Online supplementary material: Ghostbusting - Reducing bias due to identification errors in spatial capture-recapture histories

Abinand Reddy Kodi[1], Jasmin S. Howard[1], David L. Borchers[1], Hannah Worthington[1], Justine Shanti Alexander[2], Purevjav Lkhagvajav[3], Choidogjamts Byambasuren[3], Gantulga Bayandonoi[4], Munkhtogtokh Ochirjav[4], Sergelen Erdenebaatar[4], Nyamzav Battulga[4], and Koustubh Sharma[2]

[1]Centre for Research into Ecological and Environmental Modelling, School of Mathematics and Statistics, University of St Andrews, The Observatory, St Andrews, Fife, KY16 9LZ, Scotland

[2]Snow Leopard Trust, 4649 Sunnyside Avenue North, Suite 325, Seattle, WA 98103, USA

[3]Snow Leopard Conservation Foundation, 602, Khan uul tower, 3th khoroo, Khan Uul district, Mongolia

[4]World Wide Fund for Nature - Mongolia, Amar Str. 4, Internom office, 400, Ulaanbaatar 14200, Mongolia

S1 Diagnosing Ghosts - Hypothesis Test

The cost in reduced estimation precision that results from discarding single detections may outweigh the gain in reducing bias caused by the presence of ghosts, particularly for surveys of elusive species where the number of detections is low. This is particularly the case if the ghost creation rate is very low. We therefore propose a test to detect the presence of ghosts. This can be used to decide whether to conduct inference with $K = 2$ (which we call the SCR-2 model) or $K = 1$ (a standard SCR model that includes single detections).

S1.1 Method

The null hypothesis is that there are no ghosts present and the alternative is that there is at least one ghost present. Our test statistic, t, is the number of singletons, individuals detected only once. Under the null hypothesis, $t \sim \text{Po}(E(t))$, where

$$E(t) = \int_{\boldsymbol{X}} p(\omega_{i\cdot} = 1|\boldsymbol{s}; \widehat{\boldsymbol{\theta}}) D(\boldsymbol{s}; \widehat{\boldsymbol{\phi}}) d\boldsymbol{s}, \tag{1}$$

is the expected number of single detections under the estimated parameters $\widehat{\boldsymbol{\theta}}$ and $\widehat{\boldsymbol{\phi}}$ from fitting the SCR-2 model.

S1.2 Simulations - Power Analysis

We conduct the hypothesis test on the 1600 sets of capture histories simulated. The test statistic, the expected number of single captures, for each set of capture histories is computed using the parameter estimates from the SCR-2 model. We chose a significance level $\alpha = 5\%$ and evaluate the power of the hypothesis test Figure 1. The hypothesis test successfully rejected the null hypothesis ¿95% of the time, only in scenarios of high total abundance, high encounter rates and high number of ghosts introduced. Even with a high number of ghosts introduced at low abundance and low encounter rates, we were only able to reject the null hypothesis around 50% of the time. Furthermore, we reject the null hypothesis consistently more than 5% of the time even when there are no ghosts at low encounter rates.

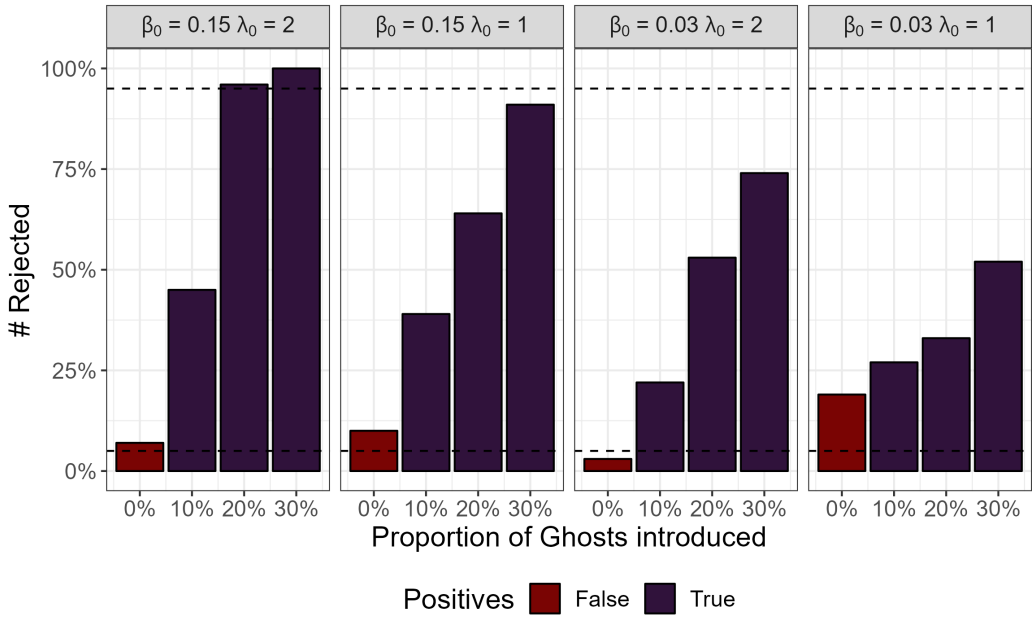

Figure 1: Results of the hypothesis test on the 1600 simulated capture histories at different levels of abundance, encounter rates and proportions of ghosts introduced. The bars represent the percentage of times the null hypothesis was rejected. Red bars represent the percentage of times the null hypothesis, of no ghosts, was rejected when there were no ghosts and blue bars represent the percentage of times the hypothesis test successfully rejected the null hypothesis when ghosts capture histories were present. The dashed lines highlight 5% and 95% levels.