COLLABORATIVE LANDSCAPE-SCALE PREDATOR CONTROL IN THE CATCHMENTS OF LAKES WAKATIPU AND WANAKA

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COLLABORATIVE LANDSCAPE-SCALE PREDATOR CONTROL IN THE CATCHMENTS OF LAKES WAKATIPU AND WANAKA

Contract Report No. 4951

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1. INTRODUCTION

Community trusts, private landowners, non-governmental organisations, and the Department of Conservation are undertaking predator control at various sites in the catchments of Lakes Wakatipu and Wanaka (the 'Project Area') to protect indigenous biodiversity (Figure 1). Although they share a common interest in the protection of New Zealand's indigenous wildlife, they are typically operating independently of each other. The launch of Predator Free New Zealand 2050 has resulted in collective interest by these groups - operating under the ambit of the Whakatipu Wildlife Trust for the purposes of this application - to examine the potential for more extensive landscape-scale predator control across the Project Area. In particular, they recognise that, due to the mobility of both predators and indigenous prey, a wider level of coordinated control is needed to protect indigenous wildlife until technology becomes available to achieve mainland predator eradications.

The community groups see an opportunity to build a large landscape-scale control programme through the establishment of connections between existing control areas, while using natural 'barriers' such as large lakes, rivers, and mountains to create a network of pest control hubs, buffers, and wildlife corridors. They recognise that the rugged terrain of the southern lakes catchments and the distances involved will be challenging for any effort to undertake large-scale landscape predator control, and before embarking on this, the group wishes to understand the biological and strategic/logistical geographical limitations of such an endeavour.

The Project Area includes the catchments of Lakes Wakatipu and Wanaka and their islands, including the valleys of the Shotover, Arrow, and Cardrona Rivers as well as peri-urban areas around Wanaka and Queenstown (Figure 1). It includes significant parts of Mt Aspiring National Park, which is part of Te Wāhipounamu South West New Zealand World Heritage Area, internationally recognised by UNESCO for its exceptional and outstanding natural characteristics. Fiordland National Park and areas west of the main divide are outside of the Project Area. The Project Area falls under the Otago Regional Council Biodiversity Strategy. One of the outcomes of that strategy is to maintain all indigenous species and ecosystems that support them by supporting, amongst other things, community-led predator control initiatives.

The groups - via the Whakatipu Wildlife Trust - commissioned this scoping study to assess the feasibility of progressively developing a landscape-scale predator control programme across these southern lakes. Specifically, the study is expected to address the potential benefits, practicalities, and costs of a core/buffer/corridor model of landscape-level predator control, at increasing scales of effort. A course of action is required, together with a corresponding blueprint that the group can work towards while maintaining and building on their current gains.

Findings will be used to confirm a shared vision and plan for landscape-scale predator control in the district. The information will also be used for sourcing the funding, people, and resources for a successful landscape-scale effort.

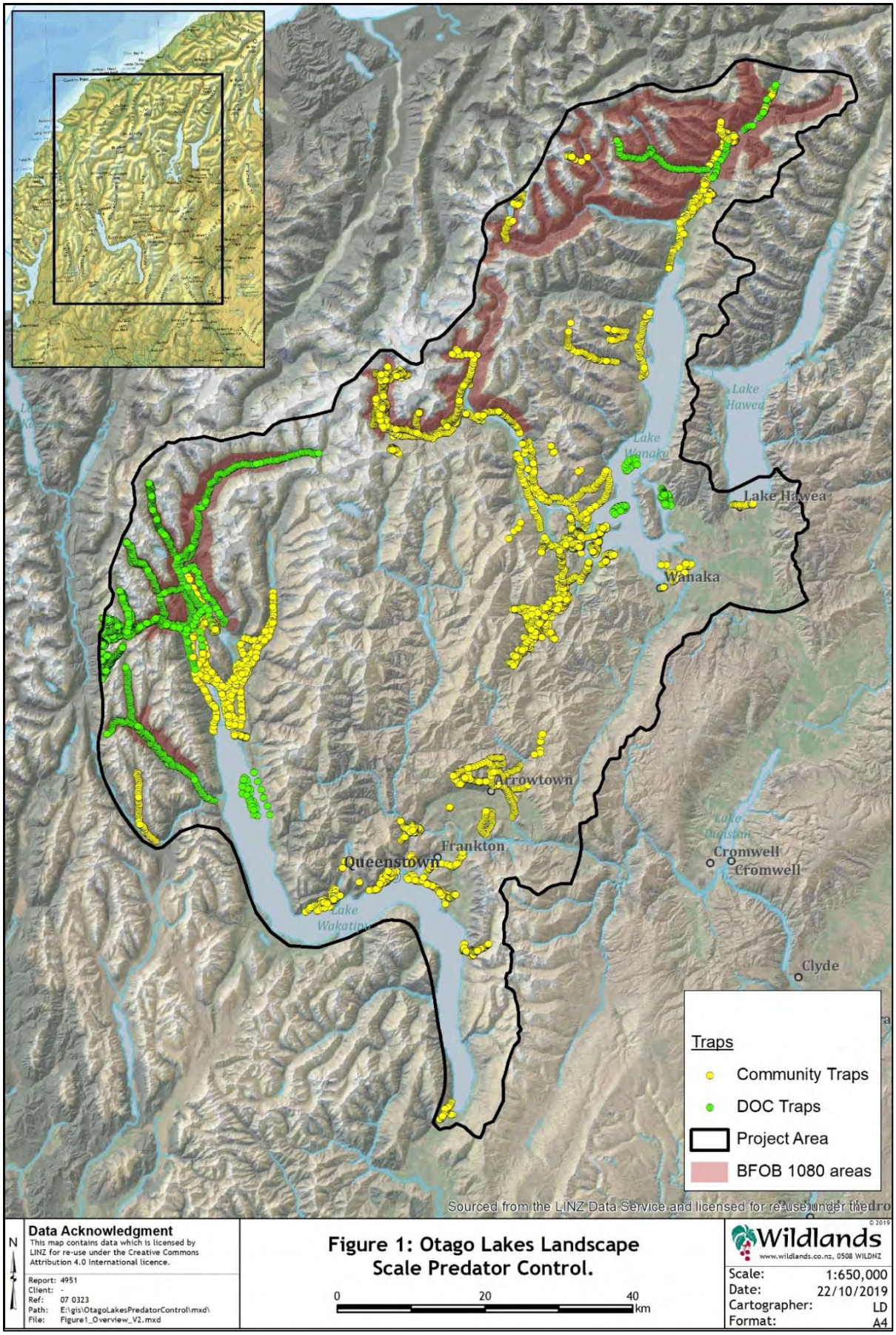

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Figure 1: Otago Lakes Landscape Scale Predator Control.

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The focus is on predator control that removes or suppresses the impacts of introduced predators on indigenous wildlife. Not in scope are the impacts of browsing pests, weeds, or habitat loss. Matters to be addressed outside of this document include governance, social impacts, public engagement, volunteer support, and fundraising. While evaluating different possibilities of enhancing landscape-scale predator control in the Project Area, consideration will also be given to whether there are opportunities to meet Predator Free New Zealand 2050 criteria.

2. WORKSHOP AND SITE VISIT

A workshop and site visit were held at the Milbrook Resort on 4 March 2019 to discuss the brief and scope with representatives from the various community groups and the Department of Conservation. Following this, a three-day road show was undertaken by Des Smith and John Parkes, during which time they visited each of the community groups in their focal areas.

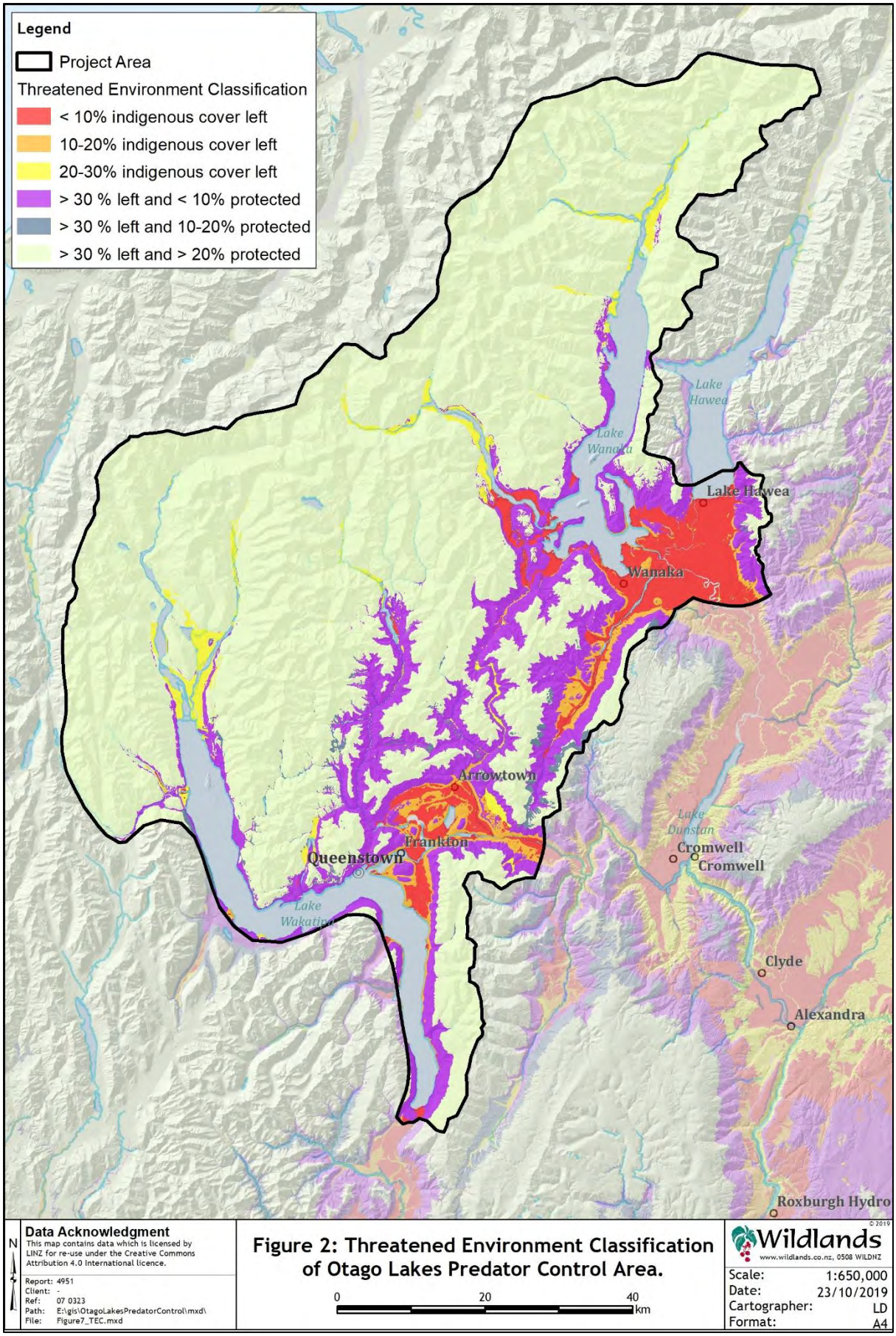
3. BIODIVERSITY VALUES IN THE PROJECT AREA

The following sections summarise known indigenous biodiversity values in the Project Area.

3.1 Land cover and threatened environments

Threatened Environment Classification and Land Cover Database maps for the Project Area are provided in Figures 2 and 3. The land cover map has the current trap network overlain on it. Most of the Project Area contains land that has >30% indigenous cover with >20% of it protected, i.e. it is covenanted or is public land with formal protection. The Land Cover Database (Figure 3) is particularly useful because it can be used to broadly define the typical ecosystems that occur in the Project Area, namely indigenous forest, alpine grass/herbfield, tall tussock grassland, and high/low producing exotic grassland associated with farming. Community trapping for the most part occurs within indigenous forest and low producing grassland (some of which is trapped to protect adjacent braided rivers). Interestingly, 'tall tussock grassland' occurs extensively in the Project Area but this is largely untrapped, with the exception of some alpine head basins and cirques in the west. A lot of these areas are remote, and difficult to access, with limited information on the biodiversity values that are present and could respond to predator control.

Department of Conservation trapping occurs primarily in indigenous forest and on islands in the major lakes.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Project Area
Threatened Environment Classification
< 10% indigenous cover left
10-20% indigenous cover left
20-30% indigenous cover left
> 30 % left and < 10% protected
> 30 % left and 10-20% protected
> 30 % left and > 20% protected
Lake Hawea
Lake Wanaka
Lake Hawea
Wanaka
Arrowtown
Lake Dunstan
Frankton
Queenstown
Cromwell
Cromwell
Lake Wakatipu
Clyde
Alexandra
Roxburgh Hydro
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Figure 2: Threatened Environment Classification of Otago Lakes Predator Control Area.
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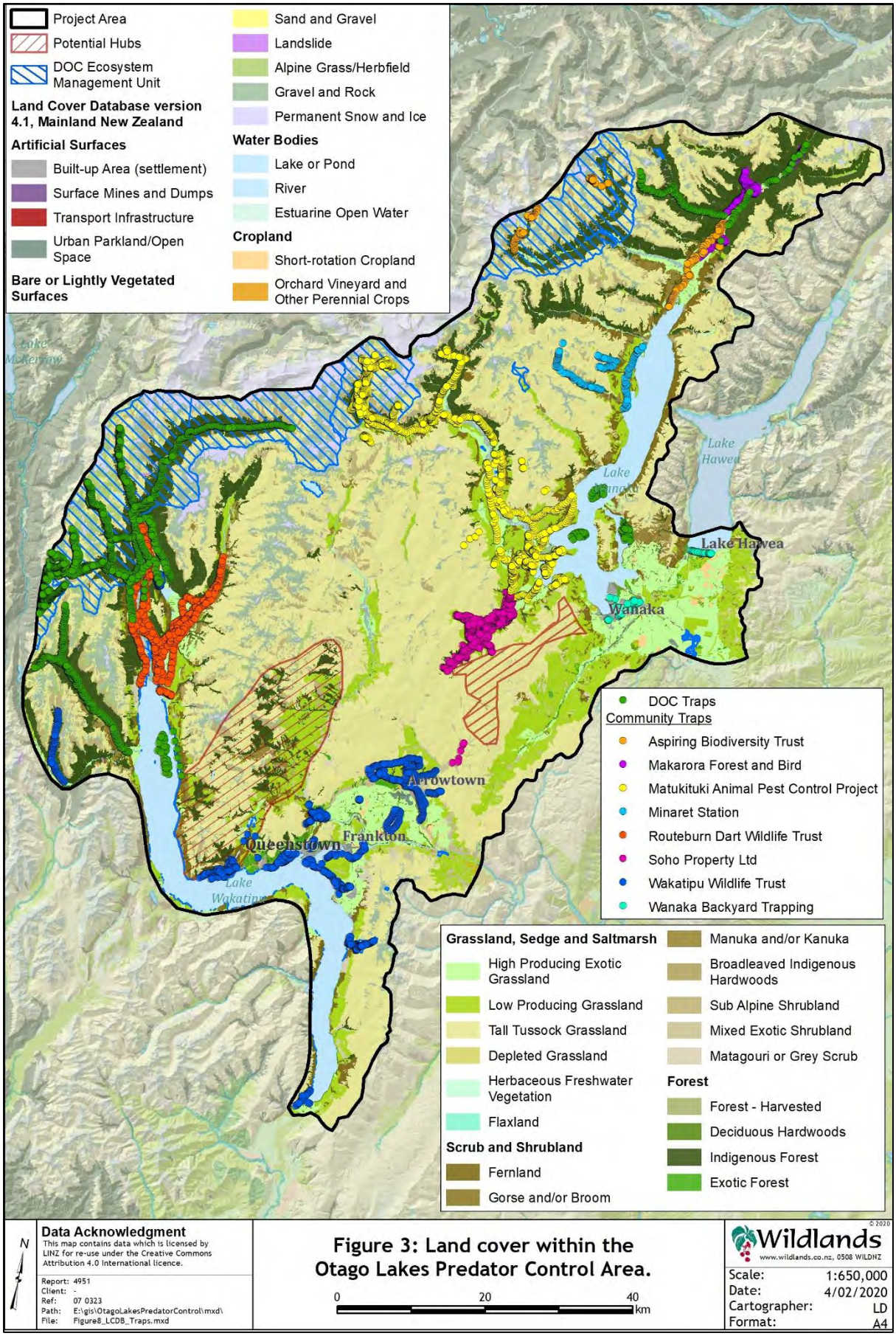

Figure 3: Land cover within the Otago Lakes Predator Control Area.

3.2 Avifauna

3.2.1 Overview

New Zealand birds have evolved in distinctive ways due to the absence of predation by predatory mammals and as a result of our long isolation from other land masses. This high level of endemism is unique and under threat from predation and habitat loss. Indigenous birds are considered a taonga, a great treasure, in New Zealand and long-term protection and conservation of bird diversity is a high priority.

Table 1 lists the bird species of interest of the Project Area and summarises their habitat preferences and their known location. Species richness of indigenous birds is highest in the western part of the Project Area where large tracts of intact indigenous forests are still present adjacent to higher altitude alpine grasslands. These areas are easily discernible from the landcover classifications in Figure 3. Species of conservation concern in these areas include rock wren (Threatened-Nationally Endangered), kea (Threatened-Nationally Endangered), whio (Threatened-Nationally Vulnerable), mohua (At Risk-Recovering), kākā (At Risk-Recovering), and South Island robin (At Risk-Declining). Other non-threatened forest birds are also common in these areas, e.g. titipounamu/rifleman (*Acanthisitta chloris*) and kākāriki/yellow-crowned parakeet (*Cyanoramphus auriceps*). Another often overlooked species that will inhabit the high alpine grasslands in the west is the New Zealand pipit (*Anthus novaeseelandiae*; At Risk-Declining). New Zealand pipit will also be present in other parts of the Project Area, including the extensive tall tussock grasslands to the south and east.

Braided river birds present within the Project Area are wrybill (Threatened-Nationally Vulnerable), black-fronted tern (Threatened-Nationally Endangered), black-billed gull (Threatened-Nationally Critical), banded dotterel (Threatened-Nationally Vulnerable), and South Island pied oystercatcher (At Risk-Declining). Population declines of riverbed-nesting birds are primarily attributed to predation by introduced mammalian predators.

The balance of the Project Area has habitats with a mixture of introduced birds and common indigenous birds, e.g. korimako/bellbird (*Anthornis melanura*) and riroriro/ grey warbler (*Gerygone igata*). Swamp birds such as matuku/Australasian bittern (*Botaurus poiciloptilus*; Threatened-Nationally Critical) are present in some wetlands. Crested grebe (*Podiceps cristatus*; Threatened-Nationally Vulnerable) occur at Lake Hayes, Lake Johnson, Lake Wakatipu shoreline near the Wakatipu Islands, Halfway Bay, Beach Bay, Kingston, Frankton Arm, and the Kawarau River upstream of the Shotover Delta. They are also well established on Lake Wanaka (where they are subject to assisted breeding), Lakes Sylvan and Diamond, and Lake Hawea, with sightings of wintering flocks near Kidd's Bush and Silver Island. Crested grebe appears to be increasing in numbers in the Project Area (Jensen and Snoyink 2005, John Darby unpubl. data) and would benefit from lakeshore trapping.

Buff weka (*Gallirallus australis hectori*; At Risk-Relict) is extinct in the eastern South Island (Beauchamp and Miskelly 2013) but has been reintroduced to islands at Lakes Wakatipu and Wanaka. Buff weka have also been the recent focus of a reintroduction attempt at Motatapu Station.

Table 1: Bird species of interest known to be present in the Otago Lakes Project Area. Conservation status as per Robertson *et al.* (2017).

Common Name	Scientific Name	Conservation Status	Habitat preference in the Project Area
Yellowhead / MOHUA	*Mohoua ochrocephala*	At Risk-Recovering	Indigenous forests in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments.
Kea	*Nestor notabilis*	Threatened-Nationally Endangered	Montane indigenous forests and subalpine and alpine zones in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments. Observed around Queenstown and in the Richardson Mountains.
Blue duck / WHIO	*Hymenolaimus malacorhynchos*	Threatened-Nationally Vulnerable	Rivers in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments.
Buff weka	*Gallirallus australis hectori*	At Risk-Relict	Wide variety of habitats, reintroduced to islands in Lake Wakatipu and Lake Wanaka
Australasian bittern/matuku	*Botaurus poiciloptilus*	Threatened-Nationally Critical	Wetlands along Lake Wanaka, Matukituki River, Lake Wakatipu, and Rees River. Lake Hayes and Matakauri Wetland in the Queenstown area.
New Zealand falcon/karearea	*Falco novaeseelandiae*	At Risk-Recovering	Wide variety of habitats, present throughout the Project Area.
Wrybill/ ngutuparore	*Anarhynchus frontalis*	Threatened-Nationally Vulnerable	Braided rivers (Makarora, Dart and Matukituki rivers)
Black-fronted tern/tarapiroe	*Chlidonias albostriatus*	Threatened-Nationally Endangered	Braided rivers in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments. Also present on lower Shotover River.
Black-billed gull	*Larus bulleri*	Threatened-Nationally Critical	Braided rivers in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments. Also present on lower Shotover River.
Banded dotterel/ tuturiwhatu	*Charadrius bicinctus*	Threatened-Nationally Vulnerable	Braided rivers in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments. Also present on lower Shotover River.
South Island pied oystercatcher/ torea	*Haematopus finschi*	At Risk-Declining	Braided rivers in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments. Also present on lower Shotover.
Rock wren	*Xenicus gilviventris*	Threatened-Nationally Endangered	High alpine grasslands, shrublands, and bare rocks in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments.
South Island robin	*Petroica australis*	At Risk-Declining	Indigenous forests in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments.
Australasian crested grebe/ puteketeke	*Podiceps cristatus*	Threatened-Nationally Vulnerable	Lakes (Lake Hayes, Lake Johnson, Lake Wakatipu Lake Wanaka (assisted breeding), Lakes Sylvan and Diamond, and Lake Hawea)
Kākā	*Nestor meridionalis*	At Risk-Recovering	Indigenous forests in the Makarora, Matukituki, Greenstone-Caples, and Dart-Rees catchments.
New Zealand pipit/pihoihoi	*Anthus novaeseelandiae*	At Risk-Declining	High alpine grasslands, tall tussock grasslands.

Figures 4, 5, and 6 illustrate habitats of Nationally Threatened bird species, and New Zealand falcon (At Risk-Recovering). The maps are largely based on eBird data. eBird is a citizen science, global database available online. New Zealand data were requested and downloaded in May 2019 (Sullivan *et al.* 2009; eBird 2019). This data set contains 147,145 species records for the Otago Region, and 24,062 records for the Otago Lakes District.

Use of the data set requires an understanding of its limitations. Anyone can submit data to the website. In New Zealand, submissions come from a range of people, from not-so-skilled bird watchers to highly experienced observers, or people working in environmental fields submitting data collected during field trips, such as Department of Conservation staff. Records submitted to eBird may include misidentifications, or locations may be imprecise. Importantly, the eBird data set is also biased towards areas where people visit, such as tourist areas, tracks, and towns. This has implications when using this data to determine 'significant' habitats.

Figures 4 and 5 show the distributions of New Zealand falcon and kea sightings separately from other species as both species have extensive distributions in the Project Area. All eBird records have been mapped to show how falcon and kea records relate to where records have been made. Figure 4 shows that falcon are distributed throughout the Project Area, that is, everywhere that records have been logged include records of falcon. In contrast, kea are commonly observed in the western parts of the Project Area, but are only observed occasionally in the eastern parts of the Project Area (Figure 5).

Figure 6 shows significant habitats for the following nationally Threatened species: South Island kākā, mohua, rock wren, blue duck, Australasian crested grebe, and Australasian bittern. It also provides the locations for globally Important Bird Areas; these are discussed in more detail below.

- South Island kākā and mohua eBird records were strongly associated with presence of indigenous forest in the Caples, Greenstone, Dart, Rees, Matukituki, Wilkin and Makarora valleys. Both species were largely absent from the Richardson Mountains.

- Significant rock wren sites were mapped where concentrations of eBird records were located; their actual distribution, according to eBird records, is much wider.

- Significant blue duck habitats were mapped based on records obtained from the Department of Conservations whio database, and from eBird records, where high concentrations of observations were found (the latter of which showed a wide distribution in the tributaries of the Makarora).

- Significant Australasian crested grebe habitats were defined from the most recent survey conducted by the Otago branch of Birds New Zealand (Thompson and Schweigman 2009). Whole lakes have been mapped; actual records within the lakes are patchier, but often widespread.

- eBird contains only four records of bittern, each a single bird, in 2010, 2012, 2016, and 2017. These have been mapped individually.

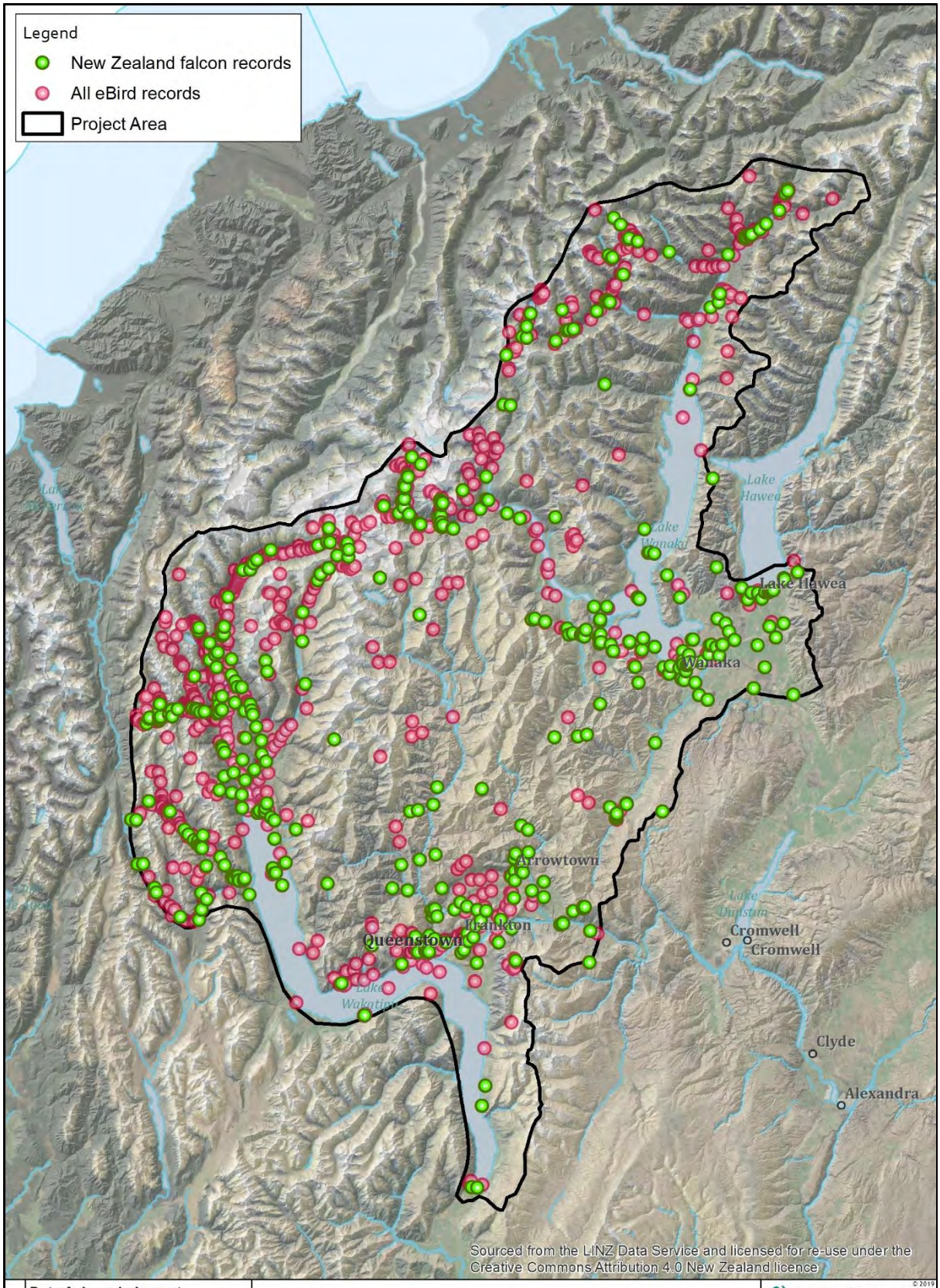

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Figure 4: New Zealand falcon distribution in the Project Area (eBird data)

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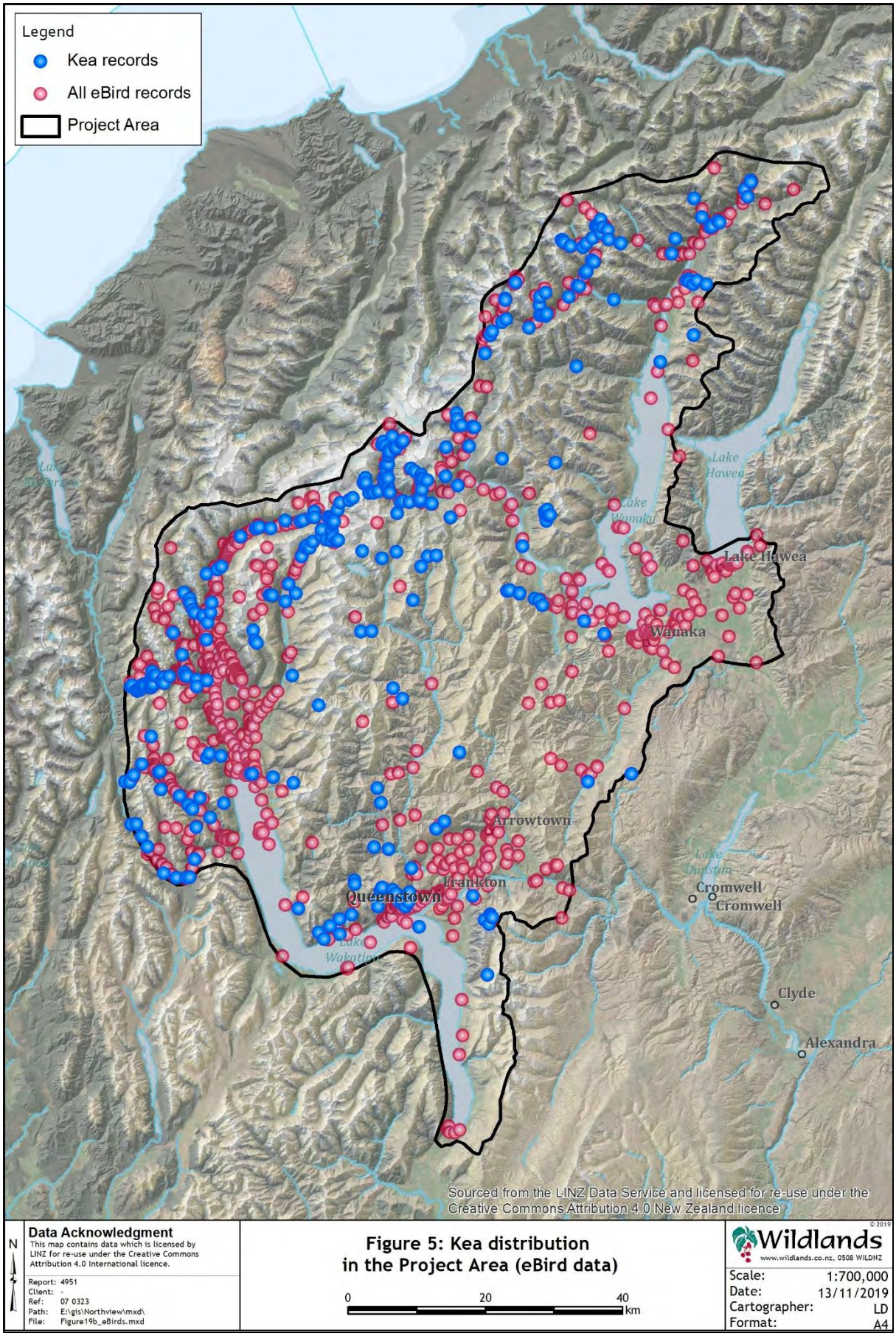

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Figure 5: Kea distribution in the Project Area (eBird data)

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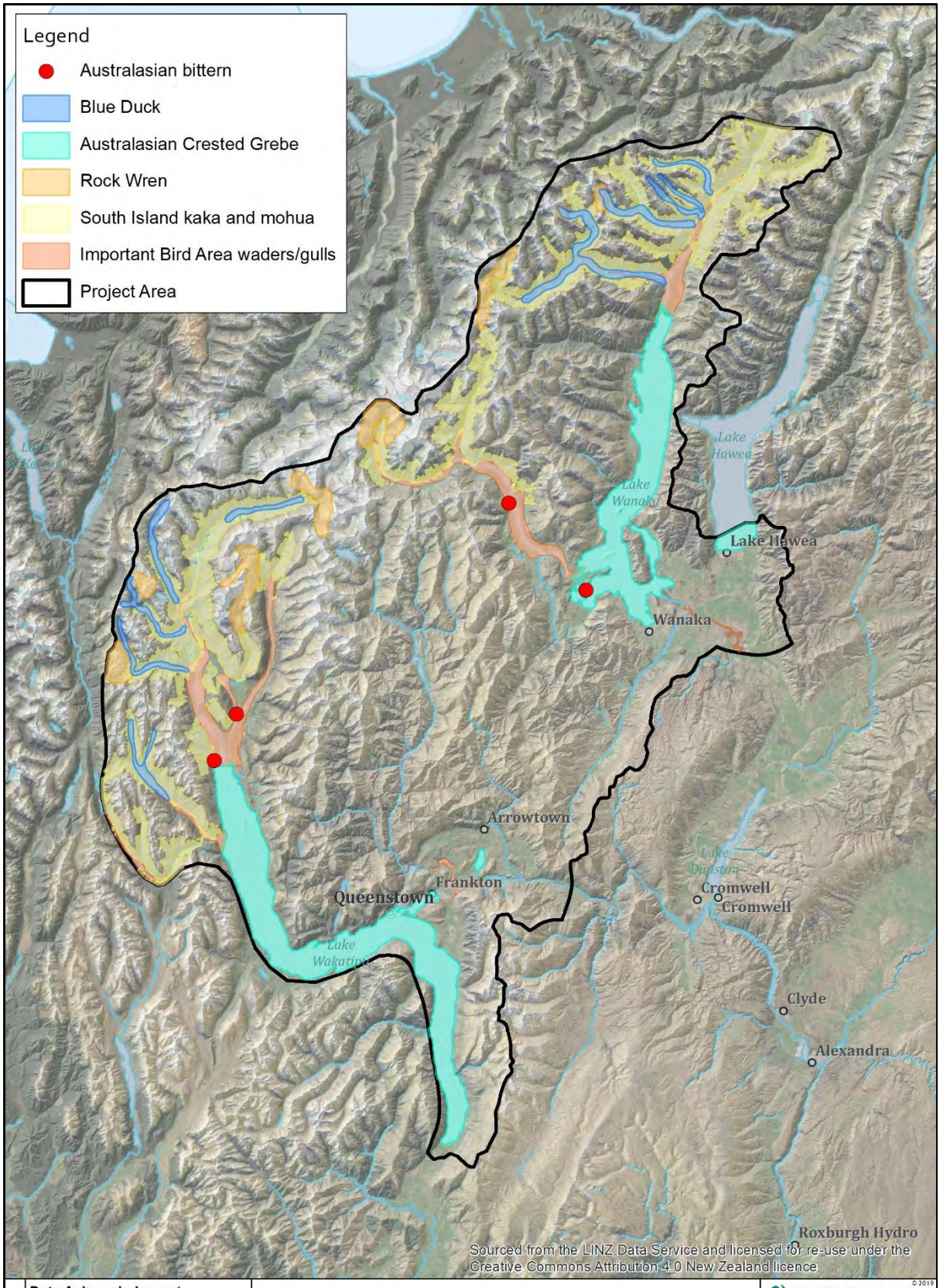

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Figure 6: Significant habitats of Nationally Threatened bird species

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3.2.2 Important bird areas

The 'Important Bird Area' (IBA) concept was developed by BirdLife International, and has been in use for over 30 years. The identification of an IBA is based on a relatively simple set of criteria that can be applied both in terrestrial and marine environments. Over 12,000 IBAs have been identified worldwide.

In New Zealand, seabird IBAs were identified in three major documents which addressed seabird IBAs at sea, coastal sites and islands, and rivers, estuaries, coastal lagoons and harbours. The identification process was undertaken by seabird scientist Chris Gaskin, on behalf of Forest and Bird (a partner of Birdlife International), and involved extensive published and grey literature reviews and communications with species experts. For this project, a 'seabird' was defined as a species that spends some part of its life cycle feeding over the open sea. This definition includes species such as black-billed gulls and black-fronted terns. Because of this, 'seabird' IBAs have been identified on inland braided riverbeds around New Zealand.

The Project Area contains six IBAs. The details of these IBAs are provided in Appendix 1, and have been taken directly from Forest and Bird (2016). The IBAs are based on the presence of breeding populations of black-billed gulls and black-fronted terns. However, these rivers also support other braided river bird species. In particular, the Dart supports an important population of wrybill, and wrybill are also present on the Makaroroa River (eBird records). Hybrid pied stilt/black stilt individuals have been reported from The Neck wetlands on three occasions, and once from the Makarora River (eBird records).

3.3 Bats

Long-tailed bats (Threatened-Nationally Critical) and short-tailed bats (*Mystacina tuberculata*, At Risk-Recovering) are known to be present in the Project Area (Figure 7). These records are for the period 1990 to present. Unsurprisingly, all observations are from forested areas in the west. The greatest number of observations of long-tailed bats has been in the Dart-Rees and this is the only location where short-tailed bats have been observed. Long-tailed bats have also been observed in the West Matukituki behind Mt Aspiring Hut, and in the Makarora valley. Bats may occur in other forested parts of the Project Area (Stewart 2016), including pine forests, but additional survey effort would be needed to assess their presence or absence.

3.4 Lizards

Fourteen lizard species are known to occur in the Project Area (Table 2, Figure 8). This represents a high diversity of lizard species. Some species, such as McCann's skink (*Oligosoma maccanni*), are reasonably widespread and abundant, but most species are restricted in their abundance and distribution. In particular, alpine areas above 1,100 metres above sea level. hold good populations of lizards and a higher diversity of species relative to the lowlands. There are six threatened species known from the Otago Lakes area: orange-spotted gecko (*Mokopirirakau* "Roy's Peak"), Otago skink, grand skink, Nevis skink (*Oligosoma toka*), Lakes skink (*Oligosoma* aff. *chloronoton* "West Otago"), and Takitimu gecko (*Mokopirirakau cryptozoicus*) (Table 2, Figure 8).

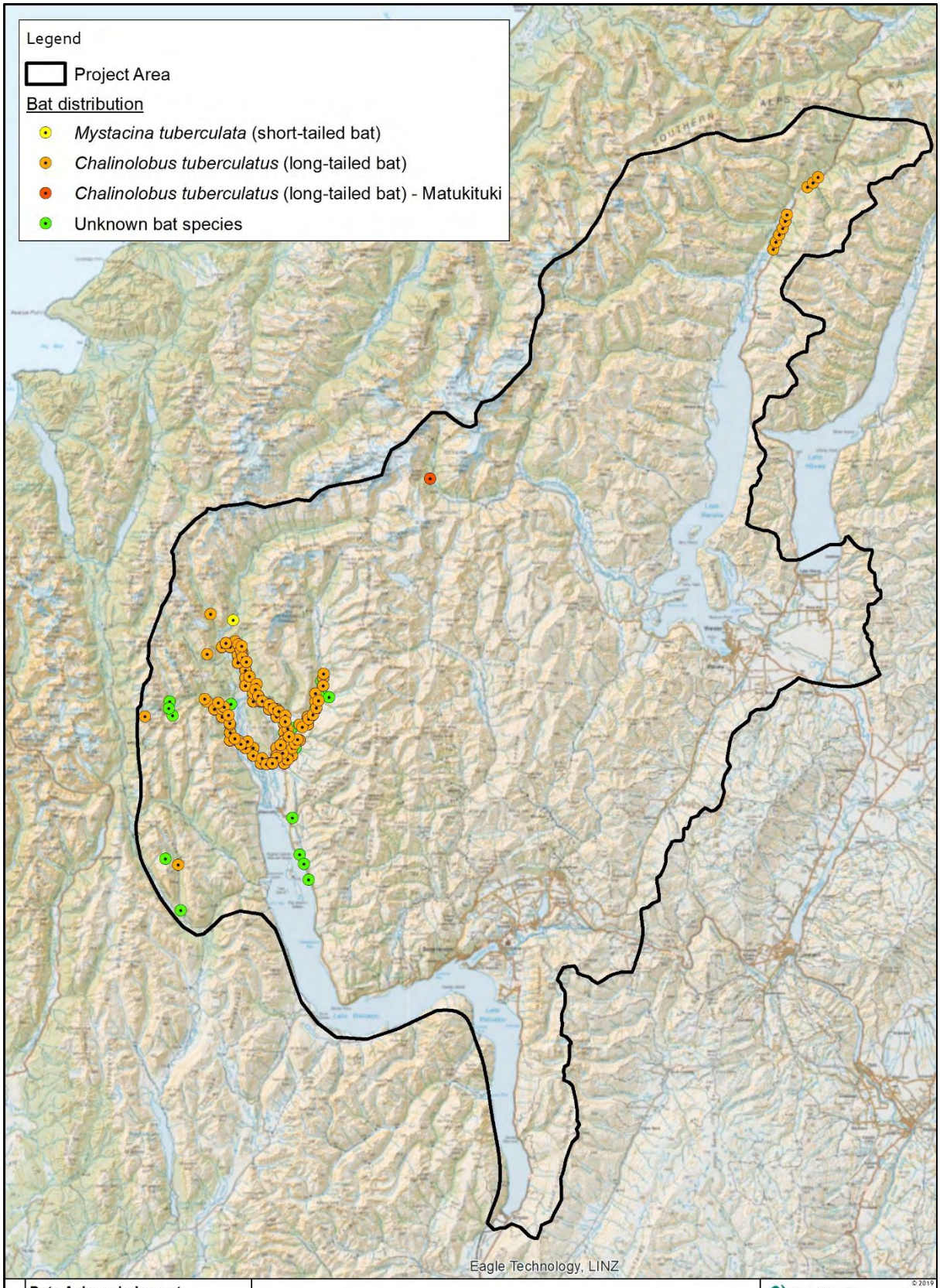

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Figure 7: Bat observations within the Otago Lakes Predator Control Area.

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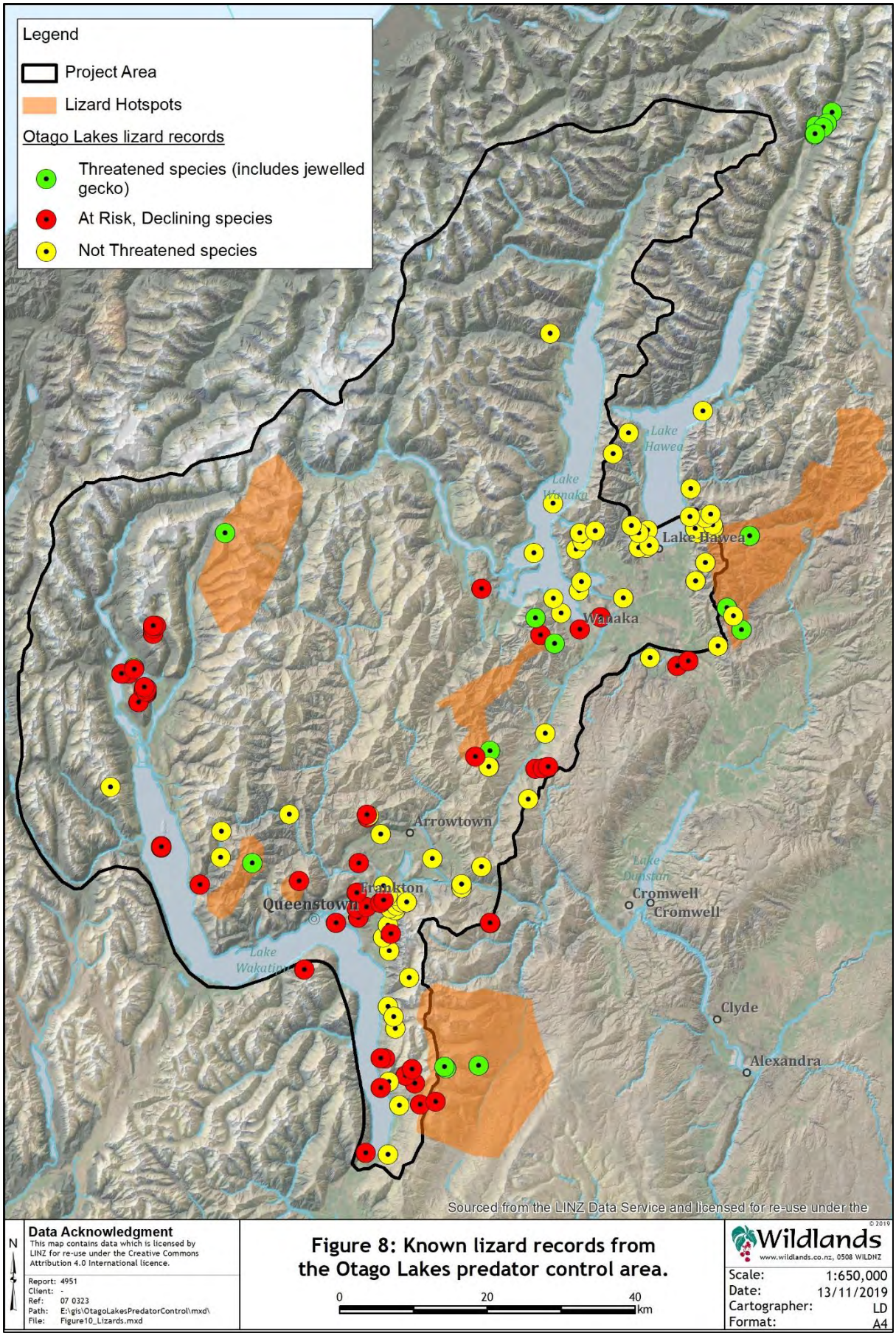


Figure 8: Known lizard records from the Otago Lakes predator control area.

Table 2: Lizard species present (or potentially present) in the Otago Lakes Project Area. Conservation status as per Hitchmough *et al.* 2016. The known habitat preferences of each species and their known distribution in the area is also provided.

Common Name	Scientific Name	Conservation Status	Notes
McCann's skink	*Oligosoma maccanni*	Not Threatened	Widespread and abundant in suitable habitats in the drier eastern half of the Project Area from valley floors to about 1,600 m asl. Either absent or less abundant in damper, western areas. Occupies a range of habitats especially dry, rocky areas.
Southern Alps gecko	Woodworthia "Southern Alps"	Not Threatened	Widespread in rocky areas (screes, tors, bluffs etc.) around Wanaka and Hawea, which represents the southwestern extent of their distribution.
Short-toed gecko	*Woodworthia* "Southern Mini"	Not Threatened	Generally found in high altitude areas from 700-1,700 m asl. Within (or close to) the Project Area they occur in the Remarkables, Hector, Eyre, Humboldt, and Thompson mountain ranges.
Korero gecko	*Woodworthia* "Otago-large"	At Risk-Declining	Occupies rocky areas typically below 1,100 m in the Wakitipu area. Within the Project Area occurs in the Hector Mountains, Remarkables, Coronet Peak, Richardson Mountains, and Mt Alfred near Paradise.
Kawarau gecko	*Woodworthia* "Cromwell"	At Risk-Declining	Occupies rocky areas up to at least 1,300 m asl. Within the Project Area occurs in the Remarkables, Pisa Range, Criffel Range, Mount Cardrona, Mt Alpha, and Ruby Island in Lake Wanaka.
Southern grass skink	*Oligosoma* aff. *polychroma;* Clade 5	At Risk-Declining	Prefers damp habitats such as rank grasslands, wetlands, stream/river edges, and gullies. Widespread in eastern areas within the Project Area. Recorded from Hector Mountains, Coronet Peak, Pisa Range, Mount Cardrona, Mt Alpha, and near Wanaka and Hawea townships.
Cryptic skink	*Oligosoma inconspicuum*	At Risk-Declining	Occupies tussock grasslands, scrublands, herbfields, wetlands, and rocky areas such as boulder fields, and screes. Favours damp areas, such as gully systems with either rocky or woody debris. Has been recorded at very high altitudes up to 1,875 m asl. Occurs around Paradise, Glenorchy, Mt Cardrona, and Coronet Peak. Probably more widespread.
Jewelled gecko	*Naultinus gemmeus*	At Risk-Declining	Found in a range of forest and scrub habitats, including Coprosma, tōtara, beech, mānuka, and matagouri. Arboreal. Also occasionally found in snow tussock grasslands. Wiped out from most of its former range, but remnant populations known from the Hunter Valley above Lake Hawea and possibly present in the Dart and Rees Valleys. There is an unverified record from Paradise in 1970, but recent surveys of the area have failed to locate this species.
Lakes skink	*Oligosoma* aff. *chloronoton* "West Otago"	Threatened-Nationally Vulnerable	A large, but cryptic species found in damp and structurally complex habitats, typically with woody or rocky cover in the form of logs, rock piles, or loose slabs, such as stream/river/lake edges, wetlands, gullies, shrublands, scree-edges, boulderfields, and tussocklands. In the Otago Lakes Project Area, known from Mt Cardrona and Mt Alpha near Wanaka. A cryptic species that may be more widespread than currently recognised.

Common Name	Scientific Name	Conservation Status	Notes
Orange spotted gecko	*Mokopirirakau* "Roy's Peak"	Threatened-Nationally Vulnerable	Only known to occur from 1,100-1,650 m asl and only known from seven sites. Primarily known from alpine boulderfields and screes. Recorded from Moke Valley near Queenstown, the Hector Mountains, Mt Cardrona, and Mt Alpha near Wanaka.
Takitimu gecko	*Mokopirirakau cryptozoicus*	Threatened-Nationally Vulnerable	Mostly known from the Takitimu Mts in Southland, but also has been found in forest in southeastern Fiordland. Occupies alpine bluffs, boulderfields, and screes as well as forests at lower altitudes. Has been recorded in the Richardson Mountains east of the Rees Valley which represents the northern extent of their known range. A cryptic species that may be more widespread than currently recognised.
Nevis skink	*Oligosoma toka*	Threatened-Nationally Vulnerable	Occurs in the Nevis Valley and parts of the adjacent Hector Mountains and Old Woman Range. Also recorded from around Lindis Pass, Mt Cardrona, and Mt Alpha near Wanaka. Occupies rock piles (including gold tailings), river terraces, damp screes, boulderfields, and *Dracophyllum* shrublands up to at least 1,550 m asl.
Otago skink	*Oligosoma otagense*	Threatened-Nationally Endangered	Strongly associated with schist outcrops including tors and rocky gully systems. Present in limited areas in the hills between Hawea and Lindis Pass.
Grand skink	*Oligosoma grande*	Threatened-Nationally Endangered	Strongly associated with schist outcrops including tors and rocky gully systems. Present in limited areas in the hills between Hawea and Lindis Pass.

Distributions and abundances of many of the lizard species known to be present in the Project Area is not particularly well understood. This is due to the remoteness of many of the mountain ranges, a lack of survey effort, and the cryptic nature of some of the species, meaning that it can be difficult to detect their presence even with dedicated survey effort.

Some parts of the Otago Lakes Project Area have been surveyed reasonably well for lizards, but many areas have received either no survey effort or insufficient survey effort for cryptic lizard species. Reasonably well-surveyed areas include between Lake Hawea and the Lindis Pass, Mt Cardrona, Mt Alpha, Coronet Peak, the Remarkables, the Hector Mountains, and the Glenorchy area.

Areas that may have significant lizard habitat values that have not been adequately surveyed include the Harris Mountains, mountains to the west of Lake Wanaka, and the Richardson Mountains (potential for orange-spotted gecko, Takitimu gecko, Nevis skink, and Lakes skink in these areas). There is also potential for jewelled gecko to be present in the Dart and Rees valleys. In Figure 8 lizard hotspots are also shown, comprising areas that are thought to have substantial lizard habitat.

3.5 Invertebrates

Invertebrates have not been included in the biodiversity review of the Project Area. In general, it is expected that the diversity of indigenous invertebrates will vary across the Project Area, and there is likely to be significant data deficiency for certain taxonomic groups.

4. PEST CONTROL METHODS

4.1 Goals of predator control

Introduced mammalian predators are controlled in New Zealand to protect indigenous fauna and plants, and in some cases to provide disease vector control (e.g. bovine tuberculosis in brushtail possums). Vector control is not within the scope of this plan, but may be an indirect benefit of some of the work undertaken by the plan's stakeholders.

For the purposes of this plan, the unifying goals of predator control are:

- To reduce introduced predator populations to a level which guarantees, in perpetuity, that predation is not a threat to the survival of Threatened or At Risk indigenous fauna populations.
- Maintain introduced predator populations to a level which guarantees, in perpetuity, that predation is not a threat to the survival of Threatened or At Risk indigenous fauna populations.

Predator control is a means to an end, but it is not the end goal. The following section describes the most appropriate pest control methods to use for this project. Methods for monitoring predator levels and biodiversity recovery are described in Section 7.1.

4.2 Species-specific methods

Indicative densities of the various predator species in different habitat within the Project Area are provided in Appendix 2, along with the rate at which their populations are known to increase. While this is useful background information it is very difficult to extrapolate trap catch results against estimate of absolute density.

4.2.1 Stoats and weasels

There is not a lot of specific information available on the management of weasels. Until this information becomes available it is assumed that stoat control methods will also control weasels.

Stoats will be ubiquitous across the Project Area, occurring in all terrestrial habitats. Smith *et al.* (2008) noted that summer to autumn stoat densities in both beech forest and alpine grasslands in Fiordland National Park were 1.5 and 1.6 km^2 and 0.8 and 1 km^2 in 2003 and 2004, respectively. There were no beech masts during these years. Alterio *et al.* (1999) estimated stoat densities in red beech-dominant forest at Maruia were 4.2 km^2 and 2.5 km^2 in summer and autumn one year after a beech mast event in 1995. Even at low densities stoats are a threat to indigenous wildlife.

Trapping with the DOC trap series (150, 200, and 250) has been used extensively to control stoats over large areas (Brown *et al.* 2015). A trial that compared DOC250 traps to A24 multi-kill traps in Trounson Kauri Park (Northland) suggested that the DOC-series traps are more effective at controlling stoats than A24 traps (Gillies *et al.* 2019).

Key Requirement

To put all female stoats at risk trap lines should be no further than 600 metres apart Smith *et al.* (2015). Stoats should therefore be controlled using DOC200-250 traps spaced 200 metres apart on lines spaced no further than 600 metres apart, where the landform is suitable.

4.2.2 Ferrets

Ferrets are common in areas where rabbits are abundant, but typically do not utilise open braider river habitats or continuous forest (Clapperton and Byrom 2005). Before the release of rabbit haemorrhagic disease (RHD), the density of ferrets in Central Otago's dry grasslands was estimated to be between 2-5 km^2 (Middlemiss 1995, Moller *et al.* 1996).

The Department of Conservation Standard Operating Procedure (SOP) specifies the use of DOC250 traps set in tunnels on lines no further than 0.8-1.0 kilometres apart, with traps spaced every 200 metres and lured with meat from their main prey in the area, which in most habitats is rabbit (DOCDM-29433(1)).

Key Requirement

Ferrets should be controlled using DOC250 traps at 200 metre intervals on lines spaced 0.8-1 kilometres apart. In rabbit-prone country, or in locations where stoats are also plentiful, line spacing should be decreased to 600 metres.

4.2.3 Rats

Density estimates for rats are surprisingly rare, but rats are typically in higher abundance in mixed podocarp-hardwood forest than in beech forest in non-mast years. In mixed podocarp-hardwood forest in the Orongorongo Valley ship rats have been estimated to be 5.4-8.7 per hectare (Wilson *et al.* 2007). Christie *et al.* (2015) estimated ship rats in red beech forest in the Eglinton Valley to be 0.38 per hectare. However, in the years following beech masts, exponential rates of increase in rat numbers have been observed (Elliott *et al.* 2018). In particular, rat population increases can be very large in red beech forest following a mast event (Choquenot and Ruscoe 2000). During these population irruptions rats can have severe impacts on indigenous bird and bat populations. Little is known about rat population dynamics in the lower altitude tall tussock grasslands and scrub habitats in Otago. Rat population dynamics are not well understood in braided river ecosystems either, but rats can sometimes be caught in high numbers at localised sites within braided rivers.

A review by the Department of Conservation in 2015 (Brown *et al.* 2015) concluded that single-kill traps aimed at rats were ineffective other than at very small scales, and past attempts to do at larger scales failed unless used in combination with toxins. Trapping alone was considered to be particularly ineffective in mast years when rat population increases outweigh mortality from trapping (e.g. Elliott & Suggate 2007). However, small-scale trials in Fiordland and on Native Island (63 hectares; off Rakiura/Stewart Island) using A24 multi-kill traps have, succeeded in reducing ship

rat indices to zero. In November 2013 on Native Island, 142 Goodnature A24 traps lured with Goodnature peanut formula, and later chocolate formula, were set at 50 metre intervals on transects 100 metres apart (maximum spacing in the Department of Conservation SOP DOCDM-29390(1) to target ship rats and Norway rats). Traps were serviced every five weeks. Tracking tunnel indices were 73% before the trapping and 0% by December 2014 (Department of Conservation 2015). The costs for the traps and servicing, assuming that no volunteers were used (excluding monitoring costs), were about $500/hectare. A24 traps (467 traps over 200 hectares) reduced ship rats to a tracking index of zero at Harts Hill in Fiordland. A24 traps set at 50-100 metre spacings have also reduced ship rat numbers to <5% tracking indices at Boundary Stream and on Mt Egmont, which is about the same efficacy as bait stations with Diphacinone (Nick Poutu, Department of Conservation, pers. comm.).

In contrast, A24 traps set over 100 hectares on Great Barrier Island at 50 metre spacing and later reduced to 25 metre spacing failed to control ship rats and kiore;tracking tunnel indices remained high (≥12.5%) compared with adjacent areas treated with 'standard rat traps' and diphacinone bait stations (0-7.5% tracking index) (Windy Hill - Rosalie Bay Catchment Trust 2018). This report also notes the failure of A24 traps to control ship rats in a 50 hectare area in the Ark in the Park programme. Otago Lakes Forest and Bird have noted that the effectiveness of A24s for rat control tapers off over-time and their effectiveness is worsened by the use of kea-proof baffles (I. Turnbull, pers. comm.).

Poison bait stations can be very effective for rat knockdown and are used for this purpose to protect mohua and long-tailed bat populations in locations such as the Eglinton Valley, Fiordland National Park. The Department of Conservation SOPs for rat traps and bait stations specify trap spacings of 50 metres (along transects 100 metres apart if set in grids) reduced to 25 metres apart when rat numbers are high.

Key Requirements

Although rats are caught in DOC-series traps laid out for mustelids, this type of trapping is not intensive enough to control rat populations. Aerial 1080 will substantially reduce the abundance of rats following beech masts. However, it should be noted that:

- Rat numbers can bounce back quickly, and this can be very local.
- Aerial 1080 cannot feasibly be applied over large parts of the Project Area.

In order to protect biodiversity, the different groups will need to undertake localised intensive rat control at certain sites where monitoring shows that rats are having an overwhelming impact on indigenous wildlife. It is therefore suggested that A24s are not used to attempt to control rat outbreaks, until further research has properly demonstrated their efficacy, and why this varies significantly in some situations.

The groups should undertake pulsed rat control using bait stations on 50 × 100 metre grids. This can be narrowed to 50 × 50 metres when rat infestations are particularly large, or when biodiversity outcome monitoring identifies urgent need for intensive rat control. The groups should have Controlled Substance License holders within their ranks, and have the capacity to apply a variety of toxins on a case-by-case basis.

The Department of Conservation has SOPs for the use of toxins in bait stations. These SOPs provide advice on maximising pest knockdowns. However, the most important guiding documentation is the manufacturers label instructions. These instructions have been set through the registration process with the Environmental Protection Agency and Ministry of Primary Industries, and are usually based on research that was required by these government agencies to achieve registration. Product label instructions provide guidance on safe deployment, environmental clean-up, dose rates, and length of deployment necessary to kill the target pest.

First generation anticoagulants such as Pindone or Diphacinone are the simplest toxins to use. Earlier trials found that Diphacinone at 0.05g/kg in a Ferafeed bait matrix (called Sentinel®) was effective, and if Feratox capsules (see the section below on possums) were added could also kill possums (Gillies *et al.* 2006). Two Diphacinone baits are available for use in bait stations or as 'strikers' nailed to trees: Ratabate from www.connovation.co.nz and Pestoff Rat Bait 50D from www.orillion.co.nz. Note that Philproof rat bait stations require special baffles to exclude kea from getting access to the baits (Kea Conservation Trust 2019). Acute toxins such as 1080 can also be applied in bait stations, and will give a rapid knockdown of rats, but this should be followed up with anticoagulant poisons targeting bait shy survivors (e.g. Smith *et al.* 2009).

4.2.4 Feral cats

Like ferrets, cats are abundant where rabbits are present. However, they are a more generalist predator than ferrets and are therefore found in most habitats. They are a particular threat to ground-nesting birds in braided riverbeds and to lizards (Gillies and Fitzgerald 2005). In some habitats, such as beech forest river valleys, cats are distributed patchily, but in others like lower altitude tall tussock grassland they are likely to be prevalent.

DOC250 traps are responsible for most cat kills in the Project Area. However, Steve Allen traps in raised sets, Belise Super X traps, and the DOC Twizel cat traps in tunnels may be better in areas where cats are a recognised problem. Timms traps with widened entrances can also be effective for cats, and could be used in areas where keas are not present.

No large-scale cat eradication project has been successful to date without the use of leg-hold traps (Victor soft-jaw 1.5 leg-holds). A recent plan for the Dart-Rees braided river habitats proposed the use of leg-hold traps to target feral cats (Waite 2017), but this has not yet been implemented. Night shooting - using spotlights and/or thermal imaging - is also an effective way to remove feral cats, particularly older and more wary animals that avoid traps.

Predastop®, a meat bait with the toxin PAPP, is now registered for use for feral cats in New Zealand. Predastop® efficacy at controlling feral cats has been demonstrated by applying it in submarine bait stations (Murphy *e al*. 2011). A cat-specific bait is now registered for use in Australia. Curiosity® is a meat sausage bait containing a hard-shelled capsule containing a toxin (1080 or PAPP) that relies on cats' particular feeding behavior: they swallow the whole bait while other species nibble it and spit

out the hard capsule (De Tores *et al.* 2011). The Department of Conservation is investigating the use of similar baits with PAPP as the toxin for mustelid and cat control in New Zealand (Elaine Murphy, Department of Conservation, pers. comm.).

Domestic and stray cats present a significant problem, as their presence limits the ability to use lethal control tools against the feral cats. However some of parts of the Project Area will be a sufficient distance from domestic cats to allow lethal control. In areas where cats cannot be controlled because of the presence of domestic cats, community education programmes should be run on the impacts of cats on indigenous wildlife. Live trapping programmes using cage traps could also be applied in important wildlife habitats in these areas, and domestic cats returned to their owners with information provided on where they were caught and the wildlife they were putting at risk (this approach has been implemented in some Auckland Council sanctuaries).

Wide-scale suppression of feral cats to protect McCann's skink was achieved at Macraes Flat by using a cat trap every 30 hectares (James Reardon, Department of Conservation, pers. comm.).

Key Requirements

DOC250 traps will kill feral cats, but may not be particularly humane. Other traps can be used to specifically target feral cats, e.g. Steve Allen traps or Timms traps with widened entrances. Having a cat kill-trap in every 30 hectares can be achieved by having a cat trap every 500 metres on mustelid lines that are 600 metres apart with traps spaced 200 metres. This should be undertaken in areas where feral cats are known to be present through monitoring.

PredaSTOP (para-aminopropiophenone delivered in a meat bait via bait stations) could also be considered. Despite having been registered for several years, its uptake has been very poor.

4.2.5 Hedgehogs

There are no best practice guidelines for controlling hedgehogs, which are most commonly caught in DOC250 traps in the Project Area. Research suggests that hedgehogs are almost nomadic with undefined or at least very large home ranges and can move long distances within a short time (Jones and Sanders 2005). They can also be highly abundant. Controlling them is therefore likely to require intensive trapping effort. Hedgehog control trials to establish best practice is urgently needed, particularly in habitats such as braided rivers. Hedgehogs are known predators of braided river bird nests (Jones and Sanders 2005) and are primarily insectivorous, meaning they potentially pose a threat to indigenous invertebrates, although this threat has not been well quantified.

Intensive trapping such as the virtual pest barrier deployed in the West Matukituki should be monitored carefully to see if these achieve localised reductions of hedgehogs. If this is the case then these could be applied in other locations such as the Dart-Rees, to prevent their spread up-valley.

4.2.6 Possums

Aerial application of 1080 in mast years will kill most possums and their numbers will not completely recover at the current frequency of application. However, successive aerial 1080 applications are likely to lead to a proportion of the possum population being bait-shy.

There are many traps that will kill possums, including the Trapinator traps currently favoured by existing groups in the Project Area. However, the trend in numbers of possums caught suggests that such trapping is merely holding possums at current densities (see Section 4.4 above) so either more intensive trapping or additional methods are required to reduce numbers.

The use of encapsulated cyanide (Feratox®) in bait stations or bait bags will produce a rapid high knock down if possums are a problem in some areas, and is used for this purpose throughout New Zealand. A controlled substances licence is required to use this method but the equipment required (bait stations, bait bags (Striker), pre-feed paste and cyanide capsules) are all available for purchase. About 200 grams of pre-feed per station should be laid about one week before the cyanide baits are used. Up to six Feratox capsules are then inserted into the pre-feed paste or up to three capsules in 20-40 grams of pre-feed within the Striker bags, and the station should be lured with flour or icing sugar to attract the possums. The stations or bags can be placed up trees to limit any non-target risks.

Key Requirements

The use of encapsulated cyanide (Feratox®) in bait stations or bait bags should be used to deliver pulsed knockdowns of possums at priority sites. At these sites annual possum control should be applied (a pre-feed followed by toxic baiting), followed by monitoring of residual possum densities (chew cards or residual trap-catch in leg-hold traps) to measure success and whether more frequent baiting is warranted.

The use of Feratox® is another compelling reason for the groups to have Controlled Substance Licence-holders within their ranks.

Trapinators can also continue to be used in locations along trap-lines where monitoring identifies possums to be more abundant.

4.2.7 Mice

Mice are widespread in most terrestrial ecosystems in New Zealand. Their populations increase rapidly following beech and snow tussock masts (King 1983, Wilson and Lee 2010), and this causes increases in the abundance of stoats. Mice are predators of lizards, invertebrates, and potentially bird's nests.

Small-scale localised control of mice could be attempted to protect certain indigenous species, e.g. lizards. Control methods would be very tightly spaced baits stations (25 × 25 metres) with anticoagulant poisons. There are currently no suitable tools available for large-scale control of mice. The only method that has been successful for controlling mice over large areas is aerial brodifacoum, which has been used to

eradicate mice from islands and predator-exclusion fenced sanctuaries. There are environmental risks with the sustained use of brodifacoum, even in bait stations, (Broome and Fairweather 2015) and its use is not appropriate unless an eradication is likely, or substantial conservation benefits can be demonstrably achieved. Potential benefits would need to be weighed against environmental risks in an environmental impact assessment.

4.3 Predator control zones

The following predator control zones have been identified across the Project Area:

- Alpine grassland.
- Forested river valleys.
- Braided riverbeds.
- Pastoral grassland (including grey scrub in pastoral grassland areas).

Predator control in each of these zones is addressed in the following sections:

4.3.1 Alpine grassland

Alpine grassland has been defined as snow tussock (*Chionochloa* spp.) habitat above the natural altitudinal limit of beech forest (1,000-1,100 metres above sea level). Trapping of introduced predators in forested valleys is unlikely to protect biodiversity living at or above treeline (Smith and Jamieson 2005). The principal predators that will be present and preying upon wildlife are stoats and possums. Rats are present occasionally, but their abundance typically declines with increasing altitude, and they are not known to occur at high densities in alpine grassland, or high altitude beech forest. Mice are present in alpine grassland, patchily distributed in most years, but reaching high densities following snow tussock masts (Wilson and Lee 2010). It is possible that feral cats can occasionally occur in alpine grasslands as they have been observed at the top of Mt Anglem/Hananui (980 metres) on Rakiura Stewart Island (Grant Harper, Department of Conservation, pers. comm.).

In the western parts of the Project Area there is substantial indigenous fauna biodiversity in alpine grassland habitat and high altitude beech forest requiring protection from predation, e.g. rock wren, kea, New Zealand pipit, alpine geckos, and an intact invertebrate fauna including weta genera such as *Hemiandrus*.

The current best practice approach for the control of predators in alpine grasslands is to establish a horizontal trap line slightly above or near treeline, and then another horizontal trap line 500 metres above it, running along a ridge, bench or similar feature. This has been used effectively to protect rock wren in the Haast Range (Department of Conservation, unpubl. data), and this method also has potential to protect kea nests. Trapinators could also be used to target possums along the lower trap line, as possums are known to attack kea nests.

This approach is preferred to sporadic targeting of alpine passes with traps, because it targets predators using habitat at and above treeline and will for the most part provide trap lines that are parallel to the valley floor trap lines (often within 600 metres, the critical distance for stoat control, as identified in Smith *et al.* 2015).

Some sections of alpine grassland will lend themselves to this approach, while in other areas it will be difficult, if not impossible. In these locations it is suggested that trap lines are established that provide 'vertical barriers' (i.e. perpendicular to the valley floor) running up obvious ridges or spurs from the valley floor through high altitude beech forest into alpine grassland.

4.3.2 Forested river valleys

In forested river valleys, stoats and rats are the main predators of concern, followed by feral cats. A best practice model to follow for forested valleys would be that used in the Landsborough Valley where significant forest bird recovery has been achieved by having a trap line on both sides of the river, with parallel trap lines on each side of the river edge trap lines, but further back in the forest, on old river terraces below the toe slopes of the valley sides. This results in four parallel trap lines in parts of the Landsborough, and at its widest point they may be as far apart as one kilometre, but sometimes a lot closer (Colin O'Donnell, Department of Conservation, pers. comm.).

This approach would provide good synergies with alpine grassland trapping.

Rat control is also essential if good biodiversity outcomes are to be achieved. Mapping of forest types is a high priority for predicting finer scale rat dynamics in forested areas.

4.3.3 Braided riverbeds

The main braided river area covers 3,800 hectares in the lower Dart and Rees valleys down to Glenorchy (Figure 1). Smaller areas of braided river habitat are present in the lower Makarora and lower Matukituki valleys (Figures 9 and 10) and a small portion of the Upper Shotover River and Shotover delta.

Predation of nesting birds in braided rivers (eggs, chicks, and to a lesser extent adults) during their breeding seasons (generally September to February) can inhibit recruitment (Keedwell and Brown 2010). Braided river birds face a vast array of predator guilds including mustelids, feral cats, rats, hedgehogs, possums, and indigenous avian predators such as kahu/harrier hawk and black-backed gulls.

Large numbers of predators can aggregate in these systems. Since 2018 the Routeburn Dart Wildlife Trust has caught 113 stoats, 14 cats, 23 weasels, 284 rats, and 57 mice in their 641 traps.

Trapping on braided riverbeds is occurring in a number of different ways in the Project Area. In the Dart-Rees, traps are largely kept out of the river with the exception of a few places in the Rees. The principal reason for this is not to lose traps, or trapping equipment, or access to traps, during times of peak flows. Trap lines typically follow both sides of each river with additional near-parallel lines set further back in the adjacent farmland. This is a good model, as traps along the river edge will pick up predators that pose an immediate threat, while traps further back in the farmland will slow reinvasion to the river/margins.

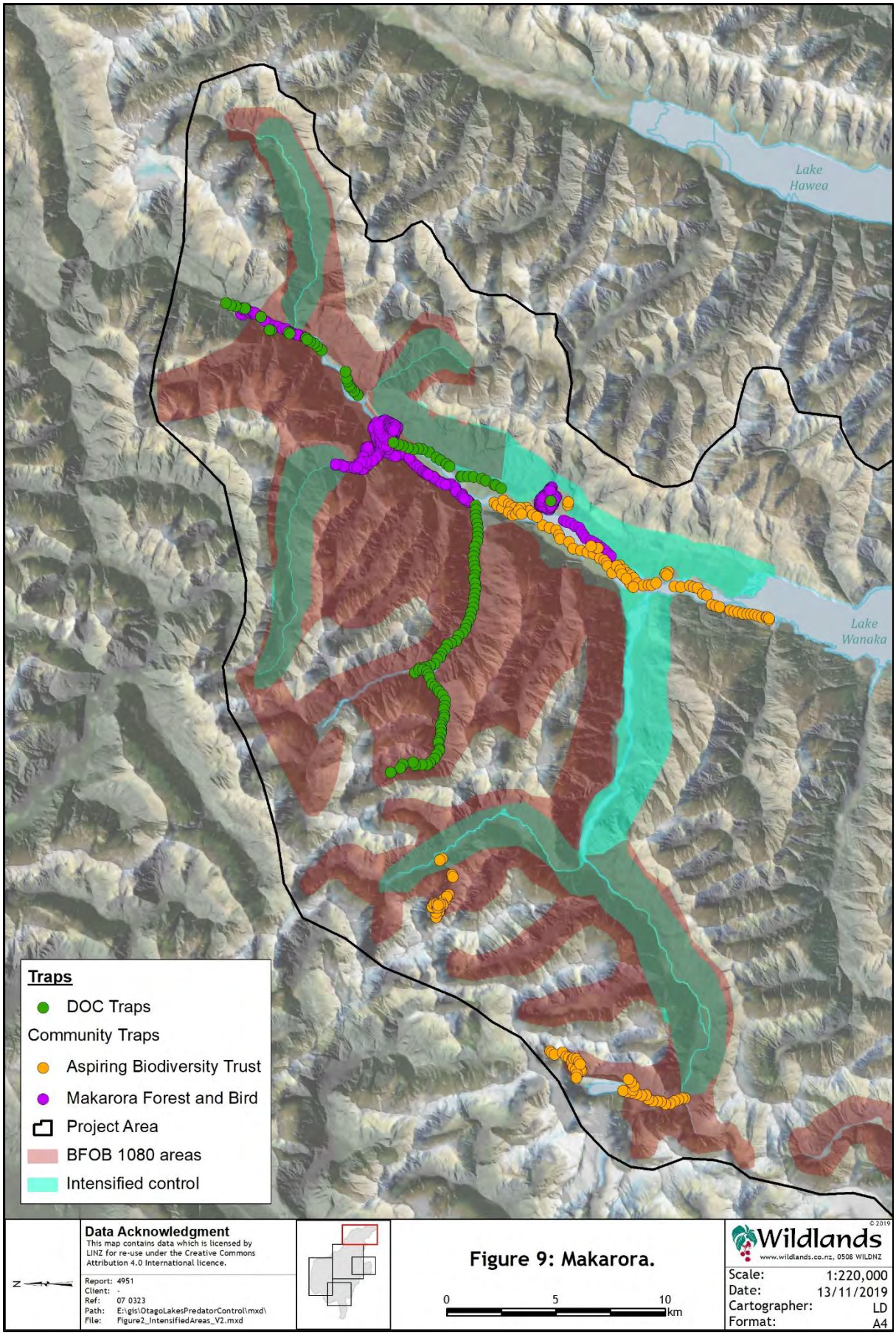
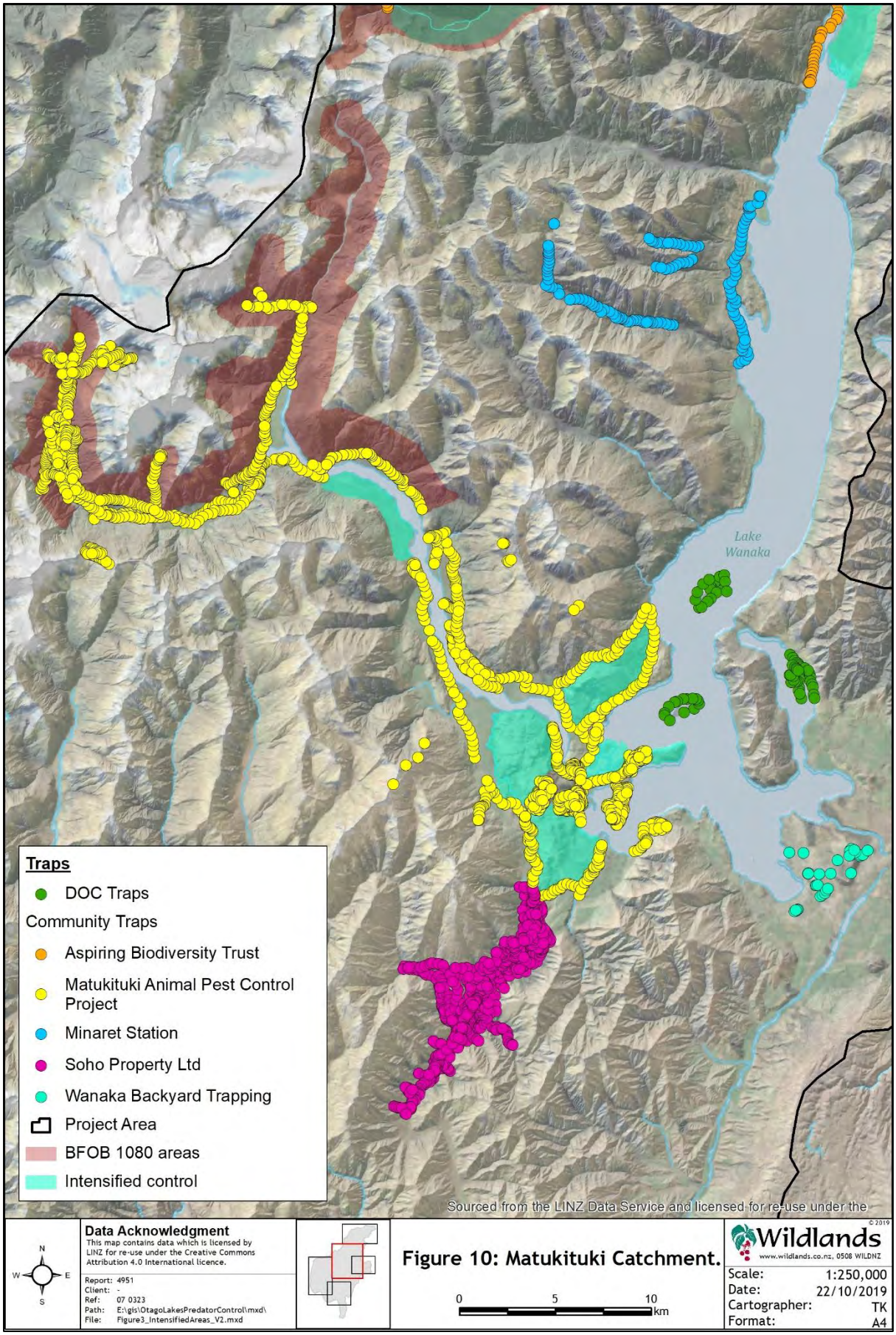


Figure 9: Makarora.


Lake
Wanaka
Traps
DOC Traps
Community Traps
Aspiring Biodiversity Trust
Matukituki Animal Pest Control Project
Minaret Station
Soho Property Ltd
Wanaka Backyard Trapping
Project Area
BFOB 1080 areas
Intensified control
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File: Figure3_IntensifiedAreas_V2.mxd
Figure 10: Matukituki Catchment.
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www.wildlands.co.nz, 0508 WILDNZ
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At Makarora, community trapping occurs on both sides of the river (in places) and in the river, on semi-permanent islands. In the large braided reaches of the Matukituki River - i.e. the main channel below the East Matukituki southeast to Lake Wanaka - trapping varies from being on the river's edge, to sometimes being set back in the farmland. Trapping occurs on both sides of the river in places, but is only undertaken on the northern side of the river in the section between the Leaping Burn and the East Matukituki.

In general, the following prescription should be used for trapping in braided river systems:

- Trapping along both river edges.
- Near-parallel trapping on adjacent land within 600 metres where possible, but if land tenure means this is not possible, then further out is still useful.
- Trapping in the riverbeds where feasible (i.e. where the risk of trap loss through flooding is low), as some predators may travel long distances up a riverbed without encountering river edge traps.

Further intensification should be guided by braided river bird outcome monitoring. Additional localised predator control may be required where patches of rats or a high density of hedgehogs are identified as a problem for braided river birds.

4.3.4 Pastoral grassland

In areas of high and low producing grassland where rabbits are present, ferrets become a more significant problem, and feral cats also become more ubiquitous in their distribution. Soho Property Ltd have implemented intensive trapping on Motatapu Station. To better understand how successful this trapping has been in this habitat, their data has been analysed as part of this project and this is presented in Appendix 3. Although they appear to have had some success in controlling stoats and weasels, they have been unable to control ferrets, which appear to be tracking the rabbit population (this analysis is described in some detail in Appendix 3). It is highly likely that the intensive best practice trapping has disrupted the resident ferret population. However, it is likely that there is massive reinvasion of the trapped area by ferrets in the surrounding farmlands and tall tussock grasslands. Ferret home ranges can vary from 18-760 hectares (Clapperton and Bryom 2005), so ferrets could potentially be reinvading from a considerable distance.

The following approach should be used:

- An expanded buffer area should be established to keep re-invading ferrets out of the core trapping area. This buffer should not just be up stream and creek valleys, but should be applied to all topographies surrounding the control area (as ferrets will be anywhere where there are rabbits, including steep hillsides). An initial one kilometre buffer should be attempted.
- Rabbit control should be trialled using Pindone, or similar, in the core trapping area, to see if the combination of pushing ferrets further back and removing their key prey reduces their abundance.

A scientific ferret control trial at Motatapu Station, following these guidelines, would be of strategic value to initiatives elsewhere in the Project Area, as best practice ferret control seems to be failing in these rabbit-prone dry grasslands.

4.4 Which traps are best?

The following table shows the catch rates of different traps, based on analysis of data from West Matukituki.

Table 3: Trap devices used in the West Matukituki and catches of introduced small pest mammal species since 2016.

Trap Type	No. Trap Checks	No. Traps Used	Number Mammals Caught						
			Mice	Rat	Stoat	Hedgehog	Possum	Cat	Rabbit
West Matukituki									
DOC200	7,318	33	401	177	161	16	2	1	1
DOC200 double	598	36	23	14	4	16	15	4	1
DOC250	3,749	75	9	91	31	656	17	28	23
Trapinator	2,551	32	0	1	0	0	221	0	0
Timms trap	100	5	0	0	2	0	2	0	0

Analysis of this data leads to the following conclusions.

- Three trap-types used by the groups are useful:
  - DOC200s are relatively effective at catching mice, rats, and stoats.
  - DOC250s are relatively effective at catching hedgehogs and cats.
  - Trapinators are relatively effective at catching possums.

- No amount of trapping with the DOC-series traps appears to have much effect on mouse or rat populations, especially when they are in an irruption phase.

- The efficacy of A24 (or A12) traps used in the Matukituki cannot be assessed as there is no catch data associated with them. However, Otago Lakes Forest and Bird have found that data from trigger counters on A24s fitted with kea exclusion cages suggests stoat and rat kills are much lower than in nearby DOC-series traps. They have also found that A12 possum traps tend to stop catching possums after a while, even though there is evidence of possums nearby. It is very difficult to compare the success of A24s to the success of DOC-series traps using tracking tunnels, when the two methods are being used in the same valley (because of the large movements made by mustelids).

- Trapping appears to have little effect on hedgehogs or possums, i.e. the number of captures is always fairly stable.

4.5 Aerial application of 1080

Battle for our Birds (BFOB) is a major Department of Conservation aerial 1080 operation to protect indigenous wildlife following beech masting. To better understand the importance of BFOB in the Project Area, an analysis of the effects of aerial 1080 from BFOB has been completed as part of this project, and provided in Appendix 4. BFOB appears to provide a big knockdown, suppressing rats, stoats, and

brushtail possums following beech masting. This is a huge advantage for the protection of indigenous biodiversity in areas where it is applied. Community groups operating in these areas should complement the role of the BFOB programme by:

- Ensuring that predators are controlled effectively in non-mast years to achieve biodiversity gains.
- Detection and suppression of any rapid recovery of rats following aerial application of 1080.

The aerial 1080 work should be viewed as a knockdown, and something to be taken advantage of. The groups should seek to exploit it by mopping up remaining predators in their operational areas.

A significant proportion of the Project Area and community groups operating within it do not fall under the BFOB umbrella, e.g. Whakatipu Wildlife Trust, Soho Properties, Wanaka Backyard Trapping, and efforts in the lower Matukituki. However, these groups are also operating in areas where beech masting is not an issue.

The only other aerial 1080 operations undertaken in the area have been undertaken by OSPRI as part of tuberculosis vector control operations. One was around Mt Gold in 2009, and two in 2015 and 2018 were outside of the Project Area - east of Lake Hawea.

4.6 New tools

There is a flurry of research and development into new tools, e.g. multi-resetting toxin devices such as the spitfire (Murphy *et al.* 2018). Unfortunately, a lot of these tools are still under development.

The groups should focus on best practice use of existing tools, while keeping an eye on the development of new tools. They should not get involved in beta-testing of new tools, particularly not at high priority conservation sites where risk of operational failure needs to be minimised.

Several of the groups are trialling smart technology methods of remote correspondence between trap lines and trappers to determine whether trap lines have been sprung. This is an interesting concept and trial results should be used to update cost-efficacy calculations in the future. These techniques need to be highly accurate if applied to live-trapping (e.g. cage trapping of feral cats), because any failures to detect triggered traps would result in animal welfare concern.

4.7 Non-target species

Due to the natural curiosity of kea, and its Threatened-Nationally Endangered status, non-target kea deaths are of real concern, particularly in the western part of the Project Area. Other potential non-targets include kākā, weka, and in some cases small forest birds.

Introduced predators are a significant risk to all these species including kea. Reducing the abundance of introduced predators can lead to dramatic increases in their breeding success (Kemp *et al.* 2018). Nevertheless, non-target adult mortality must be kept to a minimum.

Traps such as the DOC-series are used in boxes with appropriate baffle systems that, for the most part, exclude non-target species. Any trap or new tool that may be of potential or unknown risk to kea should not be deployed in kea habitat until a non-lethal trial has been completed with captive kea elsewhere in New Zealand. If any trap or tool is thought to present a risk to kea and its pest control efficacy has not been properly established, or is dubious, then it should not be deployed. Kea cages have been developed for Goodnature A24 traps, but trials by Otago Lakes Forest and Bird in the Makarora area suggest they substantially reduce the efficacy of these traps for stoat control.

Birds may also be at risk from toxins used in bait stations. The risk can be mitigated through using bait stations that exclude birds or by using toxins (e.g. cholecalciferol for possums) to which birds are not very susceptible, or by applying a kea-proof baffle to the bait station (Kea Conservation Trust 2019). These will exclude possums, but not rats. If there is any doubt about how kea will behave at bait stations, then non-toxic pre-feed should be used in the bait stations and kea behavior observed using camera trapping or a similar method.

Groups working in areas inhabited by keas should develop a relationship with the Kea Conservation Trust and Department of Conservation staff with knowledge of kea, so that an open dialogue can be maintained.

The real risks to kea need to be properly understood, and tempered against the risk to other biodiversity if predator control is not successful. This is discussed further in Section 9.2.

Urban non-target species include domestic cats, even though they are also a threat to indigenous wildlife. Wanaka Backyard Trapping use weka length DOC200 trap boxes with a cat baffle to prevent the capture of domestic cats, although this approach also excludes feral cats. Exclusion of domestic and feral cats may jeopardise conservation efforts, at least in some situations.

4.8 Natural barriers

Current thinking about natural barriers, and their potential role in restricting movement of pest animals, needs to be applied with a great deal of caution. The introduced predator species under consideration are classified as invasive pests for a reason - they all have considerable dispersal capabilities. Anthropomorphising small mammalian predator dispersal and reinvasion behaviour is a mistake as there is absolutely no evidence that predators prefer to migrate into areas in a manner similar to humans.

Stoats are a Holarctic species and have been observed foraging in the harshest Siberian frosts (Vaisfeld 1972). Mice are capable of actively foraging in the subnivean layer between the ground and snow, and stoats and weasels may hunt them

in this layer. In rugged areas, rats and possums are capable of moving through closed canopy and, with the exception of ferrets and hedgehog, the rest of the predator species under consideration have strong climbing abilities. Most of these predator species are also strong swimmers, and this is described further below.

4.8.1 Large lakes

It is well known that rats can swim between offshore islands (Russel *et al.* 2008). In particular Norway rats have been observed to regularly swim distances of one kilometre (Russel *et al.* 2008). Stoats are also capable of swimming more than three kilometres between mainland New Zealand and offshore islands (Veale *et al.* 2012), and have been witnessed swimming in the middle of Doubtful Sound (R. Griffin, pers. comm.).

Very large lakes such as Wakatipu and Wanaka will most certainly act as a barrier to the dispersal and migration of vertebrate predators. Predators may occasionally raft across these lakes, or swim long distances, but for the most part these very large lakes will inhibit typical terrestrial migration patterns. It may be possible to utilise Lakes Wakatipu and Wanaka as natural barriers to braided river trapping efforts in the Dart/Rees, Matukituki, and Makarora Rivers. This could provide an advantage over much larger braided rivers elsewhere in the South Island where braided river bird habitat extends for long distances before reaching the sea.

Consideration of large lakes as natural barriers must also recognise that beaches along lakes are easy travelling for introduced predators, and difficult to trap effectively because of variable lake levels that change the size of the beach area.

4.8.2 Mountain ranges

Mountain ranges at very best are only predator sieves. Stoats are well documented in alpine habitats (Cuthbert *et al.* 2002, Smith and Jamieson 2005, Smith *et al.* 2007, Smith *et al.* 2008) where they are a known predator of rock wren and have been observed preying on nests on cliffs (Little *et al.* 2017). Snow tussock (*Chionochloa* spp.) masting causes irruptions in mice in a manner similar to beech masting (Wilson and Lee 2010). Feral cats have been documented living at the top of Mt Anglem on Rakiura (Harper 2004). Brushtail possums can occur above treeline in patches of scrub (D. Smith, pers. obs.), and can occur near treeline, but are more abundant in forest. They have been observed well above the treeline in alpine environments in Canterbury (W. Shaw, pers. obs.).

The main synthesis of research by Smith *et al.* (2005-2009) is that rather than viewing alpine areas as barriers to stoat dispersal, conservation managers should be wary about overlooking alpine areas in their landscape predator control plans, because there may be stoat populations there that reinvade surrounding valleys.

Evidence from a range of sites suggests that rat abundance declines with increasing altitude. However, they are known to occasionally be present in alpine areas and the Matukituki Catchment Group trapped one above treeline in the Liverpool Hut area.

Intuitively, large glaciated rocky peaks will be impassable by introduced predators, but vegetated alpine areas will be passable and inhabitable by them, even if extremely rugged.

4.8.3 Rivers

In general, rivers should not be considered natural barriers to predator dispersal. The predator species of concern are ubiquitous and widespread in the Southern Alps. Radio-tracked stoats have been observed to cross the Eglinton River regularly (Murphy and Dowding 1995). A radio-tracked stoat in the Ettrick Burn, Fiordland National Park, had dens on both sides of the river, and moved across the river on a daily basis (D. Smith, pers. obs.). ZIP have done some research which suggests that rats and possum movement is slowed by rivers, but the research has not been undertaken for a long period of time, nor is it well replicated. Wildlife is likely to have crossing points, similar to a tramper. Also, small mammals are well-known rafters. When rats are at peak abundance following beech masts, juvenile rats without territories will be under pressure to disperse and may actively cross rivers.

Another important reason to not consider rivers as comprising natural barriers is that most of the avifauna being protected by predator control is capable of flying across rivers. Therefore, if Threatened species occur throughout a valley, it does not make sense to undertake predator control on only one side of the river.

5. CURRENT STATE OF PLAY

5.1 Overview

There are currently 7,300 traps deployed in the Project Area: 2,000 by the Department of Conservation and 5,300 by community groups (Figure 1). The Department of Conservation is principally operating in national parks and conservation estate in the Southern Alps in the west of the Project Area, and on islands in Lakes Wakatipu and Wanaka.

Community-based trapping in the Project Area occurs in a diverse range of locations, including national parks, the three main braided rivers, lake edges, pastoral grasslands, and peri-urban areas. Much of what the community groups are doing seems to support and buffer Department of Conservation's initiatives. However, the community groups also extend into the wider, more open landscapes eastwards from the lakes. These comprise smaller, isolated public conservation lands (PCL) away from the large tracts of PCL in the western mountains.

The following community-based and private predator land control initiatives are underway in the Project Area:

- Aspiring Biodiversity Trust.
- Central Otago Lakes Forest and Bird.
- Matukituki Catchment Animal Pest Control Project.
- Wanaka Backyard Trapping.
- Soho Property Ltd - (Motatapu Valley).

- Routeburn Dart Wildlife Trust.
- Whakatipu Wildlife Trust.

Biodiversity protection activities being undertaken in each of these projects are described below.

There are many other small scale, independent predator control efforts in the Project Area that are not directly affiliated with these major community initiatives. Owing to the small and largely informal nature of these efforts, they are not covered in this report. However, if groups are interested in becoming part of this collaborative effort then they should contact the Whakatipu Wildlife Trust.

5.2 Aspiring Biodiversity Trust

5.2.1 Current operations

Aspiring Biodiversity Trust was established in 2017 to help finance and facilitate implementation of the Makarora Catchment Threatened Species Plan. This plan includes the survey and monitoring of threatened indigenous species, and evaluation of the outcomes of predator control within the Makarora area.

The Makarora Catchment Threatened Species Plan is the Trust's working document and guides their threatened species work. The plan includes a desktop study of historical biodiversity data for the area. The plan complements and expands on the Department of Conservation Makarora Predator Control Plan, which is part of the Trust's community agreement with the Department of Conservation to work on public conservation land. These documents were not made available for review as part of this project.

Conservation efforts are focused on habitats in the alpine zone (upper North Wilkin, Crucible Basin, upper Siberia), an upper river and forest area (Siberia, North Wilkin, podocarp/beech forest), and a braided river area (Makarora and lower Wilkin Rivers). DOC150, DOC200 and DOC250 traps have been deployed over 2,950 hectares (Figure 9).

The Trust's alpine predator control plan is focussed on rock wren (*Xenicus gilviventris*) and kea (*Nestor notabilis*) recovery. Summer surveying (2017-2018) identified viable populations of rock wren at Crucible Basin and the upper North Wilkin locations with the potential to act as "source" populations for surrounding vacant habitats. Traps are on 100 to 200 metre spaced grids proximal to existing trap lines positioned in the lower alpine and upper forested tributary rivers. In the same area the Department undertakes intermittent aerial 1080 application, timed to coincide with mast years. To improve alpine trap servicing efficiency the Trust has installed Celium remote satellite technology at both rock wren sites.

The Trust's conservation efforts in the Siberia Valley have been designed to support the goals set out within the Department of Conservation's Whio Recovery Plan (2009-2019). A walkover survey (with the aid of a protected species dog) was undertaken along the Siberia Stream in the summer of 2018 and in the upper Wilkin during summer of 2019. DOC150 and DOC200 traps have been installed extending from the

North branch of the Siberia down to the gorge leading to Kerin Forks. Further trapping installation within the upper Wilkin Valley, extending from Top Forks down to the Wonderland confluence was planned for winter 2019, and has been implemented.

Conservation goals for podocarp/beech forest are to establish a bat and bird monitoring programme that targets long-tailed bat/pekapeka (*Chalinolobus tuberculatus* "South Island"), kākā (*Nestor meridionalis*), mohua (*Mohoua ochrocephala*), and other forest avifauna within areas currently extensively trapped and poisoned by the Department of Conservation (e.g. Mt Shrimpton track forest compartment), and to extend the trapping regime in collaboration with the local landowner. A series of five-minute forest bird counts have been undertaken in podocarp forest on four occasions during 2018/2019. Bat surveys will resume during the summer of 2019/2020.

Braided river habitat on the Makarora River and the lower Wilkin River was surveyed during the summers of 2017-2018 and 2018-2019. Pressures that the Makarora braided river birds face include mammalian predators, opportunistic avian predators, livestock trampling, and natural fluctuations in river levels. A dual strategy for predator control of invasive mammalian predators and significant avian predators has been developed to assist breeding success for key braided river bird species. DOC200 traps were installed initially on braided river flats, with DOC200 and DOC250 traps also installed at river hotspots.

The southern black-backed gull (*Larsus dominicanus*) is a large predatory bird with a population that is increasing steadily throughout the country. They are known to prey on the eggs and chicks of a number of endemic threatened birds that breed on braided rivers. Breeding colonies of black-backed gull to the north of the Makarora/Young confluence and south of the Makarora/Wilkin confluence were targeted for control. Initially adult birds were removed by ground shooting and any eggs and chicks were destroyed during the nesting season. In future years, poison may be used at nesting sites, away from other bird species.

5.2.2 Biodiversity values

Biodiversity values identified in the Makarora Catchment Threatened Species Plan relate to the different habitats found within the Makarora catchment. Biodiversity values to be protected and enhanced in the alpine habitat are rock wren and kea, in the upper river and forest habitat are whio (*Hymenolaimus malachorhynchos*), kea, kākā, and long-tailed bat, and in the braided river habitat are wrybill (*Anarhynchus frontalis*), black-fronted tern (*Chlidonias albostriatus*), black-billed gull (*Larus bulleriis*), banded dotterel (*Charadrius bicinctus*), and South Island pied oystercatcher (*Haematopus finschi*).

Rock wren are endemic to New Zealand and have a threat status of Threatened-Nationally Endangered, and are known to be breeding in the upper north branch of the Wilkin River. A transect monitoring survey was undertaken in the summer of 2018 in Mt Aspiring National Park - the upper north branch of the Wilkin River (Lake Diana, Lake Lucidus, and Castalia Basin) and Crucible Basin, to provide an index of relative abundance. This survey was done as per standard Department of Conservation survey

methods. The upper north branch of the Wilkin had an index of relative abundance score of 10.25 and Crucible Basin scored 11.75.

Kea are endemic to New Zealand and have a threat status of Nationally Endangered. Kea were recorded at both sites, with Lake Crucible identified as a potential nursery site for fledglings.

Whio are endemic to New Zealand and have a threat status of Nationally Vulnerable. A walk-through survey was carried out in February 2018 along approximately 13 kilometres of riverbed using a protected species search dog. Feathers and faeces were observed frequently from the top of Siberia Valley down to Crucible Stream. One pair and one juvenile were observed during the survey. A walk-through survey of the upper Wilkin was also undertaken during February 2019 and one pair of whio was observed.

Braided river bird walk-through surveys were undertaken starting at Boiler Flat and extending along the length of the Makarora River down to the delta with Lake Wanaka (approximately 22 kilometres). Breeding black-billed gull and black-fronted tern colonies have been identified and pairs of breeding South Island pied oystercatcher, banded dotterel, and wrybill were also present during both surveys.

5.3 Central Otago Lakes Forest and Bird

5.3.1 Current operations

The Central Otago-Lakes Branch of Forest and Bird established trapping lines in the Makarora valley in the late 1990s, primarily to protect mohua. Since then, the trapping programme has expanded greatly (Figure 9). Forest and Bird undertake forest-based trapping which is complementary to the trapping and bird monitoring programme in the alpine and braided river environment undertaken by the Aspiring Biodiversity Trust.

Forest and Bird's trapping programme now comprises 26 volunteers clearing 409 traps on eight lines and two grids, on a monthly roster that covers approximately 1,860 hectares: Makarora River Line, Nature Walk line, Jack Lange line, Pipson Creek Grid, Muddy Creek grid (and Link), Camp Flat, and Blue Loop lines. The Camp Flat and Blue Loop lines were completed in June 2018 in an attempt to protect a mohua "hot spot" identified by Department of Conservation monitoring. The group uses DOC150, DOC200, and Goodnature traps. Four rodent monitoring tracking tunnel lines within the Pipson and Muddy Creek trap grids are surveyed quarterly and data is fed into the Department of Conservation rodent monitoring programme.

5.3.2 Biodiversity values

The Makarora Predator Control Operational Plan, a partnership between the Department of Conservation and Forest and Bird, was developed in 2017 to protect and restore indigenous plants and fauna under threat in the Makarora catchment. The purpose, objectives, and milestones relate to rock wren, whio, mohua, long-tailed bats, braided river birds, and podocarp forest (including mistletoe and fuchsia).

The annual mohua survey undertaken by the Department of Conservation is the only forest bird monitoring undertaken at Makarora. It is unknown whether other avian populations are stable or declining outside the mohua surveys on the Bridle track, around the Blue Pools and in the lower Blue, and the Young River. The December 2018 survey showed that mohua numbers were starting to increase after several difficult years.

5.4 Matukituki catchment animal pest control project

5.4.1 Current operations

The Matukituki Catchment Animal Pest Control Project is a coalition of four community groups, nine landowners, and four local tourism businesses. These groups run trap lines along or adjacent to almost the entire length of the Matukituki River (Figure 10). This trapping encompasses a diverse range of habitats ranging from alpine snow tussock and beech forest in the West and East Matukituki, to braided river habitat adjacent to pastoral grassland in the lower reaches. In total the project has deployed 2,069 traps. The vast majority of these are DOC250 or DOC200 (single or double sets) aimed primarily at controlling mustelids, rats, and hedgehogs. However, Trapinators are deployed for possum (*Trichosurus vulpecula*) control in some locations, and small numbers of Timms Traps to target feral cats (*Felis catus*). A trial remote cat trapping project in the Matukituki has proven to be successful and will be extended to the Dart and Makarora areas in 2020. A small number of self-resetting A24 Goodnature Traps and A12 possum traps are also being used.

Trapping in the lower reaches abuts trapping efforts at Motatapu Station (Figure 10), where reasonably intensive trapping is undertaken (see Section 3.7).

Minaret Station also undertakes a trapping programme that is affiliated with the Matukituki Catchment Animal Pest Control Project. Minaret Station is a large high country farm covering most of the western side of Lake Wanaka. The station operates an alpine lodge in the Estuary Burn Valley. A trapping programme of around 130 traps has been installed in the Estuary Burn and along the shoreline of Lake Wanaka from Minaret Bay to Snag Bay, including the Rough Burn and Bay Burn valleys. This all covers approximately 2,770 hectares.

5.4.2 Biodiversity values

Biodiversity values in the West Matukituki are described in Wildland Consultants (2019), and include long-tailed bats, kea, rock wren, and other forest birds. Whio are absent. South Island robin (*Petroica australis*) have been reintroduced successfully, and have spread throughout the valley.

The middle and lower sections of the Matukituki River are braided, providing habitat for braided river birds. The Matukituki is one of only four rivers in Otago that support wrybill (Dowding 2013), with the others being the Hunter, Makarora, and Dart rivers.

Forest bird monitoring is being undertaken in the West Matukituki using distance sampling transects and looks to be a useful long term monitoring method. This work

is done by professional ecologists contracted by the West Matukituki Trust. Annual rock wren counts are also undertaken, and kea surveys have been completed in collaboration with the Kea Conservation Trust.

Australasian bittern have been observed in the lower Matukituki delta. Braided river birds are also present in the Matukituki River.

5.5 Wanaka backyard trapping

5.5.1 Current operations

Wanaka Backyard Trapping was formed early 2018 to engage and encourage local communities into trapping on public and private land in the Upper Clutha "backyard" urban and peri-urban areas (Figure 11). The overall goal is to protect and enhance the indigenous wildlife of the Upper Clutha, e.g. birds, skinks, geckos, and invertebrates. Wanaka Backyard Trapping and Whakatipu Wildlife Trust have strong synergies, with both groups being predominantly urban and peri-urban based. Wanaka Backyard Trapping was supported by Kiwibank Predator Free to kickstart private land urban trapping in 2018.

Trapping is currently undertaken by groups of volunteers on Queenstown Lakes District Council land at Hawea-Gladstone Track and Albert Town Lagoon. Other projects have been initiated on Mt Iron, Wanaka and Luggate Creek (both Department of Conservation land). Traps used include DOC200s and boxed Victor rat traps. Data is collated in Trap.nz. Some other groups also trap in the area e.g. Cardrona Skifield, but it is unclear if or where their data is collated. Pests targeted include rats, stoats, ferrets, hedgehogs and possums. Due to the urban nature of Project Area, cat predation is seen as a regional/national governance issue and cats are not currently targeted.

Pest monitoring is carried out on the Hawea trap line using ink cards in tracking tunnels twice per year. Species monitoring includes the annual Landcare Garden Bird Survey. A group of Hawea locals are undertaking monthly bird monitoring on one kilometre transects around Lake Hawea Village and the results are recorded on eBird. This is within the Wanaka Backyard Trapping Project Area, but is not directly affiliated with them. No other species monitoring is currently undertaken as yet.

5.5.2 Biodiversity values

The area includes highly modified pastoral grassland, lake and river habitat (rocky and gravel shorelines), and remnants of indigenous forest and grassland. Morepork and rifleman have been observed in remnant beech forest pockets in the Waterfall Creek catchment, two kilometres from Wanaka township during January/February 2019. Birds present in the Upper Clutha area include:

- Forest

  New Zealand falcon, tūī, bellbird, tomtit, grey warbler, kererū, silvereye, morepork, rifleman.

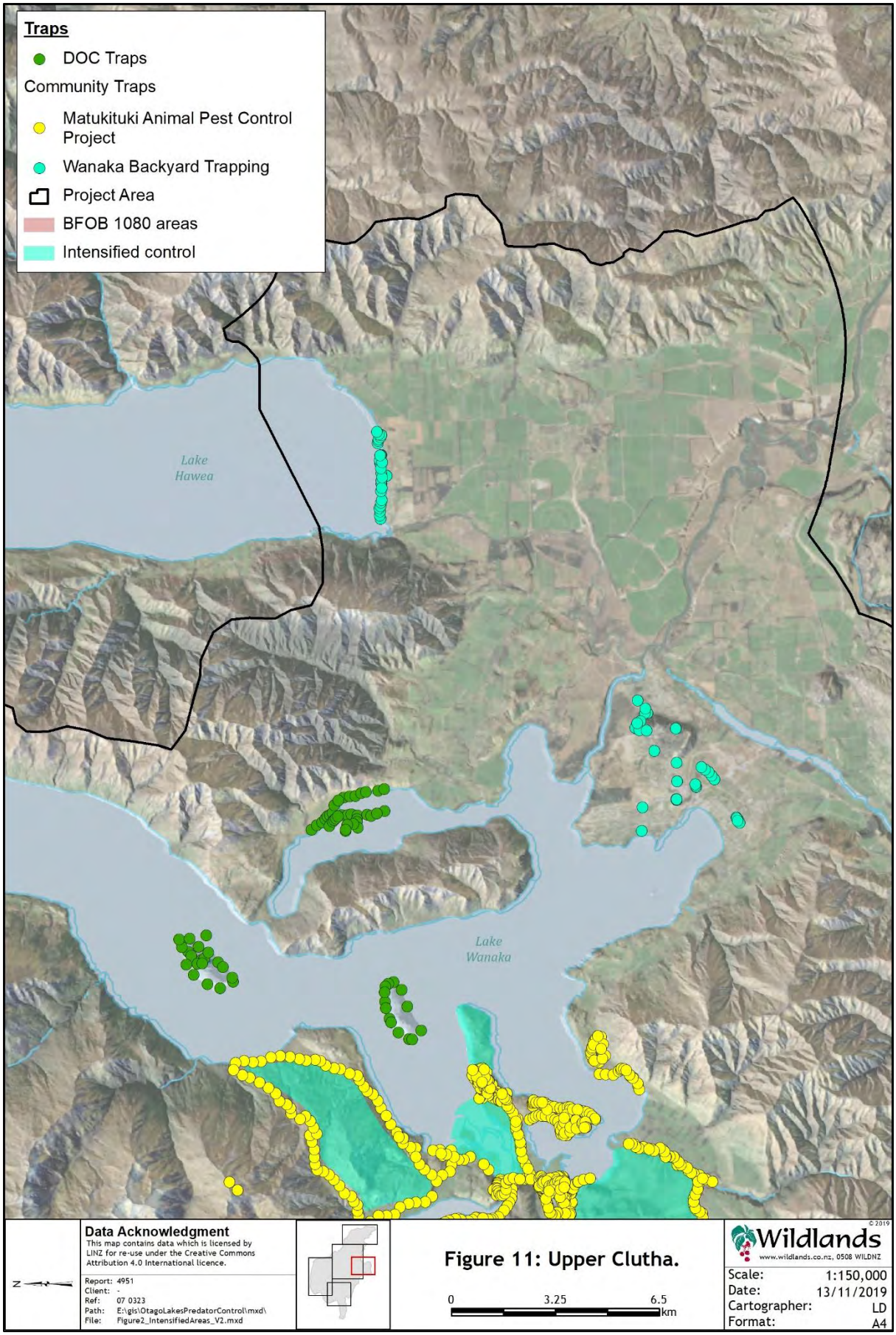
Traps
DOC Traps
Community Traps
Matukituki Animal Pest Control Project
Wanaka Backyard Trapping
Project Area
BFOB 1080 areas
Intensified control
Lake Hawea
Lake Wanaka
Data Acknowledgment
This map contains data which is licensed by LINZ for re-use under the Creative Commons Attribution 4.0 International licence.
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Figure 11: Upper Clutha.
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www.wildlands.co.nz, 0508 WILDNZ
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- Lagoons and Rivers

  Black shags, little shags, Australian coot, grey teal, paradise shelduck, and white faced heron.

- Lake

  Australasian grebe breed on Lake Wanaka and black-billed gulls are present around the lake. Banded dotterel are known to be breeding at Craig Burn, on the shore of Lake Hawea. While this is just beyond the Wanaka Backyard trapping area their presence indicates the possibility of the species being present in the study area for at least some of the time.

Skinks and geckos (Table 2, Figure 8), including At Risk-Declining and Threatened species, are present in the Upper Clutha and surrounding hill country. It would be highly desirable to undertake further lizard surveys to better understand the extent of these species in this area. There is little information on invertebrates in this area.

5.6 Soho Property Ltd

5.6.1 Current operations

Motatapu Station is a high country working sheep station located west of Wanaka owned by Soho Property Ltd (Figure 10). It is one of four QEII covenants established in 2015 which, combined with the Soho, Glencoe, and Coronet Peak Stations, comprises a 53,000 hectare area where natural values on private land are protected in perpetuity. It is hoped that the long-term effect of the covenants is that an open country "national park" is created on land that historically would have been farmed (Russell Hamilton, pers. comm.).

The Motatapu programme is supported by a long-term vision for restored ecosystems and the recovery of biodiversity. Restoration of habitat paired with predator control provides a comprehensive approach to the Station's conservation programme.

A predator control programme in the Motatapu and tributary valleys has been undertaken since October 2009. Following a limited investigation into the suitability of that habitat for takahe, the station had initially extended the trapped area into the Golspie Burn, and Soho Creek catchments and then onto the Roses Saddle, northern slopes near the Roses Hut, and the southern ridges of Soho Station (2010-2013). These higher elevation traps were subsequently redeployed to concentrate the trapping efforts into the Motatapu and tributary catchments to better support the current project to reintroduce buff weka (2013-2015). The trap network currently covers an area of about 4,000 hectares with 661 traps. DOC250 and DOC200 comprise 99% of the traps. Conibear, cage, a few Fenn traps, and shooting are also used.

The primary trapper has a predator dog (trained for mustelids) although the dog is not used to search areas independent of the trapping network. Camera traps were installed in January 2019 as a preferred means of monitoring predators independently from the trap data. Initial indications are that rabbits, possums, cats, and hares, are seen with a

high level of frequency, ferrets then stoats, hedgehog, and rats are seen with less frequency. Analysis of the data is currently underway. Rabbit control is required to remove the primary food source supporting the ferret population.

5.6.2 Biodiversity values

Motatapu Station contains a variety of vegetation types which range from open pasture grassland, tussock grassland, wetlands and hillslope seepages, regenerating mānuka, *Discaria-Coprosma-Aristotelia-Olearia* shrublands and mature beech forest fragments. Around 85% of the station land (much of which is at elevations over 1000 metres) has been fenced off and retired from grazing to create a conservation zone. Most of the trapping takes place below 1000 metres above sea level.

Since 2005 an extensive indigenous planting programme has been in place in areas where forest once thrived, aiming to restore the land to its former natural state following historical clearance by burning. Approximately 100,000 plants are planted per year under this effort.

Indigenous vegetation is used as a surrogate for monitoring indigenous biodiversity (Walker *et al.* 2007, 2005) and this may logically extend to indigenous invertebrate populations reliant upon the presence and density of host species.

Apiarist Peter Ward has been managing hives in the Motatapu catchment for 55 years, and has witnessed the effects of changing land use management on honey production and hive health under four property owners. Land use changes have seen a transition from indigenous vegetation to pastoral development, *Hieracium pilosella* infestations under a regime of regular burning, and now a return to indigenous cover. Reduced grazing has enabled plants to progress through to flowering; regeneration of mānuka (a coloniser) has enabled production of higher value mānuka honey; the requirement to feed hives in spring has reduced with increasing availability of spring flowering natives (e.g. kowhai and cabbage trees); there has been an increase in the diversity of pollen coming into the hives, bees do better with increased pollen diversity and Mr Ward has observed improving hive health with this increased diversity.

Mahu Whenua supports several University of Otago Research initiatives through their Catchments Otago programme (http://www.catchmentsotago. org/what-is-mahu-whenua). Relevant projects including and additional to the Catchments Otago programme that are underway or have been undertaken include:

- The current research of Janice Lord at the University of Otago relating to the role of mycorrhiza in supporting landscape scale mānuka and beech forest restoration; http://www.biologicalheritage.nz/news/news/scientists-striving-for-easy-grow-forests
- In 2016 a Wildlife Management student at the University of Otago undertook an assessment of bird communities within the different habitat types (beech forest, riparian, shrubland and grassland) of all four of the QEII covenant areas, including eight sites on the Motatapu Station. The survey confirmed the presence of indigenous species commonly associated with the available habitats but did not detect all of the species known to inhabit the area. At Risk species known to

inhabit the trapped area and the surrounding landscape include: NZ Pipit (At Risk-Declining), South Island pied oystercatcher (At Risk-Recovering), and eastern falcon (At Risk-Recovering).

- The 2012 research into post-release dispersal behaviour of buff weka was undertaken by Masters student Jim Watts. (https://ourarchive.otago.ac.nz/handle/10523/4105)

The objective of the predator control programme is to support the reintroduction of buff weka and other avian species in the future. Candidate species have been identified in consultation with the Department of Conservation. Weka were translocated into an enclosure in the Motatapu Valley and released in 2012 but experienced high predation rates and autopsies revealed predation by stoats and ferrets. One weka survived a cat attack but succumbed to an infection. Weka will remain in enclosures until sufficient predator suppression has been achieved, possibly in 2020 when a larger release is planned. The reintroduction of alternative species less vulnerable to ferrets and cats is being considered.

5.7 Routeburn Dart Wildlife Trust

5.7.1 Current operations

Routeburn Dart Wildlife Trust (RDWT) is a community conservation trust formed in 2013, based in Queenstown and Glenorchy. In 2017, the Trust commissioned a scoping report from the Department of Conservation for biodiversity protection in the Dart braided riverbeds (Figure 12). In 2018 the Trust placed 600 predator traps along the Dart and Rees Rivers to protect vulnerable braided river birds. The kill trap lines that have been implemented complement and strengthen the predator control network already managed by the Department of Conservation. The Trust completed its first bird count of the braided rivers in 2017 and will repeat this monitoring annually.

The Trust supports Project Rock Wren and Project Hollyford Face Restoration with 200 traps in the Harris Saddle area and on the Hollyford Valley faces where rock wren and kea are under threat from stoats. The Trust have part-funded 50 kilometres of trap lines in the Route Burn valley forests which target rats and stoats. In 2017, the Trust took over responsibility from the Department of Conservation of the maintenance of 34 single traps in a line adjacent to Lake Sylvan. The Trust's trapping network covers approximately 9,000 hectares. The Department of Conservation scoping report also suggested trapping of cats using a combination of kill and live trapping, but this has not been implemented. The Trust is liaising with Central Otago Lakes Forest and Bird will rent their mobile cat trapping network in the spring of 2019 after testing in the Matukituki Valley.

The head of Lake Wakatipu currently has no hedgehogs which is a huge advantage for the braided river species. To limit their opportunities for incursion, RDWT has installed 44 traps along both sides of the lower Bucklerburn (downstream of the bridge) which are checked on a monthly basis by volunteers. A hedgehog has been caught in a trap up Steele Creek on the western side of the lake and as a further precautionary measure, RDWT has applied to the Department of Conservation

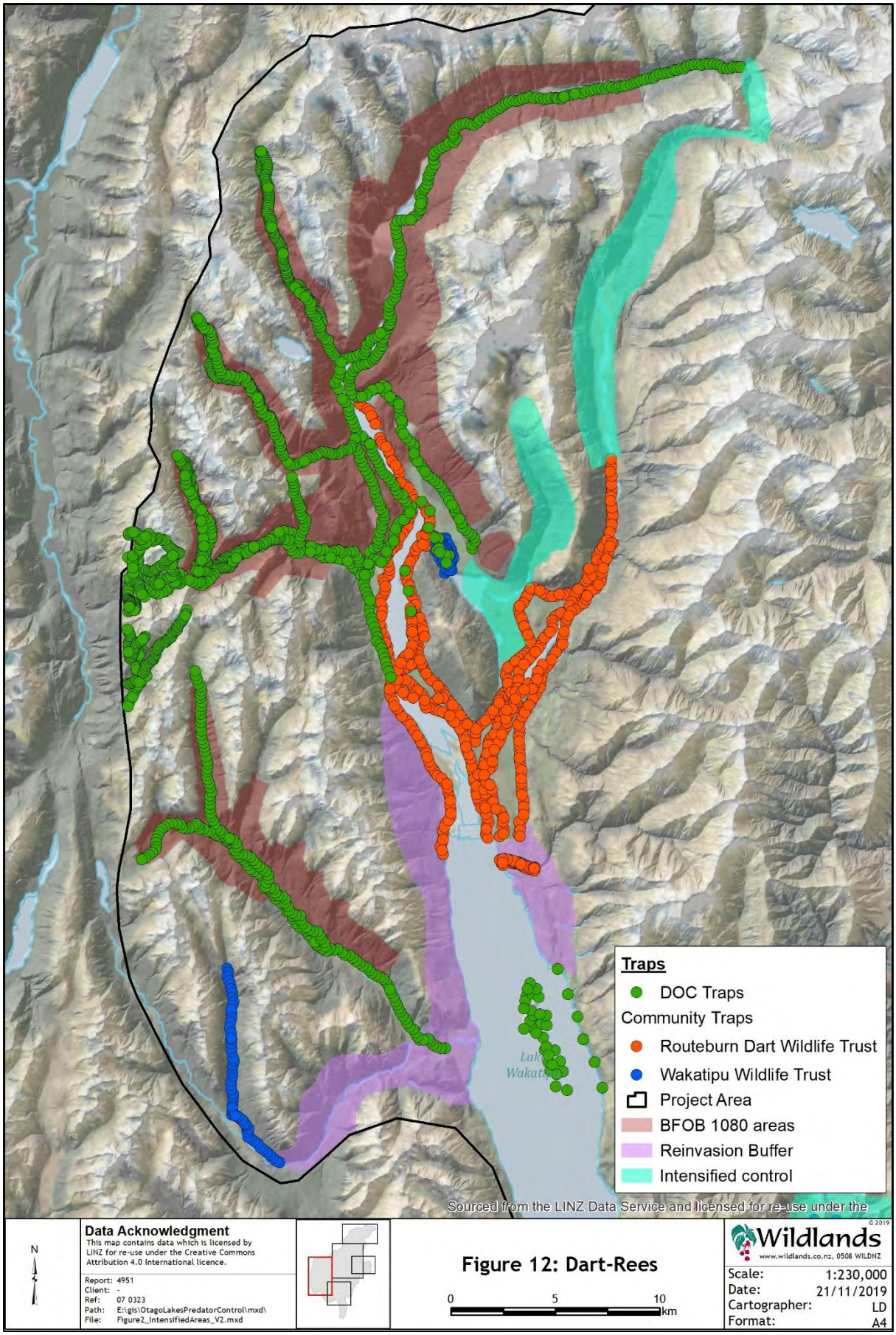

Figure 12: Dart-Rees

Community Fund to install traps along either side of the Kinloch - Greenstone Road and as far as the walking track to Lake Rere.

The work of the Trust on the Dart and Rees Riverbeds benefits from predator control work by neighbours. While some of this work is affiliated with the Whakatipu Wildlife Trust much of it is independently managed. Paradise Trust has a dense network on their property, Camp Hill has traps, Rees Valley Station does some trapping, Temple Peak Station has 60 traps across their property, Precipice Creek subdivision has traps, the Glenorchy Lagoon is trapped by Rusty Varcoe who also has a trap line along the eastern side of Mt Alfred, as far as Diamond Lake and then to the Earnslaw Burn. Wyuna Station has a few traps and Wyuna Preserve is trapped intensively by Dave Anderson. The locations of many of these traps are shown in Figures 1 and 12 (where this information has been made available).

Key target species for predator control in the area are: stoats, rats, cats, black-backed gulls, weasels (*Mustela nivalis vulgaris*), ferrets, and hedgehogs. Stoats are the key target of Department of Conservation and community trapping programmes in braided river, forest, and alpine habitats, given the severe impacts that stoats have on indigenous bird populations. Feral cats have larger home ranges than stoats and have a high degree of trap shyness. Black-backed gull abundance is elevated above normal levels in the Glenorchy area likely due to carrion available from sheep farming and they pose the greatest risk to braided river birds when their colonies are established nearby.

5.7.2 Biodiversity values

The Route Burn and Dart valleys encompass the full altitudinal sequence of habitat: alpine, beech forest, river headwaters, braided riverbeds, and lake edge. Each habitat has unique, specialised, and threatened fauna. Conservation management effort in the area historically focussed on protection of mohua in the beech forests of nearby Mt Aspiring and Fiordland National Parks. This was followed by rock wren and kea population recovery in alpine areas at Harris Basin, and whio population recovery with several translocations to the Route Burn, Rock Burn, and Beans Burn taking place in 2016 and 2017. Lower braided sections of the Dart and Rees Rivers provide breeding habitat for several threatened bird species and are the southern-most breeding area for wrybill. The Paradise area and confluence of the Route Burn and Dart Rivers are where black-fronted tern colonies have established in the past. Australasian crested grebes have been known to nest in the Glenorchy marina (Lake Wakatipu). Previous surveys by the Department of Conservation show that these species are in decline. Conservation efforts by the Routeburn Dart Wildlife Trust and the Department of Conservation in the Dart and Rees braided riverbeds have connected predator control from the mountains to the lake. Australasian bittern have also been observed in wetlands at the confluence of the Dart-Rees rivers.

5.8 Whakatipu Wildlife Trust

5.8.1 Current operations

The Whakatipu Wildlife Trust was formed in 2017 to bring together the efforts of some of the smaller trapping groups across the district in order to provide more effective and efficient predator control in the Wakatipu Basin. Their goal is to 'fill in the gaps' within the trapping network, and to encourage trapping within the community by working with local individuals and groups to get them up and running and to then support their work.

Traps are located around Lake Hayes, Arrowtown (including Bush Creek walkway, Saw Pit Gully walkway, Arrow Gorge Track, Millennium walkway, and Tobins track), Arthur's Point, Queenstown Hill, Kelvin Peninsula, Jacks Point, Wye Creek, Fernhill, Sunshine Bay, and Twelve Mile (Figure 13). NZSki Ltd have also started trapping at Coronet Peak and Remarkables skifields. Coronet Peak will be joining with the Arrowtown Predator Free lines.

5.8.2 Biodiversity values

A sub-group of the Whakatipu Trust known as Alpine Bird Song have been undertaking bird counts in the area and have made the following observations:

- Tūī, bellbird, pigeon, grey warbler, fantail, silvereye, blackbird, chaffinch, thrush, and starlings are present in regenerating lake shore habitat.
- Tomtit and brown creepers have been heard near forest fragments.
- New Zealand falcon are observed occasionally throughout the Project Area.

5.9 Department of Conservation

The Department of Conservations trapping efforts in the Project Area include:

- A substantial investment in the upper catchment of Lake Wakatipu (Dart, Rees, and Caples Rivers).
- Trapping on islands in Lake Wakatipu and Lake Wanaka.
- A trap line in the Young River, Makarora.
- Battle for our Birds aerial 1080 in the western and northern peripheries of the Project Area.

<u>Dart/Rees/Caples Rivers</u>

The Department has been trapping stoats in this area since 2000 and currently have *c.*1,200 traps in the area (mostly DOC200 double sets and DOC150 double sets) (Figure 12). The traps were originally implemented to protect mohua, but also protect whio. Whio have always been present in the area but their numbers were bolstered by supplemental releases in 2015 and 2016. In 2015 stoat traps were installed in the Harris Basin, Routeburn Track, to protect rock wren.

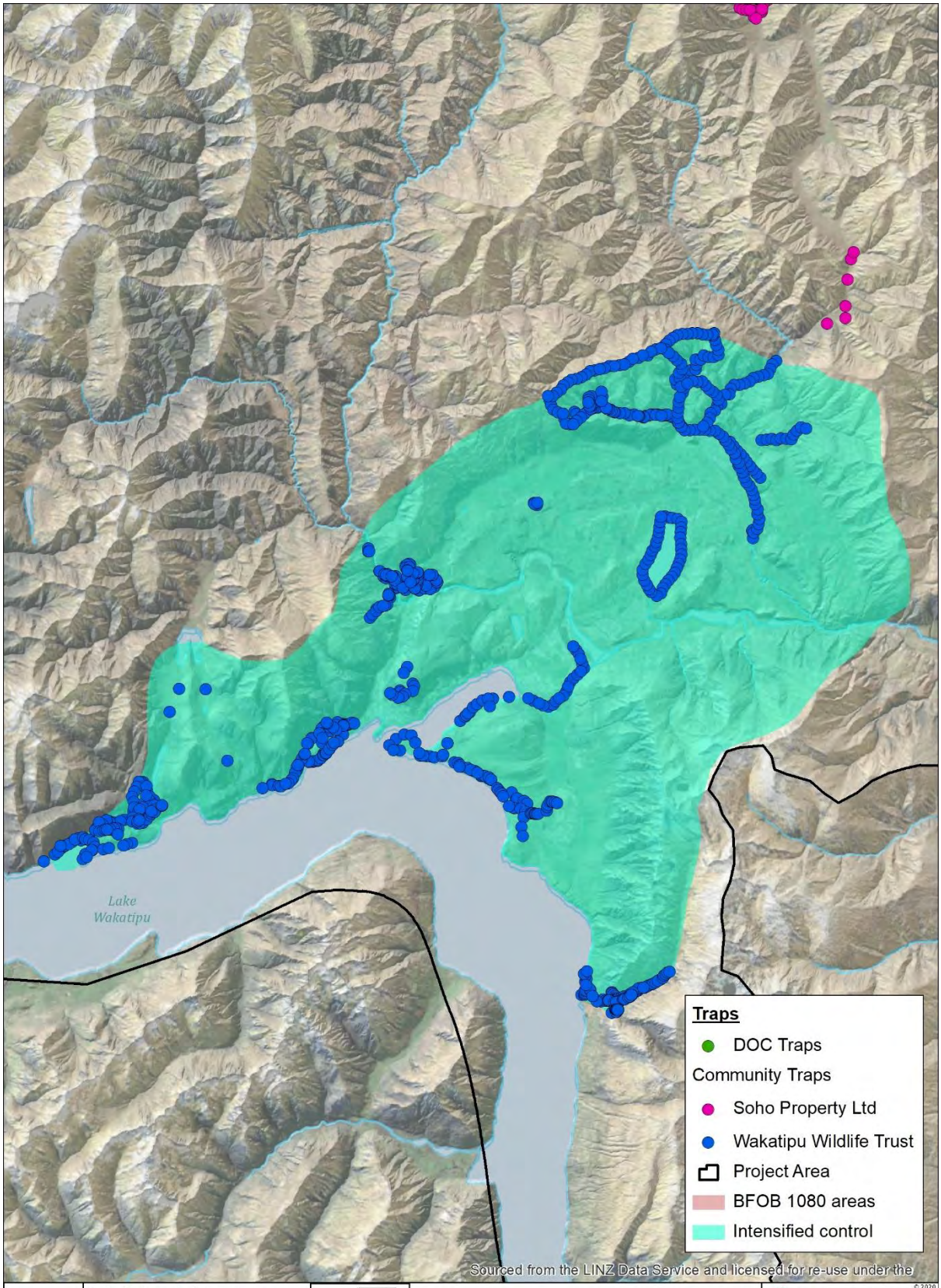

Figure 13: Queenstown.

Brodifacoum was deployed in bait stations in the Caples, Dart and Routeburn Valleys in 2006 and 2012 to specifically target rats in mohua breeding areas. Aerial 1080 has been applied to the area every 2-5 years since 2006.

Despite the Department's effort to control stoats and rats, mohua have declined substantially in the area. Indices of mohua abundance indicate that abundance dropped by 80% in 2011 following a beech mast where stoats and rats were not controlled using aerial 1080. Monitoring indicates that small declines in mohua occur following beech masts even when aerial 1080 is used.

Monitoring of rock wren in the Harris Basin suggests that their numbers have been fairly stable since trapping commenced. However, this monitoring started in 2015 and has therefore been relatively short-term.

Trapping on Islands in Lake Wakatipu and Lake Wanaka

At Lake Wakatipu, 30 traps have been placed on Wawahi Waka and Matau islands to protect weka that were translocated to the islands in the early 2000s. Some of the weka from these islands were used in the translocation to Motatapu Station.

On Lake Wanaka (Figures 10 and 11) Mou Waho Island is maintained as predator free (no mice, rats, possum, stoats and ferrets) to protect weka, gecko, weta and other forest birds. Mou Tapu Island is also predator-free and is designated as a skink translocation island, but there are also proposals to translocate Grand and Otago skinks, Jewelled gecko and possibly orange spotted geckos. Stevenson's Island is trapped to protect buff weka.

Trap Line in the Young River, Makarora

This trap line was established and is still operated by the Department to protect mohua and whio in the Young River catchment (Figure 9). Otago Lakes Forest and Bird undertake some supplementary trap clearance during the whio nesting season.

Battle for Our Birds Aerial 1080

The Department of Conservation also uses periodic aerial application of 1080 in western and northern parts of the Project Area to protect indigenous biodiversity from stoats (*Mustela erminea*) and rats (*Rattus* spp.) following periodic heavy beech seedfall. This programme is known as Battle for our Birds (BFOB) and is prioritised at a national level, with aerial 1080 also being applied at other sites throughout the South Island. The Lake Wakatipu catchment receives 1080 application in the Caples, Dart, Beans Burn, Rock Burn, and Route Burn valleys (Figure 12). The Lake Wanaka catchment receives 1080 application in the Matukituki, Wilkin, Wonderland, Newland, Siberia, Tiel, Young, Leven, Ore, Blue, Fish, Makarora, and Cameron valleys (Figures 10 and 11). Application of aerial 1080 also reduces the abundance of possums in these areas.

5.10 Summary of state of play

Table 4 summarises community group initiatives in the Wakatipu and Wanaka catchments and the extent to which biodiversity monitoring is being undertaken.

Table 4: Summary of community group monitoring/in the catchments of Lakes Wakatipu and Wanaka.

Group	Predator Monitoring*	Biodiversity Monitoring
Aspiring Biodiversity Trust	Plan to implement camera trap monitoring (summer 2019/2020).	Rock wren, whio, braided river birds and forest birds. Kea counts (dusk and dawn).
Otago Lakes Forest and Bird	Rodent tracking tunnels.	Annual mohua survey (DOC).
Matukituki Catchment Animal Pest Control Project	DOC runs a number of rodent tracking tunnel lines in both the East and West Branches.	Forest bird survey, rock wren counts, kea surveys, SI robin surveys (these surveys are collaborative between the Trust, DOC, and the Kea Conservation Trust).
Soho Property Limited	Predator abundance indices, and camera monitoring.	Weka monitoring.
Wanaka Backyard Trapping	Tracking tunnels along Hawea-Gladstone foreshore trap line.	Landcare Research Garden Bird Survey, and eBird with its limitations.
Routeburn Dart Wildlife Trust	No.	Annual braided river bird survey (RDWT). Mohua, other forest bird and rock wren counts (DOC). Long tailed bat monitoring (RDWT and DOC).
Whakatipu Wildlife Trust	Chew card and tracking tunnel monitoring (Alpine Bird Song). Tracking tunnels (Wakatipu High School).	Bird counts (Alpine Bird Song). Braided river bird monitoring (Tucker Beach Wildlife Protection Group).
Department of Conservation	Tracking tunnels in Makarora.	Mohua and blue duck surveys in the Dart-Rees Rivers. Mohua monitoring with Otago Lakes Forest and Bird in the Makarora Catchment.

* Predator monitoring beyond looking at trap catch.

5.11 What biodiversity and habitats are protected by these projects?

The existing conservation and predator control projects are already protecting a lot of the biodiversity across the Project Area. For forest bird species and bats, most of the large tracts of indigenous beech forests in river valleys in the Makarora, Matukituki, Dart, Caples, Route Burn, Rock Burn and Beans Burn catchments are protected by aerial applications of 1080. The existing trap network in indigenous beech forest was put in place to protect river valleys that are known habitats for blue duck. Blue duck habitat is well protected in the Dart-Rees, Route Burn, Rock Burn, Beans Burn, Caples, and Young catchments.

The existing trap network also targets braided rivers and helps protect all the bird species that nest and use braided rivers. A dense trap network is present in the lower sections of the Makarora, Matukituki, Rees, and Dart rivers. All these sections of braided rivers have also been identified as Important Bird Areas for seabirds. The other Important Bird Areas for seabirds that are present in the Project Area, and that are protected by the existing predator control operations, are the Upper section of the Greenstone River and the West and East branches of the Matukituki River. Small trap networks are also present in the vicinity of the Dunstan Upper Clutha River and the Nevis Shotover Rivers Important Bird Areas.

Some alpine grasslands and shrublands have been targeted for the protection of rock wren habitat in the areas around Lake Crucible, the upper North branch of the Wilkin River, the upper West Branch of the Matukituki River, and Harris Basin. These would also protect important habitat for kea, New Zealand pipit, and potentially for lizards, although there are very few known records within the existing trap network.

Traps along Lake Wakatipu, Lake Wanaka and Lake Hayes help protect the habitat of the Australasian crested grebe. Traps are also located in the vicinity of wetlands around Lake Wanaka and in the lower sections of the Dart-Rees and Matukituki rivers, which are important habitat for Australasian bittern

Some lizard and native bird habitats are protected by the trap network in high and low producing grasslands around the main town centres.

5.12 How can the groups improve their current work?

Aspiring Biodiversity Trust

The Aspiring Biodiversity Trust was only established in 2017 so it is too early to tell whether they are achieving their goals. The Trust has undertaken the following:

- Established transects and undertaken baseline surveys of rock wren in the upper Wilkin and Crucible Basin area of Mt Aspiring National Park and implemented trapping grids to protect the rock wren (Hufton 2018b).
- A whio survey in the Siberia Valley and installed traps there for whio protection (Hufton 2018b).
- A baseline survey of braided river birds in the Makarora River, implemented small mammal trapping and southern black-backed gull control to protect them (Hufton 2017a, Hufton 2017b, Hufton 2018a, Hufton 2018c).

The Trust has implemented a lot in two years and have also produced high quality monitoring reports. The Trust has a set of priorities they are working towards. The Trust should be supported in working towards these priorities. Monitoring over the next few years will provide a better understanding of whether they are achieving these goals.

Monitoring of rock wren will be a useful indicator of whether the small scale intensively spaced 100 metre × 100 metre grids are sufficient to protect rock wrens from stoats. If monitoring suggests rock wren are still affected by stoats then these grids should be expanded, where possible.

Predator control in the braided rivers looks to be progressing well. Monitoring of braided river birds should consider the measures suggested in Section 7.2.2.

Otago Lakes Forest and Bird

Pest control in the Makarora catchment undertaken by Otago Lakes Forest and Bird has been largely focussed on protecting mohua. Mohua monitoring described by Tilson (2018) indicates that mohua abundance has increased on some transects over the past 5-7 years, while remaining stable on other transects. These results suggest that Forest and Bird's efforts may be assisting the survival of mohua in the Makarora catchment, given that mohua populations have become locally extinct or severely depleted in parts of the South Island in recent decades. However, this observation is anecdotal and it is difficult to disentangle Forest and Bird's efforts from the contribution made by aerial application of 1080 following beech masts.

It is suggested that Otago Lakes Forest and Bird implement bait station grids at key mohua hotspots in the Makarora catchment and around long-tailed bat roosts, to see if rats can be maintained at very low abundance in most years. Bait stations should be rested when aerial 1080 is deployed, but implemented 1-3 months after aerial 1080 to ensure a high rat knockdown is maintained in the years following beech masts. Bait station grids should be phased in experimentally over a number of years so that the response of mohua populations within baits station grids can be compared to those in other locations.

Continued annual mohua monitoring of mohua in a standardised manner is a high priority so that data sets ≥10 years can be used in higher level statistical analyses (e.g. population viability analysis) to determine:

- The long-term population trajectory of the makarora mohua population.
- Whether management efforts are protecting the mohua population following beech mast events (this would require meta-analysis with other mohua data sets).

Matukituki Catchment Animal Pest Control Project

Significant biodiversity gains have been made in the West Matukituki (Wildland Consultants 2019). In particular, predator control efforts have helped facilitate the successful reintroduction of South Island robin into the valley. Rock wren numbers appear to be relative stable in the West Matukituki Valley, but kea monitoring results are inconclusive (Wildland Consultants 2019).

It is unclear whether biodiversity goals have been set clearly, or whether biodiversity gains have been achieved in other parts of the Matukituki Catchment. East Matukituki trapping efforts would benefit from implementing monitoring similar to that applied in the West Matukituki. Focus needs to be applied to monitoring biodiversity values and setting of biodiversity goals for the lower reaches of the catchment. Braided river and wetland birds would be obvious options, but an extensive lizard survey of the area may also be beneficial. It is important to note that the recovery of indigenous terrestrial and forest birds in the lower reaches will be

limited by habitat. Long-term habitat restoration efforts may therefore be required in these areas before the full benefits of predator control can be realised.

Soho Property Ltd (Motatapu Valley)

Despite substantial investment, Soho Property Ltd's predator trapping goals for Motatapu Station are not being achieved.

Attempts to control predators and reintroduce buff weka into a rabbit-prone part of Central Otago may be one of the visionary efforts attempted in the Project Area. The difficulty with controlling ferrets in such a rabbit-prone area is an 'elephant in the room' for the Predator Free 2050 vision.

Buffer trapping should be extended out around the current trapping area in an effort to limit ferret dispersal into the area. Rather than focussing on obvious passes, this buffer trapping should aim to surround the current operation, as it is often difficult to tell how animals travel into an area. Rabbit manipulation trials should be attempted to see if this assists with ferret control. These could be undertaken using Pindone in bait stations in areas closed off to livestock, and could be supplemented with fumigation of rabbit burrows in trial areas using Magtoxin. This is a high priority investigation as knowledge from it will provide benefits for predator control elsewhere. The use of camera monitoring may assist with this investigation.

Despite substantial restoration efforts, habitat for most indigenous species is limited on Motatapu Station. Although predation was identified as the direct cause of the failure of the weka reintroduction it is possible that there may also have been adverse interactions with habitat, i.e. in this open habitat country, weka may have had to forage or move about in a way that was more conspicuous to predators. Watts (2013) suggested that released weka were not habitat-limited at Motatapu Station because they formed home ranges, but heavy weka predation by introduced predators confounded any long-term assessment of whether the habitat available could sustain weka.

Soho Properties Ltd should continue with their habitat restoration efforts. Not only will this create more habitat for indigenous species, but in the long-term the establishment of forested areas will suppress rabbits and ferrets.

Wanaka Backyard Trapping

To deliver effective and lasting biodiversity benefits the Wanaka Backyard Trapping group should establish a focal area/s rather than expand control thinly into mixed pastoral/tall tussock habitat in and around the townships. Restoration of indigenous avifauna in their general area of interest may be hampered by a lack of habitat. Restoration plantings over time could facilitate the recruitment of birds into these areas. Predator control to protect lizards may also be a good initial focus. They could become part of a Cardrona hub initiative and/or implement lizard protection on Roys Peak and elsewhere, or on the Wanaka/Hawea Plain.

Wanaka Backyard Trapping needs to identify a clear set of biodiversity goals, rather than spreading their efforts too thinly (other sections of this report will provide

guidance on this). It is suggested that they become involved in trapping to protect lizards in their area of interest.

Routeburn Dart Wildlife Trust

The Routeburn Dart Wildlife Trust have established a significant amount of trapping in these braided rivers. The trapping aligns well with Department of Conservation efforts, completing the matrix of river trapping in the area. Unfortunately, efforts to monitor braided river birds have been inconsistent due to flooding. Annual braided river bird monitoring should be continued and consideration given to the measures suggested in Section 7.2. The Trust supports rock wren monitoring in the Routeburn area that is well monitored.

A high priority for the Trust is the monitoring and prevention of hedgehogs reaching the braided river. Having a hedgehog-free braided river is an advantage for the braided river birds nesting there.

Queenstown-Arrowtown: Whakatipu Wildlife Trust

Consolidation of trapping effort is important for the Whakatipu Wildlife Trust, rather than having trapping of small piecemeal, isolated, reinvasion-prone areas. A community engagement plan should be developed, and a questionnaire developed to collect information on the community and landowner willingness to have low intensity landscape-scale predator control implemented across their properties.

There is insufficient information on biodiversity outcomes to determine whether the Whakatipu-Wildife Trust are achieving their goals. Crested grebe monitoring at Lake Hayes would be a high priority to determine fledgling success (see Section 7.2). Monitoring of At-Risk lizards at locations identified in Figure 8 should be a high priority (see Section 7.2). Trapping efforts should attempt to protect these populations.

Department of Conservation

Although not a lot of monitoring information is available for recent years, the Department's trapping efforts in the upper Wakatipu catchment (Routeburn, Dart-Rees, Caples) is likely to be supporting whio there. Non-threatened indigenous forest birds appear to be fairly stable (Waite 2016). Species such as rifleman and kākāriki appear to have declined between 2003 and 2015, but South Island robin may have increased slightly (Waite 2016). Continued decline of mohua in the area is a concern.

More consistent biodiversity monitoring and reporting (preferably annually) would be beneficial for understanding whether biodiversity goals are being achieved in this area, but based on current information it would be viewed as mixed success.

Biodiversity on the various islands is assumed to be well protected.

The Department has continued its efforts in the Young River catchment, at Makarora, with assistance from Otago Lakes Forest and Bird during the whio nesting season. It

is assumed that their efforts have contributed to the maintenance of mohua in the area. No information has been provided on whio monitoring in the Young River.

In order to protect biodiversity in high priority habitats, and support the community groups operating in indigenous forest areas the Department needs to maintain the BFOB aerial 1080 areas as mapped in this report. The Department also needs to determine the level of support it will provide to the options described in the next sections of this report.

6. OPTIONS FOR LANDSCAPE-SCALE PREDATOR CONTROL

Priorities for predator control in the Project Area are:

- Protection of *in situ* Threatened or At Risk wildlife populations that will be lost if the predator control is not undertaken.
- Protection of intact habitat in areas adjacent to where Threatened or At Risk wildlife populations are *in situ* so that their populations may expand into these areas.
- Protection of intact habitat in areas where it may be possible to reintroduce Threatened or At Risk wildlife.
- Protection of intact habitat that may link Threatened or At Risk wildlife populations together, i.e. wildlife corridors.
- Control undertaken as part of a restoration and reintroduction programme.

Predator control in areas where Threatened wildlife populations or suitable intact habitats are absent should be considered a low priority. In fact, undertaking predator control in perpetuity in areas where biodiversity gains cannot be made may become an ethical animal welfare issue because they result in suffering of animals without a conservation justification. Control operations in such areas are only justified if the operation is:

- Acting as a reinvasion buffer.
- Being used to develop pest control methods.
- Part of a pathway to eradication.
- Undertaken for a different reason, e.g. protection of agriculture/horticulture.

The Department of Conservation currently prioritises management on public conservation land using Ecological Management Units (EMUs) and Species Management Units (SMUs). These were integrated in 2017 with sites supporting threatened species ranked based on:

- Degree of threat risk.
- Taxonomic uniqueness.
- Degree of endemism.
- The proportion of that ecosystem remaining across the rest of the country.

Ecological Management Units that fall within the Project Area are almost entirely on its western periphery in high alpine areas close to the main divide. Ecosystems in these areas are intact and have high endemism (Figure 3).

There are indigenous wildlife habitats in the Project Area that are not currently captured by the Ecological Management Units and examples include:

- Braided rivers.
- Indigenous forested valleys.
- Lizard habitats (rocky habitat, shrubland, and grassland).
- Wetlands and lakes.

Although common indigenous species such as tūī, bellbird, grey warbler, and fantail can benefit from predator control, they are not Threatened species, so predator control in areas and habitats where only these types of species are present must be considered a low priority, compared to controlling predators in areas and habitats where Threatened or At Risk species are present.

6.1 Overview

There are four existing pest control hubs evident in the Project Area, from north to south (Figure 14):

- Makarora catchment (Figure 9).
- Matukituki catchment (Figure 10).
- Dart/Rees/Greenstone catchment (Figure 12).
- Queenstown/Arrowtown (Figure 13).

These hubs are based on current large congregations of trapping effort. However, collectively, they do represent a broad cross-section of habitat types within the Project Area, including braided rivers, indigenous forests, alpine grasslands, pastoral grassland, and peri-urban areas. Given the large-scale of the Department of Conservation and community efforts in these hubs, it is not advisable to shift focus away from these areas, instead it is better to continue to develop these operations further. However, their relative contributions to biodiversity protection have been taken into account when considering priorities going forward.

A fifth emerging hub is the Soho Property Ltd land. Currently the efforts in the Motatapu catchment can be grouped with efforts in the Matukituki catchment, as the Motatapu River flows into the lower Matukituki River. However, further expansion of predator control across the Mahu Whenua covenants, coupled with ongoing restoration efforts, could result in this area becoming a separate hub. It would potentially then include tall grassland habitat. However, biodiversity values are limited in this area and issues with controlling ferrets and feral cats are problematic.

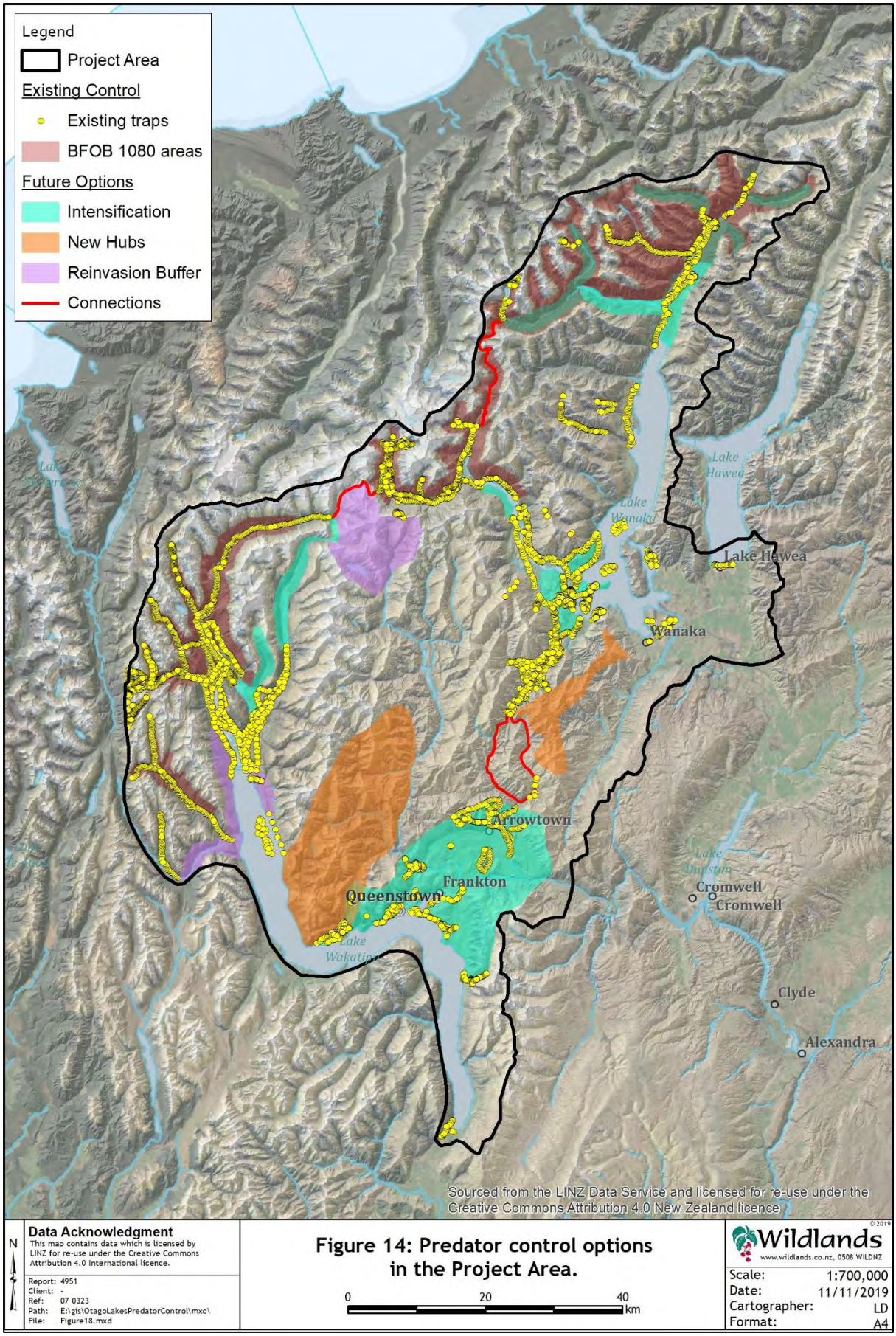

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Figure 14: Predator control options in the Project Area.

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A sixth emerging hub is in the Wanaka-Hawea Flat area, driven by Wanaka Backyard Trapping. Currently there are very few traps deployed in this area, but there is potential for expansion, as this group gains momentum. Generically this area also has low biodiversity value compared to other parts of the Project Area and this group should concentrate on a few focal points, rather than spreading control thinly in areas where Threatened or At Risk wildlife are scarce.

In the following sections a costing framework and options are provided for the intensification of landscape-scale predator control in the Project Area. These options are not necessarily mutually exclusive. However, a key priority is demonstration of biodiversity benefits resulting from current control operations in these hubs. This must be a stop-go decision point before any further landscape-scale expansion is implemented. If biodiversity is not being adequately protected in existing Project Areas, then further expansion may lead to control being spread too thinly to be effective.

6.2 Predator control methods

The options analysis assumes that the principal layer of pest control in the hubs and areas identified for intensification will be mustelid trapping at the landscape level, using traps on lines spaced 200 metres apart with lines *c*.600 metres apart. It should be noted that a distance of 600 metres between lines would be something of an average, as it will not be possible to adhere strictly to it in all landscapes. Figures 15 and 16 give examples of predator control that could be applied in rugged alpine valleys. In rugged terrain where it is not possible to run parallel lines, vertical breaks would be applied, as per the examples in Figures 15 and 16. This should equate to about one trap per 12 hectares. It is understood that these trap lines would need to be phased in and initially there may be larger gaps between trap lines. Figures 15 and 16 note how trap lines may be phased in over time to achieve this density (see Stage 1 and Stage 2 trap line examples).

Where feral cats are detected through monitoring, cat control should be implemented. Feral cat traps spaced every 500 metres on these lines would give about one feral cat trap every 30 hectares. Additional feral cat trapping could be undertaken using cage trapping techniques described elsewhere in this report.

In pastoral and farmland habitats the trapping targets described in the previous two paragraphs should also be applied as best as possible, but would follow fence lines, firebreaks, and farm tracks (where landowner permission allows).

Groups working in indigenous forest areas will need to implement rat bait stations in focal areas to protect species such as mohua or long-tailed bats. These should use the Department of Conservation best practice methods described in Section 4.2.3 and be *c*.450 hectares in size. More detail will be provided under the relevant options. 450-hectare bait station grids were used by the Department of Conservation to protect remnant mohua and long-tailed bats in the Eglinton Valley following beech masting (Smith *et al*. 2009, Department of Conservation unpublished data).

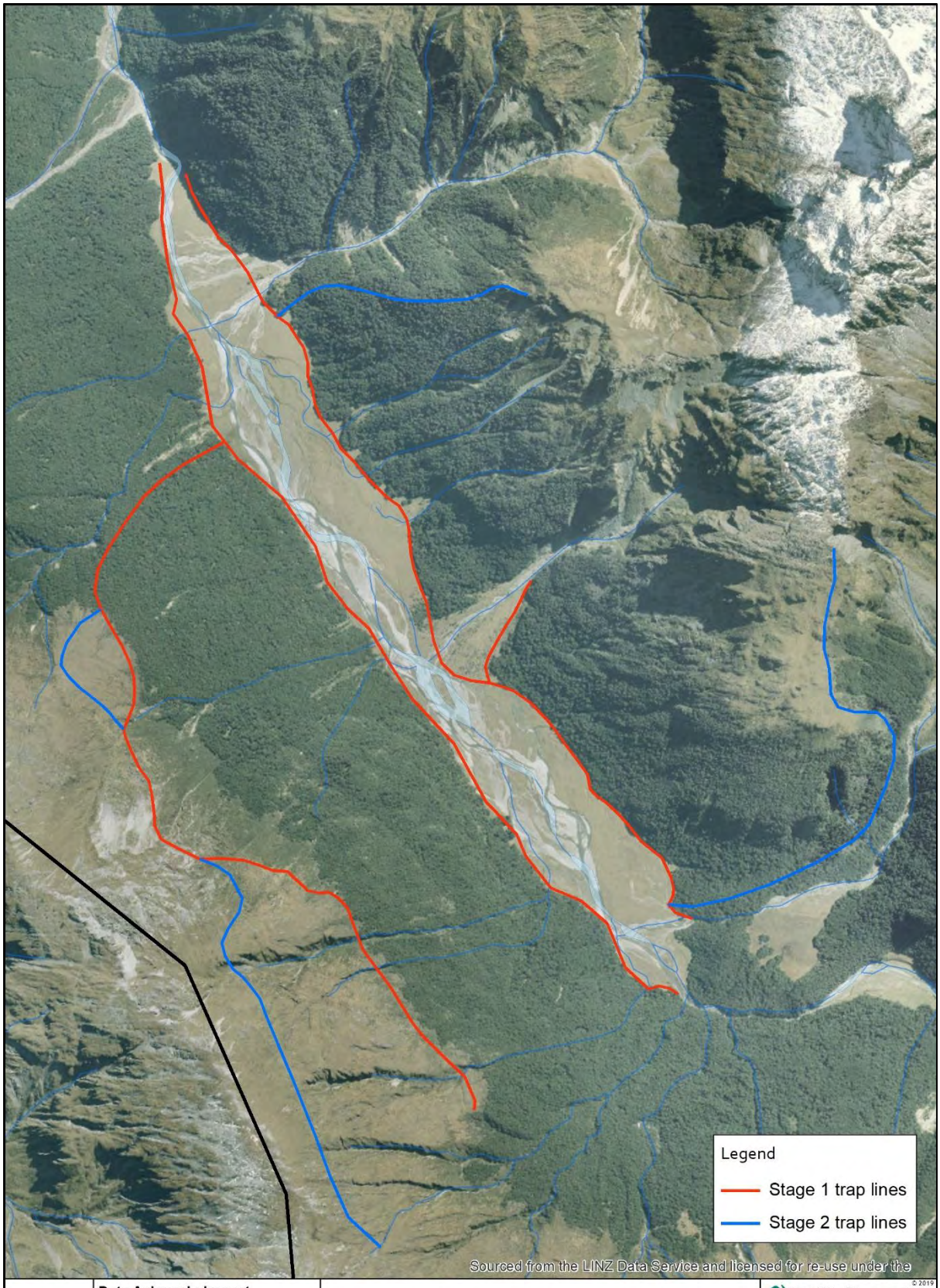

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Figure 15: Example of intensified control: Upper Makarora.

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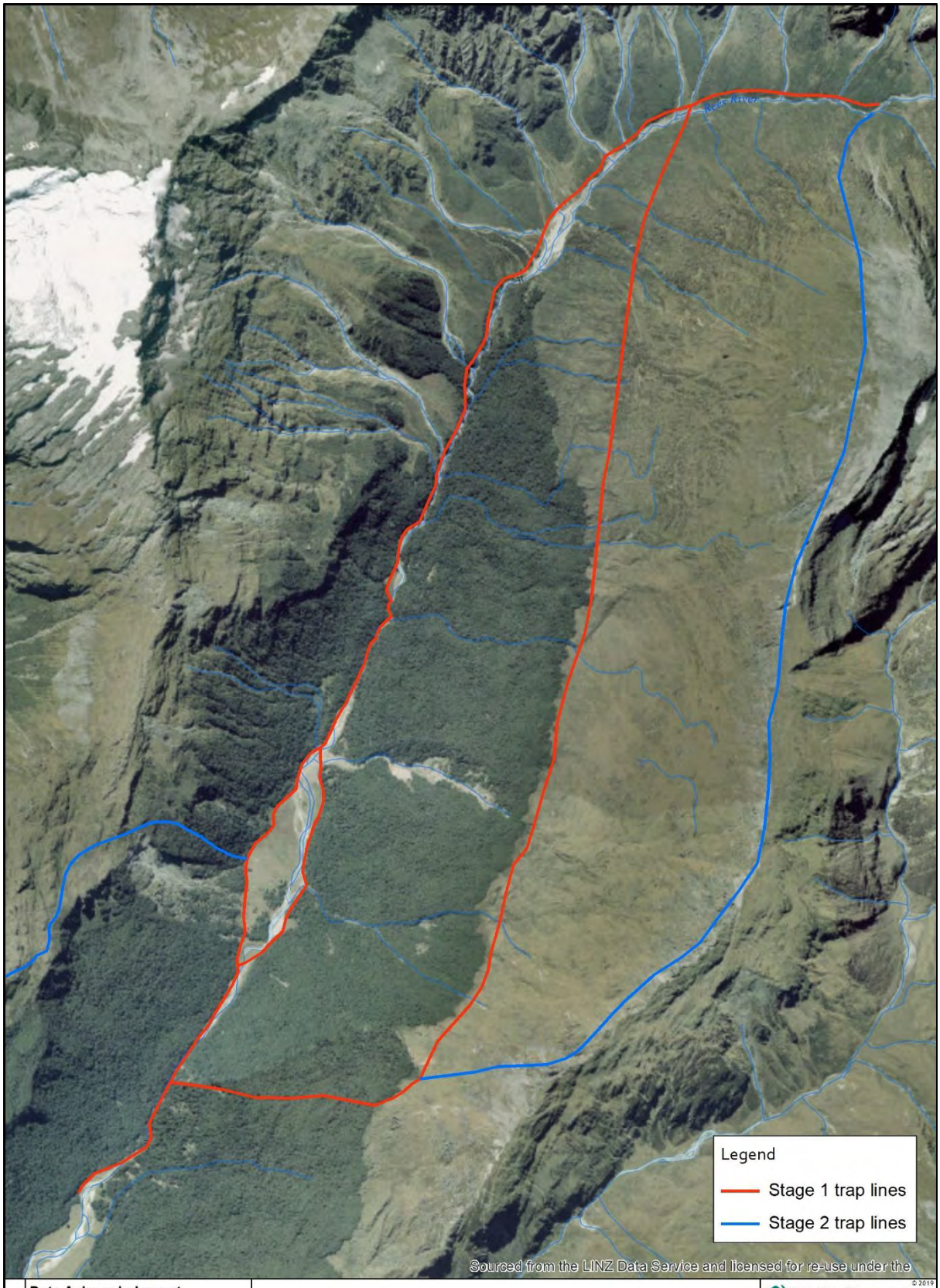

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Figure 16: Example of intensified control: Rees River.

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At present, no specific need has identified localised rat control to protect biodiversity in non-forested habitats, so it has not been included in the various non-forested options. However, monitoring may indicate a requirement for this in the future.

Brushtail possums are largely controlled in forested areas by the use of aerial 1080. In dry grassland and low producing exotic grassland they are assumed to be less of a problem. Monitoring may assess the need for localised possum control, but at this point no specific needs have been identified as part of this prioritisation process.

6.3 Costing framework for evaluation of options

Set-up and operational costs provided by each community group were used to develop a costing framework, as set out in detail in Appendices 5-7. This framework was then used to cost the options below.

Two alternatives are presented for the costing of each option: (1) labour to be undertaken by volunteers only, or (2) labour to be undertaken by contractors or the Department of Conservation. However, for the purposes of the report, costings are based on a 50% mix between volunteers and contractors or the Department of Conservation.

Set-up costs include the cost of traps, fixings, tags and signage, bait, labour, and transport to local sites and remote valleys. Transport to remote valleys includes some helicopter drop-offs, while it is assumed that transport to local sites will be done by cars and mileage will be reimbursed. Annual operation costs were estimated based on a monthly visit to each trap for each option. They take into account bait replacement costs, labour, trap maintenance, and transport to local sites and remote valleys. It is assumed that transport to remote valleys will be by helicopter for half of the trap visits. Local sites will be reached by car and mileage reimbursements have been incorporated in the costing framework.

For each costing category, all the information provided from community groups, Department of Conservation, and private organisations was pooled together and average costs per trap were calculated. Variations in the costs provided by the different organisations were important. The average costs per trap estimated in the costing framework take all this variation into account. Details are provided in Appendices 5-7.

However, this costing does not allow for site-specific control of rats using bait stations, or the ground-based use of toxins to control possums. This type of control needs to be evaluated on a case-by-case basis. Where mohua are known to be present (Makarora and Dart-Rees/Greenstone catchments), indicative rat bait costings were estimated for two 450-hectare areas. The proposed bait station density is four bait stations per hectare (50 × 50 metre grid) and it is assumed that three visits per year will be undertaken. Bait stations set-up costs are $46 per hectare and annual operation costs are $96 per hectare, including bait (Wildland Consultants 2018).

6.4 Option 1: Intensification within existing hubs

Intensification within the existing hubs (see Figures 9-10 and 12-13) is essential for two reasons:

- To ensure current operations are suppressing predators to levels necessary to achieve biodiversity protection and gains, i.e. no gaps in the jigsaw.
- To protect sufficient habitats within the hubs to allow populations of indigenous species to expand into those areas.

Makarora Catchment

Considerable expansion should occur in the Makarora catchment, which contains large areas of important wildlife habitat including a braided river, indigenous forest, and alpine grasslands. There are significant biodiversity values in the area (see Sections 3, 5.2, and 5.3). Proposed BFOB aerial 1080 areas are extensive, and spread over several parallel valleys, meaning the area of wilderness that would be protected by aerial 1080 is not narrow or fragmented. Expansion of trapping efforts in Makarora catchment would:

- Better protect *in situ* biodiversity.
- Support the spread of indigenous species throughout the extensive forest habitat, creating connectivity between surviving populations.
- Better exploit the substantial BFOB aerial 1080 operations in this area.
- Prevent reinvasion into the braided river system.

Expansion areas are shown in Figures 9 and 15 these have been selected based on biodiversity values, and the presence of walking tracks to assist with implementation. The proposed expansion areas are:

- Upper Makarora River
- Blue River
- Lower Makarora River
- Wilkin River

Intensification zones in the Makarora catchment are approximations and assume that some alpine trapping would occur as well as forest trapping. Given the extensive nature of the area, evaluation of exactly where alpine trapping should go would need to be assessed on a case-by-case basis. The lower Makarora intensification area will assist with protecting biodiversity in the area, but will also act as a reinvasion buffer for the braided river bed.

It has also been assumed that two ≤450-hectare bait station grids would be installed to protect mohua and or long-tailed bats.

Matukituki Catchment

A substantial intensive trapping effort is in place in the Matukituki catchment. Intensification should be undertaken to ensure that a major reintroduction in predators is achieved and maintained in and surrounding the braided river. Buffer areas for intensification are shown in Figure 10:

- Matukituki River (southern edge, downstream of the confluence with the East Matukituki).
- Lookout Hill.
- Motatapu River.
- Bishops Bay.
- Roys Peninsula.

Some of these extensions, e.g. Roys Peninsula, will be beneficial for wetland restoration, as well as the protection of lakeshore and river habitats.

Operations in the West Matukituki are already fairly intensive, and appear to be achieving positive biodiversity outcomes. Further intensification options for the West Matukituki have been identified by Wildland Consultants (2019). Operations in the East Matukituki should aim to intensify to a level that replicates the West Matuktuki.

Dart-Rees Catchment

Areas for intensification in the Dart-Rees catchment are (Figures 12 and 16):

- The upper Rees River.
- Diamond Lake and the Earnslaw Burn.
- Greenstone River (reinvasion buffer).
- Eastern side of Lake Wakatipu (reinvasion buffer).

Intensification should be undertaken to better connect the Greenstone and Caples valleys to the Dart-Rees trapping operations and to create a reinvasion buffer against predators moving into the Dart-Rees confluence. Expansion should also occur further up the Rees and in the Earnslaw Stream catchment, to increase the amount of forested habitat that is protected from predators, and also to create a further connection between the core Rees-Dart hub area and the Rees-Dart to West Matukituki connection (Section 6.5).

A predator control corridor linking the Greenstone-Caples to the Dart may prevent reinvasion of predators onto the lower part of the Dart braided river bed. Similar reinvasion buffering is to be applied on the eastern edge of the Lake Wakatipu. These two reinvasion buffers areas will utilise Lake Wakatipu as a natural barrier, and will also hopefully prevent the spread of hedgehogs into the Dart-Rees confluence.

It is also assumed two $\leq$ 450-hectare bait station grids will be installed to protect mohua and or long-tailed bats.

Predator-Free Queenstown

A community-led initiative equivalent to 'Cape to City' or 'Poutiri Ao o Tane' (https://www.capetocity.co.nz/) could be undertaken in the Queenstown-Arrowtown area. An indicative operational area for this initiative is shown in Figure 13. The focus of this would be a community-driven predator control project that draws people from these large urban centres into the vision for biodiversity protection and enhancement.

This is a large area, and would generate considerable public interest, and community involvement. The project would build on a growing amount of community trapping in the area. However, with the exception of crested grebe at Lake Hayes, some braided river bird breeding on the Lower Shotover River, and some At Risk Declining lizards, there is not the level of diversity of Threatened indigenous wildlife that is present in the other hubs, nor is there sufficient available habitat to reintroduce and establish viable populations of Threatened or At Risk species.

6.4.1 Cost Option 1

Table 5: Potential pest control intensification costs in the Makarora catchment based on a mix of volunteer and contractor-based labour costs.

Location	Area (ha)	No. Traps	Set-up Costs	Annual Costs
Blue River	2014	168	$31,679.90	$26,602.32
Upper Makarora River	1647	137	$27,073.28	$24,488.09
Lower Makarora River	4085	340	$54,601.26	$38,533.00
Wilkin River	7238	603	$97,251.98	$56,696.91
Bait stations for rats	900	3,600	$41,400.00	$86,400.00

Table 6: Potential pest control intensification costs in the Matukituki catchment based on a mix of volunteer and contractor-based labour costs.

Location	Area (ha)	No. Traps	Set-up Costs	Annual Costs
Matukituki River	654	55	$8,461.06	$5,279.59
Lookout Hill	1046	87	$12,229.57	$5,351.69
Motatapu River	1308	109	$15,229.69	$6,313.45
Bishops Bay	1157	96	$13,500.61	$5,759.15
Roys Peninsula	572	48	$6,801.88	$3,611.72

Table 7: Potential pest control intensification costs in the Dart-Rees catchment based on a mix of volunteer and contractor-based labour costs.

Location	Area (ha)	No. Traps	Set-up Costs	Annual Costs
Rees River	3786	316	$53,922.19	$36,810.52
Diamond Lake	2324	194	$35,571.04	$28,388.18
Greenstone River (reinvasion buffer)	5702	475	$77,971.98	$47,848.27
Eastern side of Wakatipu (reinvasion buffer)	1336	111	$17,021.58	$9,208.47
Bait stations for rats	900	3,600	$41,400.00	$86,400.00

Table 8: Potential pest control intensification costs for the Queenstown-Arrowtown area catchment based on a mix of volunteer and contractor-based labour costs.

Location	Area (ha)	No. Traps	Set-up Costs	Annual Costs
Queenstown	39,812	3,317	$492,067.73	$227,232.97

6.5 Option 2: Improved hub connectivity

There is potential to connect the four main existing hubs. These connections would utilise the natural geography of these areas and the relative proximity of each hub.

Dart-Rees-Matukituki

A trap line could be extended over Cascade Saddle between the Rees-Dart and the Matukituki Valley. This would be 13.5-kilometre alpine trap line (Figure 17). The principal predator in these habitats is stoats and stoat dispersal through the area will be limited by the steep rugged mountains. The habitat will not provide connectivity for forest birds, but would be a wildlife corridor for alpine species such as kea, rock wren, and New Zealand pipit.

This connection would utilise Marion Tower, Mt Edward, Mt Māori, and the Dart Glacier as a natural barrier in the north.

Reinvasion buffer trapping could be implemented in the South in the Snowy Creek, Tyndall Creek, and Tunnel Burn area as identified in Figure 17. Trapping in this area could be undertaken at a lower intensity with lines 1-1.5 kilometres apart. Inclusion of the reinvasion buffer would mean trapping in Threatened or At Risk lizard habitat is also covered by this option.

This connection also links two of the existing hubs (Matukituki catchment and the Dart/Rees/Greenstone catchment) through an Ecological Management Unit section that is currently unmanaged.

Traps would only be able to be cleared when free of snow, but this is typical of other trap lines in the Project Area, and elsewhere in New Zealand.

Matukituki-Makarora

The obvious connection between the Matutuki and Makarora catchments would be a 25-kilometre trap line up the East Matukituki over Rabbit Pass to the headwaters of the Wilkin River (Figure 18). Unlike the Cascade Saddle line, this line would pass through a lot of habitat that would render it very prone to reinvasion.

This connection is not within an Ecological Management Unit and observations of species such as kea are rare compared with the proposed Dart-Rees-Matukituki connection.

Matukituki-Queenstown

The obvious physical ‘boundary’ between Motatapu Station and Arrowtown is Mt Soho (Figure 19). A trapping array on Mt Soho could connect the Matukituki catchment (via Motatapu) to a predator-free Queenstown initiative. However, Mt Soho is not known to have populations of Threatened or At Risk indigenous wildlife present. There would be value in undertaking a lizard survey in area, given high value lizard habitats have been identified nearby, e.g. the Crown Range.

Data Acknowledgment
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Figure 17: Connecting the Dart-Rees to the West Matukituki.

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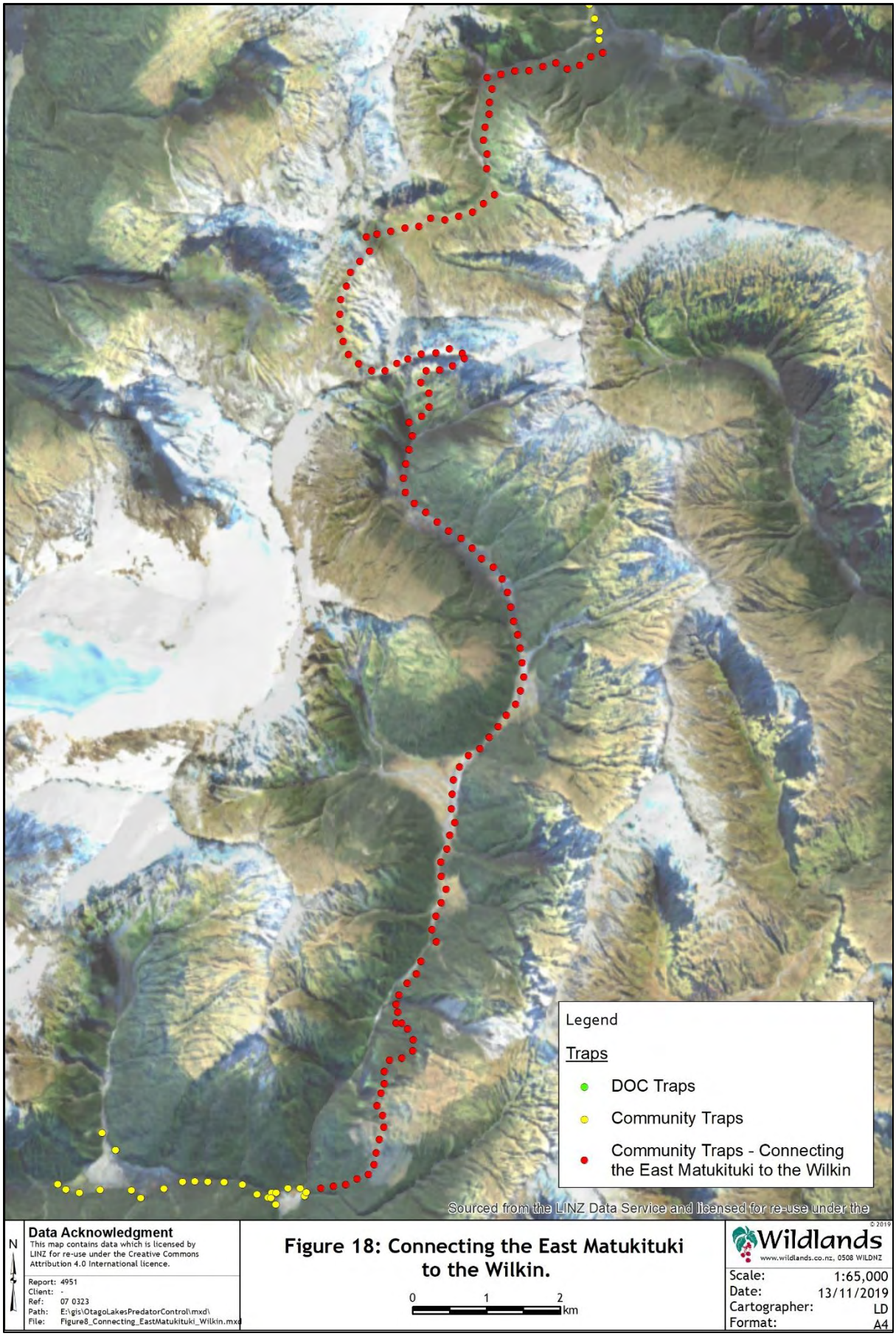

Figure 18: Connecting the East Matukituki to the Wilkin.

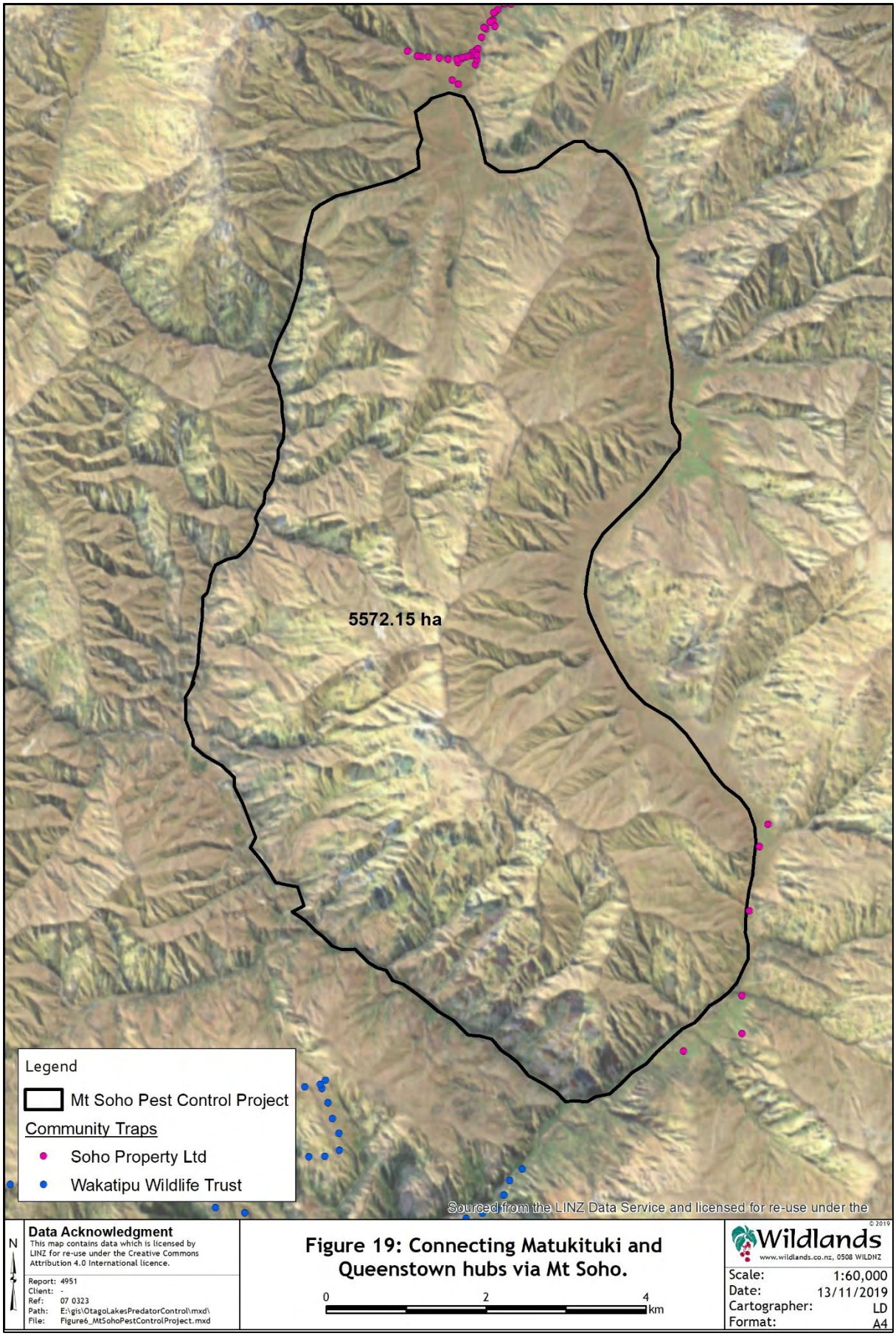

Figure 19: Connecting Matukituki and Queenstown hubs via Mt Soho.

The Takahe Recovery Team assessed this site as a potential release area for takahe in 2011. Following their visit traps were established over the southern ridges of Soho Station, over Roses Saddle and the northeast facing slopes near Roses Hut; traps were a mixture of DOC150, DOC200, DOC250 and the full suite of predators were recorded in the traps. These traps have now been redeployed to the Motatapu and tributary catchments. The Takahe Recovery Team considered that the tall tussock grassland would be suitable habitat for takahe, but the presence of all introduced predator species was a major concern; adult takahe, which struggle in the presence of stoats in the Murchison Mountains, would be very vulnerable to feral cats and ferrets. The release of takahe on to Mt Soho is unlikely without the construction of a large-scale enclosed predator-exclusion fence, and subsequent multi-species eradication within the fenced area.

6.5.1 Cost Option 2

Table 9: Potential costs of connecting existing pest control hubs in the Project Area based on a mix of volunteer and contractor-based labour costs.

Location	Distance/Area	No. Traps	Set-up Costs	Annual Costs
Dart-Rees to West Matukituki	13,419 (km)	67	$16,506.18	$20,129.08
Dart-Rees to West Matukituki with reinvasion buffer (normal trap density)	13,419 (km) 12,989 (ha)	1150	$179,545.19	$94,465.74
Dart-Rees to West Matukituki with reinvasion buffer (half of normal trap density)	13,419 (km) 12,989 (ha)	608	$98,025.69	$57,052.01
East Matukituki to the Wilkin	25,269 (km)	126	$25,430.72	$24,658.44
Mt. Soho Pest Control Project	5,572 (ha)	464	$73,140.21	$37,007.96

6.6 Option 3: Potential new hubs

Two large obvious geographical gaps in pest control in the Project Area are:

- Shotover catchment.
- The area west of Lake Wanaka, surrounding Minaret Station.

However, there is little evidence that these areas contain significant populations of Threatened indigenous wildlife or areas of habitat suitable for them. The principal land cover in these areas is tall tussock grassland and, with the exception of Minaret Station, there is no intensive predator control effort in this habitat.

Analysis of the Land Cover Database and lizard records indicates the presence of two other potential biodiversity hubs that might be worthy of investigation as areas for predator control to protect biodiversity:

- The first is a tall tussock grassland and fragmented indigenous forest mosaic at the southern end of the Richardson Mountains near Queenstown (Figures 3 and 14). Biodiversity analysis presented in this report indicates that Threatened and At Risk lizards are present and the area is used by kea, and it is also assumed that some species of indigenous forest bird will be present. Further prioritisation of this area would benefit from a dedicated biodiversity survey. The Department of Conservation and the Whakatipu Wildlife Trust should work together to develop a better understanding of the restoration potential of the Richardson Mountains.

- A potential new hub is the Crown Range which has been identified as having very significant lizard habitat values, with a high number of Threatened or At Risk lizard species in the area (Figures 8 and 14). The area between Mt Cardrona and Mt Alpha needs further herpetological survey work to better understand these values. Establishment of a predator control area here would potentially be quite feasible. This area is 8,157 hectares. Cardrona Alpine Resort is already undertaking some trapping in this area, which could provide a useful starting point.

The Crown Range idea has considerable merit as there is no dedicated trapping effort in the Project Area which has the goal of protecting lizard populations, with the exception of the Department's work on islands in the lakes. Most trapping efforts in the Project Area are focussed on protecting birds. Two At Risk indigenous bird species are likely to be present in the area: New Zealand falcon and New Zealand pipit. This would be an opportunity for a productive collaboration between the Whakatipu Wildlife Trust, Cardrona Alpine Resort, Wanaka Backyard Trapping and the Department of Conservation.

6.6.1 Cost Option 3

Table 10: Potential costs for a lizard protection hub on the Crown Range based on a mix of volunteer and contractor-based labour costs.

Location	Area (ha)	No. Traps	Set-up Costs	Annual Costs
Crown Range	8,157	680	$105,587.34	$48,503.12

6.7 Prioritisation

Options for landscape-scale predator control were assessed and ranked to determine relative priorities. The assessment took into account the importance of the biodiversity values, the feasibility of implementing the option, and the probability of success (Table 11). Seven criteria were used to assess the importance of the biodiversity and ecological values: the presence of indigenous vegetation, the presence of Threatened and At Risk species, the connectivity with existing predator control initiatives, capacity to act as a reinvasion buffer, the existence of existing geographical barriers, the presence of an Important Bird Area (IBA), and the presence of a Department of Conservation Ecosystem Management Unit.

Feasibility was assessed using four criteria: set up costs, annual operation costs, size of the area, and community uptake.

The probability of success was assessed based on the likelihood of successfully protecting Threatened and At Risk species. Probability of success considered whether there was existing adjacent control, the predator guild present, and whether there was reinvasion risk from surrounding areas.

A semi-quantitative approach was used. For each criterion, categories were defined based on the characteristics of the landscape predator control options. Each category was assigned a value which was multiplied by the weight of the criteria to determine the score. The sum of all the scores for each option was calculated and used to rank the different options. Biodiversity and ecological values criteria as a whole account

for 30 points. Feasibility criteria and probability of success have been assigned 20 points each. Options with a score higher than 46 are considered high priority options, options with a score between 23 and 46 are considered medium priority and finally, all the options that obtained a score lower than 23 are considered low priority. Appendix 8 presents details of the assessment.

Table 11: Criteria used to prioritise the predator control options.

Component	Criteria	Sources of Information	Weighting
Biodiversity and ecological values (30 points)	Presence of indigenous vegetation	• Land Cover Database version 4.1, Mainland New Zealand	5 points
	Presence of Threatened and At Risk species	• DOC reports • Conservation Trust reports • Tilson (2018) • Ebird • Mt Creighton Conservation Resources Report (2003) • All the bat, lizard, and bird information presented in this report.	10 points
	Connectivity with existing predator control initiatives	• Existing traps • BFOB 1080 areas	5 points
	Capacity of acting as a reinvasion buffer to protect areas with important biodiversity values	• Existing traps • BFOB 1080 areas	5 points
	Inclusion of existing geographical barriers to protect the biodiversity	• Land Cover Database version 4.1, Mainland New Zealand • Hydrology	2 points
	Presence of an Important Bird Area	• Birdlife International	1 point
	Presence of a DOC Ecosystem Management Unit (EMU)	• DOC Ecosystem Management Unit GIS layer	2 points
Feasibility (20 points)	Set-up costs	• Costing framework	5 points
	Annual operation costs	• Costing framework	5 points
	Size of the area	• Area	5 points
	Likelihood of community uptake	• Proximity to towns • Existing network	5 points
Probability of success (20 points)	Probability of successfully protecting biodiversity, mainly Threatened and At Risk species, if predator control was implemented as suggested in the report and existing predator control efforts continue.	• Presence of Threatened and At Risk species • Size of the area • Existing predator control • Predator guilds • Reinvasion probability • Ecological feasibility	20 points

The results of the prioritisation exercise are presented in Table 12. Care should be taken when analysing the results of the prioritisation exercise. The list of Threatened and At Risk species for some of the proposed options is probably not complete, for instance lizard surveys were not undertaken in all of the areas. This potentially lowers the biodiversity score of options or areas that were less surveyed. Total scores

should also be taken with a degree of caution. Small differences in scores should not be interpreted as a reason to discredit one option over another. The prioritisation should be used more as a general way to identify the areas were predator control efforts will have more chance of successfully protecting biodiversity and threatened species. Lower priorities might also be considered as good opportunities to expand the predator control network if other objectives are taken into consideration, e.g. community involvement and participation.

Table 12: Prioritised scores for the predator control options.

Options	Score	Priority
Intensification - Blue River	52.5	High
Intensification - Upper Makarora River	51.6	High
Intensification - Greenstone River (reinvasion buffer)	50.5	High
Intensification - Lower Makarora River	49.75	High
Connection - Dart-Rees to West Matukituki	49	High
Connection - Dart-Rees to West Matukituki and Reinvasion Buffer	49	High
Intensification - Eastern side of Wakatipu (reinvasion buffer)	47	High
Intensification - Wilkin River	44.25	Medium
Intensification - Matukituki River	42.25	Medium
Intensification - Diamond Lake	38.5	Medium
Connection - East Matukituki to Wilkin	33.75	Medium
Intensification - Rees River	33.5	Medium
New Hub - Crown Range	32.5	Medium
Intensification Queenstown Hub	27.25	Medium
Potential Hub - Richardson Mountains	23.75	Medium
Intensification - Lookout Hill	22.5	Low
Intensification - Motatapu River	22.5	Low
Intensification - Bishops Bay	22.5	Low
Intensification - Roys Peninsula	22.5	Low
Connection - Mt. Soho Control Project	11.25	Low

A lot of the projects/expansions set out in Tables 5 to 10 above are achievable over several years subject to the availability of funding. Some of the highest biodiversity benefits are to be gained from increasing pest control in the BFOB aerial 1080 areas to the standards achieved in the Landsborough and West Matukituki. Expansion of pest control in these areas would result in a large mosaic of habitat under the influence of pest control that would allow enhancement of populations of Threatened and At Risk species.

Species that would gain benefits from predator control intensification in the Makarora, Matukituki and Dart-Rees hubs would be:

- Long-tailed bat
- Rock wren
- Kea
- Mohua
- Whio
- South Island robin
- Other indigenous forest birds

Whio and mohua are not currently present in the Matukituki catchment, but population growth and expansion in the Dart-Rees and Makarora areas may strengthen the case for reintroductions into the Matuktuki.

However, other habitat types and associated biodiversity values in the Project Area should not be overlooked nor should the substantial community effort being applied in these areas. In addition, there are a number of Threatened and At Risk lizard species in these areas, along with localised special features such as Australasian crested grebe at Lake Hayes and elsewhere, as described in Section 4.2.

6.8 Summary

Options presented in Figure 14 show a core/buffer/corridor model of landscape-scale predator control that is far reaching and extensive. Core areas would be intensively trapped parts of the Dart River, the West Matukituki and the Makarora Valley, and potentially Lake Hayes. These cores would be buffered by newly-proposed intensification areas and by aerial application of 1080 (where it is used). Three corridors have also been proposed.

The prioritisation matrix presented indicates that the following areas are high priorities:

- Intensification in the Makarora catchment
- Reinvasion buffering and intensification in the Dart-Rees catchment.
- Development of the connection between the Dart-Rees and West Matukituki

Prioritisation has been based on the presence of threatened species, the presence of intact habitat, and the feasibility of success. It is well established that predator control can be implemented successfully in remote areas, so remoteness itself does not impact on feasibility, but it will affect cost. Establishment of a connection between Motatapu and Queenstown had a low score in the prioritisation not only because Threatened fauna are not present, but also because the full range of predator species is present, and based on the experiences at Motatapu, may be difficult to control to the levels necessary to protect Threatened species. The connection between the East Matukituki and the Wilkin is scored as a medium priority because evidence for the abundance of Threatened species does not seem as good as some of the other options, and the long narrow nature of it, with many linear valleys, make it prone to reinvasion.

It is not the role of this report to tell the groups what they should and should not do; rather the intention is to act as a guide. Efforts in the Queenstown Area, Motatapu, lower Matukituki and the Upper Clutha are well aligned with the conservation spirit and public mood, and will play an important role in advocacy. However, these groups should also focus on the interactions between predator control and habitat restoration. Threatened wildlife in New Zealand need two things:

- Suitable habitat.
- Protection from predators.

Motatapu Station has a habitat restoration programme, and this is a good model to follow. Although outside the scope of this report, habitat restoration should also be a major long-term focus for other areas.

Some of the medium priority options have merit. In particular the Crown Range hub may be an opportunity for collaboration between several of the groups, and would shift the focus from birds to lizards at one location within the Project Area.

7. MONITORING AND MEASUREMENT OF SUCCESS

Monitoring is essential for guiding the implementation and expansion of predator control in the Project Area. The principal purpose of monitoring is to determine whether you are making a difference for biodiversity. Monitoring also allows you to adaptively manage your project (Holling 1978), i.e. if monitoring indicates objectives are not being achieved, then changes need to be made to your predator control programme. Further monitoring will then show whether these changes have resulted in achievement of positive outcomes.

Monitoring of conservation projects that use predator control to protect threatened species should have two components:

- Predator abundance monitoring.
- Biodiversity monitoring.

Both components are important for the adaptive management of a project. Predator abundance monitoring gives you direct information on whether, or to what extent trapping or poisoning is affecting predator numbers. However, it cannot tell you whether the rate at which you are removing predators is adequate to protect rare or threatened indigenous species. Biodiversity monitoring, e.g. monitoring of threatened indigenous wildlife, will provide information on whether survival or breeding success has changed since implementation of the predator control.

7.1 Predator abundance

The following sections provide guidelines on monitoring of predators in the Project Area.

Trap-Catch Data

Trapping data are an important monitoring tool. Captures per 100 Corrected Trap Nights or C/100CTN (Nelson and Clark 1973) can be calculated for trap lines, giving an index of relative abundance that accounts for trapping effort. Some caution is required, though, because biases in C/100TN can occur when trap spacing, line density, or rate of trap checking is not consistent between sites. Nevertheless, if trap frequencies and trap check rates are kept consistent, comparable data can be achieved.

However, even without calculation of an index, trapping data can be incredibly useful. For instance, sections of trap lines can be evaluated to ascertain whether captures of each species have changed over time. Captures will fluctuate for all species, but if they show no long-term decline, then it is unlikely the population is being suppressed. However, if they do decline over time then that is a positive sign. If a section of traps consistently no longer catch a certain pest species, but used to when they were first established, this is a really positive sign, although surveillance monitoring using other

techniques should be undertaken to see whether the species still persists at this location.

Trapping data can also be used to determine whether mesopredator release is occurring, e.g. if rat numbers increase on a trap line as mustelid numbers decline.

Analysis of trap catch data is the main method the groups should use to understand the effect that their trapping is having on predator populations. Appendix 3 (Motatapu analysis) is a good example of how to interrogate a trapping data set to understand what is going on. The different groups should present graphs similar to those presented in Appendix 3 on an annual base to determine whether:

- Trapping is reducing the abundance of any predator species.
- What predator species seem unaffected by trapping, i.e. are caught in stable numbers.
- Whether any predator species are increasing in abundance despite trapping.

Warning: capture rates of pests can vary seasonally. Therefore it cannot be concluded that trapping is successful if a species is caught less often in winter compared with the previous summer. Trapping tallies are best compared yearly, or between the same seasons.

Careful recording of trap data in the field and careful data entry is paramount to successful analysis of trapping data. Trappers must record the following, as a minimum:

- Date of trap check.
- Which traps were checked, and which were not.
- What species was caught in which trap.
- Whether a trap was sprung but did not catch anything.

Use of Broad Scale Indices to Measure Pest Knockdowns

Some fairly standard techniques have been developed for providing monitoring of pests independently of traps. A standard protocol has been established for the use of tracking tunnels to monitor mustelids and rodents (Gillies and Williams 2013) and is used widely. This involves a one night index for rats using 10 tunnels, and a three night index for mustelids using five tunnels on the same line, by missing out every second tunnel. Lines are spaced a minimum of one kilometre apart. Tracking tunnels also record the presence of hedgehogs.

Larger cat tracking tunnels have been developed and can be highly effective for the detection of feral cats (Pickerell *et al.* 2014). A set protocol for their use has not been developed, but it is suggested that a cat tracking tunnel is added to each tracking tunnel line.

It is possible to dovetail other indices into tracking tunnel lines. For instance, two standard WaxTag lines, i.e. 10 WaxTags 20 metres apart, (NPCA 2015) can be used on a standard tracking tunnel line, c.f. Project Kākā in the Tararua Range. This would allow a second index of rats, and also possum monitoring.

This combination of stoat/rat tracking tunnels, feral cat tracking tunnels, and WaxTags for rats and possums should be deployed where it is practicable to do so across the Project Area. These indices will provide a broad reference as to whether pest control is reducing pest numbers in the priority areas, and which pest species are being reduced. They will also indicate whether mesopredator release is occurring, e.g. tracking tunnels can detect increases in rats if mustelids and feral cats are being controlled.

It is suggested that the groups run tracking tunnels with WaxTags at least three times per year. The groups should aim to collect data from at least three monitors before pest control starts in intensification, expansion areas, and connection areas to provide baseline indices. The groups should aim for one tracking tunnel/WaxTag line per 1 km^2. In forested valleys, lines should be run up the valley and in very long valleys kept to a maximum of 10 lines to prevent monitoring becoming too onerous.

In alpine grasslands tracking tunnel monitoring is less of a priority, because the predator guild is smaller, but should be implemented if possible. Tracking tunnels in alpine grasslands can be implemented without WaxTags.

In places such as the proposed Queenstown intensification area it would be good to work towards 30 lines, and this may provide a way of engaging the community and school groups in the monitoring programme. Similarly, for the Crown Range hub it would be good to have at least eight lines, given little is known about predators in this area. In some of these areas it may be difficult to use WaxTags because there are no trees to attach them too. In the Queenstown intensification area and in other areas such as Motatapu Station, WaxTags could be placed along shelterbelts, or attached to fence posts, where tracking tunnels are run along the fence lines. In the Crown Range, WaxTags or chew cards could be attached to the tracking tunnels, the purpose being to identify whether or to what extent possums are present in the area.

The purpose of this monitoring is to generate comparable data across the Project Area that is independent of the predator control. It will be used to determine where predators are being controlled to low levels and where they are persisting. It will also provide a second measure (the first being trap catch) of whether the abundance of one predator species is changing in relation to the abundance of another.

Camera Trapping

Camera trapping is an emerging monitoring tool, and is currently being used at Motatapu Station. Camera trapping can be useful for:

- Determining whether there are predator species present that are for some reason not being caught in traps or detected by standard monitoring.
- Identifying whether there are individuals within a trapped predator species that are not being caught.
- Solving mysteries, e.g. if indigenous wildlife deaths are noted but it is not clear which predator(s) is responsible.

Camera trapping/monitoring, has an expensive initial outlay and is labour intensive, requiring many hours to be set aside to watch footage. Camera trapping should be viewed as a surveillance monitoring tool to be applied when a problem presents itself that cannot be resolved with standard monitoring methods.

7.2 Biodiversity outcome monitoring

Robust biodiversity outcome monitoring needs to be a high priority in all hubs, as decisions about intensification and expansion must be guided by this. There is little point in using limited conservation dollars and volunteer resources to expand into new areas if current predator control efforts are not successfully protecting indigenous biodiversity.

Community groups and the Department of Conservation must have some form of quantifiable biodiversity outcome monitoring in place in all hubs.

7.2.1 Biodiversity indicators

Given the large size of the Project Area and the diversity of habitats it is impossible to identify suitable indicator species that can be used across the entire Project Area. Indicator species will be location and project specific. Habitat-based approaches for biodiversity monitoring are provided in the following section.

7.2.2 Biodiversity monitoring

Braided River Birds

The Aspiring Biodiversity Trust, the Routeburn Dart Wildlife Trust, and the Tucker Beach Wildlife Management Reserve Protection Group have undertaken (or commissioned) braided river bird counts in their hubs. While counts are useful, they can be variable and difficult to correlate with trapping data because variation in counts can be driven by other factors. The above groups and the Department of Conservation should collaborate on a braided river bird monitoring plan for the Project Area.

It is suggested that colony-nesting species such as black-billed gulls and black-fronted terns are used as indicator species. Each season, colonies should be found and mapped. The number of nesting pairs in each colony should be counted. These colonies should be re-counted every two weeks throughout the breeding season, with observations recorded of whether nests have disappeared, eggs have hatched, or birds have fledged. Following flooding events, colonies will need to be relocated to commence monitoring of new nesting attempts.

Data from this monitoring can then be used to estimate nesting success rates. For example, if 297 breeding black-billed gull pairs are counted and 87 birds are observed to fledge, then the approximate breeding success is 0.29. This is relatively crude as some data on nest success or failure will be missed between counts, but over a number of years it will nevertheless provide useful trend monitoring.

Data collected in this way could lend itself to more sophisticated modelling and analysis of fledgling success but a biometrician should be consulted on this.

Crested Grebe

Crested grebe monitoring should be undertaken in a similar manner. Although a method of passively monitoring nests needs to be developed, monitoring from kayaks, boats, or paddle boards, using binoculars, has proven to be effective on Lake Hayes.

Alpine Birds

In alpine areas, kea and rock wren need to be monitored independently.

Annual rock wren counts are being undertaken in the Makarora, West Matukituki and Routeburn. These annual counts should be continued, but it is suggested that they be combined with territory mapping (Colin O'Donnell, Department of Conservation, pers. comm.). An example of this was undertaken by the Aspiring Biodiversity Trust which has informed alpine predator trapping in the area (Hufton 2018b).

Given the ability of kea to move over large distances, kea monitoring needs to provide precise information on the following, in order to gauge whether predator control is protecting them:

- Approximately how many kea are present.
- Whether recruitment is occurring, e.g. ratio of juveniles to adults.
- Whether adult sex ratios are biased towards females.
- Information on survival.

Long-Tailed Bats

In locations where bats are present, acoustic surveys should be undertaken and repeated annually. Radio-tracking to determine the presence and location of roosts would also be beneficial in some areas, particularly in areas where intensive rat control is being implemented.

Standardised methods for acoustic monitoring of long-tailed bats are still under development. It is suggested for locations where bats are known to be present that a minimum of 10 automated bat monitoring devices are used over 10 fine nights, when temperature at sunset is ≥5 degrees Celsius (Smith *et al.* in prep). The automated bat monitors should be spaced at least 200 metres apart.

The Aspiring Biodiversity Trust have developed a bat survey proposal for the Makarora area and funding is currently being sought for this. The methodology suggested could be applied more widely through the Project Area and would provide useful cross-project information.

Mohua

Mohua monitoring is already undertaken in the Makarora catchment (Tilson 2018) and in the Dart-Rees area (Waite 2016, Molloy 2018), and should be continued annually.

As control is intensified, occasional walk-through surveys of other areas should be undertaken to assess whether mohua have spread. If mohua are spreading further, then transects should be established in the areas of spread.

Project Area-Wide Bird Survey Method

Distance sampling undertaken in the West Matukituki (Broekema 2016-2018) is a method of monitoring various indigenous forest birds efficiently and rigorously. Broekema's (2016) method is to establish transects 200-600 metres in length with a random starting point, with transects a minimum of 200 metres apart. Transects are walked slowly in the October-November period and all birds seen and heard are counted. Distances to visible birds are recorded with a laser rangefinder or equivalent.

This type of monitoring could be implemented in all major hubs or Project Areas (forested or non-forested) to provide high quality Project Area wide bird data. It probably would not be practical for all groups to pay for distance sampling analysis, but results could be summarised as mean encounter rates per transect. A Project Area-wide distance sampling analysis could be funded at some point in the future, or the data provided to a postgraduate ecology student at a University for a thesis project.

A minimum of 15 transects should be implemented in each hub or focus area (the more the better). It is also suggested that a five-minute bird count is completed at the start and end of each transect, because these counts are a common monitoring method and data can be compared with other data sets throughout New Zealand.

This approach should be implemented in forested areas, but also in dryland areas, even if it largely measures exotic birds in those locations. It should be implemented in areas of intensification to monitor improvements in bird counts in those areas following implementation of pest control.

Lizards

Lizard monitoring will be important, particularly in areas where Threatened or At Risk species have been identified. Tracking tunnels record lizard footprints (Glen *et al.* 2019) and tracking tunnels deployed for predator control may give coarse indications of changes in lizard abundance. However, intensive lizard monitoring will need to be undertaken if a project such as the Crown Range hub is instigated.

Commonly-used methods of monitoring lizards include pit-fall trapping (commonly used for skinks) and Onduline retreats (commonly used for geckos) (Lettink and Monks 2012). Pitfall traps capture lizards that are unable to climb out of them, and must be checked daily. Onduline retreats are layered corrugated bitumen placed over rock or talus areas, to create a warm habitat that lizards move into.

Herpetologists typically design site specific surveys using pitfall traps and Onduline retreats, with designs depending on the lizard species present, and the extent of the

habitat available for those species, i.e. individual rock taluses. If the Crown Range lizard hub was to go ahead the next steps would be:

- A herpetological survey of the proposed area to determine the distribution and number of lizard species present.
- A monitoring plan using pitfall traps and Onduline retreats be developed using the survey results.

Monitoring in New Areas Identified in the Options Analysis

Areas of intensification should be monitored using the Project Area bird survey method. Lizard monitoring as described above will be applied in the Crown Range hub. Rock wren and kea monitoring should be used in the Dart-Rees-Matukituki connection and in the Matukituki-Makarora connection.

8. POTENTIAL FOR PEST ERADICATIONS IN THE PROJECT AREA

Predator Free 2050 Ltd is a Crown-owned company established to assist the Government in its goal of eradicating possums, rats and stoats from Aotearoa New Zealand by 2050. Predator Free 2050 can fund proposed mainland eradications projects if they meet the following criteria:

- Funding is matched, two dollars for every one dollar of Crown investment.
- Projects should be ambitious in scale. The Trust has been advised by Predator Free that the eradication should be at least 5,000 hectares in size.
- The project should result in substantial biodiversity gain within the eradication area.
- Projects should contribute to regional development.
- Projects should have reasonably rapid timing and measurability of gains, i.e. goals should be achievable in the short to medium term.
- There should be land owner support and participation, e.g. evidence of collaboration with landowners and interested parties.
- There is potential for partnership with Māori.
- The project team should have the expertise and capacity to carry out the eradication.
- There should be support for the project within the community.
- Health and Safety standards need to be met.
- The eradication should be an opportunity to extend science and research in this field.
- The eradication gains need to be sustainable. How will predator free status of the Project Area, achieved through the eradication, be secured for the future?
- The project needs an exit strategy. How will the predator free status be maintained beyond the Predator Free 2050 investment?

The March 2019 funding application round for Predator Free 2050 Ltd only included surge regions under the Provincial Growth Fund, which excludes Otago.

It is useful to consider the types of eradication that might be possible in the Project Area:

- The successful eradication of rats over 5,000 hectares is unlikely. The only method with a track record of eradicating rats on this scale (achieved on offshore islands and in predator-exclusion fenced sanctuaries) is aerial application of brodifacoum. Brodifacoum persists in the environment and food chain, and has resulted in the Department of Conservation banning its use on public conservation land, unless there are very strong grounds for its use.

- Eradication of stoats over 5,000 hectares is also unlikely. Despite eradication efforts, offshore islands such as Secretary Island (8,140 hectares) have not been able to be achieve stoat-free status. Dispersing juvenile stoats have been observed to move ≥60 kilometres (Murphy and Dowding 1995).

- Possums might be reduced to very low densities over 5,000 hectares using intensive repeated aerial 1080 but:
  - They will not stay out of the area.
  - This may not be a significant conservation achievement in beech forest areas (with few palatable species) where possums are already controlled to low numbers using periodic aerial application of 1080. In these areas, other predators (e.g. stoats, rats, and feral cats) are also a significant threat to Threatened wildlife.
  - Intensive aerial 1080 cannot be applied in areas other than indigenous forest, because of risk to livestock, domestic animals, and low public acceptance.

In addition to the lack of a clear eradication pathway, there are other factors that make meeting these criteria operationally, ecologically, and economically unrealistic for the Project Area:

- There is no plausible eradication scenario that will link the hubs within the Project Area and consequently unify the stakeholder efforts. The eradication would need to occur at a particular site within one of the hubs. The other stakeholders could only contribute by providing resources personal or funding, which would detract from their own goals and objectives.

- An eradication of stoats, rats or possums is of little relevance to Motatapu Station, which need to find a method(s) to successfully control feral cats and ferrets over large landscapes.

- It is unlikely that eradication can be sustained. Even comparatively small predator-proof fenced sanctuaries such as Orokonui (300 hectares) can experience occasional, ecologically costly, predator excursions. In 2018, a single female stoat invaded Orokonui Sanctuary decimating the reintroduced saddleback population before being trapped (Elton Smith, pers. comm).

- A clear exit strategy is unlikely, and therefore additional funding will need to be sought when Predator Free 2050 funding is no longer available, or the project will have to be abandoned.

- An eradication will detract funding and resources away from efforts to implement expansive sustained control to protect biodiversity in the Project Area, becoming a conservation 'Trojan Horse'.

ZIP have been trialling the deployment of heavy, pre-fed aerial 1080 in South Westland (e.g. the Perth River) as a method of reducing possums and rats to zero densities (http://zip.org.nz/findings/2017/11/1080-to-zero-trial-in-south-westland). The trial was successful in keeping possums and rats to non-detectable levels for several weeks after the bait was dropped, but there were non-target deaths. Attempts to replicate this technique in the Taranaki have not been as successful at reducing pests to non-detectable levels. This technique is not particularly novel, as it has been known for a long-time that aerial 1080 can reduce pests to very low levels. Research in Tararua Forest Park showed that aerial application of 1080 reduced rats to very low levels, but 24-30 months after control they were at higher abundance than prior to control with reinvasion highest in the margins of the control area (Griffiths and Baron 2016).

The Predator Free 2050 criteria are ambitious, particularly given there is no track record of eradicating any of these species over 5,000 hectares anywhere on mainland New Zealand.

One opportunity for eradication is to attempt to eliminate stoats from some of the small cirques and head basins where rock wren are present. Locations such as the Crucible Basin, Lake Castelia area have mountains encircling them that may be natural barriers to stoats (and rats are probably not present). Access for reinvaders is potentially only from beech forest in the lower valley via the stream outlet. The Aspiring Biodiversity Trust is already running small scale intensive stoat trapping grids in this area. French Ridge, which is trapped by the Matukituki Catchment Group, may also be an opportunity to replicate this approach. The challenge would be designing virtual barrier trapping that would keep stoats out of the single ingress point following a beech mast (although all of these sites are in BFOB aerial 1080 zones).

Unfortunately, this project would not involve all of the groups or hubs unless they somehow contribute their time or effort to supporting it. The Department of Conservation and relevant groups should discuss this opportunity with Predator Free 2050, to see whether they would support such an initiative even though it is small scale, given:

- It would take place in high priority Ecological Management Units
- If successful it is likely to be sustainable
- It would protect a Nationally Endangered species
- If successful it would be the first eradication of stoats on mainland New Zealand outside of predator exclusion fences

Learnings from offshore island and predator exclusion fenced sanctuaries eradication suggest it would be unwise to launch into a large-scale terrestrial eradication, as it would be costly and prone to failure. Proof of concept mainland eradication attempts should be small scale and well thought out, and if they can be achieved and sustained, next steps to enlarge them can be decided from there.

It is beyond the scope of this report to prepare a blueprint plan for this concept.

9. RESEARCH PRIORITIES

9.1 Overview

In developing this scoping strategy, the following research priorities have been identified:

- Best practice ferret and feral cat control in rabbit-prone areas.
- Kea interference studies.
- Best practice hedgehog control.
- Aerial 1080 and trapping.
- Role of rats as predators in dry grassland ecosystems.

9.2 Best practice ferret and feral cat control in rabbit-prone areas

The difficulty faced by Soho Property Ltd with ferrets and feral cats in rabbit-prone areas is of concern, and compromises the substantial effort by this group to restore habitat and reintroduce Threatened species. Other groups that try to operate in these types of habitats will face similar problems. There is a lack of information on how to control these species in these habitats, because the research focus on predator control in New Zealand has historically been on indigenous ecosystems and/or brushtail possum vector control.

Development of best practice methods for controlling ferrets and feral cats in low producing exotic grasslands and dry grasslands is a high research priority for the Project Area. This research should consider removal of rabbits as part of the strategy as they are the principal prey base for ferrets and feral cats in these habitats, and are also a pest animal species.

9.3 Kea interference studies

Kea are ubiquitous in large parts of the Project Area and their inquisitive nature makes them a non-target risk. This puts some of the community groups between a 'rock and a hard place'.

- Should they use ineffective tools in an attempt to protect other Threatened or At Risk species in the Project Area in order to avoid kea deaths?
- How many non-target kea deaths per year in the Project Area are acceptable, given the benefits to kea and other Threatened or At Risk species of predator control?
- Can baffle systems be developed for existing tools (e.g. bait stations, Feratox strikers) that exclude kea but efficiently control introduced predators to a level that protects other Threatened or At Risk species?

A mohua breeding area following a beech mast is not the place or time to be trialing these methods. Community groups should not be advised to use kea exclusion devices that there is no efficacy data for.

Research into efficient kea exclusion devices that still allow predator control tools to be applied effectively is a high priority (at a national level). Research should initially be undertaken *ex situ* (in captivity) and then field trials undertaken in low priority conservation sties in non-mast years.

9.4 Best practice hedgehog control

Hedgehogs are a known predator of braided river birds and their absence in some of the braided rivers in the Project Area is an advantage to these programmes. There is currently no best practice technique for hedgehog control.

Intensive trapping grids should be trialled to determine whether they are capable of eliminating hedgehogs and keeping them from spreading into areas.

9.5 Aerial 1080 and trapping

It would be beneficial to have a more quantified understanding of the benefits to biodiversity of also undertaking trapping in areas where aerial 1080 is applied. This research would be a comparative study of Threatened species monitoring results in areas with similar habitats where trapping is applied without aerial 1080 and where trapping is applied with aerial 1080.

9.6 Role of rats as predators in dry grassland ecosystems

Rat irruptions in indigenous forest and the consequent impacts of increased rat populations on forest bird populations is well researched. There is very little information on rat populations in other habitat in the Project Area e.g. dry grasslands or low producing exotic grassland. It would be useful to understand rat dynamics in these areas and whether they have localised impacts on other taxonomic groups, such as lizards.

10. CONCLUSIONS

The Project Area encompasses an impressive array of significant ecosystems and habitats in protected areas, pastoral leases, and in private tenure. This includes extensive alpine habitats and indigenous forest tracts, braided riverbeds, dry grasslands, shrublands, wetlands, and large lakes. This area contains a diverse range of indigenous fauna including high alpine species such as rock wren and kea, forest birds, braided river birds, bats, wetland birds, e.g. Australasian bittern, and high lizard diversity, including many Threatened and At Risk species. Landscape-scale predator control is already being implemented and the scale and intensity of that effort is impressive. This landscape-scale predator control is occurring in almost all habitat types. Many of these predator control programmes are already in relatively close proximity to each other, and as they expand natural connections are becoming obvious.

Current trapping efforts can be divided into four main hubs:

- Makarora catchment
- Matukituki catchment
- Dart-Rees catchment
- Queenstown-Arrowtown

Community groups are committing a large amount of resources to this trapping effort. The Department of Conservation undertake a large trapping programme in the upper Dart-Rees, Routeburn and Greenstone area. They also undertake aerial application of 1080 every 3-6 years following beech masting to control rats and stoats as part of their Battle for our Birds programme.

Aerial application of 1080 following beech masting serves to achieve a broad-scale knockdown of rats, stoats, and possums following beech masting. It is important for the implementation of this scoping plan that the aerial 1080 areas are maintained at their current levels. Trapping efforts should then be focussed on mopping up surviving predators, particularly in areas where Threatened indigenous wildlife is concentrated, and controlling introduced predators in non-mast years when predators can still have adverse impacts.

Some community groups are operating in low and high producing grassland in the eastern part of the Project Area. Aerial 1080 is not applied in these areas and ferrets and feral cats are more prevalent in these areas, particularly where rabbit abundance is high. These areas also have limited habitat for Threatened indigenous species. Common indigenous wildlife are present, but with limited conservation funding it is difficult to prioritise widespread non-threatened indigenous wildlife over wildlife classified as Threatened or At Risk. Groups working in these areas should also have a long-term vision of habitat restoration to encourage the return of Threatened and At Risk species.

Predator control methods and options for intensification and connection of control areas have been identified, along with possible new hubs for predator control activity. These options have been prioritised with the prioritisation weighted towards the presence of Threatened indigenous wildlife, as these species must be considered a priority if future extinctions are to be avoided in the Project Area.

A further key priority is biodiversity outcome monitoring. It is currently very difficult to assess whether some of the community groups are achieving their goals, as it is difficult to gauge whether populations of Threatened species are responding positively to their control efforts.

Natural barriers are discussed and addressed, but considerable caution is needed when thinking about natural barriers, as introduced predators have spread throughout the entire Southern Alps and throughout Fiordland National Park. Two possible natural barriers have been identified and discussed: a possible mountain barrier to the northwest of the proposed Dart-Rees-Matukituki connection, and buffer trapping around the upper edges of Lake Wakatipu to slow reinvasion into the Dart-Rees confluence.

Options for eradication as part of a Predator Free 2050 have been explored. The Predator Free 2050 criteria are unrealistic for options in this area. An eradication attempt would be high risk (i.e. have a low chance of long-term success), and would detract investment from known conservation priorities. Eradication of stoats from alpine cirques where rock wren are present is an interesting idea, and could potentially be implemented as part of existing projects. The Working Group should have a serious conversation with Predator Free 2050, to see whether this is something they would support.

The different groups should invest in having Controlled Substances License-holders in their ranks. The use of ground-based toxins is the quickest and easiest way for the groups to improve their toolbox arsenal.

Research priorities have been identified and two major priorities are:

- Ferret and feral cat control in dry rabbit-prone areas. Analyses presented in this report indicate that best practice trapping is ineffective.
- Research into effective baffle systems that prevent kea from accessing control devices, but do not deter introduced predators. Kea are widespread in the Project Area and concern about their non-target deaths is preventing the use of tools that are used to effectively control introduced predators in other parts of New Zealand.

Future Vision

The various community groups and the Department of Conservation are already achieving landscape-scale predator control across large parts of the Queesntown-Lakes catchments. If the options described in this scoping plan are implemented in prioritised order then an unprecedented large-scale predator trapping effort to protect Threatened indigenous wildlife would be achieved that has no equal in any other region in New Zealand. This is because the Project Area has an incredible diversity of wildlife habitats that encompass alpine species, forest species, braided river birds, wetland species, and a considerable number of Threatened and At Risk lizards. Implementation of this plan would see almost all of these habitats come under some form of control of introduced predators for the first time since human settlement. If this is done well then Threatened and At Risk species that are toanga for the area will be secured for future generations.

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IMPORTANT BIRD AREAS (IBA) IN THE PROJECT AREA

NZ089	**Makarora**	**Otago**

Location	New Zealand, Otago
Central coordinates	44.273783°S, 169.185591°E (Makarora Wilkin confluence)
IBA criteria	A1
Area	4,080 ha
Altitude	279 - 400m
Year of Assessment	2013

Populations of IBA trigger species:

Species	Season	Period	Population estimate (pairs)	IBA criteria	IUCN cat.	NZ Threat Class.
Black-billed Gull	Breeding	1966-2009	142-344	A1, A4i	EN	Nationally Critical
Black-fronted Tern	Breeding	1970-1995	16-36	A1, A4i	EN	Nationally Vulnerable

Ornithological information: Besides the trigger species the following species are confirmed or likely to be breeding: Black Shag, White-faced Heron, Black Swan, Canada Goose, Paradise Shelduck, Mallard, Grey Duck, NZ Scaup, Australasian Harrier, NZ Falcon, South Island Pied Oystercatcher, Pied Stilt, Wrybill (VU), Banded Dotterel, Spur-winged Plover, Southern Black-backed Gull, NZ Pigeon, NZ Kingfisher, Welcome Swallow, NZ Pipit, South Island Fantail, South Island Tomtit, Grey Warbler, Silvereye, Bellbird, Tui, Skylark, Hedge-sparrow, Blackbird, Song Thrush, Yellowhammer, Chaffinch, Greenfinch, Goldfinch, Redpoll, House Sparrow, Starling, Australian Magpie. Other species recorded: Little Shag.

NB: Yellowhead (EN), Kea (VU), Kaka (EN), Yellow-crowned Parakeet (NT), Long-tailed Cuckoo (LC), Shining Cuckoo (LC), Morepork (LC), South Island Robin (LC), Brown Creeper (LC) and Rifleman (LC) are found in adjacent forest areas (Mount Aspiring National Park). These will be included in the IBA network in the next round (i.e. identifying sites triggered primarily by land-, water- and shore- birds).

NZ090	Matukituki River	Otago

Location	New Zealand, Otago
Central coordinates	44.481075°S, 168.819695°E (confluence of East and West Branches)
IBA criteria	A1
Area	6,015 ha
Altitude	279 - 440m
Year of Assessment	2013

Populations of IBA trigger species:

Species	Season	Period	Population estimate (pairs)	IBA criteria	IUCN cat.	NZ Threat Class.
Black-billed Gull	Breeding	1970-2011	320-952	A1, A4i	EN	Nationally Critical
Black-fronted Tern	Breeding	1971-2007	39-92	A1, A4i	EN	Nationally Vulnerable

Ornithological information: Besides the trigger species the following species are confirmed or likely to be breeding: White-faced Heron, Canada Goose, Paradise Shelduck, Mallard, Grey Duck, NZ Scaup, Australasian Harrier, South Island Pied Oystercatcher, Pied Stilt, Banded Dotterel, Spur-winged Plover, Southern Black-backed Gull, NZ Pigeon, NZ Kingfisher, Welcome Swallow, NZ Pipit, South Island Fantail, South Island Tomtit, Grey Warbler, Silvereye, Bellbird, Tui. Skylark, Hedge -sparrow, Blackbird, Song Thrush, Yellowhammer, Chaffinch, Greenfinch, Goldfinch, Redpoll, House Sparrow, Starling, Australian Magpie. Other species recorded: Black Shag, Little Shag, NZ Falcon, Black Swan.

NB: Kea (VU), Kaka (EN), Yellow-crowned Parakeet (NT), Long-tailed Cuckoo (LC), Shining Cuckoo (LC), Morepork (LC), Brown Creeper (LC) and Rifleman (LC) are found in adjacent forest areas; these will possibly be included in the IBA network in the next round (i.e. identifying sites triggered primarily by land-, water- and shore- birds).

NZ091	Dunstan Upper Clutha River	Otago

Location	New Zealand, Otago
Central coordinates	44.932603°S, 169.257946°E (Dunstan Clutha delta)
IBA criteria	A1
Area	2,236 ha
Altitude	200 - 279m
Year of Assessment	2013

Populations of IBA trigger species:

Species	Season	Period	Population estimate	IBA criteria	IUCN cat.	NZ Threat Class.
Black-fronted Tern	Breeding	2000-2012	35 (nests)	A1, A4i	EN	Nationally Vulnerable

Black Stilt (CR) and Black-billed Gull (EN). Have also been recorded on the river and at the head of Lake Dunstan.

Ornithological information: Besides the trigger species the following species are confirmed or likely to be breeding: Australasian Crested Grebe, Black Shag, Little Shag, White-faced Heron, Black Swan, Canada Goose, Paradise Shelduck, NZ Shoveler, Grey Teal, Mallard, Grey Duck, NZ Scaup, Australasian Harrier, Marsh (Baillon's) Crake, Pukeko, Australian Coot, South Island Pied Oystercatcher, Pied Stilt, Banded Dotterel, Spur-winged Plover, Southern Black-backed Gull, Caspian Tern, Californian Quail, Rock Pigeon, NZ Kingfisher, Welcome Swallow, NZ Pipit, Shining Cuckoo, South Island Fantail, Silvereye, Skylark, Hedge-sparrow, Blackbird, Song Thrush, Yellowhammer, Chaffinch, Greenfinch, Goldfinch, Redpoll, House Sparrow, Starling, Australian Magpie.

NZ092	Dart Rees Rivers	Otago

Location	New Zealand, Otago
Central coordinates	44.773793°S, 168.325396°E (Dart Bridge)
IBA criteria	A1, (A4ii)
Area	6,387 ha
Altitude	308 - 500m
Year of Assessment	2013

Populations of IBA trigger species:

Species	Season	Period	Population estimate (pairs)	IBA criteria	IUCN cat.	NZ Threat Class.
Black-billed Gull	Breeding	1967-2007	129-352	A1, A4i	EN	Nationally Critical
Black-fronted Tern	Breeding	1967-2010	34-73	A1, A4i	EN	Nationally Vulnerable
Wrybill	Breeding	1967-2007	25-41 (individuals)	A1	VU	Nationally Vulnerable

Ornithological information: Besides the trigger species the following species are confirmed or likely to be breeding: Black Shag, Little Shag, White-faced Heron, Black Swan, Canada Goose, Paradise Shelduck, Mallard, Grey Duck, NZ Scaup, Australasian Harrier, South Island Pied Oystercatcher, Pied Stilt, Banded Dotterel, Spur-winged Plover, Southern Black-backed Gull, NZ Pigeon, NZ Kingfisher, Shining Cuckoo (LC), Welcome Swallow, NZ Pipit, South Island Fantail, South Island Tomtit, Grey Warbler, Silvereye, Bellbird, Tui, Skylark, Hedge-sparrow, Blackbird, Song Thrush, Yellowhammer, Chaffinch, Greenfinch, Goldfinch, Redpoll, House Sparrow, Starling, Australian Magpie. Other species recorded: NZ Falcon, White-winged Black Tern.

NB: Yellowhead (EN), Kea (VU), Kaka (EN), Yellow-crowned Parakeet (NT), Long-tailed Cuckoo (LC), Shining Cuckoo, Morepork (LC), South Island Robin (LC), Brown Creeper (LC) and Rifleman (LC) are found in adjacent forest areas (Mount Aspiring National Park); these will be included in the IBA network in the next round (i.e. identifying sites triggered primarily by land-, water- and shore- birds).

NZ093	Greenstone Caples Rivers	Otago

Location	New Zealand, Otago
Central coordinates	44.932238°S, 168.327370°E (Greenstone Caples confluence)
IBA criteria	A1
Area	819 ha (Greenstone) 655 ha (Caples)
Altitude	308 - 620m
Year of Assessment	2013

Populations of IBA trigger species:

Species	Season	Period	Population estimate	IBA criteria	IUCN cat.	NZ Threat Class.
Black-billed Gull [1]	Breeding	1996	No counts	A1	EN	Nationally Critical
Black-fronted Tern [1]	Breeding	1996	No counts	A1	EN	Nationally Vulnerable
Weka	Resident		Present	A1	VU	Nationally Vulnerable

[1] Both these species are reported for the two valleys with 'large' (Black-billed Gull) and 'small' (Black-fronted Tern) colonies recorded for the Lower Clutha Flats (Cromarty & Scott 1996).

Ornithological information: Besides the trigger species the following species are confirmed or likely to be breeding: Black Shag, White-faced Heron, Canada Goose, Paradise Shelduck, Mallard, Grey Duck, NZ Scaup, Australasian Harrier, South Island Pied Oystercatcher, Pied Stilt, Banded Dotterel, Spur-winged Plover, Southern Black-backed Gull, NZ Kingfisher, Shining Cuckoo, Welcome Swallow, NZ Pipit, South Island Fantail, South Island Tomtit, Grey Warbler, Silvereye, Bellbird, Tui, Skylark, Hedge-sparrow, Blackbird, Song Thrush, Yellowhammer, Chaffinch, Greenfinch, Goldfinch, Redpoll, House Sparrow, Starling, Australian Magpie. Other species recorded: Little Shag, NZ Falcon, NZ Pigeon.

NB: Kea (VU), Kaka (EN), Yellow-crowned Parakeet (NT), Long-tailed Cuckoo (LC), Morepork (LC), South island Robin (LC), Brown Creeper (LC) and Rifleman (LC) are found in adjacent forest areas; these may be included in the IBA network in the next round (i.e. identifying sites triggered primarily by land-, water- and shore- birds).

NZ094	Nevis Shotover Rivers	Otago

Location	New Zealand, Otago
Central coordinates	45.174293°S, 168.996162°E (Nevis Crossing)
IBA criteria	A1
Area	685 ha
Altitude	650 - 700m
Year of Assessment	2013

Populations of IBA trigger species:

Species	Season	Period	Population estimate (pairs)	IBA criteria	IUCN cat.	NZ Threat Class.
Black-billed Gull	Breeding		No counts	A1	EN	Nationally Critical
Black-fronted Tern	Breeding	1967-2008	13-52	A1, A4i	EN	Nationally Vulnerable

Ornithological information: Besides the trigger species the following species are confirmed or likely to be breeding: White-faced Heron, Paradise Shelduck, Australasian Harrier, NZ Falcon, South Island Pied Oystercatcher, Pied Stilt, Banded Dotterel, Spur-winged Plover, Southern Black-backed Gull, NZ Pipit, Silvereye, Bellbird, Skylark, Hedge-sparrow, Blackbird, Song Thrush, Yellowhammer, Chaffinch, Greenfinch, Goldfinch, Redpoll, House Sparrow, Starling, Australian Magpie. Other species recorded: NZ Falcon.

PEST DENSITIES AND RATES OF INCREASE

Estimates of pest densities (or indices of densities) and the rates at which the populations may recover after control are important for management - if they can be measured and interpreted in relation to past and planned control actions.

The densities of the target species in different habitats in the Otago Project Area vary from zero to carrying capacity - the density they reach if not constrained by resources or by control. The problem is that some species at the same place vary across this range as they boom and bust (e.g. rodents through a beech mast) while other remain more-or-less in equilibrium with only seasonal changes (e.g. after a birth pulse in seasonally breeding species).

Rates of increase are also not some constant for each species. They are negative when populations are decreasing and positive, up to some maximum called the intrinsic rate of increase, when the populations are growing fastest which they do when about half the carrying capacity. Once the population reaches its carrying capacity the rate of increase is zero as births equal deaths. In the long-term, and without control, rates of increase for a population average at zero.

Generally, once a population is reduced by control actions the resources per capita for the animals increase and the rate of increase increases.

Therefore, it is useful to know population densities for the species with more stable dynamics but the transitory densities of the boom-bust species are only of use for the point in time they are measured - next week they will change! Similarly it is useful to know the intrinsic rate of increase for populations as this sets the worst case rate at which they will have to be culled to maintain the lowered population.

The following table presents some estimates of density and rates of increase for each species taken in New Zealand in different habitats and in light of the natural dynamics of each.

Species	Density	Rate of increase	References
Mice	Red beech forest (mast event): 4.9-50/ha Red beech forest (non-mast year): <1/ha	Exponential rate of increase Beech forest irruption: 2.28 Beech forest decline: -1.75 Podocarp-hardwood forest irruption: 1.18 Podocarp-hardwood forest decline: -1.13	Ruscoe *et al.* 2001 Choquenot & Ruscoe 2000
Ship rats	Podocarp-hardwood forest : 5.4-8.7/ha Red beech forest (non-mast year): 0.38/ha	Beech forest (mast event) Finite daily rate of increase: 1.0103 (exponential daily rate of 0.01025 or 3.74/y)	Wilson *et al.* 2007 Christie *et al.* 2015 Elliott *et al.* 2018
Stoats	Red beech (mast event-summer): 4.2/km^2 Red beech (mast event-fall): 2.5/km^2 Beech forest (non-mast event): 1.46-1.6/ km^2 Alpine grasslands (non-mast event): 0.82-1.0/km^2	Maximum rate of increase in Finland: 4.16	Alterio *et al.* 1999 Smith *et al.* 2008 Korpimaki *et al.* 1991
Ferrets	Central Otago (before RHD had reduced the rabbit population): 2-5/ km^2	Intrinsic rates of increase: 1.26	Middlemiss 1995, Barlow & Norbury 2001
Possums	Beech forests: 0.5/ha Scrubby farmland: 1.0/ha Podocarp-hardwood forests: up to 24/ha	Intrinsic rate of increase with densities reduced by control: 0.25	Efford 2000 Bayliss & Choquenot 2002
Hedgehogs	0.9 - 5.5/ha	No data available	Jones & Sanders 2005

TRAPPING IN LOWER ALTITUDE GRASSLAND AND SHRUBLAND AT MOTATAPU STATION

BIODIVERSITY VALUES

The predator control programme in the Motatapu catchment was initially established to facilitate the implementation of the Weka (*Gallirallus australis*) Recovery Plan1999 - 2009. The project is a joint venture partnership between the Department of Conservation and Ngai Tahu to reinstate a population of buff weka on a mainland site within the eastern South Island (Palmer 2018). This project provided a good fit with the vision of Soho Property Ltd to protect, enhance and reinstate biodiversity values on the property in harmony with an economic farming model. If they are able to do that there will be benefits to other indigenous biodiversity briefly discussed above in Section 5.6.2.

The Diamond Lake Conservation Trust operates traplines in the lower Motatapu River down to Lake Wanaka connecting the work of Soho Property Ltd with that of the Matukituki Catchment trusts. Their aims are more general enhancement of indigenous biodiversity values.

CRITICAL PEST SPECIES

Ferrets, stoats, and cats are considered to be the critical pests preventing weka re-establishment (Palmer 2018) and judging by the traps deployed by the Diamond Lake Trust, mustelids and cats are being targeted in downstream habitats (Anon 2017).

WHAT IS BEING DONE?

Soho Property Ltd has trapped predators in the Motatapu catchment since October 2009 with an increasing number of traps being set from 2009 (n = 107 for 2617 trap-days) until 2019 (n = 656 for over 41000 trap-days), mostly DOC200s and DOC250s (Table 1).

Table 1: Traps used in the Soho Properties project at Motatapu Station.

Trap Type	Number Deployed	Target Pest	Species trapped	Total Trapped Spring 2009 - Autumn 2019
DOC250	273	Ferrets	Ferrets	541
DOC200	263	Stoats/rats	Stoats	756
ST	42	Rats	Weasels	296
DOC150 double set	28	Rats	Cats	277
Conibear	23	Cats	Rats	1,773
BT	13	Rats/stoats	Hedgehogs	3,559
Live cage traps	7	Cats/ferrets	Rabbits	461
Fenn double set	1	Rats/stoats	-	0

Soho Property Ltd also use camera monitoring and thermal scoping to improve night shooting results, intend to use detector dogs to try and find ferrets, use opportunistic shooting while rabbit hunting, and use camera traps for the detection of predators. They realise the

trophic importance of rabbits as prey for ferrets and cats and recognise that rabbit control may reduce predator abundance.

The increasing trapping effort has resulted in stable trend in total catch for ferrets, and a marginally declining trend for cats and hedgehogs. Indices indicate stable or declining trends in stoats, weasels and rats and a slightly increasing trend for rabbits (Figures 1-7).

The introduction of independent monitoring will enable a more robust interrogation and understanding of the results and their implications for the planned reintroductions of locally extant populations. It is anticipated that camera monitoring will provide additional information regarding the presence/ occupancy rates of cats and ferrets and a means of monitoring changes to those populations independent of the trap network in response to management. The result will be improved confidence in the data relating to predation risk which informs the programme for species reintroductions.

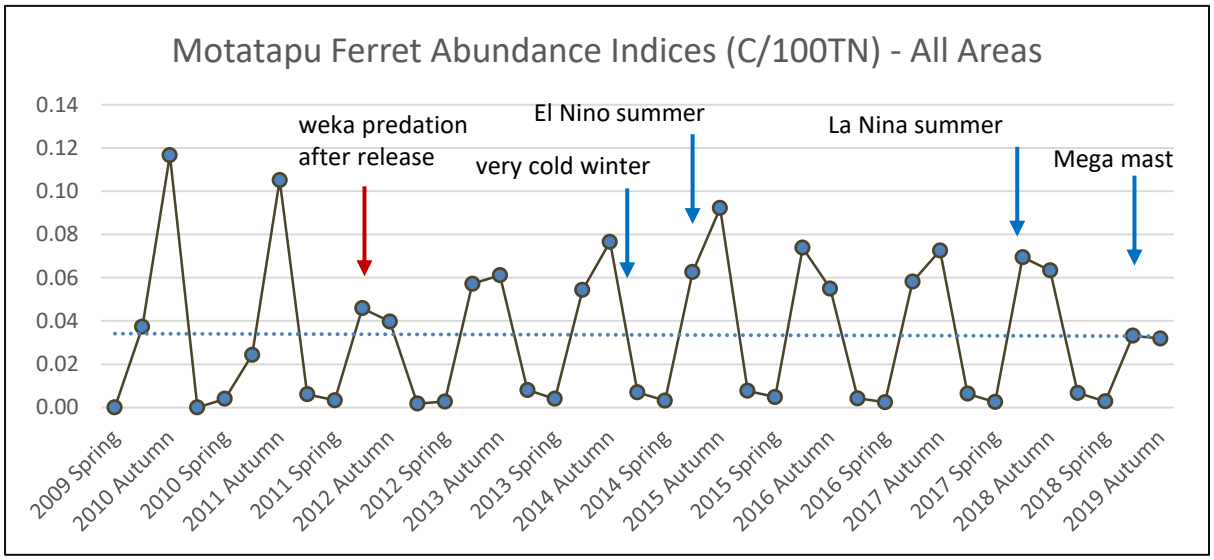

Figure 1: Ferrets.

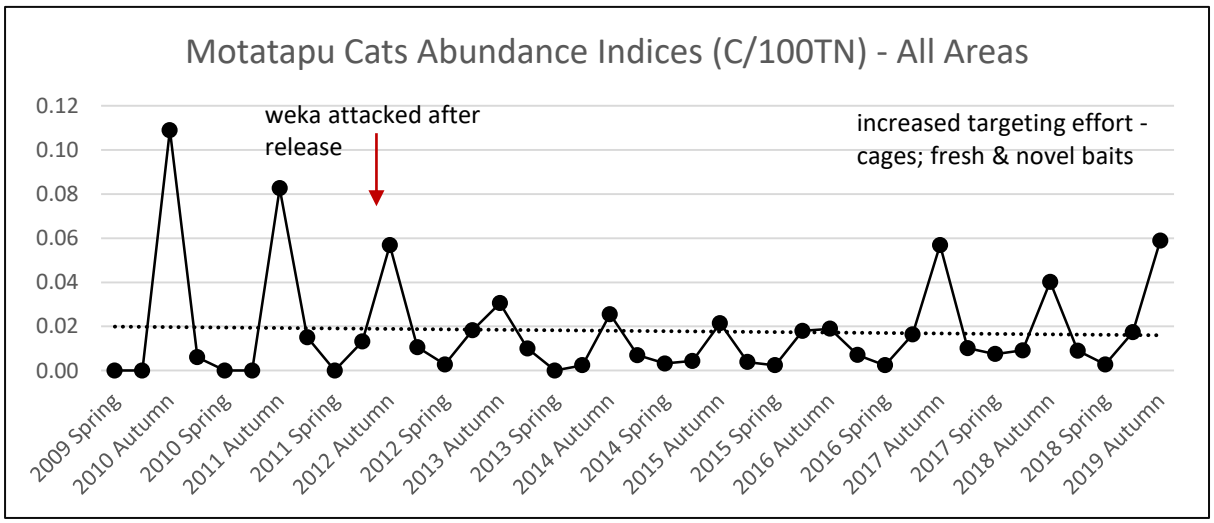

Figure 2: Feral cats.

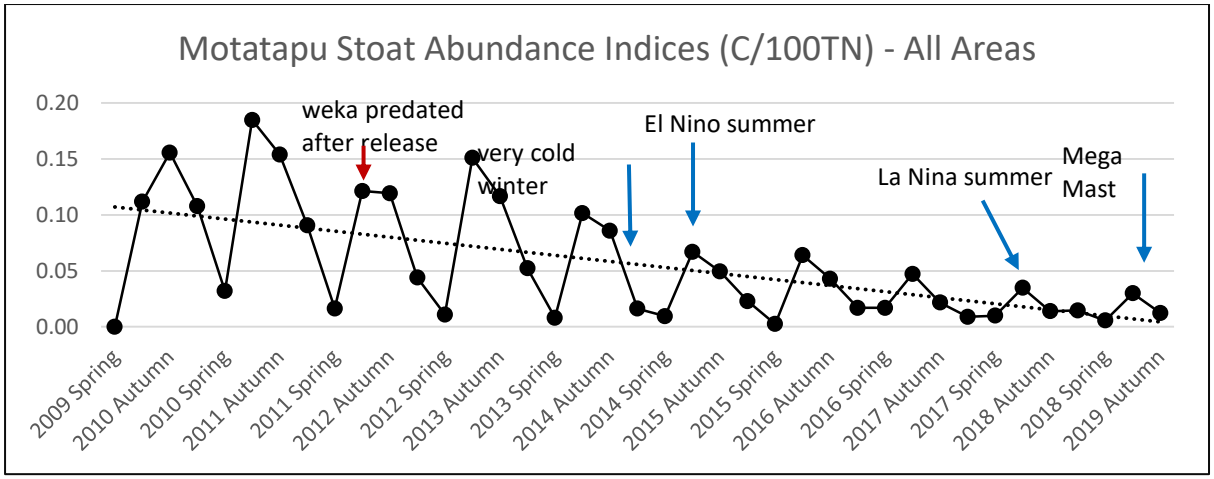

Figure 3: Stoats.

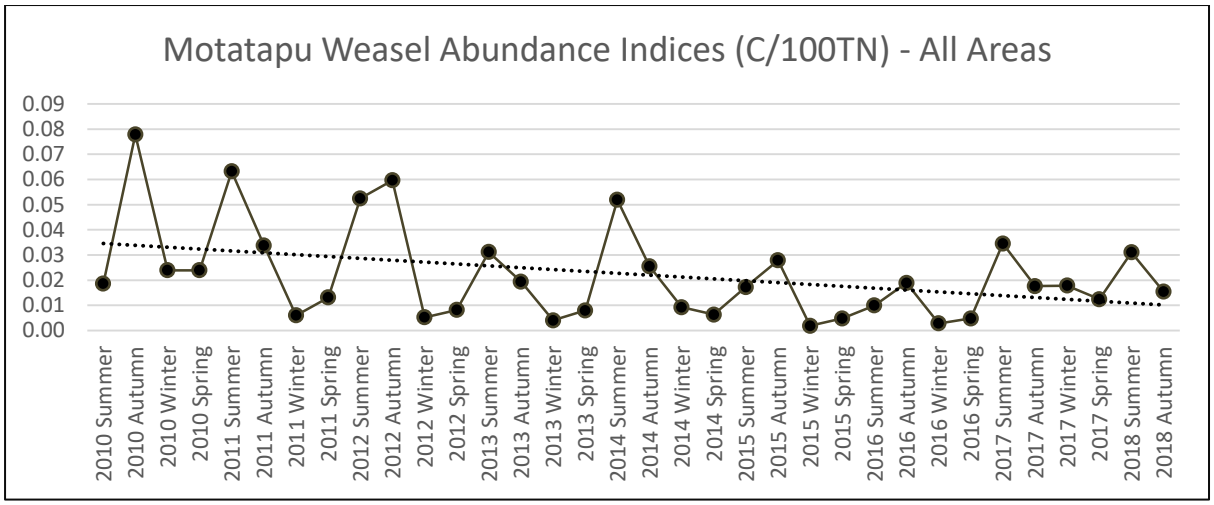

Figure 4: Weasels.

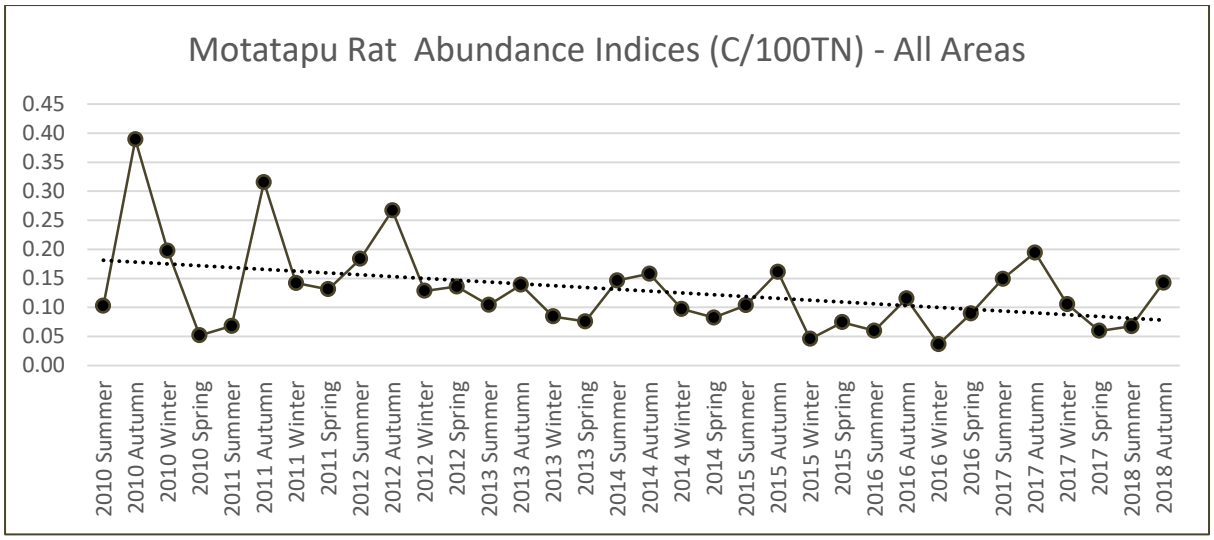

Figure 5: Rats.

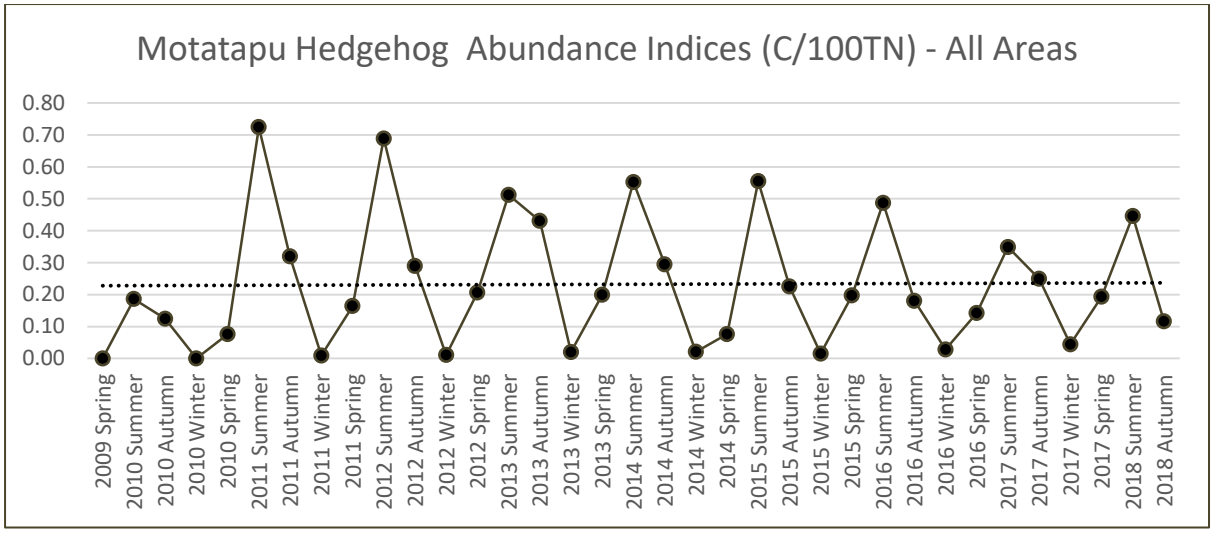

Figure 6: Hedgehogs.

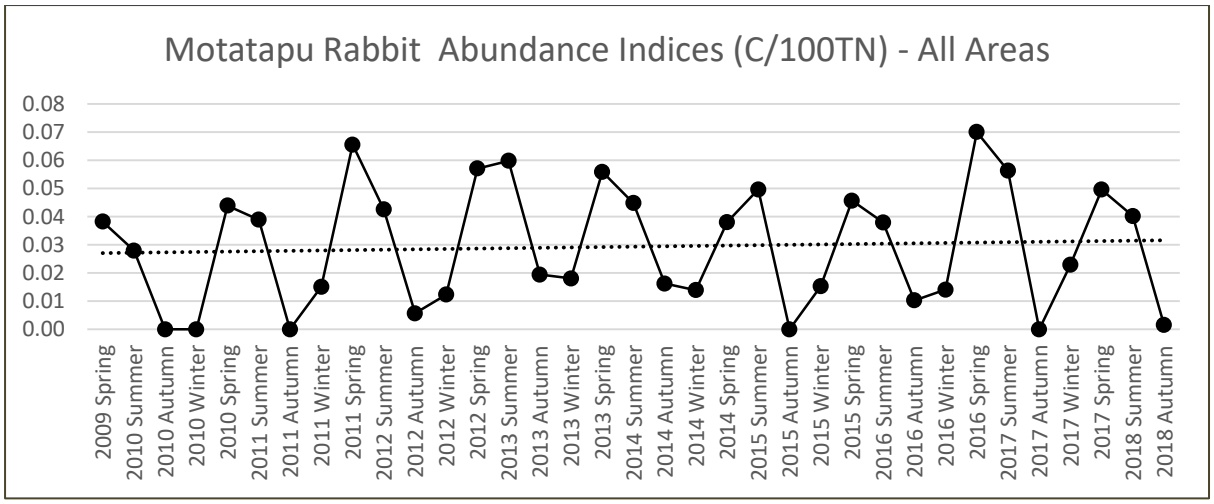

Figure 7: Rabbits.

Key conclusions from the trends in catch per unit of effort (CPUE) are:

- Ferrets and cat control is not yet being demonstrated. Ferret densities measured in central Otago were estimated at between 2 and 5km^2 (Middlemiss 1995, Moller *et al.* 1996) but this was before RHD reduced rabbit populations and the consequent decline in predators (Norbury *et al.* 2002). Conservatively, there might be several hundred ferrets as a mean population across the 45 km^2 trapped area of Motatapu Station, so an annual average kill of about 50 animals is unlikely to be effective at reducing their impacts on indigenous prey, let alone the more fragile introduced populations of weka at risk to all sorts of Allee effects[1] that accompany low population sizes.

- Both stoat and weasel populations have trended lower over the period since 2010. Whether this is a result of the trapping (only 84 stoats were trapped per year over the trapped area although normal densities in such habitats have not been estimated), or as a

[1] Allee effects are broadly defined as a decline in individual fitness at low population size or density, that can result in critical population thresholds below which populations crash to extinction.

trophic result of the presence of ferrets in not clear, camera monitoring may assist understanding of this.

- Indices of cat density appear to vary about a declining trend, which is difficult to interpret. the density is likely to be much higher than trap data suggests, a result being anecdotally supported by the early review of camera data (Palmer, pers comm). Improved cat monitoring and more targeted control is required to better understand the effectiveness of control.
- Rat abundance has declined.
- Rabbit densities have fluctuated according to the CPUE data however trapping is likely to be a poor measure of rabbit density and spotlight count trends would provide more useful information.
- Hedgehogs, as elsewhere, show no yearly trend despite a large number being killed.

EXPECTED AND ACTUAL BENEFITS FOR BIODIVERSITY GOALS

Attempts to reintroduce weka have, to date, failed so the primary goal has not been met. Failure to reintroduce weka has also occurred on Banks Peninsula but diagnosing the cause is difficult. Allee effects - essentially the role of bad luck when densities are very low - is common and many reintroductions rely on large release numbers and/or many releases to improve success rates, as well as soft-release strategies tried in the Motatapu example.

A further trial release of a larger number of weka is being planned but remains contingent upon demonstrated reductions in the density of ferret and cat populations and sustained low density stoat populations. New target densities/abundance indices/occupancy rates for these predators are yet to be determined in consultation with the Recovery Group.

Target control indices for the 2012 release were all exceeded at the time of release; however these indices proved to be insufficient and the impact of rogue animals were likely to have been under-estimated.

0.25 C/100 TN	Stoats
0.15 C/100TN	Ferrets
0.20 C/100TN	Cats

The learning from the Motatapu trapping effort will contribute to the information base of other open country projects seeking to control ferrets and cats in support of ground nesting birds.

EFFECTS OF FOREST MAST EVENTS AND SUBSEQUENT AERIAL 1080 APPLICATION ON TRAPPING RESULTS

Sets of trapping data collected by community groups or DOC and provided to Wildlands were used to explore the effects of mast events and aerial 1080 application within beech forests on the abundance of key pests, as indexed by trapping results, in areas adjacent to the forests. The first set is from the West Matukituki catchments from April 2016 to February 2019 to cover a period before and during a mast event and after an aerial 1080 baiting that DOC undertook in forest habitats in October 2017. The second set is trapping data collected before and after the 2016 mast and 1080 operation in the Wakatipu catchments.

Effect of aerial 1080 application on pests within forest habitats

The Department of Conservation measured the effect of the aerial baiting on rodents and stoats within the forests using tracking tunnels. Mice and rats populations were reduced in the Matukituki (no data for stoats) with the baiting being applied after the mast-induced irruptions (Table 1). Baiting applied before the mast-induced irruptions in the Makarora appears to have killed some mice (42% reduction) which was enough to kill the resident adult stoats but rats had not responded to the impending mast at that stage (Table 1). Effects of the 1080 application on other species were not measured.

Table 1: Changes in tracking tunnel indices of animal densities following aerial 1080 baiting in the Matukituki areas (data from Department of Conservation's reports to the EPA at www.epa.govt.nz).

Species	Matukituki Tracking Index	
	Pre-1080 (late August 2017)	Post-1080 (early December 2018)
Mice	29	1
Rats	18	0
Stoats	8	No data

Effects of trapping

Trapping by the Matukituku Charitable Trust in the West Matukituki used kill-trap devices (see section 4.4 for details on trap devices and relative success rates) and a variety of baits and lures (Erayz with and without eggs are the most common lure but we have not analysed the relative effectiveness of the options). The traps were generally set and checked every month.

Based on these data, and ignoring the effects of habitat as the traps were not distributed evenly across all habitats, the best trap to target rodents and stoats is the DOC200, the best to target possums is the Trapinator, and the best to target hedgehogs, rabbits, cats and possibly also rats is the DOC250. There appears little benefit from using the DOC200 double-set traps (compared with single DOC200s or DOC250s).

Goodnature A12 and A24 traps used in the Matukituki are multiple-kill traps so the trapping effort cannot be measured in the same units as single-kill traps, and evidence from carcasses may not be the same as that counting dead animals in the single-kill traps. The tallies (43 possums for the A12s and 54 mice for the A24s) have to be seen as minimum known to have

died as some victims may have been moved or scavenged. Use of A12 and A24 traps is discussed in Section 4.

Mice

Mice in the Matukituki did not respond to the 2017 mast event (possibly because rats did) but were affected by the 1080 operation in October 2017 (as were the rats) judging by both the trap-catch data (Figure 1a) and the Department's tracking tunnel data (Table 1) but recovered somewhat by autumn 2018.

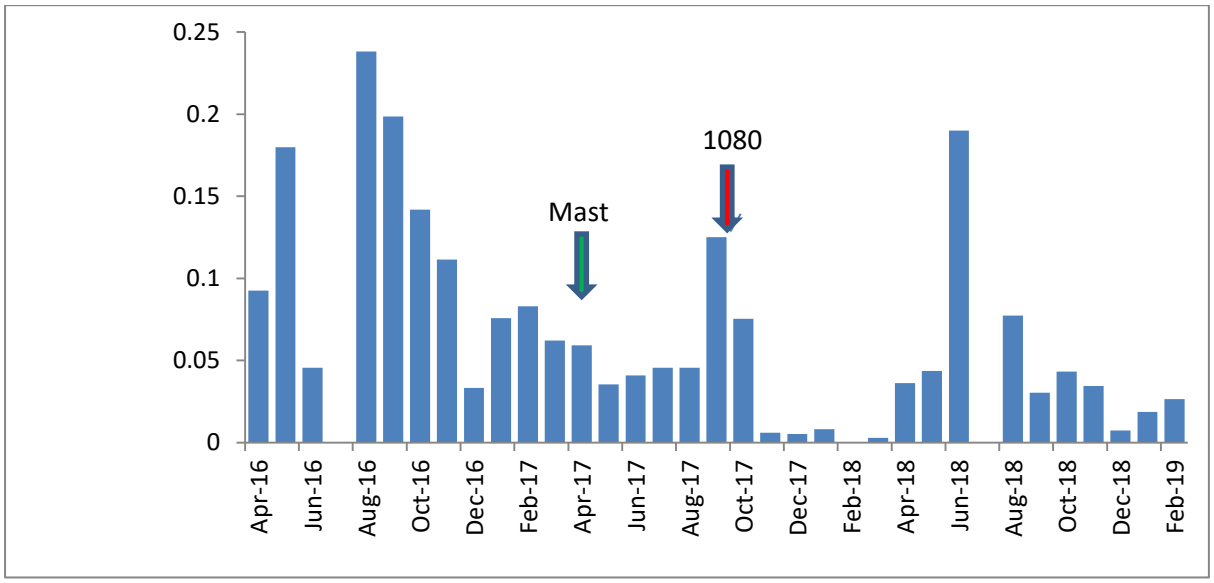

Figure 1a: Monthly index of mouse density from DOC200s, DOC200s double set, and DOC250 traps (all pooled) in trap lines in the West Matukituki catchment between April 2016 and February 2019 across a mast and 1080 aerial baiting in adjacent forests.

Ship rats

In the Matukituki, ship rats responded to the 2017 mast and were affected by the October aerial 1080 application judging by both the tracking tunnel indices (Table 1) and the trap-catch data. They did not appear to recover in 2018/19 (Figure 2a).

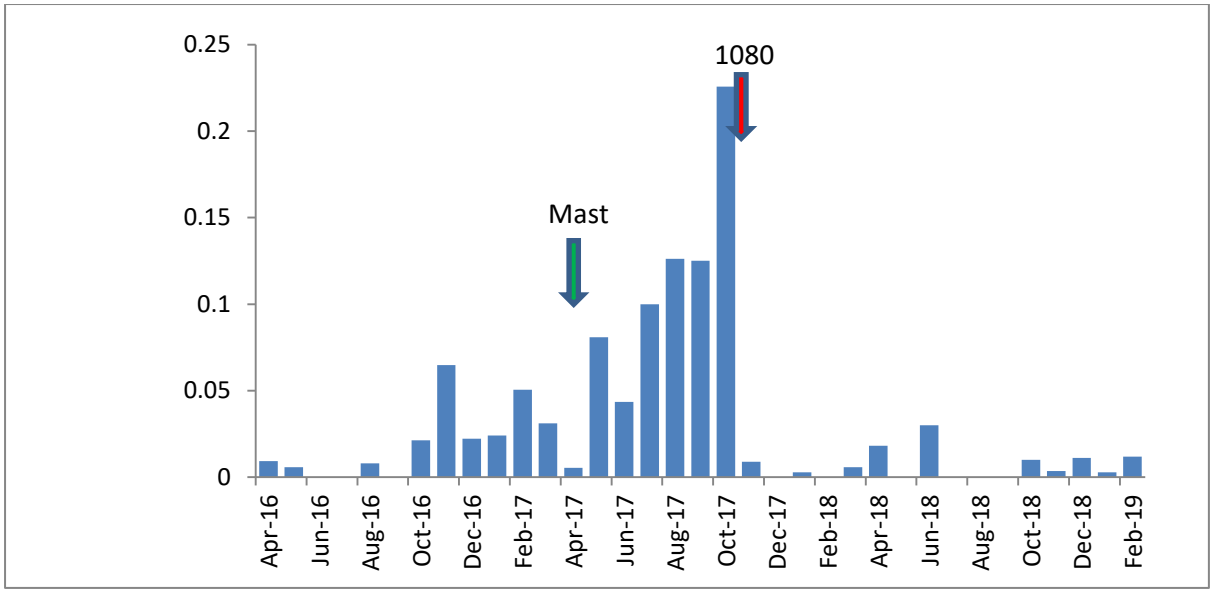

Figure 2a: Monthly index of rat density in DOC200s, DOC200s double set, and DOC250 traps in trap lines set in the West Matukituki catchment between April 2016 and February 2019 across a mast and 1080 aerial baiting operation.

Stoats

Trap indices for stoat numbers (all adults by this stage) declined over winter 2017 despite an increase in potential rodent prey. The 1080 operation may have reduced the number of juvenile stoats as evidenced by the low trap-index in spring/summer 2017 compared with 2018/19.

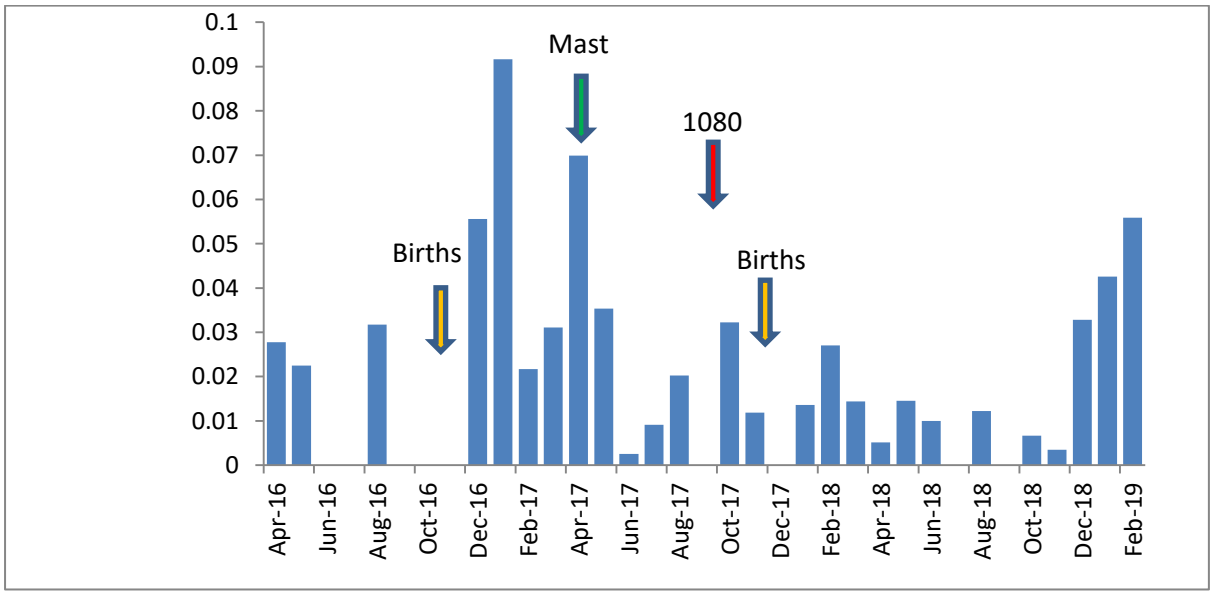

Figure 3a: Monthly indices of stoat density from DOC200s. DOC200s double set and DOC250 traps (all pooled) in trap lines in the West Matukituki catchment between April 2016 and February 2019 across a mast and aerial 1080 operations undertaken and two birth pulses of stoats.

Hedgehogs

Hedgehogs are probably not affected by masting. Mast events do trigger an increase in invertebrates but hedgehogs largely hibernate between late autumn and early spring (Jones & Sanders 2005) they largely miss the flush of food consequent on the beech mast. They appear largely unaffected by the aerial 1080 operations undertaken.

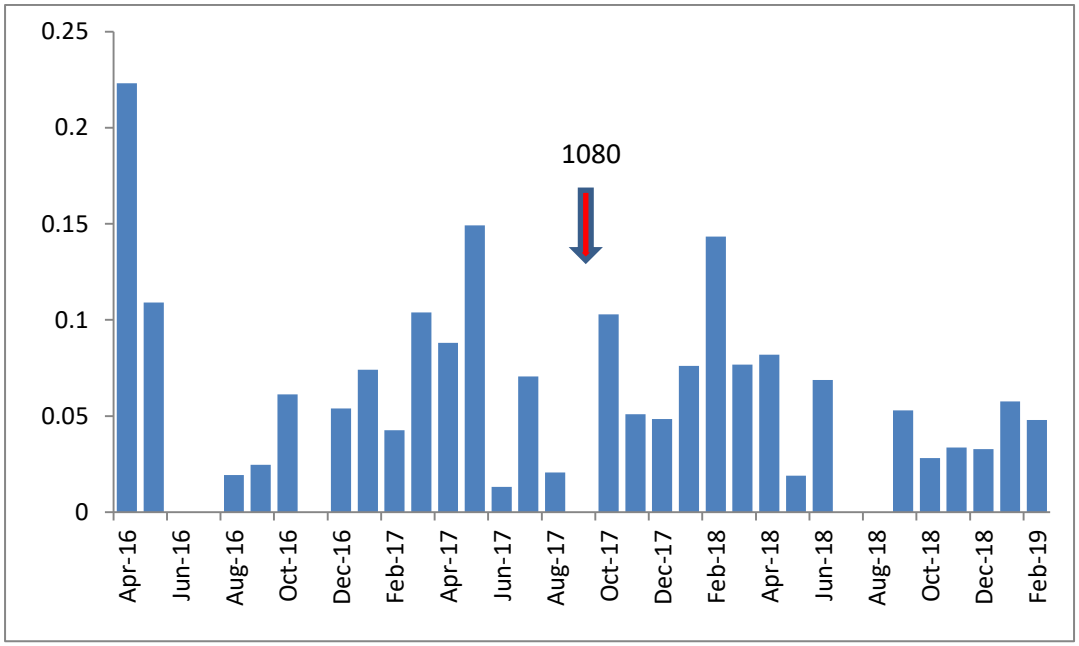

Figure 4: Monthly indices of hedgehog densities from DOC200s, DOC200s double-set and DOC250 traps on trap-lines in the West Matukituki catchment between April 2016 and February 2019.

Possums

Trap-indices for possum numbers did not appear to be much affected by the 2017 1080 aerial operation in the Matukituki, possibly because the 2017 populations contained a significant proportion of individuals that had survived the 2014 aerial 1080 operation and were bait-shy. The Department of Conservation also notes that many of the Trapinator traps set for possums were located away from areas where 1080 was applied.

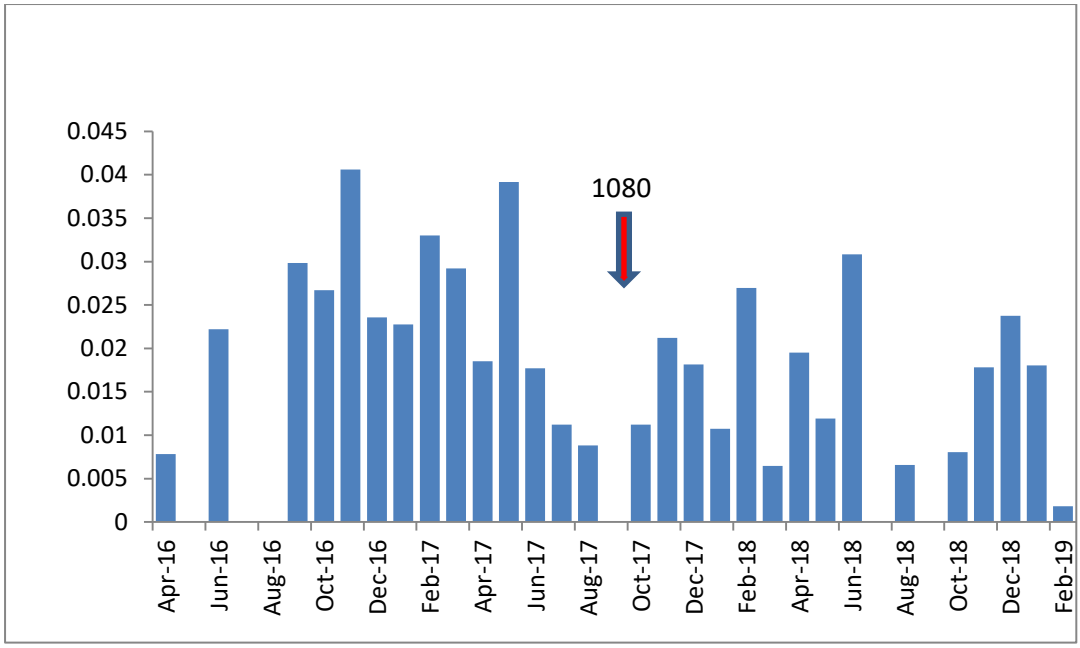

Figure 5: Monthly indices of possum densities (mostly from Trapinator traps) on trap-lines in the West Matukituki between April 2016 and February 2019.

The second data set covers the trapping of rats and stoats across the pre-mast, 2016 mast and subsequent 1080 baiting in the Wakatipu catchments.

The CPUE data for rats suggest an increase in May in both non-mast and mast years (Fig. 6) and lower indices in both summers.

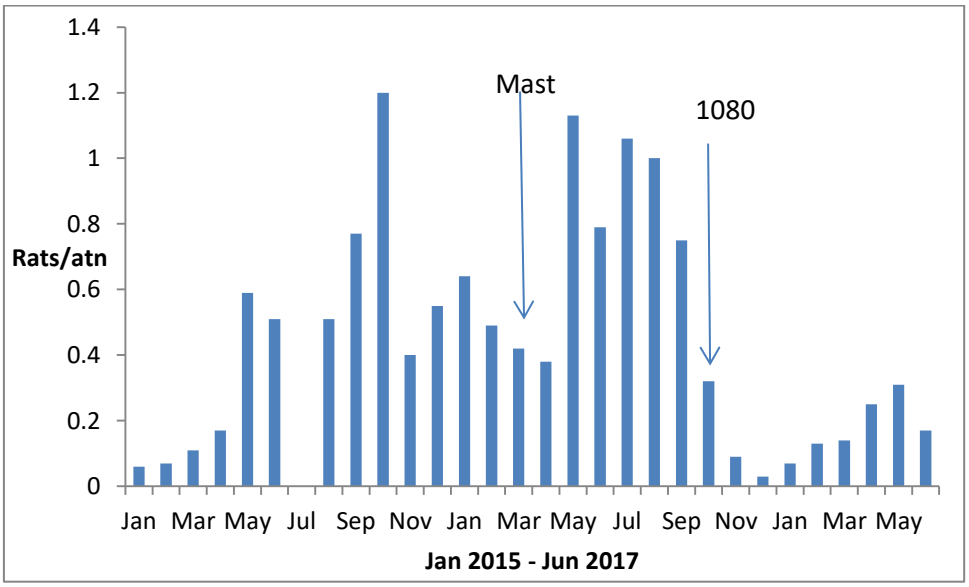

Figure 6. CPUE for rats in the trap-lines in the Wakatipu catchments, January 2015 to June 20177 across a mast and 1080 baiting

Stoat CPUE indices peaked as expected each summer as juveniles enter the population. The 1080 baiting in spring 2016 appeared to have lessened the peak (Fig. 7)

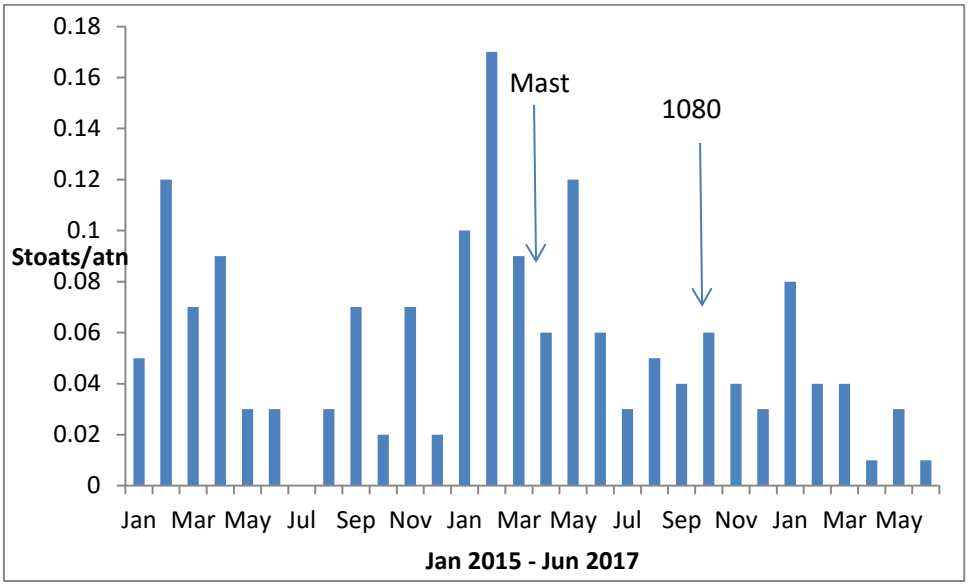

Figure 7. CPUE for stoats across a mast-1080 baiting operation in the Wakatipu catchments

COSTING FRAMEWORK FOR EVALUATION OF POTENTIAL INTENSIFICATION OF PEST CONTROL OPERATIONS

				Volunteers										
				Set-up Costs						Annual Operation Costs				
Hub	Valley	Area (ha)	Estimated Number Of Traps[1]	Estimated Trap Costs[2]	Fixings, Tags, Signage, etc.[3]	Estimated Bait Costs[4]	Labour Costs - Volunteers Only[5]	Transport[6]	Set Up Costs - Volunteers	Estimated Bait Costs[4]	Labour Costs - Volunteers Only[5]	Transport[9]	Maintenance and Servicing[10]	Total Annual Operation Costs - Volunteers
				$ 125/trap	$ 8.85/trap	$ 0.62/trap	$ 2.94/trap	Remote Valleys: $ 6400 Local sites: $ 252		12 Visits at $ 0.62/trap	12 Visits at $ 2.94/trap	Remote Valleys: $ 1250/visit Local sites: $ 126/visit	$ 1.33/trap	
Makarora	Blue River	2014	168	$20,979.17	$1,485.33	$104.06	$493.43	$6,400.00	$29,461.98	$1,248.68	$5,921.16	$15,000.00	$223.22	$22,393.06
	Upper Makarora River	1647	137	$17,156.25	$1,214.66	$85.10	$403.52	$6,400.00	$25,259.52	$1,021.14	$4,842.18	$15,000.00	$182.54	$21,045.86
	Lower Makarora River	4085	340	$42,552.08	$3,012.69	$211.06	$1,000.83	$6,400.00	$53,176.65	$2,532.70	$12,009.90	$15,000.00	$452.75	$29,995.35
	Wilkin River	7238	603	$75,395.83	$5,338.03	$373.96	$1,773.31	$6,400.00	$89,281.13	$4,487.56	$21,279.72	$15,000.00	$802.21	$41,569.49
Lake Wanaka	Matukituki River	654	55	$6,812.50	$482.33	$33.79	$160.23	$252.00	$7,740.85	$405.48	$1,922.76	$1,512.00	$72.49	$3,912.73
	Lookout Hill	1046	87	$10,895.83	$771.43	$54.04	$256.27	$252.00	$12,229.57	$648.52	$3,075.24	$1,512.00	$115.93	$5,351.69
	Motatapu River	1308	109	$13,625.00	$964.65	$67.58	$320.46	$252.00	$15,229.69	$810.96	$3,845.52	$1,512.00	$144.97	$6,313.45
	Bishops Bay	1157	96	$12,052.08	$853.29	$59.78	$283.47	$252.00	$13,500.61	$717.34	$3,401.58	$1,512.00	$128.23	$5,759.15
	Roys Peninsula	572	48	$5,958.33	$421.85	$29.55	$140.14	$252.00	$6,801.88	$354.64	$1,681.68	$1,512.00	$63.40	$3,611.72
Queenstown	Queenstown	39182	3265	$408,145.83	$28,896.73	$2,024.40	$9,599.59	$252.00	$448,918.55	$24,292.84	$115,195.08	$1,512.00	$4,342.67	$145,342.59
Glenorchy	Rees River	3786	316	$39,437.50	$2,792.18	$195.61	$927.57	$6,400.00	$49,752.86	$2,347.32	$11,130.84	$15,000.00	$419.62	$28,897.78
	Diamond Lake	2324	194	$24,208.33	$1,713.95	$120.07	$569.38	$6,400.00	$33,011.74	$1,440.88	$6,832.56	$15,000.00	$257.58	$23,531.02
	Greenstone River (reinvasion buffer)	5702	475	$59,395.83	$4,205.23	$294.60	$1,396.99	$6,400.00	$71,692.65	$3,535.24	$16,763.88	$15,000.00	$631.97	$35,931.09
	Eastern side of Wakatipu (reinvasion buffer)	1336	111	$13,916.67	$985.30	$69.03	$327.32	$252.00	$15,550.31	$828.32	$3,927.84	$1,512.00	$148.07	$6,416.23

				Contractors / DOC Employees										
				Set-up Costs						Annual Operation Costs				
Hub	Valley	Area (ha)	Estimated number of traps[1]	Estimated Trap Costs[2]	Fixings, Tags, Signage, etc.[3]	Estimated Bait Costs[4]	Labour Costs - Set Up[5]	Transport[6]	Set Up Costs - Contractors	Estimated Bait Costs[4]	Labour Costs[8]	Transport[9]	Maintenance and Servicing[10]	Total annual Operation Costs - Contractors
				$ 125/trap	$ 8.85/trap	$ 0.62/trap	$ 29.37/trap	Remote Valleys: $ 6400 Local sites: $ 252		12 Visits at $ 0.62/trap	12 Visits at $ 7.12/trap	Remote Valleys: $ 1250/visit Local Sites: $ 126/visit	$ 1.33/trap	
Makarora	Blue River	2014	168	$20,979.17	$1,485.33	$104.06	$4,929.27	$6,400.00	$33,897.81	$1,248.68	$14,339.68	$15,000.00	$223.22	$30,811.58
	Upper Makarora River	1647	137	$17,156.25	$1,214.66	$85.10	$4,031.03	$6,400.00	$28,887.04	$1,021.14	$11,726.64	$15,000.00	$182.54	$27,930.32
	Lower Makarora River	4085	340	$42,552.08	$3,012.69	$211.06	$9,998.04	$252.00	$56,025.87	$2,532.70	$29,085.20	$15,000.00	$452.75	$47,070.65
	Wilkin River	7238	603	$75,395.83	$5,338.03	$373.96	$17,715.01	$6,400.00	$105,222.83	$4,487.56	$51,534.56	$15,000.00	$802.21	$71,824.33
Lake Wanaka	Matukituki River	654	55	$6,812.50	$482.33	$33.79	$1,600.67	$252.00	$9,181.28	$405.48	$4,656.48	$1,512.00	$72.49	$6,646.45
	Lookout Hill	1046	87	$10,895.83	$771.43	$54.04	$2,560.09	$252.00	$14,533.39	$648.52	$7,447.52	$1,512.00	$115.93	$9,723.97
	Motatapu River	1308	109	$13,625.00	$964.65	$67.58	$3,201.33	$252.00	$18,110.56	$810.96	$9,312.96	$1,512.00	$144.97	$11,780.89
	Bishops Bay	1157	96	$12,052.08	$853.29	$59.78	$2,831.76	$252.00	$16,048.91	$717.34	$8,237.84	$1,512.00	$128.23	$10,595.41
	Roys Peninsula	572	48	$5,958.33	$421.85	$29.55	$1,399.97	$252.00	$8,061.71	$354.64	$4,072.64	$1,512.00	$63.40	$6,002.68
Queenstown	Queenstown	39182	3265	$408,145.83	$28,896.73	$2,024.40	$95,897.95	$252.00	$535,216.91	$24,292.84	$278,975.84	$1,512.00	$4,342.67	$309,123.35
Glenorchy	Rees River	3786	316	$39,437.50	$2,792.18	$195.61	$9,266.24	$6,400.00	$58,091.52	$2,347.32	$26,956.32	$15,000.00	$419.62	$44,723.26
	Diamond Lake	2324	194	$24,208.33	$1,713.95	$120.07	$5,687.99	$6,400.00	$38,130.35	$1,440.88	$16,546.88	$15,000.00	$257.58	$33,245.34
	Greenstone River (reinvasion buffer)	5702	475	$59,395.83	$4,205.23	$294.60	$13,955.65	$6,400.00	$84,251.31	$3,535.24	$40,598.24	$15,000.00	$631.97	$59,765.45
	Eastern side of Wakatipu (reinvasion buffer)	1336	111	$13,916.67	$985.30	$69.03	$3,269.86	$252.00	$18,492.85	$828.32	$9,512.32	$1,512.00	$148.07	$12,000.71

Cost assumptions are presented at the end of Appendix 7.

COSTING FRAMEWORK FOR NEW HUBS AND REINVASION BUFFERS FOR PEST CONTROL OPERATIONS

			Volunteers										
			Set-up Costs						Annual Operation Costs				
Hub	Area (ha)	Estimated Number of Traps[1]	Estimated Trap Costs[2]	Fixings, Tags, Signage, etc.[3]	Estimated Bait Costs[4]	Labour Costs - Volunteers Only[5]	Transport[6]	Set Up Costs - Volunteers	Estimated Bait Costs[4]	Labour Costs - Volunteers Only[5]	Transport[9]	Maintenance and Servicing[10]	Total Annual Operation Costs - Volunteers
			$ 125/trap	$ 8.85/trap	$ 0.62/trap	$ 2.94/trap	Remote Valleys: $ 6400 Local Sites: $ 252		12 Visits at $ 0.62/trap	12 Visits at $ 2.94/trap	Remote Valleys: $ 1250/visit Local Sites: $ 126/visit	$ 1.33/trap	
Crown Range Lizard	8157	680	$84,968.75	$6,015.79	$421.45	$1,998.47	$3,200.00	$96,604.45	$5,057.34	$23,981.58	$1,512.00	$904.07	$31,454.99
Reinvasion Buffer - Normal trap density	12989	1082	$135,302.08	$9,579.39	$671.10	$3,182.31	$6,400.00	$155,134.87	$8,053.18	$38,187.66	$15,000.00	$1,439.61	$62,680.45
Reinvasion Buffer - Half of normal trap density	12989	541	$67,651.04	$4,789.69	$335.55	$1,591.15	$6,400.00	$80,767.44	$4,026.59	$19,093.83	$15,000.00	$719.81	$38,840.23

			Contractors / DOC Employees										
			Set-up costs						Annual operation costs				
Hub	Area (ha)	Estimated Number of Traps[1]	Estimated Trap Costs[2]	Fixings, Tags, Signage, etc.[3]	Estimated Bait Costs[4]	Labour Costs - Set Up[5]	Transport[6]	Set Up Costs - Contractors	Estimated Bait Costs[4]	Labour Costs[8]	Transport[9]	Maintenance and Servicing[10]	Total Annual Operation Costs - Contractors
			$ 125/trap	$ 8.85/trap	$ 0.62/trap	$ 29.37/trap	Remote Valleys: $ 6400 Local sites: $ 252		12 Visits at $ 0.62/trap	12 Visits at $ 7.12/trap	Remote Valleys: $ 1250/visit Local Sites: $ 126/visit	$ 1.33/trap	
Crown Range Lizard	8157	680	$84,968.75	$6,015.79	$421.45	$19,964.26	$3,200.00	$114,570.24	$5,057.34	$58,077.84	$1,512.00	$904.07	$65,551.25
Reinvasion Buffer - Normal trap density	12989	1082	$135,302.08	$9,579.39	$671.10	$31,790.58	$6,400.00	$183,743.15	$8,053.18	$92,481.68	$15,000.00	$1,439.61	$116,974.47
Reinvasion Buffer - Half of normal trap density	12989	541	$67,651.04	$4,789.69	$335.55	$15,895.29	$6,400.00	$95,071.57	$4,026.59	$46,240.84	$15,000.00	$719.81	$65,987.24

Cost assumptions are presented at the end of Appendix 7.

COSTING FRAMEWORK FOR POTENTIAL CONNECTIONS BETWEEN PEST CONTROL OPERATIONS

				Volunteers										
				Set-Up Costs						Annual Operation Costs				
Connection	Length of Trapline (m)	Area (ha)	Estimated Number of Traps[1]	Estimated Trap Costs[2]	Fixings, Tags, Signage, etc.[3]	Estimated Bait Costs[4]	Labour Costs - Volunteers Only[5]	Transport[6]	Set up costs - volunteers	Estimated Bait Costs[4]	Labour Costs - Volunteers Only[5]	Transport[9]	Maintenance and Servicing[10]	Total Annual Operation Costs - Volunteers
				$ 125/trap	$ 8.85/trap	$ 0.62/trap	$ 2.94/trap	Remote valleys: $ 6400 Local sites: $ 252		12 visits at $ 0.62/trap	12 visits at $ 2.94/trap	Remote valleys: $ 1250/visit Local sites: $ 126/visit	$ 1.33/trap	
Dart-Rees to West Matukituki	13419	-	67	$8,386.88	$593.79	$41.60	$197.26	$6,400.00	$15,619.52	$499.19	$2,367.11	$15,000.00	$1,070.84	$18,937.13
Dart-Rees to West Matukituki with reinvasion buffer (normal trap density)		12989	1150	$143,688.96	$10,173.18	$712.70	$3,379.56	$6,400.00	$164,354.40	$8,552.37	$40,554.77	$15,000.00	$1,528.85	$65,635.99
Dart-Rees to West Matukituki with reinvasion buffer (half of normal trap density)		12989	608	$76,037.92	$5,383.48	$377.15	$1,788.41	$6,400.00	$89,986.96	$4,525.78	$21,460.94	$15,000.00	$809.04	$41,795.76
East Matukituki to the Wilkin	25269	-	126	$15,793.13	$1,118.15	$78.33	$371.45	$6,400.00	$23,761.07	$940.01	$4,457.45	$15,000.00	$2,016.47	$22,413.92
Mt. Soho Pest Control Project	-	5572	464	$58,041.67	$4,109.35	$287.89	$1,365.14	$3,200.00	$67,004.04	$3,454.64	$16,381.68	$1,512.00	$7,410.76	$28,759.08

				Contractors / DOC Employees										
				Set-Up Costs						Annual Operation Costs				
Connection	Length of Trapline (m)	Area (ha)	Estimated Number of Traps[1]	Estimated Trap Costs[2]	Fixings, Tags, Signage, etc.[3]	Estimated Bait Costs[4]	Labour Costs - set Up[5]	Transport[6]	Set up costs - contractors	Estimated Bait Costs[4]	Labour Costs[8]	Transport[9]	Maintenance and Servicing[10]	Total Annual Operation Costs - Contractors
				$ 125/trap	$ 8.85/trap	$ 0.62/trap	$ 29.37/trap	Remote valleys: $ 6400 Local sites: $ 252		12 Visits at $ 0.62/trap	12 Visits at $ 7.12/trap	Remote Valleys: $ 1250/visit Local Sites: $ 126/visit	$ 1.33/trap	
Dart-Rees to West Matukituki	13419	-	67	$8,386.88	$593.79	$41.60	$1,970.58	$6,400.00	$17,392.84	$499.19	$5,732.60	$15,000.00	$89.24	$21,321.02
Dart-Rees to West Matukituki with reinvasion buffer (normal trap density)		12989	1150	$143,688.96	$10,173.18	$712.70	$33,761.16	$6,400.00	$194,735.99	$8,552.37	$98,214.28	$15,000.00	$1,528.85	$123,295.49
Dart-Rees to West Matukituki with reinvasion buffer (half of normal trap density)		12989	608	$76,037.92	$5,383.48	$377.15	$17,865.87	$6,400.00	$106,064.42	$4,525.78	$51,973.44	$15,000.00	$809.04	$72,308.26
East Matukituki to the Wilkin	25269	-	126	$15,793.13	$1,118.15	$78.33	$3,710.75	$6,400.00	$27,100.36	$940.01	$10,794.92	$15,000.00	$168.04	$26,902.96
Mt. Soho Pest Control Project	-	5572	464	$58,041.67	$4,109.35	$287.89	$13,637.47	$3,200.00	$79,276.37	$3,454.64	$39,672.64	$1,512.00	$617.56	$45,256.84

Setup costs	Annual operation costs - Professional trappers	Annual operation costs - Volunteer trappers

Connection	Length of trapline (m)	Area (ha)	Estimated number of traps[1]	Estimated trap costs[2]	Estimated bait costs[3]	Labour costs - set up[4]	Set up costs	Estimated bait costs[3]	Labour costs (including transport)[5]	Total annual operation costs	Estimated bait costs[3]	Labour costs volunteers only[6]	Total annual operation costs
				85$/trap	0.66$/trap	15.33$/trap		12 visits at 0.66$/trap	12 visits at 11.62$/trap		12 visits at 0.66$/trap	12 visits at 3.14$/trap	
Rees-Dart to West Matukituki	13419	-	67	$ 5,703.08	$ 44.28	$ 1,028.57	$ 6,775.92	$ 531.39	$ 9,355.73	$ 9,887.12	$ 531.39	$ 2,528.14	$ 3,059.53
East Matukituki to the Wilkin	25269	-	126	$ 10,739.33	$ 83.39	$ 1,936.87	$ 12,759.58	$ 1,000.65	$ 17,617.55	$ 18,618.20	$ 1,000.65	$ 4,760.68	$ 5,761.33
Mt. Soho Pest Control Project	-	5572	464	$ 39,468.33	$ 306.46	$ 7,118.23	$ 46,893.02	$ 3,677.52	$ 64,746.64	$ 68,424.16	$ 3,677.52	$ 17,496.08	$ 21,173.60
Total	**38688**	**5572**	**3224**	**$ 274,040.00**	**$ 2,127.84**	**$ 49,423.92**	**$ 325,591.76**	**$ 25,534.08**	**$ 449,554.56**	**$ 475,088.64**	**$ 25,534.08**	**$ 121,480.32**	**$ 147,014.40**

Cost assumptions:

[1]Based on a trap density of 1 trap per 12 hectares (traps are 200 metres apart and lines are 600 metres apart) for mustelid, possum, and feral cat.

[2] DOC200 trap (stainless steel) price was obtained by averaging the following prices:

Costing from Sarah Keeble (DOC)	$140.00
Average (takes into account confidential costs provided by other organizations)	$125.00

[3] Costs for fixings, tags and signage were based on the following cost estimates:

	# Traps	Cost	Cost/trap
Wanaka Backyard Trapping	72	$770.00	$10.69
Average (takes into account confidential costs provided by other organizations)			$8.85

[4] Bait prices were obtained by averaging the following prices (donated bait was not considered):

Bait	# traps	Total costs	Cost/trap	
Erayz	400	$175.00	$0.44	https://www.connovation.co.nz/erayz-blocks
Eggs	225	$50.00	$0.22	Annual costs for Central Otago-Lakes Branch of Forest and Bird: $ 600.00, assume eggs are replaced monthly
Costing from Sarah Keeble (DOC)	100	$375.00	$0.47	Bait (meat and eggs) for 8 trap checks for 100 traps
Average (takes into account confidential costs provided by other organizations)			$0.62	

[5] Labour costs for volunteer trappers were derived from the following cost estimates and exclude the value of volunteer hours (at living wage):

Operation costs	# Traps	Operating costs only	Labour cost/trap/visit
F&B Central Otago-Lakes Branch	403	$8,338.00	$1.72
Matukituki Charitable Trust	780	$29,163.00	$3.12
Longview Environmental Trust	350	$24,000.00	$5.71
Diamond Lake Conservation Trust	346	$1,500.00	$0.36
Otago Kiwi Recovery Trust	177	$12,500.00	$5.89
Whakatipu Wildlife Trust	1101	$26,718.00	$2.02
Wanaka Backyard Trapping	72	$1,651.00	$1.91
Average			$2.96

[6] Transport costs for set up:

For set up at remote sites accessed only by helicopters (Sarah Keeble (DOC)): 4 hours of helicopter at $ 1, 600.00 /hr

Local sites (setup 2 carloads)

For local sites accessed by car (Forest & Bird Makarora):	$ 3, 066.00/yr	$255.50	per trap check visit
For local sites accessed by car (Routeburn - Dart Wildlife Trust):	$ 750.00 /yr	$62.50	per trap check visit
Average (takes into account confidential costs provided by other organizations)		$126.00	

[7] Labour set up costs for contractors were derived from the following cost estimates:

Operation costs	# Traps	# Hours	Overnight allowance (20$/night) for remote valleys	Rate	Labour costs (assuming 12 visits)	Labour cost/trap/visit
Contractor costing from Sarah Keeble (DOC)	100	100	180	50	$5,180.00	$51.80
DOC staff costing from Sarah Keeble (DOC) - Sylvan edge	41	48	100	25	$1,300.00	$31.71
DOC staff costing from Sarah Keeble (DOC) - Sugarloaf	22	96	180	25	$2,580.00	$117.27
DOC staff costing from Sarah Keeble (DOC) - Beans Burn	176	250	480	25	$6,730.00	$38.24
Average (takes into account confidential costs provided by other organizations)						$29.37

[8] Labour costs for professional trappers were derived from the following cost estimates:

Operation costs	# Traps	# Hours	Overnight allowance (20$/night) for remote valleys	Rate	Labour costs (assuming 12 visits)	Labour cost / trap / visit	
Soho Property Ltd	652				$91,350.00	$11.24	includes vehicles, excludes Erayz bait (0.44$)
Contractor costing from Sarah Keeble (DOC)	100		240	50	$8,940.00	$11.18	
DOC staff costing from Sarah Keeble (DOC) - Sylvan edge	41	60		25	$1,500.00	$3.05	
DOC staff costing from Sarah Keeble (DOC) - Sugarloaf	22	96		25	$2,400.00	$9.09	
DOC staff costing from Sarah Keeble (DOC) - Beans Burn	176	480	960	25	$12,960.00	$6.14	
Average (takes into account confidential costs provided by other organizations)						$7.12	

[9] Transport costs for trap check:

For trap check at remote sites, half of the trip will be done via helicopter drop off (Sarah Keeble (DOC)): 1 helicopter dropoff = $2,500.00

Local sites (trap check 1 carload):

For local sites accessed by car (Forest & Bird Makarora):	$ 3, 066.00/yr	$255.50	per trap check visit
For local sites accessed by car (Routeburn - Dart Wildlife Trust):	$ 750.00 /yr	$62.50	per trap check visit
Average (takes into account confidential costs provided by other organizations)		$126.00	

[10] Maintenance and service costs were estimated to be $1.33 based on confidential information provided.

[11] For remote valleys that require more than 1 day to complete the trapline visit or the set-up, it is assumed that accommodation will be provided for free in DOC huts or in camping areas.

PRIORITISATION OF POTENTIAL OPTIONS FOR PREDATOR CONTROL

Options for Landscape-Scale Predator Control	Biodiversity Values											
	Presence of Indigenous Vegetation				Presence of Threatened and At Risk species				Connectivity with Existing Predator Control Initiatives			
	Landcover Classification	Category	Values	Score	Species Present	Category	Values	Score	Connectivity	Category	Values	Score
Weight				5				10				5
Intensification Makarora Hub												
Intensification - Blue River	Indigenous forest	Indigenous vegetation is dominant	1	5	Mohua (At Risk-Recovering) Kea (Threatened-Nationally Endangered) Whio (Threatened-Nationally Vulnerable) Forest bird species	>1 Threatened species present	1	10	Completely in BFOB 1080 areas Adjacent to existing trapping network	Completely in BFOB 1080 area	1	5
Intensification - Upper Makarora River	Indigenous forest	Indigenous vegetation is dominant	1	5	Kea (Threatened-Nationally Endangered) New Zealand falcon (At Risk-Recovering) - Widespread Fores bird species	1 Threatened species present	0.66	6.6	Completely in BFOB 1080 areas Adjacent to existing trapping network	Completely in BFOB 1080 area	1	5
Intensification - Lower Makarora River	Indigenous forest High producing exotic grassland	Indigenous vegetation dominant at higher elevation, high producing exotic grassland at low elevation	0.5	2.5	Wrybill (Threatened-Nationally Vulnerable) Black-fronted tern (Threatened-Nationally Endangered) Black-billed gull (Threatened-Nationally Critical) Banded dotterel (Threatened-Nationally Vulnerable) South Island pied oystercatcher (At Risk-Declining) Forest bird species Long-tailed bat (Threatened-Nationally Critical)	>1 Threatened species present	1	10	Partly in BFOB 1080 areas Adjacent to existing trapping network	Partly in BFOB 1080 area	0.75	3.75
Intensification - Wilkin River	Indigenous forest High producing exotic grassland	Indigenous vegetation dominant at higher elevation, high producing exotic grassland at low elevation	0.5	2.5	Rock wren (Threatened-Nationally Endangered) Kea (Threatened-Nationally Endangered) Whio (Threatened-Nationally Vulnerable) New Zealand falcon (At Risk-Recovering) - Widespread Forest bird species	>1 Threatened species present	1	10	Partly in BFOB 1080 areas Adjacent to existing trapping network	Partly in BFOB 1080 area	0.75	3.75
Intensification Lake Wanaka Hub												
Intensification - Matukituki River	Low producing grassland	Modified low producing grassland	0.25	1.25	Wrybill (Threatened-Nationally Vulnerable) Black-fronted tern (Threatened-Nationally Endangered) Black-billed gull (Threatened-Nationally Critical) Banded dotterel (Threatened-Nationally Vulnerable) South Island pied oystercatcher (At Risk-Declining) New Zealand falcon (At Risk-Recovering) - Widespread	>1 Threatened species present	1	10	Adjacent to BFOB 1080 area Adjacent to existing trapping network	Adjacent to BFOB 1080 area	0.5	2.5
Intensification - Lookout Hill	Low producing grassland	Modified low producing grassland	0.25	1.25	Unknown / poor Threatened and At Risk fauna habitat New Zealand falcon (At Risk-Recovering) - Widespread	Widespread At Risk species present & poor Threatened fauna habitat present	0	0	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Intensification - Motatapu River	Low producing grassland, regenerating and existing shrubland	Modified low producing grassland	0.25	1.25	Southern grass skink (At Risk-Declining) - Widespread New Zealand falcon (At Risk-Recovering) - Widespread	Widespread At Risk species present & poor Threatened fauna habitat present	0	0	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Intensification - Bishops Bay	Low producing grassland	Modified low producing grassland	0.25	1.25	Poor Threatened and At Risk fauna habitat New Zealand falcon (At Risk-Recovering) - Widespread	Widespread At Risk species present & poor Threatened fauna habitat present	0	0	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Intensification - Roys Peninsula	Low producing grassland	Modified low producing grassland	0.25	1.25	Poor Threatened and At Risk fauna habitat New Zealand falcon (At Risk-Recovering) - Widespread	Widespread At Risk species present & poor Threatened fauna habitat present	0	0	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Intensification Queenstown Hub												
Intensification Queenstown Hub	High producing exotic grassland	High producing exotic grassland	0	0	Australasian crested grebe (Threatened-Nationally Vulnerable) Black-fronted tern (Threatened-Nationally Endangered) Black-billed gull (Threatened-Nationally Critical) Banded dotterel (Threatened-Nationally Vulnerable) South Island pied oystercatcher (At Risk-Declining) Korero gecko (At Risk-Declining) Kawarau gecko (At Risk-Declining) Southern grass skink (At Risk-Declining) - Widespread Cryptic skink (At Risk-Declining) New Zealand falcon (At Risk-Recovering) - Widespread	>1 Threatened species present	1	10	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25

Options for Landscape-Scale Predator Control	Biodiversity Values											
	Presence of Indigenous Vegetation				Presence of Threatened and At Risk species				Connectivity with Existing Predator Control Initiatives			
	Landcover Classification	Category	Values	Score	Species Present	Category	Values	Score	Connectivity	Category	Values	Score
Intensification Glenorchy Hub												
Intensification - Rees River	Indigenous forest Low producing grassland	Indigenous vegetation dominant at higher elevation, modified low producing grassland at low elevation	0.75	3.75	Mohua (At Risk-Recovering) Long-tailed bat (Threatened-Nationally Critical) New Zealand falcon (At Risk-Recovering) - Widespread Kea (Threatened-Nationally Endangered) Rock wren (Threatened-Nationally Endangered) Forest bird species	>1 Threatened species present	1	10	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Intensification - Diamond Lake	Indigenous forest High producing exotic grassland	Indigenous vegetation dominant at higher elevation, high producing exotic grassland at low elevation	0.5	2.5	Mohua (At Risk-Recovering) Kea (Threatened-Nationally Endangered) Rock wren (Threatened-Nationally Endangered) Forest bird species Long-tailed bat (Threatened-Nationally Critical) Korero gecko (At Risk-Declining) Cryptic skink (At Risk-Declining) New Zealand falcon (At Risk-Recovering) - Widespread	>1 Threatened species present	1	10	Adjacent to BFOB 1080 area Adjacent to existing trapping network	Adjacent to BFOB 1080 area	0.5	2.5
Intensification - Greenstone River (reinvasion buffer)	Indigenous forest Low producing grassland	Indigenous vegetation dominant at higher elevation, modified low producing grassland at low elevation	0.75	3.75	Australasian bittern (Threatened-Nationally Critical)) Kea (Threatened-Nationally Endangered) Forest bird species New Zealand falcon (At Risk-Recovering) - Widespread	>1 Threatened species present	1	10	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Intensification - Eastern side of Wakatipu (reinvasion buffer)	Low producing grassland	Modified low producing grassland	0.25	1.25	Poor Threatened and At Risk fauna habitat New Zealand falcon (At Risk-Recovering) - Widespread	Widespread At Risk species present & poor Threatened fauna habitat present	0	0	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
New Hubs												
New Hub - Crown Range	Tall tussock grassland	Indigenous vegetation dominant at higher elevation, modified low producing grassland at low elevation	0.75	3.75	Kawarau gecko (At Risk-Declining) Southern grass skink (At Risk-Declining) - Widespread Cryptic skink (At Risk-Declining) Lakes skink (Threatened-Nationally Vulnerable) Orange spotted gecko (Threatened-Nationally Vulnerable) Nevis skink (Threatened-Nationally Vulnerable) New Zealand falcon (At Risk-Recovering) - Widespread	>1 Threatened species present	1	10	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25
Potential Hub - Richardson Mountains	Tall tussock grassland Low producing grassland Indigenous forest	Indigenous vegetation dominant at higher elevation, modified low producing grassland at low elevation	0.75	3.75	Korero gecko (At Risk-Declining) Takitimu gecko (Threatened-Nationally Vulnerable) New Zealand falcon (At Risk-Recovering) - Widespread Kea (Threatened-Nationally Endangered) New Zealand pipit (At Risk-Declining) Forest bird species	>1 Threatened species present	1	10	Isolated	Isolated	0	0
Connection												
Connection - Dart-Reese to West Matukituki	Tall tussock grassland Gravel and rock	Indigenous vegetation is dominant	1	5	New Zealand falcon (At Risk-Recovering) - Widespread Kea (Threatened-Nationally Endangered) Rock wren (Threatened-Nationally Endangered)	>1 Threatened species present	1	10	Adjacent to BFOB 1080 area Adjacent to existing trapping network	Adjacent to BFOB 1080 area	0.5	2.5
Connection - Dart-Rees to West Matukituki & Reinvasion Buffer (half of normal trap density)	Tall tussock grassland Gravel and rock Permanent snow and ice	Indigenous vegetation is dominant	1	5	Jewelled gecko (At Risk-Declining) New Zealand falcon (At Risk-Recovering) - Widespread Kea (Threatened-Nationally Endangered) Rock wren (Threatened-Nationally Endangered)	>1 Threatened species present	1	10	Adjacent to BFOB 1080 area Adjacent to existing trapping network	Adjacent to BFOB 1080 area	0.5	2.5
Connection - East Matukituki to Wilkin	Indigenous forest Tall tussock grassland Gravel and rock	Indigenous vegetation is dominant	1	5	New Zealand falcon (At Risk-Recovering) - Widespread Kea (Threatened-Nationally Endangered) Rock wren (Threatened-Nationally Endangered) Forest bird species	>1 Threatened species present	1	10	Partly in BFOB 1080 areas Adjacent to existing trapping network	Partly in BFOB 1080 area	0.75	3.75
Connection - Mt. Soho Control Project	Tall tussock grassland	Indigenous vegetation is dominant	1	5	Poor Threatened and At Risk fauna habitat New Zealand falcon (At Risk-Recovering) - Widespread	Widespread At Risk species present & poor Threatened fauna habitat present	0	0	Adjacent to existing trapping network	Adjacent to existing trapping network	0.25	1.25

Options for Landscape-Scale Predator Control	Biodiversity Values (Continued)															
	Capacity of Acting as a Reinvasion Buffer to Protect Areas with Important Biodiversity Values				Inclusion of Existing Geographical Barrier to Protect The Biodiversity				Presence of an Important Bird Area				Presence of a DOC Ecosystem Management Unit (EMU)			
	Reinvasion Buffer	Category	Values	Score	Geographical Barrier	Category	Values	Score	Important Bird Area	Category	Values	Score	EMU	Category	Values	Score
Weight				5				2				1				2
Intensification Makarora Hub																
Intensification - Blue River	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Intensification - Upper Makarora River	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Intensification - Lower Makarora River	Acts as a reinvasion buffer for the Wilkin River and the Young River.	Yes	1	5	No	No	0	0	Makarora Important Bird Area	Yes	1	1	No	No	0	0
Intensification - Wilkin River	No	No	0	0	No	No	0	0	Makarora Important Bird Area	Yes	1	1	Yes	Yes	1	2
Intensification Lake Wanaka Hub																
Intensification - Matukituki River	No	No	0	0	No	No	0	0	Matukituki River Important Bird Area	Yes	1	1	No	No	0	0
Intensification - Lookout Hill	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Intensification - Motatapu River	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Intensification - Bishops Bay	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Intensification - Roys Peninsula	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Intensification Queenstown Hub																
Intensification Queenstown Hub	No	No	0	0	No	No	0	0	Shotover and Kawarau Rivers	Yes	1	1	No	No	0	0
Intensification Glenorchy Hub																
Intensification - Rees River	No	No	0	0	No	No	0	0	Dart Rees Rivers Important Bird Area	Yes	1	1	No	No	0	0
Intensification - Diamond Lake	No	No	0	0	No	No	0	0	Dart Rees Rivers Important Bird Area	Yes	1	1	No	No	0	0
Intensification - Greenstone River (reinvasion buffer)	Act as a reinvasion buffer for the Greenstone, Caples and the Route Burn valleys	Yes	1	5	Lake Wakatipu	Yes	1	2	Greenstone Caples Rivers Important Bird Area	Yes	1	1	No	No	0	0
Intensification - Eastern side of Wakatipu (reinvasion buffer)	Act as a reinvasion buffer for the Dart and the Reese rivers	Yes	1	5	Lake Wakatipu	Yes	1	2	No	No	0	0	No	No	0	0
New Hubs																
New Hub - Crown Range	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Potential Hub - Richardson Mountains	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Connection																
Connection - Dart-Reese to West Matukituki	No	No	0	0	Presence of glaciers and snowy peaks	Yes	1	2	No	No	0	0	Yes	Yes	1	2
Connection - Dart-Rees to West Matukituki & Reinvasion Buffer (half of normal trap density)	Includes setting up a reinvasion buffer	Yes	1	5	Presence of glaciers and snowy peaks	Yes	1	2	No	No	0	0	Yes	Yes	1	2
Connection - East Matukituki to Wilkin	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0
Connection - Mt. Soho Control Project	No	No	0	0	No	No	0	0	No	No	0	0	No	No	0	0

Options for landscape-scale predator control	Feasibility														
	Set-Up Costs				Annual Operation Costs				Size of the Area				Likelihood of Community Uptake		
	Cost	Category	Values	Score	Cost	Category	Values	Score	Size (ha)	Category	Values	Score	Category	Values	Score
Weight				5				5				5			5
Intensification Makarora Hub															
Intensification - Blue River	$31,679.90	Moderate ($25,000 - $50,000)	0.5	2.5	$26,602.32	Moderate ($25,000 - $50,000)	0.5	2.5	2014	Small (<2,500 ha)	1	5	Likely	0.5	2.5
Intensification - Upper Makarora River	$27,073.28	Moderate ($25,000 - $50,000)	0.5	2.5	$24,488.09	Low (<$25,000)	1	5	1647	Small (<2,500 ha)	1	5	Likely	0.5	2.5
Intensification - Lower Makarora River	$54,601.26	High (>$50,000)	0	0	$38,533.00	Moderate ($25,000 - $50,000)	0.5	2.5	4085	Medium (2,500 - 7,500 ha)	0.5	2.5	Likely	0.5	2.5
Intensification - Wilkin River	$97,251.98	High (>$50,000)	0	0	$56,696.91	High (>$50,000)	0	0	7238	Medium (2,500 - 7,500 ha)	0.5	2.5	Likely	0.5	2.5
Intensification Lake Wanaka Hub															
Intensification - Matukituki River	$8,461.06	Low (<$25,000)	1	5	$5,279.59	Low (<$25,000)	1	5	654	Small (<2,500 ha)	1	5	Likely	0.5	2.5
Intensification - Lookout Hill	$12,229.57	Low (<$25,000)	1	5	$5,351.69	Low (<$25,000)	1	5	1046	Small (<2,500 ha)	1	5	Very likely	1	5
Intensification - Motatapu River	$15,229.69	Low (<$25,000)	1	5	$6,313.45	Low (<$25,000)	1	5	1308	Small (<2,500 ha)	1	5	Very likely	1	5
Intensification - Bishops Bay	$13,500.61	Low (<$25,000)	1	5	$5,759.15	Low (<$25,000)	1	5	1157	Small (<2,500 ha)	1	5	Very likely	1	5
Intensification - Roys Peninsula	$6,801.88	Low (<$25,000)	1	5	$3,611.72	Low (<$25,000)	1	5	572	Small (<2,500 ha)	1	5	Very likely	1	5
Intensification Queenstown Hub															
Intensification Queenstown Hub	$492,067.73	High (>$50,000)	0	0	$227,232.97	High (>$50,000)	0	0	39182	Large (>7,500 ha)	0	0	Very likely	1	5
Intensification Glenorchy Hub															
Intensification - Rees River	$53,922.19	High (>$50,000)	0	0	$36,810.52	Moderate ($25,000 - $50,000)	0.5	2.5	3786	Medium (2,500 - 7,500 ha)	0.5	2.5	Likely	0.5	2.5
Intensification - Diamond Lake	$35,571.04	Moderate ($25,000 - $50,000)	0.5	2.5	$28,388.18	Moderate ($25,000 - $50,000)	0.5	2.5	2324	Small (<2,500 ha)	1	5	Likely	0.5	2.5
Intensification - Greenstone River (reinvasion buffer)	$77,971.98	High (>$50,000)	0	0	$47,848.27	Moderate ($25,000 - $50,000)	0.5	2.5	5702	Medium (2,500 - 7,500 ha)	0.5	2.5	Likely	0.5	2.5
Intensification - Eastern side of Wakatipu (reinvasion buffer)	$17,021.58	Low (<$25,000)	1	5	$9,208.47	Low (<$25,000)	1	5	1336	Small (<2,500 ha)	1	5	Likely	0.5	2.5
New Hubs															
New Hub - Crown Range	$105,587.34	High (>$50,000)	0	0	$48,503.12	Moderate ($25,000 - $50,000)	0.5	2.5	8157	Large (>7,500 ha)	0	0	Very likely	1	5

Options for landscape-scale predator control	Feasibility														
	Set-Up Costs				Annual Operation Costs				Size of the Area				Likelihood of Community Uptake		
	Cost	Category	Values	Score	Cost	Category	Values	Score	Size (ha)	Category	Values	Score	Category	Values	Score
Potential Hub - Richardson Mountains	Not costed. Unknown if predator control will be done in all the identified area, but presumed it will be high.	High (>$50,000)	0	0	Not costed. Unknown if predator control will be done in all the identified area, but presumed it will be high.	High (>$50,000)	0	0	Area of predator control was not defined due to uncertainty, but presumed it would be large.	Large (>7,500 ha)	0	0	Unknown	0	0
Connection															
Connection - Dart-Reese to West Matukituki	$16,506.18	Low (<$25,000)	1	5	$20,129.08	Low (<$25,000)	1	5	805	Small (<2,500 ha)	1	5	Likely	0.5	2.5
Connection - Dart-Rees to West Matukituki & Reinvasion Buffer (half of normal trap density)	$98,025.69	High (>$50,000)	0	0	$57,052.01	High (>$50,000)	0	0	13794	Large (>7,500 ha)	0	0	Likely	0.5	2.5
Connection - East Matukituki to Wilkin	$25,430.72	Moderate ($25,000 - $50,000)	0.5	2.5	$24,658.44	Low (<$25,000)	1	5	1516	Small (<2,500 ha)	1	5	Likely	0.5	2.5
Connection - Mt. Soho Control Project	$73,140.21	High (>$50,000)	0	0	$37,007.96	Moderate ($25,000 - $50,000)	0.5	2.5	5572	Medium (2,500 - 7,500 ha)	0.5	2.5	Unknown	0	0

Options for Landscape-Scale Predator Control	Probability of success Capacity of Acting as a Reinvasion Buffer to Protect Areas with Important Biodiversity Values Justification	Category	Values	Score	Total Score
Weight				20	**70**
Intensification Makarora Hub					
Intensification - Blue River	Small area with multiple threatened species and intact indigenous habitat in a sector already targeted for BFOB 1080 treatment	High	1	20	**52.5**
Intensification - Upper Makarora River	Small area with threatened species and intact indigenous habitat in a sector already targeted for BFOB 1080 treatment	High	1	20	**51.6**
Intensification - Lower Makarora River	Moderate sized area with multiple threatened species and including sectors of indigenous habitat and sectors already targeted for BFOB 1080 treatment. Considered as a reinvasion buffer that would protect braided river habitat and the Young and Wilkins valleys	High	1	20	**49.75**
Intensification - Wilkin River	Moderate sized area with multiple threatened species and including sectors of indigenous habitat and sectors already targeted for BFOB 1080 treatment.	High	1	20	**44.25**
Intensification Lake Wanaka Hub					
Intensification - Matukituki River	Small area with multiple threatened species with modified habitat in a sector with a high density of traps	Moderate	0.5	10	**42.25**
Intensification - Lookout Hill	Small area with low biodiversity value, close to a town centre	Low	0	0	**22.5**
Intensification - Motatapu River	Small area with low biodiversity value, close to a town centre	Low	0	0	**22.5**
Intensification - Bishops Bay	Small area with low biodiversity value, close to a town centre	Low	0	0	**22.5**
Intensification - Roys Peninsula	Small area with low biodiversity value, close to a town centre	Low	0	0	**22.5**
Intensification Queenstown Hub					
Intensification Queenstown Hub	Large area with Threatened and At Risk species and modified habitat, close to a town centre	Moderate	0.5	10	**27.25**
Intensification Glenorchy Hub					
Intensification - Rees River	Moderate sized area with multiple threatened species and intact indigenous habitat.	Moderate	0.5	10	**33.5**
Intensification - Diamond Lake	Small area with multiple threatened species and including sectors of indigenous habitat in an area of high density of traps.	Moderate	0.5	10	**38.5**
Intensification - Greenstone River (reinvasion buffer)	Moderate sized area with one threatened species and including sectors of indigenous habitat. Considered as a reinvasion buffer that would protect the Caples, Greenstone and Route Burn valleys. Benefits from Lake Wakatipu as a geographic barrier.	High	1	20	**50.5**
Intensification - Eastern side of Wakatipu (reinvasion buffer)	Small area with no Threatened or locally uncommon At Risk species. Considered as a reinvasion buffer that would protect the Rees and Dart valleys.	High	1	20	**47**
New Hubs					
New Hub - Crown Range	Moderate sized area with multiple threatened lizard species with a mix of intact indigenous habitat and modified habitat. Close to town centres	Moderate	0.5	10	**32.5**
Potential Hub - Richardson Mountains	Large area with Threatened and At Risk species and a mix of intact indigenous habitat and modified habitat, close to a town centre	Moderate	0.5	10	**23.75**
Connection					
Connection - Dart-Reese to West Matukituki	Small area with multiple threatened species and intact indigenous habitat. Short single trapline benefiting from geographic barrier.	Moderate	0.5	10	**49**
Connection - Dart-Rees to West Matukituki & Reinvasion Buffer (half of normal trap density)	Moderate sized area with multiple threatened species and intact indigenous habitat. Short single trapline benefiting from geographic barrier. Includes the set-up of a reinvasion buffer area.	High	1	20	**49**
Connection - East Matukituki to Wilkin	Small area with multiple threatened species and intact indigenous habitat. Long single trapline with high reinvasion risks	Low	0	0	**33.75**
Connection - Mt. Soho Control Project	Moderate size area with low biodiversity value, close to town centres. Adjacent to an area where cats and ferrets are not effectively controlled.	Low	0	0	**11.25**

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