The Wild Goose Chase

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Contents

Executive summary

- Canada geese are an invasive species that have detrimental effects on the environment. This includes water pollution and greenspace degradation.
- New Zealand Conservation Trust was concerned if the resident waterfowl species niche was being impacted by the presence of Canada geese.
- Our research aim was to investigate if Canada geese have an impact on resident waterfowl at Styx Mill Reserve (Pūharakekenui).
- We also aimed to compare the effectiveness of different management strategies, by comparing Canada geese population abundance at Styx Mill Reserve to Victoria Lake.
- The methodology we used was recording bird behaviour, and bird abundance.
- Over 9 days we observed Canada geese interactions with resident waterfowl, by recording 3 categories of behaviour: No interaction, Goose retreat, Goose advance.
- We counted each individual bird to record species abundance.
- Our results concluded that there was a significance of no interaction between Canada geese and resident waterfowl at Styx Mill Reserve and Victoria Lake.
- There was no significance between the Canada geese abundance and resident waterfowl abundance at Styx Mill Reserve.
- Styx Mill Reserve has native bankside vegetation, Victoria Lake has grass lawn.
- Euthanasia as a management strategy, shows most promise for long term removal, whilst egg pricking and decoys are effective as a short term strategy.
- A major shortcoming was that our study length was too short, which consequently made our sample size small. This limited our statistical analysis.
- Increasing sample size and study length to an annual period of observation, would increase reliability of statistical analysis.
- Future observation of geese behaviour with offspring around other waterfowl could further test the hypothesis of Canada geese aggressiveness.

Objective / Aim:

New Zealand Conservation Trust was concerned if the resident waterfowl species niche at Styx Mill Reserve (Pūharakekenui), was being impacted by the presence of Canada geese (Branta *canadensis*). In relevant New Zealand literature, there was limited information regarding the interactions of Canada geese and resident waterfowl in New Zealand. Therefore our research aim was to investigate if Canada geese have an impact on resident waterfowl at Styx Mill Reserve.

The aim was also to investigate the different management strategies at two sites, Styx Mill Reserve and Victoria Lake (Christchurch Botanical Gardens). By observing the behaviour interactions and species abundance at Styx Mill Reserve and Victoria Lake, we analysed the effectiveness of different management strategies. The management strategies include decoys, egg pricking, and euthanasia. We believe this body of research could help provide foundational information to help other locations around Canterbury that also have problems with Canada geese presences.

Introduction:

Canada geese are an invasive species that place a variety of stresses on the environment such as reducing native plant abundance through their consumption. This action minimises food availability for other native waterfowl (Coleman, 2008). Canada geese defecate up to 1kg of faeces per day, which can significantly increase pollution in local waterways. Faeces not only damage the recreational value of Christchurch City, but also pose significant health risks. Water bodies become contaminated with high concentrations of nitrogen, phosphorus and E.coli, making rivers and lakes unsafe for swimming and mahinga kai. Defecation also taints the aesthetic value of greenspaces, which deters people from using their local parks, as

residents deem the faeces “gross” (McDonald, 2020). Local communities are concerned about children’s sports and play – as parks are contaminated with large quantities of faeces (Harvie & Gibbs, 2024). Additionally, Canada geese consume significant volumes of agricultural pasture. Five Canada geese can eat an equivalent proportion to one singular sheep (Waikato Regional Council, 2024). This causes significant economic burdens for farmers and these factors threaten New Zealand's fragile ecosystems.

Literature Review:

The presence of Canada geese at Styx Mill Reserve has raised concerns about their potential impact on native waterfowl populations and the surrounding habitat. This literature review explores key themes such as population dynamics, interspecies competition, sampling methods, and management strategies, to assess the ecological impacts of Canada geese and inform future management.

Population Dynamics of Canada geese

Canada geese were originally introduced to New Zealand in 1876 for recreational hunting (Spurr & Coleman, 2005). Since then, their population has grown substantially, spreading throughout both the North and South Island (Spurr & Coleman, 2005). From just 43 geese in 1905, today’s population is estimated to have increased to 50,000 birds (Spurr & Coleman, 2005), with their distribution continuing to expand across the country.

The rapid population growth of Canada geese can be attributed to abundant food resources and a lack of natural predators (Allan et al., 1995; Spurr & Coleman, 2005). In New Zealand, they exhibit migratory behaviour, primarily moving to the Canterbury high country during the breeding and moulting seasons (Win, 2001).

Interspecies Competition and Ecological Impact

Interspecies competition between Canada geese and native waterfowl is a significant concern. Larger species, such as Canada geese, dominate feeding grounds, often displacing smaller native species that rely on similar resources (Chen et al., 2011). Their aggressive defence of nesting sites during the breeding season excludes other species from key habitats (Spurr & Coleman, 2005). This territorial behaviour, along with their strong site fidelity, results in geese returning to the same nesting locations year after year (Allan et al., 1995).

This behaviour leads to the exclusion of other species, particularly native waterfowl, as Canada geese defend their territories. Win (2001) observed that their aggression is highest during the breeding season, increasing competition for resources like nesting sites and food. Research by White (1986) also highlights how the territoriality of Canada geese disrupts the local ecosystem, leading to the displacement of smaller birds from prime nesting locations. The consistent return of geese to their breeding sites intensifies habitat competition, often forcing native species into less favourable areas (Win & Hickling, 2000).

Agricultural impact

Canada geese can significantly impact agricultural productivity. Their natural diet includes grasses and sedges, but in New Zealand, they primarily feed on agricultural pastures, leading to economic concerns for farmers (Fox & Abraham, 2017; Federated Farmers, 2018). Coleman (2005) found that geese consumption of pastures reduces food resources for livestock, particularly cattle and sheep. The foraging intake of Canada geese ranged from 90 kg/day in spring (3.7 geese/ha) to 490 kg/day in autumn (20.2 geese/ha) (Win & Hickling, 2000).

Water quality and Public health

The presence of Canada geese also has implications for water quality and public health. Geese produce large amounts of faeces, up to 1kg per bird per day, which contributes significantly to land and water pollution (Coleman, 2008). This not only diminishes the aesthetic value of public greenspaces but also poses health risks. Moriarty et al. (2011) found that Canada geese are carriers of harmful pathogens, such as Campylobacter and E. coli, which can be transmitted through water contamination. The Ministry for the Environment (2020) reported that geese faeces are a major source of pollution in urban waterways, contributing to the degradation of water quality and reducing the safety of water bodies for recreation and mahinga kai (traditional food gathering) access.

Management Strategies for Canada geese

Numerous management strategies exist in literature for combating the growing geese populations. Literature highlights the dependency of success on the type of strategy implemented, however minimal literature focuses on New Zealand implementation (Spurr & Coleman, 2005). Therefore field observation was a necessary next step.

Common Sampling Methods for Birds

Popular methods for estimating/recording bird population numbers include distance sampling methods using visual observations of individual birds (Gale et al, 2009 and Gottschalk & Huettmann, 2011). Previous literature on intraspecific competition with bird populations used timed intervals to record behaviours and bird abundance at set locations (Deguines et al, 2020).

Methods:

Observations were conducted over nine days, including three days at Styx Mill and six days at Victoria Lake.

Waterfowl species included: Black swan, Australasian coot, Australasian shoveler, Grey teal, Pied shag, Little black shag, New Zealand scaup, Paradise shelduck and the Mallard duck. These specific waterfowl species were commonly found at both locations. Bird counts were taken via visual counts of individual birds on the lake, estimating where necessary for species that were far away or obscured from view.

Behavioural interactions between Canada geese and resident waterfowl species were recorded into three different behaviour categories; no interaction (where there was no visible interaction between geese and native waterfowl populations), goose advance (where the canada geese approached or acted aggressively towards the waterfowl species) and goose retreat (where canada geese retreat or move away from waterfowl species). Behavioural sampling was conducted in ten minute intervals, with five minute breaks in between. A total of three counts of behavioural sampling was completed during each observation period. Geese movement across Victoria Lake were also recorded to determine whether there was any avoidance towards the lake-side decoys.

Statistical analysis methods included comparison of goose population abundances between each location, and then comparing total counts of all waterfowl species. A Kruskal-Wallis rank test was used to determine significance between behavioural interactions, with a Mann-Whitney U test used to determine if there was a significant difference between species' abundances at both locations.

Vegetation mapping was conducted at both locations, with vegetation being categorised as either ‘native/riparian planting’ or ‘grass lawn’. Methods for vegetation mapping included using satellite imagery from Google Earth and visual identification.

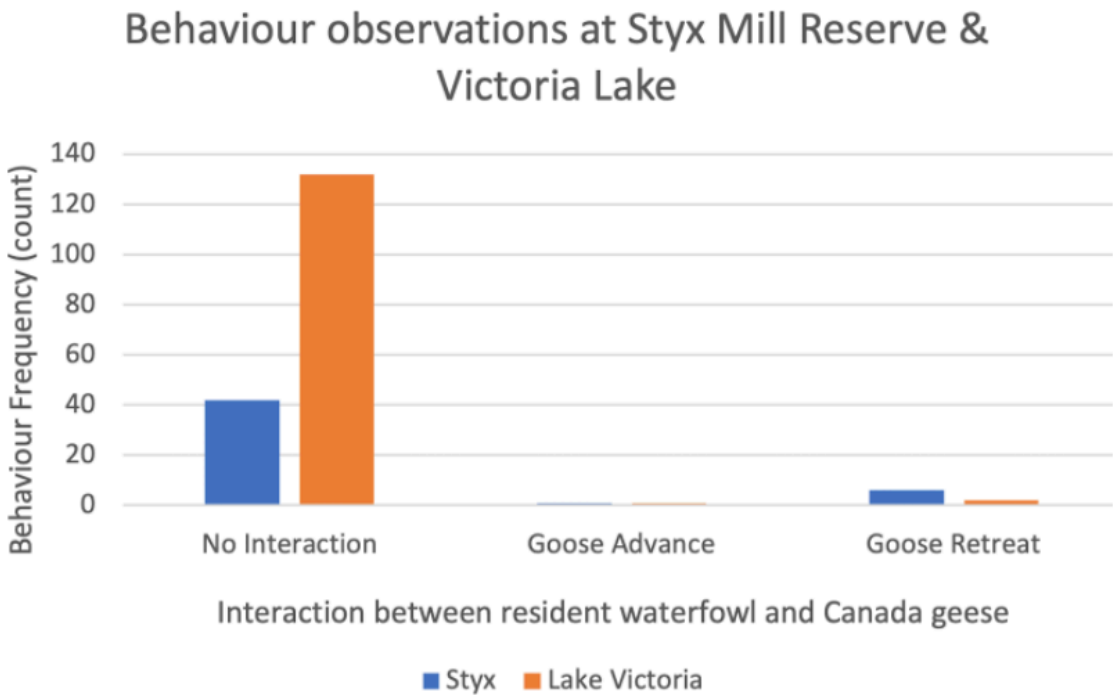
Results:

Figure 1 shows the behaviour interactions between resident waterfowl and Canada geese at both sites. Over 9 days, there were a total of 184 observations, of which 174 observations were considered ‘no interaction’, 8 observations were recorded as ‘goose retreating’, and 2 were observed as ‘goose advancing.’

We used a Kruskal-Wallis rank sum test to test the significance of the results and used an alpha value of 0.05. Figure 1 shows that there was a significance of ‘no interaction’ between Canada geese and resident waterfowl species at both sites ($x^2 = 10.426$; $p= 0.005$).

Figure 1

Difference in behaviour observations at Styx Mill Reserve (blue) and Lake Victoria (orange).

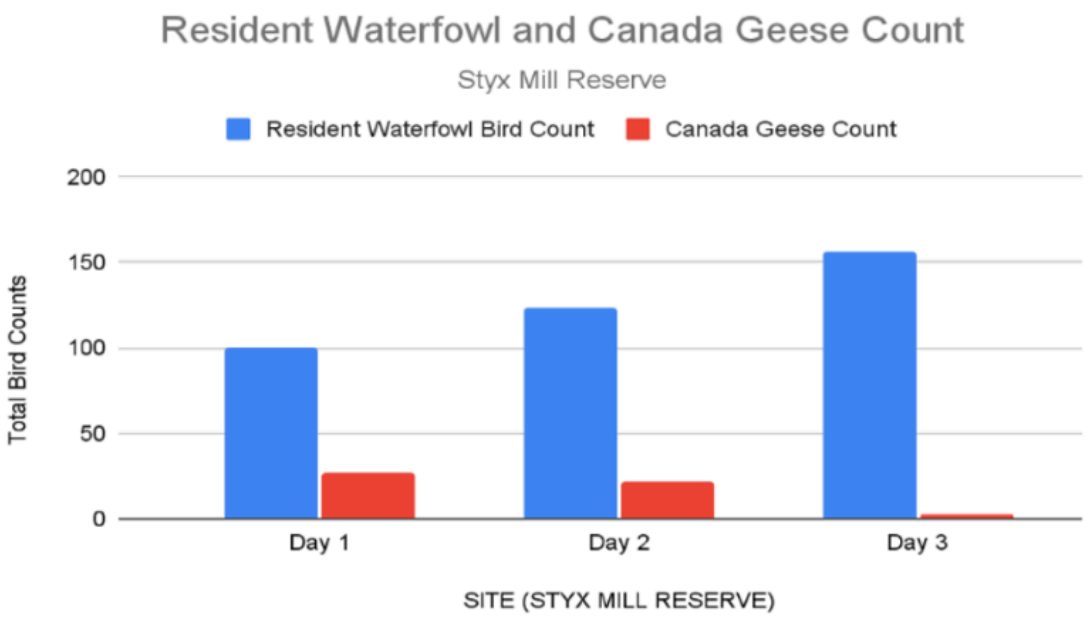


Note. Orange represents observations completed at Lake Victoria. Blue represents observations completed at Styx Mill Reserve. No interaction was defined as no visible interactions between waterfowl/geese. Goose advance was when geese move towards the waterfowl, chase them or act aggressively. Goose retreat was when goose move away from the resident waterfowl. Data was compiled over nine days of observation. Graph created using Excel.

We measured the population abundance of waterfowl species and Canada geese in Styx Mill Reserve (Figure 2) and in Victoria Lake (Figure 3). We used a Mann-Whitney U test with an alpha value of 0.05 to compare the difference between the two groups (resident waterfowl and Canada geese). There were 1241 waterfowl bird count recorded, whereas for Canada geese there were 102 recorded. In Figure 2, there was no significant difference between the waterfowl and Canada geese at Styx Mill ($W= 9$; $p= 0.081$).

Figure 2

Total abundance of resident waterfowl (blue) and Canada geese (red) in Styx Mill Reserve.

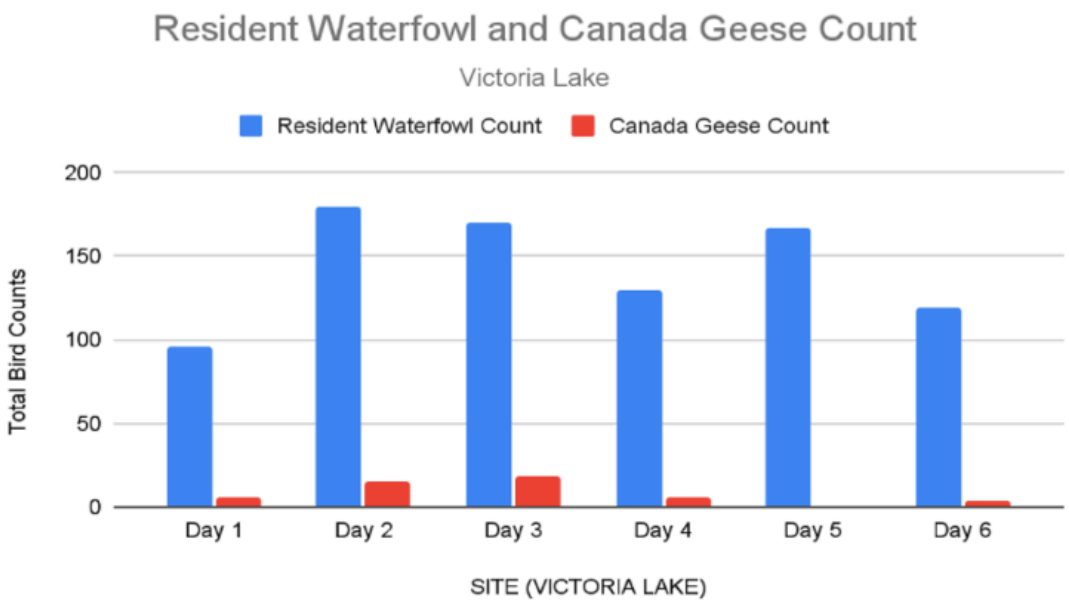


Note. Abundance of resident waterfowl displayed in blue at Styx Mill Reserve is compared to abundance of Canada Geese displayed in red at Styx Mill Reserve. These abundances are compiled from multiple days of observation. Resident waterfowl comprised of New Zealand based species. Graph created using Excel.

In Figure 3 there was a significant difference between waterfowl and Canada geese at Victoria Lake ($W = 36$; $p = 0.005$). We also used a Mann-Whitney U test ($\alpha = 0.05$) to compare the difference in Canada geese abundance at the two sites and found no significant difference ($W = 5$; p-value = 0.36). Therefore, neither management strategy (wolf decoys / egg pricking vs euthanasia) was more effective than the other at reducing the total abundance of Canada geese at each site.

Figure 3

Total abundance of resident waterfowl (blue) and Canada geese (red) in Victoria Lake.



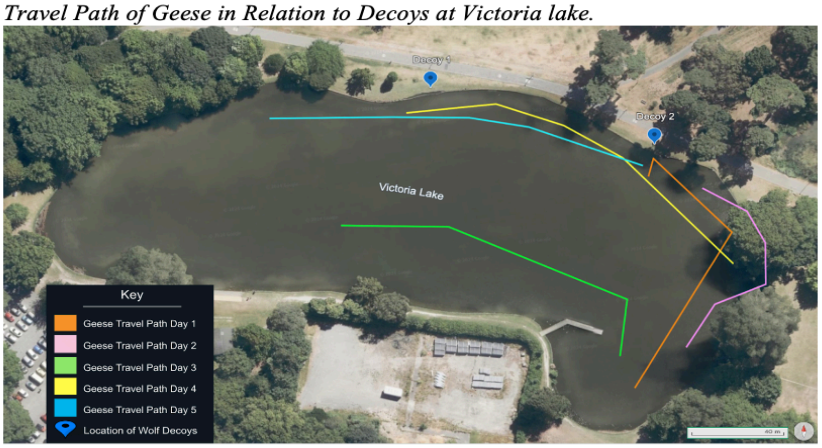
Note. Abundance of resident waterfowl displayed in blue at Victoria Lake is compared to abundance of Canada Geese at Victoria. These abundances are compiled from multiple days of observation. Resident waterfowl comprised of New Zealand based species. Graph created using Excel.

Management Strategies

The movement of Canada geese in Victoria Lake was recorded in Figure 5. The figure demonstrates approximately four out of the five paths of geese travel were directly in front or near the wolf decoys.

Figure 5

Travel Path of Geese in Relation to Decoys at Victoria lake.



Note. Each individual colour represents a different day of travel. 5 days of travel paths were recorded. 2 decoys were displayed in the shape of wolves for the entirety of observation.

In our project we only observed behaviour of Canada geese interaction with waterfowl in two locations. Therefore, we can not conclude that the observations were representative of the whole population. This is due to a very small sample size, over a small study period. If we were to increase sample size and study length, we would be able to increase the population representation.

Measurement Error

When observing the behaviour in Styx Mill Reserve, not all of the pond was visible due to thick bush. This may have caused measurement error, as it was difficult to identify each bird species from occasionally obstructed views. Victoria Lake is surrounded by grass and tall trees, which made it easy to identify and see the waterfowl. The lake's large size made it difficult to differentiate if a bird had already been counted. This measurement error at Victoria Lake was only for resident waterfowl, as the number of Canada geese were distinctively counted. The distinction in bankside vegetation at the sites can be seen in Figure 6.

Figure 6
Bankside Vegetation Differences at Styx Mill Reserve and Victoria Lake

Note. Bankside Vegetation at Styx Mill Reserve is mainly native/riparian planting and is highlighted in dark green. Bankside Vegetation at Victoria Lake is mainly grass lawn and is highlighted in light green. Map created using Google Earth.

Discussion:

Our results showed there was no impact of Canada geese on resident waterfowl at both Styx Mill Reserve and Victoria Lake, disproving our hypothesis, as they did not show an increase in aggression towards resident waterfowl. Comparing the difference in management strategies undertaken at Styx Mill Reserve and Victoria Lake was helpful in deepening our understanding in the subject area. However the management strategies did not make a noticeable difference on the abundance of Canada geese or interactions between resident waterfowl.

Migration

Our community partner, New Zealand Conservation Trust originally wanted us to observe Canada geese interactions at Styx Mill Reserve, to see if they were negatively affecting the resident waterfowl birds. In July 2024, there were approximately 30 Canada geese present onsite at Styx Mill Reserve. Populations reduced to approximately 2 Canada geese onsite by August 2024. This caused us to adapt our research aim, as there were not enough Canada geese to accurately observe behaviour interactions. Therefore, we decided to observe Canada geese at a new location (Victoria Lake), which had a higher population abundance. This allowed us to increase the sample size and avoid sampling bias. This explains why we have only 3 samples from Styx Mill Reserve, and 6 samples from Victoria Lake.

There is a roosting site on the Waimakariri River, in the high country of North Canterbury (eastern slopes of the Southern Alps). During early August- to September, Canada geese begin their migration pattern where they breed around lakes and rivers that are located inland high-country (Williams, 2013; Spurr & Coleman, 2005). Canada geese are a traditional migrant bird, which explains why they relocate for breeding (White, 1986). After the

breeding season has concluded, flocks return to coastal lakes and rivers for the remainder of the year, where they forage and undergo moulting (Spurr & Coleman, 2005).

We suspect the majority of Canada geese from Styx Mill Reserve went to the roosting site along the Waimakariri River for the breeding season. This explains why the Canada geese population decreased from approximately 30 birds in July, to 2 birds in August. It is estimated that in December, Canada geese populations will return from their roosting sites, which will increase population abundance.

This migration caused a major limitation in our research, as it meant our sample size was very small. This made it difficult to observe behaviour interactions, as there were limited Canada geese to observe. This lack of representation of the whole Canada geese population, made it difficult to draw inferences about Canada geese. Increasing study length, and sample locations would allow a more conclusive inference regarding the Canada geese population. Further research could investigate why some Canada geese remained at Styx Mill Reserve, and why the other geese migrated.

Behaviour

Canada geese are known to be highly territorial, especially during their breeding season. This behaviour, which is characterised as aggressive defence of nesting sites, typically leads to conflict with other bird species (Shearer et al., 2022). Canada geese have been recorded to hiss as an act of defence against other species, when they believe their offspring may be threatened (Shearer et al., 2022). This is due to their innate biological need to protect their offspring.

Canada geese also exhibit strong site fidelity, where they return to the same nesting location year after year (Allan et al., 1995). This site fidelity can lead to the exclusion of other species, as Canada geese become territorial of their nesting locations (Spurr & Coleman, 2005). In a study by Win (2001), he found that Canada geese exhibited strong territorial behaviour which amplifies the success of reproduction. Win (2001) found that successful female geese were more likely to return to their previous nesting sites, and home grounds. This site fidelity and territorial behaviour can amplify agonistic behaviour.

There were very small observations of Canada geese aggression towards resident waterfowl birds at both locations. Although this result is statistically significant, it does have major limitations. During our research project we observed behaviour over a short period of 9 days. This made it difficult to draw conclusive inferences regarding behaviour interactions, as it neglects an annual cycle of bird behaviour (breeding, raising offspring, moulting, and post-moulting). If we were to observe behaviour over an annual cycle, or during a different time of the year (i.e, in December, after their breeding season), this may give different interaction responses. The reason for this difference is due to the likelihood of Canada geese to become more aggressive when they have their offspring present. This would allow observations to include both before and after the breeding season data. The full scope study could potentially test the hypothesis that Canada geese are aggressive to resident waterfowl when offspring are present.

The observed results of Canada geese recorded at Styx Mill Reserve were intended to be used for other locations around Christchurch. For that reason, we decided to compare the difference in management strategies undertaken at Styx Mill Reserve to Victoria Lake. To determine effectiveness, we took the remaining birds at both locations and compared the

population abundance. The accuracy of this procedure regarding representation of management strategy effectiveness was imperfect. In order to get an accurate representation of management strategies, a sampling methodology must include the population abundance before management strategies have occurred, and the population abundance after the management strategies have occurred. A major limitation in our research was time. We could not obtain data on population abundance before management strategies had occurred, as management strategies had already concluded prior to our research. Due to this, we have analysed the effectiveness of management strategies, incorporating relevant literature that occur at both sites.

Management Strategies:

Victoria Lake: Decoys

As shown by Figure 5 in the results, the Canada geese on-site tended to congregate in close proximity to areas in which decoys were deployed.This proximity is represented below in Figure 7, as the observed geese are in front of the wolf decoys. Possible explanations for these observations relate back to published literature. Decoys when implemented on-site should be moved around periodically to mimic the natural movement patterns of a predator (Spurr & Coleman, 2005). Habituation- the act of becoming familiarised with stimuli- can quickly occur in the absence of movement (Spurr & Coleman, 2005). The stimuli in this case were two decoys with resemblance to wolves. Throughout the duration of our observations at Victoria Lake, the decoys were never repositioned, leading to noticeable habituation. Therefore, the instinctual fright of geese from the decoys was minimal. A plausible reasoning for the tendency of geese to congregate around decoys' could be linked to either the decoys' lack of movement or their inaccurate representation of wolves. This assertion is backed up by

the results that 4 out of 5 (80%) observations showed geese passing nearby and in front of the decoys.

Figure 7
Canada Geese at Victoria lake in front of the decoys.

Note. A population of Canada Geese on Victoria Lake can be seen directly in front of the decoy, which is positioned on the grassy lawn facing towards the lake. The Geese are unbothered and are showing no signs of avoidance towards the decoy.

Research makes clear, regardless of whether a decoy is being moved or not, habituation is inevitable (Spurr & Coleman, 2005). If the implementer commits to moving the decoy regularly, it only slightly extends the length before habituation occurs had they not moved it (Spurr & Coleman, 2005). Therefore we would not recommend the use of decoys in locations that are requiring long term solutions. These findings also highlight it may be an inappropriate strategy for dealing with large scale areas in which the concerned party wants the geese to leave the site entirely. Success in this management strategy has been seen in specific areas such as golf courses (Radio New Zealand, 2024). This offers a short term, cost effective solution. One must evaluate the needs of the site and the end goal they are wishing to achieve when pursuing this strategy.

Victoria Lake: Egg pricking

Unlike with the implementation of decoys, egg pricking is more inconspicuous. While physical observation is achievable for decoys, egg pricking effectiveness can be skewed by outside variables. Since the breeding season overlapped with our observations, we could not conclude egg pricking's overall role in the observed reduction in geese abundance. Regardless, various studies have provided insight into general trends following the strategy's application. Oftentimes even with rigious management, the time investment involved in pricking eggs is hardly equal to the benefits long term (Spurr & Coleman, 2005). Manipulating enough eggs to have an impact on the future generation numbers is in most cases unachievable (Spurr & Coleman, 2005). Even if one was vigilant, not every nest is going to be located for pricking to be administered (Spurr & Coleman, 2005). If a concerned party was interested in targeting a residing population, on-site egg manipulation only amplifies the issue by causing longer residence (Beaumont et al., 2018). This longer residence time relates to the behaviour of mother geese to continue laying on unviable, pricked eggs (Beaumont et al., 2018). This behaviour will persist even after other birds with unpricked eggs have completed hatching and hence moved on to the next location (Beaumont et al., 2018).

Consequently, egg pricking may see better effectiveness if used as a preventative measure for reducing populations gradually in conjunction with other strategies. Egg pricking is not a strategy that would provide immediate, quick relief to an already existing nuisance population. A principal caveat to consider with this method of management is the required upkeep that will persist for however long the strategy is deployed.

Styx Mill Reserve: Euthanasia

During the moult season, 130 geese at Styx Mill Reserve were euthanized ethically with veterinarian assistance. As it is euthanasia, direct effectiveness can be seen for those 130 geese. However due to our limited scope we are unable to know how long this relief lasts or if a new population of geese will simply replace the removed population. Therefore our conclusions on this management strategy are informed by published literature.

Comparatively speaking, euthanasia is the most confrontational of the management strategies discussed, as it involves direct killing of geese, which draws public scrutiny (Paulin, 2004). Even so, this management strategy is more publicly accepted than shooting (Paulin, 2004). One must recognize that euthanasia can be costly to apply and is a labour intensive option (Paulin, 2004). The results of the application can be seen immediately and there is no wait time. This strategy is more appropriate for managing larger scale locations and abundances (Spurr & Coleman, 2005). Out of the methods, implementations such as euthanasia have a greater potential for long term success (Spurr & Coleman, 2005). It should be acknowledged that while euthanasia is one strategy on-site, other strategies are dispatched at Styx Mill Reserve to combat the geese disturbance.

In summary, interested parties should make careful consideration of their available time investment, budget, desired target i.e future or current populations, and desired end goal i.e long term or short term management. A crucial component is also being aware of seasonal patterns of geese, public perception, and the overall nature of the site.

Bankside Vegetation

Upon observation of the two sites, numerous occasions were noted of geese feeding on grassy lawn present at Victoria Lake. In contrast, Styx Mill Reserve is covered in native/riparian plantings. Never once was a goose spotted anywhere other than in the water or feeding on bankside vegetation at Styx Mill Reserve. This is likely due to the information we have asserted regarding the food preference of geese.

Conclusion:

Canada geese are an invasive species, as they significantly degrade environmental conditions, such as water bodies, greenspaces and native plant abundance. Canada geese populations are continuing to grow, which is increasing concern as large populations continue to damage New Zealand's fragile ecosystems.

We hypothesised that Canada geese would be aggressive towards resident waterfowl. We also investigated what management strategies were most effective for reducing Canada geese populations in Styx Mill Reserve and Victoria Lake.

The methodology we used was recording bird behaviour, and bird abundance. We concluded that Canada geese did not have an effect on resident waterfowl at Styx Mill Reserve and Victoria Lake. Canada geese showed no aggression towards resident waterfowl, which proved our hypothesis as incorrect.

Although our results concluded there was a significance of no interaction between Canada geese and resident waterfowl, we believe this does not represent the population as a whole, and therefore Canada geese behavioural interactions. A major limitation in our research

project was attempting to observe behavioural interactions during the Canada geese migration period. This inhibited us from observing geese behaviour, as no geese were present at Styx Mill Reserve. As our sample size was small, it made it challenging to draw statistically significant inferences. Increasing the study length to an annual cycle, would increase sample size, which would also increase the statistical reliability. This approach would also test the hypothesis that Canada geese are aggressive towards resident waterfowl during their breeding and post-breeding season. The influence of seasonal weather patterns on behaviour could also be a point of interest.

In our results we found no significant difference between culling management strategies in Victoria Lake (wolf decoys and egg pricking) and Styx Mill Reserve (euthanasia). Difficulties arose in recording Canada geese population abundance at both locations, as their migration pattern had already begun. It was challenging to differentiate whether the decrease in population abundance was due to migration or effectiveness of management strategies. The timing of our research project made comparing population abundance before and after management strategies had occurred unachievable. Prior to our research, most management strategies had already concluded.

This narrow scope made drawing conclusive inferences on the effectiveness of strategies less reliable. For that reason, comparing strategies over an annual cycle to see the effects on population abundance would provide more clarity. Recording population abundance before and after the management strategy has occurred would be beneficial. This would give a more accurate portrayal into the effectiveness of different management strategies. Given these limitations we could still deduce that in general, decoys are more suitable short term solutions. Decoys may also provide relief in removal of geese on particular grass locations.

Euthanasia is an effective strategy for long term management and egg pricking can be effective if used in conjunction.

People of interest may benefit by adding riparian planting along water bodies of popular geese trafficking sites. Thereby reducing the grass lawn which the geese prefer. This vegetation will also provide other ecological and restoration benefits such as increasing biodiversity.

The presence of Canada geese in New Zealand significantly disturbs the environment and fragile ecosystems. Eradicating this species would have several benefits to New Zealand's irreplaceable natural resources, including cleaner waterways, an increase in aesthetic greenspaces, less competition with native birds for food resources, and less damage on agricultural pasture.

He whakataukī:

Mā te huruhuru ka rere te manu (adorn the bird with feathers and it will fly). Through conservation efforts, we can metaphorically adorn our native birds with feathers. By controlling invasive species, like Canada geese, it gives opportunity for natural ecosystems and waterbodies to reestablish into healthy conditions. This restores the hauora (health), wairua (spirit), and mana (strength) of the whenua (land), which subsequently provides a tranquil environment which supports native manu (birds) to fly.

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References

Allan, J. R., Kirby, J. S., & Feare, C. J. (1995). The biology of Canada geese *Branta canadensis* in relation to the management of feral populations. *Wildlife Biology, 1*(3), 129-143. https://doi.org/https://doi.org/10.2981/wlb.1995.018

Beaumont, M., Rodrigue, J., Pilotte, C., Chalifour, É., & Giroux, J.-F. (2018). Behavioral Response of Canada geese to Egg-Oiling and Nest Removal. *The Journal of Wildlife Management*, *82*(7), 1359–1366. https://www.jstor.org/stable/26610346

Caley, H. J. (2020). *Seasonal and diurnal patterns of behaviour and movements of the Canada goose (Branta canadensis) in Christchurch City and Central Canterbury, New Zealand.* (Master's thesis, University of Canterbury). UC Research Repository. https://ir.canterbury.ac.nz/server/api/core/bitstreams/9e8318c5-ee38-4b9c-9778-b972bf89524f/content

Chen, C. C., Wu, H. Y., Liu, T. T., & Shieh, B. S. (2011). Dominance rank and interference competition in foraging among six species of birds in a park in Kaohsiung City, Taiwan. *Taiwan Journal of Forest Science, 26*(3), 255-266. https://www.researchgate.net/publication/285526947_Dominance_rank_and_interference_competition_in_foraging_among_six_species_of_birds_in_a_park_in_Kaohsiung_City_Taiwan

Coleman, J. (2008). *Review of Impacts to Pasture Production by Black Swans (Cygnus atratus) and Canada geese (Branta canadensis) in Northland.* https://www.envirolink.govt.nz/assets/Envirolink/464-NLRC67.pdf

Deguines, N., Lorrilliere, R., Dozières, A., Bessa-Gomes, C., & Chiron, F. (2020). Any

despot at my table? Competition among native and introduced bird species at garden birdfeeders in winter. *Science of the Total Environment, 734*, Article 139263. https://doi.org/10.1016/j.scitotenv.2020.139263

Federated Farmers. (2011). *Farmers happy Canada geese finally declared a pest*. Scoop. https://www.scoop.co.nz/stories/PO1103/S00165/farmers-happy-canada-geese-finally-declared-a-pest.htm?row=2

Fox, A. D., & Abraham, K. F. (2017). Why geese benefit from the transition from natural vegetation to agriculture. *Ambio*, *46*(S2), 188–197. https://doi.org/10.1007/s13280-016-0879-1

Gale, G. A., Round, P. D., Pierce, A. J., Nimnuan, S., Pat Tanavibool, A., & Brockelman, W. Y. (2009). A field test of distance sampling methods for a tropical forest bird community. *The Auk, 126*(2), 439-448. https://doi.org/10.1525/auk.2009.08087

Gottschalk, T. K., & Huettmann, F. (2011). Comparison of distance sampling and territory mapping methods for birds in four different habitats. *Journal of Ornithology, 152*(2), 421-429. https://doi.org/10.1007/s10336-010-0601-1

McDonald, L. (2020). *Pedestrians left goose stepping on $2 million 'poop loop.* Stuff. https://www.stuff.co.nz/national/121631211/pedestrians-left-goose-stepping-o

Ministry for the Environment. (2020, April 7). *Issue 2: Water is polluted in urban, farming, and forestry areas*. Ministry for the Environment. https://environment.govt.nz/publications/our-freshwater-2020/issue-2-water-is-polluted-in-urban-farming-and-forestry-areas/

Ministry for the Environment. (2020). *Our Freshwaters 2020*. Ministry for the Environment. https://environment.govt.nz/assets/Publications/Files/our-freshwater-2020.pdf

Paulin, J. B. (2004). *Canada goose management series: Capture and euthanasia*. New Jersey Agricultural Experiment Station Rutgers Cooperative Research and Extension. https://rucore.libraries.rutgers.edu/rutgers-lib/28206/PDF/1/play/

Radio New Zealand (2024, June 12). *Wolf Decoys Used to Scare Geese Away at Christchurch Botanic Gardens.* https://www.rnz.co.nz/news/national/519322/wolf-decoys-used-to-scare-geese-away-at-christchurch-botanic-gardens

Shearer, D. J., Carter, T. C., & O'Neal, B. J. (2022). Canada geese (*Branta canadensis*) nesting on elevated structures in urban Indiana, USA. *Ecology and Evolution*, *12*(3), e8735. https://doi.org/10.1002/ece3.8735

Spurr, E. B., & Coleman, J. D. (2005). *Research, development, and improvement of kill traps to control small mammal pests in New Zealand* (Landcare Research Science Series No. 30). Manaaki Whenua – Landcare Research. https://www.landcareresearch.co.nz/assets/researchpubs/LCR_SciSeries30_Spurr2005.pdf

Waikato Regional Council. (2024). *Canada Goose: Branta canadensis maxima*. https://www.waikatoregion.govt.nz/assets/WRC/RPMP/Canada-goose-factsheet.pdf

White, E. G. (1986). *Canada geese in New Zealand.* Information Paper No.4 Centre for Resource Management Lincoln College and University of Canterbury. https://researcharchive.lincoln.ac.nz/server/api/core/bitstreams/07abbd70-fc5f-4475-9fbe-26593509a258/content

Williams, M.J. (2013). *Canada goose | Kuihi*. *In* C. M. Miskelly (Ed.), New Zealand Birds Online. https://www.nzbirdsonline.org.nz/species/canada-goose

Win, A. (2001). *Seasonal grazing of Canada Goose (Branta canadensis) on high country farmland, Canterbury, New Zealand* (Master's thesis, Lincoln University). Lincoln University. https://core.ac.uk/download/pdf/35462942.pdf

Win, A. D., & Hickling, G. J. (2000). *Seasonal grazing by Canada geese (Branta canadensis) on South Island highcountry pasture.* New Zealand Plant Protection. https://nzpps.org/_journal/index.php/nzpp/article/view/3671/3499