Bird Conservation at Styx Mill Reserve

Establishing an Ecological Diversity Benchmark to Measure the Response of Predator Trapping Efforts

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1. Executive Summary

Research context

The New Zealand Conservation Trust (NZCT) has recently established a predator trapping programme at Styx Mill Reserve to help contribute to the goal of Predator Free 2050 in New Zealand. The NZCT requires a way to measure conservation progress against.

Aim

To identify the most appropriate ecological biodiversity benchmark to measure bird conservation efforts at Styx Mill Conservation Reserve.

Methodology

- Qualitative data was collated from literature reviews to select a suitable benchmarking method and gain a better understanding of the project.
- Semi-structured interviews were carried out with experts and NZCT members.
- Fieldtrips to Styx Mill Conservation Reserve undertaken by group members.
- Bird count data used to calculate a Simpsons diversity index and graph to compare species richness and abundance of native and introduced species at the Reserve.
- Analysis and graphing of predator trapping data to visualise trapping programme progress.

Key Findings

- Biodiversity of bush bird species is currently greater and more stable for introduced species in comparison to natives.
- Biodiversity of wetland bird species until 2020 was greater for native species, however introduced are now greater in diversity.
- The trapping regime has captured a variety of mammalian predators, majority being rats.

Limitations

The datasets provided for the project were disjointed in bird species measured, methods used and timeframes. Due to this the recommended benchmarking method skewed towards a qualitative approach rather than just a numerical value of biodiversity.

Recommendations

- The recommended benchmarking method focuses around seeing an increase in native wetland and bush bird species alongside a stabilisation between native and introduced biodiversity.
- Five indicator species have also been selected for future monitoring of the conservation progress. These birds increase community engagement through increased social value.
- Additional bird count collection sites and frequent sampling is recommended to ensure high quality data availability for tracking future progress.
- Future engagement with mana whenua will provide valuable knowledge on indigenous conservation processes.

2. Introduction

The New Zealand Conservation Trust (NZCT) is a volunteer led non-profit organisation that aims to conserve and enhance native species and the environment. The trust is based at Willowbank Wildlife Park in Christchurch. NZCT has collaborated with Styx Living Laboratory Trust (SLLT) to start a trapping programme in Styx Mill Conservation Reserve (herein; SMCR), in support of New Zealand's goal to be Predator Free by 2050. The trapping programme, which started on February 20th, 2020, deployed 89 DOC 200 traps throughout SMCR.

SMCR is approximately 60 hectares in size and classified as a Metropolitan Regional Park (SLLT, n.d.). Located North of Christchurch's CBD within the suburb of Northwood, SMCR is situated between Hussey Road and Styx Mill Road.

52 species of birds have been recorded within SMCR. Currently, birds are monitored by the Christchurch City Council (CCC) along a 490 metre transect line. Birds are identified by either bird song or visual sightings. This method predominantly monitors the bush bird species at SMCR. Volunteers can also monitor birds through the use of eBird, an online public platform for keen bird watchers.

The aim of this project was to identify the most appropriate ecological biodiversity benchmark to measure bird conservation efforts at SMCR, and to monitor the success of the newly implemented trapping programme. Currently traps are aimed to reduce introduced predatory mammals including rats, stoats, weasels, ferrets and hedgehogs. This report provides NZCT with suggestions on possible ecological biodiversity benchmarks. Alongside this, it provides recommendations on the most effective bird monitoring methods and further suggestions that will aid NZCT in improving conservation efforts in future.

3. Literature Review

3.1 Conservation Reserves

The literature showed there are two ways to increase conservation efforts; predator control and habitat rehabilitation. Conservation results on both Mainland islands and Karori Wildlife reserve are attributed mainly to predator or pest eradication (Blick et al., 2008; Saunders & Norton, 2001). Many native species require rebuilding of natural habitats to maintain stable functioning populations (Saunders & Norton, 2001). This revegetation increases bird abundance through improved food resources such as fruits and nectar (Graham et al., 2013).

3.2 Bird Monitoring Methods

The two main methods of bird monitoring are point counts and line transects. The point count method involves the observer recording all birds detected from a point with a set radius. It is a valuable method as it is an easy way to monitor birds over large areas (Kułaga & Budka, 2019). Currently SMCR only records a single line transect, which is the recording of bird species which are observed from an established line (Roberts & Schnell, 2006). Bird monitoring often results highly variable data sets. To limit this, observers should be trained in the specifically chosen bird count methods (Heezik & Seddon, 2012).

3.3 Ecological Diversity Benchmarks

There is a vast range of ecological diversity indices, which academics agree can be confusing and often inaccurate (Daly et al., 2018; Hugget, 2005; Redžić, 2007; Reyers et al., 2010; Yen et al., 2019). The most common way to measure biodiversity and develop ecological benchmarks is by using both species richness and species abundance measures (Daly et al., 2018; Yen et al., 2019).

Biodiversity around the world continues to decline (Pereira et al., 2012), and there is evidence to suggest that this may be due to 'western-centric' approaches to conservation (Martín-López & Montes, 2015; Mehring et al. 2017). Using indigenous knowledge and connecting people to the value of the ecosystem and its services will provide alternative ways to measure biodiversity. SMCR is a historic mahinga kai site and this should be considered in future biodiversity measures.

3.4 New Zealand Bird/Predator Relationships

Predator/prey relationships are significantly influenced by nest location, size of eggs and ability of the predator (Smith et al., 2008). There is consensus that the most commonly depredated nests belong to easily accessible ground-nesting species (Maier & Degraaf, 2001; Smith et al., 2008).

Understanding potential unintended consequences of predator control is important to consider when implementing such projects. Starling-Windhof et al. (2011) emphasizes the concern that given the high abundances of introduced birds currently, predator control projects could result in a further increase in their population sizes due to their anti-predator adaptations.

3.5 Predator Control Methods

There are three main ways to control predators in conservation reserves; poisoning, trapping and fencing. Many species of native birds have responded positively to 1080 poison control (Wright, 2011), however it is a highly controversial toxin, and is frequently met by opposition from the public.

A major advantage of using trapping as a method of pest control is that the there is no risk of secondary poisoning (Brown et al., 2015). A downfall of trapping is that they must be regularly monitored and reset, making it a time-consuming and expensive process (Carter et al., 2016; Wright, 2011; Brown et al., 2015).

Predator fences are more expensive than other methods (Russell et al., 2015). Scofield et al. (2011) heavily critiques predator fences, claiming that the benefits are not great enough to justify the cost. Conversely, Innes et al. (2012) reports that no common predators have ever reinvaded a fully fenced sanctuary.

4. Methods

4.1 Qualitative

A large proportion of the information collected for this report was obtained from the literature reviews. Literature reviews were used to synthesise existing information surrounding the research question, and to understand where further research was required.

Additionally, information was collected by interviewing relevant experts. This included Daniel Leadbeater and Jan Hellyer from NZCT, Julia Rambacher from SLLT and Prof. Dave Kelly and Prof. Jim Briskie from the University of Canterbury. A semi-structured interview style was primarily used, which involved using a list of predetermined questions and allowing open responses from participants.

SMCR was visited to gain an insight into how bird counts are undertaken. During site visits, the bird-count transect was walked. This was to gain a real-life understanding on how data is collected to further improve data collection methods.

4.2 Quantitative methodology

Statistical data analysis and species diversity calculations were used to develop baselines for bird diversity at SMCR. Microsoft Excel was used to analyze trends in the Wetland bird abundance data (Crossland, 2013) and bush bird abundance data (SLLT, 2020). datasets through graphing and modelling techniques.

Simpson's Diversity Index was utilized to give a quantifiable measure of diversity for the past and current state of bird life. This allowed the establishment of a baseline for the proposed ecological diversity benchmark (Barcelona Field Studies Centre, n.d.). The index reads:

$$D = 1 - \frac{\Sigma n(n-1)}{N(N-1)}$$

Where *n* = the total number of individuals of a specific species; *N* = total number of individuals of all species. This index is based on the richness and the abundance of each bird species in an environment. As diversity measure increases (0-1), the richness and evenness of a community similarly increases.

5. Results

A significantly higher diversity index is demonstrated for introduced bush bird species compared to native (Fig. 1). It is important to note the stable measure of diversity in introduced bush bird species throughout the observation period. Native bush bird diversity increases in 2019-2020, this could potentially be accredited to the implementation of conservation efforts at SMCR during this time. The positive increased trend in native and the stable introduced trend in bush birds is the ideal trajectory for bird diversity at SMCR to follow in response to the trapping project.

Native wetland bird diversity in SMCR is significantly higher than introduced species diversity over the course of the observation period, 2015-2020 (Fig. 2); this trend is what is desired in future observations at the SMCR post-trapping. Both native and introduced diversity trendlines

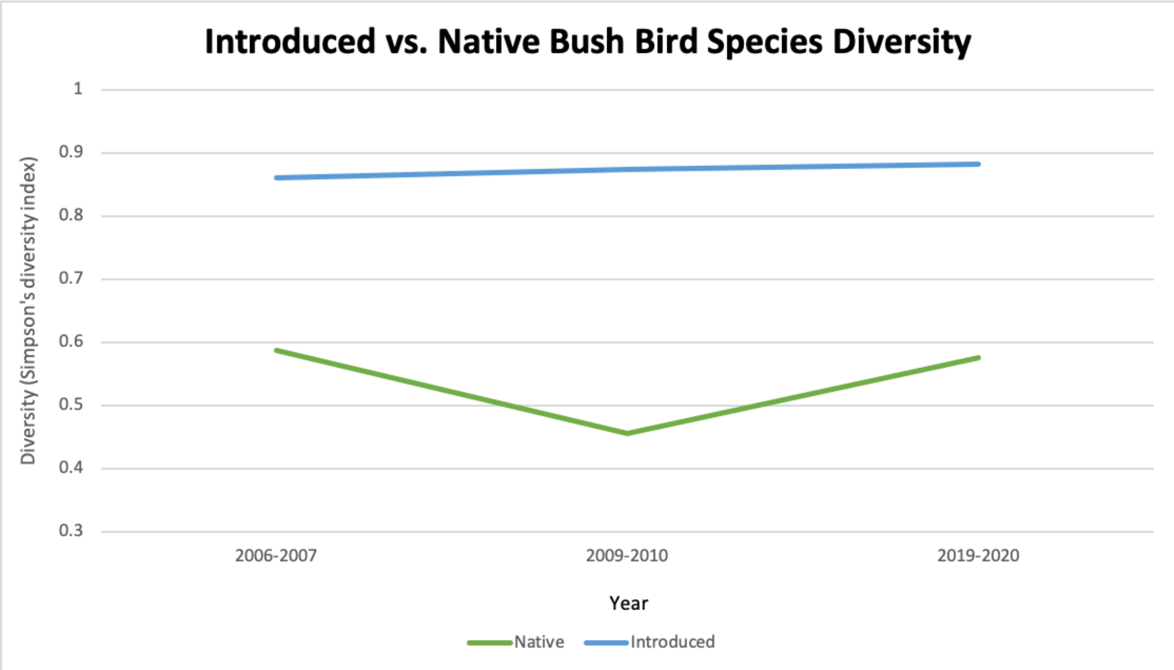

Fig. 1. The relative diversity of native and introduced bush bird. Adapted from Checklist to the Birds of Styx Mill Conservation Reserve, 5th update to January 2013, by A.C. Crossland, 2013 (Unpublished Report for Greenspace Unit, Christchurch City Council).

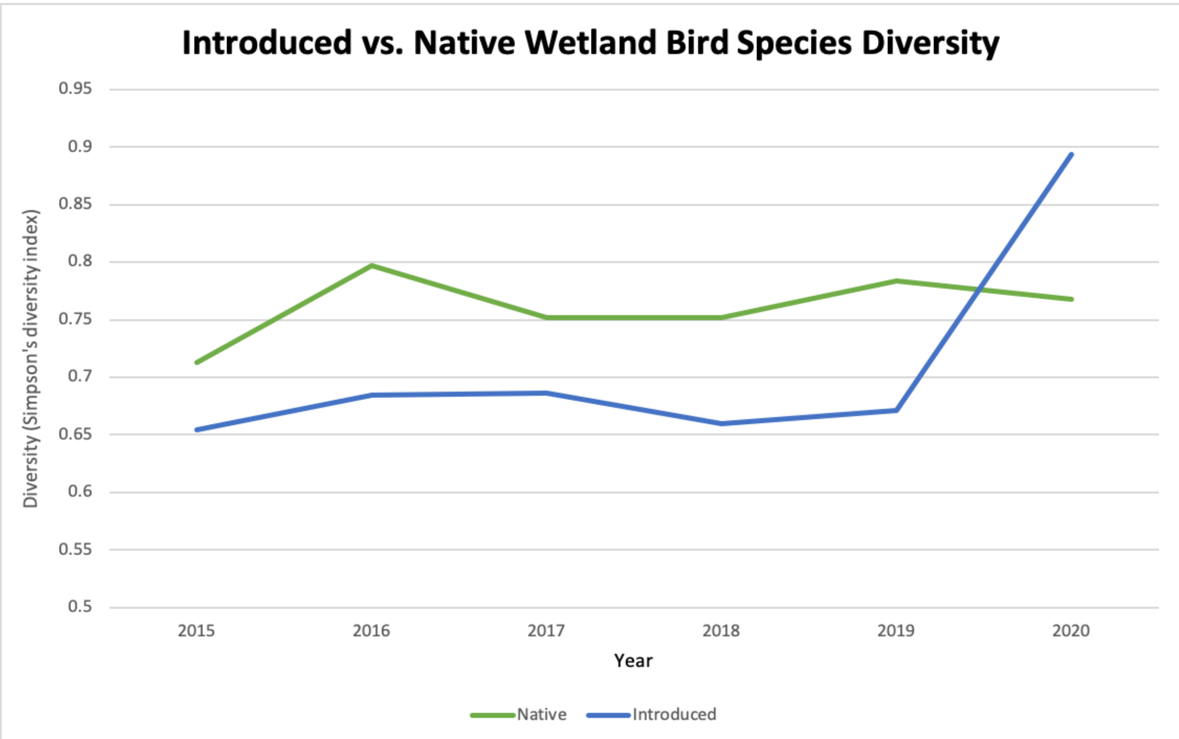

Fig. 2. The relative diversity of native and introduced wetland birds. Adapted from New Zealand eBird; Styx Mill Walkway, by SLLT Bird 2015-2020. https://ebird.org/newzealand/hotspot/L2484336

are relatively stable throughout the years, until a rapid spike in introduced diversity in 2020; this observation corresponds with the increased abundances in introduced species in this time.

It could be extrapolated that the recent establishment of the trapping regime may have led this rise in introduced species, as this was a potential outcome noted regularly throughout the literature (Starling-Windhof et al., 2011). However, without a continuous dataset, other influences cannot be ruled out.

Counts and identification of predators caught since the implementation of the trapping project are recorded in Fig. 3. The results demonstrate the various predatory mammals present at SMCR. The main predator successfully being captured are rats, suggesting they are the most abundant. It is important to note the significant rise in rats in May could be due to the emptying of traps after the COVID-19 lockdown. The recent small peak in possums and decrease in rats recorded in September may suggest a decrease in rat abundances, potentially allowing for other species to interact with traps. This may be a seasonal trend, which could be determined by future years data.

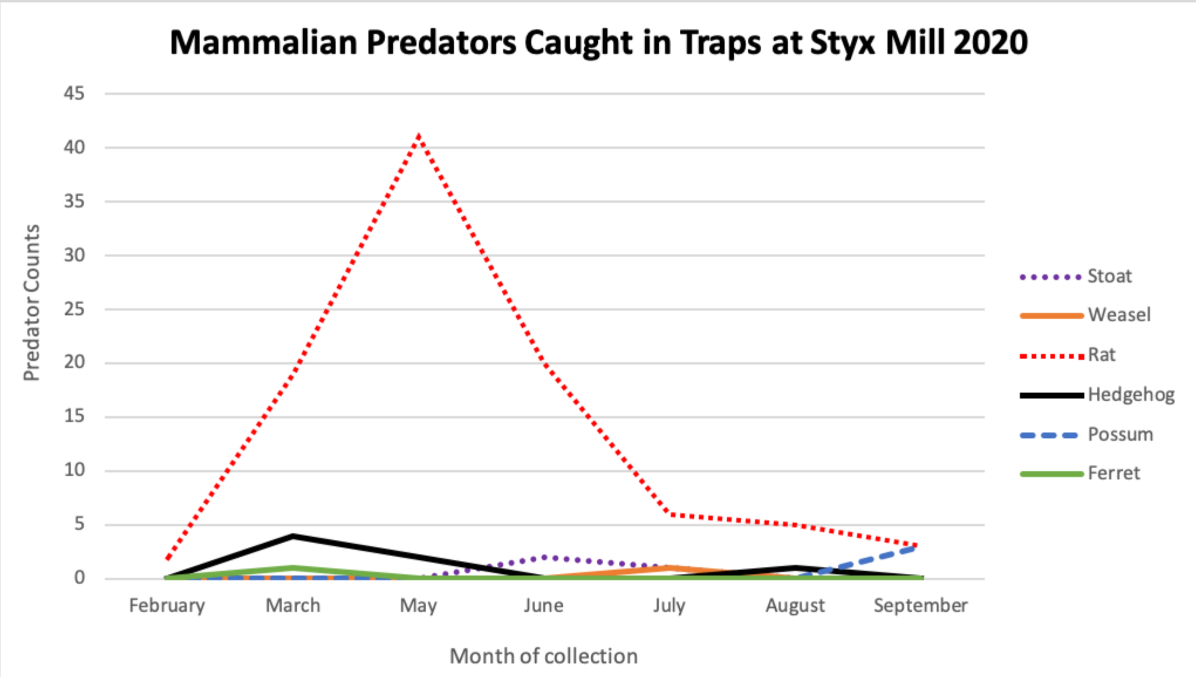

Fig. 3. Trapping data for the recently implemented regime at SMCR. Adapted from NZCT trap emptying data. Updated 6th September by Jan Hellyer.

6. Discussion

6.1 Indicator Species

The initial goal for the trapping project, as communicated by the NZCT, was for the trapping to increase the abundance of all bird species at SMCR. However, through discussions with experts and a review of the current literature, this goal was considered too general and undefined. Although increasing overall abundance at the SMCR may be positive, an increase could be due to an increase in species that generally do well in most environments and are unaffected by predators (Starling-Windhof et al., 2011).

A better measure of success for predator control efforts is to focus on the abundance and diversity of specific threatened, rare, or adored native bird species; that are typically vulnerable to predation. It is suggested that NZCT focus their conservation efforts on the Australasian bittern/matuku, bellbird/korimako, shining cuckoo/pipiwharauroa, Australasian crested grebe/kāmana, and New Zealand pigeon/kererū (Fig. 4). These species have been sighted at SMCR post-planting and since the trapping efforts were initiated (J. Hellyer, personal communication, August 6, 2020); they are also significantly impacted by the presence of predators and provide valuable ecosystem services.

Monitoring the increase of these five indicator species would provide NZCT with evidence that the removal of predators is having a beneficial impact on vulnerable native bird populations. An added benefit of focusing on rare, endemic, and adored species would work in gaining interest from the public. This could result in increased funding for the trust to implement more initiatives at SMCR, to protect and grow these populations.

Fig. 4. Five indicator species, clockwise from top left: kererū (Powlelesland, 2013); pipiwharauroa (Gill, 2013); korimako (Sagar, 2013); matuku (Williams, 2013); kāmana (O'Donnell, 2013).

6.1.1 Shining Cuckoo / Pipiwharauroa

The shining cuckoo/pipiwharauroa *(Chrysococcyx lucidus),* although considered native, is a migrant in New Zealand present during the breeding season from spring through to summer, spending winter in the tropics (Gill, 2013, Troup, 2015). Behaviourally, pipiwharauroa are brood parasites meaning they lay their eggs into a host species nest instead of incubating and rearing young themselves (Gill, 2013). Their dependence on host nests means they do not have specific habitat preference. The preferred host of pipiwharauroa are grey warblers (Beauchamp, 2017; Seabrook-Davison & Anderson, 2013). Therefore, their presence could be used as an indicator of a large healthy population of grey warblers in an environment.

The diet of pipiwharauroa consists of invertebrates, including many introduced insects and caterpillars ignored by other species. Kowhai caterpillars are also an important native food source for this species, so future planting of kowhai trees would help to increase abundance. Although the nests are not their own, the trapping of mammals would decrease nest predation on warblers, therefore on pipiwharauroa eggs/chicks. It would also benefit adult birds as they are known to be approachable when foraging, making them vulnerable to predation (Gill, 2013).

6.1.2 New Zealand Pigeon / Kererū

The New Zealand pigeon/kererū (*Hemiphaga novaeseelandiae)*, is a distinctly coloured native pigeon that is widespread throughout New Zealand (Powlesland, 2013). Kererū are a keystone species, meaning their presence has a disproportionally large effect on an ecosystem (Bond, 1994). Keystone species such as the kererū, have low functional redundancy. This means that if they disappear, no other species will be able to fill their niche role in the ecosystem (National Geographic Society, n.d.). The niche role of the kererū is the ability to ingest large fruit, such as fruit from karaka, miro, tawa and taraire (DOC, n.d.(a)). Kererū disperse fruit seeds over great distances, aiding the regeneration of our native forests (DOC, n.d.(a)).

Although kererū are not threatened, their populations are declining in areas where predators are not controlled. Rats, stoats, cats, and possums pose a serious threat to kererū as they prey on their eggs and nestlings (DOC, n.d.(a)). Population decline has been offset through the establishment of predator-free islands and the implementation of widespread pest control (DOC, n.d.(a)). In comparison to most other New Zealand native birds, kererū populations respond particularly well to predator control (Ruffell & Didham, 2016).

6.1.3 Australasian Crested Grebe / Kāmana

The Australasian crested grebe/kāmana (*Podiceps cristatus*), is a native aquatic diving bird known to breed in New Zealand high country lakes. Their populations are declining throughout New Zealand due to the presence of mammalian predators, habitat loss, and anthropogenic impacts (O'Donnell, 2013; DOC, n.d.(b)). Concern regarding their decline has resulted in their classification as 'nationally vulnerable' under the IUCN Red List (Jensen & Snoyick, 2005). There are suggested to be fewer than 1000 individuals throughout New Zealand, mainly situated in Canterbury and Otago regions (O'Donnell, 2013). Many lakes are unsuitable to support this species as vegetation is required along lake margins to attach their floating nests to, and for shelter in harsh conditions (DOC, n.d.(b)). Nests are generally constructed from sticks and reeds and can be found close to the shoreline; making eggs and nestlings significantly vulnerable as they are easily accessible to mammalian predators (O’Donnell, 2013).

Their inability to walk on land or fly also contributes to their vulnerability (DOC, 2015). Kāmana are considered a taonga species to Māori, meaning not only is their protection of great importance to New Zealand bird biodiversity, it also has cultural significance. Conservation efforts have been made to protect and grow the populations of the kāmana. The implementation of nesting platforms in Lake Wanaka has led to the occupation of several kāmana pairs after several years of just a singular pair occupying the area (DOC, 2015). Likewise, predator trapping efforts at Lake Pearson increased the amount of successfully hatched and fledged chicks; the lake is now known as a significant breeding site for kāmana in Canterbury (DOC, 2003).

SMCR has the opportunity to act as a supportive habitat for this species given the high abundance of lake margin vegetation available and the potential reduction of mammalian predators due to the trapping project. It would be beneficial for NZCT to invest in further conservation methods for the species in the future such as artificial nesting platforms.

6.1.4 Australasian Bittern / Matuku

The Australasian bittern/matuku (*Botaurus poiciloptilus*), is a globally endangered species. They are specialist wetland birds whose populations have declined by ~50% in the last century. There have been varying reasons for the decline of the matuku; including habitat degradation and modification, and the introduction of pests (O'Donnell & Robertson, 2016).

Matuku is one of the wetland species most vulnerable to introduced mammalian predators due to their ground-level nesting sites. Matuku can be used to indicate wetland ecosystem health as their occurrence depends on predator-free environments (Gilbert et al., 2007; O'Donnell, 2011). It is unclear what the true abundance of matuku is, although it is predicted there are fewer than 1000 individuals in New Zealand (O'Donnell, 2011). They are continually disappearing from areas around the country and are now no longer inhabiting the Chatham Islands (O’Donnell et al., 2015). All life stages of the matuku are known to be preyed on; most commonly eggs, chicks, and fledglings (Gilbert et al., 2007; O’Donnell et al., 2015). Matuku only have one clutch per year, approximately four eggs per season (O’Donnell et al., 2015).

SMCR has huge potential to support the bittern through predator reduction. As a single matuku has been observed in SMCR recently, they could be used as an indicator organism to measure the health of the wetland and measure the success of the trapping project.

6.1.5 Bellbird / Korimako

The bellbird/korimako (*Anthornis melanura*), is an endemic species found throughout New Zealand (Heather & Robertson, 2005). They are vital forest pollinators, feeding on plant nectar with their brush-like tongues. Like the kererū, korimako also disperse the seeds of fruits they eat, helping to keep healthy tree populations and promote plant biodiversity (DOC, n.d. (c)). Native species such as kotukutuku and kowhai benefit greatly from the presence of korimako (Chambers, 2009). Increasing plantings further will promote more pollinators such as bees, overall increasing biodiversity and health of SMCR as a mahinga kai site (DOC, n.d. (c)).

Korimako provide socio-ecological services to the areas they reside. Their distinct, bell-like song adds to the natural soundscape and rings out amongst other bird calls (Chambers, 2009). Korimako populations swiftly declined as common introduced predators such as rats and stoats arrived in the late 1800s. Sightings are still said to be rare in Canterbury, giving SMCR a special opportunity to support populations of Korimako in future years (DOC, n.d. (c)).

6.2 Benchmarks

After both qualitative and quantitative analysis, several ecological diversity benchmarks were developed. An initial measure of success would be to see an increase in the diversity of native bush and wetland birds. Fig. 5 demonstrates the ideal trajectory diversity could potentially follow, with the 2020 point displaying the current diversity at SMCR for both native wetland and bush species. This trajectory is hypothetical, and it is recommended that NZCT models diversity off a reserve of a similar size that has had trapping in place for a longer period of time. This will allow NZCT to understand how bird diversity could potentially respond to predator control. It is likely that the rate at which diversity increases will eventually slow and stabilise as carrying capacity is reached (J. Briskie, personal communication, September 24, 2019). Carrying capacity refers to the maximum population that an environment can support due to resource shortages (Wang et al., 2018).

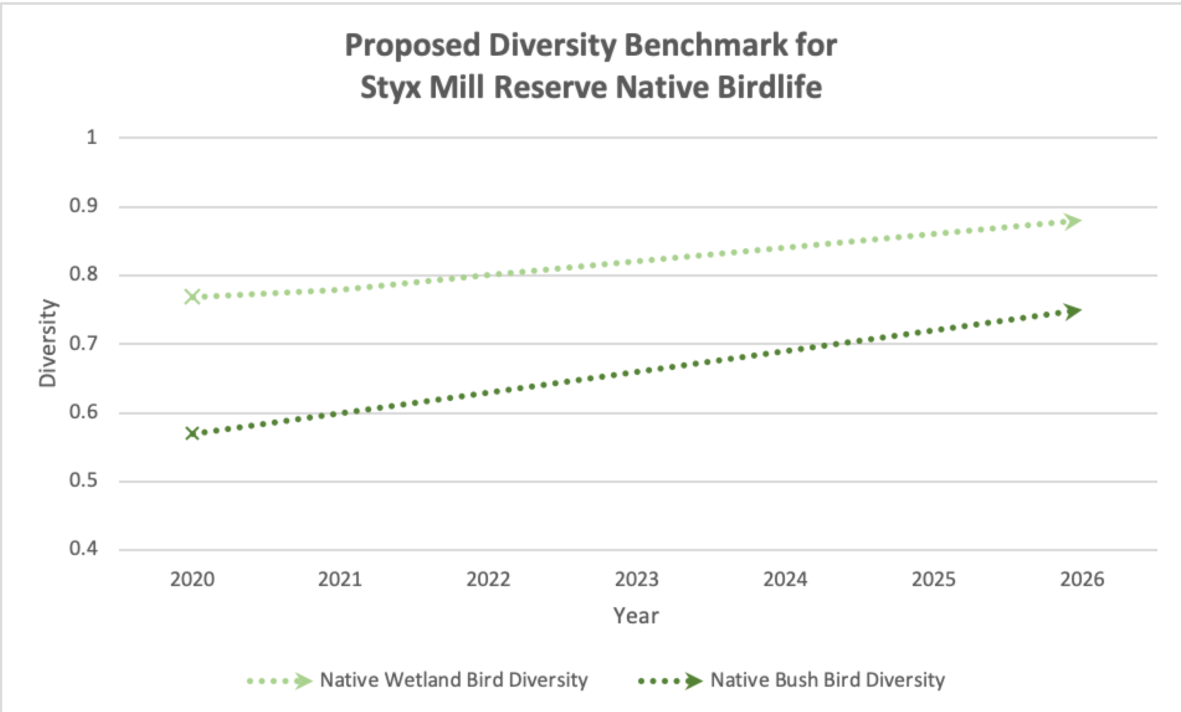

Fig. 5. Hypothetical trajectory for future diversity of native bush birds and wetland birds. Adapted from Checklist to the Birds of Styx Mill Conservation Reserve, 5th update to January 2013, by A.C. Crossland, 2013 (Unpublished Report for Greenspace Unit, Christchurch City Council); New Zealand eBird; Styx Mill Walkway, by SLLT Bird 2015-2020. https://ebird.org/newzealand/hotspot/L2484336

A further measure of success would be to see a stabilisation between the diversity of native and introduced birds. The optimal outcome from the trapping program would be for native birds to increase in diversity, while introduced birds either decline or stabilise (Fig. 6, Fig. 7) (J. Briskie, personal communication, September 24, 2020). The rationale behind opposing an increase in introduced diversity is due to concerns that this could impact native birds through competition, predation, habitat alterations, and spread of disease (Grarock et al., 2012).

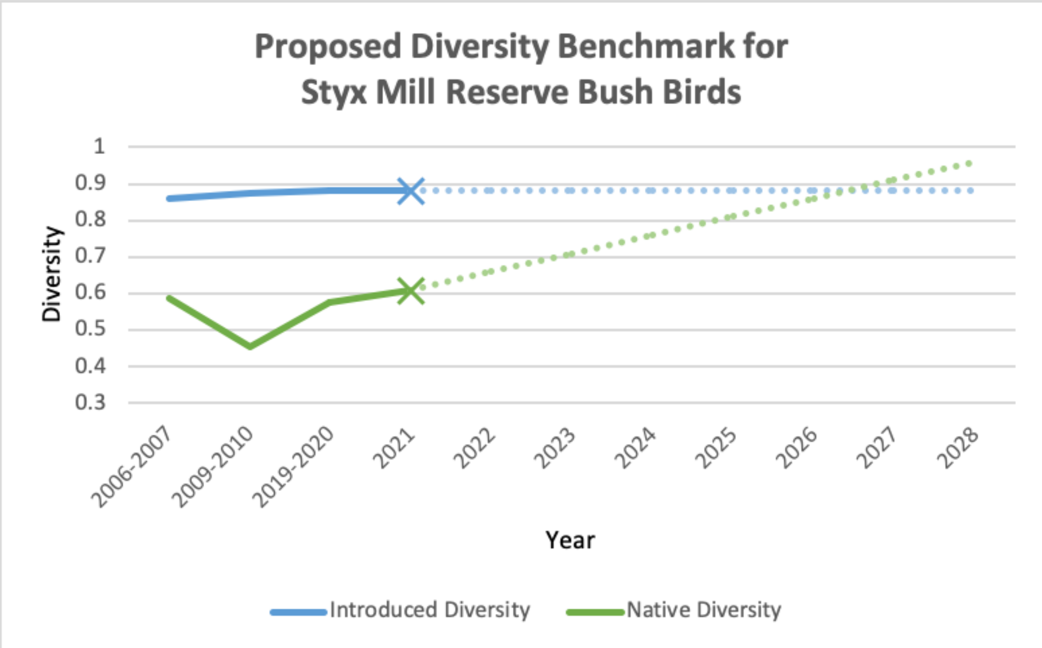

Fig. 6. Proposed diversity trajectory for native vs. introduced bush bird species. Adapted from Checklist to the Birds of Styx Mill Conservation Reserve, 5th update to January 2013, by A.C. Crossland, 2013 (Unpublished Report for Greenspace Unit, Christchurch City Council); New Zealand eBird; Styx Mill Walkway, by SLLT Bird 2015-2020. https://ebird.org/newzealand/hotspot/L2484336

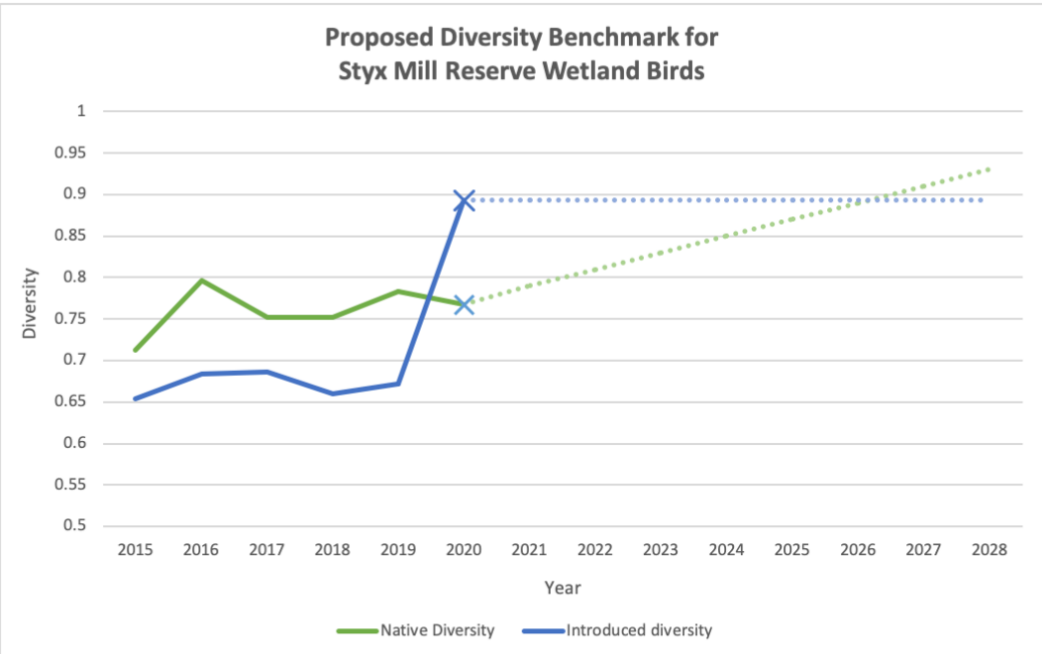

Fig. 7. Proposed diversity trajectory for native vs. introduced wetland bird species. Adapted from Checklist to the Birds of Styx Mill Conservation Reserve, 5th update to January 2013*, by A.C. Crossland, 2013 (Unpublished Report for Greenspace Unit, Christchurch City Council);* New Zealand eBird; Styx Mill Walkway*, by SLLT Bird 2015-2020. https://ebird.org/newzealand/hotspot/L2484336*

Additionally, it would be beneficial for NZCT to focus on increasing the diversity of rare, threatened or adored native birds, rather than common introduced birds that do well in most environments.

This leads to the final measure of progress, an increase in the observations of the five selected indicator species. As previously discussed, these indicator species are vulnerable to predation. Seeing an increase in the populations of these birds suggests that the trapping project is successfully reducing the number of predators in the SMCR. It is important to note that the populations of the chosen indicator species vary in size. For example, kererū normally gather in groups of 20 - 50, while there are typically only a few pairs of matuku at one site (J. Briskie, personal communication, September 24, 2020; Powlesland, 2013).

7. Recommendations

7.1 Limitations

There were multiple limitations throughout this project. This primarily occurred due to the lack of one cohesive data set. Two sets of data were provided by the NZCT to establish ecological biodiversity benchmarks. The first provided a high standard of bush bird data that was observed using a line transect over the space of a year. However, only three years' worth of data was collected over 14 years. The lack of continuous data made it difficult to measure annual bird population changes and the fluxes of bird abundance and diversity.

The second dataset was provided from the eBird database. Although eBird has a large quantity of data, not all of this was of high enough quality for the required data analysis. eBird data can be captured by the public, which introduces many variants within collection methods. One eBird dataset, collected by SLLT, was of high enough standard making it dependable and suitable for the analysis but only included wetland species. As both datasets were collected observing different bird types using multiple methods and varying time frames this created difficulties analysing overall bird diversity within SMCR.

Establishing improved bird monitoring methods outlined in section 7.4 would allow for a high standard of data collection of both bush birds and wetland bird species.

7.2 Mana whenua engagement

The Styx River Catchment was traditionally a site of mahinga kai and has held cultural and traditional values since early settlement over 600 years ago (Beattie, 1945). SMCR may be a wāhi tapu or support important taonga species. This would require engagement with local iwi in order to take kaitiakitanga into account when making suggestions for future practice at SMCR.

Furthermore, as the ecological diversity benchmark literature suggested, current conservation methods may not align with values held by mana whenua regarding trapping and killing one species, in order to preserve another (Martín-López & Montes, 2015; Mehring et al. 2017). This is a potential area of conflict between conservation management and local iwi.

It is recommended NZCT pursues a relationship with mana whenua, Ngāi Tūāhuriri, to integrate indigenous practice and mahinga kai values into future efforts at SMCR.

7.3 Predator control methods

Due to the high abundances of rats recorded in the NZCT trapping data, an investigation into different species caught in the traps would be beneficial for future conservation efforts. The ship rat *(Rattus rattus)* is suggested to be the largest threat to native New Zealand birdlife as they are skilled tree climbers and have the ability to reach difficult to reach nests (Predator Free NZ, n.d.). In comparison, the Norway rat *(Rattus norvegicus)* predominantly preys on ground-nesting birds such as the kāmana (Predator Free NZ, n.d.). Understanding what species are predominantly present at SMCR may assist in understanding the influence the trapping may have on particular birds i.e. ground nesting or tree nesting species.

It is suggested that NZCT identify and record the species of rats caught in the DOC 200 traps on collection days and implement a tracking tunnel programme. This will allow NZCT to further quantify the species of predators and their abundances within SMCR.

7.4 Data collection methods

Over the last 15 years, the line transect bird count has only been carried out on three occasions. Regular bird monitoring will give a better indication of the birds that are consistently present. Two proposed point counts are shown have been positioned near water to detect a diverse range of species (Fig. 8). One of the suggested point counts is located on Contemplation Point; while the other is located between the stream and the wetland. Standard practice is to monitor at each point for a five-minute period. The distance from the observer can be categorized into 3 distances which includes 0 - 25 metres, 25 - 50 metres, and 50 + metres (Hamel et al., 1996).

It is also proposed another line transect count is implemented. The suggested line runs approximately 230 metres along Panako Walkway and starts 35 metres from the bridge (Fig. 7). To minimise observer biases relating to miscalculations of distances line transect widths should be kept consistent. It is suggested NZCT remains with the 10 metres either side of the path for each line transect that is established. Ideally, counts will be carried out on a monthly basis at a consistent time.

A major variable that creates inconsistencies with bird monitoring data is the observers ability to identify bird species. This bias is relatively easy to mitigate. It is recommended that observers complete specific site training and regular reliability tests (Heezik & Seddon, 2012; J. Briskie, personal communication, September 24, 2020; Rosenstock et al., 2002).

Fig. 8. Map of the Styx Mill Reserve with the current line transect as well as the additional proposed line transect and point count locations. Figure generated via Google Earth by Cummack, E.

7.5 Community engagement

The five indicator species selected for our study have inherent value not only for the ecosystem and mana whenua, but also for the wider community. In a survey undertaken in Waikato region, 200 people were questioned regarding the value of native bird species. In this survey, 97% of those asked enjoyed hearing or seeing birds in the area (Kaval & Roskruge, 2009). It is likely these results represent the attitude of much of the New Zealand population. In another survey, it was found that native birds are considered to be the most valued species in New Zealand (Russell, 2014).

The increase in the abundances of the focal species at SMCR could increase its social value. Public knowledge of the recently established trapping regimes may further increase support for NZCT's efforts. The potential outcome of this is that more people would frequent SMCR, leading to wider public interest and funding opportunities.

7.6 Future Research

A valuable next research step would be an investigation into a reserve of similar size that has had a trapping programme implemented for a significant amount of time. Alongside this, it would be beneficial to estimate the carrying capacity of SMCR. This will allow NZCT to determine whether stabilisation is due to carrying capacity being met or other factors, such as an increase in predation.

8. Conclusion

The identification of an appropriate ecological biodiversity benchmark for SMCR will be successful in measuring future conservation efforts against. Our suggested benchmarks are:

1. *An increase in native bird diversity and balancing of native vs. introduced diversity and;*
2. *An increase in abundance of the five suggested indicator species*

Recommendations made will aid NZCT in reaching these benchmarks. The future increase in bird abundance will not only increase the ecological value of SMCR but also the social value. Engaging mana whenua in biodiversity goals could lead to a broader and socio-ecological idea of what future conservation might look like, as well increasing cultural value within SMCR.

9. Acknowledgements

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