

1 Feuka, A. B., Nafus, M. G., Yackel Adams, A. A., Bailey, L. L., and Hooten, M. B. 2022.  
 2 Individual heterogeneity influences the effects of translocation on urban dispersal of an invasive  
 3 reptile. *Movement Ecology*.

## 4 **Additional File 2 - Second Stage Metropolis-Hastings Ratios**

5 In the second stage of model fitting, we used the following generalized Metropolis-Hastings ratio:

$$r_{jl}^k = \frac{[y_i | \alpha_{il}^*, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}] [\alpha_{il}^* | \psi, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}] [\alpha_{il}^{k-1} | y_i]_*}{[y_i | \alpha_{il}^{k-1}, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}] [\alpha_{il}^{k-1} | \psi, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}] [\alpha_{il}^* | y_i]_*}. \quad (\text{Eqn S1})$$

6 where  $\alpha_{il}$  is the  $l^{\text{th}}$  parameter in the vector of parameters for individual  $i$ . Superscript  $k$   
 7 indicates the index for the current MCMC iteration,  $*$  indicates a proposed value,  $\psi$  is a vector  
 8 of hyperparameters for  $\alpha_{il}$ , and  $*$  indicates the second-stage proposal distribution (not the  
 9 second-stage marginal posterior distribution of  $\alpha_{il}$ ). Here,  $[y_i | \alpha_{il}^*, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}]$  is the  
 10 likelihood of the data given the individual-level model parameters, one of which is being  
 11 updated ( $\alpha_{il}^*$ ), some that have already been updated ( $\alpha_{i,1:l-1}^k$ ), and some that remain to be updated  
 12 ( $\alpha_{i,l+1:L}^{k-1}$ ) in MCMC iteration  $k$ .

13 The process distribution for  $\alpha_{il}^*$ ,  $[\alpha_{il}^* | \psi, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}]$ , accounts for cases in which  $\alpha_{il}^*$  is  
 14 correlated with other parameters in the second stage. This is the case for  $\beta_i$  in our model, which  
 15 were sampled jointly in the first stage and individually in the second stage, but remain correlated  
 16 with one another in the second stage. Therefore, when updating each  $\beta_{il}$  in the second stage, the  
 17 prior uses the joint distribution

$$\begin{pmatrix} \beta_o \\ \beta_u \end{pmatrix} \sim N \left( \begin{pmatrix} \mu_{\beta,o} \\ \mu_{\beta,u} \end{pmatrix}, \begin{pmatrix} \Sigma_{\beta,oo} & \Sigma_{\beta,ou} \\ \Sigma_{\beta,uo} & \Sigma_{\beta,uu} \end{pmatrix} \right) \quad (\text{Eqn S2})$$

18 to account for the fact that some  $\beta$  coefficients have been updated, and some have not (Cressie,  
 19 1990; Hooten, Johnson, McClintock, et al., 2017). Therefore, the process distribution for each  $\beta_{il}$   
 20 is  $[\beta_{il} | \mu_{\beta,j}, \Sigma_{\beta,j}, \beta_{i,1:l-1}^k, \beta_{i,l+1:L}^{k-1}]$ .

21 In two-stage proposal-recursive computation, the proposal distribution is the marginal  
 22 posterior distribution from the first stage  $[\alpha_{il}|\mathbf{y}_i]_*$ , where  $_*$  denotes this as the second-stage  
 23 proposal distribution and not the second-stage posterior distribution of  $\alpha_{il}$ . To reduce  
 24 computation time, we approximated  $[\alpha_{il}|\mathbf{y}_i]_*$  using the kernel density estimate calculated from  
 25 each parameter's first-stage samples. We thus obtain the following MH ratio for each  $\beta_{il}$ :

$$r_{jl}^k = \frac{\left( \prod_{t=3}^{T_i} [\delta_{it} | \gamma_i^k, \theta_i^k, \sigma_{1,i}^{2(k)}, \beta_{il}^*, \beta_{i,1:l-1}^k, \beta_{i,l+1:L}^{k-1}] \right) \times [\beta_{il}^* | \boldsymbol{\mu}_{\beta,j}, \boldsymbol{\Sigma}_{\beta,j}, \beta_{i,1:l-1}^k, \beta_{i,l+1:L}^{k-1}] [\beta_{il}^{k-1} | \boldsymbol{\delta}_i]_*}{\left( \prod_{t=3}^{T_i} [\delta_{it} | \gamma_i^k, \theta_i^k, \sigma_{1,i}^{2(k)}, \beta_{il}^{k-1}, \beta_{i,1:l-1}^k, \beta_{i,l+1:L}^{k-1}] \right) \times [\beta_{il}^{k-1} | \boldsymbol{\mu}_{\beta,j}, \boldsymbol{\Sigma}_{\beta,j}, \beta_{i,1:l-1}^k, \beta_{i,l+1:L}^{k-1}] [\beta_{il}^* | \boldsymbol{\delta}_i]_*}. \quad (\text{Eqn S3})$$

26 For movement parameters  $\gamma_i$ ,  $\theta_i$ , and  $\sigma_{1,i}^2$  in our model, the process distribution is simplified  
 27 because these parameters are sampled individually in the second stage. The generalized process  
 28 distribution for these parameters simplifies to  $[\alpha_{il}|\boldsymbol{\psi}]$ , where  $\boldsymbol{\psi}$  are parameters from each  
 29 movement parameter's prior distribution. This results in the following MH ratio for  $\gamma_i$ ,  $\theta_i$ , and  
 30  $\sigma_{1,i}^2$ , simplified from S1:

$$r_{jl}^k = \frac{[\mathbf{y}_i | \alpha_{il}^*, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}] [\alpha_{il}^* | \boldsymbol{\psi}] [\alpha_{il}^{k-1} | \mathbf{y}_i]_*}{[\mathbf{y}_i | \alpha_{il}^{k-1}, \alpha_{i,1:l-1}^k, \alpha_{i,l+1:L}^{k-1}] [\alpha_{il}^{k-1} | \boldsymbol{\psi}] [\alpha_{il}^* | \mathbf{y}_i]_*}. \quad (\text{Eqn S4})$$