Bayesian Hierarchical Modeling in Natural Resources (NRES 701B)

Spring 2020

Course Information

Instructor Information:

Register for: NRES 701B Section 1003 (Advanced Resource Management) **Instructor:** Perry Williams, Ph.D.
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Office Hours: Mon/Wed 10:00-11:00 AM

Course description

Virtually all progress is science requires using models to gain insight from data. This course will focus on gaining insight of scientific processes using statistics, mathematics, and observation. We will first review necessary probability, statistics, and computing, and then focus on Bayesian model building and implementation. The review at the beginning is primarily meant to get everyone on the same page in terms of notation and to highlight the most important aspects of the prerequisites. The data used in applications will focus on ecological applications. However, many of the concepts and models are transferable to other areas of natural resources and environmental science, including evolution, and conservation biology. Example data sets will include: wildlife and plant surveys, presence-absence (occupancy) data, mark-recapture/re-sight data, GPS animal movement data, and physical and chemical process data. We will discuss spatial and temporal aspects of analysis, including models for spatial and temporal autocorrelation. We will strive to discuss methods that are generally applicable to all areas of natural resource and environmental science. Students should have access to their own computer and a working installation of R.

Course prerequisites

Required prerequisites

- Working knowledge of `R`

Suggested prerequisites

Although not necessary, students with a course in calculus, linear algebra (MATH 330), a basic ecology course, and one of the following courses

- STAT 429/629,
- STAT 461/661,
- NRES 746,

will get the most out of the course. None of these are absolute requirements; I will review key background concepts as part of the lectures. However, that said, if you don't have at least two of these background courses, you should be prepared to do some remedial work on your own.

Required texts:

Hobbs, N. T. and M. B. Hooten, Bayesian models: A statistical primer for ecologists, Princeton University Press 2015.

Unique class procedures/ structures:

Working in groups:

You will be assigned a lab group with another colleague every other week. A team approach to work in the laboratories allows you to teach each other as well as to learn from me. It will lighten the work load by allowing you to share tasks. It is more fun.

Individual project

An individual project will be due at the end of finals week. You will write a Bayesian hierarchical model for a problem of your own choosing, hopefully related to your research. A brief write-up will describe the ecological questions addressed, the data, and the model. I will provide more details about what is expected for this project later in the semester.

Student learning outcomes:

Students will:

1. learn the basic principles of probability and statistical distributions needed to link deterministic models to data and apply these to a number of real data sets.
2. Explain maximum likelihood methods for estimating parameters in ecological models.
3. Explain key principles of Bayesian statistics. Understand the relationship between inference accomplished by maximum likelihood and by applying Bayes theorem.
4. Be able to diagram, write, and implement hierarchical models appropriate for diverse problems in ecological and natural resource science.
5. Explain how Markov chain Monte Carlo (MCMC) methods can be used to approximate marginal posterior distributions. Write MCMC algorithms and computer code in `R` implementing MCMC methods for simple Bayesian models.
6. Use software for implementing MCMC methods (i.e., JAGS, R packages) to approximate marginal posterior distributions of parameters, latent variables, and derived quantities of interest. Be able to evaluate convergence.
7. Be able to apply procedures for model checking and model selection in the Bayesian framework.

Course requirements:

Regular attendance is essential and expected.

Grades will be based on an occasional quiz as well as a sequence of approximately bi-weekly reports that may involve short-answer, essay, mathematical derivations, computer programming, data analysis, and paper summary/discussion. A final project will be due at the end of the semester, ideally, related to your research.

- Reports must be prepared using some form of TEXlanguage.
- Reports will be prepared by rotating pair groups.
- By the end of the day that reports are due, each group member must email me a brief description of their collaborator's strengths (why this person is a good collaborator). These reports will be compiled and used to determine a collaborator-score that will account for 20% of the course grade. These emails will be kept anonymous.
- The `R` software will be used for all statistical analysis and code/functions should be attached to the report as an appendix.

Grading criteria, scale, and standards:

Grading Policy: Homework and quizzes (60%), Participation and Group Collaboration (20%), final project (20%).

89.5%	$<$	A		
87%	$<$	B+	$\leq$	89.5%
79.5%	$<$	B	$\leq$	87%
77%	$<$	C+	$\leq$	79.5%
69.5%	$<$	C	$\leq$	77%
67%	$<$	D+	$\leq$	69.5%
59.5%	$<$	D	$\leq$	67%
		F	$\leq$	57%

Anticipated topics:

- Bayesian modeling basics
- Bayesian computation
- Linear regression
- Generalized linear regression
- Autocorrelation
  - Spatial models
  - Temporal models
- Movement data
  - Resource selection models
  - Dynamic animal movement models
- Mixture models
- Occupancy models
- Abundance models

University Policies

Statement on Academic Dishonesty:

The University Academic Standards Policy defines academic dishonesty, and mandates specific sanctions for violations. See the University Academic Standards policy: UAM 6,502.

Statement on disability services:

Any student with a disability needing academic adjustments or accommodations is requested to speak with me or the Disability Resource Center (Pennington Achievement Center Suite 230) as soon as possible to arrange for appropriate accommodations.

This course may leverage 3rd party web/multimedia content, if you experience any issues accessing this content, please notify your instructor

Statement on audio and video recording:

Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Additional Information

Methods for communication

In the event of class cancellation, new information on meeting times, or room changes, I will send an email to the class roster.

Additional detail about academic dishonesty

Statement for academic success services

Your student fees cover usage of the Math Center (775-784-4433), Tutoring Center (775-784-6801), and University Writing Center (775-784-6030). These centers support your classroom learning, and are there for you to leverage to improve your educational experience. Seeking help outside of class is the sign of a responsible and successful student.