

Modeling static occurrence and species distributions using site-occupancy models

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Abundance, occurrence, probability of occupancy, and distributions

- Abundance N_{it} :
State variable that denotes number of individuals at site i at time t
- Occurrence z_{it} :
State variable that denotes presence (1) or absence (0) of a species at site i at time t
Quantized version of abundance (information-poor summary)
$$z_{it} = I(N_{it} > 0)$$
- Probability of occupancy ψ_{it} :
$$Pr(z_{it} = 1) = Pr(N_{it} > 0)$$
- Species distribution: patterns of z or sum of z of a species at t

Two opposing views of occupancy: 1. Avoid it whenever possible

- Meaning of occupancy is very elusive if we think of it
- Occupancy is simply a cheap substitute for what we would really like to have: abundance N
- “The poor man’s abundance”

Two opposing views of occupancy: 1. Occupancy is great

- ... because Darryl MacKenzie says so
- Although z is a reduced-info summary of N , it still does contain information about N . Strong relationships in ecology between distribution and abundance (cf. papers by He and Gaston, ca. 2000-2003)
- If abundance cannot be reliably assessed, occupancy may be the only viable alternative
- Parametric modeling assumptions for abundance stronger (e.g., Poisson, NegBin) than for occurrence: not so much can be wrong with the simple coin-flip model
- Closure assumption for occupancy much less difficult to meet than for modeling of abundance

Two opposing views of occupancy: 1. Occupancy is great, ctd.

- Sometimes abundance may not matter, e.g., for parasite infections (don't bother whether 10^5 or 10^6 bacteria)
- Sometimes occurrence identical to abundance: when a site can be occupied by at most one individual, pair or family group (e.g., Golden Eagles at cliff sites)
- Occurrence is the sole ingredient of the most important measure of biodiversity: species richness
- and many others ... e.g., metapopulation ecology, species distribution modeling industry, ...
- Hence: modeling and estimation of occurrence very important

Meaning of occupancy depends on spatial and temporal scale of observation

- Switzerland: $\psi = 1$ if unit equal to country
- Switzerland: $\psi = 0$ if unit equal to size of stamp
- Similar for temporal scale: “distribution” goes up with increasing temporal grain
- Choose site in a biologically meaningful way, that occupancy means something useful

Meaning of occupancy depends on definition of state of “occurrence”

- permanent presence
- use
- Define “occurrence” in a biologically meaningful way

(Incomplete) Classification of occurrence data

- Presence-only data:
 - invent pseudo-zeroes and do logistic regression (bad)
 - use background sample and do MaxEnt or Maxlike (less bad)
 - directly model spatial point pattern (difficult, thorny assumptions)
- Presence/absence: Do variant of logistic regression (GLM, GAM, BRT)
- Presence/absence data replicated in time: Do site-occupancy modeling
- Count data: Do Poisson regression or Nmix modeling
- (Note: “presence/absence” misleading term, just used for convenience)

