

## *Ecological Archives* E091-239-A2.

Beth Gardner, Juan Reppucci, Mauro Lucherini, and J. Andrew Royle. 2010. Spatially explicit inference for open populations: estimating demographic parameters from camera-trap studies. *Ecology* 91:3376–3383.

Appendix B: Survival and Recruitment for  $T > 2$ .

When the number of primary sample occasions is greater than 2, we must formulate the model for recruitment by introducing another latent variable. We do this in order to ensure that an individual can only be recruited once into the population. Here, this formulation of the model uses a set of latent indicator variables  $r(i,t)$  which describe the time interval  $(t-1, t)$  at which individual  $i$  is recruited into the population. Let  $r(i,t) = 1$  if individual  $i$  is recruited in time interval  $(t-1, t)$ , otherwise  $r(i,t) = 0$ . To construct the recruitment process we make use of the standard conditional binomial construction of a removal process (Royle and Dorazio 2008). The initial state is given by:

$$r(i, 1) \sim \text{Bin}(1, \gamma_1)$$

for  $i = 1, 2, \dots, N$ . Then, for  $t > 1$

$$r(i, t) | r(i, t-1) \dots r(i, 1) \sim \text{Bin} \left( \left(1 - \sum_{\tau=1}^{t-1} r(i, \tau)\right) \times \gamma_t, 1 \right)$$

Thus each recruitment variable is conditional on whether it was ever previously recruited and this construction forces the recruitment variable after initial recruitment to be degenerate (have a sample size of 0). Then, we can describe the state variables  $z(i,t)$  by a 1st order Markov process. For  $t = 1$ , the initial states are fixed:

$$z(i, 1) \equiv r(i, 1)$$

and, for subsequent states, we have

$$z(i, t) | z(i, t-1), r(i, t) \sim \text{Bern}(\phi_t z(i, t-1) + r(i, t)).$$

Thus, if an individual is in the population at time  $t$  (i.e.,  $z(i,t) = 1$ ), then that individual's status at time  $t+1$  is the outcome of a Bernoulli random variable with parameter (survival probability)  $\phi_t$ . If the individual, however, is not in the population at time  $t$  (i.e.,  $z(i,t) = 0$ ), then the outcome is a Bernoulli random variable with probability  $\gamma_t$ , a parameter that is related to *per capita* recruitment.

LITERATURE CITED

Royle, J. A., and R. M. Dorazio. 2008. Hierarchical modeling and inference in ecology: the analysis of data from populations, metapopulations and communities. Academic Press, San Diego, California, USA.