Acoustic survey of the North Island Brown Kiwi population in the Remutaka Forest Park from 2011-2021

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with results including some surveys in collaboration with Greater Wellington Regional Council and the MOA Conservation Trust

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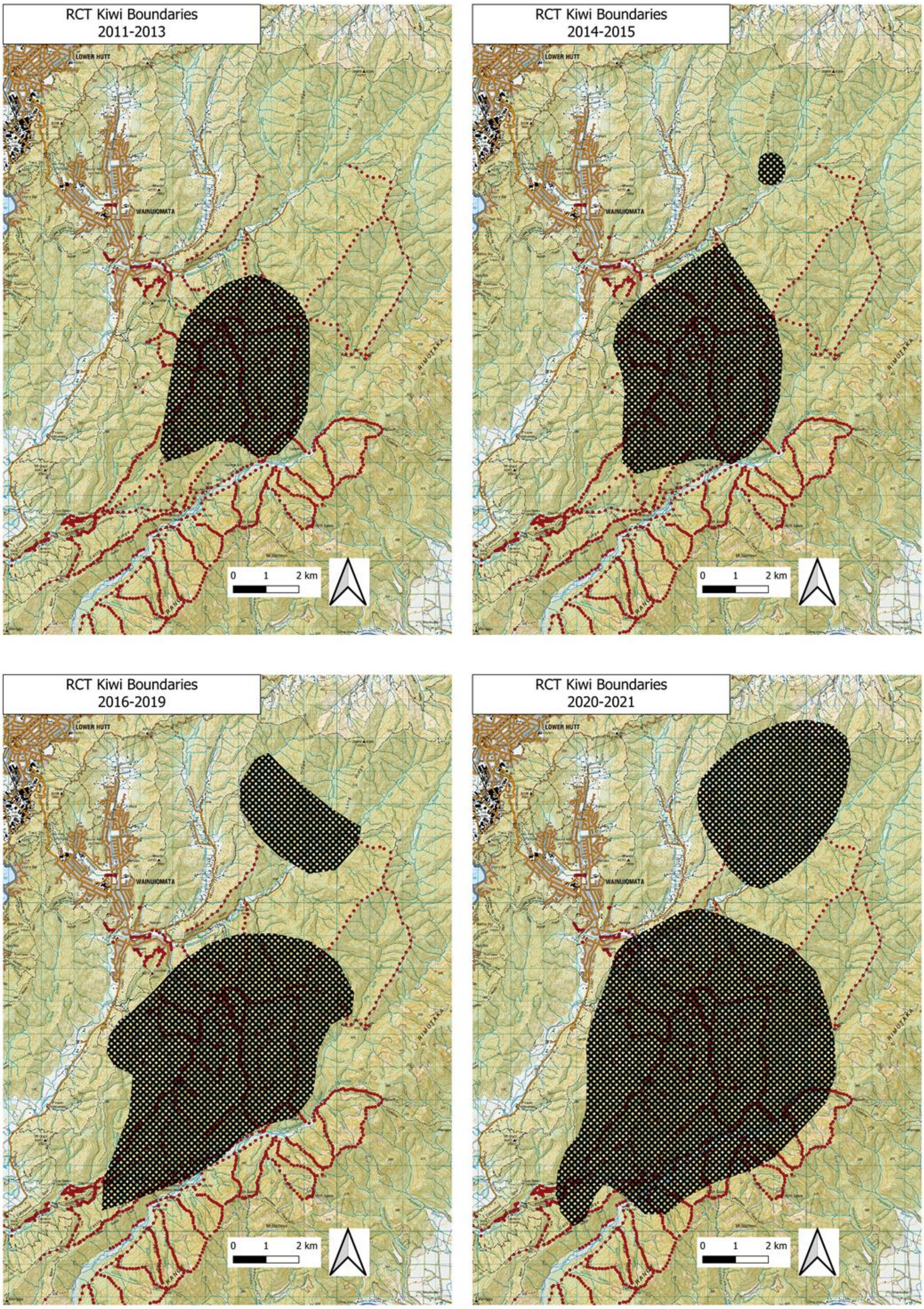
Executive Summary

From 2011 to 2021 the Remutaka Conservation Trust deployed acoustic recorders annually at up to 100 sites/year in the Remutaka Forest Park, in order to estimate the geographic spread and relative abundance of an introduced North Island Brown Kiwi population through time. Department of Conservation (DOC) AR4 recorders were used- mostly over the winter months- to record > 8 hours per night for 2-3 weeks at each site, throughout the park, with the number and spread of recorder locations increasing each year to keep up with the expanding boundary of the kiwi population. Early data were analysed using a filter developed by Dragonfly consulting, but since 2015, data were analysed using the Sound Exchange Software with human examination and scoring of each spectrogram in order to produce a robust estimate of male and female kiwi presence/absence along with average call rates per hour for each site. Our dataset includes sound recordings from the adjoining Wainuiomata Water Catchment (for which some of the collection was funded by Greater Wellington Regional Council) in 2018 and 2020; and a joint survey on the eastern banks of the Orongorongo River with MOA Conservation Trust in 2021- these results are also included here, so that we estimate kiwi abundance and spread through time not only for the Remutaka Forest Park but also adjoining parts of the Remutaka Ranges.

Results show that the kiwi population- initially introduced into the upper reaches of the Turere stream from 2006 to 2011- have spread steadily through time, with kiwi calls now recorded from the northern boundary of the Wainuiomata Water Catchment (Greater Wellington block), in the region adjoining Wainuiomata Township in the north (near Sunny Grove); from across the Orongorongo River in the east, to the Orongorongo Track/Clay Ridge area in the southwest, and the Boys Brigade region in the west. Maximum hourly call rates occur in the Turere catchment. Acoustic recorder data has been used to pinpoint breeding pairs and, in several cases, to actually locate incubation burrows to monitor breeding outcome.

The enlargement in the kiwi zone through time has made the deployment and collection of sound recorder data and the use of manual processing such as that outlined here increasingly challenging. In the final section of this report we discuss future monitoring (and processing) options that may be required in order to continue to meet our monitoring objectives.



Summary figure showing approximate kiwi zone (shaded region: kiwi calls present) grouped into 4 time intervals. Red dots show DOC200 stoat traps in the Remutaka Forest Park and environs.

Introduction

The Remutaka Conservation Trust is a community group committed to protecting and restoring the landscape and native wildlife of the Remutaka Forest Park located near New Zealand's capital city, Wellington. Our vision is a thriving forest ecosystem, rich in indigenous species, to be enjoyed by the wider community. Since 2003 the Trust has managed a flagship restoration project by reintroducing kiwi to the Remutaka Ranges. Kiwi have not been historically recorded in the Park and are presumed to have died out prior to European records in the area (Fig. 1). Following our implementation of a comprehensive stoat trapping operation over > 40 sq km of the park (from 2003- present; Fig. 2), in 2006, the Trust released the first 8 North Island Brown Kiwi (Apteryx mantelli) sourced from the captive breeding population into the upper Turere stream. Subsequently, a few more captive birds were released and in 2009 the Trust devised and carried out a catching expedition on Little Barrier Island which resulted in the introduction of a further 20 mixed lineage Brown Kiwi. In the decade following the initial kiwi release, our group also used Operation Nest Egg (ONE) on a few breeding pairs, with eggs removed and hatched in captivity. The ONE chicks were rereleased into the park once they gained stoat-proof size, generally in the Upper Turere Stream release area.

Our kiwi translocation proposal stated that we would monitor breeding outcome of the introduced kiwi with the goal to establish a self-sustaining population. Initially monitoring was via radio tracking of every single kiwi released plus their progeny, but by 2011, this intensive monitoring effort, carried out solely by volunteers, was becoming untenable; we were tracking over 50 kiwi, our population was breeding successfully and growing quite rapidly, and spreading into remoter parts of the Park.

With the removal of most of the adult kiwi transmitters in 2011 (and all of the transmitters by 2019), we have moved to less invasive monitoring techniques. Acoustic recording and call counts of adult kiwi calls is a well-established method for remote monitoring of kiwi populations (e.g., Miller and Pierce, 1995; Robertson and Colbourne, 2003, 2017; Colbourne, 2006). While a direct correlation between call rates and population density is not possible, call rates can give some indication of relative abundance (Robertson and Colbourne, 2017). In addition, since our population is entirely new and introduced at one geographic location into a large Forest Park with plenty of suitable habitat, we were interested to see how the population would spread out through time. Acoustic recorders can be used to detect kiwi calls on the outskirts of a population and thus to map the boundaries of the kiwi zone through time.

This brief report outlines the results from over 10 years of acoustic monitoring for kiwi in the Remutaka Forest Park and the adjoining Wainuiomata Water Catchment. We demonstrate the spread of the kiwi through time; the approximate boundaries of the kiwi zone; kiwi call densities; and finally discuss future monitoring directions and the changes that will be necessary to monitor the growing kiwi area in the next decade.

Method

In 2011 we purchased our first 4 recorders, with a generous donation from Dragonfly Consulting of 4 more, giving a total of 8 recorders. At that time no suitable nation-wide protocol had been developed for data storage and metadata so we established our own protocol. With only 8 recorders, the data collected from 2011-2013 were limited to the tracks bounding the core kiwi release area. In 2014 we purchased an additional 10 recorders, and since then our recorder pool has grown to more than 40, allowing us to cover a larger area.

Recorders are placed on suitable trees (mostly near stoat traps on our track network, to make it easy to locate them and match with GPS coordinates) for 2 weeks recording for 8 hours per night, typically starting an hour after dusk with the exact time varying depending on the time of year. [Note that a firmware issue with the recorders meant that some sites in 2018-2020 only recorded for 1 week and thus are undersampled]. The bulk of our surveys were carried out from May to September each year although a few sites were recorded during the summer. The AR4s were set to record low frequency data (0-4 kHz) and downloaded onto external hard drives (2 drives per dataset, i.e. creating 2 backup disks in case of disk failure). The initial data from 2011-2013 was analysed using an automated filter developed by Dragonfly consulting. These data were also scored by humans in order to improve the filter. From 2014 on, data was analysed by a batch process that converts each wav file into a sonogram (http://sox.sourceforge.net/) that can be rapidly viewed as an image file on a laptop computer. An entire night of files (15 minutes per file for 8 hours i.e. 36 files) can be scrolled through and scored by an experienced person within about 2 minutes, so that analysing one site takes about half an hour. While this is labour intensive, it means that every file since 2014 has been analysed and scored by a trained human operator, so that we have a complete record of call rates and presence/absence of kiwi rather than a statistical sample. We excluded very noisy files from our call rate calculations, although we did process noisy files to check for kiwi calls when possible, so that we would have as complete an estimate as possible of where kiwi were calling for presence/absence plots.

The kiwi release area in the upper Turere stream is flanked by the McKerrow and Whakanui tracks. In 2011 we deployed recorders on these 2 tracks, plus some side ridges, and then expanded to cover a track network over > 40 sq km by 2017. Site altitudes ranged from 73 to 702m with a mean altitude of 382m and a median of 410m.

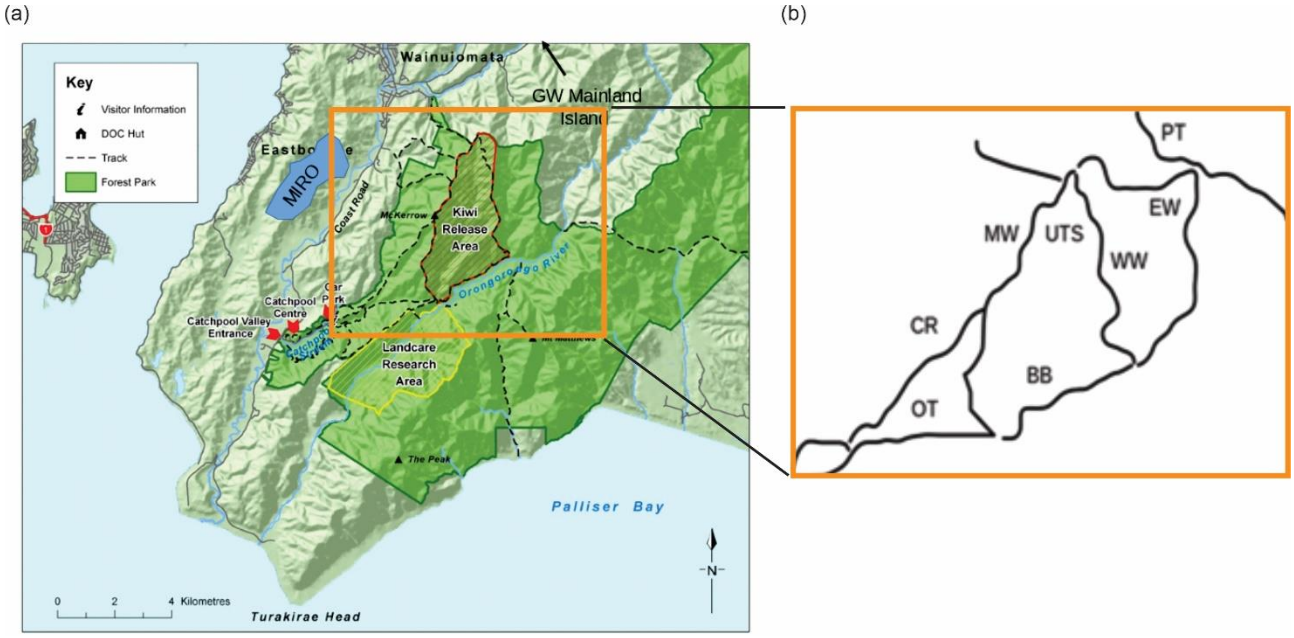


Figure 1. (a) Location of the Remutaka Forest Park (green) showing kiwi release site from 2006-2009 (hatched region, Turere catchment). Also shown are the adjacent Wainuiomata Water catchment with Skull Gully mainland island area, and Mainland Island Restoration Organisation (MIRO) trapped zone in blue. (b) Line drawing of the main tracks and areas mentioned in text. UTS=Upper Turere Stream; MW = McKerrow Track; WW = Whakanui Track; EW = East Whakanui Track; PT = Pack Track; CR = Clay Ridge; OT = Orongorongo Track.

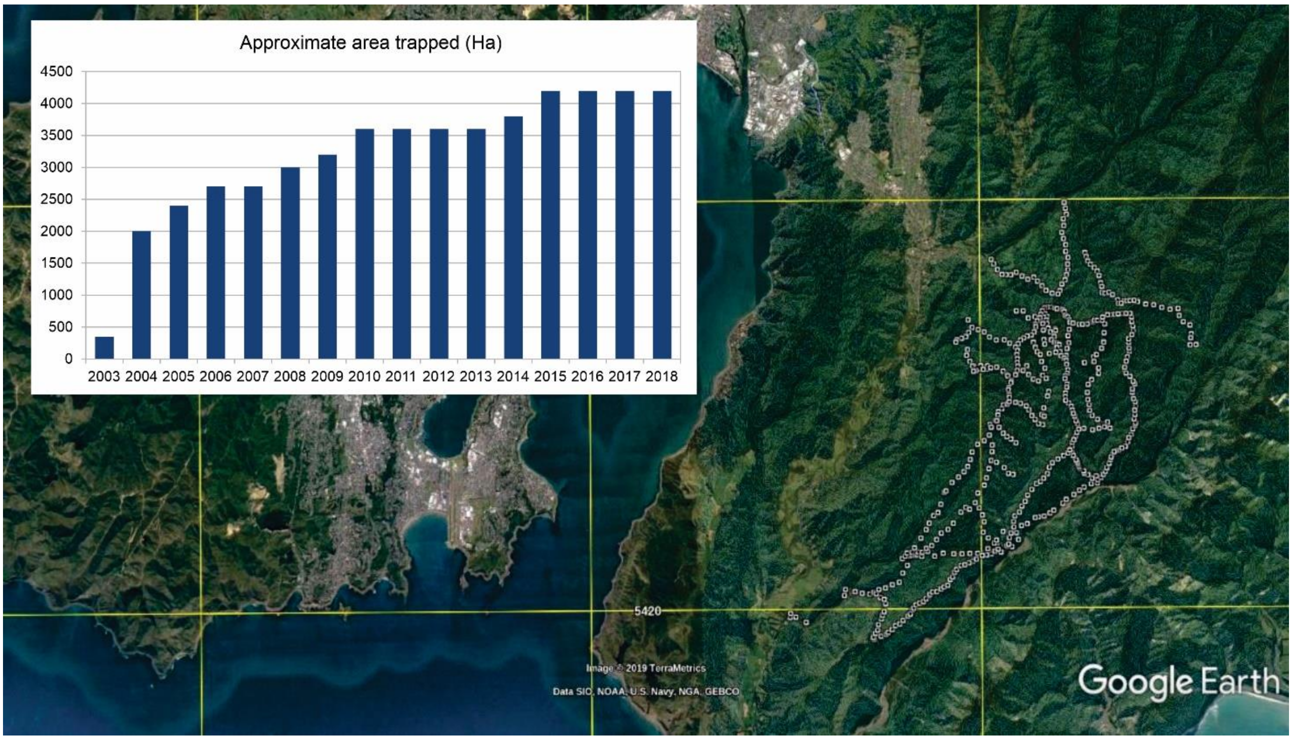


Figure 2. Location of DOC 200 stoat trap sites (white boxes) in the Remutaka Forest Park. Other traps (A24s, A12s, trapinators) not shown. Yellow grid shows 10 km spacing (NZTM). Inset shows increase in area trapped by DOC 200s through to 2018.

Results

The files were scored according to male, female, and duet calls detected and results were collated in a google drive spreadsheet. A few example lines from the spreadsheet are shown in Table 1.

Table 1. Example lines from results spreadsheet for the Big Bend line in 2020

SITE NAME	Call presence: 0=no calls, 1=single male, 2=duet, 3=female, 4=male+ female	Call volume: 0=none, 1=faint, 2=moderate, 3=loud	START DATE	number of 15 min files	number of noisy files	number valid files	number of calls	male only	female only	both (duet)	number of 15min files with kiwi present (may be < m+f+2*d)	call rate kiwi per hour
BB02	0	0	17 May 2020	472	70	402	0	0	0	0	0	0.000
BB04	0	0	17 May 2020	472	250	222	0	0	0	0	0	0.000
BB06	0	0	17 May 2020	472	70	402	0	0	0	0	0	0.000
BB08	0	0	17 May 2020	472	70	402	0	0	0	0	0	0.000
BB10	0	0	17 May 2020	472	70	402	0	0	0	0	0	0.000
BB12	1	2	17 May 2020	472	70	402	3	3	0	0	3	0.030
BB14	2	3	17 May 2020	472	70	402	24	16	0	4	20	0.239
BB16	1	2	17June 2020	504	102	402	6	6	0	0	6	0.060

(a) Kiwi presence plots – monitoring the kiwi boundaries through time

We first show kiwi presence/absence plots through time (Fig. 3). These are presented as a series of time snapshots, where data from 2011-2013, 2014-2015, 2016-2019 and 2020-2021 have been amalgamated, since it was not possible to collect data all around the network in any one calendar year. Male, female, and duet calls have all been lumped together (i.e. a black dot could represent a single male call, a single female, a succession of female and male calls, or duets). White dots show sites where no kiwi calls were detected. Note that there are some issues with the data presented in Fig. 3- in particular, the call data in 2011-2013 may have underestimated kiwi range because we did not collect data to the west of the McKerrow track; and we used a different method to detect the kiwi calls (as noted above). However, until 2011 we were tracking all adult birds, and the distribution in Fig. 3(a) matches quite well the GPSed bird locations from radio tracking, giving us confidence that the acoustic data is robust (see Fig. A1).

Results show how kiwi call distribution has spread through time from the initial release site, with approximate boundaries of the kiwi zone sketched in the bold blue polylines. Kiwi have spread south along the McKerrow, Whakanui and East Whakanui tracks, so that calls have now been picked up along the Orongorongo track, Big Bend track, and Clay Ridge track. At the same time, kiwi calls in the Pack track region of the Water Catchment- initially because of the establishment of 1 breeding pair (Colin and Kiwifruit) near the start of the track- have spread southward almost to the water intake on the Orongorongo River. And notably, kiwi have settled in the vicinity of the Greater Wellington mainland island at Skull Gully. Kiwi colonised the GW mainland island quite early (by 2014-2015) and this is one of the most common directions that juvenile kiwi migrated while being tracked with radio transmitters, perhaps indicating that this is preferred habitat for our birds. Kiwi have also now spread northward to the boundary of Wainuiomata (Sunny Grove and Mt Crowther).

In creating the boundary polygons in Figure 3, we made use of an assessment of the call volumes. If a black circle (kiwi present) only picked up faint male calls and was next to sites that did not pick up any calls, we assumed that it was within 200-300m of the kiwi boundary, whereas if loud male calls and/or female calls and duets (< 50 m away) were present and the black circle was on the edge of the measured network, we assumed that the kiwi boundary was outside of the monitored region, in which case the boundary marked is a best guess so rather imprecise.

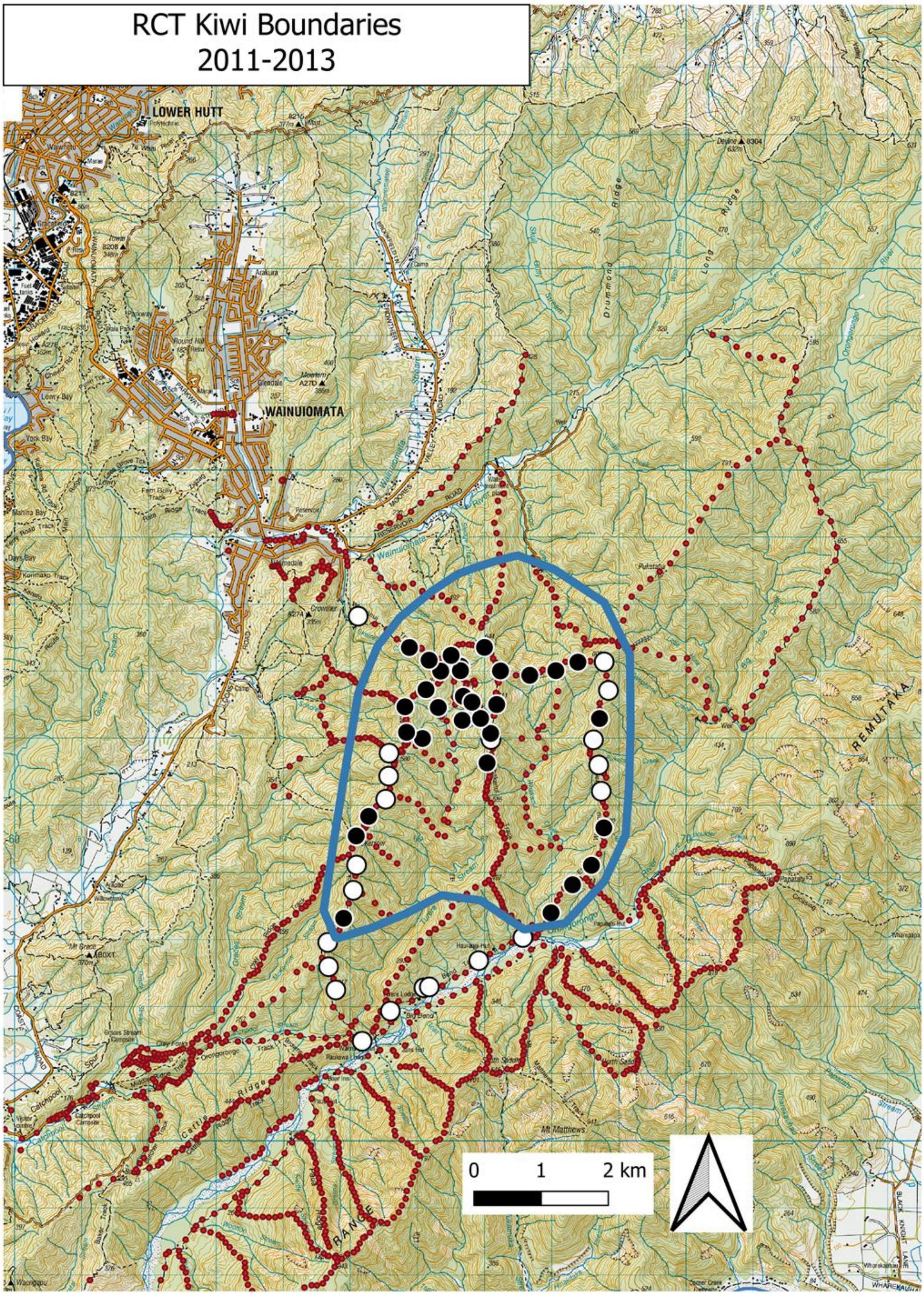


Figure 3(a). Presence/absence results for amalgamated data 2011-2013. White=measured, no kiwi calls. Black= kiwi calls (male, female and/or duet not distinguished). Bold blue polyline shows approximate estimated boundary of kiwi call zone. Red dots are DOC200 trap network.

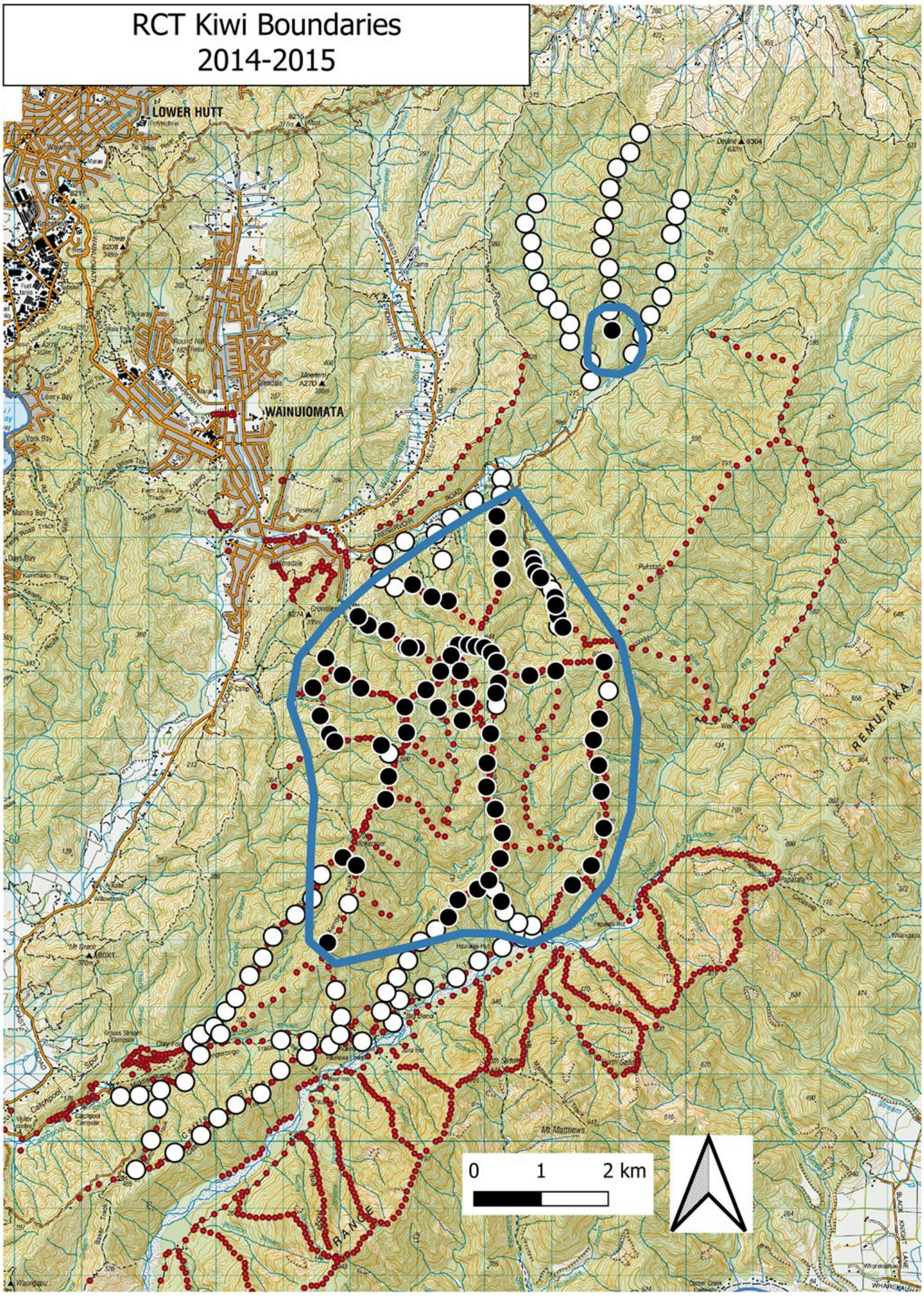


Figure 3(b). Presence/absence results for amalgamated data 2014-2015.

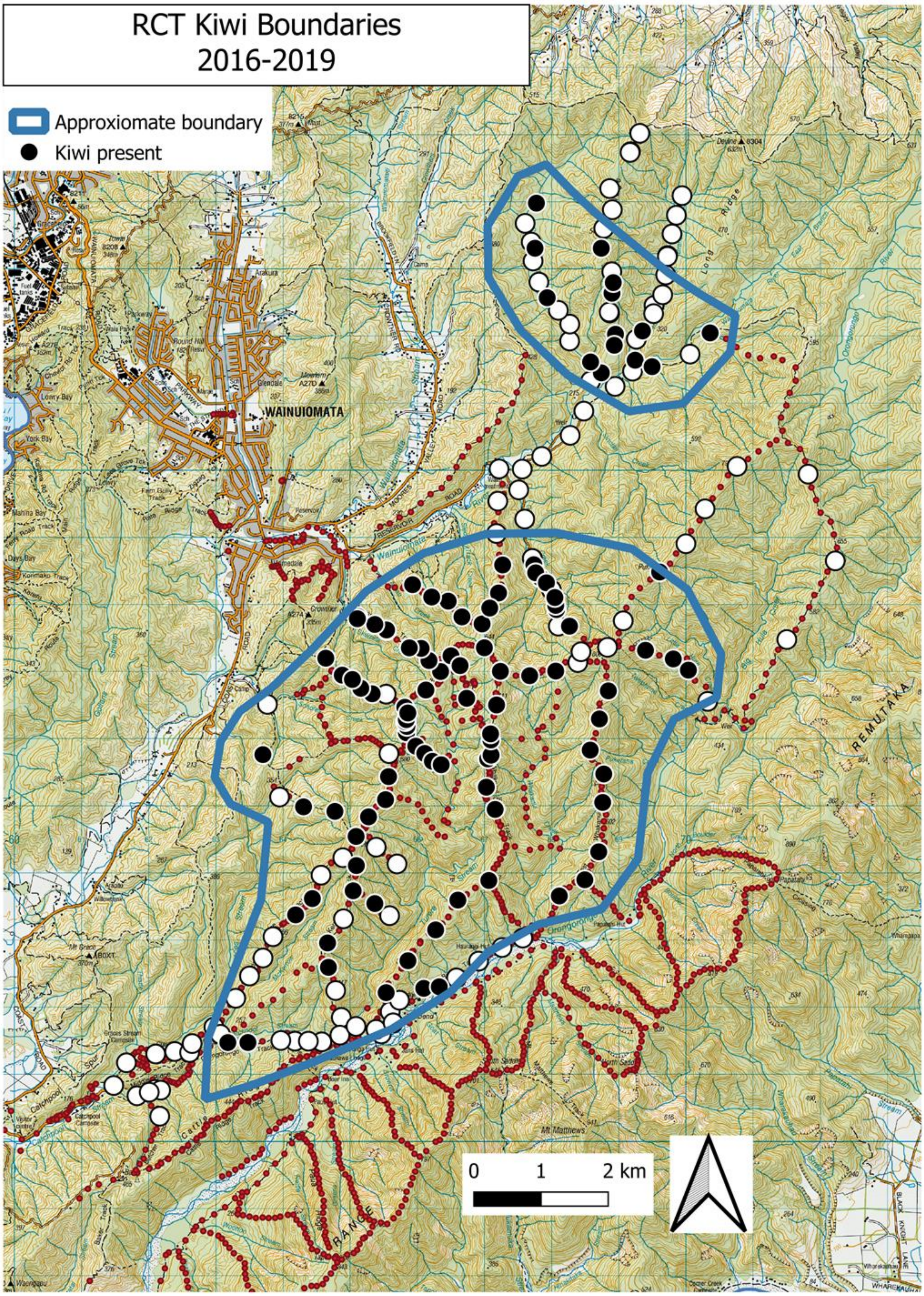


Figure 3(c). Presence/absence results for amalgamated data 2016-2019.

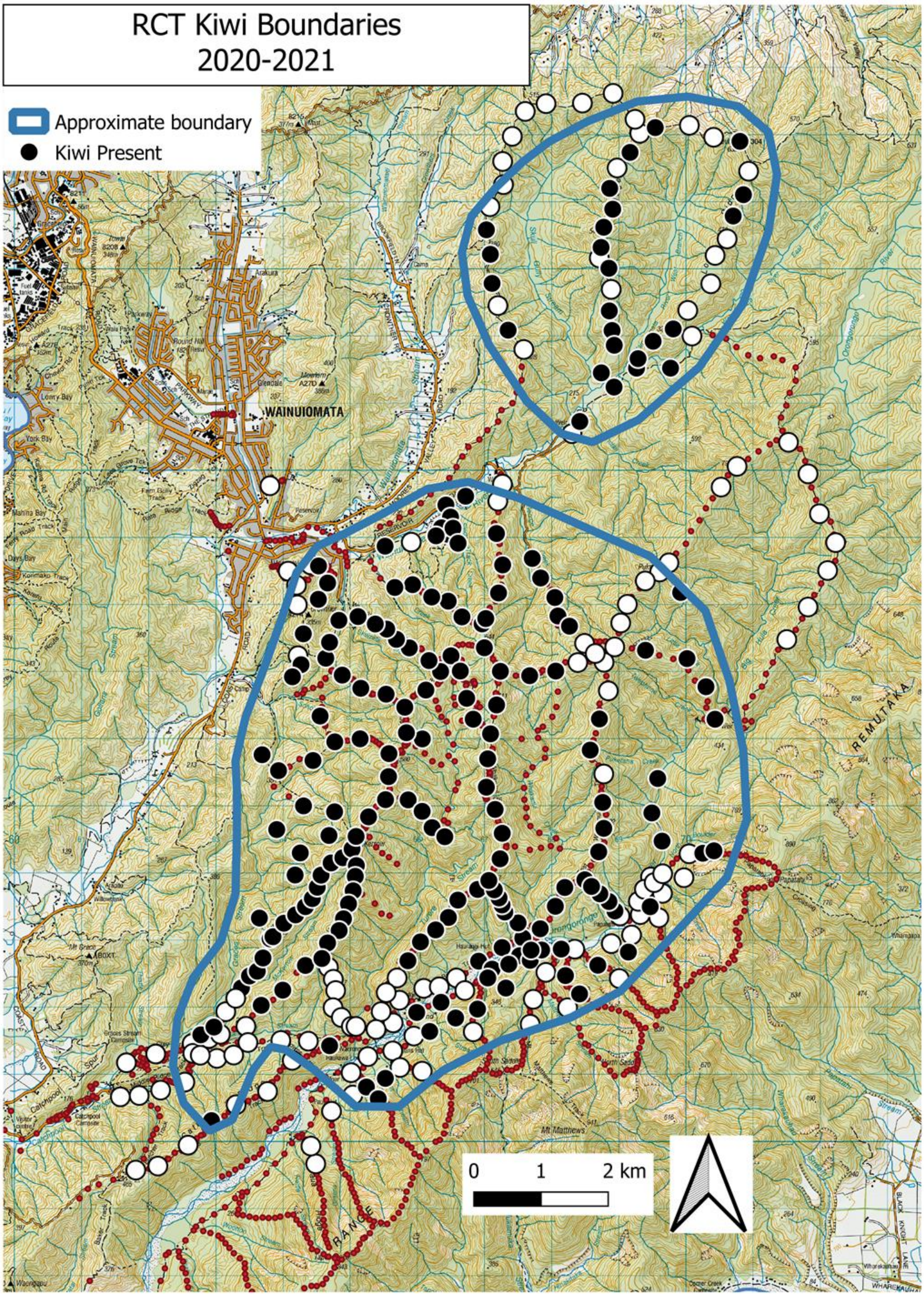


Figure 3(d) Presence/absence results for amalgamated data 2020-2021.

(b) Distribution of male calls vs female/duets

In Figure 4, we plot the 2020-2021 data but with each site colour-coded according to whether only male calls were picked up (blue circles) or female calls and duets were also detected (red stars).

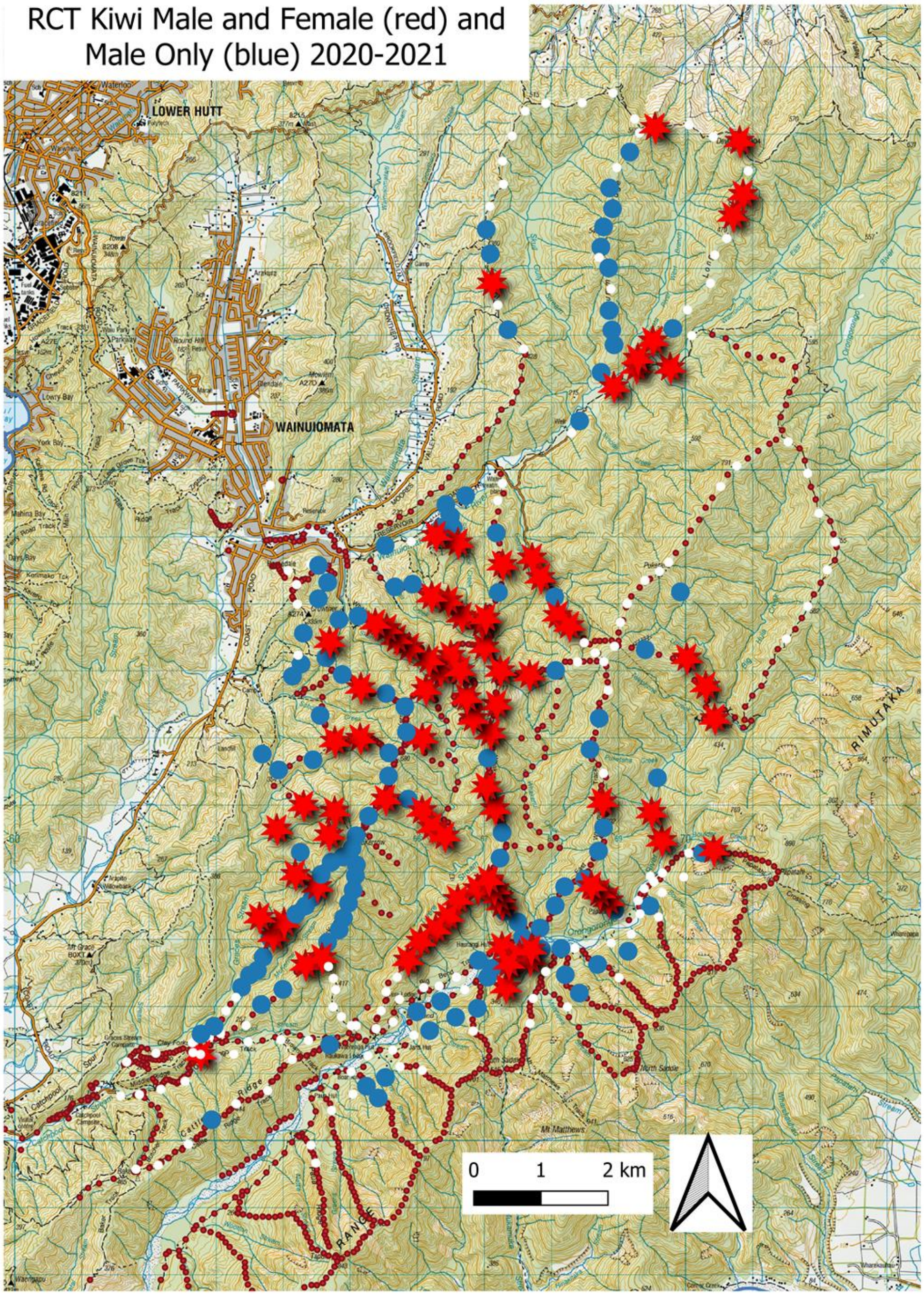


Figure 4. Example of the distribution of male only calls (blue stars) vs. female (often with male calls as duets) (red stars) for the 2020-2021 amalgamated survey data. White dots show sites where no calls were detected.

Female calls were mostly picked up at sites that also had many male calls, since kiwi male calls travel much further (up to 400 m) compared to the female calls. Most of the red stars on Fig. 4 show sites where the male and female were duetting. The red stars thus act as a proxy for established kiwi home ranges where a male and female kiwi have a territory. While the presence of some of these breeding pair sites near the boundary of the measured kiwi zone in 2020-2021 may indicate new pairings extending into previously unoccupied territory, it may also highlight the inadequate distribution of surveyed points.

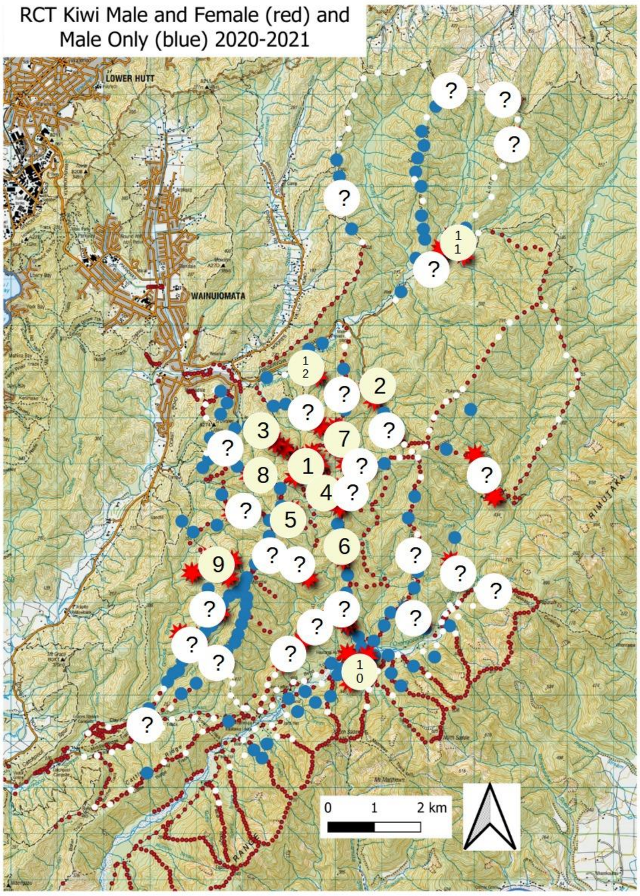


Figure 5. Same as figure 4 but possible pair locations marked by light green circles. Unknown pairs (not previously handled or caught on trailcam) shown with white circles with question marks. Possible known breeding pairs include the following males: (1) Lorenzo; (2) Colin; (3) Gonzo; (4) Marcel; (5) Tahunahuna; (6) Eddie; (7) Solomon; (8) Mr Baggins; (9) Sir Angus; (10) Unnamed pair on east side O. River (trailcam); (11) Rata; (12) Mata (trailcam).

Some of the pairs on Figure 4 correspond to known kiwi territories of males that were originally released (or tracked ONE birds). On Figure 5 we indicate possible males corresponding to these known home territories. We caution that not all of these labelled males may be correct, since in some cases we have not verified the males is still alive since 2011, though in many cases we have tracked them more recently and/or verified their presence on trailcams. (12) and (11) for example are breeding pairs that we have located using backtracking of acoustic recording (Ellis and Marsland, 2022) and studied breeding success using trailcams.

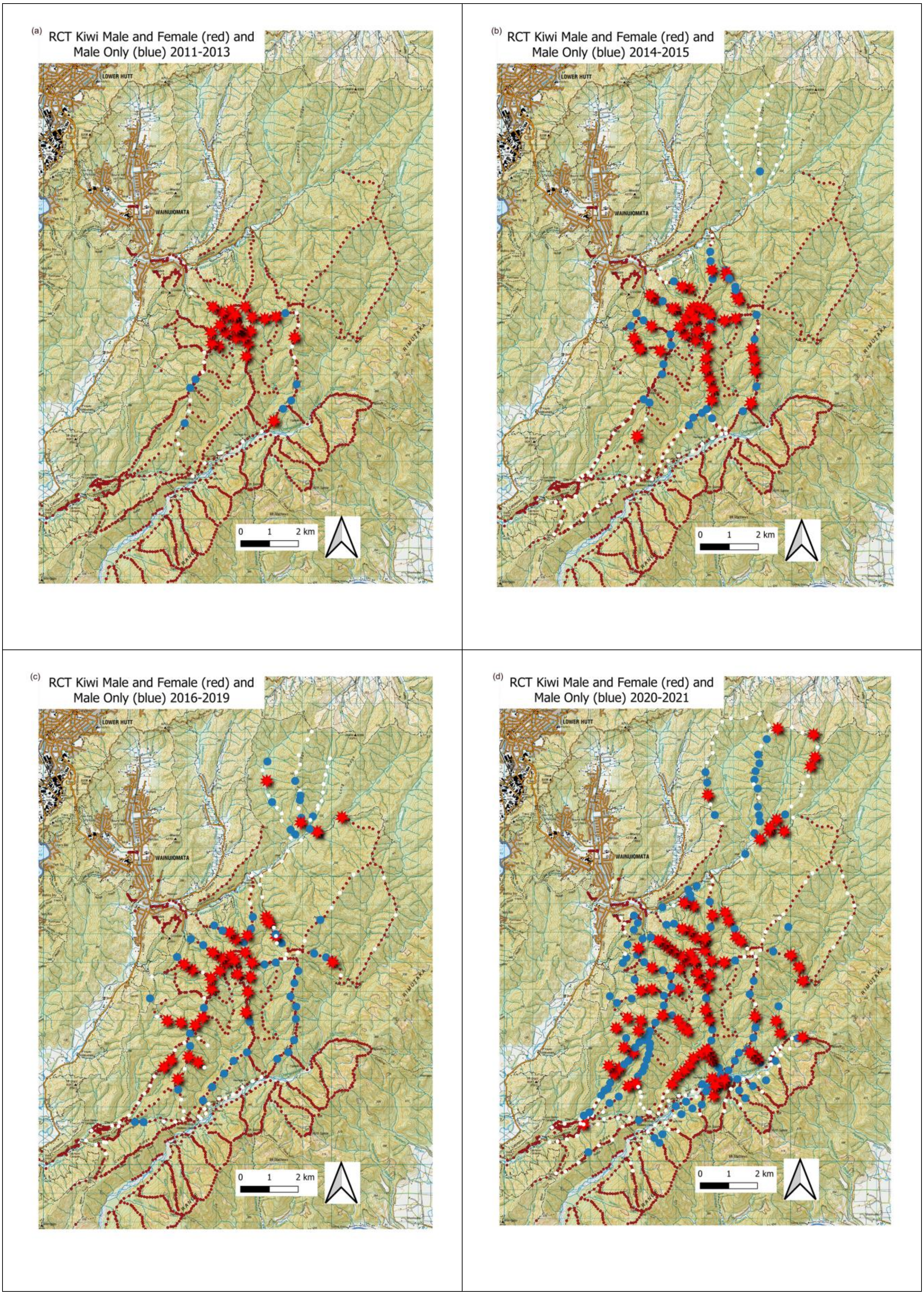


Figure 6. Evolution in call types (male only in blue stars, male and female- mostly duets- in red stars) for the four monitoring time periods.

(c) Call counts (rate of calls heard per hour)

Average call counts per hour plotted as heat maps (Fig. 7) show that in 2011-2013, the highest call rates were in the Upper Turere stream region very close to the 2006 release site. Subsequent years show high call rate areas spreading to the entre upper Turere stream catchment, with local hotspots along the Sunny Grove track, Big Bend track, and Pack track- although the call rates are not always increasing at each site, possibly because of the different collection periods in each year discussed above, and/or because of variability in the locus of kiwi activity and territories vs. location of the recorders over time. Kiwi duets are most common during breeding season (April-June) rather than later in the winter. There will also be some variability from year-to-year. Nevertheless the spread in call area through time is encouraging.

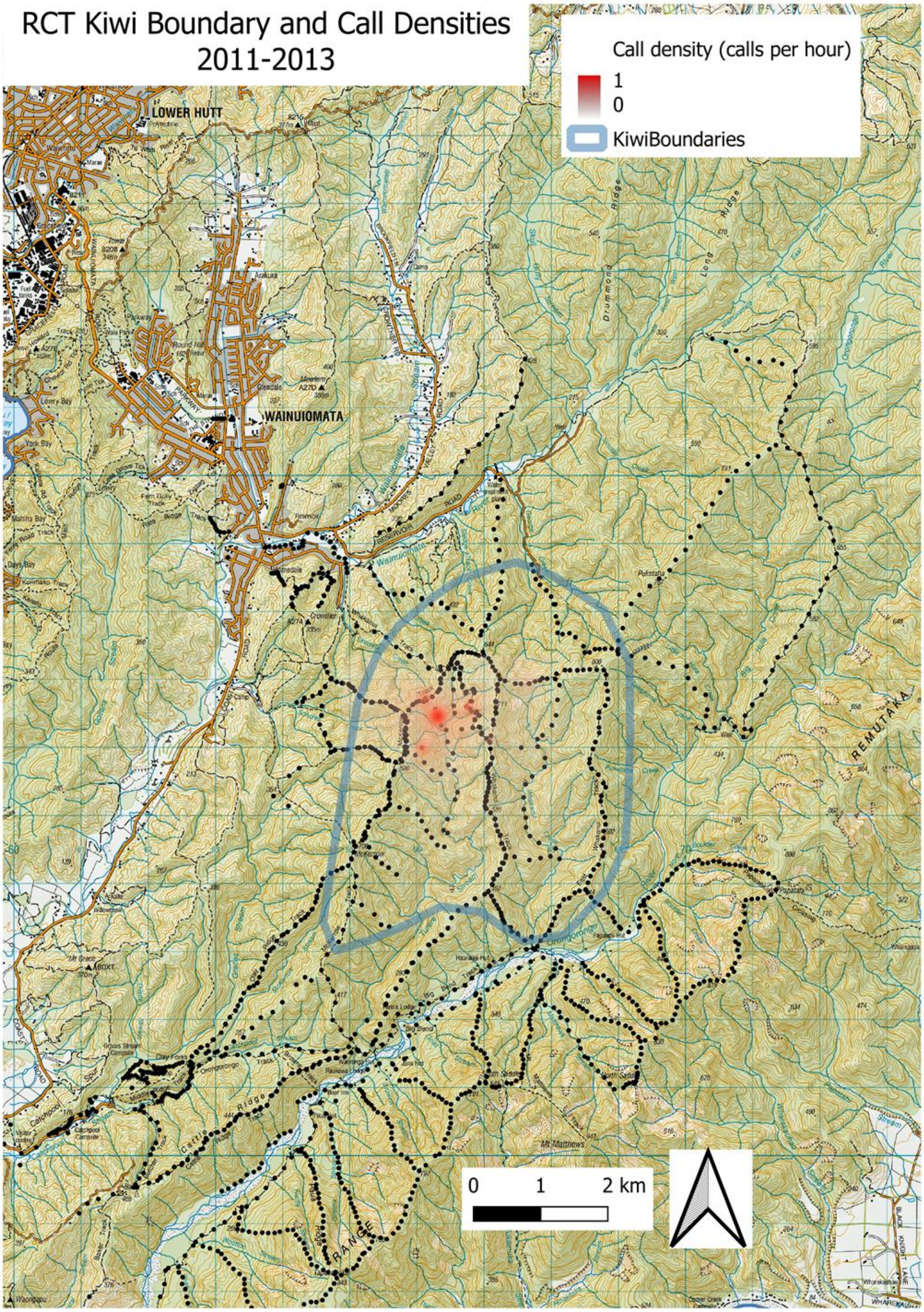


Figure 7(a). Call rate heatmap (average calls per hour of non-noisy data collected) for the time period 2011-2013. Point data interpolated using an inverse distance interpolator in QGIS, with a distance factor of 3 and a pixel size of 3. Data has been masked by kiwi call boundaries (partially transparent blue lines). Undersampling results in the bullseye patterns, so plot is indicative only.

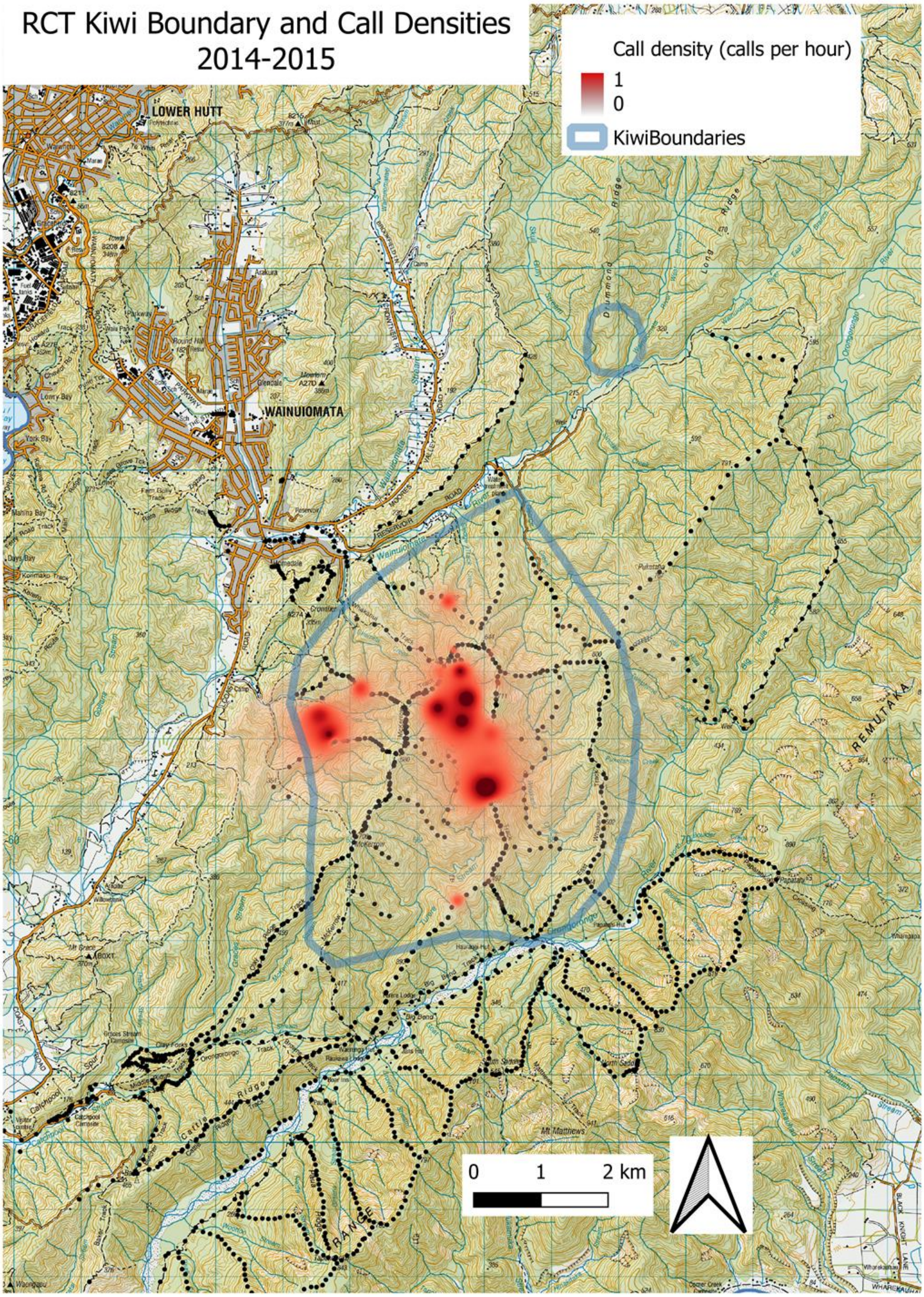


Figure 7(b). Call rates (average calls per hour of non-noisy data collected) for the time period 2014-2015.

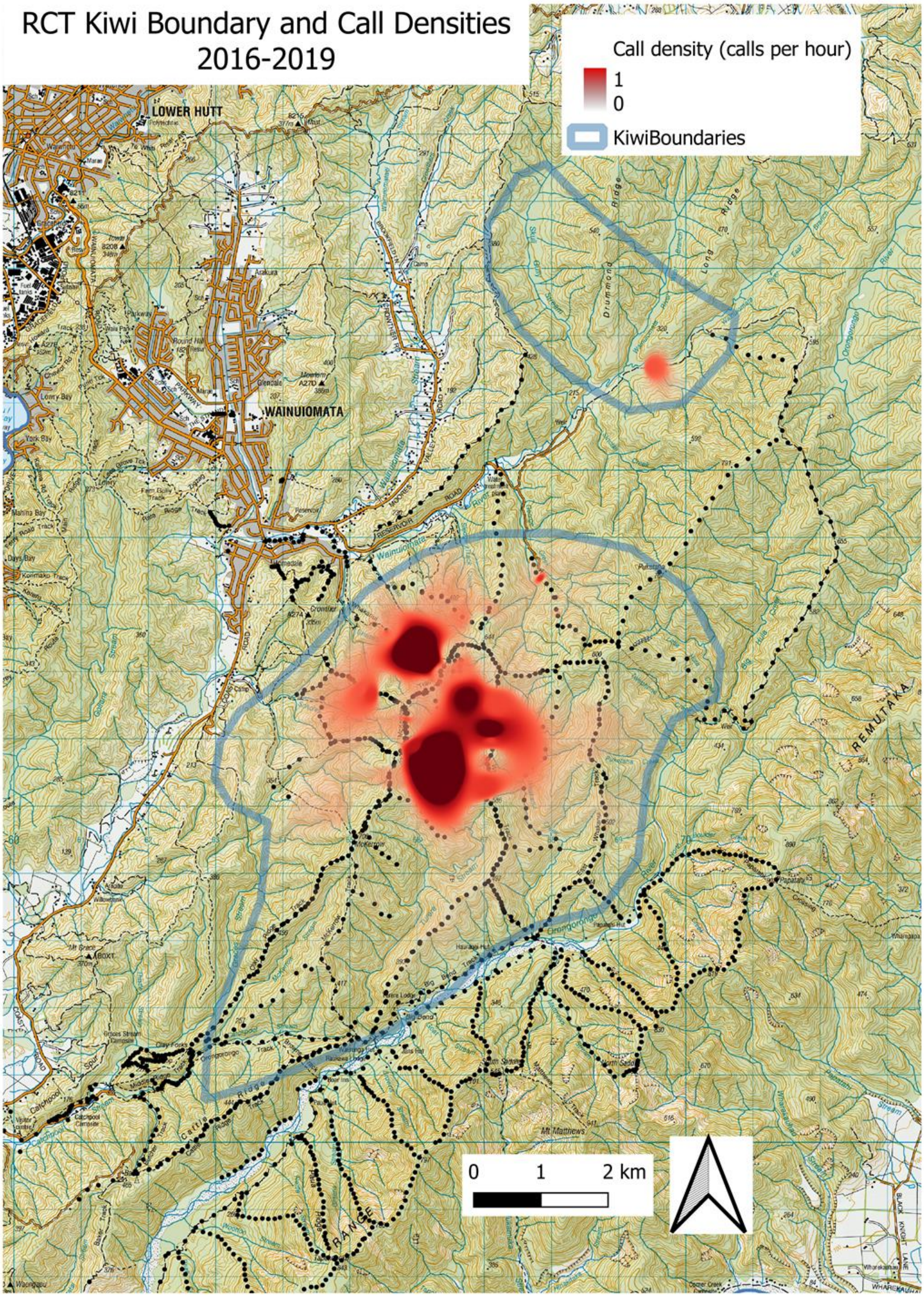


Figure 7(c). Call rates (average calls per hour of non-noisy data collected) for the time period 2016-2019.

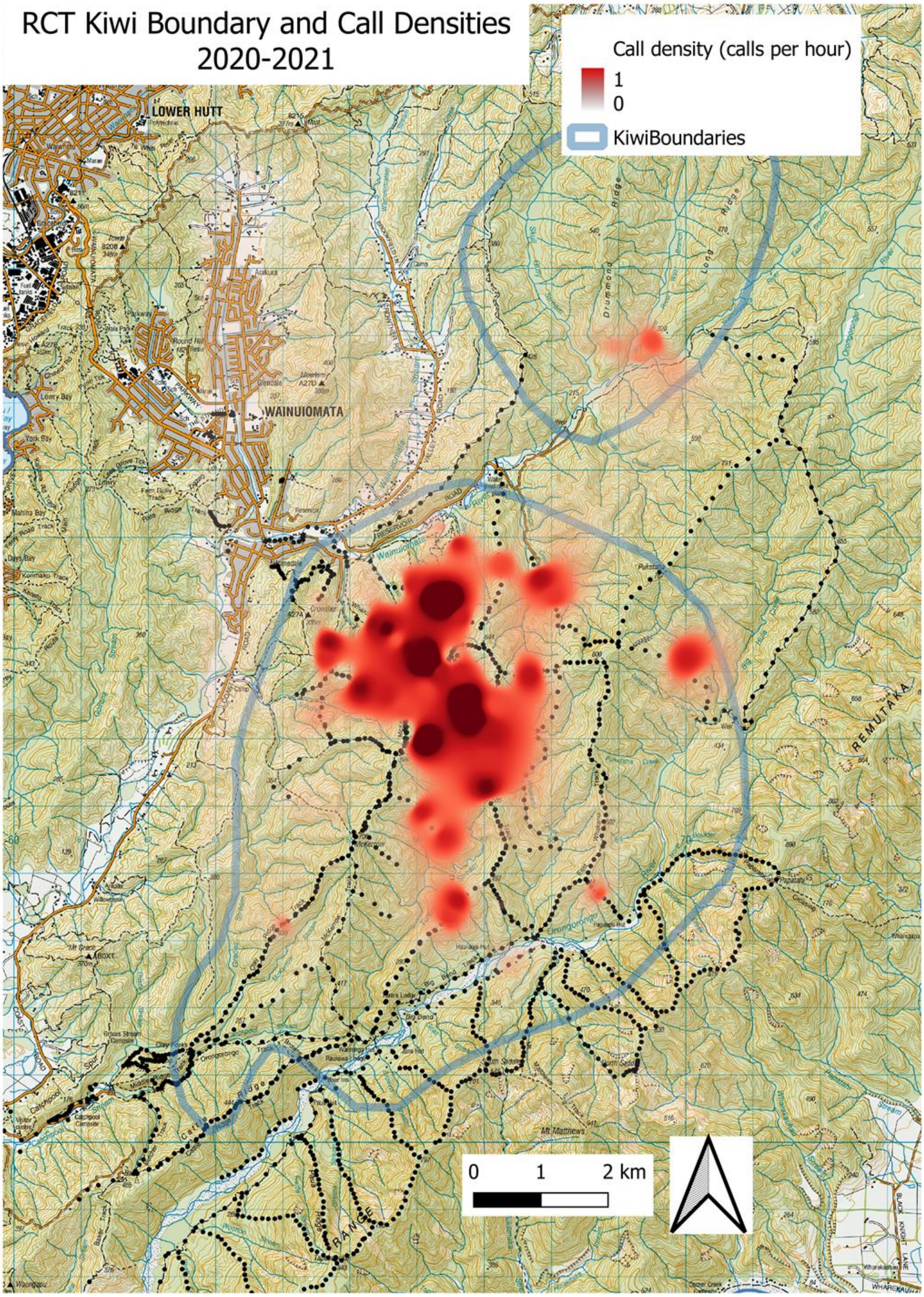


Figure 7(d) Call rates for 2020-2021 showing increase in hourly calls in the Wainuiomata Water Catchment.

Discussion

The maps presented here are in support of the main objectives in acoustic monitoring of the kiwi population in the Remutaka Forest Park which are:

- to determine whether (and how) the population is increasing and spreading outward from the release area
- to monitor sudden local events (e.g. a drop in calls) as a way to estimate kiwi adult mortality, such as may result from a dog attack
- to help inform the Trust as well as DOC, GW, MCT and other park users of kiwi presence- so that relevant signage could be placed and to aid in park management decisions (e.g., trap placement and use of hunters)

The trend in kiwi distribution and density through time, based on acoustic data

The results of the acoustic surveys suggest that the Remutaka kiwi population has spread through time at a rate of ca. 0.4 to 1 km/yr (with the fastest rate of spread northward towards the GW Mainland Island, and the slowest spread in the direction of the Catchpool valley). Notable kiwi hotspots - where several kiwi pairs have overlapping or adjoining home ranges- occur in the Upper Turere Valley along with the surrounding McKerrow, Whakanui and Lost Glenys tracks; the upper Boys Brigade; the Pack Track and along parts of Reservoir Rd; and at the southern end of the Whakanui and East Whakanui tracks. Maximum call counts (average calls per hour) have increased from a maximum of 0.65 calls/hour in 2011-2013, to > 1.5 calls/hour in 2021 in the main kiwi hotspots. It is possible that the increased call rates in the hotspot regions are because more kiwi pairs are interacting there, but this would need to be confirmed by detailed surveys (e.g. dog surveys). In 2011 the kiwi pairs in the Upper Turere valley were monitored through radio tracking. We kept transmitters on several males in this region and can confirm that they were still active (2019), but whether there has been any further infill by newly recruited adult kiwi is unknown. A linear correlation between kiwi population density and kiwi call rate is unlikely, but it is encouraging that maximum call rates have increased through time. It is also reassuring that no major “holes” in kiwi calls have appeared within the kiwi zone, i.e. there is no sign of a major mortality event from a dog attack leading to significant loss of kiwi pairs in previously established areas.

The roughly even spread in the kiwi boundaries through time around the original release area in the Upper Turere stream supports the theory (“Sound of silence”- Hugh Robertson) that new breeding pairs form around the outskirts of existing home ranges of breeding pairs. However, both the radio tracking data and the acoustic data shown here point to a modification to this theory where occasionally, a wandering pair will establish away from the existing call boundary (e.g., the second kiwi area in the GW Mainland Island region).

Have we successfully mapped the expanding boundaries of the kiwi zone through time?

Mapping of the boundaries of the kiwi call zone is challenging because of the limitations in location of sound recording stations (due to the small number of recorders available- particularly in the first few years of monitoring; and lack of volunteer time to deploy and analyse sound recordings, as noted earlier). The mapped boundaries are therefore only approximate, and we are likely to have missed some birds that wandered substantially further from the main kiwi population. We are also unable to monitor chicks and juveniles who do not call (or call only infrequently).

An ever-increasing challenge is that the length of the boundary zone has grown as the population expands outward. The estimated kiwi boundary was about 18 km in length during the surveys of 2011-2013 but has now grown to cover a length of ca. 43 km in 2020-2021. As the boundary expands, it takes more time to reach the more inaccessible parts of it with limited access and rugged terrain. At the same time, the encroachment of the kiwi boundary into Wainuiomata township (near Sunny Grove) - with increasing reports of people hearing or seeing kiwi- makes acoustic monitoring difficult due to the noisiness of the urban environment and privacy concerns for microphone placement.

Kiwi monitoring- what are our future objectives and how can we address them?

As well as the primary objectives listed at the start of the discussion, specific future monitoring needs include:
- to monitor places where kiwi may conflict with humans (e.g. Wainuiomata). If we know kiwi are moving near people's properties, perhaps we can warn them of the threat posed to kiwi by their dogs and encourage them to keep dogs inside at night.
- to monitor the spread of kiwi into untrapped or under-trapped regions so that we can continue to make informed decisions about best-practise predator control. e.g., now kiwi have moved across the Orongorongo River, should A24s baited for stoats there be augmented by DOC200 lines?
- to continue to monitor for large local extinction events (e.g., due to a rogue dog)
- to maintain awareness and education of the public about the kiwi in the Remutaka Ranges
- to help inform other groups whose aims may be different to ours (e.g., management decisions in GW blocks- hunting, plan to build and fence and introduce Rowi, coast road property owners, etc)

Given the points noted above, even with the increase in number of recorders and an efficient deployment organisation of volunteers, we will struggle to keep up with the spread of the kiwi to monitor the boundaries. A major bottleneck is the downloading, processing and analysing of the data. This must be done by at most 2 people owing to the large datasets which cannot readily be shared online, and requires some consistency and dedication, with many hundreds of hours scrolling through recordings.

Options to try to reduce this workload include:

- monitoring kiwi population less frequently (in 2022 and 2023 we took a complete break. We could aim to do a comprehensive survey in 2024, perhaps spread over 2 years, and only monitor internal "sentinel" sites rather than the whole Turere valley for example)
- investigate the use of automated filters. We have been investigating AvianZ (see Appendix 2). It may be possible to use it to monitor interior sites but will be more challenging to use near the kiwi zone boundaries, where sometimes only 1-2 calls may be picked up in 2 weeks- information that is nonetheless still useful for determining kiwi range.

- come up with a new scheme for data storage. Presently the data are backed up on 2 separate external hard drives. Are we approaching the point where we stop preserving the raw audio files and delete files once we've scored them?
- Separate the role of coordinating the deployment and collection of sound recorders (and the initial downloading of data) from the analysis role – i.e. expand the volunteer group so that there are several people who coordinate to lead the acoustic monitoring effort, with one person focusing on the operational part and another focusing on data analysis.

Link to other monitoring projects and groups

Diurnal bird monitoring was carried out by the Trust from 2015 to 2019 (remutaka.nz/downloads/downloads.htm). This baseline of data was collected with the intention to redo these diurnal surveys in 5-10 years time so that we can measure long-term trends in other bird species in the park.

A comprehensive bat survey was carried out in 2021-2022 to determine whether any bats remained in the Remutaka ranges (remutaka.nz/projects/bat_survey/bats.htm). Further bat surveys may be warranted, as even finding a solitary bat in the park would be useful information for some future effort to restore bat habitat there.

Since the kiwi are now well-established in the Greater Wellington-administered Wainuiomata water catchment and are also beginning to establish on the eastern side of the Orongorongo river, where the MOA Conservation Trust (MCT) are trapping stoats. Collaborative monitoring with GW and the MCT is a useful way to foster inter-group cohesiveness and to share in the motivational benefits of the kiwi project. The kiwi appear to have benefitted from the GW mainland island (Skull Gully) with its lush forest habitat and close network of trapping tracks with excellent predator protection. The spread of the kiwi to the east of the Orongorongo River is fairly recent, and at least 1 breeding pair are now on the eastern side of the River. Investigating their breeding territory further (and monitoring nest outcomes) would be useful to test the stoat trapping network there and to determine whether more effort needs to be focused on this region. The MIRO group (based in Eastbourne) have also bought several acoustic recorders to monitor for the future spread of kiwi into their region. We maintain regular communication with these groups. With the kiwi now approaching Wainuiomata township, it will also be important to have strong links with the local predator free Wainuiomata group who are trapping in this region. We also need to consider whether more signage and public outreach may be necessary, particularly near the bush edge along Hine Rd and Sunny Grove.

Acknowledgements

This study could not have been carried out without the perseverance, dedication, and hard work of over 100 volunteers within the Remutaka Conservation Trust. We would like to thank them for trapping, kiwi monitoring, acoustic data collection, and organisation of the kiwi project over the past 17 years. We acknowledge Peter Cooper for initiating the acoustic recording programme in 2011, and the support and advice of Ed Abraham early in our study with establishment of metadata protocols, help in the field, and providing us with access to his kiwi call filter. Greater Wellington funded additional data collection and analysis in their region in 2018 which was carried out by Ned Bruno (also a RCT member). Jamie McNaught and the MCT helped collect acoustic data on the east side of the Orongorongo River in 2021, where they maintain a network of A24 traps baited for stoats. Lastly, we would like to thank the Department of Conservation for technical advice, and particularly the DOC electronics lab (Stu Cockburn and Steve McKevitt) for their assistance in helping maintain our AR4 recorders.

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Appendix A: comparison between kiwi range estimates form radio tracking and acoustic monitoring

The data we had collected from 2009-2010 (shortly before all radio tags were taken off our population) has given us the chance to compare ranges estimated from acoustic recorder data 1-3 years later, with a known population range from radio tracking (Figure A1). This shows, in general, reasonable agreement between kiwi detected from calling and those mapped from tracking. The acoustic recorders are a rather conservative method for estimating kiwi presence compared with radio tracking, since juvenile kiwi and chicks do not call; and a low-density population has less chance of being picked up by the sparse recorder network in a given 2 week period. As expected, the call distribution is slightly contracted compared with the tracking data distribution.

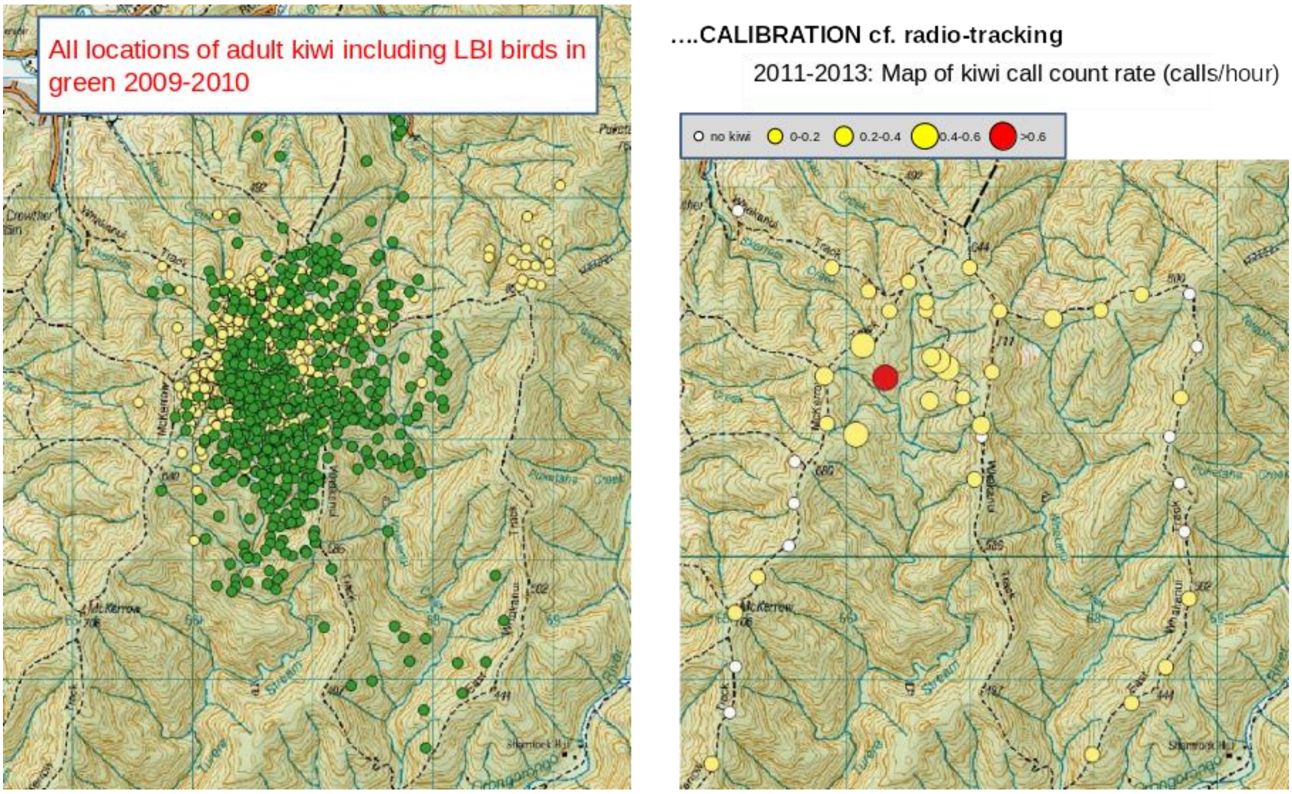

Figure A1. Comparison of 2 different monitoring techniques for a similar time periods in the Remutaka Forest Park. Left panel: all locations determined by radio tracking data from 2009-2010 for the entire population of adults, sub-adults, juveniles and chicks in the park, including released birds, their ONE progeny, and natural-hatch progeny. Right panel: 2011-2013 call rate distribution from this work.

Appendix B: Investigating the use of the AviaNZ kiwi filter to process sound files

Here, we outline a comparison of our manually-scored method using the Sound exchange Software and human scoring, to the automated filter AviaNZ (https://www.avianz.net/). We selected one night from site LPC from which we had previously found 11 male calls and 1 female call, from faint to a moderate distance away using the SOX software to create spectrograms and scored with human processing.

The use of Avianz requires specifying the filter. Avianz comes with a specified North Island Brown Kiwi filter that can be selected. This has been constructed to maximise correct identification of male and female calls while minimizing false positives. In Table B1, we document the different amount of time it took to process and analyse one night of recordings and the call accuracy (May 19th 2020) using this standard filter.

Table B1.

	SOX/human	Avianz
Number of files processed	36	36
Time to process files (auto)	2 minutes	10 minutes
Time to check files (human)	2 minutes	1 minute
Male calls found	11	1
Female calls found	1	0
Duets found	0	0
Accuracy rate	100%	~10%

The nights had some wind noise, and the male calls that were missed by Avianz were faint and partly obscured by wind, though readily recognisable to a human operator. To see whether we could increase the positive call rate, we tried training our own filter based on some other directories previously scored that contained a large number of faint male calls obscured by wind noise. However, this did not significantly improve the identification of male calls, though it did increase the number of false positives that had to be rejected by a human operator.

This is not a thorough test of Avianz but it does suggest the following:

(1) for non-skilled users, the Avianz filter and interface may be easier to use than the manual method using SOX. If we just wish to find kiwi calling close by, Avianz will find them using the standard kiwi filter.

(2) Note however that processing times will be longer (e.g., for 2 week's of data at one site (ca. 550 files) processing will take 3.2 hours (cf. 30 minutes for SOX)

(3) The time to review files will be about the same for the two methods, but SOX requires a bit more experience to assess kiwi calls. On the other hand, the graphical spectrogram created by SOX seems to make kiwi calls more visible to the user than the Avianz graphical interface- we have found it easier to identify very faint calls from the SOX spectrograms (and verified by listening to the recordings)

(4) If we wish to find every last faint kiwi call (e.g., to pinpoint that kiwi are within 400 m, for border-mapping purposes) then the best method is to use SOX.

(5) The kiwi maps and analysis reported here (and in previous reports) use SOX and analysis by an experienced operator to detect all calls- even those that are very faint or partly obscured by noise. If we switch to using Avianz it will underestimate kiwi presence near the boundaries by missing faint calls. Also, average call rates computed from the positive calls found by Avianz will be an underestimate over the entire network. To compare these with the call count rates in this report, we would need to filter out all faint male calls and recompute the call rates. Otherwise it would be like comparing apples and oranges.

In summary, we recommend continuing to use SOX for kiwi presence/absence and "gold standard" call rates. There may be a role for Avianz however, in subset analyses where we are trying to narrow in on main kiwi home ranges or incubation burrows, for example.

If we wish to switch fully to Avianz we will need to reprocess all data (from 2011 to present) in order to gauge the change in call rates and kiwi distribution from year-to-year, bearing in mind that this will underestimate both spread and call rates in the Remutaka population.

Appendix C: Testing "Kiwi Calling" software v3.3 by Colin Brown (Otanewainuku Kiwi Trust)

While finishing this report, we were generously sent a new kiwi filter package called "Kiwi Calling" by Colin Brown. This is a windows-based filter with a graphical interface. We ran the same source directory as used in Appendix B through the filter. It was very fast (less than 1 minute to process 36 wav files) but unfortunately did not identify a single kiwi call. Given the background wind during the recordings, we think that it probably works best on very loud (and close) calls and like Avianz, will not be useful for detecting very faint kiwi calls for presence/absence analysis.