An Analytical Solution for Optimising Multi-species Detection Surveys

When undertaking surveillance for multiple species the probability of detecting each species at a site for a given level of survey effort is rarely 1. As such, there is a trade-off between the number of sites to survey, and the survey effort per site. Conservation budgets are limited and inherent costs of surveying need to be considered to ensure that survey design is optimal to meet required objectives. These costs can be simplified into two categories, site establishment costs and the cost of visiting, surveying or processing a site after establishment.

Here we examine a scenario in which s species occupy a fraction of the possible survey sites (ψ_i) and there is imperfect detection of the species during each survey when a species occupies a site (p_i). The establishment of a site has a fixed cost (c) and surveying a site entails a cost (t). The cost of establishing and surveying is constrained by the total survey budget available (B).

We show that the expected number of sites with detections for s species is maximised by visiting the site with a particular survey effort (v) and that this only depends on s, the ratio between c & t and q_i's. This general analytical solution allows for optimal surveillance effort for multi-species studies and ensures researchers are able to allocate their survey effort to maximise the detection of species across multiple sites.

To illustrate the application of the method we apply this to a multi-species surveillance program which monitored two species of forest owls and four arboreal marsupials.