Appendix S4

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## Overview

Drake, J. C., Lambin, X., and Sutherland, C. 2022. Spatiotemporal connectivity dynamics in spatially structured populations. Journal of Animal Ecology. DOI: 10.1111/1365- 2656.13783

Supplemental information referred to as Appendix S4 in text, including NIMBLE code for dynamic metapopulation code with prior distribution details and GoF test statistic calculation

## Nimble Dynamic Metapopulation Model

Save this as a separate R script named “nimblecode.R” so that it can be sourced by execution script.

###################################################################  
# A Col-Ext metapopulation Goodness-of-Fit Freeman Tukey test model  
# Data:  
# Area: a vector of patch sizes  
# dmat: npatch x npatch distance matrix  
# Y: npatch x nyears matrix of detection FREQUENCIES  
# K: npatch x t matrix of number of VISITS  
# nsite: numnber of patches  
# nyear: numnber of years  
  
SPOM\_GoF <- nimbleCode({  
   
 #~~~~~~~PRIORS~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#  
   
 #PSI1 prior  
 psi1 ~ dunif(0,1)  
   
 #detection prior  
 p\_mu ~ dnorm(0,0.001)  
 p\_sd ~ dunif(0,10)  
 p\_tau <- pow(p\_sd, -2)  
 for(t in 1:(nyear.obs)){  
 P\_t[t] ~ dnorm(p\_mu, p\_tau)  
 logit(p\_t[t]) <- P\_t[t]  
 }  
   
 #####connectivity model priors  
  
 b1\_mu ~ dnorm(0, 0.01)  
 b1\_sd ~ dunif(0,10)  
 b1\_tau <- pow(b1\_sd, -2)  
   
 alpha\_mu ~ dnorm(0, 0.01)  
 alpha\_sd ~ dunif(0, 10)  
 alpha\_tau <- pow(alpha\_sd, -2)  
   
   
   
 for(t in 1:(nyear.sim-1)){  
   
 Alpha[t] ~ dnorm(0, alpha\_tau)  
 alpha[t] <- alpha\_mu + c.dyn\*Alpha[t]  
 sigterm[t] <- 1/(exp(alpha[t]))   
   
 B1\_t[t] ~ dnorm(0, b1\_tau)  
 b1\_t[t] <- exp(b1\_mu + c.dyn\*B1\_t[t])  
   
 }  
   
   
   
 #extinction model priors  
 # logit(ext) = g0 + g1 \* Area  
 g0\_mu ~ dnorm(0, 0.01)  
 g0\_sd ~ dunif(0,10)  
 g0\_tau <- pow(g0\_sd, -2)  
 g1\_mu ~ dnorm(0, 0.01)  
 g1\_sd ~ dunif(0,10)  
 g1\_tau <- pow(g0\_sd, -2)  
   
 #time specific random transition parameters  
 for(t in 1:(nyear.sim-1)){  
 G0\_t[t] ~ dnorm(0, g0\_tau)  
 G1\_t[t] ~ dnorm(0, g1\_tau)  
 g0\_t[t] <- g0\_mu + e.dyn\*G0\_t[t]  
 g1\_t[t] <- g1\_mu + e.dyn\*G1\_t[t]  
 }  
   
   
 #~~~~~~~Likelihood~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#  
   
 for(i in 1:nsite){ #initial occupancy t0  
 z[i,1] ~ dbern(psi1)  
 }  
   
 for(k in 2:nyear.sim){ #for occupancy t1 and after  
 for(i in 1:nsite){   
 for(j in 1:nsite){  
 con[i,j,k-1] <- exp(-sigterm[k-1] \* dmat[i,j]) \* #kernel  
 (1 - equals(i,j)) \* #self  
 max(z[j,k-1], struct) \* #functional weight  
 Area[j] #area weight contrib   
 }  
   
 #transition probs  
 conx[i,k-1] <- sum(con[i,1:nsite,k-1])  
 #logit(col[i,k-1]) <- b0\_t[k-1] + b1\_t[k-1] \* conx[i,k-1]   
 col[i,k-1] <- 1-exp(-b1\_t[k-1]\*conx[i,k-1]) # akin to Sutherland et al. 2014 to help with model convergence  
 logit(ext[i,k-1]) <- g0\_mu + g1\_mu \* Area[i]  
   
 #occupancy  
 mu.z[i,k-1] <- z[i,k-1] \* max(0.001, min((1-ext[i,k-1]), 0.999)) +  
 (1 - z[i,k-1]) \* max(0.001, min(col[i,k-1], 0.999))  
 z[i,k] ~ dbern(mu.z[i,k-1])  
 }  
 }  
 #### observation model  
 for(i in 1:nsite){  
 for (t in 1:nyear.obs){  
 mu.p[i, t] <- z[i,t] \* p\_t[t]   
 Y[i, t] ~ dbin(mu.p[i, t], K[i,t])  
  
 # ## observation level GOF stuff ###############################################  
  
   
 # sim & observed data  
 yrep[i,t] ~ dbin(mu.p[i,t]\*z[i,t], K[i,t]) # or K[i,t]? Also is it p\_t[t]?  
 yexp[i,t] <- mu.p[i,t]\*K[i,t]\*z[i,t] + 0.001 # or K[i,t]? Just p\_t?  
   
 #Freeman-tukeys   
 x2.obs[i,t] <- pow((sqrt(Y[i,t]) - sqrt(yexp[i,t])), 2)  
 x2.sim[i,t] <- pow((sqrt(yrep[i,t]) - sqrt(yexp[i,t])), 2)  
   
 }  
 }  
   
 ## sum over observation ############################################  
 chi2.obs <- sum(x2.obs[1:nsite,1:nyear.obs]) # sum over observations outside the loop  
 chi2.rep <- sum(x2.sim[1:nsite,1:nyear.obs]) # sum over replicates outside the loop   
   
 #### Derived parameters  
 for(t in 1:nyear.sim){  
 m.occ[t] <- sum(z[1:nsite,t])   
  
 }  
  
})