Assessing the impact of predator-proof fencing on New Zealand birds via distance sampling in Wellington through *Prosthemadera novaeseelandiae, Turdus merula, and Philesturnus rufusater*

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Abstract:

Invasive species have put the endemic wildlife of Aotearoa at risk, as seen in the drastically endangered bird species. While there are many conservation methods, predator-free fencing is one of the more popular ones. This study uses distance sampling to test if fenced ecosanctuaries (like Zealandia) benefit bird populations by comparing the population densities of tūī, tīeke, and blackbirds inside and outside of Zealandia. After data collection through transect sampling and data analysis using R Studio and the Akaike Information Criterion, we found that the tūī and the tīeke benefit the most from the fenced eco-sanctuary. The blackbird tends to have similar population densities in and out of Zealandia, showing that endemic species of birds most likely benefit more than the introduced species. It would be easy to conclude that predator-free fencing is the best way to keep endemic bird species safe, but instead, I recommend that more research is done with various sampling methods during different times of year to ensure that other factors, like observer inexperience or breeding seasons, are not at fault for skewing the results.

Introduction:

New Zealand is home to unique endemic wildlife as an island isolated in the South Pacific, but human settlement introduced new species that have disrupted the native ecosystems (Clarkson & Kirby, 2016). The introduced species have become invasive and are putting many native species at risk of extinction, causing management issues due to ecology adaptation to New Zealand's unique environment by the pests (Goldson et al., 2015). Protecting the endemic wildlife of Aotearoa is becoming a more pressing issue as species continue to go extinct due to predation by introduced mammals (Fea et al., 2020). This issue proves difficult to solve on a large island, but predator-proof fence sanctuaries have aided conservation efforts (Bombaci et al., 2018). However, predator-proof fencing is a highly contested conservation solution for protecting New Zealand's biodiversity because there is a lack of evidence of the benefits in comparison to the costs (Bombaci et al., 2018; Innes et al., 2012; Scofield & Cullen, 2012; Scofield et al., 2011). Researchers use different methods of estimating population densities inside and outside of the fences to determine if the predator-free fencing is working to protect endemic species. One commonly used estimation method is distance sampling because it allows undetected individuals to be considered (Newson et al., 2008). Estimating population densities around fenced sanctuaries is vital so that researchers can determine if this conservation method is beneficial enough to continue to put money into them. If the numbers show that the predator-proof fencing is not doing enough, researchers can focus conservation efforts in a different direction.

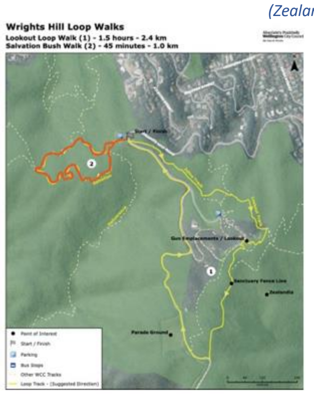
In this study, we used distance sampling to compare population densities of *Prosthemadera novaeseelandiae* (tūī), *Turdus merula* (blackbirds), and *Philesturnus rufusater* (tīeke) inside and outside of a fenced sanctuary, known as Zealandia. Tūīs are endemic to New Zealand and are known to thrive in areas of pest eradication (Fitzgerald et al., 2019). Although, they are also more resilient to mammals than other New Zealand birds (Shaw, 2023). Tīekes are also an endemic species but are shown to only survive in highly predator-controlled sanctuaries (Castro et al., 2011). Lastly, blackbirds are an introduced species to New Zealand but have rapidly become vital as they disperse seeds (Williams, 2006). Based on the life histories of these birds, we can predict that the population densities of the tūīs and the tīekes will be higher inside the fenced sanctuaries, whereas the blackbird populations will remain similar at both locations because the native birds require a predator-free environment to thrive.

Methods:

1.1 Study site and species:

Students observed tūī, blackbirds, and tīeke throughout a total of 26 different tracks. 13 tracks were in Zealandia (Figure 1) and 13 tracks were in Wrights Hill and Polhill in a Halo Reserve (Figures 2 and 3), for a total of 226 hectares covered in Zealandia and 205 hectares covered in the Halo Reserve.

Figure 1: Map of Zealandia tracks
(Zealandia, 2022)



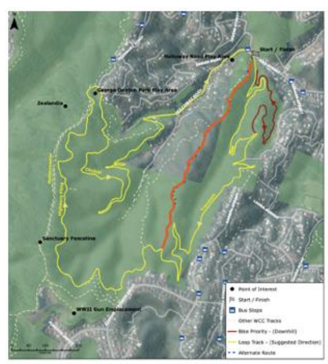


Figure 2: Map of Wrights Hill tracks *Figure 3: Map of Polhill tracks*

(Absolutely Positively Wellington City Council, n.d.-a) *(Absolutely Positively Wellington City Council, n.d.-b)*

1.2 Data collection:

Students split into 13 groups, each with an assigned track in Zealandia and the Halo Reserve for completing distance sampling in between 9:30 AM and 3 PM. They used 50 m tapes to measure six 50 m long transects along their assigned track. Each transect had a minimum of 10 m between them. After laying down each transect, students waited at least 5 minutes before beginning to sample. After 5 minutes, two observers walked along the transect at a pace 4x slower than normal to not scare the animals, observing the area using the method shown in Figure 4. When they observed one of the three birds of interest within 20 m of the transect, the students noted the perpendicular distance of the bird from the transect line. After the first pass-through, two different observers waited 5 minutes and then sampled the same transect using the same method.

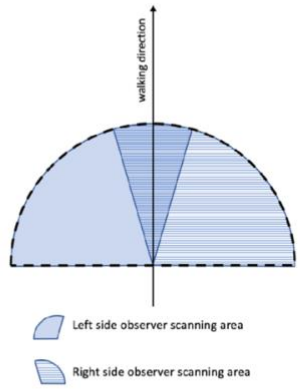


Figure 4: The method used to observe the areas around the transects for distance sampling (Shaw, 2023).

1.3 Statistical analyses:

I combined results from all groups and tracks and used R Studio to determine population densities for each bird at each sanctuary using a distance package. I used models to determine the shape of the detection function, g(x), to estimate the abundance and density of birds in each area. I created four different detection function models for each bird: a half-normal with cosine adjustment, a half-normal with Hermite polynomial adjustment, a uniform with cosine adjustment, and a uniform with simple polynomial adjustment. Then, I used the model with the lowest Akaike Information Criterion (AIC) value to be the best fit. The lowest AIC value does not necessarily mean a good fit to the data, so I completed a goodness of fit test for the data and the model using the Cramer von Mises test. A p-value of less than 0.05, making the test significant, indicates that the model is not a good fit. In addition, I used the Q-Q plot to ensure that the data was a good fit by observing if any points deviated from the line of best fit.

Results:

Figure 5: Total number of birds observed, number of birds observed at each location, Akaike Information Criterion values, and p-values for the Cramer von-Mises tests for tūī, tīeke, and blackbirds.

Species	Total number of birds observed	Number of birds observed in Zealandia	Number of birds observed in Halo Reserves	AIC	C-vM p-value
Tūī	166	120	46	908.5521	0.3731
Tīeke	38	38	0	220.2994	0.816
Blackbird	49	18	31	274.3472	0.581

2.1 Tūī:

For the tūī, our data found that the best-fit detection model was the uniform model with cosine adjustment (Figure 6). This model had the lowest AIC value of 908.5521, and the p-value of 0.3731 from the Cramer von Mises test is greater than 0.05, meaning the model is a good fit for the data (Figure 5). The goodness of fit tests also showed the most accuracy for the uniform function with cosine adjustments, meaning the data points did not deviate considerably from the line of best fit (Figure 7). Therefore, based on this data, we can see that the density and abundance of tūīs inside Zealandia are larger than in the Halo Reserves (Figures 8 and 9).

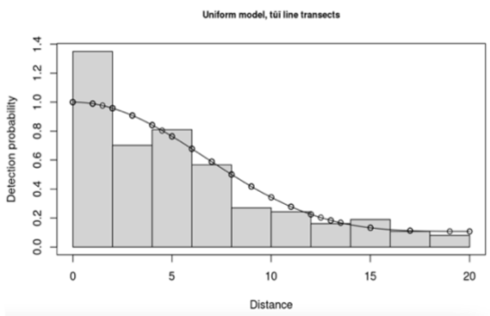


Figure 6: Fit of uniform detection function with cosine adjustment term to tūī data

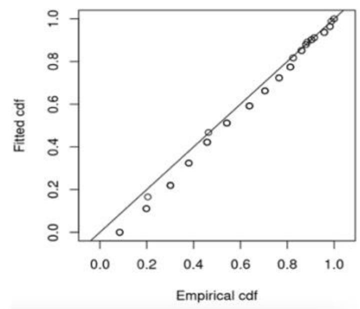


Figure 7: Q-Q plot of uniform key function with cosine adjustments fitted to tūī transect line

Figure 8: Estimated density, associated error, and confidence limits of tūīs in each location

Density:

	Label	Estimate	se	cv	lcl	ucl	df
1	Halo	3.319264	0.8405159	0.2532236	2.022585	5.447244	88.81806
2	Zealandia	8.579020	1.2531733	0.1460742	6.434145	11.438908	119.61920
3	Total	6.077280	0.8096390	0.1332239	4.679285	7.892944	218.86583

Figure 9: Estimated abundance, associated error, and confidence limits of tūīs in each location

Abundance:

	Label	Estimate	se	cv	lcl	ucl	df
1	Halo	680.4491	172.3058	0.2532236	414.6299	1116.685	88.81806
2	Zealandia	1938.8586	283.2172	0.1460742	1454.1167	2585.193	119.61920
3	Total	2619.3077	348.9544	0.1332239	2016.7717	3401.859	218.86583

2.2 Tīeke:

Our data found that the best-fit detection model was the uniform model with cosine adjustment for the tīeke (Figure 10). The model is a good fit for the data because the AIC value is 220.2994, and the p-value of the Cramer von Mises test is 0.816 (Figure 5). Figure 11 shows a line of best fit with data points that do not deviate too far, further showing that the uniform detection model with cosine adjustment is the best fit model. Based on our data, there were no tīekes seen in the Halo Reserves, so the density and abundance of tīekes is drastically higher in Zealandia (Figures 12 and 13).

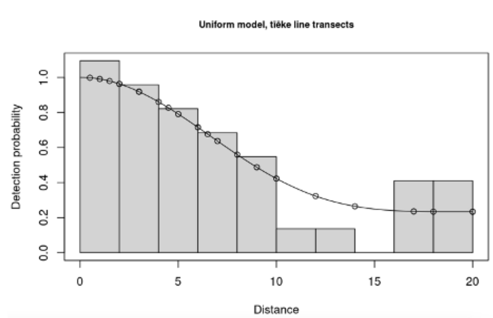


Figure 10: Fit of uniform detection function with cosine adjustment term to tīeke data

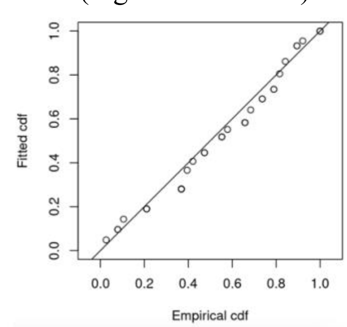


Figure 11: Q-Q plot of uniform key function with cosine adjustments fitted to tīeke transect line

Figure 12: Estimated density, associated error, and confidence limits of tīekes in each location

Density:

	Label	Estimate	se	cv	lcl	ucl	df
1	Halo	0.000000	0.0000000	0.0000000	0.0000000	0.000000	0.0000
2	Zealandia	2.342498	0.7139328	0.3047741	1.2971540	4.230258	103.4553
3	Total	1.228317	0.3743592	0.3047741	0.6801782	2.218187	103.4553

Figure 13: Estimated abundance, associated error, and confidence limits of tīēkes in each location

Abundance:

	Label	Estimate	se	cv	lcl	ucl	df
1	Halo	0.0000	0.0000	0.0000000	0.0000	0.0000	0.0000
2	Zealandia	529.4045	161.3488	0.3047741	293.1568	956.0384	103.4553
3	Total	529.4045	161.3488	0.3047741	293.1568	956.0384	103.4553

2.3 Blackbird:

The uniform model with cosine adjustment is also the best-fit detection model for the blackbird (Figure 14). The Q-Q plot for this model and adjustment had the fewest data points straying from the line of best fit (Figure 15). The AIC value is 274.3472, which was lower than the other potential models, and the Cramer von Mises p-value is also greater than 0.05 with a value of 0.581, showing that it is a good fit (Figure 5). The blackbird data differs from the other two species of birds because the density and abundance of blackbirds were higher in the Halo Reserves, not Zealandia (Figures 16 and 17).

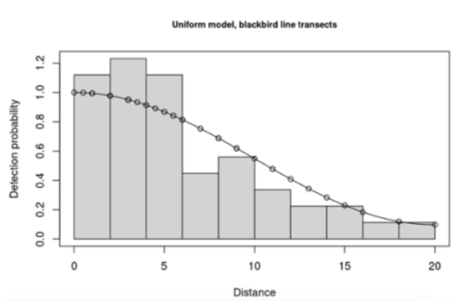


Figure 14: Fit of uniform detection function with cosine adjustment term to blackbird data

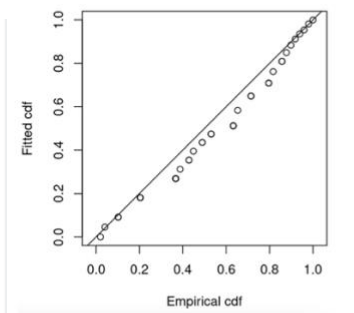


Figure 15: Q-Q plot of uniform key function with cosine adjustments fitted to blackbird transect line

Figure 16: Estimated density, associated error, and confidence limits of blackbirds in each location

Density:

	Label	Estimate	se	cv	lcl	ucl	df
1	Halo	1.828474	0.4387173	0.2399363	1.1426957	2.925817	89.01270
2	Zealandia	1.051895	0.2953906	0.2808177	0.6082777	1.819041	85.68786
3	Total	1.421265	0.2677007	0.1883537	0.9831894	2.054533	175.06478

Figure 17: Estimated abundance, associated error, and confidence limits of blackbirds in each location

Abundance:

	Label	Estimate	se	cv	lcl	ucl	df
1	Halo	374.8372	89.93705	0.2399363	234.2526	599.7925	89.01270
2	Zealandia	237.7282	66.75828	0.2808177	137.4708	411.1032	85.68786
3	Total	612.5654	115.37899	0.1883537	423.7546	885.5039	175.06478

Discussion:

There are more tūīs and tīekes per hectare inside of the fenced sanctuary, which suggests that the predator-free fencing benefits the livelihood of these species of birds (Figure 5). Furthermore, observers saw no tīeke outside of Zealandia, which suggests that they require completely predator-free environments to survive, making them dependent on the fenced sanctuaries (Figure 5). We saw more blackbirds per hectare outside the fenced sanctuary, which suggests that conservation efforts do not impact this species (Figure 5). This data supports our hypothesis that the endemic species benefit more from predator-free fencing than the introduced species. The tūī and the tīeke are native to New Zealand and, consequently, did not evolve with the introduced predators, making them less adapted to survive. Blackbirds were introduced to New Zealand and have since coevolved with mammals, allowing them time to adapt to thrive with the pests. Other studies also support that fenced reserves help restore bird populations in New Zealand (Drummond & Armstrong, 2019; Tanentzap & Lloyd, 2017; Young et al., 2013). Some studies have even gone as far as to say that predator-proof fencing is the sole reason certain species are not extinct in New Zealand (Burns et al., 2011). On the contrary, some conservationists believe that the fences cost more than the benefits they provide, along with visually disrupting the area (Murphy et al., 2019). There are sometimes issues with holes and gaps in the fences to allow for vehicles, which, in turn, let pests pass through and make the fences much less effective (Murphy et al., 2019). There are also concerns that the habitat around the fenced ecosanctuaries is low-quality, which causes populations outside to be lower (Burge et al., 2021).

Predator-free fencing is a highly debated conservation effort, so I would suggest conservationists conduct more research before concluding that it is the best method. There are limitations with distance sampling through inexperienced observers and low precision. Most birds were observed within 5 meters of the researcher (Figures 6, 10, 14), which suggests that observers naturally saw the birds they were closest to. This potential bias means that the birds farther from the transect were not included as often in the data. We placed the transects along the path where people most commonly walk so birds may not flock to that highly populated area. This disruption could lead to flaws in the data because the hikers accidentally scare the birds away into areas transects do not cover. In general, this is a limitation of distance sampling because researchers cannot tell whether the observed data is due to poor detection (Barry & Walsh, 2001). By doing more research with different methods of collecting data, researchers can compare the data to ensure that endemic bird species thrive better in fenced sanctuaries.

In addition to replicating this study with different observational methods, I propose that the data researchers take data at different times of the year. Birds are seasonal breeders, with breeding season beginning in autumn and egg-laying starting in late winter, spring, or summer (Cockrem, 1995). All data collected in this study was done during winter, which means the birds were in the breeding season. The season could affect behaviour and cause the birds to be less visible, depending on the time of year. Researchers should replicate this study throughout the year to consider the breeding seasons.

Bird species in New Zealand are quickly depleting, and we must make conservation efforts to save them, but researchers must use the most efficient and beneficial methods. Conservation efforts are expensive and require copious amounts of time, energy, and work, so thorough research is vital to ensure we do not waste resources.

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