Introduction to Quantitative Ecology and Evolution: EBIO 5460

Fall 2017

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Office hours: Mon 11-1 pm
Contacting me: I prefer email
Prerequisite: None but better if you have some math or statistics
Course: Monday & Wednesday 3:30-4:45, Ramaley N183

Course description

The course is all about how to construct models based on biology (as opposed to purely statistical models) and how to use this as a framework to test hypotheses in ecology and evolution by fitting the models to data and comparing the support of the models. This is neither a pure statistics course nor a pure modeling course. As you will see, statistics and modeling are best integrated. You will learn the fundamentals of each but most importantly, how to integrate them. This is fast becoming the most desirable approach to understanding biological processes.

Topics

Model based inference in ecology and evolution. The relationship between models, hypotheses, experiments, and data. How to make a model. How to test models against data, including likelihood and Bayesian approaches. Models for genes, individuals, populations, communities, and ecosystems. We will learn some math, some statistics, and some computer programming. We will learn R, a powerful environment for scientific computing. See the class schedule on the next page for more details.

Goals

Be able to comprehend the exploding literature in biology where the science is based on models and model fitting.
Learn to program properly, using fundamentals that apply in any programming language.
Be proficient at writing R programs to analyze models and data.
- Learn to make basic biological models.
- Learn to fit models to data.

Become confident at understanding quantitative tools developed by others.
Become confident at using customized quantitative approaches in your own research.
We will not learn about R's statistical analysis functions (that is a topic for a different course on statistical analysis).

Learning format

Quantitative ecology and evolution are best learned by doing. As much as possible, we will use active learning. This means that I will often give short periods of lecture (15-20

Class schedule. Quantitative Ecology and Evolution: EBIO 5460. Fall 2017.
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Week	Date	Topic (classes are often combined lecture/lab)	Reading*	Assignments due
Wk 1	28-Aug	Syllabus. Introduction to quantitative ecology and evolution. Introduction to R.	Bolker Ch 1	*These are*
	30-Aug	Introduction to R, a computing environment for quantitative methods		*approx dates*
Wk 2	4-Sep	**Labor day holiday**		
	6-Sep	Introduction to scientific programming	None	
Wk 3	11-Sep			
	13-Sep			Assignment 1
Wk 4	18-Sep			Selection structures
	20-Sep	Discussion: How to do science in ecology and evolution?	H&M pp 12-24	
Wk 5	25-Sep	Overview of models in ecology and evolution	H&M Chapter 1	Assignment 2
	27-Sep	Constructing models: introduction	esp. pp 32-34	Repetition structures
Wk 6	2-Oct			
	4-Oct			
Wk 7	9-Oct	Confronting models with data: introduction		Assignment 3
	11-Oct			Functions &
Wk 8	16-Oct	Topics: process and observation uncertainty		p-value algorithm
	18-Oct	Confronting models: sum of squares (a step towards likelihood)	H&M Ch 5-6, 11	
Wk 9	23-Oct	Topics: ssq profiles, optimization, model selection		
	25-Oct			
Wk 10	30-Oct	Discussion: modeling paper	Keeling et al. 2001	Assignment 4
	1-Nov	Confronting models with data: Likelihood	H&M Ch 3, 7-8	Nutrient cycle
Wk 11	6-Nov	Topics: probability models, likelihood profiles, confidence intervals, frequentist model selection		model
	8-Nov			
Wk 12	13-Nov	Likelihood advanced		
	15-Nov	Advanced likelihood topics: model checking, information theoretic approaches to model selection		
Wk 13	20-Nov	**Thanksgiving break**		Assignment 5
	22-Nov	**Thanksgiving break**		Disease outbreak
Wk 14	27-Nov	Confronting models with data: Bayesian	H&M Ch 9-10	model & SSQ
	29-Nov			algorithm
Wk 15	4-Dec	MCMC, BUGS, Stan		
	6-Dec	Discussion: Should biologists become Bayesians?	TBA	
Wk 16	11-Dec			
	13-Dec		TBA	Assignment 6
Wk 17	18-Dec	Exam week		Herbivore model
	20-Dec	Exam week		& model selection

* Reading is all available on D2L

minutes) interspersed with group work or hands-on implementation of the idea in the R computing environment. Hands on work will often be done in small groups - collaboration is encouraged. We will often share or compare approaches to an analysis with the rest of the class. Three to four classes have been set aside for structured discussion of reading material, which will include discussion of papers from the primary literature (roughly split between conceptual and technical works). The bottom line is that class participation is strongly encouraged and I hope that we can create an environment that is relaxed and nonjudgmental so that we will all feel comfortable enough to participate and also that all contributions are valued. I also hope that we can create an environment of respect for each other's learning processes and ideas.

Laptops

You should bring a laptop to every class, except perhaps the discussions. It will be handy if your laptop is wireless ready and you have set up a CU wireless account. A wireless connection will enable you to access internet based help, download R scripts, as well as participate in collaborative class exercises. If you don't have access to a laptop please let me know as soon as possible.

R computing environment

We will be using the R computing environment. You should have the latest version of R installed on your computer (please update R if you have an older version). R can be found here:
www.r-project.org/
There is a version for whatever flavor of operating system you have (Windows, Mac, Linux). Let me know if you have any problems with installation. After installation, start R and select Help > Manuals > An Introduction to R (or find it here: http://cran.stat.ucla.edu/manuals.html). This is the most useful way to get started.

You can use R immediately after installing it with its operating specific graphical user interface (GUI), which is launched in the standard way for your operating system (e.g. double clicking the R icon). However, a lot of people use R from within a different program called R Studio. I will use R Studio. R Studio is what is known as an "integrated development environment" (IDE) for R. You don't have to use this if you already prefer a different way of working. If you are new to R, then I recommend it. To use R Studio, you need to first install R (see above). Then, install R Studio (Desktop, open source edition), which can be found here (Windows, Mac, Linux):
www.rstudio.com/

Texts

There is no set text. We will sample from a number of texts and the primary literature. I will provide any reading materials. However, two texts that I think are very useful in the context of this course, and from which I will draw, are:

Hilborn and Mangel (1997) *The Ecological Detective*, Princeton University Press.

While this book is now 20 years old, it is still the best introductory text. There are several new texts that have come out in the last few years that cover more recent developments in quantitative approaches but these texts are significantly harder. Hilborn and Mangel (1997) nicely cover the fundamental concepts and approaches, which are not out of date and are needed for the more advanced texts.

Bolker (2008) *Ecological Models in R*, Princeton University Press.

This text is more in depth and specifically for the R computing environment. I will most likely reference it from time to time and I highly recommend it as supplementary reading for the course and for your shelf.

Both texts can be purchased from Amazon. Class material will be supplemented with recent and classic papers for discussion.

Desire2Learn

We will be using Desire2Learn to access course materials, and for other class functions. Go to learn.colorado.edu.

Grading

Minor assignments (3) 10%
Major Assignments (3) 80%
Discussions (3 or 4) 10%

This material is tough and multidisciplinary. I don't expect you to master every facet; that will come with time. If you complete the work this semester with attention and care, you will get an A or A-, and will have an excellent foundation for self learning going into the future.

Assignments

Each assignment will be a set project that will involve formulating models, fitting them to data, and drawing a scientific conclusion. The first three assignments will be minor assignments (each worth 3.33%) to get up to speed on programming in R. There will be three major assignments, each worth 26.66%. In all assignments, criteria for assessment will include the quality of the conceptual approach to the problem, quality of the technical implementation (code), and quality of the presentation.

Discussions

There will be three or four discussions (TBD) worth a total of 10% of your grade. Each discussion will be worth 3.33%. You will get 2% if you are present for the discussion and you turn in a summary of your points for discussion, due immediately before the class, of at least 200 words. You must attend and *submit the summary* to get *any* credit for the discussion. The idea of the written summaries is to systemize your thoughts before the discussion, rather than just reading the paper beforehand. This generally leads to more productive discussion. It means you will discuss more substantive issues and avoids talking about issues that are trivial once you give them some thought. Readings and

discussion worksheets will be posted on Desire2Learn. We'll try to work in small groups to encourage participation and to make it easier for those who are shy.

Exams

There will not be an exam. This material is not suited to exams.

Your fieldwork

I realize that as graduate students you may have fieldwork to complete during the semester. Please see me early on so we can talk about how we can work around your fieldwork.

Email

I will sometimes send out an email to the entire class. Please let me know if you would prefer for the other students not to see your email address. Also, if you would prefer to use an email address other than your CU one, email me to let me know.

Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to me in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website (www.colorado.edu/disabilityservices/students). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website and discuss your needs with me.

Religious observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, in most cases you should have sufficient time to complete the assignments and submit them on time, or early if appropriate. If this does not work for your situation, please notify me at least two weeks in advance of the conflict to request special accommodation. Please do the same for any conflict you have with discussions. See full details at www.colorado.edu/policies/observance-religious-holidays-and-absences-classes-andor-exams.

Classroom civility

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. Form more information see the policies on classroom behavior and the Student Code of Conduct:
www.colorado.edu/policies/student-classroom-and-course-related-behavior
www.colorado.edu/osccr/

Sexual misconduct, discrimination, and harassment and/or related retaliation

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist

individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the OIEC website. (www.colorado.edu/institutionalequity/).

Academic integrity

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy (www.colorado.edu/policies/academic-integrity-policy). Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at the Honor Code Office website (www.colorado.edu/honorcode/).

In this course, there will be zero tolerance for academic misconduct. Most violations, including cheating, will result in you failing the course.