

Postgraduate research projects supervised by Ben Stevenson

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These projects are suitable for BSc (Hons) or MSc students at the University of Auckland. Please e-mail me (ben.stevenson@auckland.ac.nz) if you are interested in any of the following.

Modelling morphometric data of animal populations collected by drones

Measuring the size of animals by hand can be difficult because they might be big and scary (e.g., grizzly bears), react negatively to handling (e.g., manta rays), difficult to access (e.g., mountain goats), or too large for your tape measure (e.g., blue whales). We can avoid these problems by flying drones equipped with cameras over animals, but this method introduces the issue of measurement error: when we measure the size of an animal using a drone we don't get the answer quite right.

Myself and collaborators have developed a method to estimate population-level distributions of morphometric measurements in a way that accommodates drone measurement error. This project involves extending our existing model, and developing a user-friendly R implementation.

Requirements:

- A solid understanding of statistical theory (e.g., an excellent grade in STATS 310).
- Excellent R programming skills.
- Experience with C++, or a willingness to learn.

Fitting acoustic spatial capture-recapture models with `acre`

The R package `ascr` has been in development for over a decade, and provides functions to fit acoustic spatial capture-recapture (SCR) models. A new package, `acre` is currently under development, and is a complete rewrite of `ascr`, and includes a variety of new features.

In this project, we will refit models to data previously analysed using `ascr` and make extensions using `acre`'s new features. Our goals are (1) to test `acre` to ensure it gives comparable output to `ascr` when it is supposed to, (2) try out the new features of `acre` to ensure they work as we'd expect, and (3) create example analyses to use as training materials for ecologists.

Requirements:

- Excellent R programming skill (top grades in courses like STATS 220 and STATS 380 would be a big advantage).

Spatial occupancy models for kiwi in Fiordland National Park

In statistical ecology, occupancy models are used to estimate the probability of site occupancy—or in other words, the probability that a particular species is present at a particular location. If we

detect an animal at a site then we know it is occupied. However, if we fail to make any detections then we don't know if the site is unoccupied, or if we simply failed to detect animals that are present. Occupancy models overcome this challenge by treating site occupancy as a latent variable. Spatial occupancy models allow occupancy probabilities to vary between different sites due to observed environmental covariates (e.g., altitude and forest type) and/or due to other unobserved variables or latent processes.

The Department of Conservation, Te Papa Atawhai, have deployed acoustic recording devices throughout Fiordland National Park. This project involves using existing software to detect vocalisations of the kiwi in the recordings, and use these presence/absence data to fit spatial occupancy models. We will estimate the distribution of kiwi throughout Fiordland National Park, and how it has changed throughout the monitoring period.

Cosupervised by Oliver Gansell, Department of Conservation.

Requirements:

- Excellent programming skills (top grades in courses like STATS 220 and STATS 380 would be a big advantage).
- A solid understanding of statistical theory (high grades in courses like STATS 210 and STATS 310 would be an advantage).
- Some familiarity with Bayesian statistics would be beneficial, although not required.

Estimating animal population density and call production rates using spatial capture-recapture in the presence of partial identification

Acoustic spatial capture-recapture models can estimate animal population density from passive acoustic surveys, on which a researcher deploys microphones to record vocalisations produced by wildlife. The initial models did not require the user to identify which individual animal produced each detected call, but were only capable of estimating call density (calls produced per unit space per unit time) rather than the key parameter of interest, animal population density (animals per unit space). Later models could estimate both parameters, but required the user to identify which animal produced each detected call.

However, in some cases, some proportion of the population can be identified by their calls, while others can't. For example, perhaps animals that are located close to microphones can reliably be identified, whereas those that are further from the detectors cannot. In this project, we will develop new acoustic spatial capture-recapture models to handle this situation, allowing for the estimation of population density even when not all individuals can be identified from their calls.

Requirements:

- A solid understanding of statistical theory (e.g., an excellent grade in STATS 310).
- Excellent R programming skills.
- This project would be suitable for an excellent MSc student, or perhaps a PhD student.

Comparing methods to estimate call rate and animal density from passive acoustic surveys

Estimating animal density directly from passive acoustic surveys can be problematic, because it can be hard to tell if there are a small number of animals each producing a large number of sounds, or if there are a large number of animals each producing a small number of sounds. Many statistical methods can only estimate call density (calls produced per unit space per unit time), which is the

product the two parameters we might actually care about: animal density (animals per unit space) and call rate (calls produced per animal per unit time).

Acoustic spatial capture-recapture methods have recently been developed to untangle animal density and call rate, allowing researchers to estimate both parameters directly from a passive acoustic survey (Stevenson et al., 2021; Chan, 2022). Other recent studies have estimated call density using a more *ad hoc* approach, whereby two separate models are fitted to the detection data: one to estimate call density, and the other to estimate call rate (McGrath et al, submitted; Hankinson et al, in press). Animal density can then be obtained by finding the quotient of these two estimates.

Using the same data twice within a single analysis is a bit of a statistical no-no, and might compromise properties of our estimators. On the other hand, fitting the two separate models is easier, might work reasonably well if you're careful about how you do it, and doesn't carry the same data-processing demands as the all-in-one methods.

In this project, we will compare the two different approaches, investigate how well they each perform under various scenarios, and provide guidance to users of these methods.

Cosupervised by David Chan, University of Waikato.

Requirements:

- Excellent R programming skills.

References:

- Chan, D. K. E. (2022) *Spatial capture-recapture for acoustic surveys*. PhD thesis, University of Auckland.
- Hankinson, E., Korstjens, A. H., Hill, R. A., Wich, S. A., Slate, H. D., Abdullah, A., Supradi, S., Marsh, C. D., Nijman, V. (in press) Effects of anthropogenic disturbance on group densities of Thomas' langurs (*Presbytis thomasi*) within a lowland tropical forest, north Sumatra. *Ecological Research*.
- McGrath, S. J., Liu, J., Stevenson, B. C., and Behie, A. M. (submitted) Density and population size estimates of the endangered northern yellow-cheeked crested gibbon *Nomascus annamensis* in selectively logged Veun Sai-Siem Pang National Park in Cambodia using spatial capture-recapture analysis. *PLoS ONE*.
- Stevenson, B. C., van Dam-Bates, P., Young, C. K. Y., and Measey, J. (2021) A spatial capture-recapture model to estimate call rate and population density from passive acoustic surveys. *Methods in Ecology and Evolution*, 12(3), 432–442.

Random effects for multi-session acoustic spatial capture-recapture

Acoustic spatial capture-recapture (SCR) models estimate wildlife population density from detections of individuals' vocalisations. They can also be used to estimate how density varies over space in response to spatial covariates. However, often density varies according to covariates we haven't observed or cannot observe, or perhaps due mechanisms that are unrelated to spatial covariates (e.g., spatial clustering of social animals, or spatial separation of territorial animals).

A method has been developed to accommodate how density smoothly varies in a region surrounding a single cluster of detectors for physical-capture SCR (Seaton, 2021). However, it is based on latent Gaussian fields, which introduces a great deal of computational complexity.

Acoustic SCR surveys often involve a large number of small clusters of detectors, rather than one cluster of a large number of detectors. This project involves exploring the use of cluster-level random effects to accommodate spatial variation, rather than requiring a latent Gaussian field that varies smoothly over space. Such an approach has the potential to be far more computationally efficient.

Requirements:

- Very strong computational skills.
- A solid background in statistical theory.

References:

- Seaton, A. E. (2021) *Expanding the use of spatial modelling in ecology*. PhD thesis, University of St Andrews.

The fused lasso for spatial point patterns

The LASSO uses shrinkage to perform variable selection for linear regression problems. In this project, we will investigate using the fused LASSO, an extension of the standard LASSO, to model spatial point patterns. One possible application is to species distribution models in population ecology, perhaps allowing classification of a landscape into suitable and non-suitable habitat.

Requirements:

- A solid understanding of statistical theory (e.g., an excellent grade in STATS 310).
- Excellent R programming skills.