Title: Baseline Assessment of the MacKenzie Peat Wetland Using Drone Surveying and Pest Monitoring Tools

Author: Walter Fieldes

Degree: Environmental Management (EM301), Southern Institute of Technology

Supervisor(s): Dr Tapuwa Marapara

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Abstract

Wetlands provide many important ecosystem services such as, maintaining water quality, flood protection, and habitats for both flora and fauna. It is estimated that less than 10% of NZ's wetlands remain in a natural state with Southland holding nearly 20% of this. Despite the threatened status more than 176 hectares are lost in the region every year. The MacKenzie Wetland is a 54-hectare, raised dome mire wetland located near Limehills, just out of Winton. The area was historically farmed but is now a protected QEII Covenant restoration project and is one of the last remaining wetlands in the area.

The aim of the project was to create an updated aerial image of the area using a drone and to measure and provide baseline data of mammalian pest abundance within the MacKenzie wetland.

Monitoring pest populations helps show pest abundance and potential effects on the restoration of native vegetation and on the fauna that inhabit the area. Drones are slowly becoming more accessible and can produce high-resolution imaging that is valuable for monitoring and decision making.

Two tracking tunnel surveys and a 7 night chewcard survey were carried out to compare their capabilities as survey tools and to provide Relative Abundance Indices for each identified species. Drone survey images were uploaded into software which produced a high-resolution orthophoto map of the wetlands in which native and pest plants were able to be identified.

Results from all monitoring events were uploaded to the MacKenzie Wetlands project on the Trap.nz website which is an information management system that converted results into heat maps showing areas where pest species are present. Mice were the main species detected with all methods, while cats were only detected using tunnels with fresh rabbit meat over 3 nights. Delays caused by the COVID-19 pandemic lockdown meant that monitoring took place over winter with fewer tunnels than recommended which could have influenced the results but overall, the aims of the project were met and provide a base for future monitoring projects on the wetland

Contents

List of Figures

List of Tables

1 Chapter One:

1.1 Introduction

1.1.1 MacKenzie Peatland

Wetlands provide many important ecosystem services such as, maintaining water quality, flood protection, habitats for many unique species both flora and fauna, as well as being cultural and social resources (Clarkson et al., 2014, p. 192).

Peatlands are organic soils that are formed by the accumulation of once living organisms, namely plants and vegetation matter (Hunt, 2007, p. 29). The decay of the organic matter is slowed due to the anaerobic waterlogged conditions, resulting in the accumulation and compaction of peat soils making vegetation a crucial part in wetland function and carbon sequestration (Hunt, 2007, p. 29). The impacts of drainage and the introduction of dryland plant species can have the effect of increasing nutrient availability, and oxygen penetration into the soil, leading to a shift from anaerobic process such as denitrification to aerobic respiration, increasing the soil's redox potential (Sorrell et al., 2007, p. 362). Restoring the natural hydrology and native vegetation is seen as the key steps towards restoring the natural function of wetlands.

Its estimated that just 10% of New Zealand's wetlands still remain in their natural state is now seen as an over calculation and that although Southland accounts for 18% of the remaining wetland in NZ, more than 176 hectares is lost every year in the region (Robertson et al., 2019, p. 7). This loss is equal to 1.3% every year, placing Southland on the same scale as Asia where the mass development of peatlands has caused a 1.4% annual decline in wetland area (Robertson et al., 2019, p. 7).

1.1.2 Study Site

The study site is situated within Malcolm MacKenzie's farm at 784 Limehills-Browns Road, Browns, Southland, New Zealand.

The MacKenzie Wetland is a 54 hectare raised dome mire peatland located at Limehills on the west side if Limehills-Browns Road (Rance, 2005, p. 1). The peatland is the most northern that is in the eastern Southland Plains Ecological District group of peatland bogs. The group occurs from East Limehills–Hokonui-Springhills area through to the Tussock Creek-Grove Bush-Makarewa area (Rance, 2005, p.1).

The area was historically farmed but is now a protected QEII Covenant restoration project. The wetland is surrounded by farmland, and some parts of the margins are planted with exotic *Pinus radiata.*

There are three distinct vegetation communities within the MacKenzie wetland: semi-open wirerush land, shrubland forest, and red tussock/sedgeland (Rance, 2005, p.2).These habitats represent some of the original biodiversity that was historically present and are an important place for native fauna. Gorse *(Ulex europaeus)*, blackberry *(Rubus fruticosus)* and other pest plant species are present across many parts of the wetland.

Figure 1: Google Earth. (2020). MacKenzie Wetland, 784 Limehills-Browns Road, Browns, Southland, New Zealand. (map). https://earth.google.com/web/search/784+Limehills-Browns+Road,+Browns,+New+Zealand/@46.08841881,168.40436008,55.4108836a,4890.08890218d,35y,0h,0

1.2 Rationale

Introduced mammals particularly rats, possums and mustelids have a serious threat to native fauna and flora, rats are known to eat seeds, invertebrates, lizards and predate on birds both eggs and birds (Powlesland et al., 1999, p. 6). One of the interim predator free by 2050 goals is to 'increase the area of mainland where possums, rats, and stoats are suppressed by one million hectares' (Wright, 2017, p. 25), this project aims to support these goals.

Upto date aerial imagery is now a key tool for any successful landscape management project (Marcaccio et al., 2015, p. 250). Traditional methods of gathering data use satellites or aircraft sensing however Unmanned Aerial Vehicles (UAV's) or drones are seen as a more effective tool for many applications.

Using a drone to generate an updated orthophoto map of the site will aid future work at the MacKenzie Wetland.

As there is limited predator control within the MacKenzie Wetland, the owners have the desire to start a pest control programme. Before pest control takes place, it is important to monitor the area first to establish the pest species present, abundance and their preferred habitat, to efficiently plan the work and resources (Gillies, 2013, p. 2). This is also essential for monitoring the outcomes of any pest control work that takes place and to determine the changes that take place in the environment over time.

Monitoring pest populations between the different vegetation zones and landcover will help show pest abundance and potential effects on the restoration of native vegetation and on the fauna that inhabit the area.

The Department of Conservation recommends using tracking tunnels to monitor the activity of mustelids and rats, it is preferred to kill trapping as it is more sensitive to detecting rodents at low abundance, and it does not harm or impact on the target or non-target populations(Gillies, 2013, p. 2). Chewcards provide the same services without the expensive set-up costs however are a relatively new tool.

To gain a greater understanding to the accuracy of using tracking tunnels and Chewcards, a camera will be set up to monitor activity around, and to gauge the target species engagement with the tracking tunnels.

The results will help provide baseline data for the pest monitoring and future management of the site.

As both methods only provide an estimate Relative Abundance Index (RAI), it would be useful to evaluate the performance of these methods so the most efficient device can be chosen for future monitoring of the site (Gillies, 2013, p. 3; National Pest Control Agencies, 2015, p. 3).

1.3 Aim

The aim was to measure and provide baseline data of mammalian pest abundance across different vegetation zones and land uses within the Makenzie Wetland. Different monitoring methods were used and compared to evaluate the accuracy of the techniques. The results will be used to guide further research and fieldwork within the MacKenzie Wetland.

1.4 Objectives

To design a pest monitoring plan using tracking tunnels, chewcards and cameras on the MacKenzie wetland site.

To install tracking tunnel monitoring devices, chewcards and a camera within the MacKenzie Wetland

To collect data from monitoring devices to calculate the relative abundance index for each pest species recorded.

To analyse data and determine Relative Tracking Index and Chewcard Index from data collected.

To plan and conduct a drone survey to produce an updated orthophoto map of the MacKenzie Wetlands.

To assess whether drones can be utilised for further work on the MacKenzie Wetland.

To create a project on Trap.nz website for the MacKenzie Wetland and display results and data.

To present data collected as the baseline study for a pest management plan and operation.

1.5 Timeframe & Budget

60 Tracking tunnels – Will be borrowed from various sources

20 Tracking tunnels - $12.20 each from Gotcha Traps Ltd, Self-funded

60 Ink pad cards for tracking tunnels – $0.85 each Self-funded

1 bottle of Tracking Ink - $26.00 – Self-funded

60 Chewcards – $0.35 – Self-funded

Nails – Self-funded

Drone and related data processing – Provided by the Southern Institute of Technology's Environmental Management Department.

Transport – own car, fuel – Self-funded.

Camera – Borrowed.

GPS – Borrowed.

Table 1: Timetable for Project March - June

	March	**April**	**May**	**June**
Field Work	Visit site, source equipment,	Plan field work - set transect lines, tracking tunnels in field, set up Trap.nz account		Set transect lines, install tracking tunnels in field. Conduct Drone survey
Desk Work	Research methods, design plan, write Proposal	Research and write literature review		Data analysis and reporting

Table 2: Timetable for Project July - October

	July	**August**	**September**	**October**
Field Work	Data gathering - carry out chewcard, tracking tunnel and camera surveys	Keep in contact with landowner and keep informed about progress	Follow up	Follow up
Desk Work	Data analysis and reporting	Reporting	Reporting	Reporting

1.6 Health & Safety

A detailed health and safety plan made with potential hazards and activities identified with the appropriate mitigation and actions to avoid any incidents or harm in the field. No incidents or accidents were reported during the study.

1.7 Ethics

This research proposal is covered by Southern Institute of Technology's blanket ethics approval as animals will be monitored using non-capture tracking tunnels, chewcards and a camera. Tracking tunnels record an animal's presence by the animals walking over an inkpad then card which records the footprints of the animal. Chewcards are small pieces of corflute plastic that have a small amount of peanut butter smeared in the edge. The animals bite the chewcard and their presence is recorded by their teeth marks in the card. Cameras will be focused on the tracking tunnels and chewcard.

Any discussions with the landowner are covered by the blanket ethics approval and will be conducted following the Student Research Project Ethics Guidelines which include the participants right to informed consent and confidentiality.

1.8 Delimitations of Study

Tracking tunnels and chewcards are established methods for monitoring pest populations with industry protocol and literature available.

The study area is set within the MacKenzie Wetland.

Only the rodent method will be used for tracking tunnels to mitigate additional time and costs.

Most equipment was borrowed, mitigating the costs of purchasing tools.

1.9 Limitations of Study

Costs and difficulty sourcing tracking tunnel cards, cameras and chewcards.

Tracking tunnels and chewcards can only be used for coarse index of relative abundance.

Due to time limitations and battery limitations it was only possible to conduct one drone survey of the area.

Covid-19 restrictions mean information gathering, interviews and field work were delayed, with pest monitoring taking place over winter.

2 Chapter Two:

2.1 Literature Review

2.1.1 Introduction

This is a literature review of effects of mammalian pests on wetlands and pest abundance monitoring methods used for pest control programs in New Zealand. The impacts pests have on wetlands, the role of pest population monitoring, and different monitoring methods are discussed with case examples for each method highlighted. This information will be used to help plan a pest monitoring project at the MacKenzie Wetland in Southland.

2.1.2 Pest Impacts on Wetland Restoration

Wetlands are formed by the slow accumulation of organic matter in water logged conditions, and play a significant role in maintaining water quality alongside many other ecosystem services to people, fauna and flora that cannot easily be replicated artificially (Clarkson et al., 2014, p. 192; Hunt, 2007, p. 29). These valuable ecosystems are being drained and developed across the world with Southland, New Zealand having the distinction of being a world leader in this conversion (Robertson et al., 2019, p. 7; Sorrell et al., 2007, p. 362). As a growing awareness of this significant loss, a responsibility to protect and enhance the wetlands that are left has led to an increase of wetland restoration projects across the country and legal protection under the Resource Management Act 1991(Myers et al., 2013, p. 108).

The impacts of pest animal species on restoration projects can affect both the native plant through browsing pressure and introducing invasive species, while predation of native animal species can reduce biodiversity that is important to wetland function (Clarkson, 2003, p. 16). Studies of radio-tracked domestic and wild cats indicate that they use wetlands for hunting ducklings and will cross drains and diches to reach their preferred (Morgan et al., 2009, p. 579). Similar behaviour has been recorded in hedgehogs and ferrets with them predating on birds (particularly nesting), frogs, fish, and invertebrates, while possums are noted as predators of birds and eggs and browsers of native vegetation (O'Donnell et al., 2015, p. 25).

2.1.3 Pest Monitoring

Any pest control in wetland restorations must take much more into consideration than just removing pests, factors like water eutrophication, altered hydrology and changes in vegetation can play a significant role in the presence of pest animals or native fauna (Clarkson et al., 2003, p. 3; O'Donnell et al., 2015, p. 28). Clarkson et al., list changes in browsing, predation and harvesting regimes as one of the five semi-linked indicators of the current state of a wetland, with changes in hydrological integrity, physiochemical parameters, ecosystem intactness and dominance of native plants.

Knowing pest abundances and locations is crucial for the management of pest control projects and can allow for better resource allocation of resources, ability to predict pest behaviour, preferred habitats and the impacts that pests and control of them are likely to have on the ecosystem (O'Donnell et al., 2015, p. 28). Additionally when pests are present in low numbers their behaviour and habitats may change which can reduce the effectiveness of blanket pest control, and may require an information based targeted approach to successfully eradicate or control populations (Russell et al., 2008, p. 18)

2.1.4 Pest Monitoring Methods

Monitoring methods such as five-minute bird counts, predator trapping and indirect methods such as scat tracks or footprint tracking are some non-invasive methods suggested by Clarkson et al. These recommendations are backed up by studies looking into best practice of monitoring techniques used by New Zealand councils show tracking tunnels were one of the most common used but foliar browse index and spotlight counts were favoured over wax tags and faecal pellet counts (Clayton & Cowan, 2009, p. 24).

This was further expanded in a later study where the wide range of methods used for monitoring can leave gaps in information and the inability to provide comparable data (Clayton & Cowan, 2010, p. 364). The Waxtag and Residual Trap Catch methodologies developed by the National Pes Control Agency for monitoring possums and the Department of Conservation inventory and monitoring toolbox which established national standards and specifications for methods such as tracking tunnels and five minute bird counts and it is recommended all monitoring operations should use those methods to increase the uses and benefits this data can provide (Clayton & Cowan, 2010, p. 364).

2.1.5 Tracking Tunnels

The Department of Conservation's tracking tunnel guide sets the parameters for monitoring rodents and stoats and is the preferred standardised method in New Zealand. This method uses a tunnel (usually made from plastic or corflute) that contains a piece of card with an ink pad placed in the middle. The animal is lured to the tunnel with a small amount of peanut butter at each entrance, as the animal passes through the tunnel it leaves ink footprints on the paper, after one night in the field the cards are brought back and analysed to provide a course index of relative abundance for the species recorded (Gillies & Williams, 2013, p. 2). Gillies and Williams provide updated specified guidance on choosing and setting out lines and locations for monitoring rodents and mustelids, tunnel construction, the use of tracking tunnels, counting the tracks (footprints) and calculating the activity/tracking rates. Tracking tunnels are more sensitive that trap catch methods but can be labour intensive and more expensive than Chewcards, and that larger animals are unlikely to be recorded as they cannot walk through tunnels designed for rodents/mustelids (Gillies, 2013, p. 2). Tracking tunnels are also prone to recording non-target species such as birds, reptiles and insects but computer imaging is becoming available that gives better accuracy of species identification (Russell et al., 2008, p. 25).

Tracking tunnels have been used in many studies over the years, some examples include at Moehau, Coromandel Peninsula where results following pest control operations showed a decrease in rat abundance compared to non-treatment sites (Rate, 2009, p. 17). The non-invasive method was used in field trials for the development of a multi-species toxic bait, and was able to show post operation tracking showed just one tunnel recorded footprints compared to the 52 out of 100 stations that recorded footprints prior to the operation, a reduction of 98% (Moran et al., 1996, p. 11).

2.1.6 Chewcards

Chewcards are small square pieces of corflute plastic, usually peanut butter or another type of bait is applied in the corrugated sides, the card is nailed to a tree or suitable stake, spaced along a transect line and left in the field for a number of nights (Ruffell, Innes, Bishop, et al., 2015, p. 642). Pest animals chew the card and bite marks are identified and recorded, from this a Chewcard Index (CCI) can be worked out to provide a Relative Abundance Index (RAI), a standardised methodology for the design, use and information management for monitoring possums was published in 2015 and is able to be used for other species that are recorded (National Pest Control Agencies, 2015, p. 6).

The use of chewcards for population monitoring is relatively new in New Zealand but it is becoming more popular due to the vastly reduced cost and labour hours that are needed in the field for setting up and retrieving but have been noted as being prone to saturation and double-counting in areas with dense pest counts (Ruffell, Innes, & Didham, 2015, p. 90). Ruffell et al., recommended that in areas of low pest abundance that a longer monitoring period but found that results correlated with indices based in tracking tunnels and Waxtags.

Chewcards were used in trials of pest monitoring methods for Waingake Bush, the report concluded by recommending the use of chewcards every second year following standard methodologies to determine pest densities and the success of control operations (Latham et al., 2017, p. 5). In the report Latham et al., also note it is useful to use cameras in conjunction with chewcards as they are able to judge the effectiveness of the chewcards and tracking tunnels.

2.1.7 Camera Traps

Camera traps which use cameras that are remotely-activated by movement, to take one or more photos is a new technology that allows long term, accurate monitoring of multi species in many environments (Anton et al., 2018, p. 74). However, cameras are known to record vast amounts of data that can be time consuming to analyse, they are expensive to purchase and if left in public places are prone to theft. There are many variables that can affect the results, some are identified such as trigger settings, sensor/camera types, the camera orientation, hight, detection zone, and if any bait is used (Anton et al., 2018, p. 74; Nichols et al., 2017, p. 145).

Landcare Research has published a standard operating procedure to provide a monitoring design for camera traps, this was used in the Waingake Bush study where it was recommended that camera traps be spaced 300-500 metres apart and placed randomly within the study so the sample size is suitable to detect relative abundance trends in pest species (Latham et al., 2017, p. 6). Results from another study show that cameras were able to clearly identify cats, stoats, hedgehogs, possums and mice but it was noted that capture rates may be higher than kill traps as individual animals can be captured multiple times and capture many untargeted species (Glen et al., 2014, p. 158).

2.1.8 Drone Surveying

Aerial imagery has become a fundamental tool in conservation for creating and achieving a successful management plan (Marcaccio et al., 2015, p. 250).

Unmanned Aerial Vehicles (UAV's) or drones are remote controlled, multi-rotor or gliding vehicles that that fly without a pilot onboard (Marcaccio et al., 2015, p. 249). Small drones under 25kg that are equipped with GPS (Global Positioning System's) and high resolution or multi spectrum digital cameras are increasingly becoming more advanced and cheaper to buy, making this technology readily available for environmental managers, scientists and everyday people (Aydogan, 2018, p. 36; Marcaccio et al., 2015, p. 249).

These advancements have provided a valuable, lower cost alternative to traditional satellite and aircraft photography for remote sensing of landscapes and areas that are difficult to access (Ruwaimana et al., 2018, p. 2) and have been used for many research applications such as crop monitoring, hazard and landslide mapping, vegetation and environment mapping (Woodget et al., 2017, p. 4), and precision pest management (Iost Filho et al., 2019, p. 2). Remote sensing drones can utilise a variety of cameras/sensors for environmental monitoring - Red, Green, Blue (RGB) sensors, a multispectral sensor which can usually detect 3 and 12 broad spectrum bands of acoustic or electromagnetic energy, or hyperspectral sensors that are equipped with hundreds of narrow spectral bands (Iost Filho et al., 2019, p. 3).

Definitions for these sensors are constantly evolving but multi and hyper spectral technology generally requires larger drones, require more time and experience to operate and are more expensive, however unlock a multitude of remote monitoring abilities such as monitoring plant stressors, nutritional deficiencies (Iost Filho et al., 2019, p. 3) and mapping plant biomass (Doughty & Cavanaugh, 2019, p. 10). RGB sensors are somewhat cheaper and have limited capabilities but are still able to produce valuable information such as 3D maps, as was used successfully by Woodget et al., 2017, to classify river habitats in Chile and England.

Some of the advantages of using sensing drones for these applications over satellites and aircraft include the flexibility to fly at low altitudes, hover and obtain high spatial resolution imagery when traditional methods are affected by cloud cover and they can be obtained and operated without massive costs and training (lost Filho et al., 2019, p. 3; Ruwaimana et al., 2018, p. 2). There are some disadvantages with utilising drones for fieldwork which were listed by Woodget et al., 2017. Including, limited battery life, weather conditions affecting the ability to fly the drone or light conditions which contribute to image blur. Lost Filho et al., 2019 discussed the high initial buy in costs of drones, software needed, the vast amounts of data that is collected and the time it takes to process and analyse this information. These issues can be successfully navigated through careful planning meaning the advantages for using drones for environmental monitoring far outweigh the negatives.

Utilising a drone to take aerial imagery of a worksite can reduce time spent navigating and scouting in the field, potentially find pest plant species that are hard to find at ground level and help avoid damage to sensitive habitats.

2.1.9 Conclusion

This review found that monitoring vegetation and pest abundances is vital for any environmental management and specifically for restoration projects and any resources that are used during the project to avoid any negative outcomes (budget blowout, failure to reduce pest abundance, etc). Standardised data and methods provide comparable results that can improve knowledge and pest control techniques throughout New Zealand.

Tracking tunnels and chewcards have been used for some time in NZ and standard operating procedures have been published. Protocol for the use of camera traps is limited but their use will become more common in time and will allow for techniques to be standardised. Remote sensing using drones is a tool that is rapidly advancing in their abilities and access to the general public.

This literature review has found that utilising these tools for environmental monitoring can be of great benefit for managers of these projects.

3 Chapter Three:

3.1 Methodology

3.1.1 Planning

A desktop study and literature review were conducted to evaluate pest animal monitoring in New Zealand.

Meetings and discussions with Malcolm and Margret MacKenzie (Landowners) about their wishes for the study and their knowledge of the site were carried out before fieldwork began and will continue throughout the study.

Health and safety plans were made and signed before any site-work started.

Mapping distinct eco-tones using a printed vegetation map that was provided by Malcolm and on-site surveying was completed. It is noted that on-site water levels may have changed between the initial site visit and data collection.

The Trap.nz website was utilised for information management and mapping; this will provide a publicly accessible map and database that can be used in and future work on the site.

The drone and related software, tracking tunnels, chewcards, inkpads, and other materials were sourced from the Southern Institute of Technology Environmental Management Department, Mark Oster from Environment Southland, Jessie Bythell from the QEII Trust, Chris Rance, with additional equipment purchased online. Drone piloting and data processing was carried out by Phil Lockett.

All work was carried out under the supervision of Dr. Tapuwa Marapara.

The locations of all tracking tunnels were mapped using a Garmin hand-held GPS unit with the data uploaded into the Trap.nz database. A drone survey was also planned to produce an orthophoto map of the site to aid planning and fieldwork.

All fieldwork was carried out with the help of Trent Robertson.

Due the Covid-19 restrictions all work on-site was delayed for over eight weeks, this meant all fieldwork apart from the initial site visits was completed in winter during late June/early July.

3.1.2 Literature Review

A desktop-based review of relevant published literature. Pest animal monitoring methods and the use of drones with remote sensing capabilities for aerial mapping were assessed, with the positive and negative attributes of the methods summarised along with case examples.

Due to time restrictions, issues with securing enough tracking tunnels and the harvesting of the surrounding pine trees it was decided to select representative environments of the site. The habitats chosen were around the restoration and pond area, the semi-open wire rush vegetation, the shrubland area which is now dominated by willow and gorse, and the recently felled pine blocks which was comprised of no ground cover, pine stumps and forestry debris. A shortage of tracking tunnels meant the pine area was only surveyed using chewcards.

3.1.3 Tracking Tunnel Monitoring

The survey followed the method outlined in the DOC tracking tunnel guide v2.5.2. for rodent monitoring (Gillies & Williams, 2013, p. 9).

Vegetation zones were identified using a vegetation map that was provided and by on site identification so that the different zones could be sampled and compared.

The start points of each transect line was chosen using available maps with the points located in the field using a GPS unit. The exact bearings were decided in the field. Vegetation on the site had changed significantly since the last aerial images were taken, this meant that while every effort was made to maintain a direct compass bearing it was often impossible to achieve so the 'path of least resistance' was taken.

The pine trees that were standing at the north and southern ends of the site had been harvested, these areas were included in the monitoring site. 200 meters was required between monitoring lines.

Once the start point and direction were selected lines were set up and tracking tunnels placed in the field at least three weeks before monitoring started.

A GPS was used for measuring, with tunnels placed every 20 m in the best position within 2 m of the 20 m mark along the line, with a total of 10 tracking tunnels per line.

Tunnels were pegged into ground with wire pegs and left in the field for four weeks until data collection began.

Tunnels were labelled and marked in the field with flagging tape, and each tunnel’s location marked on the GPS with data transferred onto Traps.nz.

Figure 2: Tracking tunnel, chewcard and camera in the field

Figure 3: Trap.nz, (2020) Tracking tunnel locations. https://www.trap.nz/view/monitoring-overview-map?field_retired_value=0&title=&field_type_target_id_entityreference_filter%5B%5D=108&field_tags_tid%5Btextfield%5D=&field_tags_tid%5Bvalue_field%5D=%22%22%22%22&i

3.1.4 24 Hour Tracking Tunnel Survey

After four weeks, ink cards were placed in tracking tunnels with peanut butter on the inkpad which is in the middle of the tracking card

Monitoring for rats took place over one night with clear weather over the 24 hour period.

Tracking cards were labelled, placed in each tunnel and left for one night then collected the next day for analysis with all results and notes uploaded into the Trap.nz database.

Results were used to calculate a Relative Abundance Index for each species identified by monitoring.

3.1.5 Three night Tracking Tunnel Survey

The three night survey began a week after the 24 hour survey due to bad weather and time restrictions. It was decided to use the same methodology as the 24 hour survey for rodent monitoring but to extend it for three nights using fresh rabbit meat as bait rather than use the mustelid monitoring technique as suggested in the DOC tracking tunnel guide (Gillies & Williams, 2013, pp. 7,8,9). This allowed us to directly compare the bait and time differences between the surveys.

Tracking cards were labelled, placed in each tunnel. Fresh rabbit meat was cut into small pieces for bait, each tracking card had one piece of meat placed in the middle of the inkpad.

Cards were left for three nights then collected the next day for analysis with results recorded and uploaded into the Trap.nz database. Calculations were completed using Microsoft Excel.

3.1.6 Calculating Relative Abundance/Tracking Tunnel Index (RAI/RTI)

Methods were adapted from DOC tracking tunnel guide v2.5.2. for rodent monitoring, p.10

1. Total the number of tunnels on each line that have, doing each species separately.
2. Divide the number of tunnels traced on each line by the number of available tunnels in each line and multiply this figure by 100. This gives the percent tracking rate for each line. This is done separately for each species.
3. Calculate the mean percent across all tracking lines by adding the percentage of tracking rates from each line and divide the total by the number of lines. This is done separately for each species.

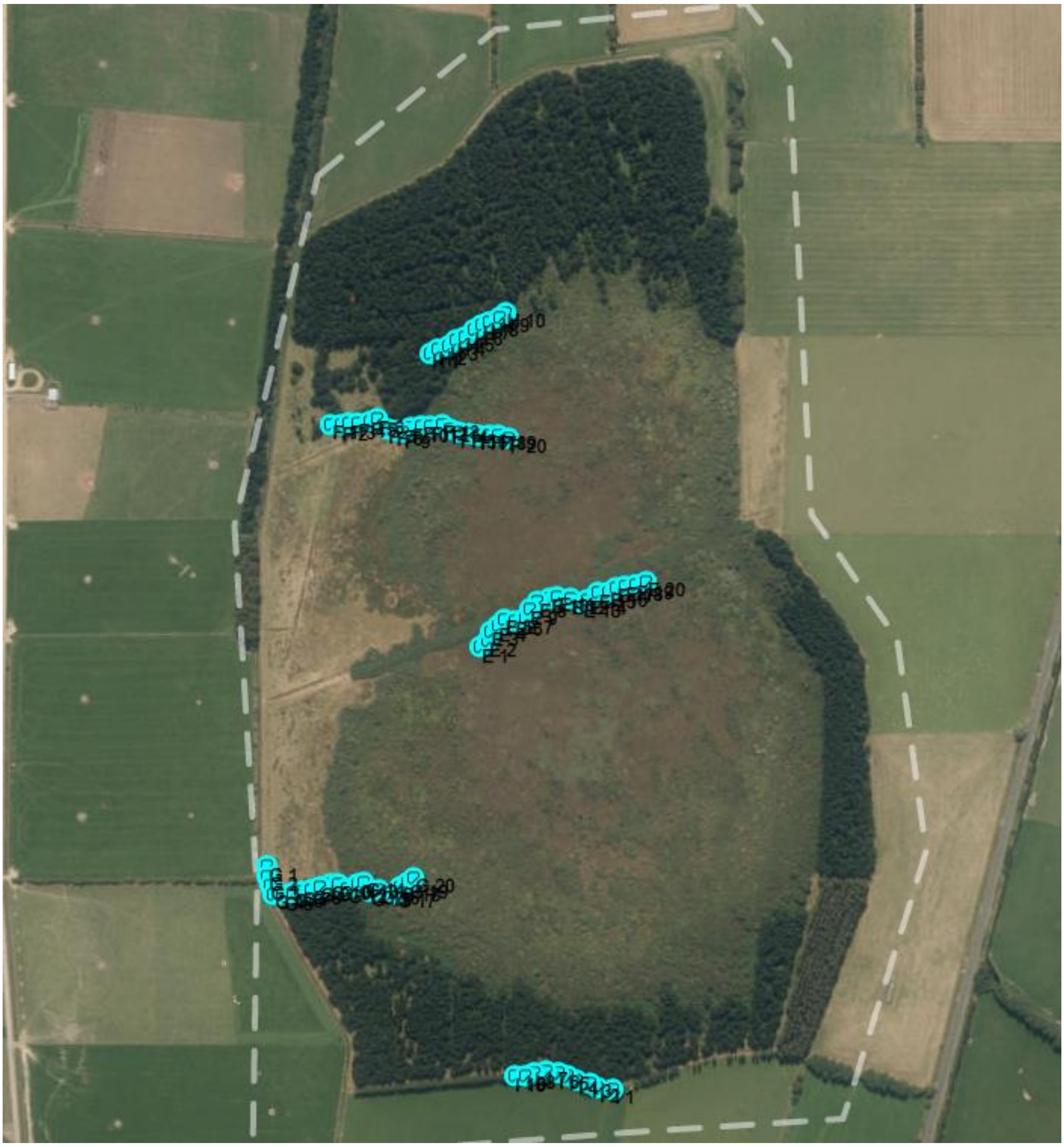
4. Calculating the standard error of mean. Microsoft Excel was used to calculate the standard deviation of the tracking rate percentage of each survey line. The standard error is equal to the standard deviation divided by the square root of the sample size, which for these surveys is the square root of the number of lines. This was done separately for each species.

3.1.7 Chewcard Monitoring

Chewcards were installed at the same time as the 24 hour tracking tunnel cards and were collected for analysis seven days later when the three night survey cards were deployed.

As transect lines had been established for the tracking tunnel monitoring the same lines were used for chewcards with the addition of two 10 card lines in the freshly harvested pine area, The spacings between chewcards were adapted from the National Pest Control Agencies - A1 Possum Population Monitoring using Trap-Catch, Waxtag and Chewcard Methods (2015). 20 chewcards were placed along the same line as the A, B and C tracking tunnel lines at distances of 10m apart, these lines were labelled E, F and G lines. The two 10 card lines were labelled H and I lines

Figure 4: Trap.nz, (2020). Chewcard locations, https://www.trap.nz/view/monitoring-overview-map?field_retired_value=0&title=&field_type_target_id_entityreference_filter%5B%5D=107&field_tags_tid%5Btextfield%5D=&field_tags_tid%5Bvalue_field%5D=%22%22%22%22&items_p



Chewcard design is an 8 x 18cm card made of 3mm white plastic corflute with a peanut butter or similar bait applied to the internal channels at each end of the card.

Cards were folded in half then applied to a tree 30cm off the ground using a flathead nail positioned 10mm from the folded edge on the top side and about 5mm on the bottom fold. Where no suitable tree could be used the chewcard was attached to a metal peg that was stuck into the ground.

Cards were labelled, and marked in the field, with flagging tape used to help identify the site and each cards location recorded in the GPS.

One chewcard was placed at the start of the transect line with a spacing of 10 metres between each chewcard with 20 chewcards per line.

The differences between chewcard and tracking tunnel methods mean that one line of 10 chewcards could only monitor half the distance of tracking tunnels. To ensure a full comparison of the methods over the same area three of the tracking tunnel transect lines were monitored using 20 chewcards per transect line.

Analysis of chewcards and calculating Relative Abundance/chewcard Index (RAI/CCI) followed protocols outlined in section 3.1.8 (National Pest Control Agencies, 2015, p. 37) with the addition of including separate indicies for any pest species identified.

Results were uploaded into the Trap.nz database and used to create a heatmap for pests detected during the survey.

3.1.8 Calculating Chewcard Index (CCI/RAI)

Steps 1-5 were adapted from the National Pest Control Agencies – Possum population monitoring using the trap-catch, Waxtag and Chewcard methods, p.37.

1. For each line count the number of devices with bite marks for each species.
2. Divide the number of devices with bite marks on each line with the total number of devices per line.
3. Using the line values calculated in 2 calculate mean proportion of devices with bite marks for all lines on site i.e. the sum of the proportion of devices with possum bite marks calculated from each line/number of lines. Multiply by 100 to get the RAI.
4. Calculate the standard error (SE) for each line i.e. standard deviation of the RAI/square root of the number of lines.
5. Calculate the combined SE for all lines.

Steps 1 -5 were done for each species (rats, mice, possums etc.).

3.1.9 Camera monitoring

A camera was set up to monitor the interactions of pest species with tracking tunnels and chewcards following Landcare Research best practice guidelines.

Data was to be recorded and analysed using tracking ink cards, chewcards, and digitally on camera. A ratio of interaction with the monitoring device compared to avoidance of device would be determined.

Interaction was defined as leaving recorded evidence in the form of footprints on the tracking tunnel card or identifiable chew marks on the chewcard. Avoidance was defined as changing direction of travel or motion to the device, and/or interacting with device but not leaving identifiable evidence on the device.

Any additional pest species record by the camera but not by the other devices would have been included in the pest management plan.

The results of the camera trial will help future research decide if the technology is suitable for use on the site.

Due to the disruption of Covid-19 only two cameras were able to be sourced instead of one for each line which was the initial plan

3.1.10 Data Analysis

Site measurements were taken using a Garmin GPS unit with the data uploaded into Trap.nz to create heat maps.

Data in the form of ink footprints on card and teeth marks on the chew cards, was analysed by eye and entered into Microsoft Excel. All data including tracking and chew cards was kept and stored.

Results were used to calculate a Relative Abundance Index for each species.

RAI results will be used for the development of a pest management plan after the completion of this monitoring report.

Data was uploaded into the MacKenzie Wetland project on the Trap.nz website which can be used to manage data and generate heatmaps where pests are detected or trapped.

3.1.11 Drone Survey

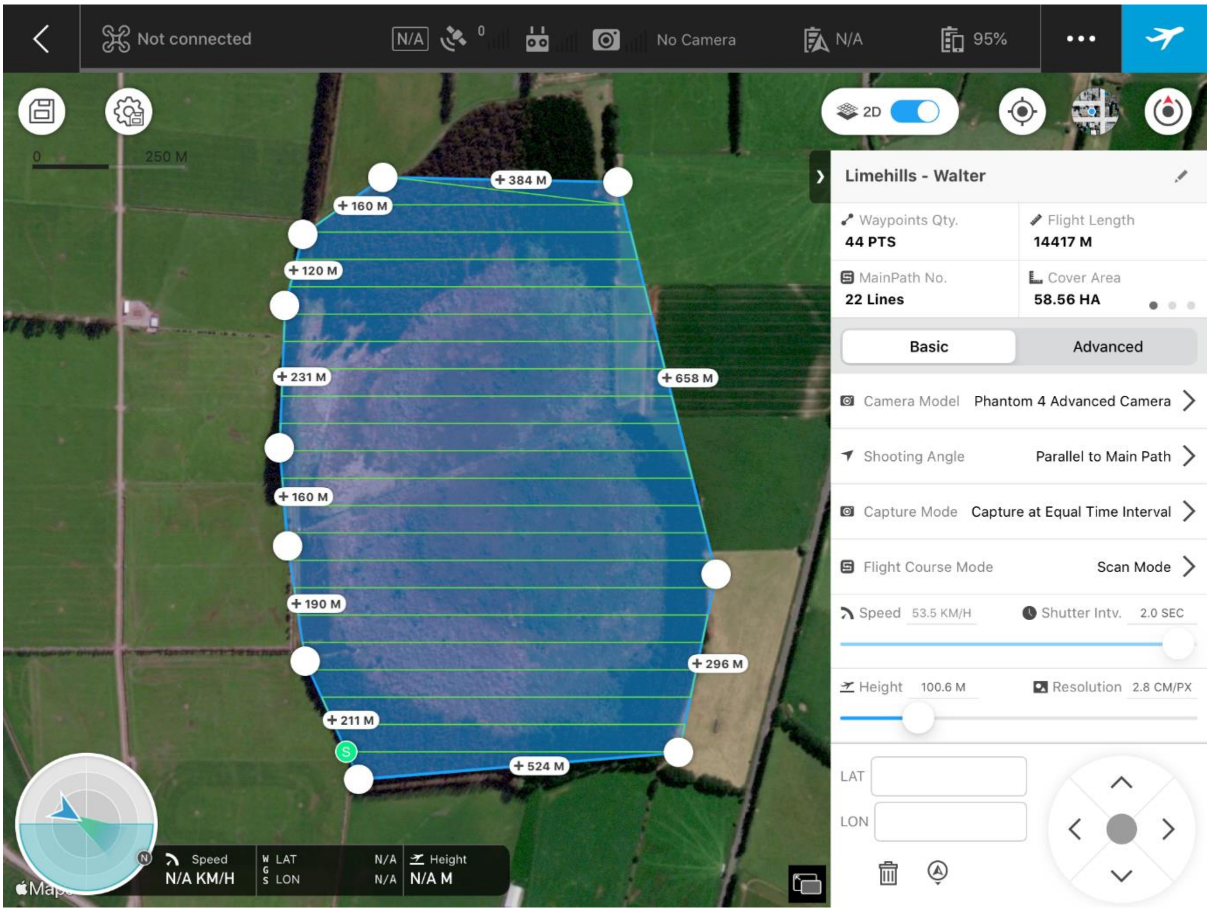
To gain a better picture of the wetlands and evaluate whether it was feasible to take aerial imagery of the site using an Unmanned Aerial Vehicle (UAV/ Drone) equipped with a DJI FC6310 camera, then use these images to create an updated orthophoto map.

The drone was supplied by the Southern Institute of Technology's Environmental Management Department with the flight planning and flying carried out with Phil Lockett.

The flight plan was made using the DJI DS Pro software on an iPad (Figure 5). Field data was processed using the Maps Made Easy online software. The resulting orthophoto map was available digitally within seven hours of uploading raw data.

Drone surveying was carried out when weather conditions were favourable and were completed with a total of 543 images taken at an average altitude of 100m. Battery limitations meant that it was not possible to survey a small section of the felled pine stumps at the northern tip of the site. A low definition 3D image was also generated however a different flight plan is required to generate a high definition 3D image and this was not able to be achieved within the timeframe.

Figure 5: DJS Pro. (2020). Drone survey flight path.



Information for the MacKenzie Wetland pest monitoring project can be found at: https://www.trap.nz/node/2467010

4 Chapter Four: –

4.1 Results

4.1.1 24 Hour Tracking Tunnel Survey – Peanut Butter Bait

Of the forty tunnels used in the 24 hour peanut butter survey six recorded the presence of mice and one tunnel recorded an unspecified disturbance. C line recorded mouse tracks on 50% of the tunnels while only A line recorded any other disturbances with just one tunnel recording mice. Figure 7 shows the number of tunnels that recorded tracks of mice and an unidentified species over each line. Overall, the average Relative Abundance Index (RAI) or relative tracking index across all lines for mice was 15% with a Standard Error (SE) of 12%. The large SE reflects that one line recorded almost all tracks and the distribution is limited. RAI for unspecified species sits at 3%. RAI's from this survey are displayed in Figure 8.

4.1.2 24 Hour Tracking Tunnel Survey Heatmap

The trap.NZ heatmap shown in Figure 9 provides a clear visualisation of the locations where the presence of mice and one unspecified species were detected. Mice are present along the southern banks of what is now the southern pond and along the northern bank of the northern pond. Both areas are raised earth banks and were noticeably dryer than the surrounding areas. The Trap.NZ uses a base layer image that was taken in 2012, before the ponds were built and filled. Red indicates areas with heavy presence which fades to green/yellow with lower presence.

Figure 6: C-1, 24 Hour Survey

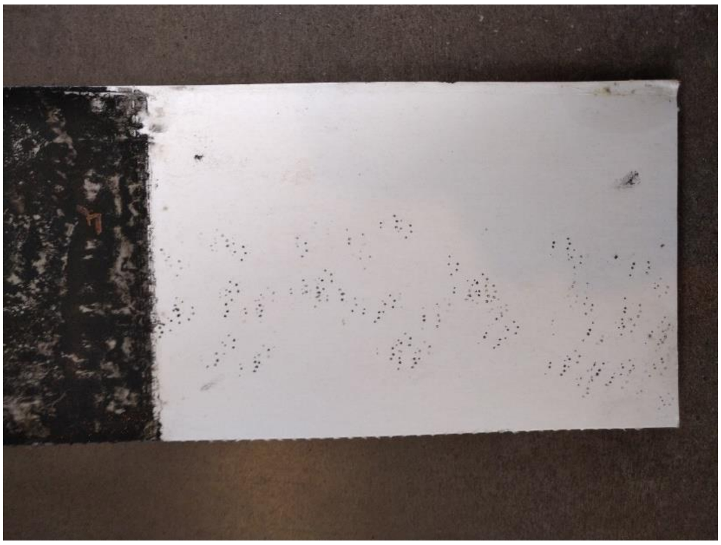


Figure 7: 24 Hour Tracking Tunnel Survey Totals Graph

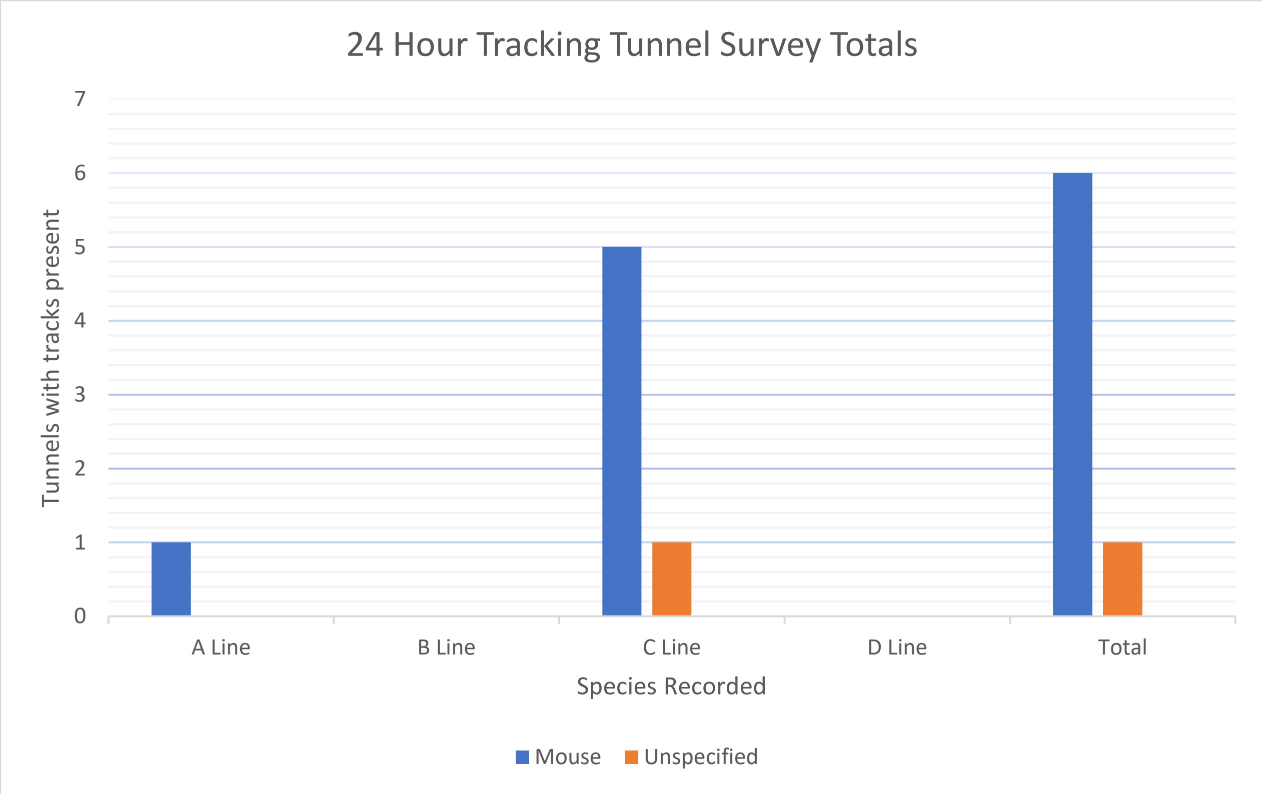


Figure 8: 24 Hour Survey Relative Abundance Index Graph

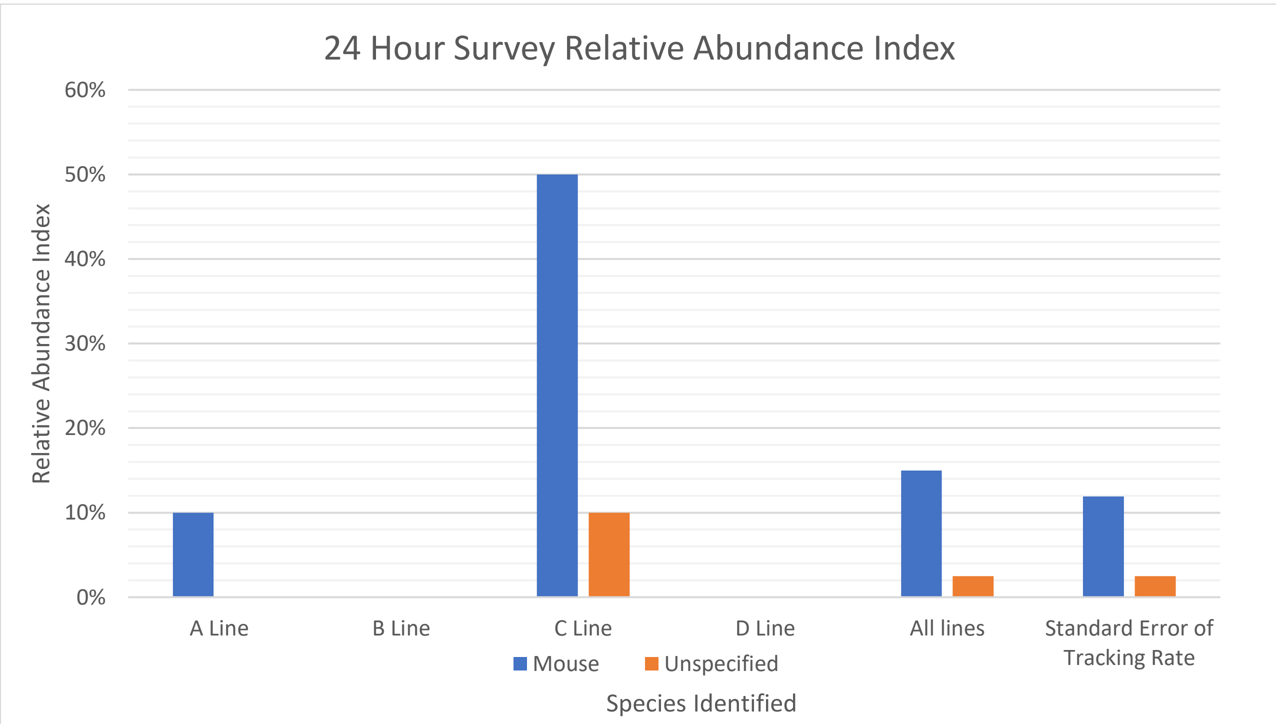


Figure 9: 24 hour Tracking Tunnel Survey Heatmap. From MacKenzie Wetlands Monitoring Records, 2020, https://www.trap.nz/view/report-monitoring-records?title=&field_type_target_id%5B%5D=108&field_monitoring_species_new_target_id%5B%5D=466&field_mon

4.1.3 Three night Tracking Tunnel Survey – Fresh Rabbit Meat

The three-night tracking tunnel survey which used fresh rabbit meat bait recorded a significantly higher presence of mice than the 24 hour event. Mice were recorded across all lines and the presence of cats was detected on one tracking tunnel card. C line again record the highest presence of mice and was where the cat was recorded. An unidentifiable insect print was recorded on A line. The totals for each line is displayed in Figure 11. RAI for mice over all 40 tracking tunnels was 43% with a standard error of 16% (Figure 12). Cats and Insects were calculated at 3% ± 3%.

4.1.4 Three night Tracking Tunnel Heatmap

The heatmap for the three night tracking tunnel survey shows all species that were detected with a wider distribution across the wetlands than from the 24 hour survey. Mice were detected across all lines, the heatmap provides a valuable picture for future monitoring surveys and is displayed in Figure 13. Orange/Red indicates higher detection rates with yellow to green lower rates.

Figure 10: Tracking cards from three night survey. Top and bottom cards show mice prints, centre card with cat prints

Figure 11: Three-night Tracking Tunnel Survey Totals Graph

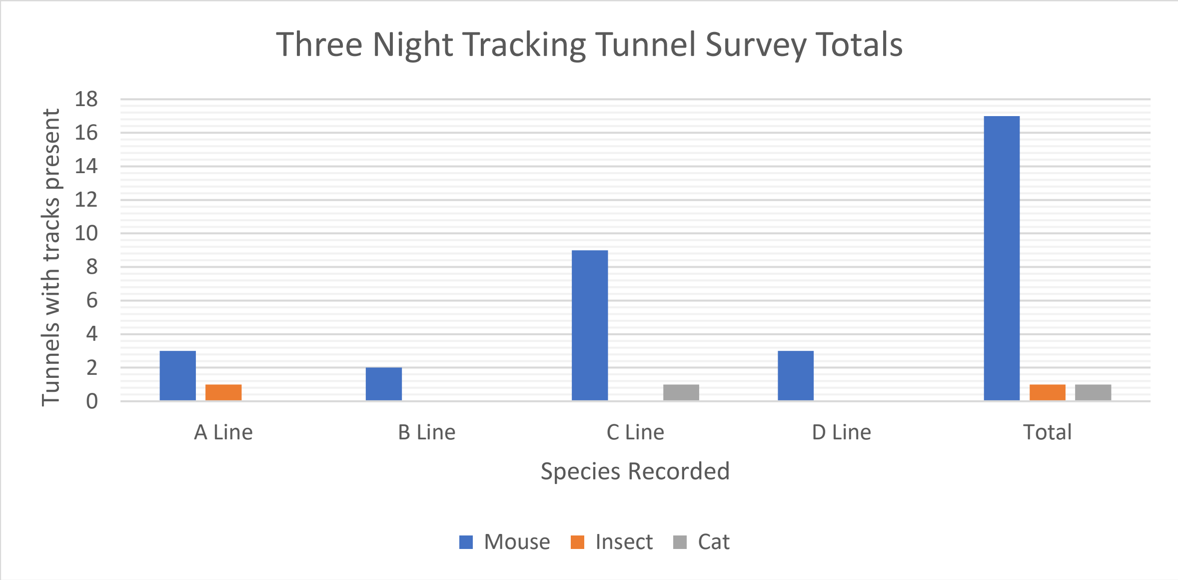


Figure 12: Three Night Survey Relative Abundance Index Graph

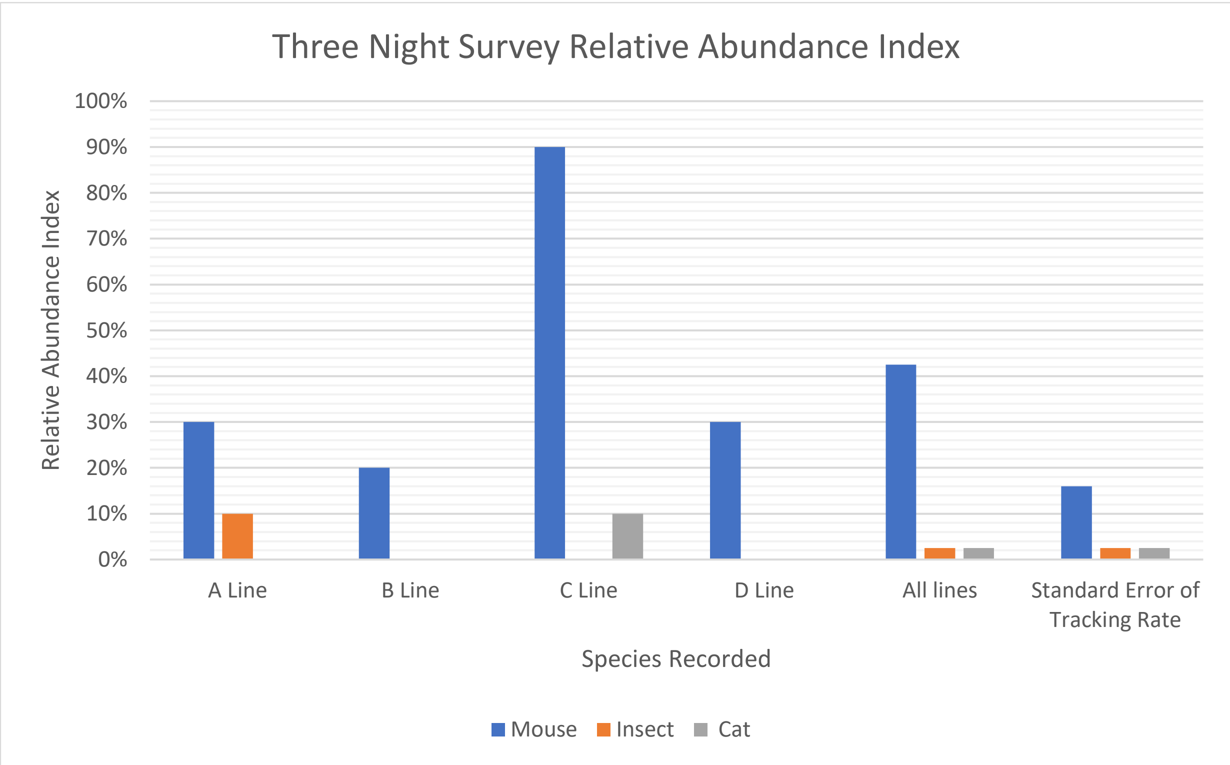


Figure 13: Three Night Tracking Tunnel Survey Heatmap. From MacKenzie Wetlands Monitoring Records. By W. Fieldes, 2020, https://www.trap.nz/view/report-monitoring-records?title=&field_type_target_id%5B%5D=108&field_monitoring_species_new_target_id%5B%5D=466&field_mon

4.1.5 Seven Day Chew Card Survey – Peanut Butter

Results for the seven day chewcard survey show only mice were detected. 20 chewcards were placed along the same line as the A, B and C tracking tunnel lines at distances of 10m apart, these lines were labelled E, F and G lines. G line was on the same track as C line and recorded the 13 cards with evidence of mice. The Relative Abundance Index (RAI) of E, F and G lines was 28% ± 13%. Two lines (H&I) with 10 cards each were placed at the northern and southern ends of the wetland site where no monitoring with tracking tunnels had taken place. H and I lines recorded a RAI of 35% ±25%. The RAI calculated for all chewcards across the site was 31% ±13%. These results are displayed as a graph in Figure 14. The heatmap generated from Trap.nz (Figure 15) indicates that mice utilise the area with freshly harvested pine trees surrounding the wetland as well as being present across all the lines placed in the wetland.

Figure 14: Seven Day Chewcard Survey Relative Abundance Index Graph

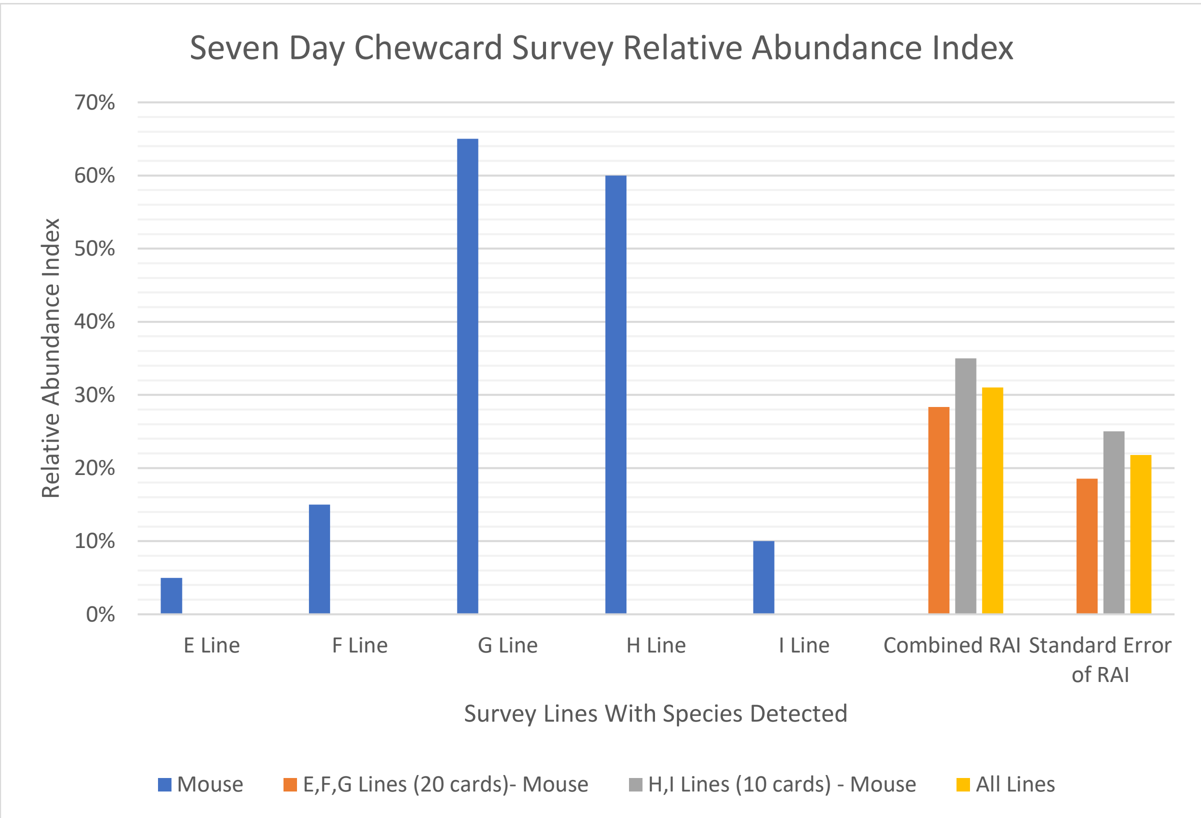


Figure 15:Seven Day Chewcard Survey Heatmap, From MacKenzie Wetlands Monitoring Records. By W. Fieldes, 2020, https://www.trap.nz/view/report-monitoring-records?title=&field_type_target_id%5B%5D=108&field_monitoring_species_new_target_id%5B%5D=466&field_mon

4.1.6 Camera Traps

Results from the cameras were inconclusive. Of the two cameras used one did not record any pictures from the survey events. The second camera was set up to record activity around a chewcard, the chewcard was untouched by pests and the camera was set up incorrectly and did not detect any activity

4.1.7 Drone Mapping

The images taken from the drone and the subsequent map that was made out of the images has provided a high-quality and up to date aerial image of the study site that can be used for planning and carrying out activities on the wetland. The updated image displayed in Figure 17 shows that water levels in the two ponds has risen significantly since the trap.nz base layer image was taken. It is possible to detect some plant species from the image and this could be helpful for any vegetation work. A 3D map of the survey (Figure 16) was also produced at the same time, although this survey was not set up for 3D imaging the map gives a good indication of vegetation heights and could become valuable tool for monitoring the wetland's vegetation over time.

Figure 16: Screenshot of the 3D map generated from the drone survey

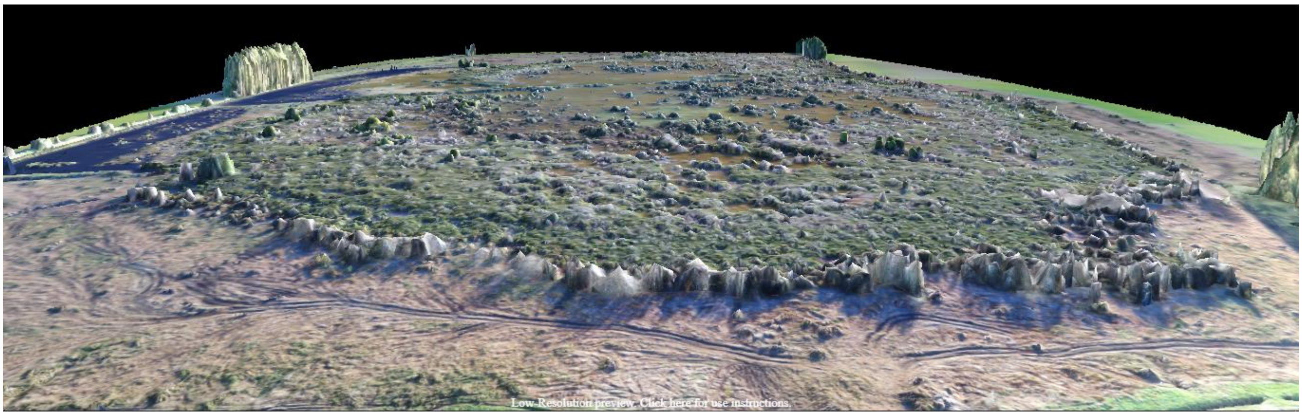
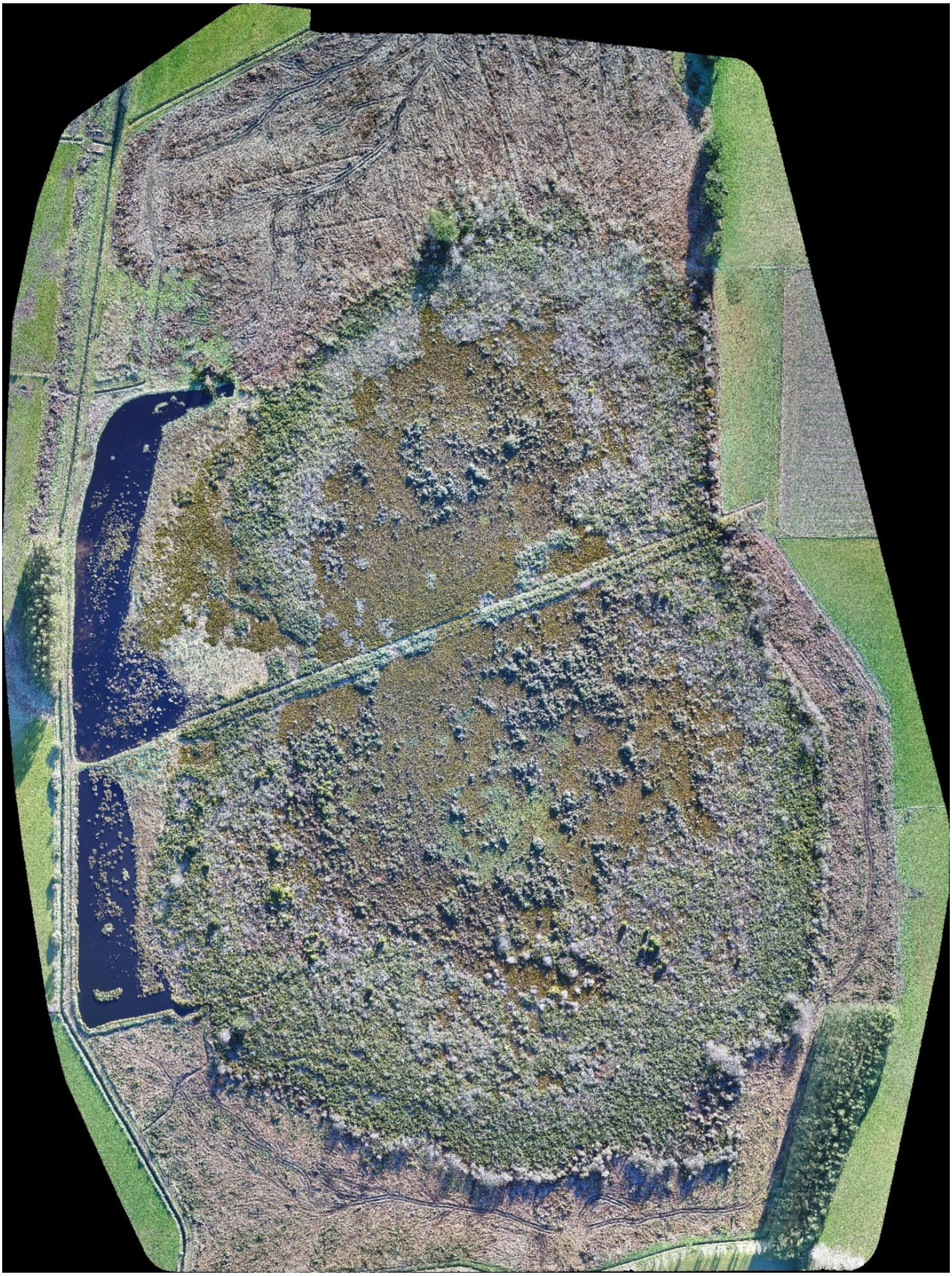


Figure 17: Orthophoto Map of MacKenzie Wetlands, generated from drone survey



5 Chapter Five

5.1 Discussion

5.1.1 Pest Monitoring Surveys

Due to the unforeseen circumstances bought about by the Covid-19 nationwide lockdown there were significant delays in sourcing both the tracking tunnel and chewcard equipment and being able to begin monitoring. The original plan was to install 80-100 devices across the entire wetland to gain a complete picture of the distribution of pest species in the area, in the end only 40 tracking tunnels and 60 chewcards were able to be sourced for the project. As the methodology recommended using a minimum of 60-80 tunnels in areas less than 300 ha (Gillies & Williams, 2013, p. 4), it can be assumed that the low number of tunnels contributed to the high standard error rate from all surveys. It was not possible to survey the entire wetland due to these constraints, so it was decided to place two lines within the restoration area surrounding the ponds and two others placed to intersect different vegetation zones of the wetland. This provided qualitative information that is useful to the restoration project, but the results cannot be used to compare pest distribution among the different habitats.

Both tunnel surveys and the chewcard survey detected mice *(Mus musculus)* as the predominant species however the three night tunnel survey shows their presence along all lines and was able to record two other species that were not found during the one night survey. The longer time period and the use of fresh rabbit meat are the factors that contributed to the higher detection rates and the detection of cats found in the three night survey as cats are carnivores and generally do not take food based baits such as peanut butter (Fisher et al., 2015, p. 92). As cats are not a target species for tracking tunnels, the indices and SE rates were determined using the same formula as was used for mice.

Mice are known to predate native birds, invertebrates and reptiles and can have a detrimental effect on native plants as they consume new sprouts and seeds, particularly of tussock species *(Chionocloa sp.)* (Badan, 1986, p. 139; Miller & Webb, 2001, p. 54; Ruscoe et al., 2004, p. 259). Mice typically breed during spring-autumn but can continue into winter if food availability and conditions are favourable, meaning mouse populations peak over winter before declining (Ruscoe, 2001, p. 128). This may have been a factor in mice being the only rodent species detected on the wetlands as rats have different food and habitat preferences and population dynamics (Choquenot & Ruscoe, 2000, p. 1064). Prior to the commencing of monitoring the pine trees (*Pinus radiata)* that surrounds the native wetland area was harvested and the effects of this on the distribution of pest mammals is not known as it was not possible to survey the area before harvesting started. Mice are known to use exotic pine plantation habitats (Ruscoe, 2001, p. 127), and prefer habitats with dense ground cover as they provide more suitable food and shelter (King et al., 1996, p. 235).

Removing the trees and ground cover may have caused the mice to disperse from the logged area however two short chewcard lines were set in the cleared pine areas to the north and one on the southern boundary of the cleared area with the presence of mice being detected in both areas, these results fit with a study which found mice still present in areas that had been cleared and with little groundcover (King et al., 1996, p. 233). King et al., 1996, also state that mice populations often slowly develop high densities in areas that have been disturbed and in new exotic plantings as ground cover increases, something that may affect the site in the future if it is to be replanted with pines again. An increase in mouse densities been linked to an increase in predatory species such as stoat *(Mustela erminea)* and weasel *(Mustela nivalis)* population increases as mice are a dominant food source (Blackwell et al., 2001, p. 228).

The presence of cats on the wetland presents a threat to the restoration efforts in the area as they are known predators of mammals, birds, lizards and invertebrates (Fisher et al., 2015, p. 90; Gillies, 2001, p. 206). Small mammals such as rabbits *(Oryctolagus cuniculus)* and rodents (mice, rats) typically makeup the majority of cats diet when available (Gillies, 2001, p. 205) but some cats have been recorded as having a strong preference for birds and skinks and are capable of swimming short distances to access nesting sites of birds (Harper, 2004, p. 26; Morgan et al., 2009, p. 578). Significant numbers of ducks and other waterfowl were witnessed on the ponds and in the surrounding vegetation during fieldwork, cats may be having a negative effect on these birds use of these habitats. Cats are known to be vectors of diseases and parasites such as bovine tuberculosis (Norbury et al., 1998, p. 149), *Sarcocystis gigantea* and *S. medusiformis* (Langham, 1990, p. 243) which could be of concern as the MacKenzie Wetland is surrounded by farmland in all directions.

Cats were recorded in tunnels that also had mouse sign and were always found in areas directly surrounding the ponds and it can be assumed that there is some predation by cats which could help regulate mice numbers but if mice numbers fall cats will switch to a more abundant prey (Fisher et al., 2015, p. 90; Harper, 2004, p. 7). This factor should be considered for any future pest control and management on the wetlands.

Interestingly no rats were detected by any device during the surveys, this could be a positive finding if future surveys are able to confirm this. No definitive conclusion could be drawn whether rats are present in the area as it was not possible to get good spatial coverage of the wetland with the resources available.

The results from the three night tracking tunnel survey that used fresh rabbit meat for bait provided the best picture of the various species present on the wetland which makes them the recommended tool for future monitoring but the price difference and versatility of the chewcards allowed a much larger area of the site to be monitored. If future monitoring wish to only target rodents and possums then chewcards will provide a useful and time effective method for this.

The failure to gain any useful data from the two cameras used in the project was disappointing and does not reflect the capabilities of cameras as monitoring tools. It was found that operator error can be attributed to being the cause of this, one camera's memory card was found to be unformatted and the other camera was left on the wrong recording setting which meant both devices were unable to record any data that they captured. Camera's still have some of the most potential as pest monitoring devices and their use should be continued if these issues can be mitigated.

5.1.2 Drone Survey

Using a drone (Unmanned Aerial Vehicle) to capture aerial imagery and turn the images into an orthophoto map has proven to be one of the most exciting tools found during this study. The aims of using the drone was to produce a map to aid the planning and fieldwork of the pest monitoring survey and assess whether there is further potential to use drones as a vegetation and pest plant monitoring method, which the results show were both successfully achieved. The orthophoto map was available the same day it was uploaded to the Maps Made Easy software, the fast processing time was particularly useful as the map could be used for planning fieldwork and navigating the site during fieldwork.

Surveying was carried out at an altitude of 100m yet still produced a map that clearly can identify individual wire rush *(Empodisma minus)* and *Carex sector* plants. Timing of the drone survey coincided with the flowering of the pest species gorse *(Ulex europaeus)*. The bright yellow flowers can clearly be seen in the orthophoto map and gives a qualitative picture of the spread and density of gorse on the wetlands. These results correlate with other studies which successfully identified pest plants and other vegetation using remote sensing drones (Iost Filho et al., 2019, p. 18; Ruwaimana et al., 2018, p. 17). Although no formal ground truthing was done for this project the species identified in the map were confirmed during on the ground fieldwork, which provided further confirmation that drone technology can play an important role in landscape restoration projects.

6 Chapter Six:

6.1 Conclusion

The use of non-lethal methods for monitoring mammalian pest abundance in the MacKenzie Wetland is important part of the restoration project currently taking place. Tracking tunnel surveys carried out over three nights using fresh rabbit meat as bait detected more species on the wetland when compared to the 24 hour tracking tunnel, chewcard and camera trap surveys. Detecting all pest species present in the area will allow for a more effective and sustainable pest monitoring and control program to be developed and implemented, with a higher chance of achieving the desired outcomes. Both mice and cats present the biggest threat to the fauna living within the wetland. Mice predate on vegetation and may have a detrimental effect on the efforts to restore native plant biodiversity in the MacKenzie Wetland. Trap.NZ's online software is free to access, easy to use and provides many tools for data management and communication, its use can be of great benefit to the restoration project.

Drones with remote sensing capabilities are becoming increasingly accessible for environmental monitoring. By using a drone to take aerial images of the MacKenzie Wetland it was possible to produce an updated, highly detailed orthophoto map which was used for project planning and during fieldwork for the pest monitoring surveys. Drone imaging is used in precision agriculture for identifying pest plant species in crops and show huge potential for managing pest plants on wetland sites that are difficult to access and monitor.

The unique challenges placed on the project by the impacts of Covid-19 highlighted the importance of using tools and methods that can be easily used and adapted for environmental management.

The MacKenzie Wetland is an important remnant of Southland's once vast wetlands, continuing the hard work that was started by Malcolm and Margaret and so many others is critical to ensuring that this threatened and diverse ecosystem continues to function long into the future.

6.2 Recommendations

Its recommended that:

- Future mammalian pest monitoring surveys use tracking tunnels over three nights with fresh rabbit meat as bait. These tools and methods will allow more species to be detected than other methods.
- A minimum of 60 – 80 tracking tunnels should be used in future surveys; this will provide better spatial coverage of mammalian pest abundance in the wetland.
- Surveying of the MacKenzie Wetland should take place multiple times throughout the year, across the seasons, this will provide a clearer picture of pest species use of the area in different conditions.
- Future projects should use camera traps, with emphasis on making sure the equipment is set up and operated correctly. It should be confirmed before leaving site that the camera is working, and images capture the intended area.
- Invertebrate surveys and bird counts should be carried out to provide a better understanding of the native fauna that inhabit the wetland and the potential effects that introduced species have on them.
- A pest management plan should be developed for the MacKenzie Wetland using information provided by this report and future surveys.
- Drones should be utilised for planning all work on the wetland, a quick fly over before commencing fieldwork can save time and energy spent walking and navigating in the challenging wetland conditions.
- Permanent vegetation plots should be set up and vegetation surveys undertaken. This will allow ground truthing of orthophoto maps generated by drone surveys.
- Regular drone surveying should be carried out to monitor seasonal changes to vegetation, ground conditions and pest plants in the wetland.
- Further investigation into the potential of high resolution 3D imaging generated from drone surveying.
- Investigation of different drone survey methods and whether flying at a lower altitude can produce better information.
- All future work on the MacKenzie Wetland should continue to add data and utilise the Trap.NZ data management software.

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6.4 Appendix

6.4.1 Chapter Three - Methods

Table 3: Tracking tunnel GPS points

Tracking Tunnel	Latitude	Longitude		Tracking Tunnel	Latitude	Longitude
A 1	-46.086106	168.400938		C 1	-46.090566	168.400041
A 2	-46.08610	168.401174		C 2	-46.090727	168.400126
A 3	-46.086125	168.401727		C 3	-46.09072	168.400378
A 4	-46.086096	168.401477		C 4	-46.090681	168.400645
A 5	-46.086176	168.40197		C 5	-46.090647	168.400912
A 6	-46.08611	168.402232		C 6	-46.090662	168.401175
A 7	-46.086118	168.402514		C 7	-46.090618	168.401409
A 8	-46.086191	168.40275		C 8	-46.090681	168.401651
A 9	-46.086206	168.40304		C 9	-46.090645	168.401934
A 10	-46.086219	168.403332		C 10	-46.090558	168.402115
B 1	-46.088296	168.403038		D 1	-46.089448	168.405846
B 2	-46.088134	168.403174		D 2	-46.089626	168.405853
B 3	-46.088064	168.403405		D 3	-46.089796	168.405717
B 4	-46.088022	168.40370		D 4	-46.089998	168.4057
B 5	-46.087861	168.403873		D 5	-46.090186	168.405704
B 6	-46.087789	168.404143		D 6	-46.090189	168.4060
B 7	-46.087857	168.404477		D 7	-46.090312	168.40609
B 8	-46.08778	168.40472		D 8	-46.090467	168.406216
B 9	-46.087711	168.404996		D 9	-46.090567	168.406406
B 10	-46.087711	168.404996		D 10	-46.090781	168.406373

Table 4: Chewcard GPS Points

Chewcard	Latitude	Longitude		Chewcard	Latitude	Longitude
E 1	-46.0883	168.40306		G 1	-46.0905	168.40
E 2	-46.0882	168.40316		G 2	-46.0906	168.40
E 3	-46.0881	168.40319		G 3	-46.0906	168.40006
E 4	-46.0881	168.4033		G 4	-46.0907	168.40012
E 5	-46.088	168.40339		G 5	-46.0907	168.40025
E 6	-46.088	168.40354		G 6	-46.0907	168.40039
E 7	-46.088	168.40369		G 7	-46.0907	168.40051
E 8	-46.0879	168.40375		G 8	-46.0907	168.40065
E 9	-46.0879	168.40388		G 9	-46.0907	168.40077
E 10	-46.0878	168.40405		G 10	-46.0906	168.40092
E 11	-46.0878	168.40416		G 11	-46.0906	168.40103
E 12	-46.0878	168.40433		G 12	-46.0907	168.40116
E 13	-46.0879	168.4045		G 13	-46.0906	168.40132
E 14	-46.0878	168.40458		G 14	-46.0906	168.40141
E 15	-46.0878	168.40472		G 15	-46.0907	168.40149
E 16	-46.0878	168.40488		G 16	-46.0907	168.40162
E 17	-46.0877	168.40498		G 17	-46.0907	168.40185
E 18	-46.0877	168.40511		G 18	-46.0907	168.40191
E 19	-46.0877	168.40526		G 19	-46.0906	168.40202
E 20	-46.0877	168.40542		G 20	-46.0906	168.40212
F 1	-46.0861	168.40094		H 1	-46.0854	168.40235

F 2	-46.0861	168.40107		H 2	-46.0854	168.40245
F 3	-46.0861	168.40118		H 3	-46.0853	168.4026
F 4	-46.0861	168.40131		H 4	-46.0853	168.40271
F 5	-46.0861	168.40148		H 5	-46.0852	168.40284
F 6	-46.0861	168.40159		H 6	-46.0852	168.40296
F 7	-46.0861	168.40173		H 7	-46.0851	168.40307
F 8	-46.0862	168.40185		H 8	-46.0851	168.40318
F 9	-46.0862	168.40196		H 9	-46.085	168.40334
F 10	-46.0861	168.40207		H 10	-46.085	168.40342
F 11	-46.0861	168.40222		I 1	-46.0926	168.40495
F 12	-46.0861	168.40234		I 2	-46.0926	168.40474
F 13	-46.0861	168.40251		I 3	-46.0926	168.40462
F 14	-46.0862	168.40263		I 4	-46.0926	168.40443
F 15	-46.0862	168.40275		I 5	-46.0925	168.4043
F 16	-46.0862	168.40291		I 6	-46.0925	168.40416
F 17	-46.0862	168.40304		I 7	-46.0925	168.40399
F 18	-46.0862	168.40318		I 8	-46.0925	168.40382
F 19	-46.0862	168.40332		I 9	-46.0925	168.40369
F 20	-46.0862	168.40346		I 10	-46.0925	168.40354

6.5 Chapter Four – Results

6.5.1 24 Hour Tracking Tunnel Survey

Table 5: *24 Hour Tracking Tunnel Totals*

	A Line	B Line	C Line	D Line	Total
Tunnels on line	10	10	10	10	40
Mouse	1	0	5	0	6
Unspecified	0	0	1	0	1

Table 6: *24 Hour Tracking Tunnel Survey Relative Tracking Index Totals*

	A Line	B Line	C Line	D Line	Average tracking rate over all lines	Standard Error of Tracking Rate
Tracking Rate-Mouse	10%	0%	50%	0%	15%	12%
Tracking Rate-Unspecified	0%	0%	10%	0%	3%	3%

6.5.2 Three Night Tracking Tunnel Survey – Rabbit Meat

Table 7: *Three Night Tracking Tunnel Survey Totals*

	A Line	B Line	C Line	D Line	Total
Tunnels on line	10	10	10	10	40
Mouse	3	2	9	3	17
Insect	1	0	0	0	1
Cat	0	0	1	0	1

Table 8*: Three Night Tracking Tunnel Survey Relative Tracking Index Totals*

	A Line	B Line	C Line	D Line	Tracking rate over all lines	Standard Error of Tracking Rate
Tracking Rate- Mouse	30%	20%	90%	30%	43%	16%
Tracking Rate- Insects	10%	0%	0%	0%	3%	3%
Tracking Rate- Cats	0%	0%	10%	0%	3%	3%

6.5.3 Seven Day Chew Card Survey – Peanut Butter

Table 9: *Seven Day Chewcard Survey Totals*

	E Line	F Line	G Line	H Line	I Line	Total
Chew Cards on line	20	20	20	10	10	80
Devices with Mouse Bites	1	3	13	6	1	24

Table 10: *Seven Day Chewcard Relative Abundance Index*

	E Line	F Line	G Line	H Line	I Line	RAI	Standard Error of RAI
Mouse	5%	15%	65%	60%	10%		
E,F,G Lines (20 cards)- Mouse						28%	19%
H,I Lines (10 cards) - Mouse						35%	25%
All Lines						31%	22%

6.6 Risk Analysis and Safety Management System (RASMS)	**No.** **Issue** **Date Issued** **Review Date**	Form Four 30/06/2011 01/07/2016

Activity: Pest monitoring

SECTION A **"Significant refers to the potential for any harm that is not trivial and would warrant a response or intervention"**

RISK	HAZARD OR HARM	POSSIBLE OUTCOME (PERIL)	SIGNIFICANT	ACTION	DOES ACTION ELIMINATE, ISOLATE OR MINIMISE RISK
Physical	Tripping or falling over	Injury to feet or body	Yes	Wear appropriate footwear and outdoor clothing.	Minimise
	Not equipped for wetland work or cold weather	Hypothermia/cold and wet	Yes	Wear suitable clothing, carry spare dry clothes and a gas cooker to make hot drinks. Choose weather conditions that are fine.	Minimise
	Getting lost	Injury	Yes	Cell phone, handheld GPS, compass and maps will be carried at all times. Plan for the day will be left with independent person.	Minimise
Emotional	Stress	Burnout	Yes	Plan project so to make time for work and to relax	Minimise

Social/ Cultural	Upsetting landowner	Loss of research site	Yes	Gain permission talk and work with landowners, be upfront about methods and possible outcomes.	Eliminate
Financial	Running out of money	Won't be able to complete project.	Yes	Borrow equipment from as many places as possible, set project within financial abilities.	Minimise
Environmental	Weather	Sunstroke/ hypothermia	Yes	Wear appropriate clothing, carry spares, only work in good weather conditions.	Eliminate
Other					
Should loss occur, what will you need to have in place to minimise the loss?				First aid trained and carry first aid kit. Carry GPS, cell phone, maps, compass, spare clothing, gas cooker, food and water. Intentions logged with someone.	
IMPORTANT This RASMS form is not complete unless attached to Section B and signed off by Manager					

Name: Walter Fieldes____ Date of Review 9/3/2020

SECTION B "Significant refers to the potential for any harm that is not trivial and would warrant a response or intervention"

Activity: Pest monitoring

INDUSTRY STANDARDS	POLICIES/GUIDELINES	STAFF SKILLS	OFFICIAL APPROVAL	
Department of Conservation Best Practice Guidelines Fit and competent for bush navigation. Able to identify animal tracks and bite marks	Animal pests: tracking tunnel indices of small mammal abundance Version 1.0 Must be capable Must be capable.	Research and read DOC guidelines Must be fit and trained in bush navigation Introduction to predator trapping methods course completed.	**Section A Checklist**	
			No. of sheets checked	
			Risk	
			Hazard/harm	
			Outcome	
			Severity	
			Action	
			Eliminate, isolate or minimise	
			Emergency	
			Section B Checklist	
			Industry standards	
			Policies and guidelines	
			Staff skills	
			Approved:	Not approved:
			Name: Position: Date:	
This activity is not officially sanctioned until this box is completed by Manager and attached to Section A				

Name: Walter Fieldes Date of Review: 9/3/20

Student signature: Staff signature:

(Append Form Daily Schedule – as appropriate)

Proposed Activity: Install tracking tunnels, MacKenzie Wetland

Departure Date: July 8th 2020 Return Date: July 8th, 2020, c 18.00pm

Departure Time from Home: around 7 am

Return Time : around 5pm

Venue/Location- 784 Limehills-Browns Road,

Browns, Southland, New Zealand.,

Phone (02108815863).

Aims/objectives of activity: Install tracking tunnels and chewcards in the MacKenzie Wetland

Level of Difficulty/Identification of Hazards: (Attach completed RAMS Form as appropriate)

This is a medium risk trip, with road traffic, working in a wetland environment and weather conditions being the major hazard. .

...

Number of students participating: approximately 1 Participation list appended Yes/No

Transport: Own vehicle

Participants have signed 'Disclaimer' Yes

Staff Involved:

Name	Address/Phone	Responsibilities
Tutor in Charge	Tapuwa Marapara	Supervisor
	Walter Fieldes	Researcher

Signature(s) ________________________________ (Tutor in Charge)
(Head of School/Programme Manager)

Date ________________________________