Terrestrial Carbon Cycles
11:375:431 Spring (even years)
Instructor: Mary Whelan, mary.whelan@rutgers.edu

Course Goals
Use models to understand biogeochemical cycling
Identify and explain processes and externalities in Earth's carbon cycle
Interpret data effectively and understand if more information is needed
Appreciate the complexity of the carbon cycle and how it affects life on Earth

Course Assignments

Pre and Post Assessments	4%
6 Problem Sets (PS)	30%
3 Lecture Preparation (LP) Activities	12%
3 Open-Note Exams	54%

Problem Sets For each problem set, students will be assigned a collaboration group. Each student will turn in their own answers to problems. Different collaboration groups will have slightly different, but related questions that will aid in subsequent class discussion.
Exam Redux Exam questions with incomplete or incorrect answers can be corrected and turned in for half credit a maximum of 1 week after the exam is handed back.
Texts are all available as pdfs on the Canvas site.

Schedule and Goals

Week	Topic/*Reading*/*Assessments*	Goals
0	Motivation *Course pre-assessment* *LP: Picture Your Ecosystem*	Recall the structure of carbon and isotopes Investigate the concept of biogeochemical cycles Review the greenhouse effect in context Build a simplified carbon cycle
1	**Act 1: Carbon Uptake** Photosynthesis, generally *Ehleringer 2005*	Assess the relative importance of photosynthesis in the carbon cycle Clarify the difference between C3 and C4 photosynthesis and their geographic distributions
2	Farquhar *Farquhar et al. 2001* *PS 1 due*	Examine plant behavior under light/temperature/water and nutrient stress Figure out how the Farquhar Model expresses variation in plant carbon uptake
3	CO_2 plant response *Walker et al. 2020 (Box 1 + 2)* *PS 2 due*	Discover how photosynthesis changes under elevated CO_2 Examine the evidence for this change from the last 100 years
4	Review and Synthesis *Exam 1: Carbon Uptake*	Synthesize what we have learned about photosynthesis by discussing the last glacial maximum
5	**Act 2: Enter Soil and Water** What is soil? *NRCS Soils Primer*	Uncover the factors that affect soil formation Appreciate the scale of soil genesis Classify the forms of carbon in soil

6	Carbon-Climate Feedbacks *Walker et al. 2020 (Section II: Theory)* *PS 3 due*	Connect the process of photosynthesis with other processes in the carbon cycle, including respiration Contrast information about nitrogen limitation and phosphorus limitation Consider biomass storage for carbon sequestration
7	Reticent Soil Carbon *Amundson and Biardeau 2018, Loisel et al. 2019* *PS 4 due*	Investigate soil structure variability Deduce how soil structure affects carbon transport Distinguish between carbon escape to atmosphere and carbon escape to water transport
8	Review and Synthesis *Exam 2: Soil Carbon, Links to GPP*	Synthesize what we have learned about soil carbon through examining soil carbon sequestration efforts
9	Carbon on the Redox Ladder *LaCroix et al. 2019*	Link soil structure to oxygen variability Compare oxic and anoxic carbon transformation Recall the different climate impact of CH_4 and CO_2 Examine implications for wetlands
10	Lakes, Rivers, Wetlands *Mendonça et al. 2017* *PS 5 due*	Classify forms of carbon in lakes/water ways Determine the impact of precipitation variability on carbon transport Understand why small mountain rivers outgas an outsized amount of CO_2
11	**Act 3: Disturbance** Land on Fire *Lasslop et al. 2019* *LP: What Is Fire*	Describe what is meant by “fire” Recognize what makes landscapes flammable Investigate the impact of fire on the carbon cycle Link to precipitation effects on carbon transport Examine the role of agriculture and fire.
12	Land Use Change *Arneth et al. 2017* *PS 6 due*	Define what is meant by land use change Interpret carbon data from different land uses Test what happens during transitions
13	Carbon Capture and Storage *Exam 3: Carbon landscapes*	Discuss fossil fuel burning in the carbon cycle Argue for the most efficient method of removing carbon from the atmosphere
14	Review and Synthesis *Course post-assessment* *LP: Picture Your Ecosystem*	Assemble our more complex carbon cycle

Environmental Science Undergraduate Program Goals and Assessment

Apply knowledge, skills and techniques from the sciences and mathematics to identify, characterize and provide solutions to environmental problems

Increasing CO_2 and CH_4 in Earth's atmosphere and the associated climate change is the key problem addressed in this course.

The problem is characterized simply in Week 1. The interrelated nature of the carbon cycle under climate change is explored more deeply by investigating individual fluxes and reservoirs in the carbon cycle in subsequent weeks.

In order to explore solutions, students must demonstrate their knowledge of the problem in order to propose and assess perturbations that can be made to the carbon cycle to reduce the amount of CO_2 and CH_4 in the atmosphere.

The skills and techniques used include box models, analyzing and interpreting published data, and drawing conclusions about how specific perturbations affect carbon in the atmosphere.

Assessment: Problem sets and exams have short questions to allows students to demonstrate their knowledge of the problem (true/false or multiple choice).

Longer essay and derivation questions centered around published data prompt students to use data to assess observed changes in the carbon cycle.

Communicate technical information effectively

Students are called upon (1) to respond to problem sets and exams in a written format and (2) to complete lecture preparation activities, where students orally present a short dataset that describes carbon exchange in an ecosystem they are familiar with.

Assessment: The effectiveness with which students are able to communicate will be graded on the accuracy and cohesiveness of their overall idea.

Function effectively on teams to accomplish collaborative tasks

The instructor assigns students to groups for each problem set. Each group works on a problem set that is slightly different. For example, one team may examine $^{13}CO_2$ exchange for C4 plants, while another team looks at $^{13}CO_2$ exchange for C3 plants. The lecture for which the problem set is due, the students are divided into groups again, with representatives from each problem set group in each. Students then engage in a collaborative discussion comparing the two examples and present their findings to the entire class.

Assessment: Students who effectively work in teams will be able to generate complete answers to questions which will be reflected in their problem set grade.