Predator Free Port Hills: Current Trapping Efforts and Future Directions

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Executive Summary

Aotearoa was introduced to three species of rats in the 18th century, causing detrimental impacts to the country's native wildlife and biodiversity. Rats are one of the main contributors to the decline of native bird populations, alongside other pests. For this reason, Predator Free Port Hills (PFPH) have asked for support in their mission by analysing the distribution of trapping efforts throughout the Port Hills as our region of interest (ROI). To do so, three sub-questions were provided by our community partner:

1. Where are the residential gaps in trapping effort?
    a. How does this compare to the gullies of the catchment?
2. Many trapping households occur in "clusters". Is the trapping density in each cluster enough to create a buffer between the urban area and the bush?
3. Non-residential areas: What are they, and who owns them? Is there trapping happening?
    a. How does this help the residential buffer and influence where PFPH should focus efforts?

These questions provide context and collate to form our research question; "Where are the residential gaps in trapping efforts, how does this impact residential trapping buffers between urban and bush areas, and how do non-residential areas impact this buffer?". ArcGIS Pro, a geographic information systems (GIS) tool, was used to analyse spatial data provided by PFPH alongside data sourced from the LINZ Data Service and TrapNZ. Gullies were first delineated using the hydrology toolkit to indicate rat movement. Residential trapping efforts were classified using a 50m radius around each household, a substitution for the 100m trapping lines recommended by the Department of Conservation (DOC) to specify our analysis of residential trapping efforts used by PFPH. Residential trapping buffers were analysed using relative point densities of trapping households versus total households in each

area. Findings indicate significant trapping gaps throughout Hillsborough, Cashmere, and Heathcote Valley, with effective rural/bush buffers across Lyttelton, Governors Bay, and Diamond Harbour. Henceforth, PFPH should focus on trapping gaps across the urban side of the Port Hills. These findings aim to identify and, therefore, optimise trapping efforts from PFPH by ensuring areas with the greatest potential for trapping are targeted. However, this project is limited by the accuracy of spatial data provided by PFPH, whereby incomplete trapping data necessitates that households were utilised as ‘traps’ within spatial analysis, and the difficulty in obtaining information regarding non-residential trapping efforts and projects. Henceforth, future research should consider methods of mediating this inconsistency, such as assigning a unique ID to future households upon registration and collating non-residential trapping projects throughout the ROI.

Introduction

Aotearoa has one of the highest proportions of threatened species in the world. The increasing pressure from terrestrial pests that threaten the country's ecosystem and economy requires ongoing improvement in pest management methodologies (Goldson et al., 2015). Given New Zealand Aotearoa's unique environment, the ecology of invasive species cannot be presumed to be the same as that of their native ranges. Yet, many pests in New Zealand are managed with a poor understanding of their bionomics and impacts (Goldson et al., 2015). Consequently, our objective is to analyse current trapping efforts within the Port Hills region and communities managed by PFPH, as shown in Figure 1, by considering three sub-topics to evaluate findings. This paper consults existing literature on five topics related to the PFPH mission; this includes a historical viewpoint of pests, understanding pest behaviour, distribution of trapping methods, GIS methods for analysing and mapping multiple conditions and trapping distribution. This rationalises our methodologies and subsequent spatial analysis of trapping efforts throughout the Port Hills.

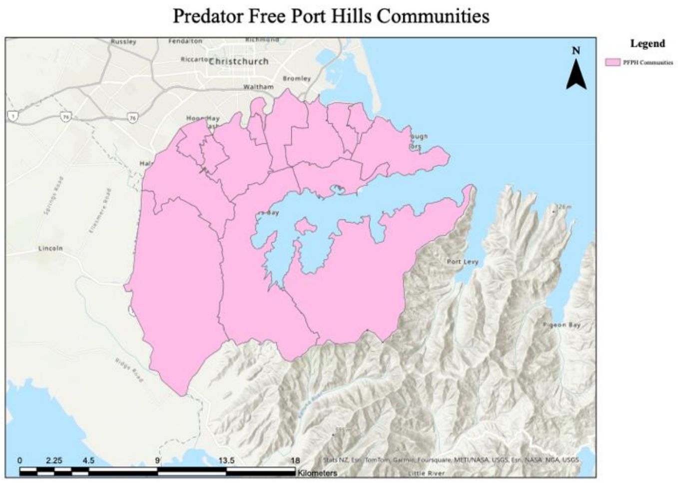

Figure 1: Study Area and Communities Managed by PFPH

Literature Review

Predators in New Zealand:

Aotearoa was introduced to three different species of rats by early settlers. These rats include the Kiore rat (Rattus exulans), introduced by Polynesians, and the Norway (Rattus norvegicus) and Ship rat (Rattus rattus), introduced in the 18th century through European ships. Currently, the Kiore rat species are in decline due to potential competition with the Norway rat (King & Veale, 2022). These rats prefer lowland podocarp-broadleaf forests where many other native species live. Being omnivores, they have caused significant harm to native birds, lizards, and plants by competing with these species for food resources and eating native bird nests (Brown et al., 2015). Within four years following their arrival into the country, five native bird species became extinct (O'Donnell, 1996). For example, the native Mohua population are still being impacted by rat and stoat populations, which has led to a significant decline following the introduction of these pests. Research has shown that most bird nests are targeted by rats and mustelids, which prevent populations of native species from increasing (Cuthburt & Davis, 2002). Historical views have stayed similar throughout their time in Aotearoa, and plans to exterminate them remain in action until today (King & Forsyth, 2021). Therefore, contemporary trapping efforts aim to minimise the damage these rats cause to wildlife and biodiversity and to preserve and reintroduce various native species into different habitats across Aotearoa.

Pest Behaviour and Movement:

Understanding the habitat and dispersal patterns of Ship rats is essential for developing effective urban-rural buffer zones. Innes et al. (2010) found that ship rats can travel distances greater than 250 meters, even when exposed to increased predation. This makes it easy for them to invade urban environments. While ship rats thrive in various habitats, research shows they are particularly abundant in gully systems. Despite similar grass cover, Morgan et al.

(2009) observed that ship rats are found in higher densities in gullies than in other habitats. The grass in gullies is typically less disturbed, suggesting that denser vegetation provides the shelter and protection rats prefer. The undisturbed vegetation likely offers rats a stable environment with fewer threats from predators, making it ideal for foraging. King and Forsyth (2021) further support this finding, noting that ship rats favour foraging in sheltered areas like gullies, where the tall vegetation provides protection and an enclosed habitat. Their study also highlighted that ship rats are less abundant in early successional vegetation, which lacks the dense plant cover they need. This has important implications for managing rat populations, as it suggests that trapping efforts should be prioritised in areas with dense, undisturbed vegetation, especially gullies, where rat populations are likely to be highest.

However, while less attractive to rats, early successional areas should not be ignored entirely. Although Ship rat populations are lower in such areas, changes in vegetation density over time could make these regions more suitable for rats in the future. Therefore, trapping should focus primarily on high-density areas like gullies, as we can prevent rats from dispersing to other areas. However, it will still be important to trap in areas where rats are typically less abundant, as they are still found in less desirable habitats such as early successional forests.

DOC Trap Distribution:

The DOC in Aotearoa aims to be predator-free by 2050. To this end, DOC is using different trapping methods and has created a “trapping guide” to help inform and educate the public about pest control, suggesting that monitoring of native species and mammalian predators in the selected area must be conducted prior to implementing trapping networks (DOC, 2023). Monitoring mammalian predators uses tracking tunnels and chew cards in desired regions (Ruffel et al., 2015). Once the fauna in the area is determined, appropriate traps can be selected. The National Animal Welfare Advisory Committee must approve of the trap selected.

While there is little scientific research regarding urban pest monitoring and trapping, Balls (2019) set up 24 mammal monitoring sites around Wellington City. From the three sites utilised, Urban forests being areas of primary or secondary bush growth, amenity sites being parks or coastal walkways, and residential areas being backyards of people's homes, rats were predominately found across all of Wellington, and possums and mustelids were not expected. This indicates that across the urban and rural fringe, the spatial variation of pests was predominantly consistent; this variation of environments is also found in the Port Hills catchment area.

The DOC (2023) trapping guideline for rats states that traps are placed every 100m along designated lines, creating a 'buffer zone' trapping network. Carter et al. (2016) set up a trapping network on Native Island off the coast of Stewart Island that had traps at 100m intervals, and this worked successfully to rid the island of rats. These traps were also 700mm off the ground to stop non-target species from interfering. The current project adjusted this to 50m per household to account for the household trapping organised by PFPH. Therefore, the guidelines presented by DOC provide a research-informed account for ideal trapping networks, which can be applied to the PFPH project.

GIS Methods:

GIS emerges as a computer analysis tool for analysing, managing, visualising, and interpreting geospatial data. GIS uses vector (points, lines, and polygons) and raster (grid-like structures representing variables) data. Raster data often represents continuous datasets, such as satellite imagery, elevation, or temperature (Mulrooney et al., 2024). These datasets can be visualised within ArcGIS Pro, allowing a range of spatial analysis tools to compare, reclassify, and organise data appropriately. Multi-criteria analysis (MCA) is employed in this project to integrate different variables (Case et al., 2023; Sahraei et al., 2023) and analyse trapping density throughout the Port Hills. MCA is adaptable; Case et al. (20203) used MCA to identify agroecosystems in Aotearoa needing revegetation through a structured approach: identifying spatial indicators, standardising them with the reclassify tool, and assigning relative importance using a 1-5 scale. Weights applied via the Weighted Overlay tool in ArcGIS produce a raster highlighting spatial priorities. While other methods are available, such as the Analytical Hierarchy Process utilised by Mashi et al. (2024) and Kebeba et al. (2024), the method used by Case et al. (2023) is suitable for the current project, as limited datasets were available that meaningfully impact the output; therefore, the pairwise comparison is appropriate. Within the current project, trapping density, distance to gullies, and land use are all relevant variables that indicate the efficacy of trapping efforts. Thus, identifying areas with low efficacy will determine gaps that require future efforts.

This project is concerned with a diverse range of spatial data and subsequent analysis methods. For instance, this project is primarily concerned with the spatial distribution of trapping households throughout the port hills, regarding gullies and non-residential trapping areas. This household data is represented as point features within vector data layers (Li & Zhang, 2007). Spatial analysis assesses the spatial relationship between points based on their relative positioning within space (Li & Zhang, 2007). Point-density analysis emerges as an ideal tool within the current project to identify the relative distribution of trapping households throughout the Port Hills urban fringe. Within ArcGIS Pro, the point density calculates the point features around each output raster cell to define a neighbourhood around each raster cell. Research from Mulrooney et al. (2024) measured a comparison of raster-based point density calculations to vector-based counterparts applied to the study of food availability. This method measured the magnitude of dollar stores per unit area within a 3-mile neighbourhood around each raster cell (Mulrooney et al., 2024). This methodological approach was suitable for analysing trapping distribution in the Port Hills, where point density parameters can be set to include households within a 50m radius.

Methods

Overview:

This project employed secondary data collection methods. ArcGIS Pro was used to collate and analyse datasets within the ROI. Each dataset involved different methodological processes.

Tools:

This project relied on ArcGIS Pro for all geoprocessing (Esri, 2024). Additionally, the Rasterio library was used within Google Collab for the preprocessing of Digital Elevation Models (DEM).

Data Collection:

This project employed secondary methods of data collection. The main dataset used was the geodatabase provided by PFPH (Williamson, 2024). This includes geocoded points identifying households, traps, and catches. This database also includes polygons displaying the trapping communities PFPH governs throughout the Port Hills.

Land Information New Zealand (LINZ) was also a primary data source. The LINZ Data Service (2024) was used to extract DEMs from three 1m resolution LiDAR datasets: Christchurch and Ashley River (2018-2019), Banks Peninsula (2018-2019), and Selwyn (2023) DEM. These were essential to cover our ROI. Datasets of NZ Addresses, residential areas, and reserves were also sourced from LINZ.

Public Parks were sourced from Canterbury Maps (2024). TrapNZ (2024) is a national trapping database that was used to supplement PFPH trapping data. Data scraping accessed this data, whereby geospatial data from TrapNZ was imported into a local database based on its code (Khder, 2021). As this data is publicly available, it was accessed legally through this method; however, we also requested formal access to retain the ethical usage of data.

Known trapping reserves were identified through spatial analysis. The remaining reserves and parks were analysed through correspondence with stakeholders identified by our community partner.

Data Preprocessing:

All DEM files were imported into Google Drive. Google Collab was used to merge GeoTIFFs using the Rioxarray library. Output rasters were exported and loaded into ArcGIS Pro; the Mosaic to New Raster Tool was used to combine the Christchurch, Banks Peninsula, and Selwyn DEMs into a single output.

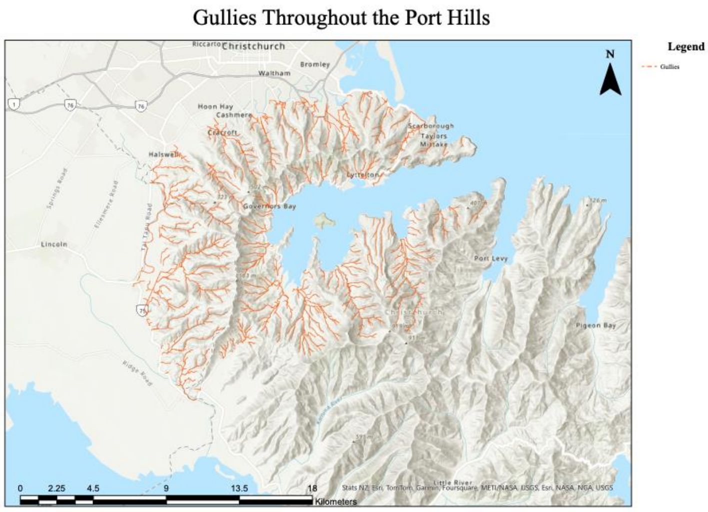

Figure 2: Delineated gullies to be recognised as pest movement

Gullies were delineated using the hydrology toolkit, using the Fill, Flow Direction, and Flow Accumulation tools; the symbology was adjusted thereafter to discern major tributaries before using the Raster to Polyline tool to export gullies as a vector layer shown in Figure 2.

Data Analysis:

Question 1:

LINZ classified residential areas based on population density, representing a minimum area of 90,000m. A 50m radial buffer was applied to trapping households, as traps should occur once per 100m. This method displays trapping gaps within residential polygons based on the coverage of current trapping households.

To inform future trapping efforts, the ModelBuilder was used to identify most residential areas that need attention. As visualised in Figure 3, the Distance Accumulation tool was used to produce raster datasets showing the Euclidean distance of a cell from the nearest trapping household or gully. These datasets were combined using the Weighted Overlay tool, identifying residential areas most in need of trapping based on these two criteria.

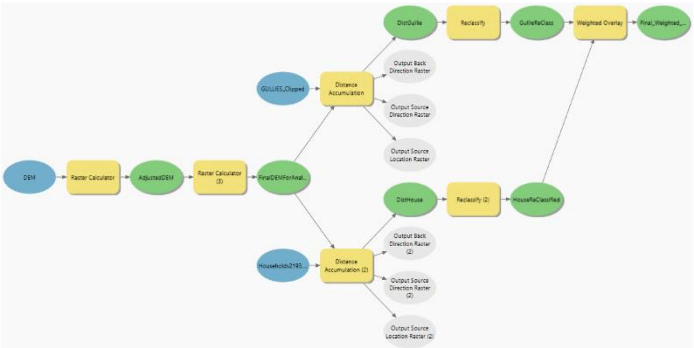

Figure 3: ModelBuilder layout used in ArcGIS Pro

Question 2:

An internal buffer of 250m was set within the residential polygon layer, edited to display buffers between urban/bush areas, as shown in Figure 4. Both trapping and total household layers were clipped to this urban buffer. The Point Density tool was used on this buffer's trapping and total households. These outputs were normalised using the raster calculator, dividing the trapping household's density output by the total household's density output. This output was

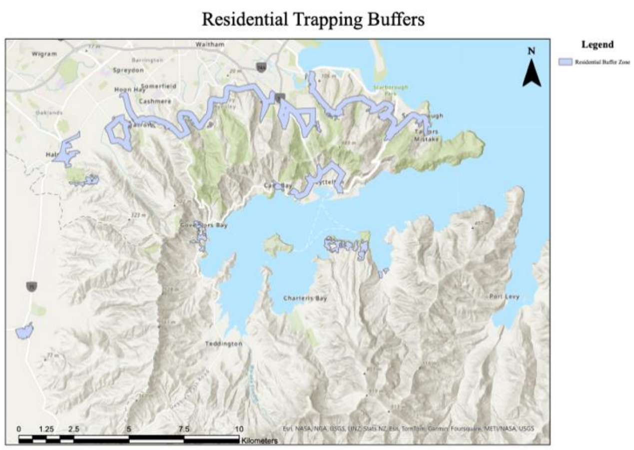

Figure 4: Residential trapping buffers set to 250m

reclassified to display areas where 1 = areas with low trapping density relative to total household density, whereas 5 = areas with high trapping density relative to total household density. Additionally, by integrating trapping areas/reserves (question 3) that intersect or are close to this buffer, this can determine how these reserves support the residential buffer based on trapping vs. non-trapping areas.

Question 3:

Known trapping reserves and parks were identified within ArcGIS Pro using a spatial query (Boorman, 2010; Patroumpas et al., 2014) with both PFPH and TrapNZ trapping data. The resulting list was analysed through correspondence with community contacts. Reserves were classified as 'trapping' vs. 'unknown'. Additionally, trapping areas were sourced from maps provided by Towards Pest Free Waitaha and the Banks Peninsula Conservation Trust. These maps were integrated to display a final output showing all trapping areas/reserves throughout the Port Hills region.

Results and Discussion

Question 1: Where are there Residential Gaps in Trapping efforts

Figure 5 visualises an overview of the region PFPH targets to become pest-free, including specific residential areas throughout the Port Hills, such as Governors Bay, Lyttelton, Diamond Harbour, and the Christchurch urban fringe. Areas outlined in black are identified as residential areas. Yellow polygons represent the area trapping households effectively cover based on the 50m ‘trap’ radius. Based on Figure 5, there

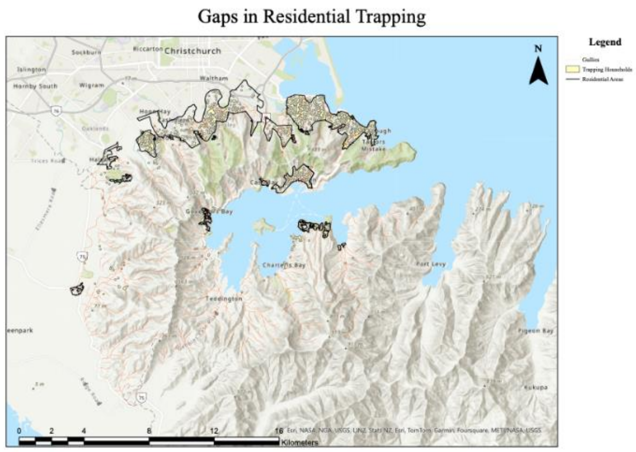

Figure 5: Overall gaps in residential trapping throughout the port hills, with reference to gully systems

are apparent residential trapping gaps across the Christchurch urban fringe, particularly in the Cashmere, Hillsborough, and Ferrymead areas, clearly identifying areas needing greater residential trapping.

Figure 6, a detailed enlargement of Figure 5, shows a lack of trapping efforts between Hillsborough and Woolston, suggesting a need to improve trapping efforts in that area. It should be noted that this area is mostly industrial, indicating that PFPH should explore targeting this clientele. However, Mount Pleasant has a fair distribution of traps, suggesting that fewer trapping efforts are needed within this area.

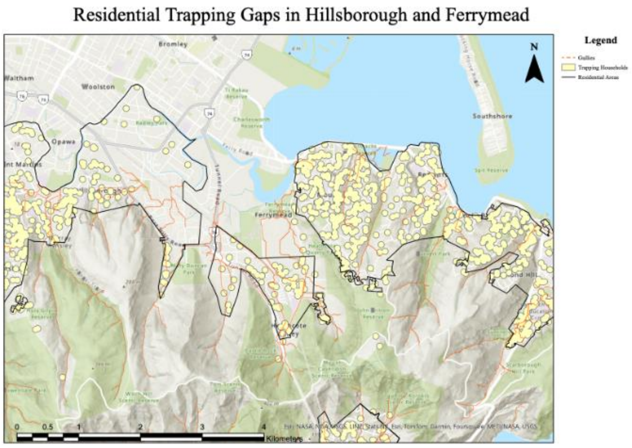

Figure 6 Residential trapping gaps throughout Hillsborough and Ferrymead

Figure 7 shows that there is a fair distribution of residential trapping efforts within Westmorland and Huntsbury, with significant gaps in residential trapping throughout Cashmere and Hoon Hay. This indicates specific areas where further trapping efforts are needed, particularly considering the presence of gully systems in that area.

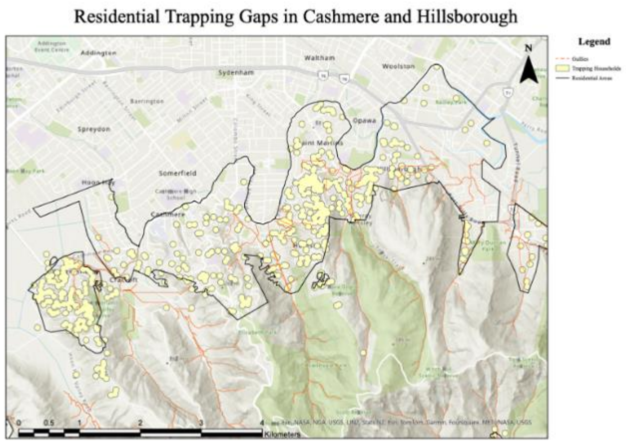

Figure 7: Residential trapping gaps throughout the Cashmere and Hillsborough areas

a. How do these Compare to the Gullies of the Catchment

Figure 8 displays merged quantitative data, visualising where PFPH should focus their future trapping efforts based on proximity to gullies and trapping households within residential areas. This is represented in a choropleth map of different colour classifications,

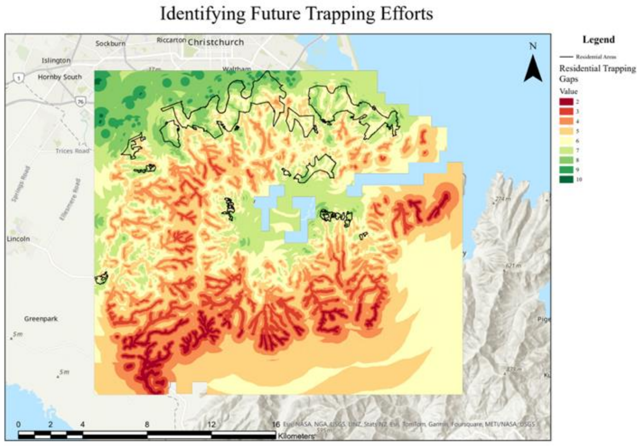

Figure 9: Identification of future trapping efforts, based on gully systems and residential trapping gaps

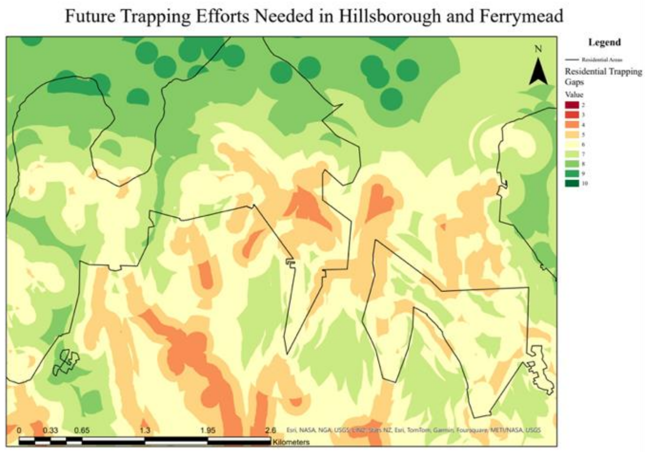

Figure 8: Enlargement of Figure 8, identifying trapping efforts needed within Hillsborough and Ferrymead

identifying the influence of missing residential trapping efforts. While parameters can be adjusted to modify data and visualisation aspects (Netek et al., 2018); in this case, the colour spectrum ranges from red to green. Areas classified in red indicate areas within the gully range and far away distance from households trapping.

Figure 8 is, therefore, limited to be useful only within residential areas, as it classifies areas based on their distance to other trapping households. Most residential areas are indicated as green, particularly areas that are far from the mouth of a gully system, indicating areas less in need of future trapping efforts. Additionally, areas such as Lyttleton, Governors Bay, Diamond Harbour, and Purau all show strong localised trapping areas based on proximity to trapping households.

Figure 9 identifies significant gaps in trapping efforts between Hillsborough and Ferrymead, indicated by lower values classified as red. Furthermore, areas that have moderate engagement (values between 4 and 6) present an opportunity for future growth. To some degree, trapping already occurs, however, boosting participation here could further enhance pest control outcomes.

Question 2: Many trapping households occur in "clusters". Is the trapping density in each cluster enough to create a buffer between the urban area and the bush?

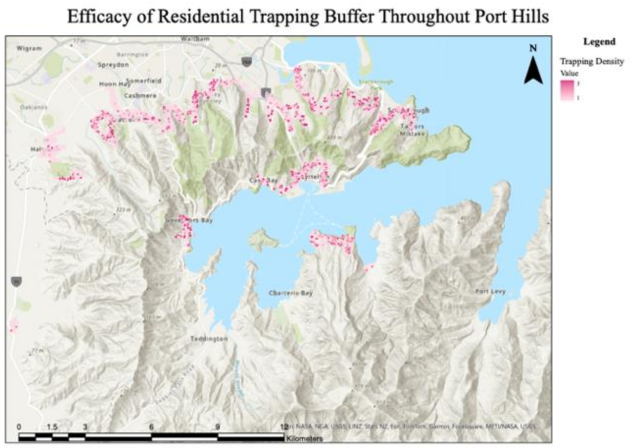

Figure 10: Efficacy of residential trapping buffers; low values = poor, high values = effective.

Figure 10 utilises the residential buffers shown in Figure 4, visualising the efficacy of trapping buffers across the Port Hills. Low (1) values indicate areas where residential trapping is low relative to the total density of households within that area; alternatively, higher values (>1) indicate areas where residential trapping is high relative to the total households in that area. As displayed, urban buffers across Lyttleton, Governors Bay and Sumner have a high density of dark pink areas, indicating an effective buffer between rural and urban areas. The lighter pink area around Hillsborough and Halswell Quarry suggests less trapping occurs in these areas. Therefore, future trapping efforts should focus on the areas visualised in lighter pink to create a more substantial buffer between rural and urban areas. However, this map is limited by its omission of non-residential trapping efforts, thereby missing informative data.

Question 3: Non-residential areas: What are they, and who owns them? Is there trapping happening?

Figure 11 offers a visual representation of the non-residential reserves and parks, classified as trapping (green) or unknown (orange). These areas include council-owned reserves and parks, privately owned farmland, educational areas and more. There appears to be a cluster of trapping areas above the Lyttelton township, through Cass Bay and Governors

Bay to Diamond Harbour. There is a notable absence of known trapping areas occurring east of Gebbies Pass Road and non-residential reserves across the urban side of the Port Hills below Summit Road, indicating an area Predator Free Port Hills could focus their efforts on.

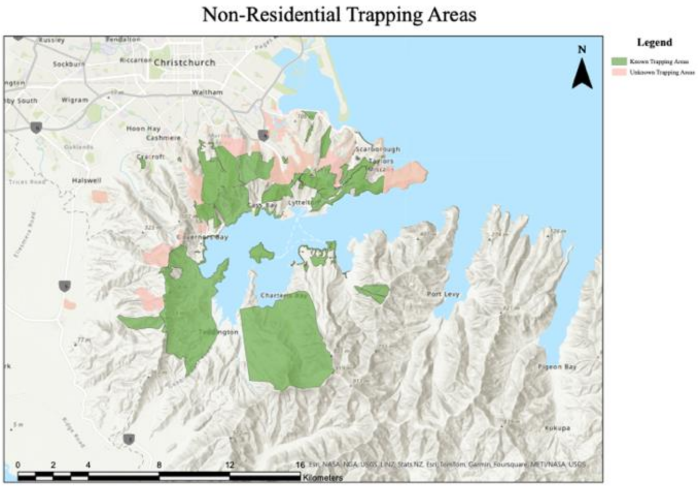

Figure 11: Non-residential trapping areas

a. How does this help the residential buffer and influence where PFPH should focus efforts?

Orange lines indicate a gulley system, as identified in Figure 2. Similarly to Figure 10, light and dark pink indicate high and low trapping density, while dark green represents the non-residential areas where trapping is known. As shown in Figure 12, dense clusters of households are trapped west of Hillsborough. Another cluster is near Heathcote Valley, with relatively dense trapping surrounding the Mount Pleasant Area. Several large non-residential trapping areas cover most of the gully systems above the buffer zone. However, there are some areas where the buffer is ineffective, particularly at the base of Hillsborough across households surrounding Alderson Avenue, the base of Port Hills Road between Hillsborough and Ferrymead, and the base of Mount Pleasant.

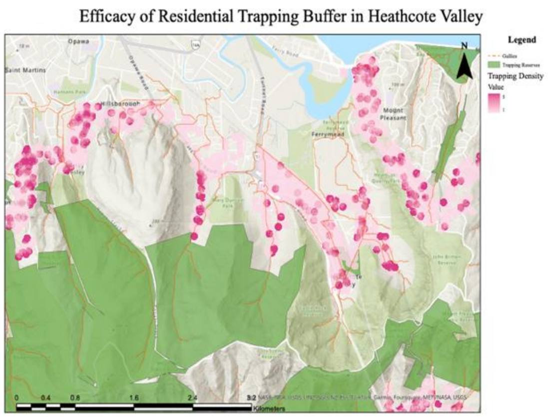

Figure 12: Point density visualisation of the residential trapping buffer efficacy across Heathcote Valley

Figure 13 shows large clusters of residential trapping across Mount Pleasant, surrounding Redcliffs, above Moncks Bay, and the Richmond Hill and Sumner area. There are limited gaps of household trapping occurring within those areas. There are large areas where non-residential trapping occurs, including the area between Sumner and Lyttelton and a few smaller reserves in the Redcliffs area. Barnett Park significantly contributes to the urban zone through its location within a gully. Most gully systems have a reasonable residential and non-residential trapping buffer. However, gaps are present, particularly near Taylor Mistake, Clifton (towards the coast), to the right of Moncks Bay, and the area above Drayton Reserve.

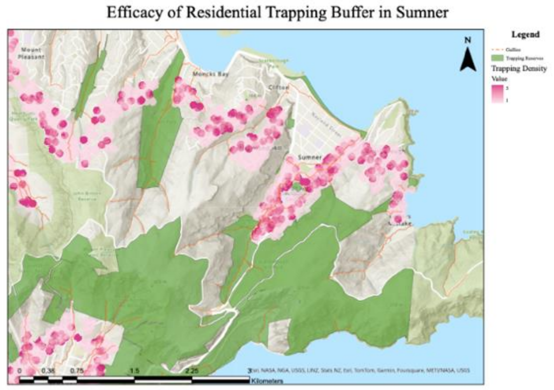

Figure 13: Point density visualisation of the residential trapping buffer efficacy across Mount Pleasant and Sumner

Figure 14 indicates a dense cluster of residential trapping throughout Governors Bay, particularly within the northern end. There is a large area where non-residential trapping is occurring, including below Governors Bay, all the way up the coast, and above Governors Bay. However, further exploration should consider the east face to identify if non-residential trapping is impacting this buffer.

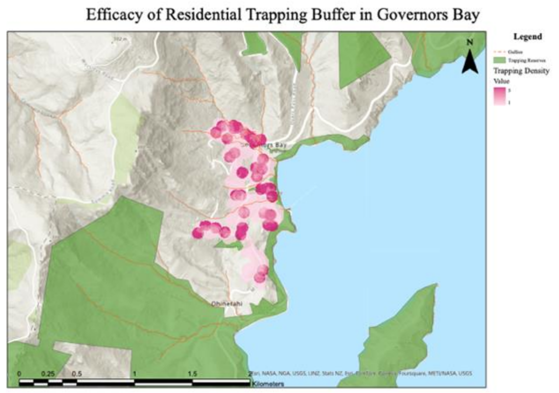

Figure 14: Point density visualisation of the residential trapping buffer efficacy across Governors Bay

Figure 15 shows a dense area where household trapping occurs in Westmoreland and Huntsbury; however, most other areas show sparse trapping efforts. There is limited non-residential trapping within the area, with

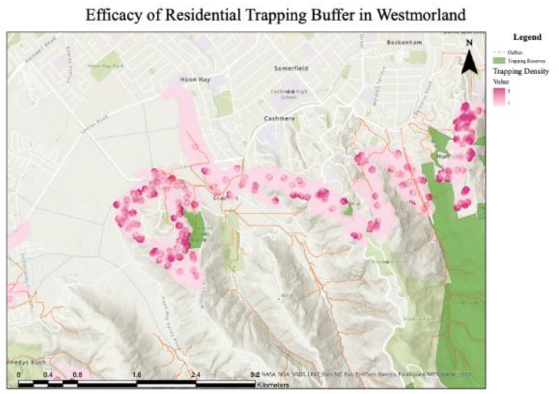

Figure 13: Point density visualisation of the residential trapping buffer efficacy across Westmorland

only two reserves trapping. This indicates a poor buffer zone, with significant gaps in Hoon Hay, Cracroft and Cashmere. Specific areas for PFPH to focus efforts include Cracroft and the Cashmere Hills, particularly along Hackthorn, Dyers Pass Road, and Bowenvale Avenue.

These point density maps provide a clear visual representation of the gaps in trapping efforts, allowing for recommendations to be given to Predator Free Port Hills on where they should focus their efforts. These areas include Ferrymead, Heathcote Valley, to the right of Mount Pleasant, to the right of Hillsborough, Taylor's Mistake, Clifton, to the Right of Moncks Bay, Cashmere, Cracroft, and Hoon Hay.

Limitations and Future Research

Throughout this project, several limitations were encountered regarding the PFPH dataset. Households are geocoded when a trap is purchased; however, trap locations require a second input from the buyer. As a result, trap locations are often underreported, resulting in an incomplete dataset. Henceforth, household locations were used as ‘traps’, with a 50m buffer applied, assuming the area the household covers equates to 100m. Furthermore, household and trapping datasets do not share an attribute and, therefore, cannot be connected. Therefore, it cannot be determined the quantity of traps placed by a household or if the household is actively trapping. As a result, within this project, it is assumed that all households own one trap and are actively trapping. This acts as a major limitation regarding the accuracy of our dataset and conclusions. This also means that traps cannot be filtered by type. Therefore, it is assumed that all traps ‘traps’ operated by a household are rat traps.

Regarding trapping reserves, it is difficult to state how effective they are at improving urban and rural buffers. Reserves were classified as ‘trapping’, ‘unknown’, or ‘non-trapping’ due to the limited information obtained through online and stakeholder resources. Therefore, there may be variable upkeep of trapping reserves. Additionally, reserves classified as “trapping” based on a spatial query may not be actively managed by trapping groups or the council; this further impacts the efficacy of trapping reserve classifications. Furthermore, various groups manage different areas throughout the Port Hills region; reserves classified through correspondence with community stakeholders produced conflicting classifications regarding areas that are and are not trapping. Communication between these groups also posed barriers to attaining this information within an ideal timeframe.

Therefore, future research should focus on adapting the PFPH data capture methods. Specifically, assigning a unique ID to registered households and subsequent trap purchases would allow these datasets to be matched based on a shared attribute. This would significantly improve PFPH trapping data by identifying the number of traps per household, where traps are placed, and how actively individual households purchase and place traps. This would also allow trap distribution analysis to include household and trap data, based on the types of traps sold by PFPH, to identify locations lacking possum or stoat-specific traps within the gully areas. Additionally, further integration of private and corporate trapping projects outside the PFPH system would supplement this data improvement.

Conclusion

In conclusion, our analysis of residential trapping efforts highlights the importance of addressing uneven trapping patterns to ensure adequate pest mitigation controls across the Port Hills. Certain areas exhibit strong community participation, forming clusters of high-density trapping. However, Hillsborough, Cashmere and Ferrymead pose significant gaps in trapping efforts. ArcGIS spatial analysis tools have shown gaps, allowing Predator Free Port Hills to prioritise future outreach and resource allocation. Furthermore, the proximity of active trapping households to rural-urban boundaries highlights the potential for creating effective buffer zones; combining targeted efforts in low-density areas will be essential to strengthen these defences.

Looking into the future, better refinement of current methods of data collection and improved accuracy of trapping locations will better assess household engagement. Implementing more collaborative efforts with non-residential landowners and reserves will further increase urban bush buffer effectiveness.

Acknowledgements

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