Figure 1).

2.2 Carry out an effective search and control programme in all areas of the catchment as per the frequency and timing detailed in Table 1.

3. Exclude wallabies and feral pigs from operational areas where they are currently not present

Limiting wallaby and feral pig dispersal and excluding them from establishing in new areas (exclusion) is important to reduce the total cost of the programme long-term, due to having a smaller area for regular search and control. This is both difficult to achieve and difficult to measure in cryptic species such as wallabies, whereas feral pig presence can be more easily determined due to more obvious field sign.

Objectives

3.1 Monitor areas where wallabies and feral pigs are not known to be present, at least once per annum

3.2 Record all reported sightings or sign found near “exclusion” operational areas to understand if wallabies and feral pigs are close to establishing in these areas

4. **Provide education to landholders and agencies within, and the public who visit, the upper Rangitata River catchment**

   Wallabies and feral pigs leave unique sign (e.g. scat/droppings, rooting) which can confirm their presence across the landscape (NPCA(a), 2018; ORC, 2018). People commonly accessing remote areas of the country should be educated on what to look for so they can identify and report this sign. The aim is for all farm workers, agency staff, hunters, anglers and hikers being able to confirm the presence of wallabies and feral pigs before proactive search takes place, or as a way to add extra search effort to the programme.

   Objectives

   4.1 Relevant agencies (ECan, DOC, LINZ) continue to update landholders, public and field staff on latest wallaby information, including known distribution, provide education on identifying wallaby and feral pig sign and encourage them to record sign and sightings via the ECan wallaby app (ecan.govt.nz/wallaby).

   4.2 Landholders and aerial operators to inform recreational users of the upper Rangitata (e.g. hunters, hikers, anglers) of wallaby and feral pig sign, encourage them to record sign and sightings via the ECan wallaby app (ecan.govt.nz/wallaby) and destroy all animals found where possible. Signage should be erected to inform those who have no contact with landholders or agencies.

7.0 Annual Operational Planning

To date, there has been no operational planning to manage wallabies and feral pigs in the upper Rangitata. This results in a lack of timely response to any wallaby or feral pig detection, as there is no clear direction as to how and when follow-up control should occur, or whose responsibility this is. This Plan breaks down the catchment into manageable operational areas and gives guidance on control and monitoring tools and priorities. As more information on wild animal abundance and dispersal is gained, the priorities and objectives should be adjusted accordingly and operational plans for each area developed. If further funding is allocated to this programme, 'eradication' management outcomes may become achievable, particularly on the true-left of the Rangitata River.

Operational planning should involve rūnaka, landholders, ECan, DOC and LINZ. It is important for planning to look at past monitoring and control data to make informed decisions on future management. This will include studying animal abundance and distribution within each operational area, where search and control has occurred, and the efficacy of previous years' control. Reactive control to follow up on chance sightings should not be considered as an effective management programme.

An operational plan must be produced annually, and be based on up-to-date information, to ensure objectives are still realistic and relevant to the overall programme.

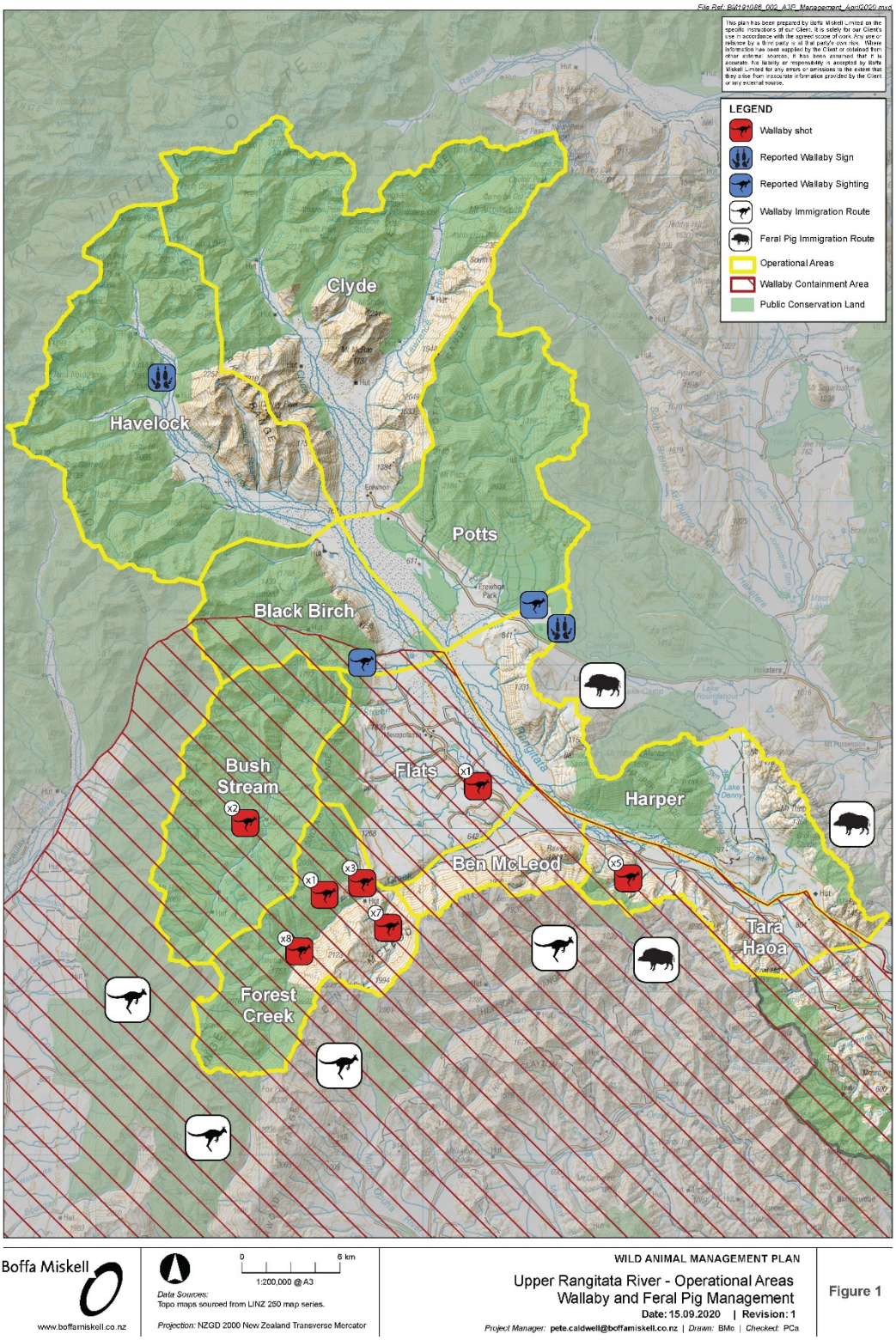

Figure 1: The upper Rangitata River catchment operational areas. Wallaby sightings, field sign and probable immigration routes up to and including September 2020 are shown, with reports dating back to 2005 and most wallabies shot since 2016. Feral pig presence within the catchment is not shown, due to their tendency to regularly move throughout a catchment when disturbed. The white wallaby and feral pig icons show the general area of populations, and probable immigration routes of wallaby and feral pigs outside the upper Rangitata catchment, not exact locations.

Table 1: Priorities and actions for wallaby and pig management in the upper Rangitata River operational areas. Because the level of future funding is uncertain, control and monitoring activities have been ordered from highest to lowest priority. Follow-up control refers to maximum time before revisiting an area after detecting but not despatching a wallaby or feral pig.

Priority	Operational Area	Species Targeted (Management Programme)	Control Type	Frequency and timing of control	Explanation
1	Potts (Potts River and edge of Harper operational area)	Wallabies (Exclusion) Feral pigs (Progressive Containment)	Ground search, aerial search.	Ground search May, aerial search May/June. Follow-up control: • wallabies, within 3 days • feral pigs, within 1 week	High priority to prevent wallabies establishing here. A possible wallaby sighting and possible wallaby sign was reported here. If wallabies/sign are found, this area remains highest priority. Pigs are present in this catchment and reducing densities will slow dispersal into Clyde operational area.
2	Bush Stream	Wallabies (Progressive Containment) Feral pigs (Exclusion)	Ground search. Aerial search/control focused on areas of known wallaby presence.	Initial control May. Aerial search May/June, to align with snow event. Follow-up control: • wallabies, within 2 weeks • feral pigs, within 1 week	Mid and lower Bush Stream have not been searched. Aerial control can spend majority of effort on areas where wallabies are known to be. This is important if trying to cover vast areas at the ideal time after a snow event.
3	Flats	Wallabies (Progressive Containment) Feral pigs (Progressive Containment)	Ground search likely areas for wallaby sign. Aerial search for pig sign (rooting), aerial thermal if possible.	Ground search, May. Aerial search, May/June. Follow-up control: • wallabies, within 1 week • feral pigs, within 1 week	This area adjoins the Rangitata River. Wallabies in this area must be eliminated to prevent further dispersal. Feral pig search will be minimal, looking at open areas for obvious pig sign. If found, follow up control will be required to prevent damage and establishing in forestry.

Priority	Operational Area	Species Targeted (Management Programme)	Control Type	Frequency and timing of control	Explanation
4	Black Birch	Wallabies (Progressive Containment) Feral pigs (Progressive Containment)	Ground search at area where wallabies were reported previously.	Ground search during May. Follow-up control: • wallabies, within 1 week • feral pigs, within 1 week	This Operational Area is mostly outside the containment area and adjoins the Rangitata River. Wallabies in this area must be eliminated to prevent further dispersal. Follow up control on pigs or sign found will reduce damage and dispersal.
5	Forest Creek	Wallabies (Progressive Containment) Feral pigs (Exclusion)	Initial search/control on ground, multiple personnel. Aerial control focused on areas of known wallaby presence.	Ground control May. Aerial control May/June, to align with snow event. Follow-up control: • wallabies, within 2 weeks • feral pigs, within 1 week	Aerial control can spend majority of effort on areas where wallabies are known to be, due to previous monitoring of this area. This is important if trying to cover vast areas at the ideal time after a snow event.
6	Ben McLeod	Wallabies Feral pigs (Progressive Containment)	Aerial search for pig sign (rooting) and pigs using thermal.	Aerial search, ideally with thermal in May/June. Follow-up control: • wallabies, within 1 week • feral pigs, within 1 week	Feral pigs will likely begin to disperse into this area from Tara Haoa operational area. Identifying feral pig sign early ensures swift control and reduces dispersal further up the Rangitata River, including into the forestry area at Forest Creek.
7	Tara Haoa	Wallabies (Progressive Containment) Feral pigs (Sustained Control)	Ground search/control. Aerial thermal search/control if possible.	Ground search, May. Aerial search, May/June. Follow-up control: • wallabies, within 1 week • feral pigs, within 2 weeks	This operational area adjoins the Rangitata River, so maintaining very low densities of wallabies is important. Feral pigs are immigrating into the area from the south (Orari River catchment). Keeping feral pig densities low will

Priority	Operational Area	Species Targeted (Management Programme)	Control Type	Frequency and timing of control	Explanation
					prevent or reduce dispersal further up the Rangitata River.
8	Clyde	Wallabies (Exclusion) Feral pigs (Progressive Containment)	Aerial search	Aerial Search May/June. Follow-up control: • wallabies, within 3 days • feral pigs, within 1 week	Aerial search required for pig sign in areas where pigs have been reported. Pristine country with high biodiversity values, which are adversely affected by feral pigs. If wallabies are detected, this operational area becomes highest priority.
9	Havelock	Wallabies (Exclusion) Feral pigs (Progressive Containment)	Aerial search	May/June. Follow-up control • wallabies, within 3 days • feral pigs, within 1 week	If wallabies are detected, this operational area becomes highest priority. Wallaby sign was found in 2005. Feral pigs have been reported in this area previously. It is important to keep feral pig densities to very low levels to protect biodiversity values.
10	Harper	Wallabies (Exclusion) Feral pigs (Sustained Control)	Aerial search	May/June. Follow-up control: • wallabies, 3 days • feral pigs, generally within 2 weeks, but will depend on their location	Feral pigs are living in this operational area. Pig abundance may be reduced if budget allows. This would ideally be flown with aerial thermal, particularly after significant snow event. If wallabies are detected, this operational area becomes highest priority.

8.0 Risks

It is important to understand risks to achieving effective, long-term invasive wild animal management in the upper Rangitata. There are several key risks to achieving the objectives set out in this plan, these are summarised below.

1. **Insufficient funding**

   There is currently no funding allocated to this programme beyond December 2020. The modest funding to date has been from the World Wildlife Fund and ECan, to reduce adverse effects on biodiversity. These are not the long-term funding streams required for an effective programme. Unless significant funding is found before July 2021, wallaby and feral pig abundance will likely continue to increase and have detrimental effects over the landscape. To safeguard against this risk, it is vital that additional funding avenues are explored and secured.

2. **Increased immigration of wallabies and feral pigs**

   Wallaby and feral pig abundance in surrounding catchments will increase if they are not adequately managed, which will cause increased dispersal into the upper Rangitata. Eventually, attempting to sustain very low densities and exclusion areas in the upper Rangitata River would become cost-prohibitive. It is vital that control programmes in surrounding catchments are developed and have robust management approaches, including achievable and measurable outcomes, to ensure that dispersal remains at manageable levels.

3. **Incomplete landscape control**

   For a programme to be effective it must have complete buy-in from all land managers and stakeholders. Without this, 'holes' are left across the landscape, harbouring wallaby and/or feral pig populations which will disperse into previously controlled areas. To date, the upper Rangitata has been a great example of land managers supporting pest management programmes. Continued communication between agencies and landholders is paramount to ensure this coordinated approach continues.

4. **Illegal liberations**

   The probability of this risk is difficult to quantify. However, anecdotally this has occurred within the area. From historic accounts, it appears feral pigs are more commonly liberated than wallabies. Vigilance around this issue is important, particularly if there are reports of this activity occurring. Education from key hunting groups (NZ Game Animal Council, NZ Deerstalkers Association, NZ Pig Hunting Association) is important to remind all hunters that illegal liberations are not permitted and that severe penalties apply to anyone caught carrying out such activities.

9.0 Funding

Initial funding in this area (search and control targeting wallabies) was Mesopotamia-funded aerial transport and Boffa Miskell Ltd time. Subsequent research into wallaby distribution and

detection was funded by Boffa Miskell, with funding contributions from ECan, DOC and LINZ. ECan staff have also assisted with fieldwork.

Significant funding is now required to ensure wallaby and feral pig control works throughout the upper Rangitata are meaningful, coordinated, and are achieving management outcomes for each operational area. If control is not undertaken in a cohesive manner, wallabies and feral pigs will continue to invade new areas and eventually effective control of these species over such a vast landscape will be virtually impossible with current tools and technologies. Due to the remote nature of this work, aerial access is required for search throughout many areas. This includes aerial search and aerial transport for ground-based contractors.

To maximise what can be achieved with minimal funding, volunteers should be used where possible. These volunteers are required to be experienced, and generally include DOC and ECan staff, contractors working pro bono, and experienced hunters. This is only possible due to good relationships with such volunteers, and the level of volunteer time will always be limited. It is not a viable option to only use volunteers to carry out the scale of activities required for an effective programme.

Under the Canterbury Region Pest Management Plan (CRPMP), landholders and managers have primarily funded control works for wallabies and feral pigs to date. As the numbers and dispersal of these animals continues to increase, it is not feasible for this group to continue to bear the cost of control. The potential of these species to invade and destroy biodiversity-rich ecosystems requires much more control than what is currently being delivered under the CRPMP.

An annual budget of $135,000 would enable control of wallabies and feral pigs to low levels in each operational area and limit the rate of dispersal into new areas. As more search and control data is gained there will be a more accurate estimate how much funding is required to achieve the desired management outcomes for each operational area. If dispersal from surrounding catchments increases, the level of funding required will also increase.

10.0 Conclusion

The upper Rangitata River is an area of very high cultural, biodiversity, recreational and agricultural values, with numerous threatened species reliant on the braided river system. To date, the management of wallabies and feral pigs has been carried out predominantly by landholders in this area but controlling the increasing dispersal into new areas will require a more coordinated and comprehensive programme. Damage from wallabies and feral pigs will undoubtedly be having some effect on indigenous biodiversity and farmland at this point in time, and these impacts will become more severe with increasing wallaby and feral pig abundance. It is recommended that coordinated and effective management commences soon, as once established, it becomes very difficult, and possibly cost-prohibitive, to remove wallabies and feral pigs from the landscape. Management in this area will require continued coordination between all stakeholders and a sufficient budget to maintain very low abundance/eliminate wallabies and feral pigs within this landscape. A range of monitoring and control methods will be required to achieve this result, as will a reduction in wallaby and feral pig immigration from surrounding areas into the upper Rangitata.

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Appendix 1: Biology, Monitoring and Control

1. Bennett's Wallaby

1.1 Biology

Bennett's wallabies (*Macropus rufogriseus*) were introduced from Tasmania to Christchurch in 1870 (King, C. M., 1998). Following their introduction, three individuals were liberated into the Hunter Hills near Waimate, South Canterbury, for the purpose of sport, hunting, and for the value of their skins (Heliventures, 2020). This triggered a population explosion and they are now widespread over multiple land tenures covering approximately 450,000ha in the South Canterbury region (Lambie, 2018). Furthermore, based on outlier sightings and illegal liberations, they are suspected to be spread over 1.5 million hectares and have encroached on the North Otago region (Latham, Latham, & Warburton, 2018).

Bennett's wallabies are the largest marsupial species in New Zealand. They measure 1.2-1.4m in body length and adults weigh up to and over 20kg (King, 1998; Lambie, 2018). Their pelage is grey-brown with a rufous tone over the shoulders and paler grey on the chest and belly – a perfect camouflage in the tussock grasslands of South Canterbury (Figure 3a). Bennett's wallabies prefer to live on the edge of tussock grassland, browsing at night in the open, and take cover in scrub on the edge of forest margins during the day (King, 1998; NPCA, 2018). Bennett's wallabies are solitary animals and can be found through a multitude of elevation profiles up to 2000m a.s.l (King, C. M., 1998). Populations currently occur at low-moderate densities with localised pockets of high-density populations (Ecan, 2020).

Bennett's wallabies are indiscriminate grazers and are known to compete with sheep for food, foul pasture through grazing, damage agricultural crops, and negatively impact plantation and native forests (King, 1998; Latham *et al*, 2018). They form distinctive pad runs through tussock grassland often leading to tunnels in dense scrub and flax (Figure 3b; King, 1998). Faecal pellets have a distinctive square-flattened shape, although they can be more elongated and round at times (similar to feral cat scat) (ECan, 2018).

Figure 3: a) Bennett's wallaby (M. rufogriseus), b) Bennett's wallaby track through pasture. Source: pestdetective.co.nz

1.2 Control options

Bennett's wallaby populations are under a sustained control programme by Environment Canterbury (ECan). A Wallaby Containment Area has been delineated by ECan which aims to prevent any establishment of populations outside that area (Figure4; Lambie, 2018). As wallabies have been treated as an 'emergent pest' by the Ministry for Primary Industries (MPI), managing populations on the mainland has been a low priority for land managers. Control options for this species are therefore sparse as research and development of effective control methods has been limited (MPI, 2017; NPCA, 2018).

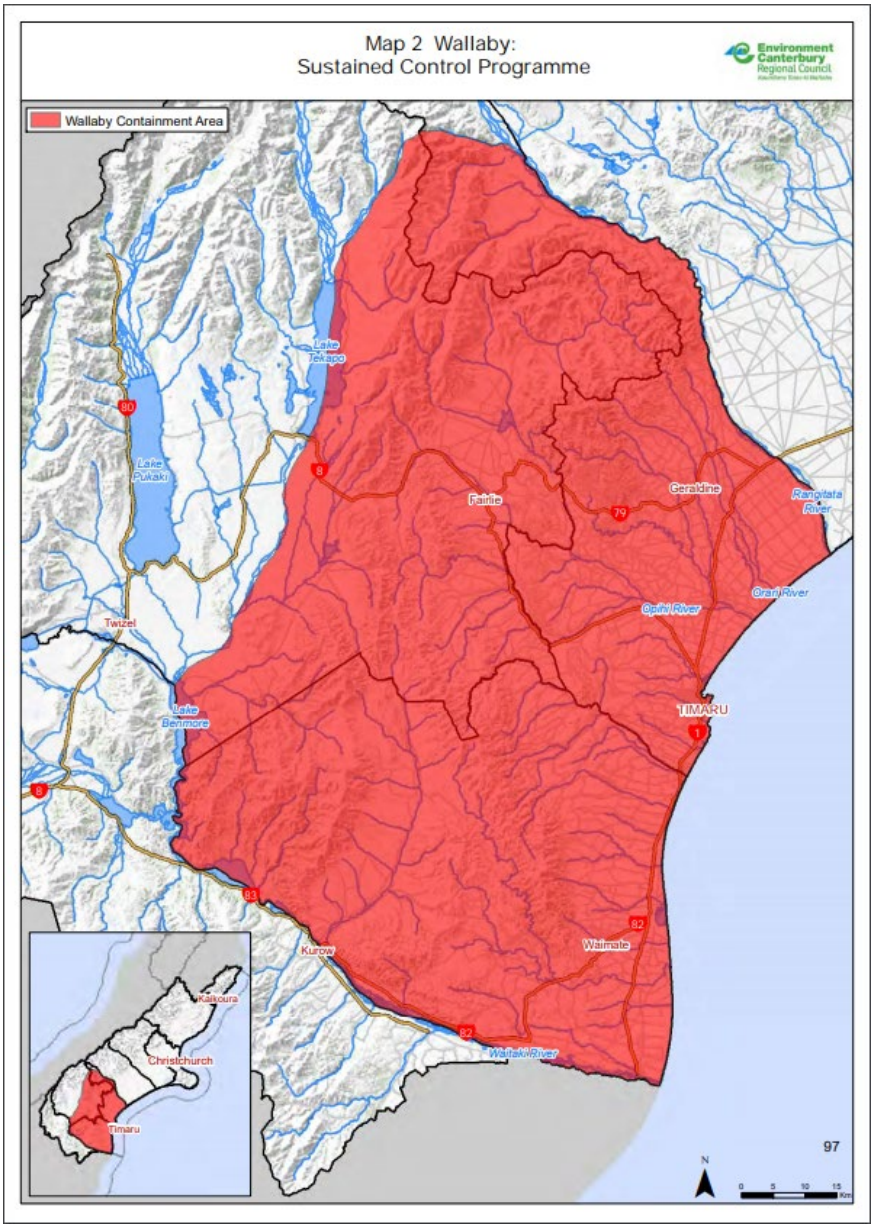

Figure 4: Wallaby Containment Area defined by Environment Canterbury Regional Council (Lambie, 2018). This area covers 900,000ha of land across South Canterbury.

The following Bennett's wallaby control methods have been used in New Zealand:

1.2.1 Hunting

Night shooting of wallabies is a common control method for this species. Night shooting allows the hunter to target wallabies when they are out in the open feeding. It is effective for initial knockdown of a population however is restricted by access, especially when using a vehicle to navigate through an area (NPCA(b), 2018). Hunting during the day can be effective, through shooting wallabies when they are at high densities, or to search for field sign (e.g. scat, footprints) at low densities. Ground hunting with dogs during the day is also utilised as a control tool, as dogs are able to flush wallabies from cover. Thermal imaging equipment is also used to good effect, but does have limitations, especially when used in clear, warm weather.

Aerial shooting in combination with thermal imagery systems is changing how wallabies are controlled in New Zealand. Thermal imagery systems enable detection of animals that live in scrub or open forest as well as those moving through tussock land seemingly unnoticed by the naked eye due to the exceptional camouflage properties of their pelage. This control method has no restrictions to topography, creating efficiencies for wallaby control far greater than what can be achieved on the ground (Heliventures, 2020; NPCA, 2018; Trap and Trigger Ventures, 2017). *For more information see 2.2.1.*

1.2.2 Repellents

As wallabies threaten regeneration of native forests or the establishment of plantation forests, forage on pasture or agricultural crops, and have devastating effects on tussock grassland communities, repellents are occasionally used to discourage foraging (NPCA(b), 2018). Repellents are most commonly applied as foliar sprays and are employed immediately after planting. Two repellents are used in New Zealand: egg-based repellent and mutton fat-kerosene repellent (NPCA(b), 2018). The egg-based repellent is both an odour and palatability repellent and is commonly used against browse in Australian plantation forests (Miller *et al*, 2008). These repellents are most effective in the initial weeks following planting and are inexpensive and easy to use (NPCA(b), 2018).

1.2.3 Fencing

Wallaby exclusion fencing is utilised as a cost-effective strategy in high density wallaby areas within the horticultural industry. Over large areas of land however, wallaby exclusion fencing is not a cost-effective option in preventing wallaby damage. This option may be used in some areas to provide a defendable boundary when preventing dispersal and/or eradicating wallabies from an area.

1.2.4 Pesticides

Bait-stations, ground baiting and aerially applied pesticide operations have all proven successful as a wallaby control measure in New Zealand (King, 1998; NPCA, 2018). Aerially applied pesticides have no limitations to topography and provides a cost-effective strategy in wallaby control (NPCA(b), 2018). 1080 (active ingredient – sodium fluoroacetate) is a proven pesticide for wallaby control in New Zealand. Cereal baits can be applied aerially, by hand-broadcast or via bait-stations. 1080 in gel form is occasionally used where wallaby densities are high and targeted control is required. However, 1080 use on farmland has limitations due to stocking requirements during and after control. Potassium cyanide offers a targeted approach to controlling wallabies but is a more expensive method, and not suitable for control over large areas.

2. Feral Pigs

2.1 Biology

Introduced to New Zealand in the late 1700's, pigs (*Sus scrofa*) were an important source of food for settlers, sealers and whalers, and quickly became an essential bartering tool with Māori. By 1840 pigs were commonplace in and around human settlement and were often held in a semi-feral state (Wodzicki, 1950). Nevertheless, some animals remained truly 'wild' and this population now inhabits many of New Zealand's unique ecosystems; they are classified as feral pigs (Bionet.NZ, 2018; King, 1998).

Feral pigs are smaller and more robust than their domestic counterparts (Figure 5). They have powerfully built shoulders and thick neck muscles, providing them with the ability to root (dig) through soil and partly rotten logs. Hair is longer and coarser when compared with domestic pigs and most commonly black and/or brown in colour, however local variation can occur (Figure 5). They have very acute senses of smell and hearing, but their eyesight is poor. Tusks extend out from the lower jaw and curve upwards, outwards and backwards as they grow and are common among both sexes (Figure 5; King, 1998).

Figure 5: New Zealand feral pig (Sus scrofa). Feral pigs are typically black and/or brown in colour with long coarse hair. They have thick shoulder and neck muscles with smaller hindquarters. Snouts are large and long in comparison to their domestic counterparts and tusks are common in both sexes, however area larger and more pronounced in boars (King, 1998). Source: pestdetective.co.nz

Feral pigs occupy areas that provide reliable cover while also providing consistent food and water resources. For example, they can be found inhabiting native and exotic forests, river flats and tussock grassland with matagouri (*Discaria toumatou*), manuka (*Leptospermum scoparium*)

and/or extensive areas of bracken (*Pteridium esculentum*) or gorse (*Ulex europaeus*) cover, and pastoral farmland. In some places within New Zealand suitable habitat can be found up to 1200m asl (King, 1998). Feral pigs are active during all times of the day and night; however, during hot weather and in areas with high hunting pressure, their activity becomes more nocturnally based. They are highly social animals and normally form mobs (sounders) where they occupy specific home ranges whereby their movement patterns commonly follow similar routes (King, 1998; Koichi & Halliday, 2015).

Feral pigs are omnivorous, opportunistic feeders. Their diet consists of a wide variety of foods such as grasses, roots, seeds, carrion, invertebrates, lizards, amphibians, ground nesting birds, bird eggs, carcasses and livestock. Rooting is a natural pig behaviour where the animal uses its snout to push or dig something repeatedly. Feral pig rooting of soil, pasture, vegetation or crops is the most common field sign for this animal (Figure 6). Faeces, mud wallows, and pad runs are also common field signs of feral pigs.

Figure 6: Feral pig rooting. A) Rooted pasture adjacent to forest, Lake Mason, Canterbury (2019). B) Rooted pasture on edge of/in manuka and kanuka scrub, Hadfield Clearing, Abel Tasman National Park (2018). (Source: Sian Reynolds).

Following the naturalisation of pigs in New Zealand, their subsequent population increase resulted in economic impacts within the agricultural and horticultural sectors. Pigs were no longer welcome in the New Zealand landscape marking a shift in their status of that to '*pest*' (King, 1998). Feral pigs impact native ecosystems, affect pastoral production practices through the uprooting of land and pose serious biosecurity risks through the transmission of diseases such as bovine tuberculosis (Tb) (NPCA(a), 2018).

Along with other introduced mammals, the ecological impacts of feral pigs can be seen throughout many ecosystems in New Zealand. Feral pig foraging behaviours disturb ecological processes such as plant regeneration and nutrient cycling (NPCA(a), 2018). They pose biosecurity risks to New Zealand ecosystems through the spread of weed species (Koichi & Halliday, 2015). They are known to have devastating impacts on ground dwelling animals in New Zealand and have affected native bird, frog, lizard and snail populations (King, 1998). For example, pigs were the main cause of mortality in populations of *Powelliphanta hochstetteri*

obscura on D'Urville Island and were also found to compete with snails for worms as a food source. Over three years, 73% of surveyed adult shells had been predated by pigs and when pigs were excluded from an area on the island, snail populations rapidly grew (Coleman, Parkes, & Walker, 2001; Figure 7).

Figure 7: Powelliphanta hochstetteri obscura killed by feral pigs (Source: Department of Conservation, Kath Walker).

The economic impacts of feral pigs on pastoral land can be quantified through the reduction of crop yield, loss of pasture or livestock. Feral pigs are known to damage the roots, and dig up, young exotic trees in plantations and can have devastating impacts on their establishment (King, 1998). Pasture and crop damage most commonly occur when adjacent to native forest, exotic plantations or large scrubby habitats (Bionet.NZ, 2018; King, 1998). As well as this, feral pigs have been known to predate newborn lambs and cast sheep (Bionet.NZ, 2018; King, 1998). Problems of this sort within front-country blocks in New Zealand are less common now as pest management is more readily implemented by farm managers. Back-country feral pig management, however, can be a lot harder to maintain when source populations are readily nearby i.e. pasture adjacent to un-managed native bush.

Feral pigs play a role in New Zealand's primary production through the spread of bovine tuberculosis (Tb) and are considered a major biosecurity threat as potential carriers of exotic diseases not yet in New Zealand, for example, foot-and-mouth disease (Bionet.NZ, 2018; Pestsmart - Feral pig, 2017). Feral pigs are not reservoir hosts for Tb, they are incidental carriers (NPCA(a), 2018). Through illegal transportation of feral pigs to new areas the main risk to New Zealand's primary production is the incidental movement of Tb to Tb-clear areas. Feral pigs are very susceptible to catching Tb and the occurrence of the disease in these animals is probably through eating Tb-infected possum carcasses (NPCA(a), 2018). Due to the high

susceptibly of feral pigs to Tb, they are commonly used as survey animals for the disease. Uninfected radio-collared feral pigs are released into survey areas and re-captured after a standard time period. If Tb is present in the survey area then the feral pig is highly likely to be infected with the disease and therefore provides indication of the disease in the survey area (NPCA(a), 2018).

2.2 Control

Feral pigs are difficult to control due to the gregarious and intelligent nature of the species. Not only are they able to breed quickly and increase in number, they reply rapidly to control measures by changing their behaviour and movement patterns. According to Koichi & Halliday 2015, successful feral pig control operations require an annual 50-70% population reduction within a management area. Part of the lack of success in feral pig control within New Zealand lies with the absence of focussed and sustained control attempts. At moderate densities feral pigs are seldom seen, however economic and environmental impacts can be significant.

The following feral pig control measures are used periodically throughout New Zealand:

2.2.1 Hunting

Ground hunting is the most commonly used control method for this species in New Zealand. Ground hunting using dogs is largely a recreational sport within the country. It is also used in a non-recreational context, where professional hunters are contracted for specific management areas, such as for farm management or where feral pig disturbance is threatening high-value biodiversity (NPCA(a), 2018). Ground hunting is limited by topography and the presence of indigenous, threatened, ground-dwelling birds such as kiwi. Predation of these birds by dogs is a serious risk and may outweigh the benefits of feral pig control in those areas. In feral pig control operations, ground hunting teams are often used in combination with aerial shooting teams.

Aerial shooting is cost-effective when pig densities are high but is habitat-limited i.e., you cannot always safely identify a target through forest or dense scrub (Bionet.NZ, 2018; Pestsmart - Feral pig, 2017). As feral pigs within New Zealand prefer habitat with sufficient cover, this control method is utilised less frequently by land managers. The combination of thermal animal detection systems (TADS) and aerial pest management in New Zealand are however, increasing. Thermal imaging technology allows for the detection of warm-blooded animals in practically all weather conditions, vegetation type and topography. For example, detection of an animal is achievable while 95% obstructed by vegetation (Trap and Trigger Ventures, 2017). Thermal imagers are very sensitive from up to 200m from the target, and have the ability to detect just five centimetres of a heat signature (Trap and Trigger Ventures, 2017).

‘Judas pigs’ can enhance the effectiveness of both ground and aerial hunting operations. ‘Judas pigs’ are those that are tracked via radio-collar and are released into an area where certain mobs are difficult to locate. Sows are generally used for this purpose due to their social status within mobs. This technique is typically used at the end of eradication programmes where locating the last remaining animals can prove extremely difficult in remote settings (Pestsmart - Feral pig, 2017).

2.2.2 Exclusion

Specific feral pig exclusion fencing can be effective at localised, high-value sites. Once a fence is established at a site regular maintenance checks are required to ensure it is in working order

(NPCA(a), 2018). Although effective at keeping feral pigs out of an area, exclusion fences do not aid in the reduction of the actual feral pig population. At landscape-scale, over multiple land tenures, exclusion fencing is not a practical option (Pestsmart - Feral pig, 2017).

2.2.3 Trapping

Live-capture traps are not common practice for control of feral pigs in New Zealand. Live-capture trapping is labour intensive, requires good access to a site and is limited by vegetation type, i.e. traps cannot be erected in thick vegetation (Pestsmart - Feral pig, 2017). In Australia feral pig trapping is used in combination with other control methods in co-ordinated programmes. Trapping is only effective on low-medium population densities and is often used as a follow up control mechanism once the initial control operation has been undertaken. The use of other control measures while trying to trap pigs is counterproductive as pigs may alter movement and/or feeding patterns in response to those measures; thus, removing any chance of catching the mob. Table 1 outlines the different live-capture trap designs utilised in feral pig control.

Table 2: Feral pig live-capture trap types. There are three main trap types used in feral pig control operations: panel traps, silo traps and box traps.

Trap Type	Permanent	Gate Type	Transportable	Example
Panel Trap	No, can be dismantled and re-used at another location. Can adjust trap to suit location, terrain and can accommodate a lot of pigs.	Hinged or gravity fed gate using trip wire.	Yes, easy to construct, dismantle and transport.	
Silo Trap	Semi-permanent; are constructed from one continuous sheet of mesh. Ability to accommodate a lot of pigs.	Funnel entrance.	Not easily.	
Box Trap	No, can be moved on the tray of 4WD or by trailer. Useful on smaller properties or in areas with low density pig populations as size of trap cannot be adjusted.	One-way swing door.	Yes, but cannot be dismantled so needs to be transported via 4WD or trailer.	

There are four critical steps in the successful live-capture trapping of feral pigs:

1. Pre-feeding

Feral pigs are neophobic and cautious of new food types. Before there is any thought of erecting a trap in a location, pigs need to be habituated to a food type that will be used to bait them into the trap. Once fresh sign is seen, free feeding of the area should occur with the chosen bait for approximately 10-14 days, or once all pigs in the mob are conditioned to eating the new food source. Fermented barley, commercial pig or poultry pellets, and/or fruit and vegetables can be used as bait for traps. Caution needs to be exercised if using carcasses as bait as feral pigs are vulnerable to spreading disease. The most commonly used bait is fermented barley as it has a strong odour, is likely to be found by feral pigs and can be fed by automatic feeders. Human activity should be reduced at the trap site; trail cameras and automatic feeders should be considered in the set-up.

2. Trap construction

Trap construction should begin once pigs have consistently been seen feeding on bait for a few days. Traps should not be 'set' but rather allow the animals to become familiar with its presence in the area. When first constructed, bait should be trailed to the entrance of the trap and be placed just inside the entrance way to encourage pigs to enter the trap. Maintain feed in this state to allow the pigs to acclimatise. Once they are eating freely and are conditioned to entering and leaving the trap unharmed, the trap can be set. Trap-shy individuals are common, thus free feeding with bait in this way usually requires 10-14 days before the entire mob will enter the trap (Sharp, 2012).

3. Setting the trap

The Animal Welfare Act 1999 requires live-capture traps to be inspected daily, within 12 hours of sunrise. Feral pigs struggle to thermoregulate as they lack sweat glands so traps should be inspected and cleared well before midday to reduce any unnecessary stress on the animals (NPCA(a), 2018). Trip wire gate types are common among feral pig traps. Remote monitoring technology can be applied to these gate types, enabling more efficient and cost-effective options when using live-captures traps as a control method. Current remote monitoring technology for trapping in New Zealand is provided by: Encounter Solutions, ThinkXtra Xtrap, MinkPolice Trap Monitor, and Econode SmartTrap (Predator Free NZ, 2019).

4. Despatching trapped pigs

In accordance with Section 36 of the Animal Welfare Act 1999 and MPI guidelines for good practice, a plan should be established for appropriate disposal of the trapped animal/s.

2.2.4 Pesticides

Pesticide use in New Zealand for the control of feral pigs is not common, but this control technique is used more frequently in Australia. Bait stations are used, with pre-feeding essential for establishing consistent mob feeding patterns. 1080 (active ingredient – sodium fluoroacetate) is the most widely used pesticide in Australia for feral pig control. Within New Zealand however, 1080 is only registered for use on rodents and possums with active concentration rates in baits reflecting this. Bait-Rite Paste (active ingredient – sodium nitrite) was registered for feral pig control in New Zealand in 2014. In field trials using Bait-Rite Paste on feral pigs, kill rates have varied from <33% to 92% (Fairweather, 2018). Pre-feeding of bait stations is an essential part of this control method. Not only is habituation to a non-toxic food

source required, there is the added pressure of conditioning the mob to eating from the bait station. In pen trials conducted by Shapiro *et al* 2015, bait station lids were held open until pigs were consistently consuming non-toxic bait from them. Once lid restrictions were removed, pigs had to learn to open the lids to access food (Figure 8). This adds another dimension when conditioning feral pigs to a site for pesticide control in the wild.

Figure 8: Bait station use by feral pigs (Source: lincolnecology.org.nz)

Appendix 2: Alignment with plans and strategies

It is important that wild animal management plans align with relevant regional and local legislation, strategies and plans. This will ensure the direction of animal management in the upper Rangitata River is consistent with higher-level coordination. The summaries and excerpts below are from Canterbury documents relevant to the Plan. The Plan seeks to align with these goals and objectives to ensure correct prioritisation of control and to guarantee best chances of continued and increased future funding for monitoring and control activities.

Canterbury Regional Pest Management Plan 2018-2038 (CRPMP)

The CRPMP establishes the regulatory basis for pest management in Canterbury. This document defines which species are considered pests, and which rules (if any) are applied to those species. The purpose of the plan is to:

- Minimise the actual or potential adverse or unintended effects associated with harmful organisms; and
- Maximise the effectiveness of individual actions in managing pests through a regionally coordinated approach.

The CRPMP includes pest species listed within the following programmes: Exclusion, Eradication, Progressive Containment, Sustained Control or Site-led. The National Policy Direction for Pest Management 2015 (NPD) states that management outcomes must align with one of these 5 programmes.

Within the CRPMP Bennett's wallabies are listed as "Pests" whereas feral pigs are listed as "Organisms of Interest." The CRPMP has rules for Bennett's wallabies, requiring land managers to undertake control only at high densities (level 4, Guilford Scale), but no control or management is required for feral pigs, even when densities are adversely affecting the landscape. This means that no agency is directly responsible for Bennett's wallaby control (inside the containment area) and no landholder or agency is required to manage feral pigs at all, which will undoubtedly result in increasing abundance and adversity to the landscapes they inhabit.

The Implementation Strategy for the Braided River Flagship Project

The desired outcomes of the Implementation Strategy for the Braided River Flagship Project (for the upper Rangitata River) are:

1. Maintain the upper catchments as largely natural ecosystems and landscapes
2. Implement actions to correct the decline in freshwater species, habitat quality or ecosystems
3. Enhanced and protected breeding populations of indigenous braided river birds (i.e. those which are have declined such as wrybill, black-fronted tern, black-billed gulls, and banded dotterels)
4. Correct the decline in useable braided river bird habitat (e.g. prevent establishment or clear braided river beds of woody weeds)

5. Protect the indigenous habitats in riparian wetlands and springs associated with braided rivers
6. Prevent further loss of area of naturally occurring wetlands
7. Involve Papatipu Rūnanga in the Immediate Steps restoration programme and the setting of priorities
8. Highlighted any high-country spring-fed or foothill streams where ecosystem health is declining, and identified the cause with an action plan in place

These outcomes are largely being achieved under the current programmes in the upper Rangitata. However, increasing abundance of wallabies and feral pigs will see a decline in the success of these outcomes. This is due to the adverse effects wallabies and feral pigs have on native vegetation through browsing and rooting, and feral pigs predating on braided river bird eggs, lizards and invertebrates. Furthermore, increasing abundance of wallabies and pigs detracts from upper catchment status' of being largely natural ecosystems and landscapes. Te Rūnanga o Arowhenua have been engaged with planning this programme and will continue to be involved throughout the programme.

It is, therefore, fundamental that sufficient budget is allocated to managing wallabies and pigs ensure these outcomes are achieved long-term.

Canterbury Water Management Strategy (CWMS)

The relevant key outcome from the CWMS, "*ecosystems, habitats and landscapes will be protected and progressively restored, and indigenous biodiversity will show significant improvement,"* reinforces the focus of protecting and restoring areas, which will in turn improve indigenous biodiversity. Controlling invasive wild animal species is a key example of protecting ecosystems and habitats from browsing and rooting, which can dramatically change community species composition, as well as enhancing water quality.

The relevant goals within the CWMS are to achieve:

By 2020:

- All foothill rivers and high country rivers and/or lakes either in good ecological health or better, or showing upwards trends
- Protected all existing wetlands
- Protected significant habitat for a full range of indigenous braided river flora and fauna
- Protected and enhanced habitats in riparian wetlands, springs and the lagoons associated with braided rivers
- Increased the abundance of, access to and use of mahinga kai

By 2040:

- Canterbury's braided rivers show the dynamic, braided nature typical of such rivers
- Protected all wetlands
- All indigenous braided river-dependent species are showing positive trends in abundance and health
- Increased habitat area usable by all species of braided river indigenous birds.

With increased funding, the upper Rangitata River catchment is on track to achieve these goals. Continued coordination and management of invasive animal species will ensure the riverbed, tributaries, wetlands, and the species that occupy these areas remain in good ecological health.

Canterbury Biodiversity Strategy

The Canterbury Biodiversity Strategy's six goals are listed below:

- Goal 1 Protect and maintain the health of all significant habitats and ecosystems.
- Goal 2 Restore the natural character of degraded indigenous habitats and ecosystems.
- Goal 3 Increase the integration and sustainable use of indigenous species in modified environments (e.g. farm, urban, lifestyle blocks).
- Goal 4 Enhance public awareness, understanding and support of biodiversity.
- Goal 5 Encourage, celebrate and support action by landowners and communities to protect, maintain and restore biodiversity.
- Goal 6 Improve the range and quality of knowledge and information about Canterbury's biodiversity for its sustainable management.

The management of the upper Rangitata River is currently fulfilling the six goals of the Canterbury Biodiversity Strategy to various degrees. All six goals are currently being achieved through information sharing through regular Upper Rangitata Gorge Landcare Group meetings, to date predominantly focused on weed management by landholders and multiple agencies. This Plan seeks to ensure these goals continue to be achieved by managing invasive animals to levels that do not adversely affect indigenous biodiversity. If wallabies and feral pigs are allowed to increase in density and distribution, Goal 1 and Goal 2 will become progressively more difficult to achieve.

All four key documents listed above are consistent in seeking improvements to protect indigenous species and natural areas. This Plan will assist in supporting this ongoing work. However, increased funding for the Wild Animal Management Programme is essential to ensure all these goals are met.

Appendix 3: Photos

Photos are ordered by geographic area, from upper tributaries downstream.

Figure 1 : Forbes River*, Aciphylla spp. (indigenous speargrass).* Feral pigs commonly destroy Aciphylla species by digging up their roots.

Figure 2 : Mount Cook buttercup (indigenous), Forbes River. At risk from mammalian browsing.

Figure 3 : Havelock River, ideal cover for invasive wild animal species

Figure 4 : Havelock River, looking upstream toward Forbes River confluence. Extensive matagouri provides good cover for wallabies and feral pigs

Figure 5 : Havelock River, stable island, provides habitat and cover for wallabies and feral pigs moving across the river

Figure 6 : Upper Lawrence River, true right. Excellent habitat and cover

Figure 7 : Upper Lawrence River, looking upstream.

Figure 8 : Upper Clyde River, an example of a natural landscape.

Figure 9 : Mt Potts Station. Heavy tussock and scrub cover provide excellent habitat for wallabies

Figure 10 : Rangitata riverbed, wallaby containment area boundary, looking downstream. Wallabies and feral pigs can travel through open riverbeds and cross river channels.

Figure 11 : Thick tussock habitat, upper Bush Stream catchment

Figure 12 : Bennett's wallaby, Forest Creek catchment

Figure 13 : Bennett's wallaby as seen through thermal imaging equipment, Forest Creek catchment

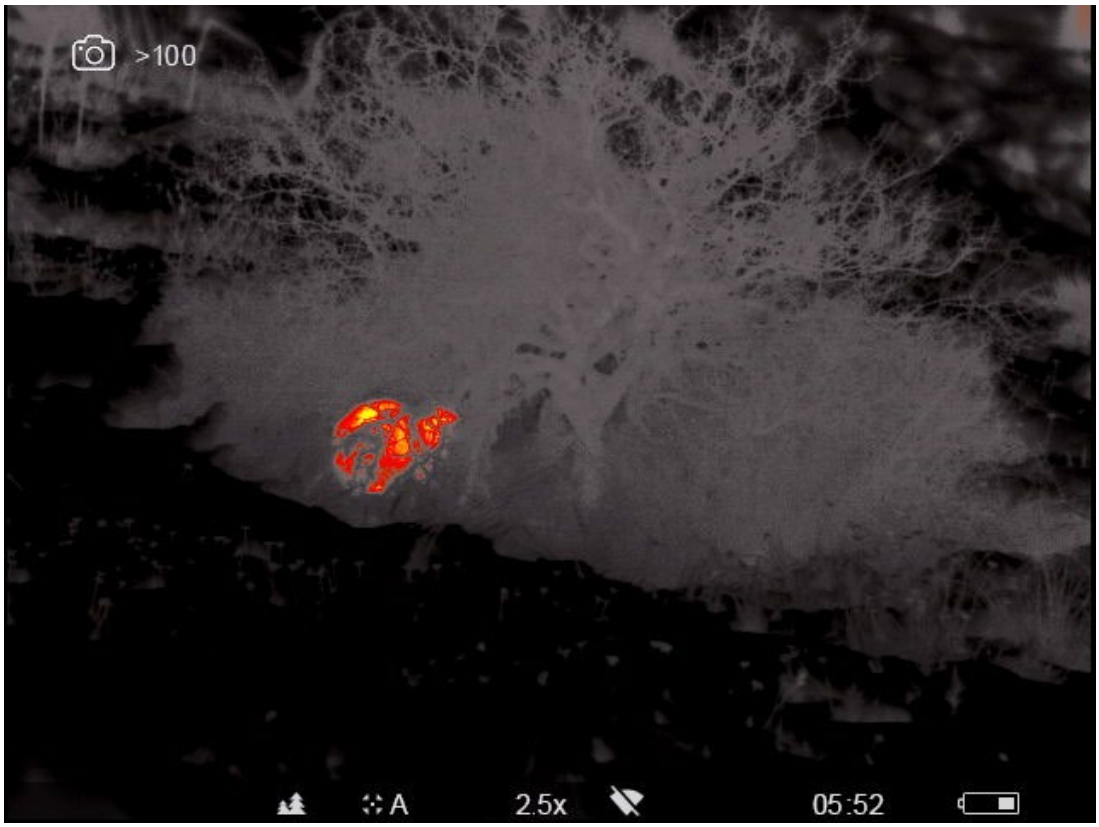

Figure 14 : Bennett's wallaby as seen through thermal imaging equipment, within a matagouri bush and unseen to the naked eye, Forest Creek catchment

Figure 15 : The Ice Rink wetland, adjacent to Harper Range. Wetlands are vulnerable to damage from feral pigs.

Figure 16 : Bennett's wallaby surviving well in harsh conditions, Forest Creek catchment

About Boffa Miskell

Boffa Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a significant number of projects that have shaped New Zealand's environment.

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