ANALYSIS AND MODELING OF ECOLOGICAL DATA
SCHOOL OF NATURAL RESOURCES AND ENVIRONMENT
WINTER 2017

COURSE NO.: NRE 549 ANALYSIS AND MODELING OF ECOLOGICAL DATA

INSTRUCTOR: Inés Ibáñez - Dana 2546 - iibanez@umich.edu

MEETING TIMES: Monday and Wednesday 10:00-11:30 AM - DANA 2024

OFFICE HOURS: Mondays 12:00-4:00 PM by appointment.

COURSE DESCRIPTION:

This course will consist of an overview of standard and innovative methods in ecological data analysis and modeling. Topics will include: maximum likelihood, mixed effects models (fixed and random effects), generalized linear models, survival analysis, time series, spatial analysis; all with a particular emphasis in Bayesian and hierarchical/multilevel Bayesian approaches and multilevel models (a model with varying parameters that are given a probability model with parameters of their own). The course will be a combination of lectures and computer labs, for which we will be using open source programs, R, RStudio, JAGS and OpenBUGS.

This course is designed for students to work on their own data, or simulated data, related to their research projects or scientific interests. While reviewing the major statistical techniques, students will work on their projects and will be writing a complete research manuscript along the semester. The analysis of the data will consist of: initial exploratory data analysis, selection of statistical analysis or modeling approach, implementation, and presentation and discussion of results.

PREREQUISITES:

Students taking this course are expected to have a background (undergraduate level) in calculus, algebra and statistics. Students will need their own laptops for the R, RStudio, JAGS and OpenBUGS lab tutorials.

LECTURES, WORK PLANS, AND COURSE OBJECTIVES:

Lectures and class assignments will be organized around the several steps involved in analyzing and modeling data (see list below). We will practice these steps by working on students' models along the course. By the end of course students will have an understanding of the basic approaches used in ecological data analysis and modeling and they will be ready to jump-off into more advance understanding and use of these methods. They will have become proficient in the specific techniques chosen for their work (their own analyses) and will have the necessary knowledge and tools to understand work done using all the other methods addressed in the lectures (lectures and analyses from other students).

Steps to modeling:
Step 1: Formulate the question
Step 2: Determine the basic components
Step 3: Explore the data
Step 4: Qualitative description of the system
Step 5: Quantitative description of the system
Step 6: Analysis and coding
Step 7: Checks and balances
Step 8: Relating results to the question

DAY	**TOPIC***
	*Lecture topics may be revised depending on the addition of new topics or the need to revise already covered material.
Jan 9	Introduction to Analysis and Modeling of Ecological Data. Modeling steps.
Jan 14	Introduction to R.
Jan 16	Exploratory data analysis. Common functions.
Jan 21	Martin Luther King Day, no class. **Homework 1 due - Formulate Research Question & Exploratory Data Analysis (Steps 1, 2 and 3).**
Jan 23	Probability theory and common probability distributions.
Jan 28	Parameter estimation: Least Squares, Maximum Likelihood.
Jan 30	Parameter estimation: Bayesian methods. Methods for finding optimal parameters: Markov Chain Monte Carlo (MCMC) simulations.
Feb 4	Introduction to OpenBUGS and JAGS. **First Assignment due - Introduction (Step 1).**
Feb 6	Linear models .
Feb 11	Generalized linear models (GLM) I.
Feb 13	Students' models (Steps 1 to 8).
Feb 18	Generalized linear models (GLM) II. Mixed (fixed and random effects) models I. **Homework 2 due - Qualitative/Quantitative Description of Analysis and Alternative Models (Steps 4 and 5).**
Feb 20	Students' models (Steps 1 to 8).
Feb 25	Hierarchical/multilevel models.
Feb 27	Students' models (Steps 1 to 8).
Mar 5	Winter recess, no class
Mar 6	Winter recess, no class

Mar 11	Model selection: Goodness of fit, AIC, DIC, Predicted Loss. **Second Assignment due - Revised Introduction and added Methods.**
Mar 13	Students' models (Steps 1 to 8).
Mar 18	Correlated random effects. Time series analysis I.
Mar 20	Students' models (Steps 1 to 8).
Mar 25	Time series analysis II. Spatially explicit models. **Homework 3 due - Computer Code (Step 6).**
Mar 27	Students' models (Steps 1 to 8).
Apr 1	Survival analysis: proportional hazard, frailty and count process models.
Apr 3	Students' models (Steps 1 to 8).
Apr 8	Zero Inflated models.
Apr 10	No class this day. **Homework 4 due - All Potential Figures Generated from the Analysis (Step 8).**
Apr 15	Students' models (Steps 1 to 8).
Apr 17	Students' models (Steps 1 to 8). **Third Assignment due - Revised Introduction and Methods and added Results (Step 7).**
Apr 22	Students' presentations.
May 1	**Final: Fourth Assignment due 6:00 pm - Revised Introduction, Methods, and Results, and added Discussion.**

ACADEMIC ACCOMMODATIONS

If you need any particular accommodations for a disability please let your instructors and Services for Students with Disabilities (SSD) know, we will work to the best of our abilities to address your needs. Any information provided will be treated as confidential.

DIVERSITY, EQUITY AND INCLUSION

This course abides to the UM policies and procedures on Diversity, Equity and Inclusion, which can be found at http://diversity.umich.edu.

GRADING AND ASSIGNMENTS:

Grading will be based on class participation, oral presentations, homework, class assignments and a final paper:

* class participation	5%
* homework	15%
* first assignment	10%
* second assignment	10%
* third assignment	10%

* fourth/final assignment	40%
* oral presentations	10%

Grade assignments:

95.1-100	A+
90-95	A
88-89.99	A-
86-87.99	B+
80-85.99	B
78-79.99	B-
76-77.99	C+
70-75.99	C
68-69.99	C-
66-67.99	D+
60-65.99	D
58-59.99	D-
<=57.99	F

-**Class participation**: students' questions and comments are encouraged during the lectures and after the oral presentations. Class participation takes into account attendance, being on time for lectures, turning in assignments on time and participation in the discussion of assigned class readings.

-Oral presentation: Students will present their work at the end of the semester Presentations will be followed by a discussion/questions&answers session. Presentations will be evaluated on scientific content and clarity. Presentations will take place on **April 22** during the class period.

-**Homework***: along the course homework will be assigned to report progress on students' individual projects. Homework assignments will be focused of the necessary work we perform while analyzing data, but that is not usually reported in the final manuscript. Homework will be due on the **assigned date** (**Jan 21**, **Feb 18**, **Mar 25, Apr 10**) right before lecture, **10:00 am**.

-**First assignment***: will consist of an introduction to the student's class paper. It should follow the guidelines of a scientific research paper, including a title, introduction to the problem, justification, background and research question and/or hypothesis that will be addressed. Section specifications: no more 5 pages (excluding references), double spacing, 1" margins, 12 pt font. **Due February 4th 10:00 am.**

-**Second assignment***: will include the revised section from the first assignment and will incorporate a detailed description of the methods. The methods section will include a description of the lab and/or field-work involved and of the statistical analysis. The methods section specifications are: no more than 5 pages, double space, 1” margins, 12 pt font. **Due March 11th 10:00 am.**

-**Third assignment***: will include the revised two sections from the second assignment and will incorporate results from the analysis. The result section specifications are: no more than 3 pages (figures and tables excluded), double space, 1” margins, 12 pt font. **Due April 17th 10:00 am.**

- Fourth and final assignment*: will include the revised sections from the third assignment and will incorporate a discussion section commenting the results. Discussion section specifications are: no more than 5 pages, double space, 1” margins, 12 pt font. **Due May 1st 6:00 pm.**

*Homework and Assignment grades will be penalized for late submission, 10% of their value will be subtracted for each hour they are late.

HONOR CODE

All students are expected to abide by the University Student Honor Code.
Plagiarism will result in direct failure of the course. Plagiarism includes: 1) the direct use of any written material (e.g., books, journals, internet) without proper quotations and citation or 2) the submission of a document, in part or wholly authored by someone other than the student.

GENERAL REFERENCE MATERIAL

*References specific to assigned topic will be provided each week as we are constantly updating our bibliographic data set with new material.

Reference books

Albert, J. 2007. Bayesian computation with R. Springer, New York, NY.

Bolker, B. 2008. Ecological Models and Data and R, Princeton University Press. ISBN 978-0-691-12522-0.

Clark, J.S. 2007. Models for Ecological Data. Princeton University Press. ISBN 978-0-691-12178-9

Crawley, M.J, 2007. The R book. Wiley. ISBN 978-0-470-51024-7

Dalgaard, P. 2008. Introductory statistic with R. Springer.

Gelman, A. and Hill, J. 2007. Data analysis using regression and multilevel/hierarchical models. Cambridge University Press. ISBN 0-521-68689-X

Gilks, W.R., S. Richardson, D.J. Spiegelhalter. 1996. Markov Chain Monte Carlo in Practice. Chapman & Hall/CRC.

Hilborn, R., M. Mangel. 1997. The Ecological Detective. Princeton University Press. ISBN 0-691-03497-4

McCarthy, M. Bayesian methods for Ecologists. 2007. Cambridge University Press.

Otto, S.P. and Day, T. 2007. A Biologist's Guide to Mathematical Modeling in Ecology and Evolution. Princeton University Press. ISBN 0-691-12344-6

Parent, R. and Rivot, E. 2012. Introduction to hierarchical Bayesian modeling for ecological data. Chapman & Hall/CRC Applied Environmental Statistics. Chapman and Hall/CRC. ISBN-13: 978-1584889199.

Royel, J. A. and Dorazio, R.M. 2008. Hierarchical modeling and inference in ecology: the analysis of data from populations, metapopulations and communities. Academic Press. ISBN-13: 978-0123740977.

Quinn, G.P. and Keough, M.J. 2002. Experimental design and data analysis for biologists.

Stauffer, H.B. 2007. Contemporary Bayesian and Frequentist Statistical Research Methods for Natural Resource Scientists. Wiley. ISBN 978-0-470-16507-1

Winkler, R.L. 2003. An Introduction to Bayesian Inference and Decision. Probabilistic Publishing, Gainesville, FL.

Zuur, A. F., E. N. Ieno, N. J. Walker, A. A. Saveliev, and G. M. Smith. 2009. Mixed effects models and Extensions in Ecology with R. Springer Science+Business Media LLC, New York.

Web pages & freeware

BUGS (and WinBUGS) software (*Bayesians Using Gibbs Sampling*):
http://www.mrc-bsu.cam.ac.uk/bugs/welcome.shtml
Includes the freeware package WinBUGS and OpenBUGS and lots of good information about: links to Bayesian courses, examples, tutorials, references

Michael Lavine's web book (work in progress), Introduction to Statistical Thought:
www.stat.duke.edu/~michael/book.html

The R Project for Statistical Computing: http://www.r-project.org/
Free software package for statistical analysis and computing.

The RStudio webpage: https://www.rstudio.com/
Free software package for statistical analysis and computing, and easier way to work with R and JAGS

The JAGS webpage: http://mcmc-jags.sourceforge.net/
Just Another Gibbs Sampler, a program for analysis of Bayesian hierarchical models using Markov Chain Monte Carlo (MCMC) simulation