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METHODS FOR ESTIMATING OCCUPANCY

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The estimation of the probability of occupancy of a site by a species is used to monitor the distribution of that species. Occupancy models have been widely applied and several limitations have been identified (see [2–5]). In this thesis we resolve some of these problems. In particular, we focus on limitations of maximum likelihood estimators (MLEs) and the associated interval estimators, and the difficulties associated with the extension from linear to generalised additive models (GAMs) for the relationship between occupancy and covariates.

Initially we consider in detail the basic occupancy model which includes two parameters, ψ and p. Our primary concern is the probability that the species occupies a particular site, ψ. The other parameter, the detection probability p, is a nuisance parameter. We first derive the joint probability mass function for the sufficient statistics of occupancy which allows the exact evaluation of its mean and variance, and hence its bias.

We show that estimation near the boundaries of the parameter space is difficult. For small values of detection, we show that estimation of occupancy is not possible and specify the region of the parameter space where MLEs exist, and give the equations for the MLEs in this region.

We next demonstrate that the asymptotic variance of the estimated occupancy is underestimated, yielding interval estimators that are too narrow. Methods for constructing interval estimators are then explored. We evaluate several bootstrap-based interval estimators for occupancy. (This work has appeared in [1].)

Finally, instead of the full likelihood we consider a partial likelihood approach. This gives simple closed-form estimators in a basic model with only a small loss of efficiency. It greatly simplifies the inclusion of linear and nonlinear covariates by

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allowing the use of standard statistical software for generalised linear model and GAM frameworks, and in our simulation study there is little loss of efficiency compared to the full likelihood.

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