Estimating detectability in population assessments

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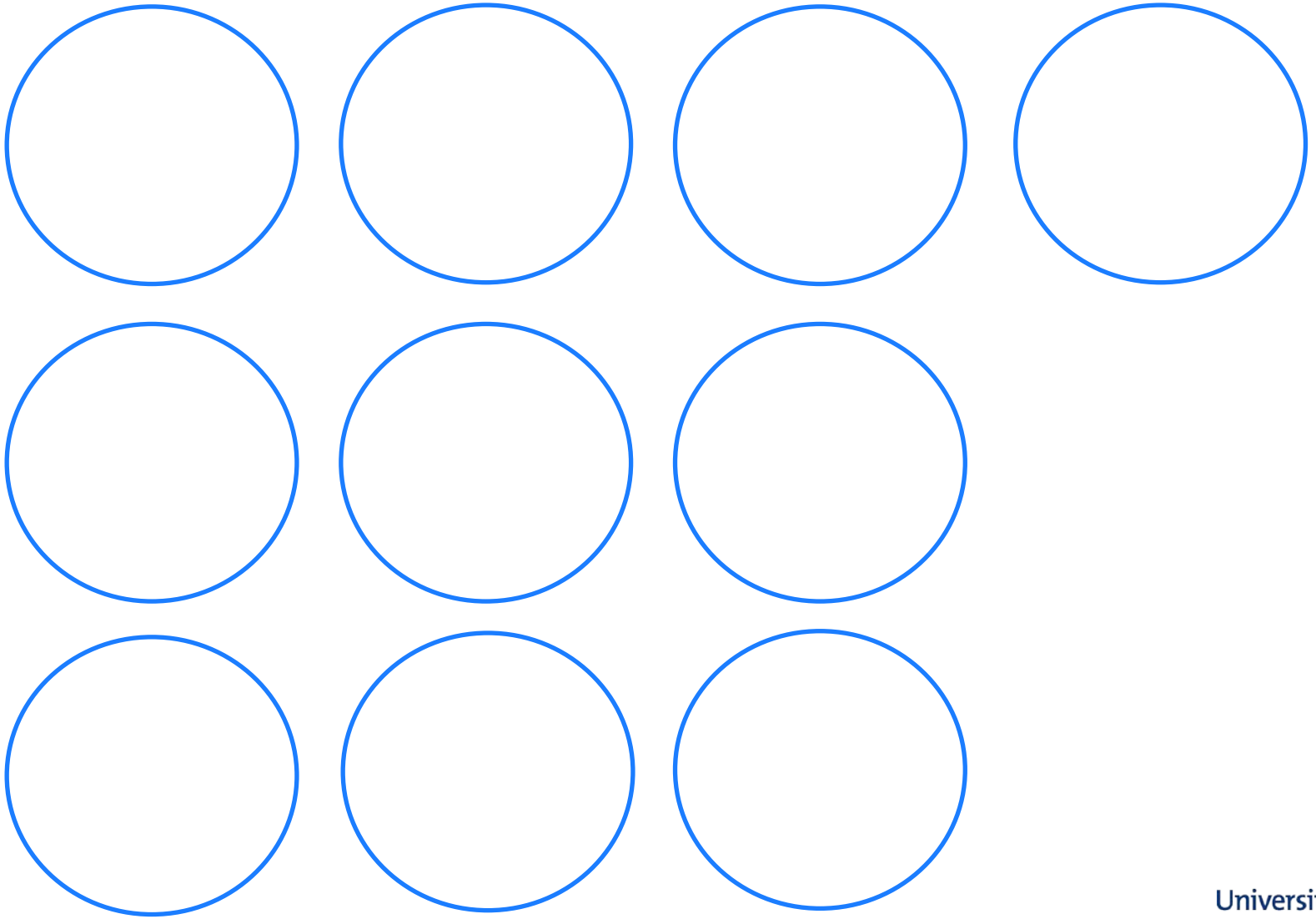
Overview

- Types of data
- Occupancy models
- Advanced occupancy models
- Related models

Data collection

- Capture-mark-recapture relies on individual identification and capture/re-sighting of animals
- Not possible for some species
- Alternative data collection:
  - Presence/absence

Do we need to account for detectability?



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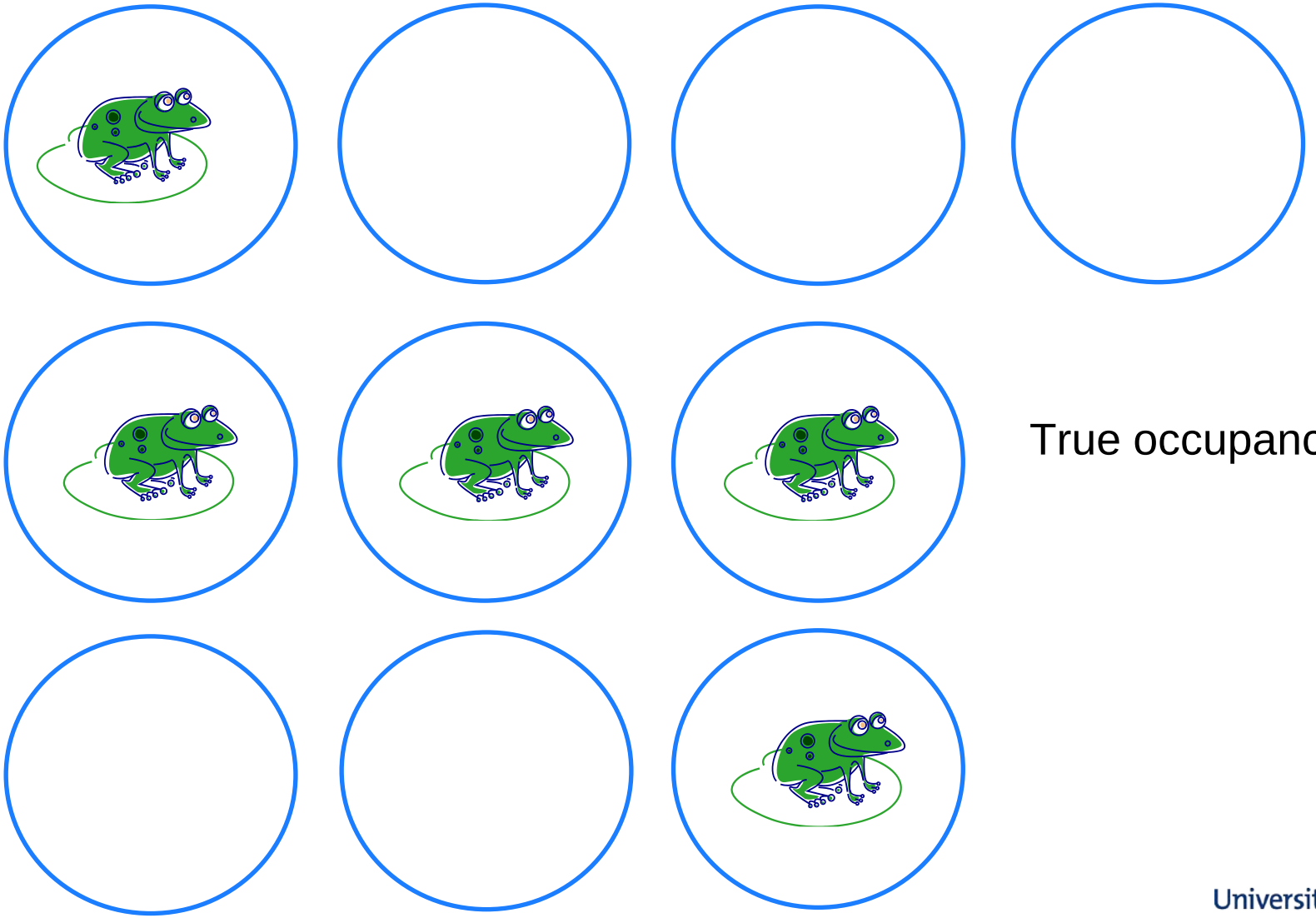
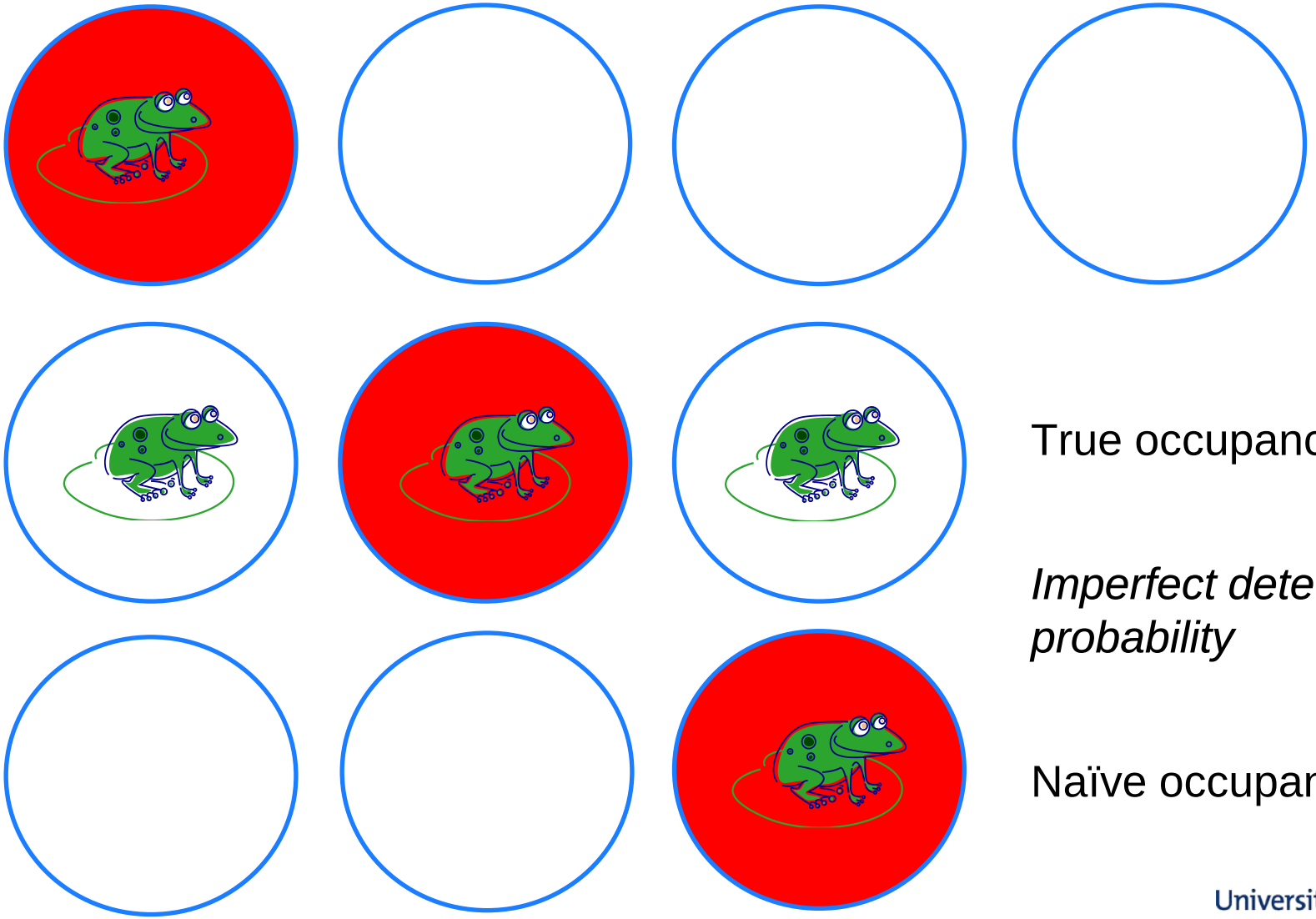


True occupancy = 0.5

Do we need to account for detectability?



True occupancy = 0.5

Imperfect detection probability

Naïve occupancy = 0.3

Simple occupancy model

- Multiple sites, multiple occasions
- Detection history for each site
- Examples:
  - 0101
  - 1110
  - 0000
  - …
- Conceptual model:
  - A site may be occupied or not
  - If the site is occupied, there is some probability of detecting the species

Formalising the model

- Parameters:
  - ψ: probability the site is occupied
  - p_j: probability species is detected at occasion j
- Construct probabilities

$$Pr(h_i = 0101) = \psi(1-p_1)p_2(1-p_3)p_4$$

$$Pr(h_i = 0000) = \psi(1-p_1)(1-p_2)(1-p_3)(1-p_4)+(1-\psi)$$

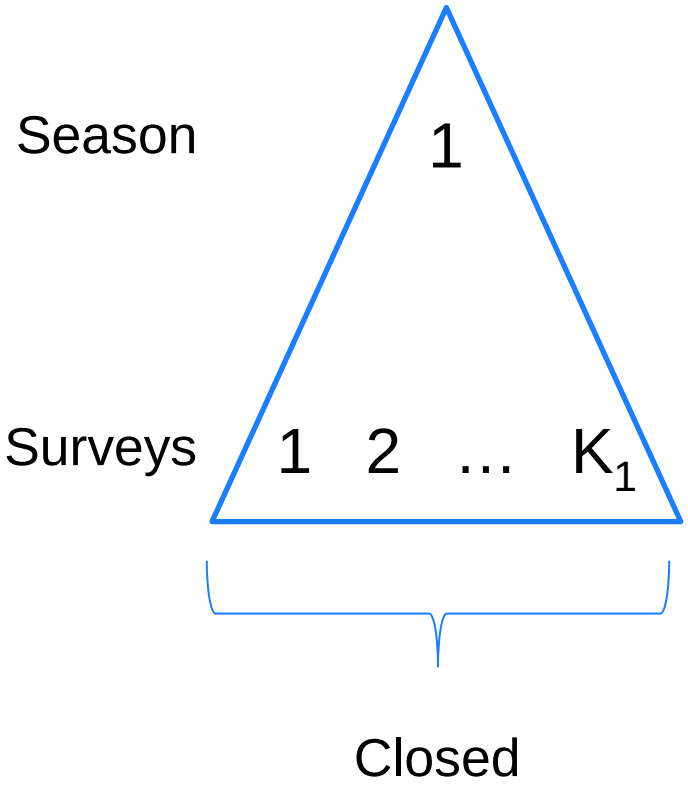
Multinomial likelihood

$$L(\psi, p|h_1, \ldots\ldots, h_s) \propto \prod_{i=1}^{s} \Pr(h_i)$$

Alternative models

- Constant detection probability
- Relate detection to covariate values
- Relate occupancy to covariate values
- Incorporate heterogeneity (finite and infinite mixtures – recall capture-mark-recapture work)

Advanced models: multiple-season models



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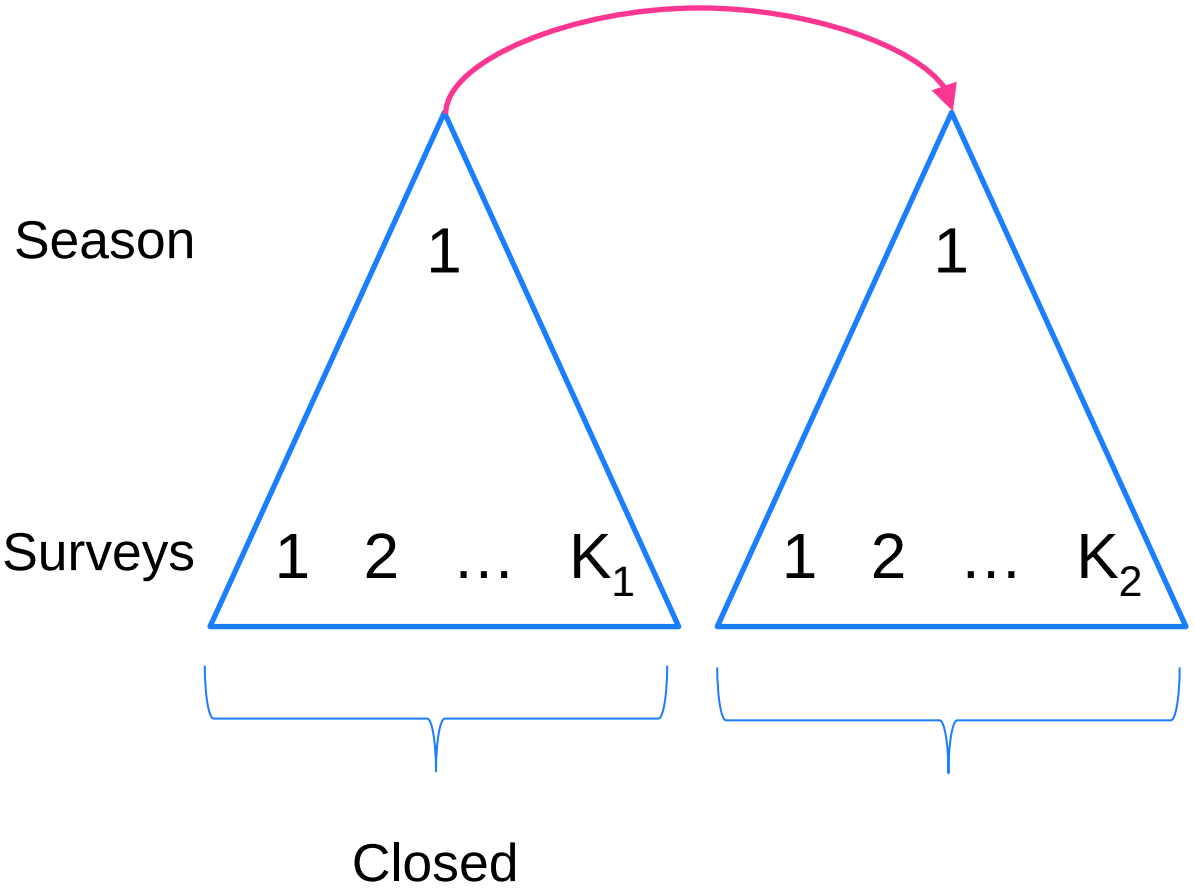
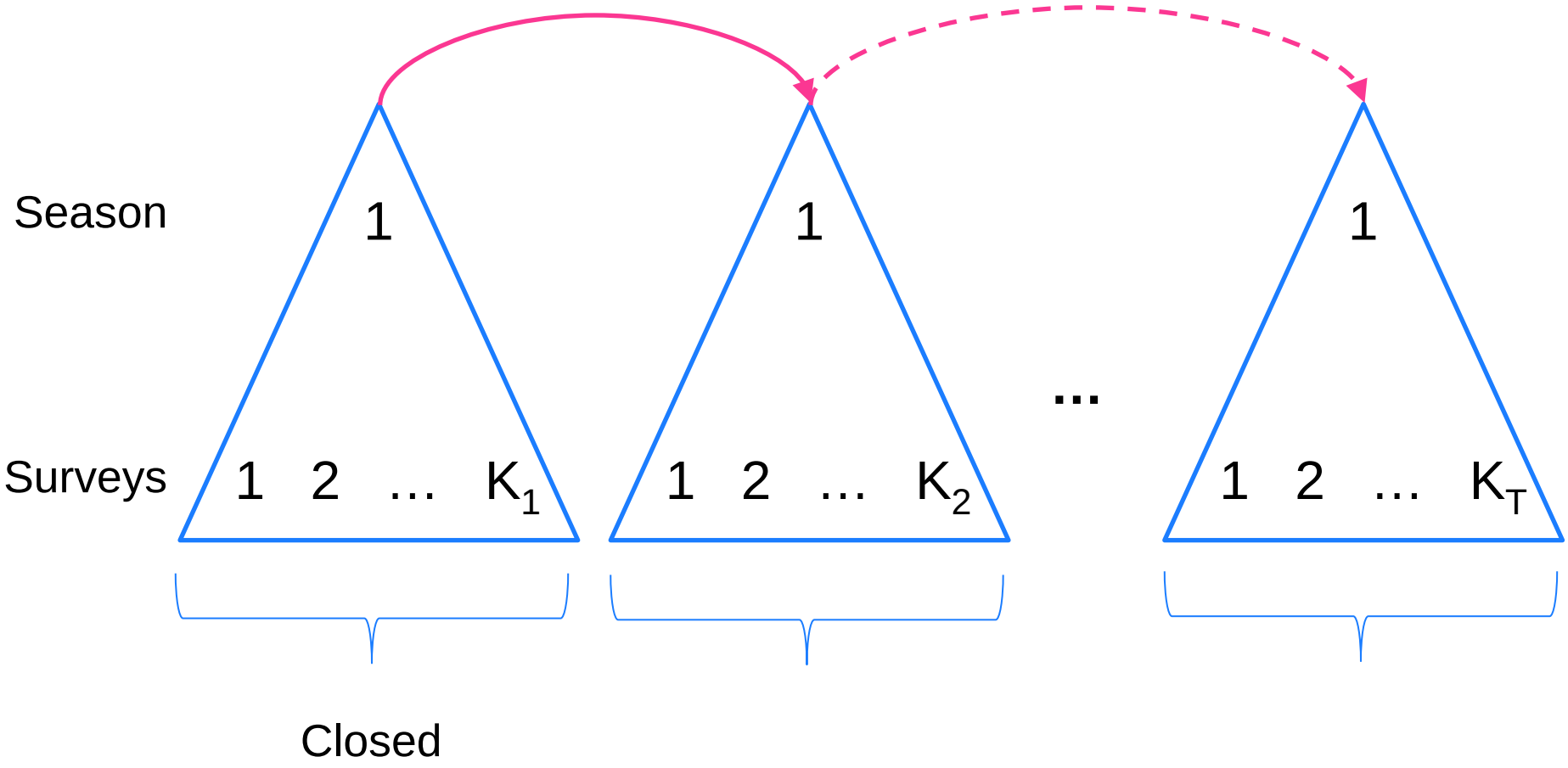


Extinction or colonisation

Advanced models: multiple-season models



Advanced models: multiple-season models

- Example detection history:

110 000 010

- New Parameters

COLONISATION

- γ_t: the probability that an unoccupied site in season t is occupied by the species in season t+1

EXTINCTION

- ε_t: the probability that a site occupied in season t is unoccupied by the species in season t+1

Advanced models: multiple-season models

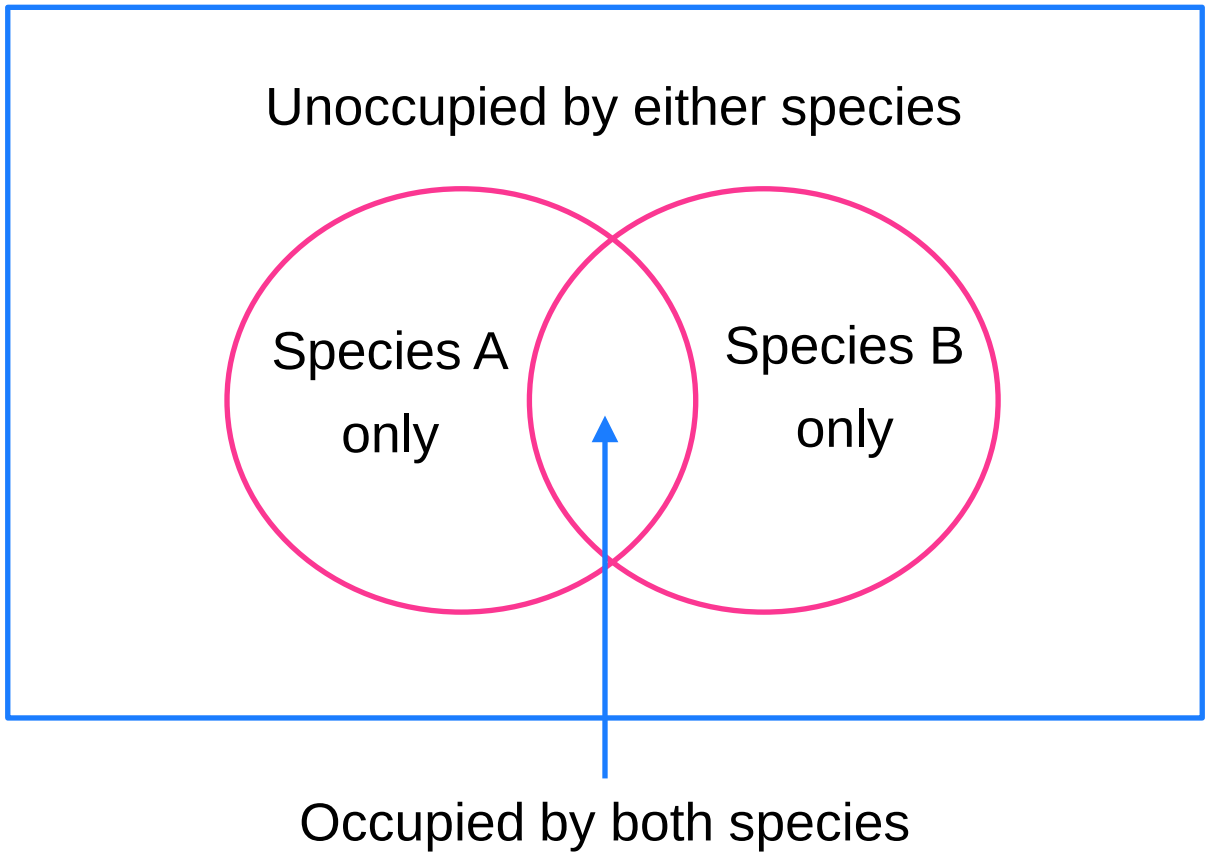
- Example detection history:

110 000 010

- Extended Parameters
  - ψ_t: probability a site is occupied in season t
  - p_{tj}: probability of detecting the speices in the j^{th} survey of a site during season t

Advanced models: multiple species models

- Species interactions

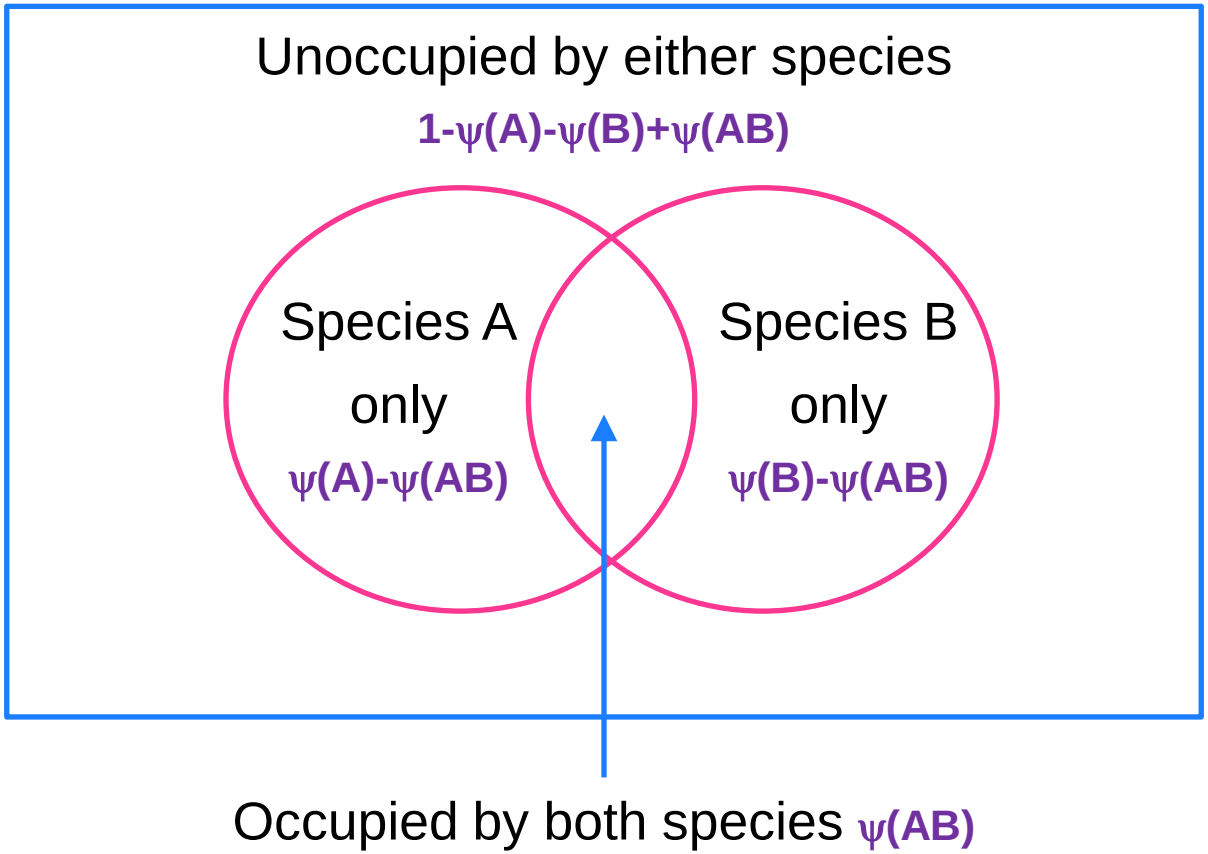


Advanced models: multiple species models

- Species interactions:
- ψ(A): probability species A occupies a site
- ψ(B): probability species B occupies a site
- ψ(AB): probability both species occupy a site site

Advanced models: multiple species models

- Species interactions



Advanced models: multiple species models

- ψ(A): probability species A occupies a site
- ψ(B): probability species B occupies a site
- ψ(AB): probability both species occupy a site site

- p_j(A): probability of detecting species A during the j^{th} survey, given only species A is present

- p_j(B): probability of detecting species B during the j^{th} survey, given only species B is present

Advanced models: multiple species models

- $r_j(AB)$: probability of detecting both species during j^{th} survey, given both are present
- $r_j(Ab)$: probability of detecting species A but not B during j^{th} survey, given both are present
- $r_j(aB)$: probability of detecting species B but not A during j^{th} survey, given both are present
- $r_j(ab)$: probability of detecting neither species during j^{th} survey, given both are present

- $r_j(ab) = 1 - r_j(AB)-r_j(Ab)-r_j(aB)$

Advanced models: multiple species models

- Depending on parameters of inetrest, there are reparameterised forms:

- Species interaction factor

$$\varphi = \frac{\psi(AB)}{\psi(A)\psi(B)}$$

- “how much more or less likely the species are to co-occur at a site compared to what would be expected if they co-occurred independenly”

Related models

Presence/absence data

Capture-recapture data

N-Mixture models

- Spatial and temporal replication
- Counts rather than presence/absence data
- Allows estimation of animal abundance

- Royle (2004) N-mixture models for estimating population size from spatially replicated counts. *Biometrics*, **60**, 108-115.
- Dennis, Morgan and Ridout (2014) Computational aspects of N-mixture models. *Biometrics.* In press.

Batchmarking models

- Animals are marked in cohorts, but are not distinguished.
  - Colour marking insects
- Comparable to Lincoln-Petersen approach for multiple capture occasions
- Similar analysis approaches to capture-recapture data

Viallefont, Besbeas, Morgan and McCrea (2010) Estimating survival and transition probabilities from aggregate sightings of animals. *Journal of Ornithology.* **152**, S381-391.

Cowen, Besbeas, Morgan and Schwarz (2013) A comparison of abundance estimates from extended batch-marking and Jolly-Seber type experiments. *Ecology and Evolution*. **4**, 210-218.

Useful References

- MacKenzie, Nichols, Royle, Pollock, Bailey and Hines (2006) *Occupancy Estimation and Modeling: Inferring patterns and dynamics of species occurrence.* Academic Press.
- Guillera-Arroita, Ridout and Morgan (2010) Design of occupancy studies with imperfect detection. *Methods in Ecology and Evolution.* 1, 131-139

- Gurutzeta Guillera-Arroita's website and blog:
- https://gguilleraresearch.wordpress.com/