Introduction to Applied Bayesian Analysis in Wildlife Ecology

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Bonus: occupancy models



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 - Spatial autocorrelation

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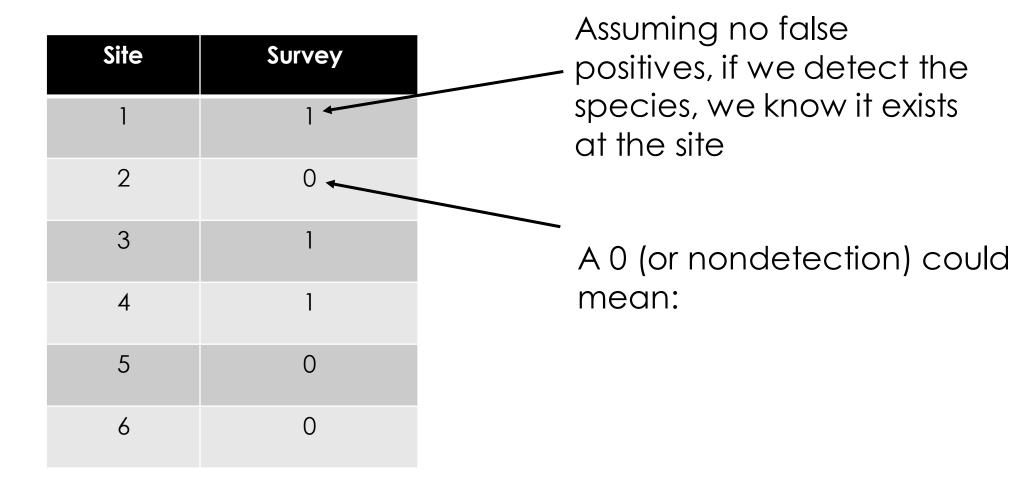
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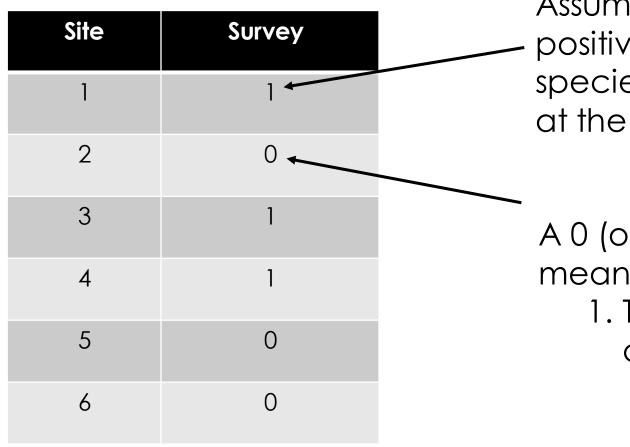
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1	1		
2	0		
3	1		
4	1		
5	0		
6	0		

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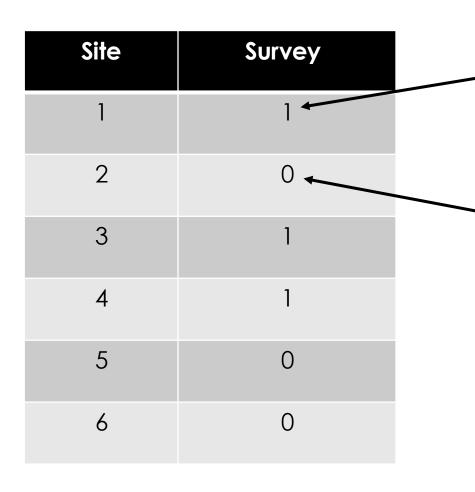




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A 0 (or nondetection) could mean:

- 1. The species does not exist at the site
- 2. The species exists at the site, but we failed to detect it.

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- Fundamental concept: obtain "repeated surveys" at a given site during some period of closure
 - Key assumption: the species does not move in or out of the site during this time period
- "Repeated surveys" usually come in the form of multiple visits to a site during some time period, but can also take different forms (e.g., multiple observers, spatial replicates)

Data for occupancy modeling

Detection-nondetection matrix (y)

V	_
N	

Site	Survey 1	Survey 2	Survey 3	Survey 4
1	1	0	0	1
2	0	0	0	0
3	1	Ī	0	NA
4	1	NA	0	NA
5	0	1	1	1
6	0 _	0	0	1

- J sites with K_j replicate surveys at each site j
- Assume no false positives
- Any variation in the observed data values across surveys is assumed to arise from imperfect detection.

Occupancy model structure

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Occupancy model structure

- Two distinct sub-models
 - Model occupancy probability as a function of site-level covariates
 - 2. Model detection probability as a function of site and/or survey-level covariates
 - Can only detect a species if it truly occupies a site
 - Detection probability is modeled "conditional" on true occupancy

Single-species occupancy model

Occupancy (ecological) sub-model

$$j = 1, ..., J$$
 (site)
 $k = 1, ..., K_j$ (replicate)

$$z_j \sim \text{Bernoulli}(\psi_j)$$

 $\text{logit}(\psi_j) = \beta_1 + \beta_2 \cdot X_{2,j} + \dots + \beta_r \cdot X_{r,j}$

 z_j True occurrence of the species at site j

 ψ_j Occurrence probability at site j

 $X_{r,j}$ The rth covariate at site j (e.g., habitat variable)

Single-species occupancy model

Detection (observation) sub-model

$$j = 1, ..., J$$
 (site)
 $k = 1, ..., K_j$ (replicate)

$$y_{j,k} \sim \text{Bernoulli}(p_{j,k} \cdot z_j)$$

 $\text{logit}(p_{j,k}) = \alpha_1 + \alpha_2 \cdot V_{2,j,k} + \dots + \alpha_r \cdot V_{r,j,k}$

 $y_{j,k}$ Detection-nondetection data at site j during replicate k

 $p_{j,k}$ Detection probability at site j during replicate k

 $V_{r,j,k}$ Covariate affecting detection at site j during replicate k

spOccupancy



- Designed to fit Bayesian single-species and multi-species occupancy models
- Efficient options (NNGPs) to account for spatial autocorrelation
- Workflow completely in R (no Bayesian programming languages necessary)
- PGOcc -> single-species occupancy model
- spPGOcc -> spatial single-species occupancy model
- The "PG" stands for Pólya-Gamma (Polson et al. 2013)

Example: European goldfinch distribution across Switzerland



8-occupancy-models.R

