BIOL 6750: Measuring and Modeling the Terrestrial C Cycle

Instructor: Dr. Bonnie Waring
Contact: bonnie.waring@usu.edu

Location: Geology 301
Schedule: MWF 8:30 – 10:20 am

Course Objectives

This course focuses on important ecological processes that influence the terrestrial carbon (C) cycle, and how they are represented in predictive ecosystem models. The primary course emphasis is placed on the belowground (soil) C cycle. In this course, you will:

- *engage with fundamental concepts in ecosystem ecology, soil microbial ecology, and soil biogeochemistry by reading and discussing the primary literature.* Each week, you will read selected publications representing the current 'state of the art' in terrestrial ecosystem ecology. Following a brief lecture, you will discuss the readings, summarizing how each contribution has advanced the field.
- *apply your knowledge to interpret the (often contradictory) predictions of the most commonly used biogeochemical models*. All biogeochemical models have unique strengths and limitations. Through class discussions and model simulation exercises, you will learn to apply your foundational knowledge to evaluate model predictions in the context of real-world data.
- *hone your scientific communication skills through written assignments and oral presentations.* Throughout the course, you will have the opportunity to present summaries of assigned readings to the rest of the class, distilling key findings and relating them to the fundamental course themes. You will also be required to write a short literature summary on a course-related topic of your choice. In addition to strengthening your engagement with course content, these assignments will enhance your ability to collaborate with peers, translate the primary literature to a general audience, think critically about course content, and write technical documents.

Learning Objectives (USU IDEA Center)

1. Learn fundamental principles, generalizations, and theories related to soil microbial and terrestrial ecosystem ecology
2. Apply course materials to the evaluation of biogeochemical model predictions, improving rational thinking and problem solving skills
3. Learn to analyze and critically evaluate ideas, arguments and points of view

Course Materials

You will have access to all assigned readings through the course Canvas website.

Course Structure

Reading Assignments and Class Discussions

Each week, you will read 3-4 *Core Papers* and 3-4 *Related Papers* on a selected topic in the terrestrial carbon cycle.

1. On Mondays, there will be a brief lecture presentation to familiarize you with key themes and concepts of the *Core Papers.* The lecture will be followed by a group discussion.
2. On Wednesdays and Fridays, small student groups will be assigned to present a short summary of the *Related Papers* to the rest of the class. These presentations should focus on synthesizing important concepts or findings of the *Related Papers* with the themes addressed by the *Core Papers*. Student presentations will be followed by group discussion.

Simulation Model Exercises

Each week, you will complete a modelling problem set in the *R* programming environment. The goal of these programming exercises is to deepen your understanding of course material through ‘hands-on’ experience with the simulation models we will be discussing. **You should have a very basic (beginner-level) familiarity with R in order to do well in the course**; however, you will receive instruction in the techniques necessary to build these models (e.g. manipulating matrices, writing loops, etc.)

1. On Mondays, problem sets will be distributed, and you will receive a simple tutorial for implementing specific model structures in R.
2. The second hour of class time on Wednesdays and Fridays will be devoted to the completion of problem sets. Dr. Waring will be available to answer questions or provide feedback during this time.
3. Model problem sets are due at 5 pm every Friday.
4. Solutions to the problem sets will be available following their submission.

Grade Breakdown and Policy

In-class participation through group discussions and paper presentations will comprise 40% of your overall grade. Additionally, you will complete simple model exercises in the *R* programming environment. Finally, you will also be required to write a short literature review and synthesis about a course-related topic of your choice; this assignment counts for 35% of your grade.

Assignment	Weight (% of Grade)
Class participation (group discussions)	15
Related paper presentations	25
Modeling exercises	25
Literature review and synthesis	35
TOTAL	*100*

Final course grades are based on the following scale and **will not** be rounded up to the nearest whole number: A (94-100%), A- (90-93.9%), B+ (87-89.9%), B (84-86.9%), B- (80-83.9%), C+ (77-79.9%), C (74-76.9%), C- (70-73.9%), D+ (67-69.9%), D (64-66.9%), D- (60-63.9%), F (below 60%).

How will class participation be graded?

It is expected that you will read **all assigned papers** each week, and be able to actively contribute to the class discussion of these papers. Here are some tips for effective class participation:

If you are leading a discussion…

- Take no more than 5-10 minutes to present an assigned paper to the rest of the class. You do not need to provide an exhaustive overview of every detail, nor should you just reiterate what everyone has read. Your main goal is to promote discussion: by linking your assigned paper to the larger themes of that week's readings, and by providing your own critical evaluation (be it positive or negative) of the paper.
- Come prepared! Make a list of questions to promote discussion within the group (more than you think you will need).
- Listen! Part of leading a discussion is knowing when to direct the conversation, and when to let it flow. Let the conversation develop organically – I don't expect you to *dominate* the discussion by giving an in-depth analysis of every technique/analysis/finding. I do expect you to be familiar enough with the paper to *guide* discussions on these topics.

If you are participating in a discussion…

- Discussing a paper does not necessarily mean that you need to find its flaws, or point out where the authors may be wrong. Of course, if you find an issue or inconsistency, it is totally appropriate for you to bring this up! However, you may also point out areas where the authors excelled, or aspects of the paper you particularly liked. In other words, 'paper discussion' and 'paper criticism' are not synonymous.
- If you find some aspect of the paper to be extremely challenging, it is fine to ask for clarification from the rest of the group. Asking questions also counts as 'discussion.' However, I do expect you to make an effort – if there is a recurring, important concept that you are not familiar with, explore the literature on your own to provide context (I am happy to guide you.)

How will modeling exercises be graded?

In programming, there are many different paths to a simulation model that works – in other words, there is no single 'correct answer' for how to implement a given model in R. Therefore, 80% of your grade on model problem sets will be based on effort: your **documented** attempts to get a particular model working. The remaining 20% of your grade is dependent on whether or not the model actually runs correctly. If you get stuck, approach me for help during the classroom hours set aside for this purpose!

Course Schedule

	Topic	Core Papers	Related Papers
Week 1	Fundamentals of the terrestrial carbon cycle	Houghton 2003 *Treatise Geochem* Luo et al. 2014 *GCB* Bradford et al. 2016 *NCC*	Stockmann et al 2013 *AGEE* Ballantyne et al. 2012 *Nature*
Week 2	Plants and the carbon cycle	Wright et al. 2004 *Nature* Moorcroft et al. 2001 *Ecol Mono* Wullschleger et al. 2014 *Ann Bot* Fisher et al. 2017 *GCB*	Scheiter et al. 2013 *New Phytol* Reich 2014 *J Ecol* Donovan et al. 2014 *J Ecol* Díaz et al. 2016 *Nature*
Week 3	Microbes and the carbon cycle	Fierer et al. 2007 *Ecology* Bradford et al. 2008 *Ecol Letts* Melillo et al. 2017 *Science*	Strickland et al. 2009 *Ecology* Fierer et al. 2011 *ISME J* Matulich and Martiny 2015 *Ecology* Hartman et al. 2017 *ISME J*
Week 4	Evaluating current ecosystem models and their assumptions	Todd-Brown et al. 2013 *Biogeosci* Todd-Brown et al. 2014 *Biogeosci* Zaehle et al. 2014 *New Phyt* Luo et al. 2016 *GBC*	Parton et al. 1987 *SSSAJ* Norby & Zak 2011 *Ann Rev Ecol Evol Syst* Wieder et al. 2017 *GCB*
Week 5	Explicitly representing microbes in ecosystem models	Schimel and Weintraub 2003 *SBB* Allison et al. 2010 *Nature Geosci* Davidson et al. 2012 *GCB* Wieder et al. 2013 *NCC*	Mooshammer et al. 2014 *Nat Comm* Frey et al. 2013 *NCC* Poll et al. 2006 *Eur J Soil Sci*
Week 6	Microbial resource allocation in ecosystem models	Moorhead & Sinsabaugh 2006 *Ecol Mono* Moorhead et al. 2012 *SBB* Allison 2012 *Ecol Letts*	Sinsabaugh et al. 2009 *Nature* German et al. 2011 *Ecology* Talbot & Treseder 2012 *Ecology* Manzoni et al. 2017 *Ecol Letts*
Week 7	Microbe-mineral interactions in ecosystem models	Wang et al. 2013 *Ecol App* Wieder et al. 2014 *Biogeosci* Sulman et al. 2014 *NCC*	Torn et al. 1997 *Nature* Six et al 2002 *Plant Soil* Schmidt et al. 2011 *Nature* Cotrufo et al. 2013 *Global Change Biology*

The Honor System and Plagiarism

To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge: "I pledge, on my honor, to conduct myself with the foremost level of academic integrity." A student who lives by the Honor Pledge is a student who does more than not cheat, falsify, or plagiarize. A student who lives by the Honor Pledge:

- espouses academic integrity as an underlying and essential principle of the Utah State University community;
- understands that each act of academic dishonesty devalues every degree that is awarded by this institution;
- is a welcomed and valued member of Utah State University.

Plagiarism includes knowingly "representing, by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes the unacknowledged used of materials prepared by another person or agency engaged in the selling of term papers or other academic materials." The penalties for plagiarism are severe. They include warning or reprimand, grade adjustment, probation, suspension, expulsion, withholding of transcripts, denial or revocation of degrees, and referral to psychological counseling.

<u>Violation of the Honor System</u>*:* If you are found to be cheating on an exam or written assignment, you immediately forfeit your grade on that assignment. There are no exceptions to this policy.

Students with Disabilities

The Americans with Disabilities Act states: "Reasonable accommodation will be provided for all persons with disabilities in order to ensure equal participation within the program. If a student has a disability that will likely require some accommodation by the instructor, the student must contact the instructor and document the disability through the Disability Resource Center (797-2444), preferably during the first week of the course. Any request for special consideration relating to attendance, pedagogy, taking of examinations, etc., must be discussed with and approved by the instructor. In cooperation with the Disability Resource Center, course materials can be provided in alternative format, large print, audio, diskette, or Braille."