Spring 2-1-2018

BIOB 595.10: ST: Ecological Models and Data

Robert Ogden Hall
University of Montana, Missoula

Ecological Models and Data
BIO 595 Spring 2018 3 Cr. Location BRB 102.

"Models without data are fantasy, data without models are chaos" (R. Hirsch, Found on Twitter, Dec. 2017)

Instructor: Robert Hall, Flathead Lake Bio Station.
bob.hall@flbs.umt.edu
Office hours: Wednesday 10-12, 416A Health Science

Learning outcomes

1. Learn a diversity of approaches in the context of ecological modeling, ranging from analytical, deterministic, probabilistic
2. Create your own ecological models, ideally in the context of your graduate research
3. Learn to confront these models with data
4. Continue a never ending quest to perfect your written and graphical display of scientific information and understanding

Course audience
I will steer his course to beginning graduate students with varying ranges of modeling skills and interests. It will not be an advanced class in discipline-specific models or statistics. If you are in your 4th year of a epidemiology Ph.D. you may already have the skills your need.

Course requirements and grading
Course participation 50%
Semester-long project 50%

This class will take a generalist approach to describing, creating and testing ecological models. Ask 10 ecologists what a "modeling" class entails and you will get 10 different answers ranging from analytical population models (Lotka-Volterra), to physiological-based models, "small" ecosystem / food web models, "large, complex" ecosystem models, simple statistical models (regression), complex statistical models, and combinations of all of the above. The goal of this class is to explore general principles behind these models and then you will explore the suite of modeling approaches that are most relevant to your graduate research. Thus the course will comprise two parts:

1. One week intensive course in modeling principles
2. Weekly course meetings for ad hoc topics, readings, and project work.

This course will have focused time the week before class. This will allow you and me to put all of our efforts in 6 h/d without the usual distractions of the semester.. During the semester we will meet weekly for readings, discussion and work together. I will also allocate time for 1:1 time helping with research projects. Your project will be one, hopefully related to your research interests, where you pose a hypothesis, build a model, and confront with data. If you have no data, then find data from a published study. There is so much data out there that one can be very successful (if not bored) by never going outside to collect more. For example, we have modeled primary production for >300 streams (>100,000 days) without ever leaving the computer. You will have no problem finding data!

Caveat. I make no claim whatsoever to be either an ecological modeler or a statistician. Nearly all I know comes from 20 y or working with people much more knowledgeable than myself and then hundreds of hours of self teaching combined with choice words to describe the behavior of my computer. But this observation brings me to the 3 tenets of the course:

1. The tools and instruction for effectively using and testing ecological models with small to giant datasets have increased greatly in the past few years.

2. Given these tools, one does not need to be a specialist in ecological modeling to effectively use these tools and approaches.

3. Through instruction from me, teaching yourself, working with others, reading lots of good books, and assiduously practicing coding and math you can fearlessly learn new methods that will transform your abilities as a researcher.

Books I hesitate to recommend a book because there are a zillion texts in ecological modeling and statistics and your favorite book will depend on your field and your approach. That said, there are two required texts: Hilborn and Mangel (1997). The book that got me started. Must reading, simple computationally. It focuses on population ecology, but is relevant for all subfields. Plus the population first version of modeling has a long history in ecology (Wiegert, 1975). That said we will use newer solution methods for models in this course. The other book is Bolker (2008). This book is a newer, parallel example of H&M. I ask you to read parts of it it because I find having two teachers is better than one.

Here are my other favorites:

Kruschke (2014) The stats book every grad class would use in an alternative universe where computers were developed before methods of statistical inference.
Hobbs and Hooten (2015) New book on Bayesian confrontation for ecologists. Focuses on theory and not computation. I love this book.,
Gelman and Hill (2007). *The* book on hierarchical modeling. New edition supposedly on the way.

More specific ecological subject matter books include
Caswell (2001) Matrix population models
Agren and Bosatta (1998) A rare one on ecosystem models
Gotelli et al. (1995) Classic on mathematical population biology
Grimm and Railsback (2005) A method you may need
Haefner (2012) Standard of the industry for deterministic model methods
Soetaert and Herman (2008) Have not seen it, but new and uses R

Books that live near my computer
Wickham and Grolemund (2016) No escaping this one.
Murrell (2016) Handy reference for graphics.

Course prerequisites
1. Some understanding of a programming language. I use R as do many other ecologists, and it is fast becoming the lingua franca for many quantitative sciences. There is a lot of ink spilled on why R and I won't repeat it here. If you know some other language like Python, Matlab, etc., go ahead and use that; if you know these then you probably don't need my programming help anyway. But you should know enough R before this course to be able to load data, write a simple function, use a *for()* loop, make a scatterplot.
2. Enough statistics to understand things like regression, sums of squares, binomial probability, normal probability distribution. Enough math to explain $\frac{dN}{dt} = r_{max}N(1 - \frac{N}{K})$ and solve for its equilibrium.
3. Use of LaTeX and/or RMarkdown for your project and occasional assignments.. These are much better for writing technical literature. MSWord works great for letters and 3-page papers for classes. But for serious writing (papers, proposals, dissertations etc.) LaTeX is the industry standard. There is no easier way for writing equations. Learn it now and you will be happy. Wait until you are 49 and learn it with a 25-page LTER proposal on the line and it is a different story.

Learning disabilities
The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. If you have a disability that adversely affects your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or 406-243-2243. I will work with you and Disability Services to provide an appropriate modification.

Course schedule

Course begins in 4 days prior to the start of classes for intensive work. We will meet weekly during the semester to work on projects, discuss further reading and address topics of student interests.

Date	Morning (0900-1200)	Afternoon (1300-1600)	Reading
Tuesday 16 Jan.	Model philosophy and types of models	Deterministic model examples	Levins, HM 1,2, Bolker 1
Wednesday	More determinism	Probability	Wiegert , Bolker 3, HM 3
Thursday	Probability with R	Likelihood	Bolker 4, HM 7
Friday	Likelihood confrontation	Begin Bayesian?	Bolker 6 HM 8

Below is a ROUGH schedule for the semester. I am going to keep the semester portion of the class flexible so that we can go at a pace suitable to you and your research interests. The below is merely a starting point.

Week	Topic	Reading
24 Jan.	Probability distributions (you will pick 1 to lead the class)	
31 Jan.	Structural equation models 1.	
7 Feb.	Structural equation models 2.	
14 Feb.	Time series	
21 Feb.	Time series: Observation vs process error	
28 Feb.	model assessment via forward simulation	
7 Mar.	Equifinality in models, model selection	
14 Mar.	Multilevel models	HM 8,9
21 Mar.	More multilevel models	
28 Mar.	Spring Break	
4 Apr.	Equifinality in models, model selection	
11 Apr.	The statistical crisis	Gelman and Loken, Lemoine
18 Apr.	Project help	
25 Apr.	Project help	
2 May	Project presentation	
9 May	Projects due	

Project
A central part of this course is a project where you will build a model(s) and confront this model with either data you collected or harvested from some repository. There are huge amounts of data on the web (see, for example hubbardbrook.org or the Hawaii Ocean Time Series) if you do not already have some data of your own. I am going to keep the requirements of this part flexible so that you do what you want to do. But at a minimum, projects should test an ecological question by confronting models with data using likelihood or Bayesian approaches. Models are wide open and can be of regression type, SEM, dynamic models, time series, or anything else you can dream up. They should be written as a scientific paper, albeit a short one (10 pp text and ∼5 display items should be ok). Each paper should have its code and output as a supplement written in RMarkdown to enable easy duplication and understanding (and grading) of the work. Bring your idea for a project to me by 7 Feb. I will be around to assist with your project all semester. I the last week of class you will give a 15-min oral presentation of your project. Please make this project as relevant to your dissertation work as possible.

References

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Wickham, H. and G. Grolemund. 2016. R for data science.

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