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A Gibbs sampler for multi-species occupancy models

Multi-species occupancy (MSO) models use detection-nondetection data from several species observed at different locations to estimate the probability that a particular species occupies a particular location. The models are particularly useful for estimating the occupancy probabilities associated with rare species since they are seldom observed when undertaking field surveys. In this, article we develop Gibbs sampling algorithms that can be used to fit various Bayesian MSO models to detection-nondetection data. Bayesian analysis of these models can be undertaken using statistical packages such as JAGS and Stan, however, since these packages were not developed specifically to fit occupancy models, one often experiences long run times when undertaking analysis.

In a single-season (single-species) nonspatial and spatial occupancy modelling context, Clark and Altwegg (2019), show that special purpose Gibbs samplers can produce posterior chains that mix faster and have larger expected sampling rates (Holmes and Held (2006)) than those obtained using JAGS and Stan. These results suggest that such algorithms could potentially lead to significant reductions in the run-times of MSO models.

This article illustrates how to fit MSO models when the detection and occupancy processes are modelled using logit link functions and apply these methods to a camera-trapping study undertaken by Drouilly et al. 2018. Variable selection is undertaken using a reversible-jump Markov chain Monte Carlo (Barker and Link (2013)) algorithm. We found that the Gibbs sampling algorithm developed produces posterior samples that are identical to those obtained when using Stan, resulting in faster run times and has a larger expected sampling rate than Stan when analysing the above-referenced data set.