Mustelid movement in the Taranaki ring plain: update 2020

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Summary

Project and client

- The Predator Free Taranaki programme aims to suppress mustelid numbers across the ring plain surrounding Taranaki Mounga.
- Manaaki Whenua – Landcare Research was contracted by Taranaki Mounga Project Ltd and the Taranaki Regional Council to investigate mustelid movements on the ring plain.

Objective

- Investigate mustelid movements, particularly of stoats (*Mustela erminea*), to ascertain fine-scale movements in relation to habitat use, dispersal, and reinvasion potential in the Taranaki ring plain.

Methods

- Tracking devices were deployed on mustelids within the Taranaki ring plain: seven stoats (four with VHF radio collars and three with GPS tags) and two ferrets (*M. putorius furo*; with GPS collars).
- Due to complications with trapping, tagging and tracking, useful data were collected from only three stoats, two with VHF radio collars and one with a GPS tag.
- DNA was extracted from tissue from stoats, weasels (*M. nivalis*) and ferrets in the Taranaki region to provide information on where mustelids are moving across the landscape.

Results

- Of the VHF radio-collared stoats tracked monthly, all positions were within 3 km of their initial trapping location, with no locations within the Taranaki National Park.
- From the single successfully GPS-tagged stoat, a total of 32 positions were obtained over 5 days. The stoat moved during both day and night, but mostly in the afternoon and early evening.
- In general, stoat movement appeared to be centred on complex habitat, utilising and revisiting patches of dense vegetation located throughout the agricultural landscape.
- DNA was extracted from 27 ferret, 33 weasel, and 132 stoat samples. These data will help to identify where mustelids are moving across the landscape, but the samples are still being processed and this work is ongoing.

Conclusions

- Obtaining fine-scale movement data for mustelids is challenging, but here, for the first time, we showed GPS technology is a possible method to use for stoats.
- While GPS devices are better able to collect fine-scale movement data than VHF radio devices, there is currently no GPS device on the market that is ideal for stoats.

- Obtaining multiple fixes every day is not feasible with traditional aerial or ground-based VHF radio telemetry, especially if multiple tagged animals are present throughout the area.
- In future, the most plausible approach that maximises data quality and efficiency of collection is to use unmanned aerial vehicles (UAVs; sometimes referred to as drones) in combination with VHF radio-collars.
- At some point, when the appropriate GPS technology is available for stoats, fine-scale GPS data collection may be possible using UAVs or possibly through LoRa (long range) technology.
- Genetic sampling shows promise as another tool to investigate dispersal. These results will be reported once the full molecular analyses are completed.

Recommendations

- Continue to collect mustelid fine-scale movement and habitat use data, with an emphasis on stoats.
- Modify the trapping protocol for stoats to focus on animal welfare and minimise data loss by incorporating bedding or other absorbent material, and adjusting the frequency or time of day that traps are checked based on observed stoat activity (e.g. twice a day or late afternoon checks).
- Utilise more effective and efficient methods to locate the signals of tagged animals and to retrieve location data. In particular, pursue the use of UAVs that utilise multi-frequency receiver technology capable of identifying VHF radio signal positions automatically without the need for triangulation.
- Continue to assess the availability, and potential use, of GPS devices appropriate for stoats, ideally collars that are compatible with UAV tracking and/or LoRa technology, to allow the collection of fine-scale data that is not possible with VHF radio telemetry.
- Continue to collect mustelid samples for molecular analyses, including inside the national park and the surrounding ring plain.

1 Introduction

Mammal predator control programmes are currently being carried out in the Taranaki region within the overarching context of Predator Free 2050. The goal of Predator Free Taranaki is to remove all invasive mammalian predators from the Taranaki National Park, and to supress their numbers in the surrounding ring plain to prevent reinvasion. In order to successfully control these predators at this landscape scale, Predator Free Taranaki need to understand how each species uses and disperses across the Taranaki ring plain. Understanding these parameters will enable future trapping regimes to target immigrants to the mountain and provide realistic scenarios of the reinvasion risks.

In order to understand how mustelids use the ring plain, fine-scale movement data are required. Only VHF (very high frequency) radio-tracking devices, not GPS (global positioning system) devices, have been deployed on stoats (*Mustela erminea*) in New Zealand (King & Powell 2007; King & Veale 2020). This is primarily due to the weight restrictions of the GPS devices currently available. The acceptable mass of a collar with device is limited to no more than 5% of the individual's body mass (Sikes 2006). On average, female stoats in New Zealand weigh approximately 200 g, and adult males weigh approximately 250 g (King & Veale 2020), so the options for GPS devices are extremely limited (McMahon et al. 2017).

While GPS devices for mammals, including those used on ferrets (*M. putorius furo*) caught in this study, are traditionally mounted on collars, lighter GPS devices in the form of 'tags' now exist and have been used for other species, such as birds, that have sensitive maximum weight restrictions. Data collected via GPS are better suited to finer-scale movements than via VHF radio, because a greater number of positions are usually possible. Specific types of movement data that would be useful include identifying movement corridors, dispersal behaviour, home range size, and habitat use, much of which is currently unknown for stoats in New Zealand. Information on these parameters is also critically important for parameterising pest eradication models.

An alternative strategy to tracking is using genetic approaches to determine how connected populations are across the landscape. By correlating patterns of genetic relatedness to landscape features, it is possible to ascertain the movement of genes across an environment, and hence the animals these genes belong to (Etherington 2016). This technique has several advantages over tracking techniques. The genetic landscape represents the movement of genes across the whole landscape rather than the movements of specific individuals. Some age or sex classes may be missed by chance in a tracking study, especially very young individuals during their dispersal phase. Also, large numbers of samples are often possible with genetic studies, enabling a more general picture across a landscape. Finally, genetic studies can be undertaken on dead individuals captured during control operations.

All of these factors mean that landscape genetic studies of pest species can provide different and complementary information on the movement of individuals across a landscape. Tracking studies provide fine detail on habitat use and movement patterns of individuals, whereas genetic studies provide broader generalisations about how individuals on average move across the landscape (Storfer et al. 2018).

2 Objective

Investigate mustelid movements, particularly of stoats, to ascertain fine-scale movements in relation to habitat use, dispersal, and reinvasion potential in the Taranaki ring plain.

3 Methods

3.1 Trapping

Mustelids were trapped on the western side of the Taranaki peninsula on private land on the ring plain in February and December 2019. Plastic cantilever live traps (M. Holden, Amberley, NZ) were baited with rabbit meat to target stoats and ferrets. Traps were typically placed along transects 100 m apart or in areas thought to be highly utilised by mustelids. Care was used to avoid exposure to weather.

Traps were checked daily and bait replaced every three days. Animals caught were immediately removed from traps, anaesthetised, and a VHF radio or GPS device applied. All animals were released at the site of capture immediately after processing, and allowed to recover in a position protected from the elements. All devices and corresponding signals were confirmed correct and functioning prior to each release.

3.2 Devices

3.2.1 VHF radio collars

In February 2019, VHF radio collars (Sirtrack Ltd, Havelock North, NZ; item V1C 118B) were attached to four stoats, as discussed in García-Díaz & Niebuhr 2019 (Figure 1). A mix of ground-based radio telemetry and aerial telemetry (via a fixed-wing aircraft) was used to locate collared animals. After initial ground-based telemetry attempts proved difficult, aerial telemetry was used once a month to locate individuals. Following zero stoat locations in July, and only one in August 2019, aerial telemetry was ceased.

3.2.2 GPS devices

In December 2019, GPS devices were attached to three stoats and two ferrets. For stoats, a GPS tag (Lotek Wireless, Ontario, Canada; model Pinpoint VHF 120) was applied with veterinary glue to the back of the animal, just behind the neck, with a lightweight 'breakaway collar' added for stability (Figure 2). These GPS devices were originally developed for birds due to their light weight. For ferrets, a GPS collar (Lotek Wireless; model LiteTrack 40) was attached to the neck (Figure 3). GPS devices were set to collect hourly data. Conventional ground-based VHF radio telemetry was used to locate all collared animals, and when in range (approximately 200 m, depending on conditions), stored GPS data were remotely downloaded using a receiver (Lotek Wireless, Pinpoint Commander).

Figure 1. VHF radio collar attached to a wild stoat in Taranaki.

Figure 2. GPS tag attached to a wild stoat in Taranaki.

Figure 3. GPS collar attached to a wild ferret in Taranaki.

3.3 Animals processed

Ten stoats (all female), two ferrets (male and female), and two weasels (*M. nivalis*, sex unknown) were trapped in the Taranaki ring plain. Devices were deployed on seven stoats (four VHF radio collars and three GPS tags) and two ferrets (GPS collars). From those, useful data were collected from three stoats: two with VHF radio collars and one with a GPS tag.

Stoats

The four VHF radio-collared stoats were caught in February 2019. Three were caught in the same trap, but on separate occasions, and all four appeared healthy and active. The remaining animals were caught in December 2019. Of the three GPS-tagged stoats, one was later tracked and data retrieved. Another appeared lethargic when first encountered, but was active enough to require anaesthesia to be handled, so a GPS tag was applied; however, it was found dead the next morning in the same location. The third tagged stoat, recaptured the day after release, was found with its tag not properly attached. The tag had partially ripped from the animal's back, leaving a wound exposed. Given the flexibility of stoats, the tagged individual may have been able to reach part of the tag and tear it off. We removed the tag and the stoat was transferred to a nest box with bedding, water and food, with the intention of sending it to the Manaaki Whenua – Landcare Research animal facility. However, it died later that day.

Following this, fieldwork was postponed to re-assess the trapping and tagging methods. Two other stoats appeared lethargic and wet when encountered in the trap. It was unclear if they were exposed to urine or water from the environment. Neither of these individuals recovered.

The final stoat was caught the morning the fieldwork was postponed, so no attempt was made to apply a tag. This individual was transferred to a nest box with bedding, water and food, and sent to the Manaaki Whenua – Landcare Research animal facility.

Ferrets

Two ferrets were caught and collared. The collar of the female, which was trapped in a hay barn, was found in the barn a few days later, entangled in hay twine. We presume the animal was able to use the entanglement as resistance to slip out of the collar. The only data points retrieved were in the immediate vicinity of the barn. The male ferret was never located after collaring, despite multiple attempts to locate it via ground-based telemetry.

Weasels

One weasel was found dead in the trap when first checked, while the other was caught on the final morning of fieldwork. It appeared slightly lethargic and no device was attached.

3.4 Genetics

DNA was extracted from stoat, weasel and ferret tissues collected from a variety of sources around Taranaki (e.g. trapped animals, roadkill) to provide information on where mustelids are moving across the landscape. It was important to obtain as many samples as possible, with clear labels and good location details, to maximise the resolution of the results. DNA extraction was performed with a QIAcube column-based DNA extraction system, with an overnight digest using proteinase K according to the manufacturer's protocols, and submitted for sequencing using genotyping-by-sequencing.

4 Results

4.1 VHF radio telemetry

Aerial and ground-based radio-telemetry was used to locate four VHF radio-collared stoats between February and August 2019 (Figure 4.). Positions from two of the four stoats were collected almost once a month over a 5- to 7-month period. The degree of resolution varied, although it is not clear if this was related to poor signal or the amount of effort put into triangulation, or both. It is likely these individuals were established in the area, with each position within 3 km of the initial trapping location, and with no locations within the national park. For the other two stoats, one was located only once after collaring and the other was never located again after collaring. It is unclear if these two stoats had dispersed out of the area, the collars had malfunctioned, or they were simply unable to be located with the methods used here.

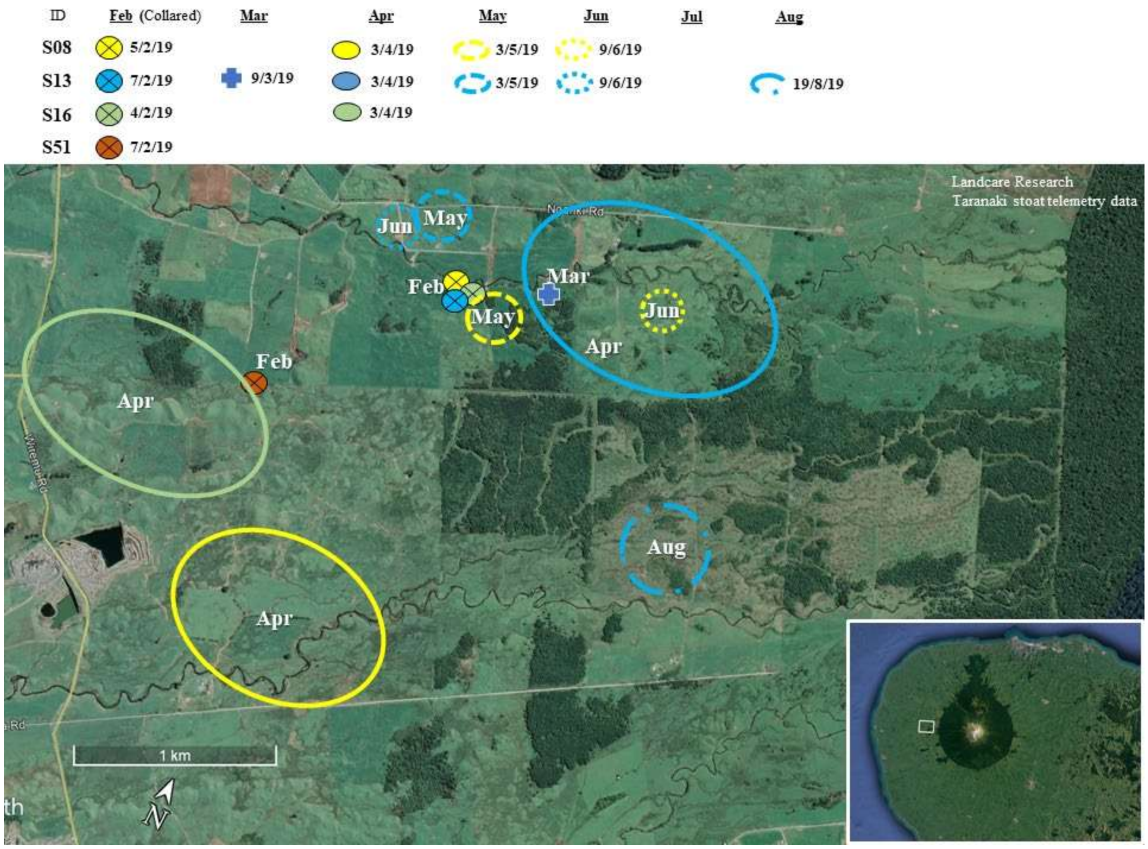

Figure 4. Positions of collared stoats via radio telemetry, Taranaki, 2019. Symbols with an X inside a circle indicate the site of capture and release. The blue cross symbol represents a stoat located by ground-based telemetry. All other coloured circular or oval symbols indicate general stoat locations identified via aerial telemetry, with varying degrees of resolution.

4.2 GPS telemetry

One GPS-tagged stoat was tracked via VHF radio telemetry, with stored GPS data uploaded as often as possible. In total, 32 positions were obtained over 5 days (11−15 December 2019) (Table 1; Figures 5 and 6). Although the GPS device was set to record hourly fixes, often points were missing, with the interval between downloaded points ranging from 1 hour to 23 hours (mean 3.2 hours, ±0.8 S.E.). We suspect the incomplete data were a result of the device having difficulty connecting with the necessary number of satellites when located in patches of vegetation, or due to poor weather.

Fixes were retrieved during the day and night, with the majority occurring in the afternoon and early evening. On two separate days, consecutive hourly fixes at different locations were recorded in the afternoon (between approximately 13:45 and 17:45), indicating activity during this period (Table 1). Movement was also recorded in the early and later morning. In general, stoat movement appeared to be centred on complex habitat, with the individual utilising, and revisiting, patches of dense vegetation located throughout the agricultural landscape.

Table 1. GPS positions from a tagged stoat in the Taranaki ring plain

Date/time	No. of hours between fixes
11/12/2019 13:47:14	
11/12/2019 14:46:48	1
11/12/2019 15:47:02	1
11/12/2019 16:47:16	1
11/12/2019 17:46:48	1
11/12/2019 18:46:43	1
11/12/2019 19:46:47	1
11/12/2019 21:47:15	2
12/12/2019 07:46:58	10
12/12/2019 12:46:50	5
12/12/2019 14:47:02	2
12/12/2019 17:47:13	3
12/12/2019 19:46:55	2
12/12/2019 23:47:12	4
13/12/2019 02:46:47	3
13/12/2019 03:46:44	1
13/12/2019 04:46:44	1
13/12/2019 05:46:43	1
13/12/2019 07:46:43	2
13/12/2019 09:47:04	2
13/12/2019 10:46:37	1
13/12/2019 11:46:37	1
13/12/2019 12:46:56	1
14/12/2019 11:46:59	23
14/12/2019 14:47:03	3
15/12/2019 04:46:49	14
15/12/2019 09:46:45	5
15/12/2019 13:46:41	4
15/12/2019 14:46:41	1
15/12/2019 15:46:57	1
15/12/2019 16:46:34	1
15/12/2019 17:46:37	1

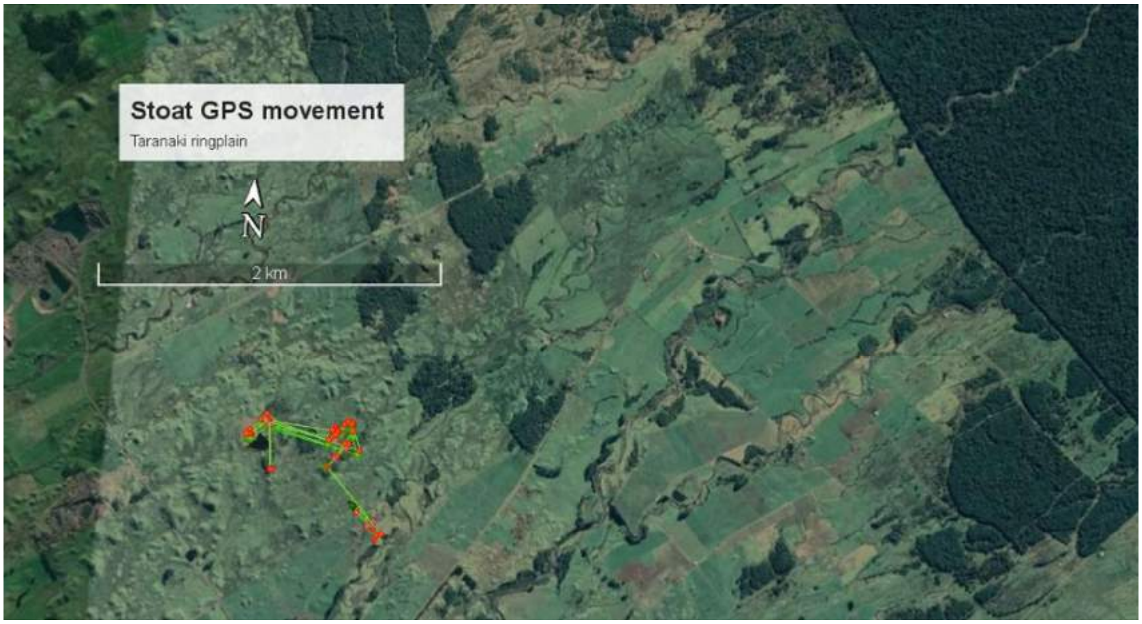

Figure 5. GPS positions from a tagged stoat in the Taranaki ring plain. Note that while the GPS device was set to record hourly fixes, the interval between the points shown here varies (mean of 3.2 ± 0.8 S.E.) due to incomplete data.

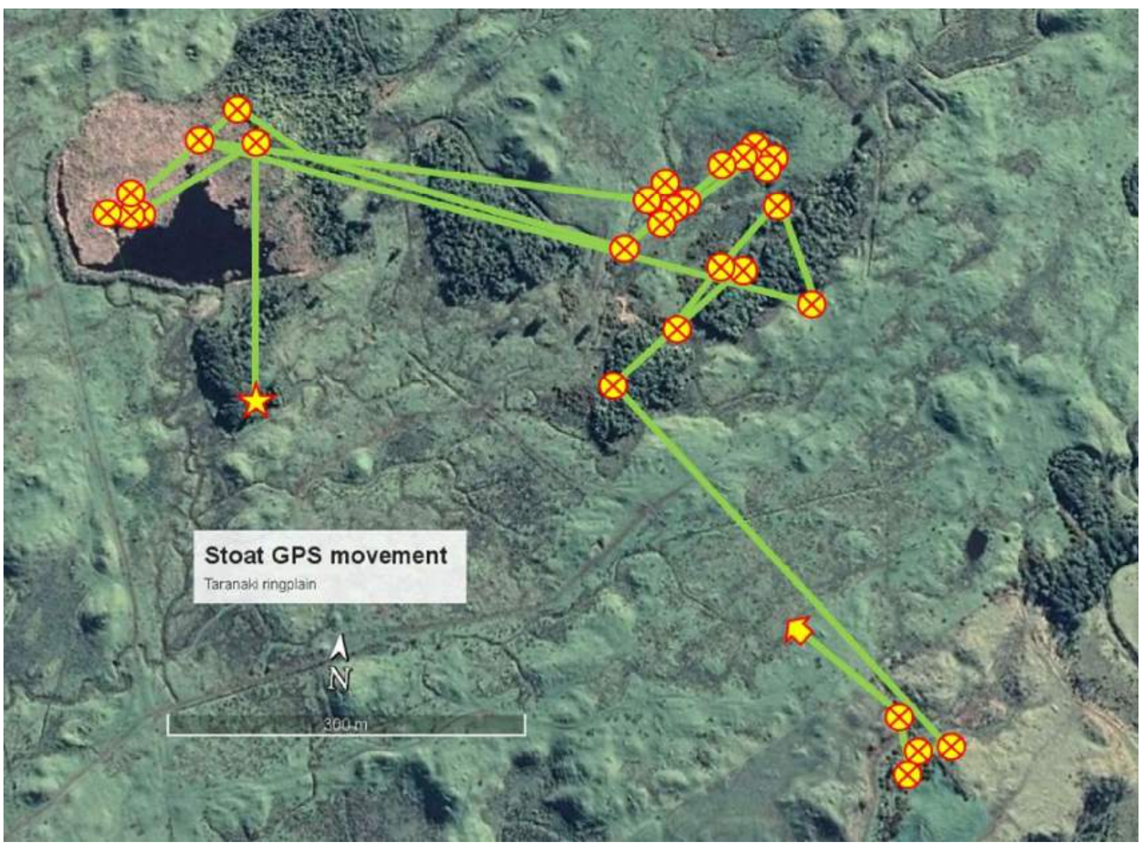

Figure 6. Zoomed in from previous figure. The release site and final data point are indicated by a star and arrow, respectively.

4.3 Genetics

DNA was extracted from 27 ferret, 33 weasel, and 132 stoat samples collected from across the Mounga and the ring plain (Figure 7). Over 80% of samples yielded sufficient quality and quantities of DNA for sequencing from the first extraction, and the remainder are currently being re-extracted with the expectation that a reasonable proportion of the remaining samples will be able to have DNA extracted. Samples have been submitted for sequencing and results are expected before the end of August. Due to Covid-19 there were significant delays in extracting and sequencing the samples in the laboratory, but these delays have now ended and further analyses will progress rapidly.

Prior to nationwide lockdown we received genotyping-by-sequencing results for ferrets from Southland, which were processed through the same analysis pipeline. During the break in lab work we refined the pipeline so that it is now optimised for mustelids. Each purified DNA sample (already obtained from the Taranaki samples) will be digested with a restriction enzyme (spf1), which cuts at specific sequences throughout the genome, and then the genetic sequence next to these cut sites is barcoded (identifying the individual) and sequenced. These are then mapped to the stoat genome that has just been released by A. Veale (Manaaki Whenua – Landcare Research).

For the Southland ferrets, we obtained between 24,000 and 100,000 variable markers using this technique (depending on the filtering parameters). Depending on the application, these marker sets were then reduced to c. 5,000 markers. These data sets gave precise relatedness values between all of these ferrets – something not previously possible with earlier genetic markers. The results will now be easily replicated across the mustelids in Taranaki.

Based on these pairwise relatedness values, we calculated the probable dispersal distances and ranges for each species across different terrains. By combining these data we aim to create what is called a 'friction surface' that will predict mustelid movements across the Taranaki region. This basically involves correlating landscape features to the pairwise genetic distances. If the relatedness of animals is unaffected by landscape features, the only factor that will determine how related any two individuals are is the geographical distance between them. This would be a 'flat' landscape friction. If, however, some landscape features, such as forests, are more readily used by mustelids than open grassland, this will be reflected in the model. We aim to produce a map of the whole of the Taranaki region with these friction surfaces, predicting where mustelids will move, and hence where trapping should be directed. This work is ongoing.

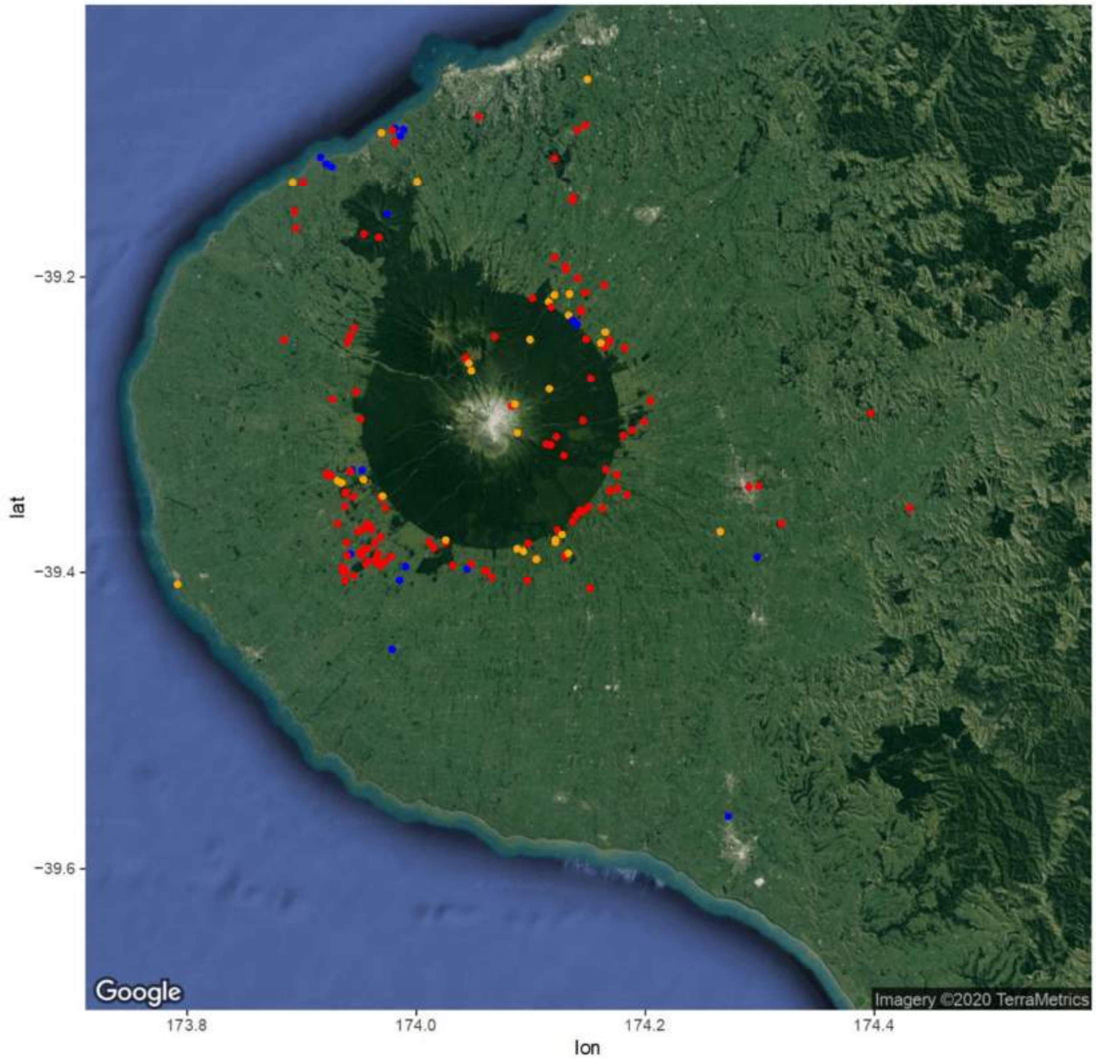

Figure 7. Collection sites of mustelids included in genetic analyses, Taranaki. Red = stoat, orange = weasel, blue = ferret.

5 Discussion

We have learnt a number of lessons about mustelid trapping, tagging and telemetry, which will help to inform and improve future research. Trapping success varied, but it can be easily improved to increase capture rates and minimise impacts on live-caught animals. Modifications to traps may be required to prevent moisture from urine or the environment contacting animals. Edgar traps might also be considered in the future for easily accessible areas, as these have nest boxes attached (although they are much heavier and more difficult to deploy). Also, to minimise the time an animal spends in the trap, checking traps later in the day, as opposed to morning, may be more appropriate for individuals that are active during daylight hours (something observed here). The use of lures (P. Garvey, Manaaki Whenua – Landcare Research), may also help to increase capture rate, thus minimise overall trapping effort.

In general, obtaining fine-scale movement data for mustelids – be it dispersal, home range, or habitat use – has proven challenging, but here for the first time we showed GPS technology is a possible method for stoats. However, the GPS tags used were not ideal for stoats, so we recommend a collar design for future work. Furthermore, there were gaps in the GPS data when the device had difficulty connecting with satellites. This can be a result of weather, topography or vegetation, or if the animal is underground. Battery life for GPS devices is more limited than that for VHF radio telemetry devices, which can also be exacerbated if the device is having trouble connecting with satellites (i.e. draining the battery while constantly searching for satellites). Nevertheless, the accuracy and frequency of positions collected using GPS technology were far superior to those of VHF radio technology, and with less effort needed. Even with an increase in effort, it is unlikely that traditional VHF radio telemetry methods are capable of collecting data of similar quality, especially outside of daylight hours.

Since both device types used here (GPS and VHF radio) involved a VHF radio telemetry component, many difficulties arose. Ground-based telemetry was difficult and labour-intensive, in part due to limitations with line of sight caused by uneven terrain and patches of dense vegetation (both resulting in weak or zero signals), as well as limitations associated with manoeuvrability and access throughout the landscape. While we had more success locating animals via traditional aerial telemetry (i.e. a fixed-wing aircraft), individuals still went missing, probably due to infrequent searches (monthly in our case) and imprecise fixes. While aerial telemetry may be useful for locating tagged individuals that have previously been undetected due to travelling outside the range of ground-based efforts, this method is not appropriate for collecting frequent fixes, even once a day, because of the high costs. For ground-based VHF radio telemetry, trying to collect even a single fix a day for each animal was a significant challenge, and obtaining multiple fixes a day was simply not feasible, especially if multiple tagged animals were present throughout the area.

Alternative methods for tracking mustelids in Taranaki are worth considering. Here we discuss two approaches. The first approach will improve the searching process for signals of tagged animals. Unmanned aerial vehicles (UAVs; sometimes referred to as drones) are often used in wildlife telemetry to increase data collection capacity. One study showed a 50% improvement in bearing and location estimates compared to ground-based telemetry (Shafer et al. 2019). Another study, conducted in Taranaki, utilised UAV telemetry to locate the roosting sites of tagged bats (P. Quilter, Tonkin & Taylor Limited, personal communication). This method reduced line-of-sight complications, as the UAV was able to effectively locate signals over uneven terrain, including areas with extreme elevational changes such as deep gorges.

This bat study utilised a multi-frequency receiver attached to the UAV, which was capable of searching for and receiving multiple signals at once, unlike traditional aerial or ground-based VHF radio telemetry, which uses single-frequency receivers. With traditional single-frequency receivers, signals must either be searched for one at a time, or a scanning receiver used to cycle through frequencies. However, by doing this, sometimes signals can be missed. Once a signal of interest was received, the UAV was manoeuvred in an attempt to locate a tagged individual. UAV telemetry allowed researchers to search large areas relatively quickly and identify positions within 100 m of a tagged individual. Subsequent ground-based telemetry was used to quickly locate individual tree roosts for tagged bats. Another study on penguins developed a multi-frequency receiver on a UAV that went one step further, not only being able to receive multiple signals at once (up to 50), but also capable of collecting fixes from multiple individuals ‘automatically’, without having to manoeuvre the UAV to a specific signal (Muller et al. 2019). The UAV could be fully automated with signal locations recorded using strength of signal (like a ’heat map’) with no need to deviate from its pre-programmed flight path to identify individual animal positions (e.g., via triangulation). The accuracy of the signal position can be controlled by adjusting the separation distance between flight lines. In this study, 25% of penguins were never located again after tagging when using ground-based VHF radio telemetry, but 100% of penguins were located using their UAV telemetry system. The accuracy of this system varied depending on the placement of the flight lines, but with a 30-m separation, the accuracy was < 25 m. This allowed ground-based telemetry efforts to quickly and easily find the exact position of the animal if needed.

In the case of standard GPS devices that require downloading of stored data via ground-based VHF radio telemetry at close range (approximately 200 m, depending on conditions), a similar approach to narrowing down positions could be used, which may improve data collection and decrease costs. The system developed by Muller et al. (2019) allows for the location data to be available and readable in the field from a UAV. As far as we know, based on the GPS technology discussed here, it is not currently possible to download stored GPS data remotely via UAV, but this may be worth investigating further because it could eliminate the need for ground-based telemetry altogether. While UAV telemetry appears to have some advantages over traditional aerial and ground-based telemetry, all of these methods require users to be present in the field to collect data. A second approach that could improve locating animals removes the active components of telemetry altogether by collecting and sending both real-time and stored data (e.g. from a GPS device) to the user without the need to ever be in the field. One such method is via LoRa (long range) technology, which is currently being utilised as part of the trapping system in Taranaki. Here, data from a device (i.e. a trap) are automatically sent to a nearby base station (e.g. an antennae attached to a tower) using the LoRa radio network, which is then uploaded to the internet and available to the user in real-time. While updates to the network coverage (e.g. additional base stations) may be needed for full coverage of the Taranaki ring plain, this technology is currently available and theoretically could be adapted for animal telemetry.

However, no device currently exists for mustelids that can utilise both GPS and LoRa technologies. The development of a GPS device with an appropriate design (e.g. collar) and size that is within the acceptable weight range of stoats would be the first crucial step if pursuing this approach. Jordan Lasenby (Taranaki Regional Council) and C. Niebuhr (Manaaki Whenua – Landcare Research) are currently in the early stages of investigating this option.

6 Conclusion

Fine-scale GPS location data collected passively (e.g. with LoRa technology) may ultimately be the ideal approach, in terms of both data quality and efficiency of collection, for monitoring mustelid movement behaviour in Taranaki. However, further development and testing are needed. In the meantime, the most suitable approach for collecting movement data appears to be UAVs and VHF radio collars using a fully automated, multi-frequency receiver system that does not require triangulation. This could be used for resident and dispersing adults or juveniles of a certain size. While we are unsure of the logistics of flying a

UAV at night in the area, it should be possible to collect location data three times a day (dawn, mid-afternoon, and dusk). Obtaining three fixes per day for at least 2−3 weeks from multiple individuals, would significantly improve our understanding of mustelid habitat use and dispersal. Investigations into the development of GPS collars that are appropriate for stoats should continue, and if achieved, further consideration for use with UAV or LoRa technology should be given.

With the genetic samples now processed and the analysis pipeline optimised, landscape genetics also appears to be a promising way of understanding mustelid movement patterns across the region, particularly given the difficulties of using telemetry. The use of biomarkers, such as Rhodamine B, is another option for understanding general movement patterns (Fry & Dunbar 2007). While there are many options for measuring animal movements, the type of data collected, the accuracy of the data, and the cost and effort of collecting the data need to be considered when choosing an appropriate method.

7 Recommendations

- Continue to collect mustelid fine-scale movement and habitat use data, with an emphasis on stoats.
- Modify the trapping protocol for stoats to focus on animal welfare and minimising data loss, by incorporating bedding or other absorbent material and adjusting the frequency or time of day that traps are checked based on observed stoat activity (e.g. twice a day or late afternoon checks).
- Utilise more effective and efficient methods to locate the signals of tagged animals and to retrieve location data. In particular, pursue the use of UAVs that utilise multi-frequency receiver technology capable of identifying VHF radio signal positions automatically without the need for triangulation.
- Continue to assess the availability, and potential use, of GPS devices appropriate for stoats, ideally collars that are compatible with UAV tracking and/or LoRa technology, to allow the collection of fine-scale data that is not possible with VHF radio telemetry.
- Continue to collect mustelid samples for molecular analyses, including inside the national park and the surrounding ring plain.

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