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A Bayesian hierarchical modelling approach to estimating landbird detectability in a multi-species context

The NA-POPS project (https://na-pops.org) has developed an open-access database of detectability estimates for well over 300 species of North American landbirds to date. These detectability estimates are produced using the QPAD methodology developed by the Boreal Avian Modelling project. QPAD allows for estimates of the components of detectability (availability and perceptibility) for a given bird species to be derived from heterogenous removal and distance sampling methods, given a set of covariates and a sufficient number of data points. In cases where insufficient data is available for a given species, detectability estimates cannot be derived using the traditional QPAD methods. However, because bird species traits such as song pitch, body size, and habitat preference have been shown to predict detectability, species with similar traits may have similar detectability. Therefore, we can take advantage of information from data-rich species with specific traits to help inform estimates of detectability for data-sparse species with similar traits. One way to share information between units is by using hierarchical Bayesian models. Here, we present a hierarchical Bayesian implementation of the QPAD methodology that allows for estimates of availability and perceptibility to be derived within a multi-species context, allowing for the sharing of information between species with similar traits. Using designed simulation studies, we first demonstrate the validity of this Bayesian implementation by comparing results from this implementation to the current maximum likelihood QPAD models. Then, we show how this Bayesian implementation can improve detectability estimates for a simulated data sparse species that is modelled in a multi-species context with other simulated data-rich species. Finally, we apply this Bayesian implementation to the NA-POPS database, where we show how the sharing of information can help predict detectability of data-sparse species that NA-POPS could not previously model. This Bayesian QPAD framework is the next step in producing accurate detectability estimates for as many North American landbird species as possible. In turn, these detectability estimates will allow for better estimates of population sizes, and can facilitate data integration across disparate survey types.