150

A penalized likelihood for multispecies occupancy models improves estimates of species interactions

Occurrence of species in space is influenced by biotic and abiotic environmental conditions. Interspecific interactions are important biotic conditions that are likely to have a strong influence on species distributions. As a consequence, contemporary statistical ecology research has focused on developing applications of joint species distribution modeling and multi-species occupancy modeling. A common challenge when modeling species interactions occurs when species are rarely or never observed at the same location. This can often be explained by spatial covariates, but strongly negative interactions between species can also lead to lack of observed co-occurrence and cause estimation problems in certain classes of multi-species occupancy models. In particular, failing to observe co-occurrences can lead to separation, whereby estimates of species interaction terms and their standard errors can be unreasonably large, often as a result of boundary estimates. In this talk, we demonstrate the application of a penalized likelihood to multi-species occupancy models when species are rarely or never observed at the same location. A penalized likelihood imposes a penalty on large absolute values of coefficient estimates, shrinking estimates toward 0. By imposing this penalty, a small amount of bias is introduced in coefficient estimates in return for a substantial reduction in estimated variance. We report simulation results demonstrating that when species are rarely or never detected at the same site, a penalized likelihood substantially reduces mean squared error and incidence of boundary estimates of estimated species interaction terms. However, we also demonstrate that at sample sizes common for many ecological studies, coverage of estimated species interaction terms may be lower than nominal, leading to overly precise estimates. We follow this with an application to avian point count survey data collected in the central Appalachian Mountains, USA. We highlight the problem of separation when estimating co-occurrence probability between two potentially interacting species that are never observed at the same site. We then demonstrate how a penalized likelihood can overcome such problems in practice and allow meaningful inference. We believe our application, which has been integrated into the Program R package “unmarked”, will be useful to many users of multi-species occupancy models.