Judas wallaby trial

Assessing the Judas technique for detecting Bennett's wallabies

Prepared for Otago Regional Council

19 June 2025

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Cover photograph: Still from thermal drone footage showing a collared Judas wallaby. Trap & Trigger Ltd.

Executive Summary

The Judas animal technique uses collared animals (e.g. satellite and/or VHF collar) to lead control operators to other individuals of the same species, significantly reducing the effort required to find and remove those conspecifics. This ‘proof-of-concept’ pilot trial aimed to assess whether the Judas animal technique may have utility in the detection of Bennett’s wallabies in low-density environments. We did not aim to directly compare the Judas animal technique to any other wallaby management practices.

In Phase 1 of the trial (Dec 2023 – Sep 2024), ten Bennett’s wallabies were captured from wild populations. These wallabies were kept in captivity for a short duration during which they were sterilised and fitted with a satellite/VHF radio collar. The wallabies were then released as Judas animals in ten different locations in South Canterbury, six within the wallaby containment area and four to the south of the containment area, where wallaby population density was estimated to be low based on data from the previous three years. The release sites were grouped into two general areas termed the Northern Group Area and the Southern Group Area. Monthly aerial control operations were undertaken from January to May 2024 in which Judas wallabies were tracked and conspecifics within 1 km of their location (and within the same catchment) were shot.

In Phase 2 (mid-Sep 2024 – Mar 2025), research methods were altered, due to longer-than-anticipated timeframes for contractors to reduce conspecific density during control operations in the Northern Group Area, and conspecifics being either absent or undetectable in the Southern Group Area. In September 2024 four Judas wallabies were relocated from the Northern Group Area to the Southern Group Area, within 2–3 km distance of the resident Judas wallabies in that area. Remotely-retrieved GPS data was used to determine the movements of the collared wallabies in relation to each other, including whether they located each other over the 2–3 km distance, and quantifying the amount of time spent within proximity of each other. Thus, the research in Phase 2 constituted a more detailed investigation of the spatial behaviour of the collared wallabies.

Key outcomes of the Judas wallaby pilot trial were:

- In Phase 1, Judas wallabies in the Northern Group Area largely remained close to their release site. Given that Judas wallabies in the Southern Group Area had substantially larger activity range areas during the same time period, it suggests that population density had an influence on the extent of ranging movements.

- A small number of long-distance dispersal movements were observed during this trial, including one Judas Wallaby in the Southern Group Area that travelled an approximately 50 km route over a two-week period.
- Estimated minimum daily movements from throughout the entire trial showed that male Judas wallabies tended to move larger distances than the females within the same trial area throughout the year. Males' movements were also more variable between seasons, with larger movements recorded in summer than in winter.
- Proximity analysis on three Judas wallabies showed that, despite substantial overlap in their ranging areas, Judas wallabies spent a very low proportion of their time in close proximity to each other.

While based on a very small sample size (n=11 for daily movements and n=3 for proximity analysis), these results give little support for the use of the Judas animal technique in Bennett's wallabies, if the expectation is that Judas wallabies would lead control operators directly to uncollared conspecifics. Based on our results, wallaby programme managers would not have high confidence that Judas wallabies would reliably locate conspecifics and remain in close proximity to them for a large proportion of the time.

Nevertheless, there is the opportunity for further research to determine to what extent (if at all) collared wallabies could reduce the search effort and cost required to find conspecifics in very-low-density areas. For instance, even if Judas wallabies do not reliably lead operators directly to conspecifics in real-time, they could potentially still reduce search area or frequency. Currently, the effort and cost required to surveil low-density areas is very high, with many areas having no wallabies present. Any knowledge which reduces the search area or frequency would be valuable.

CONTENTS

Introduction

1.1 Wallabies as a pest species

Native to Australia, Bennett's wallabies (*Notamacropus rufogriseus rufogriseus*) were introduced to Aotearoa New Zealand in the late 1800s. They have since established self-sustaining populations throughout Southern Canterbury and are increasing in numbers and range, with some wallabies present in Otago. Models predict that, without widespread intensive control, the range over which Bennett's wallabies are present may increase seven-fold within 50 years (D. M. Latham et al., 2019). Bennett's wallabies are considered to be a moderately gregarious species (A. D. M. Latham & Warburton, 2021), they are not a herding species but are commonly found associating in pairs or small groups.

Due to their negative impacts on native forests, agricultural productivity and the physical landscape, Bennett's wallabies (along with two other introduced wallaby species) are now considered to be a serious pest species in New Zealand (A. D. M. Latham & Warburton, 2021). Together, pest wallabies are estimated to cost tens of millions of dollars per annum in lost farm production and environmental benefits nationwide (Tipu Mātoro Wallaby Free Aotearoa, 2022). The Tipu Mātoro National Wallaby Eradication Programme (Tipu Mātoro) was established in 2020 to eradicate wallabies and protect New Zealand's natural and primary production environments. The programme's initial aim is to contain wallabies within designated areas by 2025 as the first step towards eradication. This involves:

- Eliminating outlier populations
- Reducing wallaby numbers within buffer areas inside containment, and
- Developing innovation in wallaby detection and control methods.

Current wallaby control methods include baiting, ground-based shooting, and aerial shooting. These methods have successfully reduced wallabies in local areas where wallaby density is high but are costly and logistically challenging to implement at the landscape scale and in low-density wallaby populations, such as in Otago and parts of South Canterbury. Tipu Mātoro recognises that innovation in wallaby detection and control methods is required to achieve the aims of containment and ultimately eradication. In particular, the ability to find wallabies at low and very-low densities is singled out as a critical research need.

1.2 The Judas animal technique

The Judas animal technique uses collared animals (e.g. fitted with a satellite and/or VHF collar) to lead control operators to other individuals of the same species (called 'conspecifics'), significantly reducing the search effort required. The Judas animal technique relies on gregarious tendencies, common to many mammalian species, which can create a strong desire for individuals to seek out conspecifics which are then dispatched by control operators. The Judas animals then continue to seek out further conspecifics in the area until no more individuals can be found. This technique has been successfully used with feral goats, pigs, and deer in eradication and control programmes internationally and in New Zealand (e.g. Campbell et al., 2004; Carrion et al., 2011; Crouchley et al., 2011; Cruz et al., 2009; Parkes et al., 2010; Ramsey et al., 2022).The use of the Judas technique is not limited to ungulate species; for example the technique has been used with wild turkeys (Morrison et al., 2016), and raccoon dogs (Sundin, 2024).

1.3 Research aims

The overall aim of this research was to assess whether, at proof-of-concept level, the Judas technique may have utility in the detection of Bennett's wallabies in very-low-density environments. The current tools and tactics for detecting Bennett's wallabies in very-low-density areas are expensive and unreliable. Some wallabies are missed, even with extensive ground and aerial-based searches, utilising trained dogs and thermal imaging equipment. The project addresses one of the critical research needs identified in Tipu Mātoro

– i.e. the ability to find wallabies at low densities. To our knowledge, this is the first time that the Judas technique has been tried with this species.

The 'Judas wallaby' technique has the potential to increase detection rates and accelerate the containment and eradication of Bennett's wallaby if successful. Tipu Mātoro and Otago Regional Council (ORC) support the need to assess the efficacy of Bennett's wallaby as a Judas animal and have committed to undertake research through an agreement for research services. The research detailed in this report was funded by Tipu Mātoro (via the Ministry for Primary Industries (MPI)) and ORC, who commissioned Boffa Miskell Ltd (BML) to project manage and deliver the research across the life of the project (2023-2025).

2.0 Overview of methods

This research was undertaken as a pilot trial in two phases, as described in Section 2.1. This overview section provides a description of methods which apply to both of the research phases. Figure 1 summarises the major phases of this pilot trial.

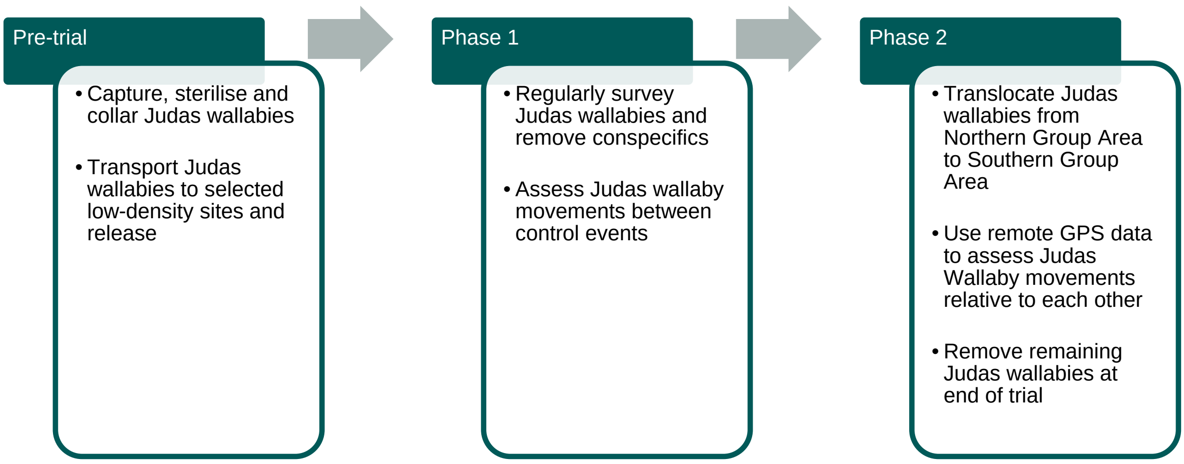

Figure 1: High-level overview of Judas Wallaby pilot trial methods.

2.1 Research Phases

2.1.1 Phase One

The initial objectives of the research were to:

1. Capture, sterilise, collar, and release 10 Judas wallabies in two trial areas (6 in the area referred to as the 'Northern Group Area' and 4 in the 'Southern Group Area').
2. Remove all conspecifics within a 1 km radius of each Judas wallaby once per month.
3. Assess Judas wallaby movement between control events.

The intention behind culling conspecifics each month was to create a social 'vacuum' around the collared wallabies, and then assess whether this would prompt them to seek out other conspecifics. The potential suitability of the Judas technique for Bennett's wallabies was to be assessed on a proof-of-concept basis by observing the movement of the Judas wallaby between control operations, and the number of conspecifics detected. However, this approach did not produce the expected results in the Northern Group Area due to the longer-than-anticipated timeframes to reduce conspecific density through control operations. Despite efforts to adjust monthly culling protocols to improve hunting efficacy, this issue wasn't resolved. Conversely, in the Southern Group Area, conspecifics appeared to be either absent or at such low density that they were undetectable. Consequently, in August 2024 a proposal was developed to modify the research approach for the remainder of the trial. The proposal was reviewed and approved by the Tipu Mātoro Research Advisory Group (RAG) and Environment Canterbury (ECan), and subsequently implemented in September 2024.

2.1.2 Phase Two

In Phase Two, the objectives of the research shifted in focus from monitoring Judas Wallaby movement in relation to un-collared conspecifics (i.e. the approach during Phase One), to instead tracking collared wallaby movements in relation to each other, which meant that the Judas wallabies were viewed as conspecifics to each other.

This was achieved by relocating Judas wallabies from the Northern Group Area to the Southern Group Area, within a 2-3 km distance of the resident Judas wallabies in that area. GPS data obtained from satellite collars was then used to determine the movements of the collared wallabies in relation to each other, including whether they located each other over the 2-3 km distance, and quantifying the amount of time spent within proximity of each other.

2.2 Release site selection

Ten Judas wallaby release sites were selected across South Canterbury (Figure 2) in consultation with Environment Canterbury. Six were within the wallaby containment area (referred to as the 'Northern Group Area') and four were outside (referred to as the 'Southern Group Area').

In the interest of generating sufficient data to assess the Judas wallaby technique on a 'proof-of-concept' level, the aim was to select sites within areas where wallaby population density was estimated to be low (approximately between 0.1-1.0 wallaby per km^2) The criteria for sites falling into the **low-density** category were:

- Wallabies estimated to be present at 0.1-1.0 per km^2
- At the upper limit of this category, there are no more than 100 wallabies in a 100 km^2 area.
- Difficult to detect wallabies, but it can be done with focused surveillance (e.g. contractors with dogs, thermal etc.)
- Isolated wallaby sign is present but not widespread
- Many 1 km grid squares have no wallabies, even at the upper limit of 1 per km^2.

It is acknowledged that application of these criteria was subjective, as actual population density was not known.

Sites in the Northern Group Area were expected to fall into the low-density category, due to prior wallaby control efforts in the area. Four collared wallabies (J15, J30, J35, J01) were released within areas subject to large-scale aerial 1080 poisoning in May and June 2023. Subsequent camera monitoring recorded very few wallaby detections through till at least mid-November the same year (less than a month before the Judas wallabies were released) (Morriss et al., 2024). The other two Northern Group Judas wallabies were released at sites which had undergone less recent control. The release site for J20 was subject to aerial 1080 in August 2021, and aerial shooting in October 2021, June 2022, and July 2022. The release site for J40 was treated with aerial 1080 in May 2022, and follow up shooting in August 2022.

Sites in the Southern Group area were selected with reference to data from Wall-IS wallaby control operations showing that some, but not many, wallabies were shot in the area in the years preceding the Judas wallaby trial (Table 1).

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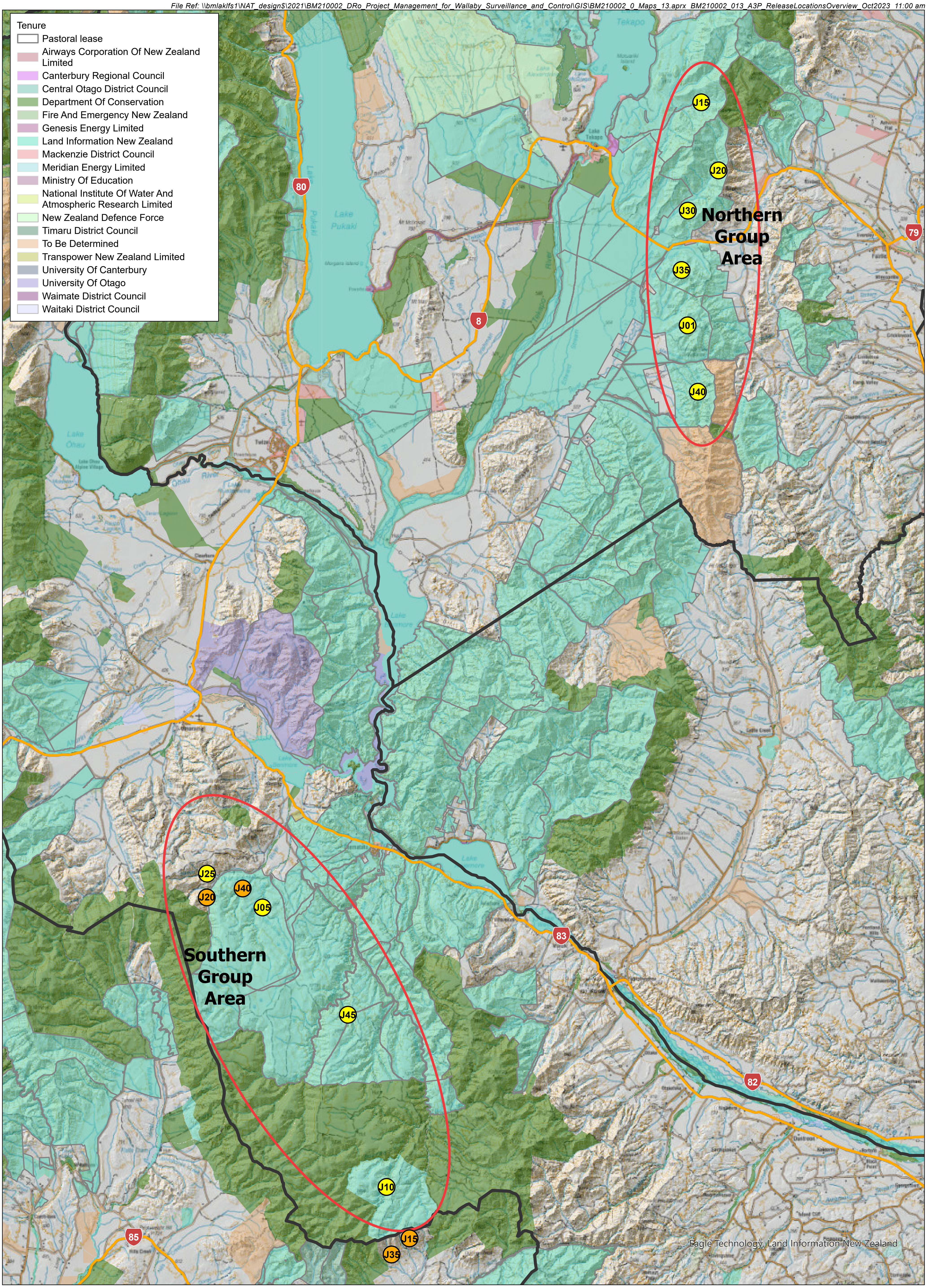

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Data Sources:
Tenure sourced from CROSL, LINZ data service
Public Conservation Land streamed from DOC feature service

Projection: NZGD 2000 New Zealand Transverse Mercator

LEGEND
- Approximate release location
- Translocation release sites (September 2024)
- Wallaby group
- NZ Territorial Authorities

WALLABY SURVEILLANCE AND CONTROL 2023/24

Judas Wallaby Release Location

Date: 19 June 2025 | Revision: 0

Plan prepared for ORC by Boffa Miskell Limited

Project Manager: pete.caldwell@boffamiskell.co.nz | Drawn: BMc | Checked: PCa

Figure 2

Table 1: *Wallaby Information System (Wall-IS) data showing wallaby kills in the vicinity of Southern Group Area release sites from Oct 2021 to Oct 2023.*

Judas wallaby	**Wallaby kills within 3 km of release site**
J05	0
J10	0
J25	3
J45.1	7

Further details on the site selection process are documented in previous reports *Judas wallaby research plan 2023-2023* (Boffa Miskell Ltd, 2023a) and *Judas wallaby site selection* (Boffa Miskell Ltd, 2023b).

2.3 Permits and approvals

The live capture of Bennett's wallabies, holding of these animals in captivity, associated manipulations (including sterilisation and collaring), and their transportation and release required various permissions. All relevant permits and permissions obtained for this research are listed in Table 2.

Table 2: Permits, approvals, and permissions to undertake the Judas wallaby trial.

Permitting Organisation	**Permit type**	**Permit Number**	**Date approved**
Manaaki Whenua Landcare Research Animal Ethics Committee (AEC)	An AEC application to undertake capture, transport, containment, and surgical procedure on Bennett's wallabies. Additional amendments to approve changes to personnel, methodologies, and extend trial duration were approved throughout the course of the research.	AEC # 23/09/02, PRJ4047	31 Oct 2023 and amendments 27 Feb 2024 and 11 Sep 2024.
MPI	Unwanted organisms permit to hold and release Bennett's wallaby under Section 52(d) of the Biosecurity Act 1993. Issued to Gavin Udy (ORC)	C0035207	3 Oct 2023
DOC	Permissions to conduct aerial and ground hunting operations on PCL. Issued to Brent Glentworth (ECan)	7354167 353478 7053613	3 Jul 2023 23 May 2023 16 Jun 2022
Private landowners	Permission to release wallabies on private land. Permission to undertake aerial thermal surveillance flights and aerial/ground control operations on private land. Permission to access private land.	na	Various

2.4 Judas wallaby capture, husbandry, and collaring

All manipulations were carried out as per Animal Ethics approval from the Manaaki Whenua Landcare Research Animal Ethics Committee (AEC # 23/09/02). Bennett's wallabies were captured by a contract trapper on Mahoe Farm near Cave in South Canterbury using ground-set tunnel net traps set at wallaby runs under farm fences from 24-26 October 2023 (with the exception of one female wallaby that had been previously captured on Bluecliffs farm, Timaru on 11 August 2023). Tunnel net traps were only set on days when no rain or excessively hot or cold temperatures were forecast and were checked each morning starting at daylight.

Captured wallabies were transferred from tunnel net traps to sacks then transported to the Manaaki Whenua Landcare Research (MWLR) Animal Facility in Lincoln, a journey of approximately two hours. Upon arrival at the facility, wallabies were sedated with Zoletil and weighed, sexed, inspected for injury and pouch young, and ear tagged by MWLR staff. Any pouch young were removed and euthanised. The wallabies were confined in individual outdoor pens and monitored at least once daily to assess health and acclimatisation over a period of at least three weeks.

Sterilisation surgeries (vasectomies for males and ovariectomy for females, henceforth sterilisation) were undertaken by contracted veterinary staff on the 15th and 22nd November 2023. Ten days after surgery, the wallabies were sedated to allow inspection of surgery sites and attachment of a Lotek Iridium 250 satellite transmitter collar, weighing approximately 250 g.

One additional wallaby was added to the trial later, due to one of the original Judas wallabies (J45.1) slipping its collar early in the trial. The new wallaby (J45.2) had been captured in the same October trapping session as the previously-released Judas animals and was still in captivity at the MWLR facilities. Sterilisation surgery and collar attachment was performed on 6th and 20th March 2024, using the slipped collar that had been recovered from the field. It was released on 27th March 2024.

Table 3 provides key capture and husbandry details for all individual Judas wallabies.

Table 3: Key information on individual Judas wallabies.

ID	Sex	Capture date	Breeding status at capture	Weight at capture (kg)	Weight at post-surgery check up (kg)	Phase 1 Group	Phase 2 Group
J01	Female	26/10/2023	No pouch young	10.0	9.1	Northern	na
J05	Female	26/10/2023	Lost pouch young in field	10.1	9.3	Southern	Southern
J10	Female	11/08/2023	Pouch young removed	10.9	11.2	Southern	Southern
J15	Male	25/10/2023		17.1	18.1	Northern	Translocated to Southern
J20	Female	26/10/2023	Pouch young removed	11.8	10.4	Northern	Translocated to Southern
J25	Male	25/10/2023		15.3	16.0	Southern	South
J30	Male	26/10/2023		17.1	15.0	Northern	na
J35	Male	26/10/2023		21.0	20.0	Northern	Translocated to Southern
J40	Male	26/10/2023		16.0	16.0	Northern	Translocated to Southern
J45.1	Male	24/10/2023		13.1	13.1	Southern	na
J45.2	Male	24/10/2023		9.0	11.5	Southern	na

2.5 Judas wallaby release

After a post-surgery recovery period of at least two weeks and vet-check, collared wallabies were transported in sacks by vehicle and helicopter to pre-selected release points (Section 2.5) and released. Figure 2 shows the locations of all release sites.

The first 10 wallabies were transported and released on the 10th and 11th December 2023. The eleventh wallaby, J45.2, was transported and released on the 27th March 2024 at the same site where J45.1 was initially released (Figure 2).

The total time spent in captivity by Judas wallabies used in this research (i.e. the time between initial wild-capture and release) was between 45–48 days for the majority of individuals. However two individuals spent longer in captivity due to earlier capture (J10, 122 days in captivity) or later release (J45.2, 155 days in captivity).

2.6 Transmitter programming

GPS and VHF settings varied throughout the course of the research programme. For most of the time, collars followed the 'basic' schedule, briefly described below. However, settings were remotely programmable and were periodically adjusted to an 'enhanced' schedule to assist contractors working in the field.

2.6.1 Basic schedule

GPS settings:

- GPS fixes taken at 4-hourly intervals.
- Iridium schedule set to send all fixes to satellite in batches of 12 fixes.

VHF settings:

- Between 10 Dec 2023 and 19 Apr 2024: VHF beacon always on.
- From 20 April 2024 VHF beacon operational for a 5-hour window every Tuesday. Note that this change in VHF schedule was implemented after consultation with Lotek as a means to extend battery life.
- When in recovery mode (i.e. when the main battery was depleted) VHF signal always on.

Mortality settings:

- Mortality alert activated after 24 hours with no movement.

2.6.2 Enhanced schedule

In periods leading up to and during fieldwork, collar settings were remotely adjusted to increase the quantity of data available to guide the search for wallabies in the field. Typically, enhanced settings were activated 3-4 days before scheduled fieldwork, and deactivated when fieldwork was complete.

GPS settings:

- GPS fixes taken at 30-minute intervals.
- Iridium schedule set to send all fixes to satellite in batches of 6 fixes.

VHF settings:

- VHF beacon always on.

Mortality settings:

- Mortality alert activated after 24 hours with no movement.

2.6.3 Data analysis

Data cleaning

After the field trial had concluded, all GPS location fixes were downloaded for all Judas wallabies from Lotek's web-server – a total of 30,913 fixes. Prior to spatial analysis, a data-cleaning process was undertaken to:

- Reduce the dataset to consistent 4-hourly fixes by deleting additional fixes recorded during periods when the enhanced GPS schedule was active (see Section 2.6.2); and,
- Remove location fixes that did not represent the Judas wallabies' self-initiated movements. That is, fixes recorded during collar testing, transportation of wallabies (including during the translocation in September 2024), or transportation of collars recovered from the field; and,
- Remove post-mortality location fixes, i.e. duplicate points at the location where a Judas wallaby died or slipped its collar.

Minimum convex polygons

100% Minimum convex polygons[1] (MCPs) were created in ArcGIS for each Judas wallaby, in each month. Individuals that were translocated in September had two MCPs calculated for that month, representing their activity before and after translocation.

Daily movements

Minimum daily movement distances were estimated for each Judas wallaby by calculating the Euclidean distance between consecutive GPS fixes and then summing these values across a given day. For the four wallabies that were translocated from the Northern Group Area to the Southern Group Area fixes from the date of the translocation were excluded from the dataset.

Proximity analysis

For the post-translocation period, preliminary visual inspection of point location data on a map showed substantial overlap in the activity ranges of the three Judas wallabies (J10, J15, and J35) that were located in the south-eastern part of the Southern Group Area, termed the Kyeburn area. The proportion of time that each possible two-wallaby combination in this area (J10-J15, J10-J35, and J15-J35) spent in proximity to each other was estimated by matching location fixes by a shared timestamp, then measuring the Euclidean distance between each matched pair of location fixes.

2.7 Contractors

A small number of key contractors were engaged to help deliver this research.

Manaaki Whenua Landcare Research led the animal husbandry aspects of the research programme. They carried out capture of wild wallabies, husbandry while in captivity, veterinary services (including surgeries), collar fitting, and transport and release of wallabies.

Trap and Trigger Ltd were engaged to use thermal technology and VHF tracking to locate Judas wallabies and remove conspecifics by aerial shooting during Phase One of the trial. They searched for wallabies (both from the ground and air) in instances where collar connection to satellite was lost, and removed remaining Judas wallabies by shooting at the end of the trial.

[1] While it is common practice to exclude a proportion (typically 5%) of location fixes when calculating animal home or activity ranges, 100% MCPs were preferred for this study, as the focus on seeking behaviour meant that extreme points were highly relevant data.

Heliventures Ltd were the helicopter operator engaged to assist Trap and Trigger Ltd. to locate and hunt wallabies aerially, as well as assisting Manaaki Whenua Landcare Research to transport collared wallabies to site.

3.0 Phase 1: 10 Dec 2023 – 18 Sep 2024

3.1 Phase 1 Methods

Operations to surveil Judas wallabies and remove conspecifics were carried out on a monthly basis five times between January and May 2024 (Table 4 summarises the field activities over this period).

The intention behind culling conspecifics each month was to create a social 'vacuum' around the collared wallabies, and to see whether this would prompt them to travel to seek out other conspecifics i.e. exhibit gregarious tendencies. In the absence of detailed information about social behaviour in Bennett's wallabies, the choice to define conspecifics as non-collared wallabies within a 1 km distance of Judas animals, and within the same catchment, was based on practical considerations including:

- The feasibility of the Judas Wallaby technique from a management perspective – in practice, implementing a large search area around Judas wallabies would be likely to be cost-prohibitive; and,
- The need to keep helicopter and hunting time within levels permitted by the project budget.

On each surveillance/culling occasion (with some exceptions - see Table 4), a helicopter equipped with a VHF telemetry receiver was used to locate all Judas wallabies in the field, and hunters equipped with thermal detection gear attempted to shoot all non-collared wallabies within an approximately 1 km radius of each Judas animal, which were considered to be conspecifics.

Contractors recorded locations of the Judas wallabies and conspecifics as waypoints, and (if possible) also recorded the sex and approximate age class (juvenile or adult) of each conspecific that was shot. Contractors also made a general assessment of the apparent health of Judas wallabies sighted, noting any obvious external injuries.

The first two attempts at implementing this method highlighted some constraints, including:

- Measuring a 1 km radius area around Judas wallabies 'on the fly' during the operation was not practical; and,
- It was not always possible to locate and/or sight all Judas wallabies, and time spent searching for difficult-to-find individuals was sometimes longer than anticipated, leading to increased costs to undertake searching.

In subsequent operations, the following methodological refinements were therefore implemented:

- Shapefiles defining a 1 km radius around predicted locations of Judas wallabies were provided to contractors the day before each operation (based on recent fix locations); and,
- The 'enhanced schedule' for transmitters (Section 2.6.2) was implemented in the 3-4 days preceding each operation, to ensure ample data was available to inform shapefile construction; and,
- The search time to locate Judas wallabies was limited to 5 minutes (if wallaby approximately located), or 10 minutes maximum before ceasing the search; and,
- A maximum of 20 minutes was permitted to search for and cull conspecifics around each Judas wallaby, with the aim of achieving high confidence that a social 'vacuum' around the Judas animal had been created.

Figure 3 shows an indicative example of the GIS data from one of the surveillance/culling operations.

Table 4 Summary of field activities during Phase 1.

Month	Field activity	Notes
Dec-23	• 10 Judas wallabies released 10-11 Dec	
Jan-24	• Aerial surveillance and conspecific cull 22 Jan	• Did not search for J45.1 due to long-distance dispersal by this individual from Canterbury into Otago
Feb-24	• Aerial surveillance and conspecific cull 22 Feb • Slipped collar (J45.1) recovered from field	• Did not locate J05
Mar-24	• Aerial surveillance and conspecific cull 27-28 Mar • One new wallaby (J45.2) fitted with re-deployed collar and released 27 Mar	
Apr-24	• Aerial surveillance and conspecific cull 23-24 Apr • Ground surveillance of J20 only 24 Apr	• J20 search from the ground instead of the air at landowner request • Did not search for J45.2 due to landowner muster
May-24	• Aerial surveillance and conspecific cull 28-29 May • Collar J01 recovered after wallaby mortality • Searched for J30 from ground and air after collar lost connection to satellite	• J20 not searched for at landowner request • Lost wallaby J30 not located
Jun-24	n/a	• Re-design of the research programme, prior to transitioning to Phase 2
Jul-24	• Aerial surveillance of Southern Group Judas wallabies only 2 Jul	• No conspecific wallabies sighted
Aug-24	• J45.2 removed from trial and collar recovered after collar battery failure	
Sep 24	• Translocated remaining 4 Judas to Southern Area Group. See Phase 2 for details	

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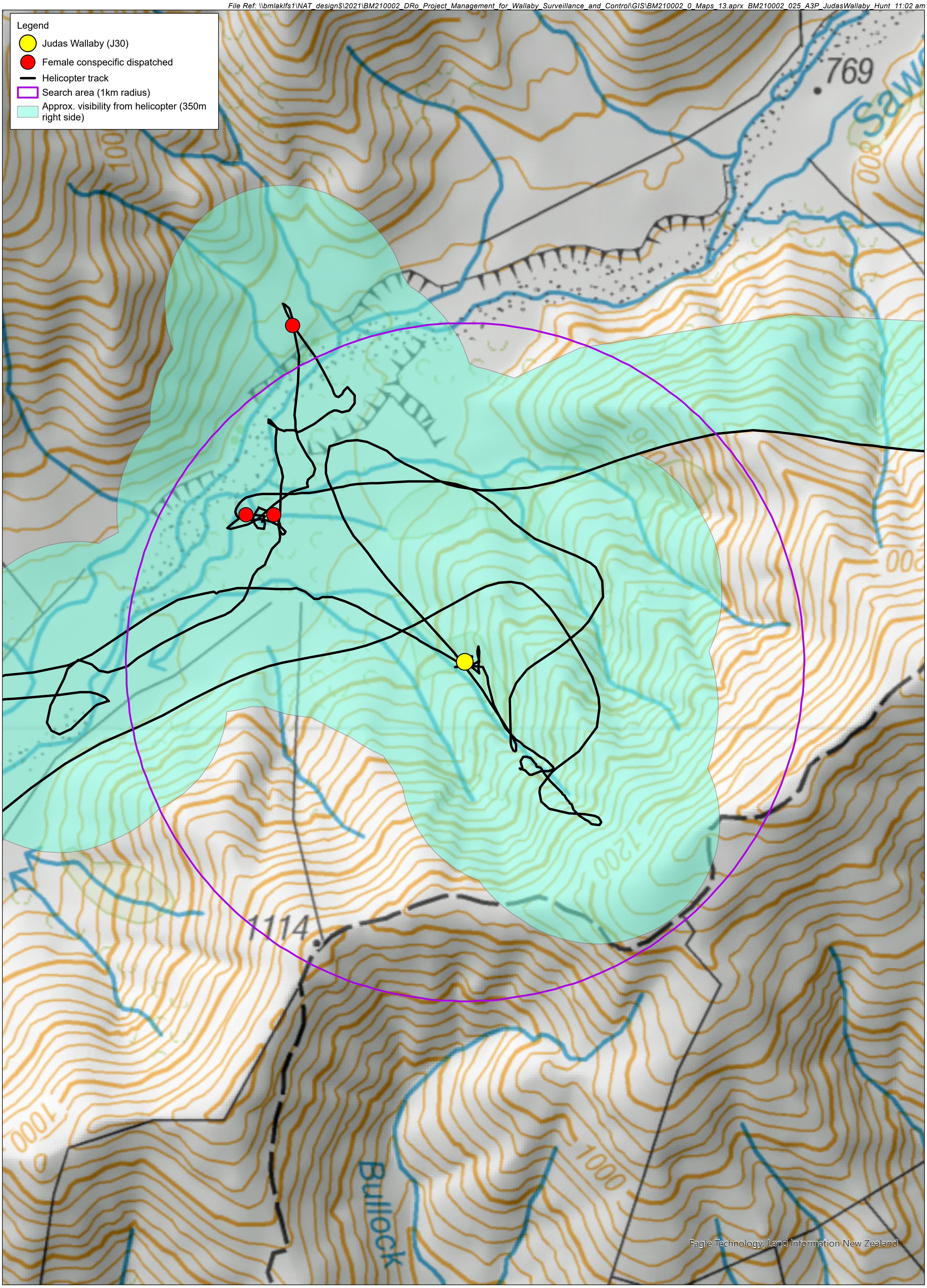

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WALLABY SURVEILLANCE AND CONTROL

Phase 1 March 2024 Judas Wallaby Hunt

Date: 19 June 2025 | Revision: 0

Plan prepared for ORC by Boffa Miskell Limited

Project Manager: pete.caldwell@boffamiskell.co.nz | Drawn: BMc | Checked: PCa

Figure 3

3.2 Phase 1 Results

3.2.1 Site fidelity

During the active fieldwork period of Phase 1 (i.e. December 2023 to Sep 2024[2]), Judas Wallabies in the Northern Group Area displayed high site fidelity with relatively small activity range areas, as indicated by 100% minimum convex polygons (Figure 4). The median activity range area for Northern Group wallabies during this period was 40.6 ha (range = 4.9 – 447.7 ha).

In the Southern Group Area wallaby J45.1 was an outlier, with extremely large activity range areas, driven by several large movements in January and February 2024, including a long-distance displacement of >30 km Euclidean (straight-line) distance from its release point (Figures 5 and 6). In April 2024, wallaby J10 also relocated a substantial distance of approximately 14 km away from its initial release site following a sheep muster on the property. At 170.3 ha (range = 2.4 – 5,935.0 ha) the median activity range area was larger in the Southern Group area compared to the North, although the ranges around the median overlap for the two groups. If outlier activity ranges >1000 ha (n = 4) are excluded from the dataset, the median for the Southern Group area reduces to 151.8 ha (range = 2.4 – 711.3 ha).

Detailed analyses of the extent Judas wallaby movements over the full course of the research are reported on as a whole in Section 4.3.1.

[2] For Judas wallabies that were translocated in September, the minimum convex polygon for that month represents pre-translocation fixes only.

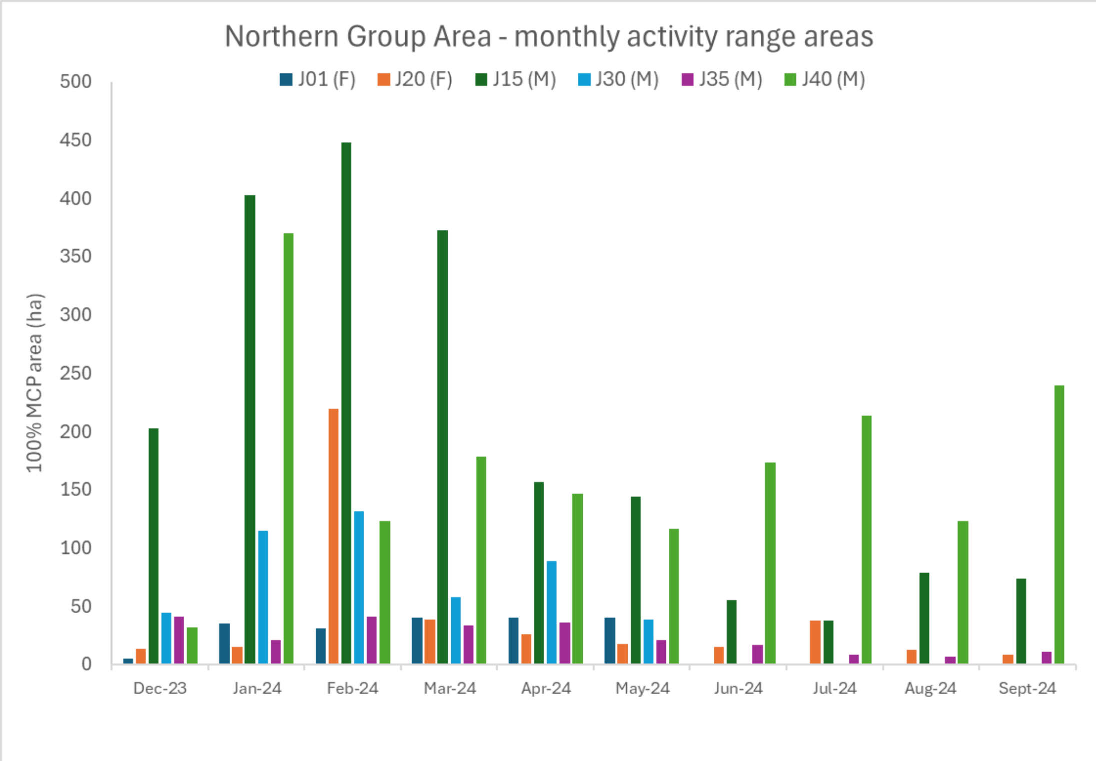

Figure 4: Activity range areas for Northern Group Area Judas wallabies from Dec 2023 to Sep 2024. For Judas wallabies that were translocated in September, the minimum convex polygon for that month represents pre-translocation fixes only.

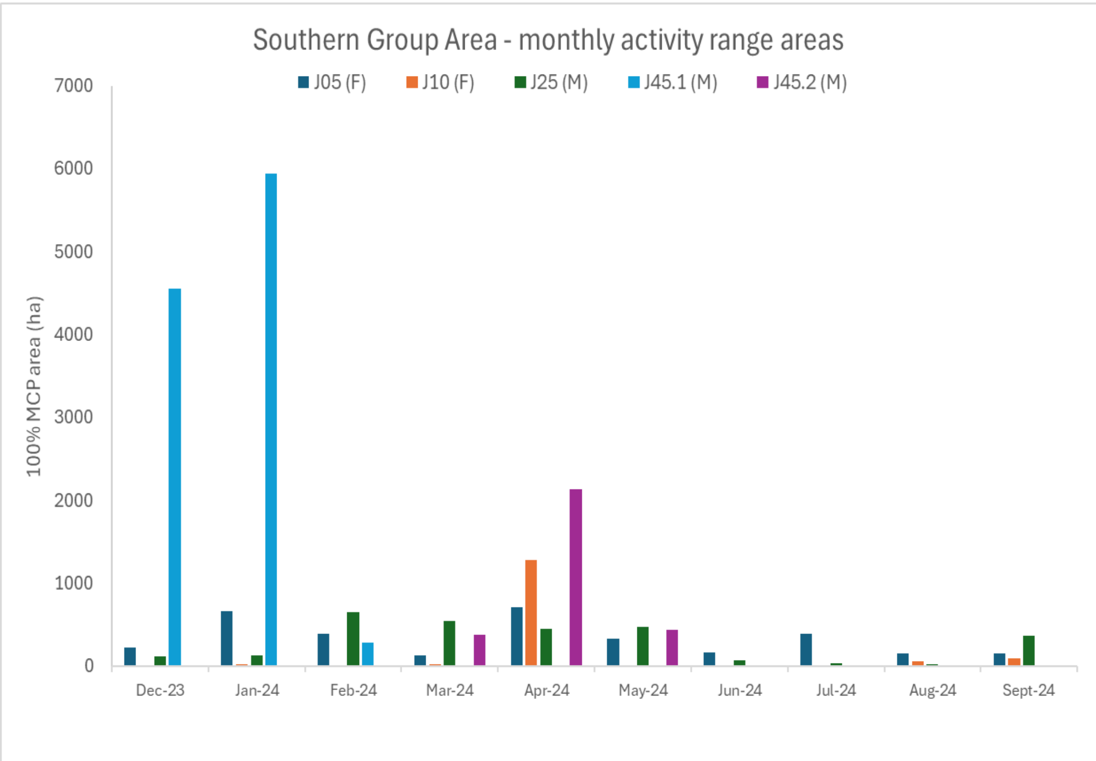

Figure 5: Activity range areas for Southern Group Area Judas wallabies from Dec 2023 to Sep 2024.

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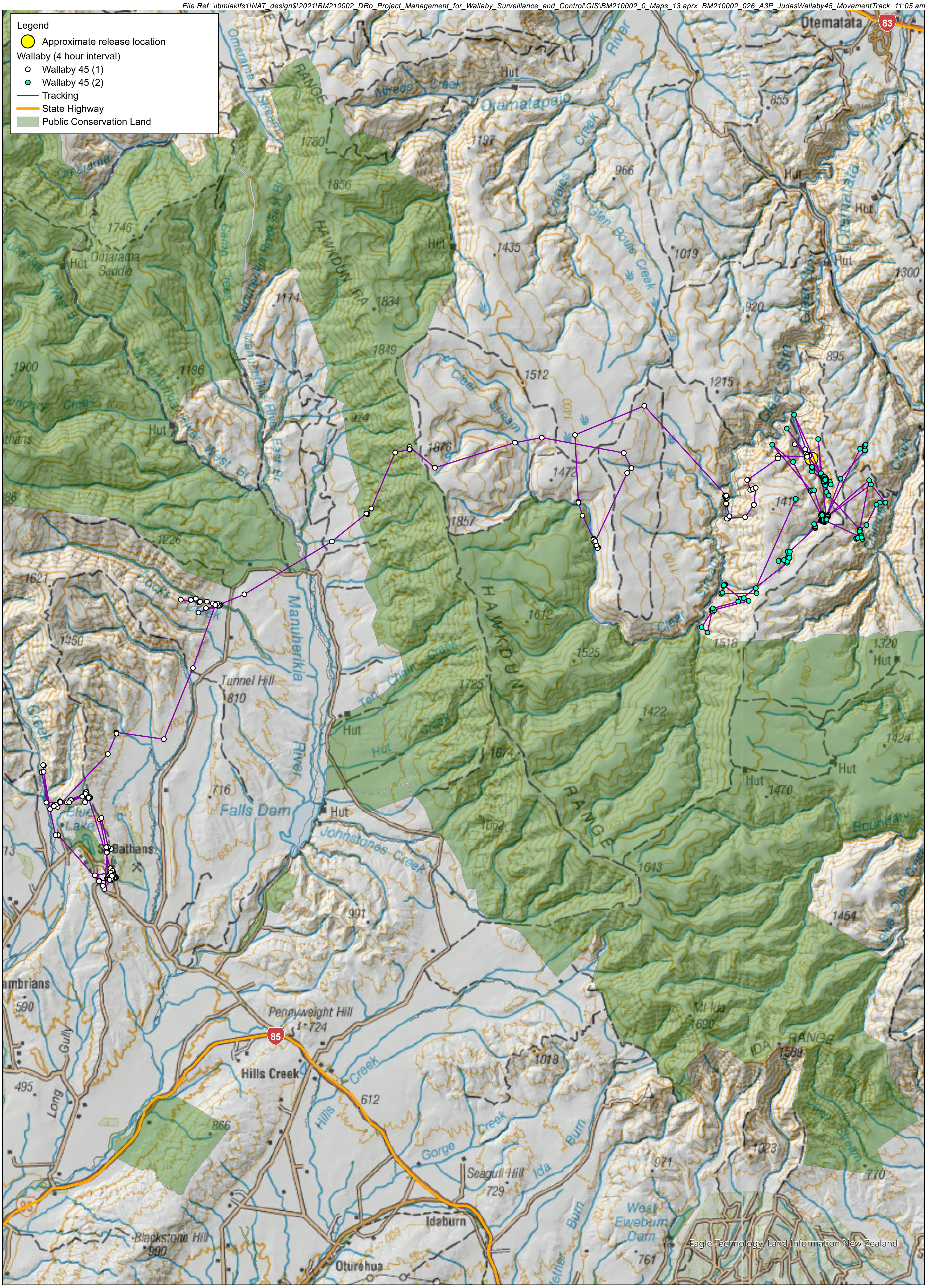

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WALLABY SURVEILLANCE AND CONTROL

Judas wallaby 45 – Long Distance Movement

Date: 19 June 2025 | Revision: 0

Plan prepared for ORC by Boffa Miskell Limited

Project Manager: pete.caldwell@boffamiskell.co.nz | Drawn: BMc | Checked: PCa

Figure 6

3.2.2 Conspecifics

Table 5 shows a monthly breakdown of all conspecifics sighted during aerial operations from January to July[3] 2024, including those that were successfully culled, and those that were sighted but escaped.

A total of 43 conspecific wallabies were culled during the monthly operations between January to May 2024, including 17 females, 11 males and 15 individuals of undetermined sex (Table 5, Figures 7 and 8). Most were either adults (n = 19) or of undetermined age (n = 19), with only 5 culled individuals identified as juveniles. A further five conspecifics were sighted but escaped.

All conspecifics sighted were in the Northern Group Area (Figure 7). No conspecific wallabies were sighted in the Southern Group Area at any time throughout the research, despite recent historic data suggesting wallaby presence in the area (see Section 2.2).

Three additional non-collared wallabies (not included in Table 5) were shot during the research. These included:

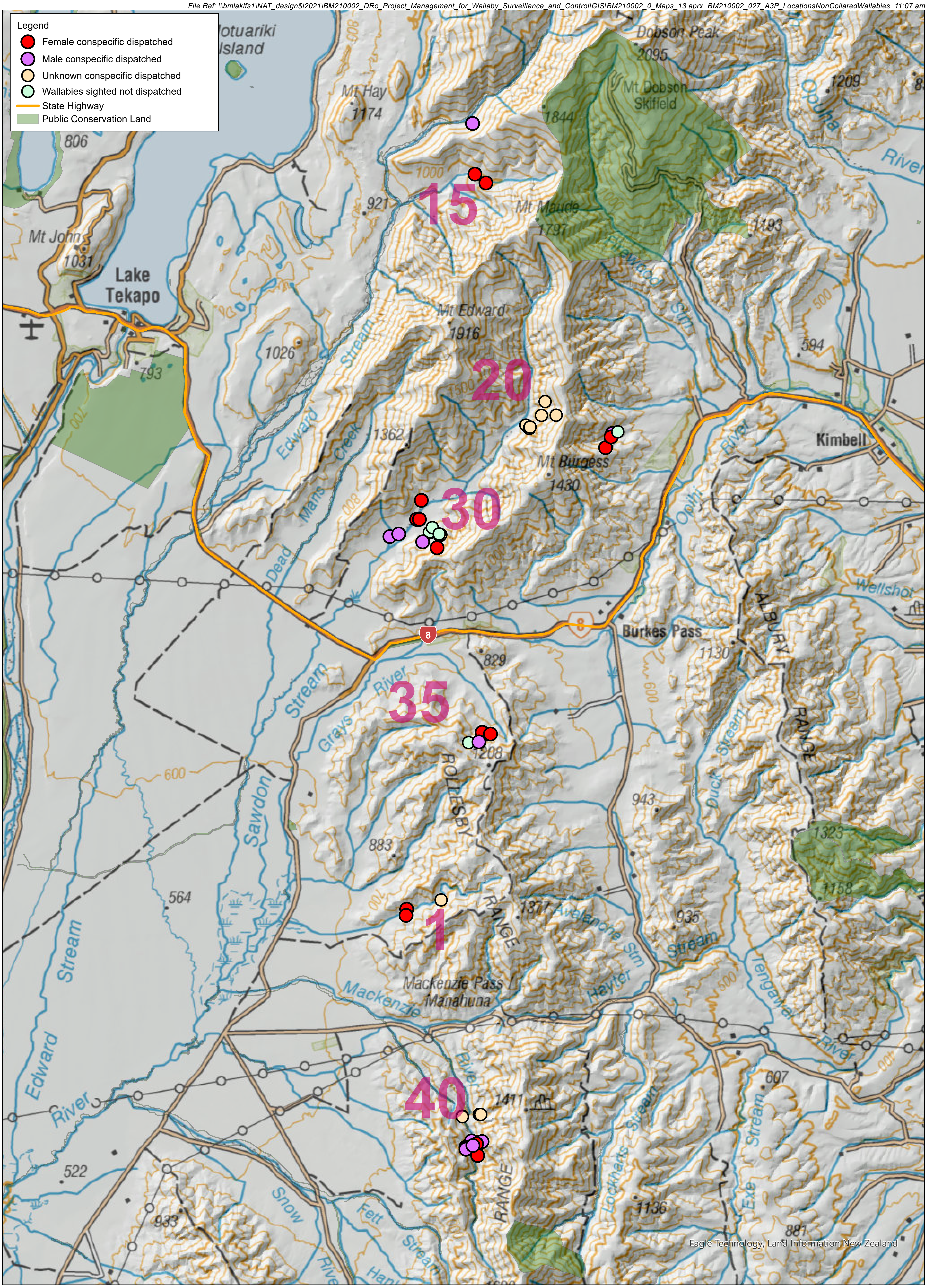
- Two wallabies that were further than 1 km from the nearest Judas wallaby (J30) when they were shot in March 2024 (i.e. outside of the defined range for conspecifics), and;
- One wallaby that was shot in the area where contractors were searching for J30 in May 2024, however as J30 was not located that month, conspecific status could not be confirmed.

The range of Judas-to-conspecific distances (calculated using GPS data after the operation) was from a minimum of 8 m to a maximum of 823 m, with a median distance of 298 m (Figure 9). The upper quartile value was 545 m, meaning that 75% of conspecific individuals were sighted at <545 m from the Judas wallaby at the time of the operations.

Table 5: Number of conspecifics sighted and culled in the ~1 km radius search areas around Judas Wallaby locations from Jan to Jul 2024. Counts of culled conspecifics are shown in normal font, while counts of conspecifics that were sighted but not successfully culled are shown in bracketed italics. A zero value indicates that the Judas wallaby was located but no associated conspecifics were sighted, a value of NS indicates that the Judas wallaby was not searched for, and a value of NL indicates that the wallaby was searched for but not located.

		Count of conspecific wallabies							
Area	**ID**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Total**
Northern	J01	1	1	0	1	NS	NS	NS	3
Northern	J15	1	1	0	0	1	NS	NS	3
Northern	J20	6	1	1	1 (*1*)	NS	NS	NS	9 (*1*)
Northern	J30	4 (*2*)	2	2	(*1*)	NL	NS	NS	8 (*3*)
Northern	J35	0	0	1	(*1*)	3	NS	NS	4 (*1*)
Northern	J40	5	4	3	3	1	NS	NS	16
Southern	J05	0	NL	0	0	0	NS	0	0
Southern	J10	0	0	0	0	0	NS	0	0
Southern	J25	0	0	0	0	0	NS	0	0
Southern	J45.1	NS	-	-	-	-	-	-	0
Southern	J45.2	-	-	-	NS	0	NS	0	0
TOTAL		**17 (*2*)**	**9**	**7**	**5 (*3*)**	**5**	**NS**	**0**	**43 (*5*)**

[3] No aerial surveillance operations were undertaken after July.



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WALLABY SURVEILLANCE AND CONTROL

Phase 1 Locations of all non-collared wallabies

Date: 19 June 2025 | Revision: 0

Plan prepared for ORC by Boffa Miskell Limited

Project Manager: pete.caldwell@boffamiskell.co.nz | Drawn: BMc | Checked: PCa

Figure 7

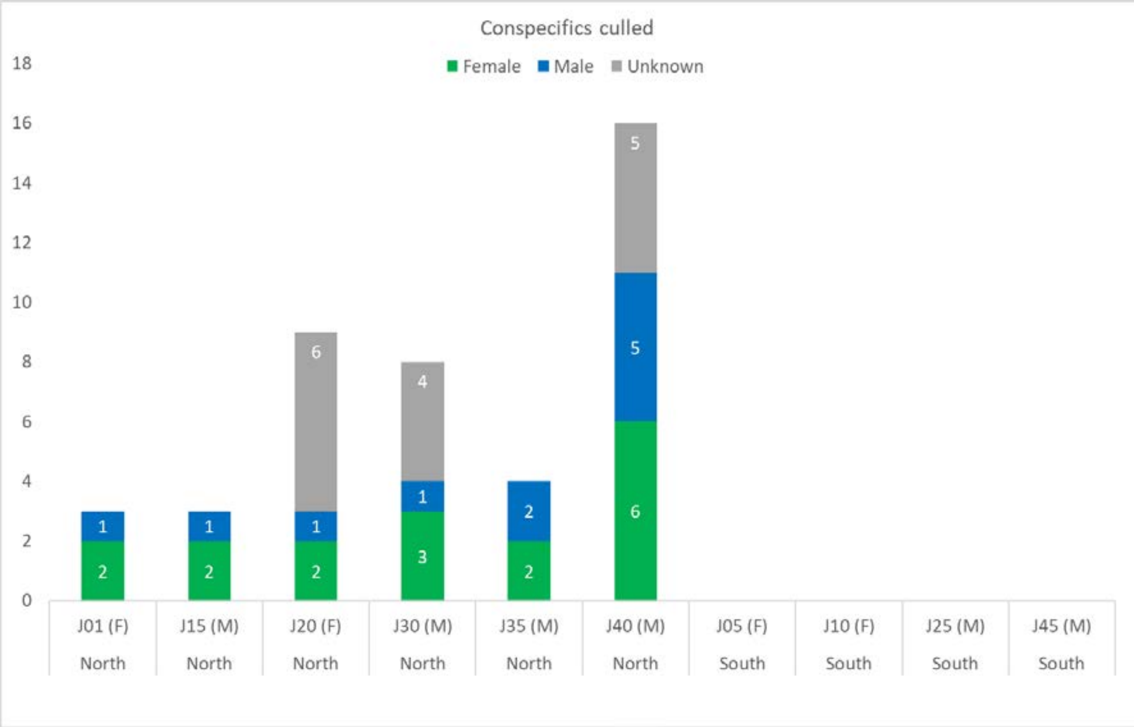

Figure 8: Number and sex of non-collared conspecific wallabies culled during surveillance/hunting operations from Jan – May 2024.

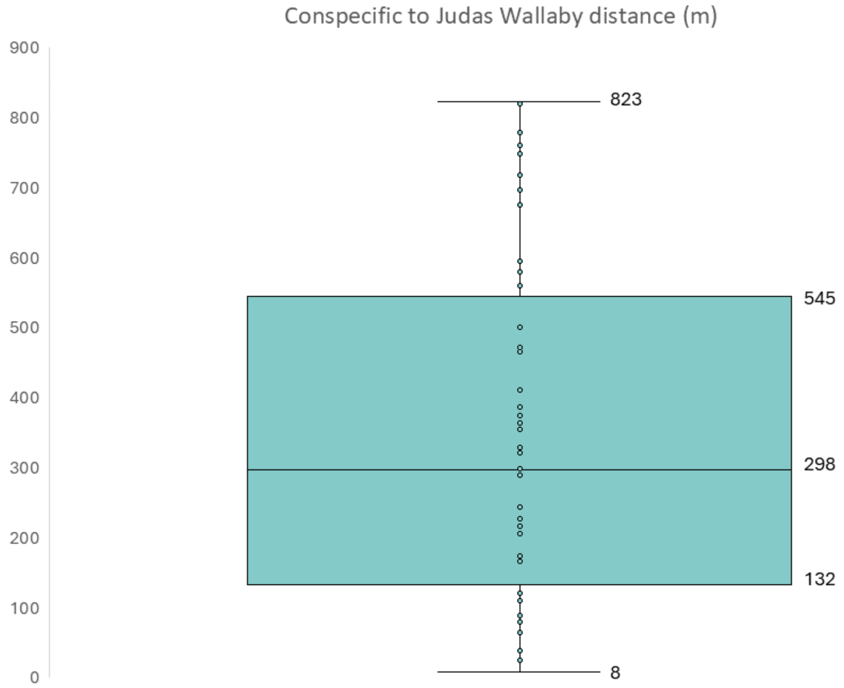

Figure 9: Conspecific to Judas wallaby distances during monthly operations Jan–May 2024.

3.3 Phase 1 Discussion

3.3.1 Phase 1 limitations and challenges

Confounding variables

There were several potentially confounding conditions which were unable to be controlled during Phase 1. These included:

- Habitat – in the assessment of the Judas animal technique, there is an implicit assumption that physical proximity of animals is a reflection of social tendencies. However, the same physical proximity could equally represent preferences for certain habitat types, or landscape features. This study design did not allow us to distinguish between these two major drivers of spatial behaviour.
- Husbandry effects – all Judas animals were collared and underwent sterilisation surgery prior to being translocated and released at the study sites. There is the potential that collared and sterilised wallabies may behave differently than uncollared, intact individuals. In particular, female Judas wallabies underwent ovariectomy which stops the production of oestrogen and progesterone, and is likely to alter the females' breeding behaviour by preventing them from coming into heat. This, in turn, is likely to reduce the motivation of male Judas wallabies to spend time in proximity to the sterilised females.
- Disturbance – the use of aerial surveillance by helicopter as the predominant search method may have influenced the behaviour observed during surveillance/culling operations. For example, if moving away and hiding from the helicopter caused wallabies to move either closer to, or further away from each other than they were prior.
- Source – all Judas animals were sourced from within the South Island containment area in an area with a high density of wallaby. The effect on their behaviour of being moved from a relatively high density area to an area with lower density is unknown.
- Imperfect detection - there is no current detection method that will reliably detect all wallabies all of the time (A. D. M. Latham et al., 2021). Therefore, it is likely that some conspecific wallabies that were present in the proximity of Judas wallabies were not detected during our operations.

Judas wallaby mortality and slipped collars

Two Judas wallabies were lost from the trial during Phase 1. These were:

- J45.1, slipped collar 5 February 2024 (later re-deployed on a new Judas animal, J45.2); and,
- J01, mortality 26 May 2024.

The fates of all Judas wallabies are discussed in detail in Section 5.2.

Collar failure

During Phase 1, two GPS/VHF collars lost communication with satellite, resulting in a truncated dataset for these individuals:

- J30, last fix 9 May 2024; and,
- J45.2, last fix 9 June 2024.

Collar failures throughout the trial are discussed in detail in Section 5.3.

Density-related terminology

There remains variability in how areas of low density (and very low density) wallabies are described. There is no consistent terminology or definitions used to describe areas where wallabies are at very low densities. The approach to surveilling and controlling populations / individuals changes between these various densities, and it would be beneficial to be able to use agreed density categories (measured or estimated) to allow wallaby programme managers to have a common understanding.

Surveillance methods

As briefly discussed in Section 3.1 practical and budgetary constraints had a large influence on managing the surveillance / culling operations in Phase 1. Contractors were provided with a shapefile comprising a 1 km radius search area, based on recent fix locations for that individual. In most cases, this approach worked well as Judas wallabies were typically located close to where they were expected to be, and the pre-determined 1 km search radius was acceptably accurate. However, in the few cases where Judas wallabies were not located in the predicted area, the search areas were approximated 'on the fly' and are therefore less accurate.

Another issue is that the search method (i.e. locate Judas wallaby first, then search around it for conspecifics) could have resulted in a bias towards increased detectability of conspecifics that were close to the Judas wallabies. Equally, disturbance from the helicopters could have reduced detectability by alerting wallabies and prompting them to seek cover.

Furthermore, because the time permitted for the search and cull around each wallaby was limited, it is possible that some conspecifics were present but not sighted (particularly at further distances from Judas wallabies). Contractors reported that when the time to search for a Judas wallaby had been long, or when there were many conspecifics to be culled, time was a significant constraint.

It is worth noting that similar methodological issues and constraints, including budgetary constraints, would also apply in a real-world deployment of a Judas wallaby.

3.3.2 Conspecific wallabies

Given that the pre-trial site selection analysis (Section 2.2; Boffa Miskell Ltd, 2023b) had indicated that wallaby population densities were likely to be low in the selected research areas, the number of conspecific wallabies sighted in the Northern Group Area during Phase 1 exceeded expectations. There were no clear patterns in terms of the sex or age class of conspecific wallabies relative to the nearest Judas animal. While juvenile wallabies appeared to comprise a small portion of the dataset, this is potentially misleading as there was a high proportion of conspecifics that were classed as 'unknown' age class.

Conspecifics sighted in the Northern Group Area tended to be within a relatively short distance of Judas wallabies, with a median Judas-to-conspecific distance of 298 m, and an upper quartile value of 545 m. However, it is possible the search method (i.e. locate Judas wallaby first, then search around it for conspecifics) could have resulted in a bias towards increased detectability of conspecifics that were close to the Judas wallabies, or that wallabies were congregating in favoured habitats in the landscape.

Although the number of conspecifics sighted in the Northern Group Area trended mostly downward over time, by May 2024 it was evident that densities weren't being reduced quickly or significantly enough to replicate the intended management scenario.

On the other hand, the complete lack of conspecific wallaby sightings in the Southern Group Area was also unexpected. This, too, resulted in a situation we were unable to assess the utility of the Judas animal technique for detecting conspecifics.

3.3.3 Judas wallaby movements

The high level of site fidelity shown by Judas wallabies in the Northern Group Area during Phase 1 is not what was expected to be seen in an effective Judas animal. While the median activity range area in the Southern Group Area was larger than that in the North (even with outlier large activity ranges excluded), the smallest activity range was also in the Southern Group.

The movements of Bennett's wallabies have been little studied in New Zealand until recently. In 2023, Latham et al. (2023) undertook a GPS tracking study which produced home range estimates for 30 adult wallabies at three different high-country stations in South Canterbury. They found seasonal home range sizes varied from 1.2 – 101.9 ha. Mean seasonal home ranges were similar for males and females (26.8 ha and 24.8 ha, respectively), but the largest home ranges belonged to large males. Although this study produced activity ranges rather than home ranges (as the latter term represents an individual's 'normal' activities and is therefore inappropriate for translocated animals), the median range area in the Northern Group Area (40.6 ha) falls within the range of home range areas recorded in Latham's (2023) study, while the median in the Southern Group Area (170 ha) is larger.

See Section 4.4.2 for a more detailed discussion around Judas wallaby movement behaviour throughout the entire duration of the trial.

3.3.4 Conclusion

At the outset of Phase 1, the overall aim of this research was to assess whether the Judas technique has utility in the detection Bennett's wallabies in very-low-density environments. Despite efforts to select research sites where wallaby density was in the appropriate range for the management scenario we aimed to model, the actual population density within our research areas turned out to be too high in the Northern Group Area, and too low in the Southern Group Area. For this reason, the data collected during this period are largely unsuitable for assessing the utility of the Judas animal technique for wallabies. Nevertheless, the movement data collected during this period did provide some insights, including that long-distance movements are occasionally undertaken by individual wallabies, and that there was a slight tendency for larger activity ranges in the area with lower population density, although there was high variability between individuals, and further research with a larger sample size would be needed to be more confident that this result is generalisable to other wallaby populations.

4.0 Phase 2: 18 Sep 2024 – 26 Mar 2025

4.1 Phase 2 research approach

The research approach in Phase 2 constituted a major departure from Phase 1. Instead of monitoring Judas Wallaby movement in relation to non-collared conspecifics (i.e. the Phase 1 approach), the focus of the research shifted to tracking Judas wallaby movements in relation to each other. In other words, the Judas wallabies were considered as conspecifics to each other in Phase 2.

The re-designed research approach required the following changes:

- The four remaining Judas wallabies in the Northern Group Area were translocated to the Southern Group Area, within 2-3 km distance of the Judas wallabies that were already resident there; and,
- Subsequent to the translocation, remote-collected GPS data were used to track Judas wallaby movements in relation to each other to determine whether the Judas wallabies find each other and spend enough time in close proximity to each other to be useful from an operational perspective; and,
- Regular aerial surveillance and conspecific removal operations were discontinued (ground-based or thermal drone monitoring continued on an occasional basis, see Table 6) and,
- The scheduled end of trial was extended until March 2025, as an attempt to capture data through the wallaby breeding cycle.

4.2 Phase 2 Methods

4.2.1 Pre-translocation surveillance

Prior to translocation, surveillance was undertaken around the Southern Group Judas wallabies with the primary aim of checking our assumption that there were no non-collared wallabies living in this area (or if there were, that they were present at undetectable levels). This was a necessary step, because the approach in Phase 2 was centred on the premise that the Judas wallabies would be motivated to seek each other out due to a lack of other wallabies in the area. The rationale for releasing translocated wallabies within 2-3 km distance of resident Judas wallabies was based on the practical constraints of search and destroy operations in terms of search unit area. If Judas wallabies are not able to locate conspecifics at a minimum of 2 km distance, then the number of Judas wallabies that would need to be released into the landscape in practice would be too large, and financially inviable.

Pre-translocation surveillance activities (see Table 6) included:

- Aerial surveillance around the four original Southern Group Judas wallabies in July 2024; and,
- Ground-based surveillance using tracking dogs in September 2024, prior to the translocation.

No conspecific wallabies were sighted on either of these occasions, however some wallaby scats were located during the ground-based search in September (noting that the scats may have been produced by the Judas animals). While we are unable to entirely exclude the possibility that some non-collared wallabies were present within the Southern Group Area, we were satisfied that, if present at all, conspecific wallaby density was at an undetectable level with a reasonable level of effort.

Table 6: Summary of field activities during Phase 2.

Month	Field activity	Notes
Pre-translocation	• Aerial (helicopter) surveillance of Southern Group Judas wallabies only 2 Jul	• No conspecific wallabies sighted
Sep-24	• Ground surveillance with dogs to check for presence of conspecifics ahead of translocation 12 Sep • Translocation of 4 remaining Judas wallabies from the Northern Group Area to the Southern Group Area 18 & 21 Sep	• No conspecific wallabies sighted during surveillance, but a few scats found
Oct-24	n/a	
Nov-24	• Ground surveillance 26 Nov • Search for wallabies with lost satellite connection using ground-based telemetry (J05, J25)	• Neither of the lost wallabies was located
Dec-24	n/a	
Jan-25	• Thermal drone surveillance 27-28 Jan • Search for wallabies with lost satellite connection using ground-based telemetry (J05, J25, J20) • Collar J40 recovered after collar slipped or wallaby shot	• None of the lost wallabies were located
Feb-25	n/a	
Mar-25	• J15 and J35 removed from trial 26 Mar	• Whole Kyeburn surveyed with aerial thermal from helicopter at time of cull. No conspecific wallabies sighted.
Apr-25	• J10 removed from trial 3 Apr	

4.2.2 Judas wallaby translocation

At the time of translocation, there were four Judas wallabies with functional GPS collars remaining in the Northern Group Area (see Sections 5.2. and 5.3 for detail). These were J15, J20, J35, and J40. On 18 September 2024, contract staff from Heliventures located each of these individuals in the field and attempted to flush them from cover and capture them using a net-gun. J15, J20, and J35 were successfully captured on the first day, however J40 was located in tricky terrain with little open ground and, despite several attempts, contractors were unable to capture this individual at this time.

On 21 September, once remote GPS data indicated that J40 was situated in more open terrain, the translocation team re-grouped for another attempt to capture J40. On this occasion, a muzzled wallaby detector dog was used to assist with the operation by flushing J40 out of a patch of scrub, where it was successfully captured using the net-gun.

Upon capture, wallabies were placed into sacks to create a dark and calm environment and were tied to an anchor point while contractors were capturing the other Judas wallabies. For transportation to pre-determined release sites in the Southern Group Area, the wallabies (still inside the sacks) were loaded into helicopter pods for the duration of the short flight. At the release sites, wallabies were removed from the sacks and examined for any evidence of injury (including in the collar area) or other wellness issues. All Judas wallabies appeared to be in good health, with no obvious injuries. Once the wellness check was complete, wallabies were released, and contractors departed.

4.2.3 Surveillance

Following the successful translocation in September, Judas wallaby movements were monitored using remote GPS data. In-field surveillance was carried out on two further occasions in November 2024 (ground-based search with dogs) and January 2025 (thermal drone), as outlined in Table 6. The purpose of this surveillance was:

- To continue to check our assumption that non-collared conspecifics were absent; and,
- To search for Judas wallabies whose collars had ceased to function (see Section 5.3).

4.2.4 Judas wallaby removal

Phase 2 was scheduled to conclude at the end of March 2025. Contractors located the three remaining Judas wallabies with functional collars and removed them from the trial by shooting. J15 and J35 were culled on 26 March, and J10 on 3 April.

4.3 Phase 2 Results

4.3.1 Judas wallaby ranging movements

Taking the entire daily movement dataset as a whole (i.e. one minimum daily movement measure per Judas Wallaby, per day when collar was functional, including both Phases 1 and 2), there was a very large range of daily movements recorded over the course of this research, from a minimum of 22 m to a maximum of 11 km. The median daily movement was 586 m.

Mean daily movements over each month for each Judas wallaby are shown in Figures 10 (for individuals that stayed in the same research area (either North or South) for their entire tenure in the study) and 11 (for individuals that were translocated from the Northern Group Area to the Southern Group Area). Maps of location fixes and tracks are shown in Figures 12 (Northern Group Area) and 13 (Southern Group Area). The patterns observed were variable among individuals, however females' daily movements tended to fluctuate less throughout the year than males did.

The daily movements of the three male wallabies that were translocated to the Southern Group Area in September 2024 all trended clearly upwards after being translocated, and by the summer months of December 2024 to February 2025 daily movements were larger than in the summer spent in the Northern Group Area the year prior. The one translocated wallaby that was female (J20) also slightly increased her daily movement in December 2024 compared to the previous year, however the effect was not as pronounced in this case and the collar on this individual failed before January 2025, so it was unable to be determined if this trend continued.

To illustrate broad trends more clearly, Figure 14 shows the mean daily movements per month, pooled by sex and trial area. Males tended to have larger daily movements than the females within the same trial area throughout the year. Wallabies in the Southern Group Area nearly always had larger daily movements than Northern Group individuals of the same sex in the same month. With the exception of Southern Group females, all sex-area groupings reached their peak values of mean daily movement in February 2024, and generally moved greater distances in the summer months than in winter.

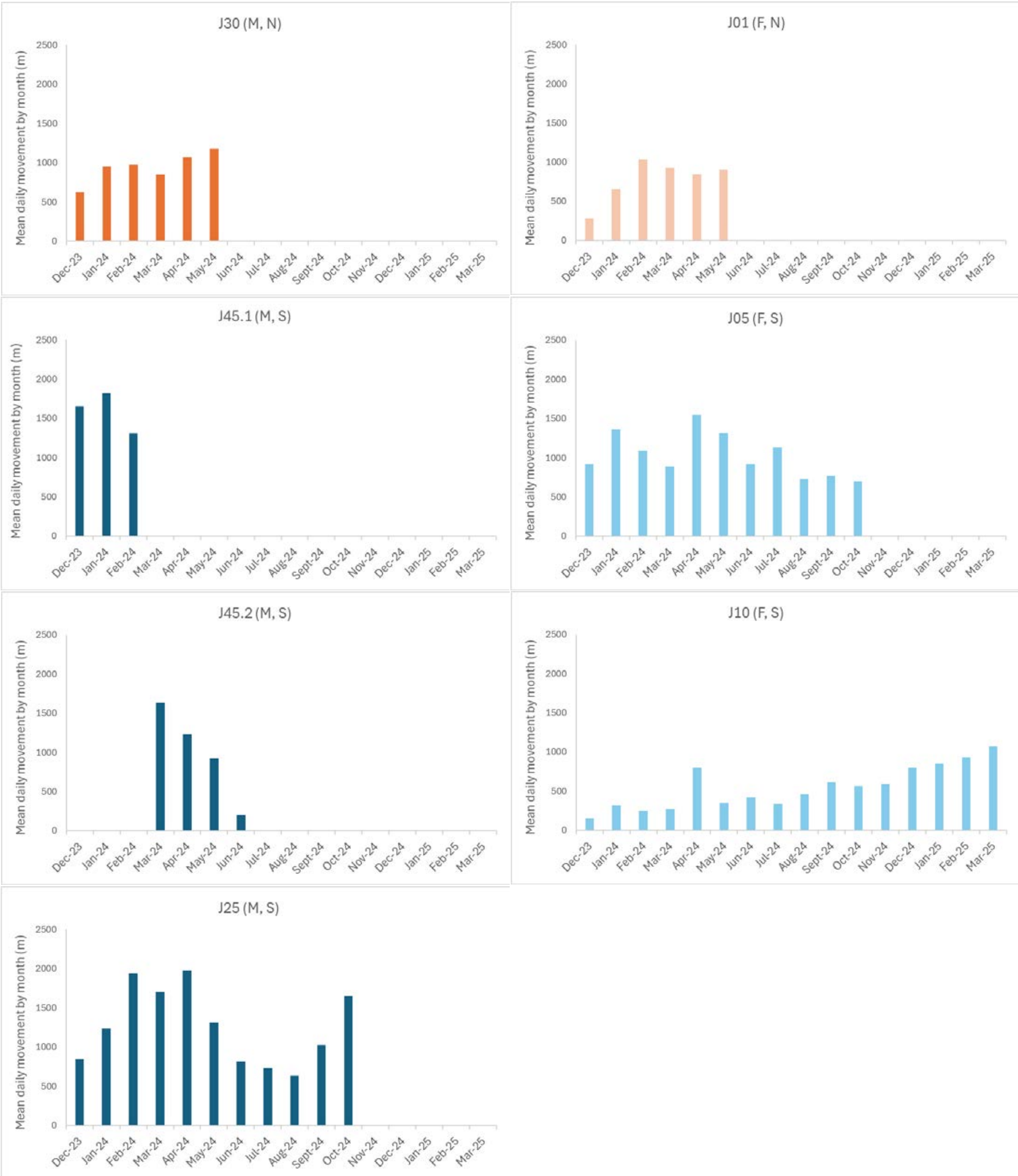

Figure 10: Mean daily movement by month for Judas wallabies in the Northern Group Area (orange) and the Southern Group Area (blue). Darker shaded bars indicate male individuals, and lighter shades indicate females.

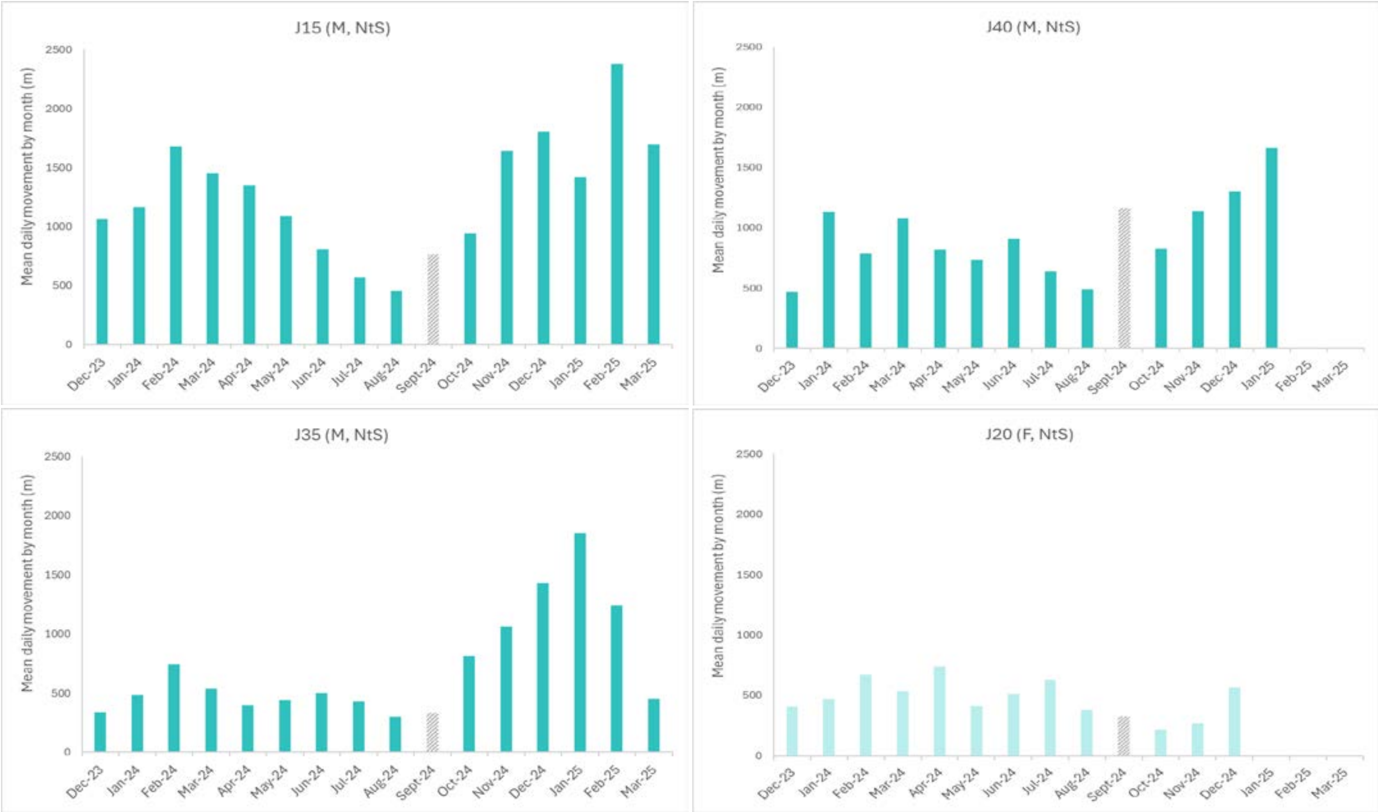

Figure 11: Mean daily movement by month for Judas wallabies that were translocated from the Northern Group Area to the Southern Group Area for Phase 2. Grey striped bars indicate the month when translocation occurred (i.e. part of the month was in the North and part in the South). Darker shaded bars indicate male individuals, and lighter shades indicate females.

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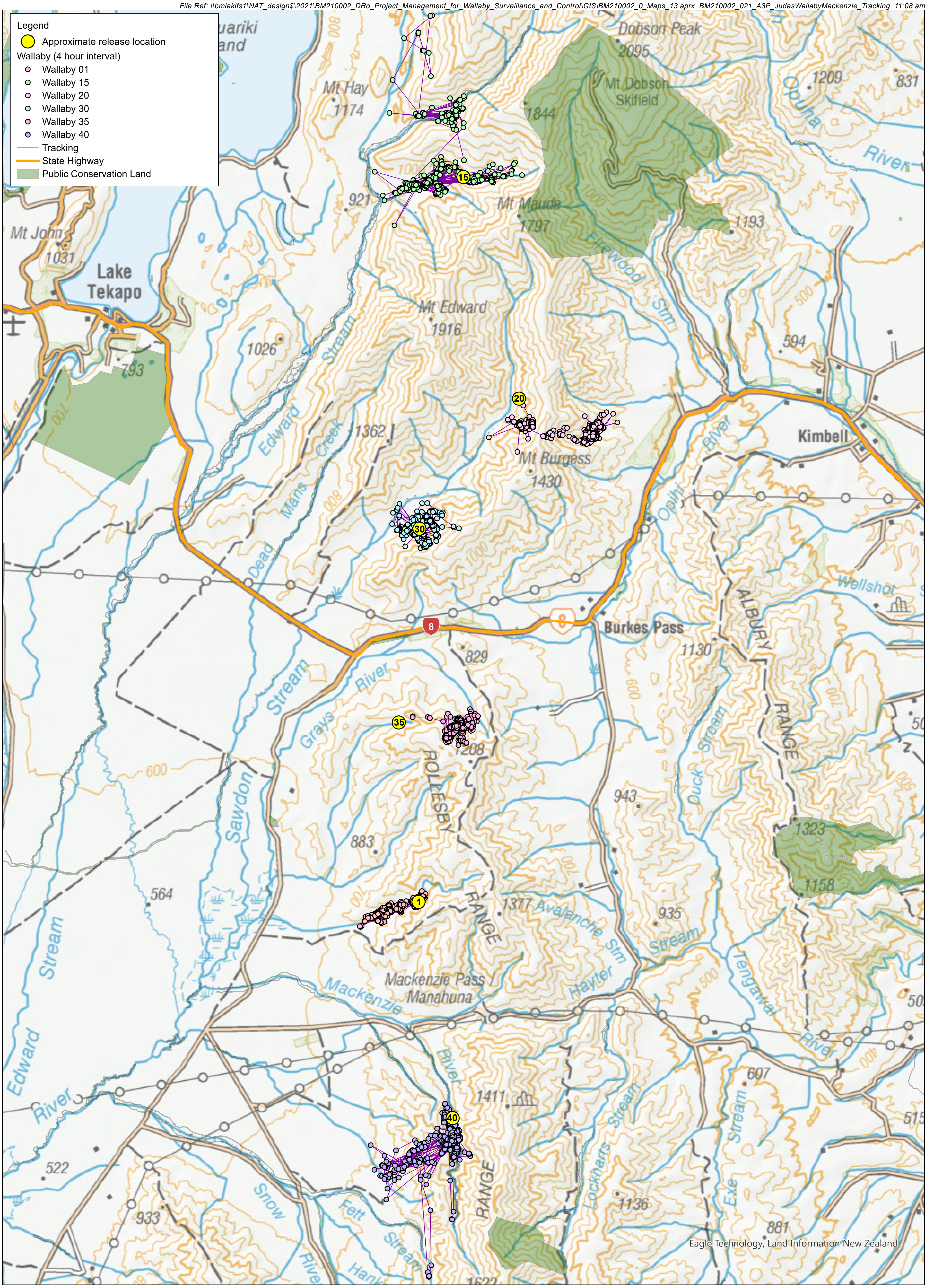

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WALLABY SURVEILLANCE AND CONTROL

Judas wallaby tracking – Northern Group Area

Dec 2023 to Sep 2024

Date: 19 June 2025 | Revision: 0

Plan prepared for ORC by Boffa Miskell Limited

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Figure 12

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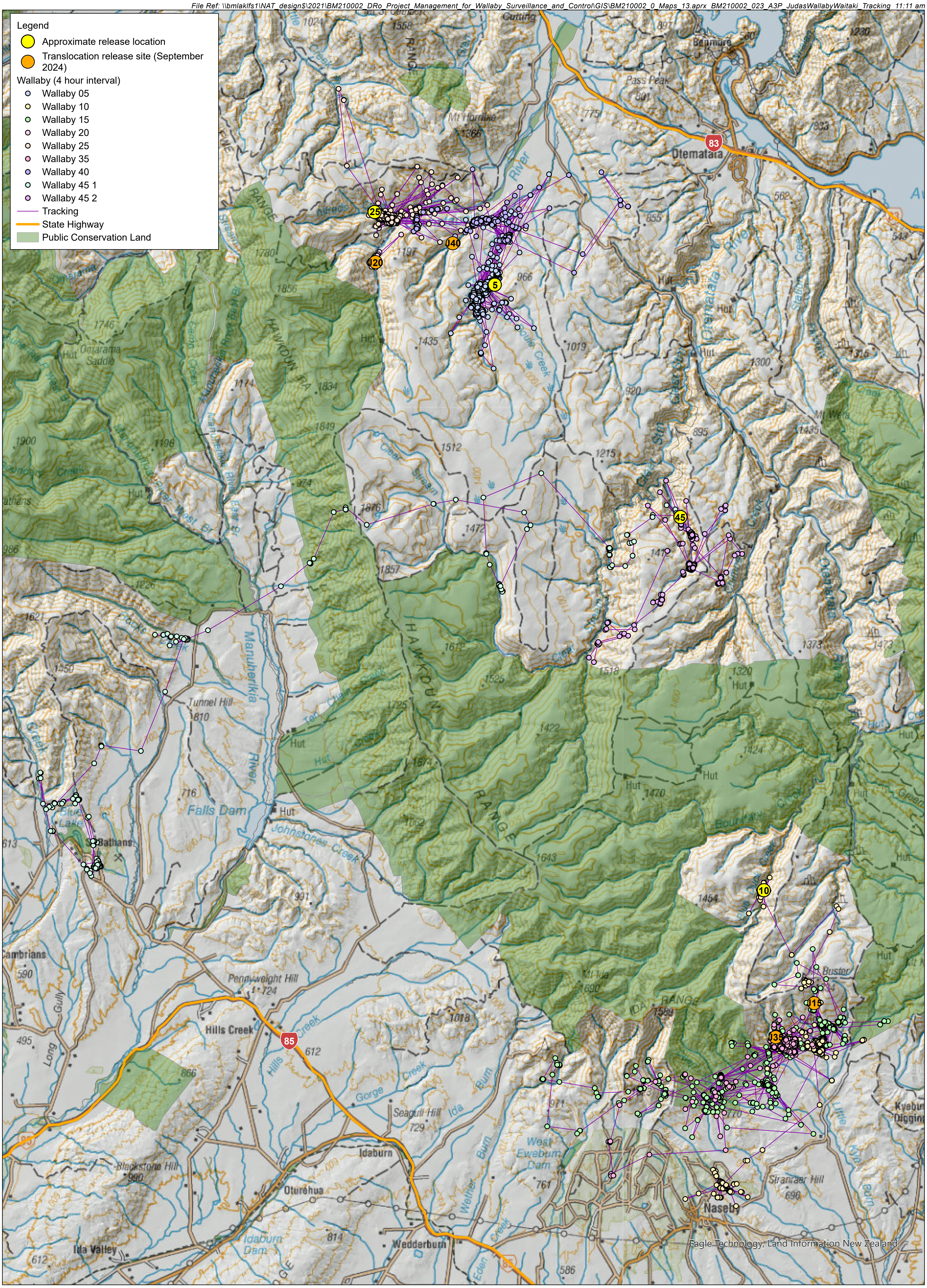

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WALLABY SURVEILLANCE AND CONTROL

Judas wallaby tracking – Southern Group Area

Dec 2023 to Mar 2025

Date: 19 June 2025 | Revision: 0

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Figure 13

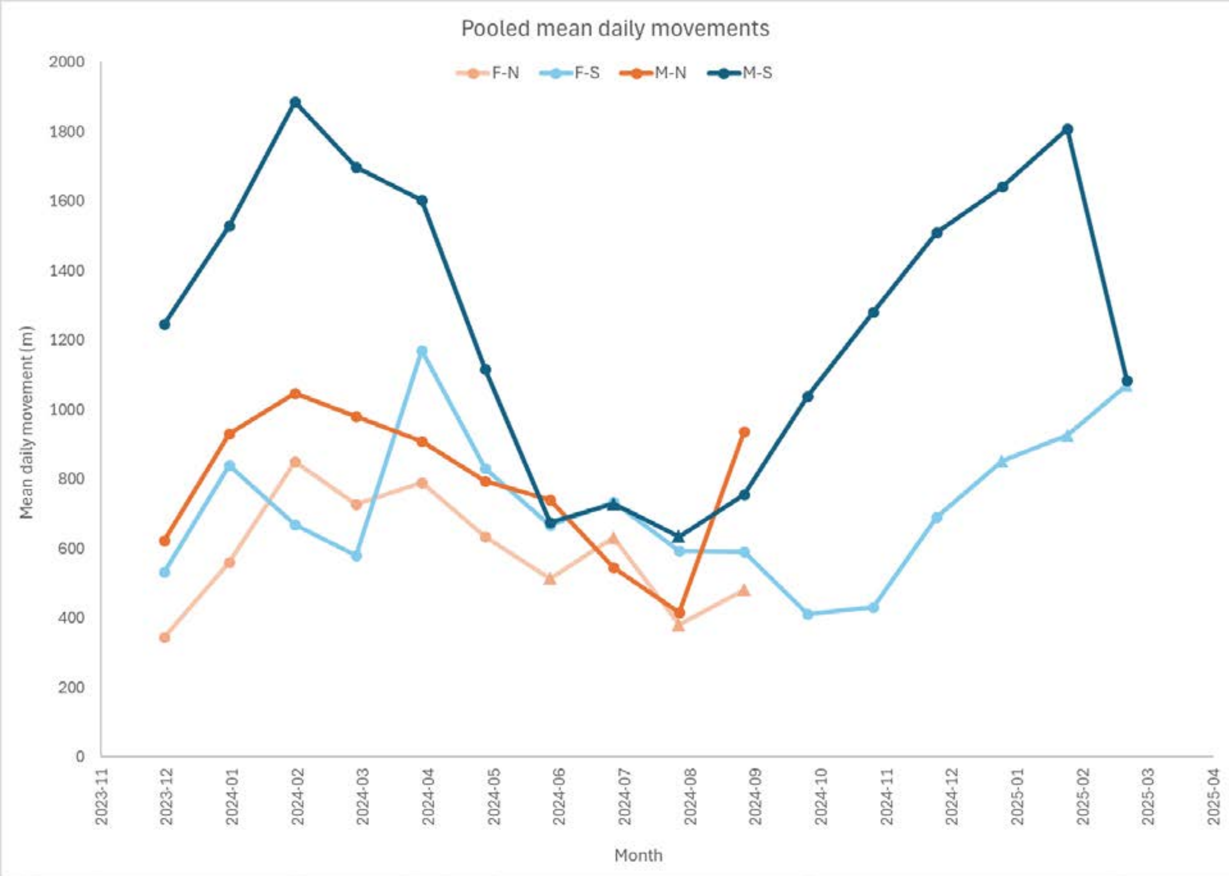


Figure 14: Mean daily movement by month, pooled by sex and trial area. Triangular markers indicate that the category consists of only a single individual in that month.

4.3.2 Proximity analysis

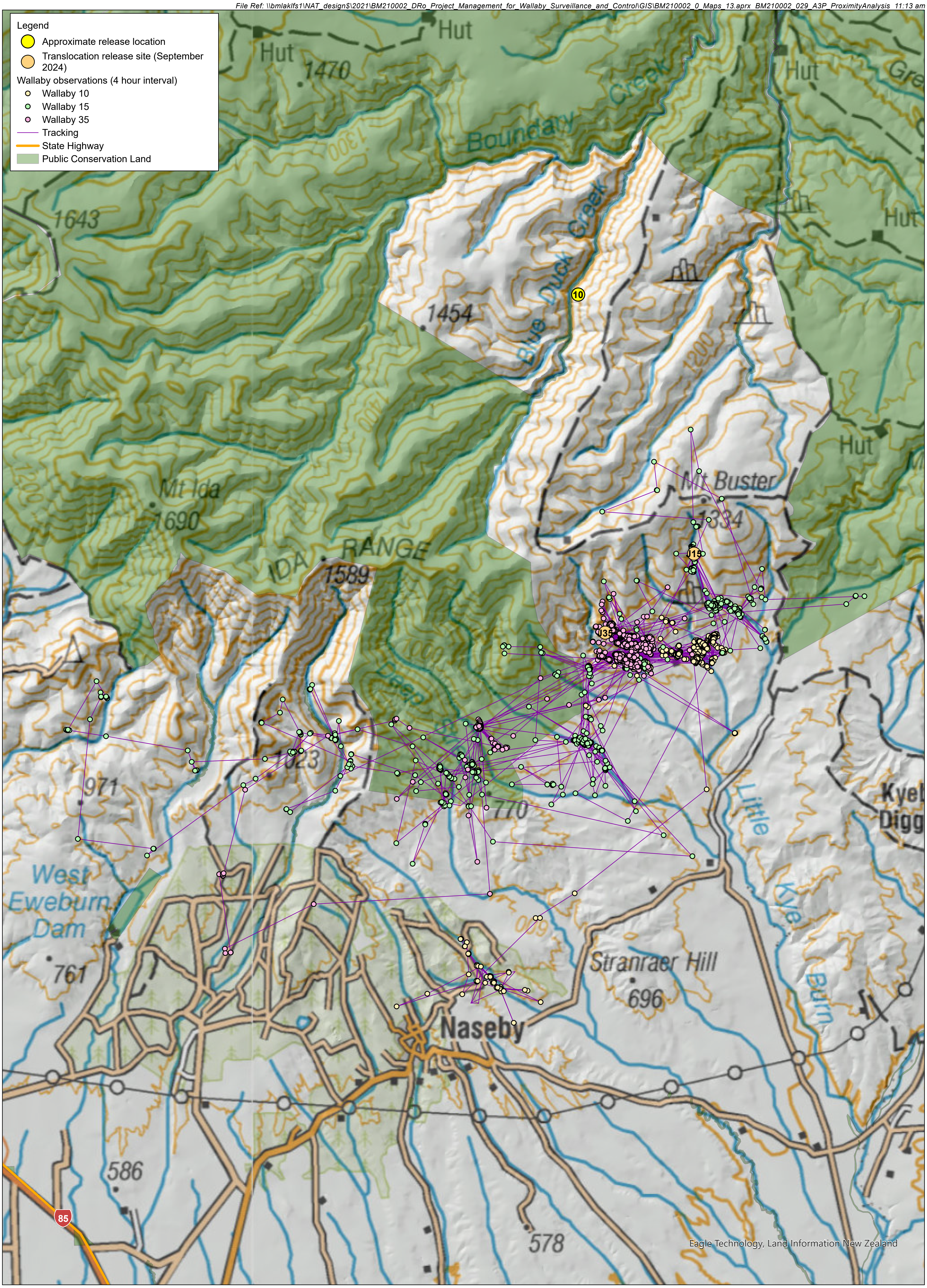
The proximity analysis for the three possible two-wallaby combinations (i.e. sets of two wallabies associated for analytical purposes) in the Kyeburn area (Figure 15) showed that, for all combinations, <2% of paired location fixes were recorded within 150 m, and <10% within 500 m of each other. For wallaby combinations J10-J15 and J15-J35, the greatest proportion of time was spent >2 km apart, while for the J10-J35 combination, it was between 1.5–2 km apart (Table 7).

Although the proximity analysis pooled all paired location fixes >2 km apart (as a reflection of practical management constraints), the raw data show a distribution that is highly skewed to longer distances (Figure 16)

Table 7: Proximity of paired location fixes for Kyeburn area Judas wallabies from 18 Sep 2024 to 26 Mar 2025

	J10 (F) -J15 (M)		**J10 (F) -J35 (M)**		**J15 (M) -J35 (M)**	
Proximity	***n***	**%**	***n***	**%**	***n***	**%**
0 to 150 m	11	1.0%	19	1.7%	10	0.9%
150 to 300 m	11	1.0%	9	0.8%	29	2.6%
300 to 500 m	29	2.6%	28	2.5%	71	6.3%
500 to 1000 m	180	15.9%	125	11.1%	73	6.5%
1000 - 1500 m	195	17.2%	210	18.6%	36	3.2%
1500 to 2000 m	158	14.0%	429	38.0%	168	14.9%
>2000 m	547	48.4%	308	27.3%	741	65.7%

.



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0 2 km
1:65,000 @ A3

Data Sources: Public Conservation Land streamed from DOC feature service

Projection: NZGD 2000 New Zealand Transverse Mercator

WALLABY SURVEILLANCE AND CONTROL

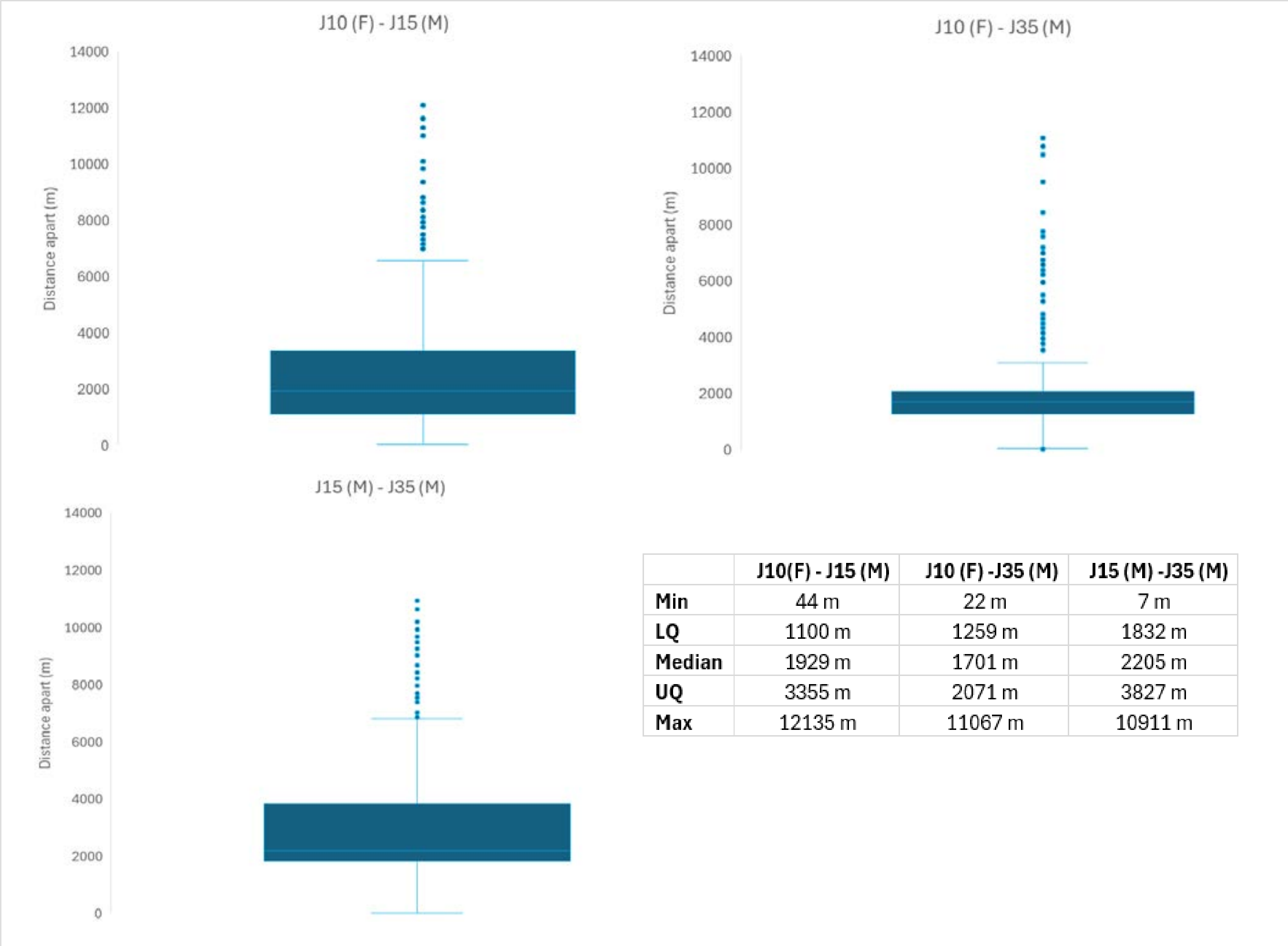
Phase 2 paired-fixes proximity analysis

Date: 19 June 2025 | Revision: 0

Plan prepared for ORC by Boffa Miskell Limited

Project Manager: pete.caldwell@boffamiskell.co.nz | Drawn: BMc | Checked: PCa

Figure 15

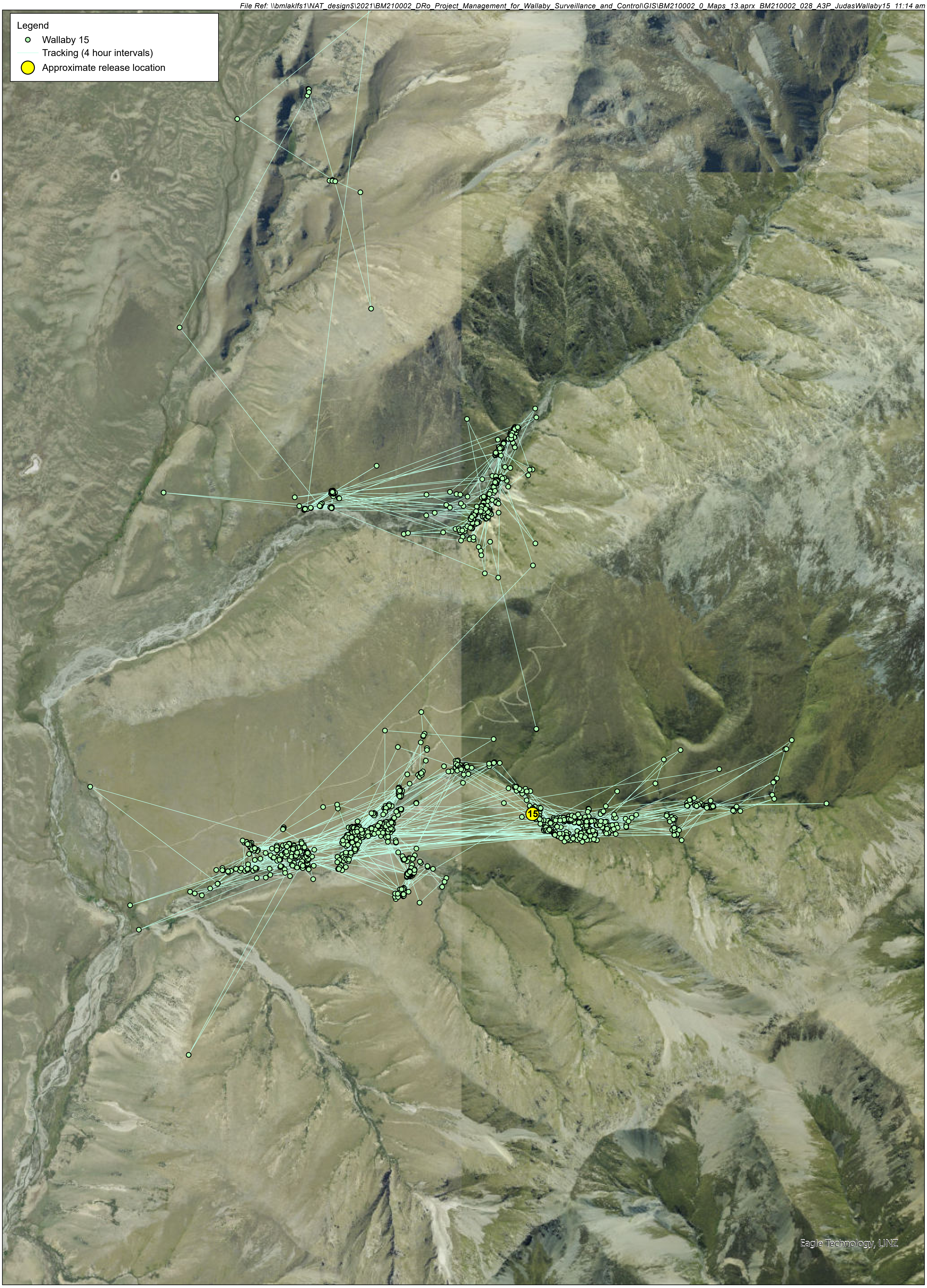


	J10(F) - J15 (M)	J10 (F) -J35 (M)	J15 (M) -J35 (M)
Min	44 m	22 m	7 m
LQ	1100 m	1259 m	1832 m
Median	1929 m	1701 m	2205 m
UQ	3355 m	2071 m	3827 m
Max	12135 m	11067 m	10911 m

Figure 16: Location fixes for Judas wallaby J15 showing association with gully and stream habitat.

4.3.3 Habitat association

The Judas wallaby fixes were more commonly found in areas of cover, such as scrub and higher stature tussock within gullies and around streams. This can be clearly observed by viewing fixes with a satellite imagery basemap (for example Figure 17). Fewer fixes were found in areas of higher altitude and along ridgelines where there is less cover. This is consistent with where they are commonly found in their natural home-ranges in South Canterbury. This association with habitat likely drives Judas wallabies into reduced areas in the landscape, but given the widespread availability of these areas of cover in the South Canterbury and Central Otago landscape, it would be unlikely to influence wallaby movements enough to drive Judas wallabies together and emulate them seeking each other out.



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0 600 m

1:20,000 @ A3

Data Sources:
Public Conservation Land streamed from DOC feature service

Projection: NZGD 2000 New Zealand Transverse Mercator

WALLABY SURVEILLANCE AND CONTROL

Location fixes for Judas wallaby J15

Date: 19 June 2025 | Revision: 0

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Figure 17

4.4 Phase 2 Discussion

4.4.1 Phase 2 limitations and challenges

Overall, Phase 2 of the research proceeded more smoothly than Phase 1, however there are still some conditions to note.

Small dataset

At the outset of Phase 2 there were seven collared wallabies in the trial (3 females, 4 males). By the end of the trial in March 2025, only three wallabies with functioning GPS collars remained. Due to this small sample size, inference is limited and where average values are presented these represent a maximum of 4 individuals. In some cases, only one individual is represented by a group average.

Confounding variables

As with Phase 1, potentially confounding habitat variables were unable to be controlled, and use of sterilised Judas animals may have impacted their behaviour, particularly in the case of females (see Section 3.3.1 for further discussion).

Judas wallaby mortality and slipped collars

One Judas wallaby was lost from the trial during Phase 2:

- J40, slipped collar (or possible mortality) 28 Jan 2025.

The fates of all Judas wallabies are discussed in detail in Section 5.2.

Collar failure

During Phase 2, three GPS/VHF collars lost communication with satellite, resulting in a truncated dataset for these individuals:

- J05, last fix 4 Oct 2024; and,
- J25, last fix 27 Oct 2024; and,
- J20, last fix 27 Dec 2024.

Collar failures throughout the trial are discussed in detail in Section 5.3.

4.4.2 Judas wallaby movements

A high degree of individual variability was found in Judas wallaby mean daily movements throughout the trial. However, some trends were observed:

- Males tended to have larger daily movements than the females within the same trial area throughout the year; and,

- Wallabies in the Southern Group Area tended to have had larger daily movements than Northern Group individuals of the same sex in the same month; and,
- Wallabies typically moved greater distances in the summer months than in winter; and,
- Male wallabies that were translocated from the Northern Group Area to the Southern Group Area increased their daily movements during the summer months relative to the same months the year prior.

Warburton et al. (2024) ran a comparable study tracking the movements of six translocated wallabies over an initial period of 5 months, between May and October 2023. Average daily movements during this period were larger than those reported here (mean of 1.8 ± 0.05 km), but with larger daily movements up to a maximum of 9 km recorded, and no significant difference between males and females. Activity range sizes ranged from 200 to 1,029 ha.

After the initial 5-month trial, data from three wallabies that were not successfully removed at the conclusion of the initial trial continued to be collected (Warburton et al., 2024). Over the next 3-4 months, these three individuals dispersed away from their release sites, with approximate total distances dispersed of 37 and 40 km for two individuals in November, and 18 km for the third individual in January. Overall, results from that study bear some striking similarities with the results from this study, including high site fidelity of translocated wallabies initially, but with some long-distance movements recorded in the warmer months, coming into the breeding season.

4.4.3 Time spent in proximity

Proximity analysis demonstrated that the three Judas wallabies that had the most overlap in activity ranges (Figure 17) nevertheless spent the majority of their time apart, at distances greater than 1.5 km. Instances where these Judas Wallabies were recorded within very close proximity (<150 m) were rare, at <2% of the time for each possible social pairing.

While the possibility that other non-collared wallabies were present in the area cannot be ruled out, no such individuals were detected during pre-translocation thermal drone surveillance in July, nor at the end of the trial when the whole Kyeburn area was surveyed using aerial thermal from helicopters. While we acknowledge that these detection methods may have failed to detect un-collared wallabies present in the area, we nevertheless consider it unlikely that alternative social relationships were the reason why the Judas wallabies spent little time together.

To use Judas wallabies efficiently in an eradication operation, they would need to consistently display tendencies of keeping close to conspecifics once they are found. Although the sample size in this study is low, the collared, translocated wallabies did not reliably remain within close proximity of conspecifics. Therefore, Bennett's wallabies may not be a practical candidate for use of the Judas animal technique. As a 'moderately gregarious' species (A. D. M. Latham & Warburton, 2021), Bennett's wallabies may lack the necessary social drive to be as effective as more highly gregarious species such as pigs and goats when used as a Judas animal.

Spatial data from this study may be used for better understanding wallaby movements and preference in these specific locations, such as within the Kyeburn area. It is possible that the areas where Judas Wallabies spent the most time would also be preferred by wallabies that had dispersed to this area (or were born in, or transported to, this area). However, the Judas Wallabies in the Kyeburn area did not venture into some areas, such as Near Undaunted Creek, where wallabies have previously been found and destroyed under the Otago Regional Council control programme. This elucidates that there is sufficient cover and food throughout these landscapes, and there may not be enough of a draw to any specific areas to reduce the search area for wild wallabies.

5.0 Judas wallaby condition, fate, and collar performance

5.1 Judas wallaby condition

From January to July 2024 Judas wallabies were successfully located and sighted from the helicopter 42 times. On each of these occasions, Judas wallabies appeared to be in good health, and there was no obvious evidence of injury or impediment. While it was not possible to closely inspect the wallabies from an aerial perspective, all Judas wallabies that were translocated in September 2024 (*n* = 4) and/or successfully removed during or at the end of the trial (*n* = 6) were examined carefully. There was no evidence of injuries other than those that were the cause of death (i.e. gunshot, or suspected poisoning in one case), including in the collar area.

5.2 Judas wallaby fates

Of the 11 collared wallabies that were released for this trial, the fates of 6 are known, with 5 being removed by contractors during or at the end of the trial, and 1 found dead due to suspected 1080 poisoning following a landowner rabbit control operation (Table 8). The fates of the remaining 5 collared wallabies are unknown, as individuals were unable to be relocated in the field after they either slipped their collar, or the collar lost communication with satellite (Table 8). Attempts were made to locate each of the five lost wallabies using VHF tracking both from the air and on the ground but were unsuccessful.

5.3 Collar performance

A number of failures of GPS/VHF collars occurred throughout the course of the trial (Table 8). These included:

- Three cases where the collar lost connection to satellite, with cause undetermined (J05, J25, J30); and,
- One case of premature battery depletion (J45.2). This collar was recovered and sent to the manufacturer (Lotek, Canada) for inspection. Their engineers were unable to find a problem with the GPS components of the collar, so concluded that battery failure was the problem.
- There was one further instance where a collar battery was depleted before the end of trial (J20); this was unexpected based on the estimated battery life calculated in conjunction with Lotek.

Table 8: Fate of all Judas wallabies and GPS collars used in this trial.

Collar Channel	Wallaby fate	Collar recovered?	Collar fate	Detail
45.1	Removed from trial after collar slipped (identified by ear tag)	Y	Slipped collar - re-deployed	First deployment of J45 collar. Wallaby slipped collar on 5 Feb 2024. Collar recovered from field on 7 Feb 2024. Wallaby destroyed 16 February 2024.
45.2	Removed from trial after collar failure	Y	Battery failure	Second deployment of J45 collar, wallaby released 27 Mar 2024. Last GPS fix received 9 Jun 2024. Wallaby removed and collar retrieved 28 Aug 2024. Collar was sent to Lotek engineers in Canada for inspection who diagnosed premature battery failure.
20	Unknown - unable to relocate wallaby	N	Battery depleted	Last GPS fix received 27 Dec 2024. Remote voltage data indicates battery depletion within expected range of battery life.
30	Unknown - unable to relocate wallaby	N	Lost	Lost connection to satellite - cause undetermined. Last GPS fix received 9 May 2024. No evidence of battery depletion from remote voltage data.
25	Unknown - unable to relocate wallaby	N	Lost	Lost connection to satellite - cause undetermined. Last GPS fix received 27 Oct 2024. No evidence of battery depletion from remote voltage data.
05	Unknown - unable to relocate wallaby	N	Lost	Lost connection to satellite - cause undetermined. Last GPS fix received 4 Oct 2024. No evidence of battery depletion from remote voltage data.
40	Unknown - Mortality function triggered. The collar was recovered but there was no wallaby carcass. Potentially slipped collar, or wallaby shot by unknown hunters and collar removed.	Y	Mortality or slipped collar	Wallaby mortality (or slipped collar) 28 Jan 2025. Collar recovered 29 Jan 2025. The wallaby collar was re-located 4 km away from the previous location (i.e. last fix before movement ceased).
01	Mortality. Suspected 1080 poisoning (landowner toxin operation)	Y	Mortality	Wallaby mortality 26 May 2024. Collar recovered 28 May 2024
35	Removed at end of trial	Y	Functional till end of trial	Wallaby removed at end of trial 26 Mar 2025
15	Removed at end of trial	Y	Functional till end of trial	Wallaby removed at end of trial 26 Mar 2025
10	Removed at end of trial	Y	Functional till end of trial	Wallaby removed at end of trial 3 Apr 2025

6.0 Study Conclusions

A number of unexpected challenges occurred throughout the course of this research, most notably longer than expected timeframes to reduce conspecific wallaby density at the research sites, and a high rate of GPS collar failure. For Phase One in particular, the inability to reduce conspecific density in the Northern Group Area, as well as conspecifics being undetectable in the Southern Group Area, severely limited the ability to replicate the conditions required to demonstrate proof-of-concept for the Judas technique in Bennett's wallabies.

In the Northern Group Area, Judas Wallabies displayed a high degree of site fidelity, instead of the widely-ranging 'seeking' behaviour that is typically associated with Judas animal technique. Judas wallabies in the Southern Group Area had somewhat larger activity range areas during the same time period, but high variability and small sample size limits the ability to draw generalisations from this result.

Estimated minimum daily movements from throughout the entire trial reinforced the tentative Phase 1 finding that wallabies in the Southern Group Area tended to move larger distances than those in the Northern Group Area. They also showed that males tended to have larger daily movements than the females within the same trial area throughout the year. A seasonal effect was also evident, with wallabies typically moving greater distances in the summer months than in winter, which is in line with previous research on this species (Warburton et al., 2024).

The two Judas wallabies (J45.1, J10) that travelled from Canterbury into Otago provide invaluable information on how wallabies may navigate this landscape. The data provides insight into how these animals move at different times of year, and how quickly they can travel large distances into new areas. It also provides a reminder that if a travelling wallaby is detected (e.g. reported by landowner, contractor or member of the public), it may not be detectable again in that area because it moved quickly through and into a new landscape. This information may be used to refine search areas and timeframes when responding to wallaby reports in very low-density areas.

Based on the movement data alone it would appear that Bennett's wallabies, specifically males, fulfil one key criteria of successful Judas animals, in that they will tend to range widely especially in the peak of the breeding season. However, in order to be useful from a practical perspective, Judas animals must also be capable of 'leading' eradication practitioners to conspecifics, allowing those conspecifics to be culled. The proximity analysis (Phase 2), which treated Judas wallabies in the same area as conspecifics, was the most informative approach to assessing this criterion. The proximity analysis of the Kyeburn group showed that, despite substantial overlap in their ranging areas, Judas wallabies spent a very low proportion of their time within a proximity to each other that would be useful from a management perspective.

While based on a very small sample size, this result gives little support for the use of the Judas animal technique in Bennett's wallabies in the traditional sense of the term which implies that Judas wallabies lead control operators directly to uncollared conspecifics. To justify the expenditure and time commitment that the Judas animal technique requires, eradication managers would need to have high confidence that Judas wallabies will reliably locate conspecifics and remain in proximity to them for a large proportion of the time. Based on these results, this is very unlikely to be the case and Bennett's wallabies do not appear to be a practical candidate for use of the Judas animal technique. Whether collared wallabies could still have some utility in reducing search area or frequency, and to what extent, is potentially a topic for future research.

7.0 Operational insights and research needs

The methodological challenges encountered during the course of this proof-of-concept study highlighted some key operational insights and research gaps:

- A better scale is needed to more accurately describe the densities of wallabies (that can be detected) within the 'very-low-density' and 'low-density' ranges. The Guildford scale is not fit-for-purpose, as it completely misses much of the very-low-density range, e.g. where sign can be found (therefore, not level 1) and pellet groups not found when traversing most 100 m sections (therefore, not level 2). The Guildford scale could only be accurately used at a very fine scale (e.g. in 100 m sections), which is not helpful for categorising catchments/subcatchments into estimated density categories. Examples from Wall-IS could be used to visually display different densities.
- Analysis of Wall-IS data would likely help refine future search in very-low-density areas. Providing that effort/coverage is taken into account, one could refine the areas searched to those where wallabies, or their sign, have been found over the last 5 years. This could take into account elevation, vegetation, time of year etc. Although areas of suitable habitat cannot be completely excluded from searches, the approach could be refined. For example, every second round of surveillance could focus only on optimal areas, and every other round of surveillance covering all suitable habitat.
- A critical research need is to determine how wallabies are most efficiently found in very low densities. Much of the research to date has been focused in moderate-density areas which does not address this key operational need.
- There is an opportunity to continue research on whether the use of collared wallabies has any utility in reducing search area or frequency, perhaps in particular circumstances. For example, use of collared males in breeding season only, when they are highly motivated to find females (noting that because we used ovariectomies to sterilise female Judas wallabies in our pilot trial, it is likely that their attractiveness to male Judas wallabies was reduced).

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9.0 References

Boffa Miskell Ltd. (2023a). *Judas wallaby research plan 2023-2025: Assessing the Judas technique for detecting Bennett's wallabies* (Report BM210002R). Prepared by Boffa Miskell Ltd for Otago Regional Council.

Boffa Miskell Ltd. (2023b). *Judas wallaby site selection: Site selection report 2023* (Report BM210002R). Prepared by Boffa Miskell Ltd for Otago Regional Council.

Campbell, K., Donlan, C. J., Cruz, F., & Carrion, V. (2004). Eradication of feral goats *Capra hircus* from Pinta Island, Galápagos, Ecuador. *Oryx*, *38*(3), 328–333.

Carrion, V., Donlan, C. J., Campbell, K. J., Lavoie, C., & Cruz, F. (2011). Archipelago-wide island restoration in the Galápagos Islands: Reducing costs of invasive mammal eradication programs and reinvasion risk. *PLoS One*, *6*(5), e18835.

Crouchley, D., Nugent, G., & Edge, K.-A. (2011). Removal of red deer (*Cervus elaphus*) from Anchor and Secretary Islands, Fiordland, New Zealand. In *Island Invasives: Eradication and Management* (pp. 422–425). IUCN.

Cruz, F., Carrion, V., Campbell, K. J., Lavoie, C., & Donlan, C. J. (2009). Bio-economics of large-scale eradication of feral goats from Santiago Island, Galapagos. *The Journal of Wildlife Management*, *73*(2), 191–200.

Latham, A. D. M., Latham, M. C., & Warburton, B. (2023). Spatial ecology of invasive Bennett's wallaby in South Island, New Zealand. *Wildlife Research*, *50*(12), 1109–1122.

Latham, A. D. M., & Warburton, B. (2021). *Macropus eugenii, M. r. Rufogriseus, M. parma, M. dorsalis, Petrogale penicillata, Wallabia bicolor*. In *The Handbook of New Zealand Mammals. Family Macropodidae* (3rd ed., pp. 1–26). CSIRO Publishing.

Latham, A. D. M., Warburton, B., Latham, M. C., Anderson, D. P., Howard, S. W., & Binny, R. N. (2021). Detection probabilities and surveillance sensitivities for managing an invasive mammalian herbivore. *Ecosphere*, *12*(10), e03772.

Latham, D. M., Latham, M. Cecilia, & Warburton, B. (2019). Current and predicted future distributions of wallabies in mainland New Zealand. *New Zealand Journal of Zoology*, *46*(1), 31–47.

Morrison, S. A., DeNicola, A. J., Walker, K., Dewey, D., Laughrin, L., Wolstenholme, R., & Macdonald, N. (2016). An irruption interrupted: Eradication of wild turkeys *Meleagris gallopavo* from Santa Cruz Island, California. *Oryx*, *50*(1), 121–127.

Morriss, G., Warburton, B., Sutton, L., & Binny, R. (2024). *Determining the rate at which Bennett's wallabies reinfest an area treated with toxic bait* (Landcare Research Contract Report LC4563). Prepared by Manaaki Whenua Landcare Research for the Ministry for Primary Industries on behalf of the Tipu Mātoro National Wallaby Eradication Programme.

Parkes, J. P., Ramsey, D. S. L., Macdonald, N., Walker, K., McKnight, S., Cohen, B. S., & Morrison, S. A. (2010). Rapid eradication of feral pigs (*Sus scrofa*) from Santa Cruz Island, California. *Biological Conservation*, *143*(3), 634–641.

Ramsey, D. S. L., Campbell, K. J., Lavoie, C., Macdonald, N., & Morrison, S. A. (2022). Quantifying the probability of detection of wild ungulates with the Judas technique. *Conservation Biology*, *36*(4), e13898.

Sundin, O. (2024). *The use of the Judas animal method to detect and prevent an invasion of raccoon dogs (*Nyctereutes procyonoides*)* [Unpublished Master of Science thesis, Uppsala University]. https://www.diva-portal.org/smash/get/diva2:1889515/FULLTEXT01.pdf

Tipu Mātoro Wallaby Free Aotearoa. (2022). *Aotearoa New Zealand Wallaby Strategy—Acheiving a wallaby-free Aotearoa* (p. 28). Tipu Mātoro Wallaby Free Aotearoa.

Warburton, B., Sutton, L., & Whitehead, A. (2024). *Translocation of Bennett's wallabies and its utility for mobile surveillance detection probability research* (Landcare Research Contract Report LC4416). Prepared by Manaaki Whenua Landcare Research for the

Ministry for Primary Industries on behalf of the Tipu Mātoro National Wallaby Eradication Programme. https://www.mpi.govt.nz/dmsdocument/66615-Translocation-of-Bennetts-wallabies-and-its-utility-for-mobile-surveillance-detection-probability-research

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