Spatial Capture-Recapture: Alternative Observation Models

PART 3: OBSERVATION MODELS

- Bernoulli/Binomial model: 1 capture/trap, multiple individuals per trap. Typical device: hair snares, also camera traps in most cases.

- Poisson model ("count detector"): We could have individuals captured > 1 time in a trap during some occasion. Maybe y[i,j,k] ~ Poisson() is a suitable model (or some other count model).

- Multinomial models: Individuals can be captured in 1 trap. Traps hold 1 individual (single-catch), or multiple (multi-catch).

- Area search models: Can observe an individual anywhere (not restricted to trap locations)

POISSON ENCOUNTER MODEL

- Observations y[i,j,k] are Poisson encounter frequencies at each trap or search area j and occasion k.

```
y[i,j,k] ~ dpois(lam[i,j,k])
lam[i,j,k]<- z[i]*exp(alpha0)*exp(alpha1*d[i,j]*d[i,j])
```

- Or if we use the summed frequencies (over all K occasions)

```
y[i,j] ~ dpois(lam[i,j])
lam[i,j]<- z[i]*K*exp(alpha0)*exp(alpha1*d[i,j]*d[i,j])
```

- Data augmentation proceeds exactly the same way as with the Bernoulli model

POISSON ENCOUNTER MODEL

```
model {
   alpha0~dnorm(0,.1)
   alpha1~dnorm(0,.1)
   psi~dunif(0,1)

for(i in 1:M){
   z[i] ~ dbern(psi)
   s[i,1]~dunif(xlim[1],xlim[2])
   s[i,2]~dunif(ylim[1],ylim[2])
  for(j in 1:J){
      d[i,j]<- pow(pow(s[i,1]-X[j,1],2) + pow(s[i,2]-X[j,2],2),0.5)
      y[i,j] ~ dpois(lam[i,j])
      lam[i,j]<- z[i]*K*exp(alpha0)*exp(- alpha1*d[i,j]*d[i,j])
  }
}
N<-sum(z[])
D<- N/64   # area = 64 for the simulated grid
}
```

For occasion-specific effects replace K by a loop from k=1:K

DON'T USE COUNT FREQUENCY MODELS

- Encounter frequencies over short periods of time are mostly due to individual behavior and do not provide much if any direct information about the encounter process.
- Are they independent encounters? Doubtful.
- They may require additional parameters to model within sample cluster size/variance.

MULTINOMIAL MODELS

Two varieties:

1. Independent multinomial model (“multi-catch”). A device captures and holds an individual, but may hold multiple individuals. Mist-nets.

2. Dependent multinomial trials (“single catch”). A device captures and holds an individual, only holds one individual. Live traps.

MULTINOMIAL/CATEGORICAL IN BUGS

To fit multi-catch models in BUGS we use the categorical distribution:

```
y[i,k] = trap of capture
y[i,k] ~ categorical( probs[1:(J+1)] )
```

- By convention define "not captured" = J+1
- Multinomial logit relating trap-specific encounter probabilities to the latent variable s:

```
probs[x,s]  = exp(alpha0 + alpha1*dist(x,s)^2 )
                 ---------------------------------------------
              1 + sum_{x} exp(alpha0 + alpha1*dist(x,s)^2 )
```

- probs[] should also depend on k if there are occasion-specific effects

MULTINOMIAL MODEL IN BUGS

```
model {

[…. Prior distributions removed ….]

for(i in 1:M){
  z[i] ~ dbern(psi)
  s[i,1] ~ dunif(xlim[1],xlim[2])
  s[i,2] ~ dunif(ylim[1],ylim[2])
  for(j in 1:ntraps){
        d2[i,j] <- pow(pow(s[i,1]-X[j,1],2) + pow(s[i,2]-X[j,2],2),1)
  }
  for(k in 1:K){
    for(j in 1:ntraps){
      lp[i,k,j] <- exp(alpha0 - alpha1*d2[i,j])*z[i]
      cp[i,k,j] <- lp[i,k,j]/(1+sum(lp[i,k,]))
    }
    cp[i,k,ntraps+1] <- 1-sum(cp[i,k,1:ntraps])  # last cell = not captured
    Ycat[i,k] ~ dcat(cp[i,k,])
  }
}
N <- sum(z[1:M])
A <- ((xlim[2]-xlim[1]))*((ylim[2]-ylim[1]))
D <- N/A
}
```

Notice data augmentation variable here

Categorical distribution

MULTINOMIAL MODEL

- R work session

THE OVENBIRD DATA

```
library(scrbook)
library(secr)
data(ovenbird)
?SCRovenbird
```

Features of the ovenbird data:

(1) multi-years of data

(2) one individual died on capture

(3) Use of “dcat” distribution in BUGS

CLASS WORK SESSION

- Fit the multinomial model to the 1st year of the ovenbird data (2005). Requires R function get

- Use our simulated data and script as a template

- Data set: see ovenbird script from day 1
- Model: see R script for simulating data and fitting the model
- Merge the two.
- Use a state-space buffer of 150 m
- Make sure starting values are chosen in a reasonable way

SINGLE CATCH TRAPS

- Live traps and related devices catch and hold individuals so that (1) they can't be captured multiple times per occasion and (2) traps typically can only hold 1 individual.
- The observation model is multinomial but NOT independent. Capture probabilities are modified each time some individual is captured.
- NO FORMAL METHOD FOR ANALYSIS
- Well approximated by independent multinomial model (multi-catch) if encounter rate is low.
- Probably well approximated by Poisson or Bernoulli models too

SUMMARY

The Bernoulli/binomial model is our standard SCR model but other models are possible

- Poisson encounter frequencies (or negative binomial, etc..)
- Multinomial "multi-catch" observations models apply to mist-nets or pitfall traps
- Multinomial "single-catch" observation models apply to hold traps