Interagency Ecological Program 2023 Workshop
IEP Training Course #2

Course Title:

Introduction to hierarchical models in R with application to abundance modeling

Course Location:

Friday, March 29, 2023, from 9:00 a.m. – 12:00 p.m. 2nd floor in Room 2-301
CNRA Headquarters (715 P Street, Sacramento, CA 95814)

Registration:

Seating is limited to 25 participants. Registration is required to attend this class. Registration information can be found on the IEP Workshop web page.

Instructor:

Dr. Brock M. Huntsman, U.S. Geological Survey, bhuntsman@usgs.gov

Course Description:

The goal of this class will be to introduce the concept of hierarchical models and how they can be used to answer different ecological questions. We will focus specifically on using these tools to develop models commonly used to evaluate population and community structure that address issues created by imperfect catchability/detection efficiency. We will use data simulations to generate data with known parameter estimates to explore the "nuts and bolts" of different types of hierarchical models. We will also use various R packages within a frequentist statistical framework (program unmarked) to understand how to analyze survey data commonly collected by fisheries scientists.

Prerequisites for the Course:

This class is offered as a relatively specialized topic as it pertains to statistical analyses and programming. Therefore, this class will be considered an advanced class that will require attendees have experience with basic programming using program R. Comfort in program R is a must in order for us to cover the main topics of the course within the time constraints of the workshop. Attendees should be comfortable with the following prior to attending this workshop:

- "Reading" data into program R
- Data wrangling in R (e.g., sub-setting, merging)
- Regression analysis
    - Gaussian, Poisson, negative binomial distributions

What to Bring:

- A laptop computer. If your laptop battery does not last, I recommend you bring your laptop charging cords and an extension cord for plugging in for power.
- Program R (R: The R Project for Statistical Computing (r-project.org)) installed on your device.
    - I recommend working with R-studio (Posit | The Open-Source Data Science Company) but this isn't necessary for the workshop.
- Wear comfortable clothing. No food is allowed inside the room. Water bottles are okay. A café is located on the 1st floor that sells food, snacks, and drinks. Water fountains and water bottle filling stations are located near the restrooms.

Outline of the Course:

- Definition of Hierarchical Models
- Hierarchical Models and Survey Data
    - Replicates!
        - Spatial
        - Temporal
    - Abundance Models
        - Zippin-Type Depletion Models
        - Binomial N-Mixture
            - Replicates without removal sampling
        - Multinomial N-Mixture
            - Replicates with removal sampling
            - Replicates with multiple surveyors
            - Multiple gear deployment
- Special Topics (If Time Permits)
    - Bayesian Approaches
        - Flexibility!!!
            - Relax Assumptions (Pass closure)
            - Survey Issues
                - e.g., unequal passes
    - Multiple Occasions with Spatial Replicates
        - Static Models
        - Dynamics Models
            - Exponential, Logistic, Ricker, Gompertz
            - Dail and Madsen (2011)
    - Adding the sampling model
        - Leasure et al. (2019) Model
    - Integrated Data Sets
        - Occupancy with Abundance Surveys
        - Dual Gear

Instructor Bio:

My name is Brock Huntsman and I am a Biologist with the USGS at the California Water Science Center. I received my master's degree in biology at the University of Alabama and my PhD in Forestry and Natural Resources at West Virginia University. I consider myself a quantitative ecologist that specializes in aquatic environments, and I've worked in systems ranging from cave streams in the southeastern U.S. to subarctic streams in the interior of Alaska. My research typically involves the analysis of population and community data sets, where hierarchical abundance models are among the most common class of models I develop. I typically employ the freely available R programming language for data processing and analysis, as well as to interface with other software packages. In addition to frequentist and information theoretic approaches to data analysis, I commonly employ Bayesian methods to analyze data sets using WinBUGS language.

Suggested Readings:

There are numerous texts on these topics and listed below are but a few that I often revisit when developing count and occupancy-based models using program R and JAGS (Just Another Gibbs Sampler).

- **Books**
    - Royle, J., and R. Dorazio. 2008. Hierarchical modeling and inference in ecology: the analysis of data from populations, metapopulations and communities. Elsevier.
    - Kéry, M., and J. A. Royle. 2016. Applied Hierarchical Modeling in Ecology: Analysis of distribution, abundance and species richness in R and BUGS: Volume 1: Prelude and Static Models. Academic Press.
    - Kéry, M., and J. A. Royle. 2020. Applied Hierarchical Modeling in Ecology: Analysis of Distribution, Abundance and Species Richness in R and BUGS: Volume 2: Dynamic and Advanced Models. Academic Press.
- **Papers**
    - Amundson, C. L., J. A. Royle, and C. M. Handel. 2014. A hierarchical model combining distance sampling and time removal to estimate detection probability during avian point counts. The Auk 131:476–494.
    - Barker, R. J., M. R. Schofield, W. A. Link, and J. R. Sauer. 2018. On the reliability of N-mixture models for count data. Biometrics 74:369–377.
    - Dail, D., and L. Madsen. 2011. Models for estimating abundance from repeated counts of an open metapopulation. Biometrics 67:577–587.
    - Duarte, A., M. J. Adams, and J. T. Peterson. 2018. Fitting N-mixture models to count data with unmodeled heterogeneity: Bias, diagnostics, and alternative approaches. Ecological Modelling 374:51–59.
    - Graves, T. A., K. C. Kendall, J. A. Royle, J. B. Stetz, and A. C. Macleod. 2011. Linking landscape characteristics to local grizzly bear abundance using multiple detection methods in a hierarchical model. Animal Conservation 14:652–664.

- Hostetler, J. A., and R. B. Chandler. 2015. Improved state-space models for inference about spatial and temporal variation in abundance from count data. Ecology 96:1713–1723.
- Hostetter, N. J., B. Gardner, T. S. Sillett, K. H. Pollock, and T. R. Simons. 2019. An integrated model decomposing the components of detection probability and abundance in unmarked populations. Ecosphere 10:e02586.
- Kéry, M. 2018. Identifiability in N-mixture models: a large-scale screening test with bird data. Ecology 99:281–288.
- Langtimm, C. A., R. M. Dorazio, B. M. Stith, and T. J. Doyle. 2011. New aerial survey and hierarchical model to estimate manatee abundance. Journal of Wildlife Management 75:399–412.
- Leasure, D., S. Wenger, C. N, N. H, D. D, R. Bjork, K. Fesenmyer, J. Dunham, M. Peacock, C. Luce, A. Lute, and D. Isaak. 2019. Hierarchical multi-population viability analysis. Ecology 100:e02538.
- Nichols, J. D., L. Thomas, and P. B. Conn. 2009. Inferences About Landbird Abundance from Count Data: Recent Advances and Future Directions. Pages 201–235 Modeling Demographic Processes In Marked Populations.
- Royle, J. A. 2004. N-Mixture Models for Estimating Population Size from Spatially Replicated Counts. Biometrics 60:108–115.