NRES/IB 516 – Spring 2017
Ecosystem Biogeochemistry

Tu,Th 8:30-9:50*, 208 Agricultural Engineering Sciences Building*

Instructor:

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Description:

Biogeochemistry is the study of i) processes that control the exchange of chemical elements between living organisms and their abiotic environments and ii) the resultant spatio-temporal patterns in concentrations and chemical forms of the elements. The role of biogeochemical processes as an important regulator of ecosystem function will be explored in the context of forested, agricultural, and aquatic ecosystems. The linkages between terrestrial and aquatic compartments of watersheds will also be examined in detail. The relationship of biogeochemical dynamics, as affected by human activities, to a variety of global changes (e.g., climate change, eutrophication, acidic deposition) will be explored through students: i) engaging text and lecture material, ii) leading discussions and giving presentations, ii) generating annotated bibliographies, iii) working problem sets, iv) taking written examinations, and v) developing a semester-long project.

Objectives:

- To examine the biogeochemistry of several key elements in forest, agricultural, and aquatic ecosystems at an advanced level,
- To understand linkages between the biogeochemical cycles in terrestrial, wetland, and aquatic ecosystems,
- To learn how changes in biogeochemical cycles exert effects at global scales,
- To integrate biogeochemical concepts across spatial and temporal scales,
- To understand how biogeochemical processes connect living organisms with their abiotic – physical and chemical – environments in a variety of ecosystems.

Scope:

- An advanced, graduate-level study of the biological, geochemical, and physical processes that comprise the main elemental cycles in a variety of forest, agricultural, and aquatic ecosystems,
- Examines multiple elements, including carbon, nitrogen, phosphorus and others,

- Considers both pollutant and nutrient roles of elements in terrestrial and aquatic ecosystem processes,
- Explores the mechanisms that link different element cycles,
- Describes connections between forest, agricultural, wetland, and aquatic components of watershed ecosystems,
- Investigates biogeochemical patterns and processes at varying spatial and temporal scales,

Required textbook:

Schlesinger, W.H. and E.S. Bernhardt. 2013. Biogeochemistry: An Analysis of Global Change, 3rd edition, Academic Press, New York.

Prerequisite:

400-level courses in two or more of the following areas: soil science, aquatic science, ecology, and hydrology; or consent of instructor.

Course structure:

Class sessions will primarily follow a lecture format. Students will also be required to make presentations and lead discussions during some class sessions. In addition to reading from the required textbook, students will gain wide exposure to recent biogeochemical literature by preparing annotated bibliographies for parts of the course. Problem sets will be aimed at developing critical and quantitative analytical skills. A class project (presentation and paper) will require developing an in-depth synthesis of the literature on the biogeochemical cycle of an element or compound at watershed or larger scale. Finally, a mid-term exam will be administered in order assess student understanding of biogeochemistry.

Evaluation:

- Class participation / annotated bibliographies (10%)
- Discussion leadership (10%)
- Problem sets (2) (20%)
- Mid-term exam (15%)
- Final exam (20%)
- Individual research project presentation and paper (25%)

Description of Coursework Components:

Annotated bibliography

An important part of professional training is becoming familiar with the current literature on important topics in one’s domain. Having a command of the literature provides you with essential background information that will deepen your professional abilities. Presenting such information verbally and in written form is a necessary skill that must be developed and refined through practice. Annotating bibliographies is an excellent means of practicing these skills.

For the five class sessions indicated on the schedule below, each student must conduct a literature search and prepare an annotated bibliography comprising five papers from the recent, scientific literature on one element (carbon, nitrogen, phosphorus, cations, and sulfur). The student bibliographies will serve as supplemental readings used to enhance class discussions.

a. Articles selected should be relevant to the class and published in the last 2-3 years.
b. Each citation must include a brief summary of the results/findings and the significance of the paper.
c. When annotating the citation, be thorough and clear. Make it informative.
d. The bibliography must be word processed and formatted in a professional manner.
e. A textbook, whether used in this class or not, is not an acceptable primary source. Recent textbooks, however, may be useful for identifying such sources.

An example annotation follows:

Rustad, L.E., J.S. Kahl, S.A. Norton, and I.J. Fernandez. 1994. Underestimation of dry deposition by throughfall in mixed northern hardwood forests. J. Hydrol. 162: 319-336.

> At Bear Brook watershed in Maine, dry and wet deposition were examined as inputs to a northern hardwood /mixed conifer watershed. Two approaches were used to estimate dry deposition of sulfate and chloride: throughfall collection and catchment mass balances. Using throughfall, sulfate dry deposition was estimated to be 0.9-times the wet inputs, whereas the catchment mass balance yielded 1.7-times wet. These estimates of dry deposition were much greater than other watersheds/stands in the northeastern US. Net throughfall was thought to underestimate dry deposition (compared with other ecosystems) because of the importance of super-dominant conifers in this ecosystem. These conifers would have caused an uneven canopy architecture and increased dry and occult (fog water/cloud) deposition due to increases in aerodynamic roughness. This type of forest is a common part of the landscape in New England as a result of natural and anthropogenic disturbances.

Discussion leadership

For some class meetings, students will be assigned as presenter/discussion leaders. You will have this assignment once or twice during the semester, depending on class size. You will be asked to sign up for dates at the beginning of the semester. As presenter/discussion leader, you should make a brief presentation that summarizes the subtopic based on readings in the textbook and/or journals, and then expand on it with the help of your annotated bibliography. This should then lead into a discussion by the rest of the class, using their annotated bibliographies as a guide.

This aspect of the course will allow each student to evaluate the literature and provide a verbal summary of it. Also, students will learn to moderate and facilitate discussion of a topic, a difficult but important skill.

Exams

Midterm

Students will be allowed to take home the midterm exam to work on for one week. The exam will test the level of familiarity and skill gained with respect to the textbook and lecture materials. The exam will include a mixture of essay and quantitative analysis questions.

Final Exam

The final will be a 2-hour long, in-class exam held during the time posted on the final exam schedule. It will focus on the material presented after the mid-term, but may require the use of some general materials and methods presented earlier in the class. The exam will include a mixture of multiple choice, quantitative analysis, and short essay questions.

Individual research project

Submit a summary paper (maximum 10 pages of text) by the first day of finals. This paper should be on a topic different than your thesis topic and be general enough to include multiple aspects of biogeochemistry. You will need to select a particular biogeochemical cycle and ecosystem – e.g., nutrient cycling in mangrove swamps – in consultation with the instructor. Expected types of work to be performed for the paper include gathering publicly-available data (LTER sites, National Agricultural Statistics Service, FAOSTAT), data synthesis and analysis.

1. All students must make a short oral presentation of their project proposal before spring break. These presentations should include: 1) the topic to be investigated, 2) specific objectives, questions, and hypotheses, 3) data sets to be used.
2. The paper (maximum 10 pages of text) should include all content described below. Further details will be given in class.
3. In addition to writing the paper, the synthesis and key results must be presented in research seminar format, with Powerpoint slides, near the end of the semester,

Each paper must consider the following aspects of the biogeochemical cycle investigated:

1. Introduction,
    a. Overview of cycle,
    b. Why it is important,
    c. Hypothesis(es) to be tested (as appropriate).
2. Conceptual model of biogeochemical cycle showing,
    a. Key environmental compartments/pools,
    b. Chemical forms of the element in each compartment,
    c. Biogeochemical transformation processes,
    d. Physical transport processes.
3. Descriptive summary of each compartment/pool.
4. Descriptive summary of each process, including controlling factors.
5. Quantitative summary of elemental inventory in each pool and flux associated with each process in the form of a table or figure, preferably for multiple sites.
6. In-depth discussion of most important components of the cycle,
    a. Present alternative hypotheses for controlling factors, rates, etc.

   b. Summarize evidence for alternatives.
7. Discussion of how this biogeochemical cycle may be impacted by global change,
   a. Global warming,
   b. Increased atmospheric CO_2 concentrations,
   c. Decreases/increases in acidic deposition,
   d. Terrestrial ecosystem nitrogen saturation,
   e. Hydrologic cycle intensification.
8. Overview of key models describing the cycle,
   a. Description of the models,
   b. Description of similarities and differences.
9. Summary and conclusions concerning hypothesis and cycle.

Session	Topic	Textbook Chapters	Lecturer	What's due
1.1	Introduction	1	Hudson	
1.2	Major pools and processes in global biogeochemistry	2, 3, and 10	Hudson	
2.1	Hydrology and the small watershed approach		Hudson	
2.2	Stable isotopic techniques		Hudson	Problem Set 1
3.1	Ecosystem stoichiometry		Hudson	
3.2	Carbon (overview)	5, 8, 9	Hudson	
4.1	Carbon (aquatic)		Hudson	
4.2	Carbon (agricultural)		Hudson	
5.1	Carbon and global change	11	Students	Initial project topic; C biblio
5.2	Nitrogen (agricultural)	6, 8, 9, 12	Hudson	
6.1	Nitrogen (forest)		Hudson	Problem Set 2
6.2	Nitrogen (aquatic and terrestrial linkages)		Hudson	Revised project topic
7.1	Nitrogen and global change		Students	N biblio
7.2	Phosphorus (terrestrial)	6, 7, 8,12	Hudson	
<u>Mid-term exam – take home, due in one week</u>				
8.1	Phosphorus (aquatic)	8, 9,12	Students	P biblio
8.2	Wetlands		Hudson	
9.1	Agriculture			
9.2	Oral project proposal presentations		Students	Written proposals
<u>Spring Break</u>				
10.1	Major cations	4	Students	Cation biblio
10.2	Trace elements (terrestrial/aquatic linkages)		Hudson	
11.1	Sulfur (watershed)		Hudson	
11.2	Sulfur (global)		Students	S biblio
12.1	Acid deposition effects	6	Hudson	
12.2	Mercury biogeochemistry		Hudson	
13.1	Biogeochemical models (watershed)		Hudson	
13.2	Biogeochemical models (global)		Hudson	
14.1	Student presentations		Students	
14.2	Student presentations		Students	
15.1	Student presentations		Students	
	Final Exam			