Soil Properties and Processes

NRE 430 - EEB 489

10:00-11:00 Monday & Wednesday

Fall Term 2004

Instructor:

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Graduate Student Instructor

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Office Location and Hours:, Dana 2556; Friday 9:30-11:00 AM

Course Homepage: http://www.umich.edu/~nre430/

Course Objectives

This course centers on the overlap of soil science and ecology. Our goal is to understand: (1) how the interactions of landform, topography, climate, and biota result in patterns of soil development and the distribution of soils that we observe within the landscape; (2) how physical, chemical and biological properties of soils affect water and nutrient availability to plants; and (3) how nutrients are cycled within terrestrial ecosystems and how these processes are influenced by human activities.

In the field portion of the course, we will sample and describe soils of four ecosystems and observe first-hand how differences in landform, topography, climate and biota influence soil development. In the laboratory, we will analyze our soil samples for a number of physical, chemical, and biological properties. Using laboratory data in conjunction with field data, each student will select two of the four ecosystems for detailed comparison in a research paper. Although we will focus our attention on local ecosystems of Michigan, skills learned in this course may be broadly applied within a variety of terrestrial ecosystem types in other geographic regions.

Prerequisites

Students are expected to have a background in chemistry and biology. In particular, a working knowledge of chemical equilibria, ionic solution chemistry, pH, and oxidation-reduction reactions is highly recommended. Students without such background should consult with the instructor before enrolling. Also useful (although not required) are familiarity with biochemistry, plant physiology, microbiology, geology, and local flora. You will find it very helpful if you have had, or are currently enrolled in, Woody Plants (NRE 437). If you have not done so, we *highly recommend* that you enroll in these courses concurrently!

Required Texts

Brady, N.C., and R.R. Weil. 2002. The Nature and Properties of Soils, *13th Edition*. Collier MacMillan Publishers, N.Y.

Barnes, B.V., D.R. Zak, S. Denton, and S. Spurr. 1998. Forest Ecology. *4th Edition*. John Wiley & Sons. NY.

Grades

Course grades are distributed as follows:

Exam 1	30%
Exam 2	30%
Term Paper	25%
Lab Assignments	15%

The two exams are one hour each and will be graded on a 100 point scale. The second exam is cumulative and will be given during the final exam period. Exams cannot be made-up without prior notice to the instructor. Note that all students with exam grades below 60 will be asked to consult with the instructor. Final letter grades will be assigned based upon the point distribution with consideration of other aspects of performance, such as effort, participation, and improvement.

Laboratory

While the lecture portion of the course provides background knowledge, the laboratory portion of the course is an opportunity for students to gain hands-on experience sampling and describing soils in the field and analyzing various soil physical, chemical, and biological properties in the lab. The importance of the laboratory is reflected in the proportion of the time each week devoted to it. In each lab section, students will be grouped into teams of two or three. Activities and assignments in the lab will be cooperative efforts among team members. Attendance is critical to permit equal participation among team members, and all laboratory assignments are due at the beginning of the next laboratory meeting. Assignments will vary with each specific activity, and specific instructions for each lab assignment will be contained in the weekly lab handout.

Research Paper

The culmination of all the work in the field and lab is a research paper. The purpose of this paper is to integrate field and laboratory data in a comparison of two forest ecosystems. Questions to address include*: What are the main factors influencing soil formation between ecosystems? How have these contrasting factors affected the physical, chemical and biological properties of these particular soils? How and why have soil properties influenced plant composition within each ecosystem, and visa versa? How and why do patterns of nutrient cycling differ between your ecosystems? And, how do differences in plant communities influence patterns of nutrient cycling?* Your paper should be limited to 8-12 pages (typed, single-sided, double spaced), not including tables/figures and literature cited, and should be written in the format used by the *Soil Science Society of America Journal* or *Ecology*. Following a title page, please include:

I. Abstract: Summarize the entire paper in one page or less, including background, objectives, methods, main findings, and conclusions. The abstract should be on the page following the title page. Begin the introduction on a new page. (1 page)

II. Introduction: Provide both a background and a rationale for the work presented in the paper. ***Clearly state the objectives and the approach of the study***. Provide details on how the main questions of interest were addressed with the methods. In other words, don't leave the reader wondering why you did something when he/she gets to the methods section. (2 pages). **It is important to use scientific literature to support your rationale you present in the Introduction.**

III. Methods: Concisely and clearly describe both the field and laboratory methods you used. Give enough detail to make it clear what was done, but NOT so much detail as in the lab handouts! It is helpful to organize methods into subsections by type. For example: Site Description and Field Soil Sampling, Soil Physical and Chemical Properties, etc. (2-3 pages)

IV. Results: Present the results in the same order as the methods were described (i.e., use the same subsections). State the facts without interpretation (That's what the discussion section is for!). Present results in tabular or figure form (where appropriate) on the page directly following their description. Data should be organized *logically* and presented *concisely*. Be sure to include *units* for all numbers. (2-3 pages)

Suggestions: You might group data into two or three different tables and a figure. Each table and figure should be assigned a number (referred to in the text) and have its own heading, such that it stands on its own (e.g., Table 1: Overstory and soil properties of two ecosystems of southern Michigan...). It is appropriate to state a comparison and refer to the numbers in a table: "Microibal respiration rates were 20% greater in the northern hardwood ecosystem, compared to the oak-hickory ecosystem (Table 3)."

V. Discussion: This is the most important part of the paper. Clearly and concisely integrate your results. Link the relevant information and key findings together in addressing the main questions of interest, which you stated in the introduction in the form of objectives or hypotheses. Compare your findings to those of others, where appropriate, and include literature citations. Finally, state conclusions in a summary paragraph. Your discussion will specifically be graded on: answering the main questions of interest, integration of results, thoroughness of library research, and conclusions. (3-4 pages). **As with the Introduction, it is important to support your contentions and interpretations with the use of scientific literature.**

VI. Literature Cited: List citations in the standard scientific style (See Soil Science Society of America Journal or Ecology).

VII. Appendix: Please include a copy of your site and soil profile descriptions as an appendix.

Library Reserves

We will place examples of several outstanding research paper on reserve in the Science Library. While this material provides you with a good example for your paper, students are expected to conduct independent library reseach (i.e., look up and read scientific papers on this topic) using the Science Library's resources (for example, Web of Science; www.isiknowledge.com) to locate relevant citations for the project paper.

Scientific Journals Relevant to Research Paper

Soil Science Society of America Journal	Soil Biology & Biochemistry
Ecology	Oecologia
Ecological Applications	Journal of Ecology

Lecture Schedule

Date	Subject	Reading Assignment[†]
W Sep 8	Introduction to the Soil Resource	NPS, ch. 1
	I. Soil Physical Properties	
M Sep 13	A. Soil Texture, Structure & Color	NPS, pp. 121-136
W Sep 15	Texture, Strucutre & Color (continued	
M Sep 20	B. Master Soil Horizons, Bulk Density and Soil Pore Space	NPS, pp. 136-52;69-74
W Sep 22	C. Soil Water	NPS, ch. 5
M Sep 27	Soil Water (continued)	
W Sep 29	D. Soil Atmosphere	NPS, pp. 272-286
	II. Soil Chemical Properties	
M Oct 4	A. Structure & Function of Clay Minerals	NPS, pp. 316-336
W Oct 6	Clay Minerals (continued)	
M Oct 11	B. Soil Organic Matter	NPS, pp.498-507
W Oct 13	C. Cation Exchange Reactions and Base Saturation	NPS, pp. 336-354
M Oct 18	***No Class – Fall Break***	
W Oct 20	D. Soil Acidity & Buffer Capacity	NPS, pp. 363-376
M Oct 25	Soil Acidity (continued)	
W Oct 27	**EXAM I**	
	III. Soil Biology	
M Nov 1	A. Soil Microbial Community	NPS, ch. 11
W Nov 3	Soil Microbial Community: Interactions with Plant Roots	
M Nov 8	B. Roots & Nutrient Acquisition	FE, ch 19 pp. 534-540
W Nov 10	Roots & Nutrient Acquisition (continued)	
	IV. Soil Development	
M Nov 15	A. Parent Material, Climate, Biota	NPS, ch. 2
W Nov 17	B. Topography and Time	
M Nov 22	C. Soil Classification	NPS, ch. 3
	V. Ecosystem Dynamics and the Soil Resource	
W Nov 24	A. Ecosystem Carbon Balance	FE, ch 18 pp. 486-503
M Nov 29	Carbon Balance (continued)	FE, ch 18 pp. 503-520
W Dec 1	B Litter Dynamics	FE, ch 19 pp. 547-557
M Dec 6	C. The Nitrogen Cycle	FE, ch 19 pp. 524-547
W Dec 8	The Nitrogen Cycle (continued)	FE, ch 19. pp 557-575
M Dec 13	Course Synthesis & Summary	
T Dec 21	**EXAM II -- 10:30 - 12:30**	

[†] NPS = Nature and Properties of Soil FE = Forest Ecology

All Assignments are Due at the Beginning of the Next Laboratory Meeting

Week	Date	Subject
1	Sep 6, 7	**No Lab**
2	Sep 13, 14	Tour of Landforms, Soils, and Vegetation
3	Sep 20, 21	Soil Profile Descriptions - Saginaw Forest
4	Sep 27, 28	Radrick Forest – Mixed-Oak Ecosystem
5	Oct 4, 5	Stinchfield Woods – Oak-Hickory Ecosystem
6*	Oct 9 (Saturday)	Northern Forest Ecosystems - Manistee Forest
	Oct 11, 12	Soil Texture *(Begin meeting indoors – 2556 Dana)*
7	Oct 18, 19	**No Lab – Fall Break**
	Oct 25, 26	Soil Moisture and Bulk Density/**Field Presentations**
8	Nov 1, 2	Soil pH and Organic Matter
9	Nov 8, 9	Microbial Activity in Soil
10	Nov 15, 16	Cation Exchange Capacity and Base Saturation
11	Nov 22, 23	Ecosystem Biomass and Nutrient Pools Complete Microbial Biomass/N Mineralization Lab
12	Nov 29, 30	**No Lab -** Preparation Time for Final Presentations
13	Dec 6, 7	**Final Presentations, Summary and Integration**
14	Dec 14	**Term Paper Due by 5:00 pm**

Please Note: On weeks 1 through 4, we will depart for our field trips at *1 p.m.* from the parking lot between the Dana Building and Randall Labs. Please notify us ahead of time if you will not be able to attend a field trip. **Plan to get dirty on these outings!** Dress appropriately and bring warm clothes and/or rain gear if the weather looks threatening. **Please do not wear sandals – we will be digging soil pits, and sandals simply don't work for the task.** Also, don't forget your lab handouts (which you've read ahead of time), a notepad, and a writing instrument that works on wet paper. Do *not* bring anything that you want to keep clean, like lecture notes. Beginning week 6, we will meet indoors in the Soils Teaching Lab, 2556 Dana Building.

* We will leave for the Northern Field Trip promptly at 7:00 a.m. Saturday, October 9 from the Dana Building to visit two northern forest ecosystems. Please pack a lunch and we will stop for dinner on our way back to Ann Arbor. We should return by 9:30 p.m. Please bring warm cloths and rain gear!