The application of remote sensing technology for monitoring burrow-nesting seabirds

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One of the most acute threats to seabirds is introduced predators, which depredate seabirds at all life stages from eggs to adults. Consequently, predator eradication has been identified as an effective and commonly used seabird conservation method. Seabird recovery post-eradication is influenced by complex and interacting environmental and demographic factors, though gaps remain in our understanding of the speed at which ecosystems respond to seabird recolonization. While monitoring seabird colonies post-eradication can help improve this understanding, limited resources and the remoteness and number of seabird islands challenge our ability to achieving long-term monitoring and research objectives. Therefore, economical and effective monitoring tools are needed.

Remote sensing has been used for decades in agriculture to evaluate crop nutrient status. Advances in remote sensing tools have improved the quality and reliability of applying this technology to evaluate a ranges of ecological systems. Seabirds can introduce large quantities of guano, effectively fertilising their island habitats. Concentrations of ammonia in soils have been positively correlated to seabird burrow density, and deposition rates of nitrogen into low nesting density systems can be as much as 3 times the rate of standard agricultural fertilisation rates. Our research investigates if methods used for evaluating crop nutrient status on agricultural fields can be applied to a heterogeneous forest canopy. In this way, remote sensing could be used for monitoring long-term changes in seabird nesting density by evaluating canopy nutrient status.

To test this hypothesis, we are investigating the relationship between seabird burrow density, and soil nitrogen and canopy level nitrogen on islands in the Mercury Island group, off the east coast of the Coromandel. We used a UAV (unmanned aerial vehicle) mounted multispectral sensor to collect extremely high resolution images (5cm). This imagery is used to evaluate canopy composition and the spectral reflectance signature of pōhutukawa (*Metrosideros excelsa*), in relation to seabird density. We sampled and analysed soil and leaves from pōhutukawa trees on Korapuki (18 ha), Middle (13.5 ha), Green (2.5 ha), and Great Mercury (1867 ha) islands for total nitrogen and carbon:nitrogen ratios. Seabird nesting density on the islands ranges from low (1 burrow/m^2) to high (10 burrows/m^2). As expected, we found a strong relationship between seabird nesting density and soil nitrogen. However, our preliminary results indicate this relationship is not strongly transmitted to the canopy of pōhutukawa. This result may be attributed to the physiology of pōhutukawa, which is a highly stress tolerant species. Pōhutukawa distribution is predominantly coastal, trees must be adapted to salt spray, arid environments, poor quality soils, often establishing on rocky steep cliffs. We postulate that given these stress tolerant adaptions, pōhutukawa may uptake and store only the nutrients it requires for growth and homeostasis, and perhaps is limited by other resources, so is not responding to nutrient enrichment in a way that is detectable in canopy spectral reflectance.

With these results in mind, our research continues to evaluate the spectral response of other island canopy species to seabird nutrient enrichment, and the topographic and environmental influences that might affect forest canopy reflectance. In the coming field season, we will be evaluating the emergent canopy species māhoe (*Melicytus ramiflorus*) and milk tree (*Streblus banksii)* to compare the results of pōhutukawa with and identify other species that may act as proxies for evaluating seabird nesting density changes over time. Predator eradication is an effective tool for protecting New Zealand's seabirds. However, to ensure that seabirds populations are stable or increasing in the face of additional threats, such as fisheries and pollution, long-term monitoring is needed. Developing methods using remote sensing technology provides the opportunity to achieve these goals in an affordable way, across larger spatial scales than has been previously possible.