**Background**

The RG, in its management of hihi, needs to consider what sites are available for reintroduction. There is however considerable uncertainty about where translocations of hihi will do well. We accept supplementary feeding has costs and is undesirable for aesthetics and potentially other reasons. On the other hand, it can also be a helpful tool in advocacy. We have developed a set of explicit and measurable objectives:

1. Maximize number of hihi, measured by number of populations and the number of hihi in each population.
2. Maximize natural ecological setting, measured by the presence of non-native disease causing agents; presence of non-native predators; the number of rare alleles; the provision of sugar water and nest boxes.
3. Minimize costs, measured in $ spent.
4. Maximize public appreciation, measured by numbers of visitors to sites, numbers of publications and media posts/stories.

We need to develop alternative strategies to achieve these objectives. Using an adaptive management approach, we can identify the best strategy for managing multiple populations, including but not limited to translocations and provision of feeding, taking into account that improving our knowledge of how the system works can help us make better decisions in the future.

Adaptive management of hihi goes back 20 years, on Mokoia when birds where fed sometimes and not others, using predictive modelling, to meet the two of goals of managing populations while studying the effectiveness of different management, to keep improving in time. To be more effective with adaptive management, we as the recovery Group need to develop a framework for adaptive management of multiple populations, so we can apply the information collected from one population, e.g. about the results of supplementary feeding, to other populations. In the past, decisions have focused on expert judgment of habitat complexity and carrying capacity at current sites and potential sites and its relationship to survival and fecundity. New sites get discussed at meetings, but we need a more formal method to decide which sites get hihi and how to manage existing sites.

**Aim of the model**

The purpose of this model in particular is to provide information about different strategies and allow us to compare them. For example, we may have a strategy where birds are translocated annually from the largest population to the site that is currently unoccupied but which has the best estimated habitat quality. How will that strategy fare in terms of bird numbers, cost, advocacy? And will the information provided by adding a new site and observing the population dynamics allow us to make better decisions in the future?

**How the model works**

The model is based on a simulation. It is assumed that population growth responds to site characteristics and additional management, in particular (1) habitat quality and (2) provision of feeding, with an interaction between the two. We have limited information about the actual strength of that response. But we can learn by observing the outcomes of future translocations. For every simulation run, the model does the following:

1. Randomly draws a value for the strength of the relationship between site and management and population growth (either fecundity and survival, or site carrying capacity). This corresponds to a simulated “truth”; by drawing randomly over a large range, we are effectively carrying out a broad sensitivity analysis that reflects our currently limited knowledge.
2. Calculates “estimates” based on our current knowledge, for example the mean of a range of possible values for the (unknown) “truth” mentioned above. Makes a decision of whether, where and how many birds to move, and whether to manage them by feeding or any other criterion coded in a given management strategy. For example, move birds to the site with the highest estimated growth rate.
3. Simulates the outcomes of that decision (how many birds survive on each island), depending on the strategy used, and the simulated “true” parameters.
4. Takes those outcomes as observed, and passes them to an estimation model which then updates our initial “estimates”. This effectively simulates how we would collect and treat information: after releasing birds and observing survival, we would put the data in a model to improve our estimates. We will never get to the “truth”, but ideally will get more and more refined estimates as more data are collected.
5. Again makes a decision, as in point (2), based on the updated estimates, and so on, simulating multiple years. Throughout the years, the underlying “true” parameters will remain the same, with possibly some variation (good and bad years), but our estimates should improve.

We can code as many possible strategies as we can think of (different rules for moving and feeding birds; for example, trying the removal of feeding at sites that seem to be doing well, or doing small translocations for genetic purposes, and so on), and compare the expected results.

**Considerations**

Site characteristics (mostly vegetation complexity), which in turn influence population dynamics, are largely based on “site complexity”, a method developed by Troy. This is a rapid vegetation analysis method, by looking at known nesting sites, and quantifying vegetation by point intercept sampling which combines diversity and amount of vegetation in tiers into a complexity score. For sites where this score is not directly measured, it is guessed by experts by ranking on a scale based on how we compared the vegetation on those sites versus the measured sites.

It is also important that our timescale does not allow much background change in site effects as this will hamper learning (if the thing we are learning about – in this case, site characteristics – is changing). We should consider time scales which balance a long enough time series to accrue knowledge but short enough for site based effects to not change substantially. This can include vegetation complexity, climate change and pest removal.

Ultimately, the idea is not to develop the perfect strategy but to be creative and compare strategies. For example, if we put all the birds on sites with fewer visitors, the results for a persistence objective may be good, but the public might not be engaged effectively. Strategies can combine general rules and site-specific ones (for example, set some population size below which we never harvest, but also never take birds from a given island, or never provide feeding on another, and so on). Simulation can also allow us to try creative things in a risk-free environment: for example, putting birds in islands perceived as poor may fail as a translocation in itself, but it might provide important information for assessing habitat suitability, which will then benefit future attempts.

Future extensions of the model can include dispersal from release sites; translocations for genetic purposes; site vulnerability to disease or predator incursions (it is assumed that any new site coming under consideration will already have met basic conditions such as being predator-free). In this sense, the group will need to discuss how to engage with stakeholders to involve them in the broader decision process.