CSP4141\_Wednes\_FollowAlongEx\_MS-Occupancy

Wednesday, May 23rd, 2018

“Introduction to Multi-Season -Single-Species Occupancy Model” Follow-Along Exercise

First, we will simulate a data set with values needed for the multi-season model (i.e., number of sites, years, and surveys per year). We are generating a single realization from a stochastic system that we are defining (by specifying bounds). The values for the parameters for each year will be drawn from a uniform distribution bounded by specific quantities.

nSites <-100 # number of sites  
nYears <-5 # number of years of surveys (primary sample periods)  
nSurveys <- 3 # number of surveys (secondary sample periods)  
psi <-rep(NA, nYears) # Occupancy Probability  
expectedOcc <- z <-array(dim= c(nSites, nYears)) # Expected and realized occurrence  
y<- array(NA, dim=c(nSites, nSurveys, nYears)) # Detection histories (data)  
set.seed(13973)  
psi[1] <-0.4 # Initial occupancy probability  
p <-c(0.1,0.3,0.5,0.5,0.2)  
phi <-runif(n=nYears-1, min=0.6, max=0.8) # Survival probability (1-epsilon)  
gamma <- runif(n=nYears-1, min=0.1, max=0.2) # Colonization probability

Recall unMarked utilizes hierarchical structures, so now we need to generate latent states of occurrence. We’ll generate the initial occupancy state and the latent occupancy for subsequent years (after year 1).

z[,1] <- rbinom(nSites, 1, psi[1]) # Initial occupancy state  
  
# Later years  
for(i in 1:nSites){ # Loop over sites  
for(k in 2:nYears){ # Loop over years  
expectedOcc[k] <- z[i, k-1]\*phi[k-1] + (1-z[i, k-1])\*gamma[k-1]  
z[i,k] <- rbinom(1, 1, expectedOcc[k])  
}  
}

Now we need to generate detection/non-detection data.

# Generate detection/non-detection data  
for(i in 1:nSites){  
for(k in 1:nYears){   
 prob <- z[i,k] \* p[k]  
for(j in 1:nSurveys){  
y[i,j,k] <- rbinom(1, 1, prob)  
}  
}  
}  
# Compute annual population occupancy  
for (k in 2:nYears){  
psi[k] <- psi[k-1]\*phi[k-1] + (1-psi[k-1])\*gamma[k-1]  
}

To analyze this data set with a dynamic occupancy model in unmarked, we first load the package. Next, we reformat the detection/non-detection data from a 3-dimensional array (as generated) into a 2-dimensional matrix with M rows. We put the annual tables of data (the slices of the former 3-D array) sideways to produce a “wide”" layout of the data. Then, we create a matrix indicating the year each site was surveyed.

library(unmarked)

## Warning: package 'unmarked' was built under R version 3.3.3

## Loading required package: reshape

## Loading required package: lattice

## Loading required package: parallel

## Loading required package: Rcpp

yy <- matrix(y, nSites, nSurveys\*nYears)  
year <- matrix(c('01','02','03','04','05'),  
nrow(yy), nYears, byrow=TRUE)

To organize the data in the format required by colext, we make use of the function ‘unmarkedMultFrame’. This function constructs a unmarkedFrame for data collected during primary and secondary sampling periods. For the help files, type ??unmarkedMultFrame

simUMF <- unmarkedMultFrame(  
y = yy,  
yearlySiteCovs = list(year = year),  
numPrimary=nYears)

We are ready to fit a few dynamic occupancy models. We will fit a model with constant values for all parameters and another with full time-dependence for colonization, extinction and detection probability.

m0 <- colext(psiformula= ~1, gammaformula = ~ 1, epsilonformula = ~ 1,  
pformula = ~ 1, data = simUMF)  
summary(m0)

##   
## Call:  
## colext(psiformula = ~1, gammaformula = ~1, epsilonformula = ~1,   
## pformula = ~1, data = simUMF)  
##   
## Initial (logit-scale):  
## Estimate SE z P(>|z|)  
## -1.5 0.326 -4.59 4.41e-06  
##   
## Colonization (logit-scale):  
## Estimate SE z P(>|z|)  
## -1.61 0.194 -8.33 8.3e-17  
##   
## Extinction (logit-scale):  
## Estimate SE z P(>|z|)  
## -0.382 0.274 -1.39 0.164  
##   
## Detection (logit-scale):  
## Estimate SE z P(>|z|)  
## -0.518 0.153 -3.37 0.000739  
##   
## AIC: 855.9874   
## Number of sites: 100  
## optim convergence code: 0  
## optim iterations: 23   
## Bootstrap iterations: 0

All parameters were estimated on the logit scale. To back-transform to the original scale, we can simply use the inverse-logit function, named ‘plogis’ in R. You can also use ‘backTransform’, which computes standard errors using the delta method. Confidence intervals are also easily obtained using the function ‘confint’

plogis(-1.5)

## [1] 0.1824255

names(m0)

## [1] "psi" "col" "ext" "det"

backTransform(m0, type="psi")

## Backtransformed linear combination(s) of Initial estimate(s)  
##   
## Estimate SE LinComb (Intercept)  
## 0.183 0.0487 -1.5 1  
##   
## Transformation: logistic

confint(backTransform(m0, type="psi"))

## 0.025 0.975  
## 0.1054491 0.2976101

Next, we fit the dynamic occupancy model with full year-dependence in the parameters describing occupancy dynamics and also in detection. This is the same model under which we generated the data set, so we would expect accurate estimates.

m1 <- colext(psiformula = ~1, # First-year occupancy  
gammaformula = ~ year-1, # Colonization  
epsilonformula = ~ year-1, # Extinction  
pformula = ~ year-1, # Detection  
data = simUMF)  
m1

##   
## Call:  
## colext(psiformula = ~1, gammaformula = ~year - 1, epsilonformula = ~year -   
## 1, pformula = ~year - 1, data = simUMF)  
##   
## Initial:  
## Estimate SE z P(>|z|)  
## -0.586 0.924 -0.635 0.526  
##   
## Colonization:  
## Estimate SE z P(>|z|)  
## year01 -0.931 0.781 -1.19 2.33e-01  
## year02 -8.934 33.052 -0.27 7.87e-01  
## year03 -1.385 0.355 -3.90 9.48e-05  
## year04 -1.713 1.203 -1.42 1.54e-01  
##   
## Extinction:  
## Estimate SE z P(>|z|)  
## year01 -0.663 0.790 -0.840 0.4010  
## year02 -0.666 0.472 -1.411 0.1582  
## year03 -1.650 0.924 -1.784 0.0744  
## year04 0.255 1.616 0.158 0.8747  
##   
## Detection:  
## Estimate SE z P(>|z|)  
## year01 -1.816 0.728 -2.496 1.26e-02  
## year02 -1.292 0.258 -5.008 5.49e-07  
## year03 0.372 0.259 1.437 1.51e-01  
## year04 -0.230 0.266 -0.863 3.88e-01  
## year05 -2.035 1.023 -1.989 4.67e-02  
##   
## AIC: 815.4589