

Occupancy modeling in BUGS/JAGS and unmarked – Hierarchical models for species occurrence and communities

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Why this workshop ?

- Occurrence, species richness and related quantities important in ecology and applications
- Spatially structured data on occurrence and communities extremely common in ecology and related fields
- ... and in monitoring and inventories !
- Have to deal with measurement error = observation process: Imperfect detection hallmark of all such data (also false positives)
- Hierarchical models can accommodate both spatial/temporal/spatio-temporal structure and observation process
- Tremendous developments in hierarchical models and computation over last 10 years



“Occupancy models” and Hierarchical models

- Site-occupancy paper by MacKenzie et al. (2002; & Hines & Royle)
- Very vigorous development over last 10 years
- 2003 – Dynamic occupancy model (MacKenzie et al, Ecology), Royle-Nichols model (Ecology)
- 2004 – N-mixture model (Royle, Biometrics), hierarchical distance sampling (Royle et al., Ecology)
- 2005 – Removal sampling Nmix (Dorazio et al., Biometrics), multi-species occupancy (Dorazio & Royle, JASA)
- 2008 – First synthesis: Royle & Dorazio book
- NOT just occupancy models ! RATHER: Hierarchical models for abundance, occupancy, species richness
- BUT: Development of original occupancy model has catalyzed much development

Examples of further developments

- 2005-2009 various multistate occupancy models (Royle & Link; Nichols et al., MacKenzie et al.)
- 2010 dynamic community models (Dorazio et al.)
- 2011 abundance in open populations (1): temporary emigration Nmix models (Chandler et al.)
- 2011 abundance in open populations (2): population dynamics model of Dail and Madsen (Biometrics)
- 2011 mis-classification in occupancy (Miller et al.)
- ...



Software crucial

- Available software instrumental for wide adoption of new models/methods!
- Windows program MARK
- Windows program PRESENCE (Jim Hines)
- Custom code in generic programming languages: **R** and **BUGS**
- New **R** package **unmarked**
- Lots of published, but dispersed code in the BUGS family: WinBUGS, OpenBUGS, JAGS
- Existing demographic estimation programs can be tweaked to fit occupancy models: e.g., E-SURGE (Gimenez et al., MEE, in revision)



Increasing number of Bayesian analyses

- Availability of BUGS software
- Introductory books such as McCarthy (2007), Kéry (2010), Kéry & Schaub (2012)
- BUGS language gives ecologists tremendous modeling freedom
- All BUGS software can be integrated with **R**
- Parallel computing possible with BUGS in **R**



Summary

- Models for occurrence and communities with spatially structured data very relevant
- Lots of new development over past 10 years (statistics, computation)
- Hierarchical model as overarching theme
- Great new (and less new) software: **unmarked** and BUGS
- Number of Bayesian analyses increasing all the time



Goals of workshop

- Accessible overview of hierarchical models for occurrence and communities
- Synthesize exciting developments of the last 10 years
- Emphasize overarching framework of hierarchical models
- Preach opportunism wrt to frequentist/bayesian inference
- Accessible: give plenty of template analyses in **unmarked** and BUGS
- **ALSO:** Try out material for a new book, Kéry & Royle (2015): *Hierarchical modeling of distribution, abundance and species richness*, Academic Press. — Comments welcome !



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