Soil Ecology

EAS/ENVIRON 430 - EEB 489
10:00-11:00 Monday & Wednesday
1028 Dana

Instructor
Dr. Donald R. Zak
2540 Dana Building
Phone: 763-4991
Office Hours: Monday and Wednesday 9:00
by appointment, or anytime my door is open.
Email: drzak@umich.edu

Graduate Student Instructor
Will Arigroff
Email: argwill@umich.edu
Office Location: 2556 Dana Building
Office Hours: Monday at 11:00 am and Wednesday 11:00 am, or by appointment

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 influence the development and distribution of soils; (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 formation. 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 ecosystems in other geographic regions.

Manditory Prerequisites

Students are expected to have a strong background in chemistry (CHEM 130) and biology (BIO 171). 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 plant physiology, microbiology, geology, and local flora. You will find it very helpful if you have had, or are currently enrolled in, Woody Plants (ENVIRON/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.

*13th or 14th edition are both fine

Supplemental Material for Lecture and Lab

We will regularly post any material that supplements lecture or lab at our UM Canvas website

Grades

Course grades are distributed as follows:

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

Exams will focus on concepts covered in lecture and amplified by the readings; ***what I discuss in class is what I want you to know!*** The two exams are one hour each and will be graded on a 100 point scale. The second exam 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 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 and mandatory for equal participation among team members. ***All laboratory assignments are due at the beginning of the next laboratory meeting to the GSI.*** 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 vice 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 highly synthetic but limited to 10-12 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*.

Research Paper Structure
Due Wednesday, Dec. 11 5:00 pm

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)

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. 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.**

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)

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: "Microbial respiration rates were 20% greater in the northern hardwood ecosystem, compared to the oak-hickory ecosystem (Table 3)."

Discussion: This is the most important part of the paper. Clearly and concisely integrate your results, and discuss them in the context of what's known in the scientific literarure on this subject. 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 conclusions and interpretations with the use of scientific literature. You may NOT rely directly on the text book or our lectures to formulate this section of the paper.***

Literature Cited: List citations in the standard scientific style (See Soil Science Society of America Journal or Ecology). ***It should be clearly evident that you conducted "library research" – evidence for this is a rich literature cited section.***

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

Canvas

We will place examples of several outstanding research paper on the Soil Ecology Canvas site. While this material provides you with a good example for your paper, students are expected to conduct independent library research (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.

Lecture Schedule – *Brady & Weil 13th Edition*

Date	Subject	Reading Assignment†
W Sep 4	Introduction to the Soil Ecosystem	FE, ch 11
	Physical Environment	
M Sep 9	A. Soil Texture, Structure & Color	NPS, pp. 121-136
W Sep 11	Texture, Structure & Color (continued)	
M Sep 16	B. Horizons, Bulk Density and Soil Pore Space	NPS, ch. 2 & pp. 136-152
W Sep 18	C. Soil Water	NPS, ch. 5
M Sep 23	Soil Water (continued)	
W Sep 25	D. Soil Atmosphere	NPS, pp. 272-286
	Chemical Environment	
M Sep 30	A. Structure & Function of Clay Minerals	NPS, pp. 316-336
W Oct 2	Clay Minerals (continued)	
M Oct 7	B. Soil Organic Matter	NPS, pp.498-507
W Oct 9	C. Cation Exchange Reactions and Base Saturation	NPS, pp. 336-354
M Oct 14	***No Class – Fall Break***	
W Oct 16	D. Soil Acidity & Buffer Capacity	NPS, pp. 363-376
M Oct 21	Soil Acidity (continued)	
W Oct 23	**EXAM I**	
	Soil Biology & Ecology	
M Oct 28	A. Microbial Communities	NPS, ch. 11 pp. 449-459
W Oct 30	Microbial Communities (continued)	NPS, ch 11, pp. 459-495
M Nov 4	B. Analyses of Soil Microbial Communities	
W Nov 6	C. Microbial Interactions with Roots	
M Nov 11	Microbial Interaction with Roots (continued)	FE, ch 15 pp. 384-386
W Nov 13	D. Roots & Nutrient Acquisition	FE, ch 19 pp. 534-540
M Nov 18	Roots & Nutrient Acquisition (continued)	
	Ecosystem Dynamics & Soil Processes	
W Nov 20	A. Plant Litter	FE, ch 18 pp
M Nov 25	B. Litter Decay	FE, ch 19 pp. 547-557
W Nov 27	C. Organic Matter Decomposition	FE, ch 19 pp. 524-547
M Dec 2	Decomposition (continued)	FE, ch 19. pp 557-575
W Dec 4	D. Soil Nitrogen Dynamics	
M Dec 9	Nitrogen Dynamics (continued)	
W Dec 11	Course Synthesis & Summary	
W Dec 18	**EXAM II – 4:00 to 6:00 pm**	

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

Lecture Schedule – *Brady & Weil 14th Edition*

Date	Subject	Reading Assignment†
W Sep 4	Introduction to the Soil Ecosystem	FE, ch 11
	Physical Environment	
M Sep 9	A. Soil Texture, Structure & Color	NPS, pp. 121-136
W Sep 11	Texture, Structure & Color (continued)	
M Sep 16	B. Horizons, Bulk Density and Soil Pore Space	NPS, ch. 2 & pp. 136-152
W Sep 18	C. Soil Water	NPS, ch. 5
M Sep 23	Soil Water (continued)	
W Sep 25	D. Soil Atmosphere	NPS, pp. 266-280
	Chemical Environment	
M Sep 30	A. Structure & Function of Clay Minerals	NPS, pp. 310-327
W Oct 2	Clay Minerals (continued)	
M Oct 8	B. Soil Organic Matter	NPS, pp.498-506
W Oct 9	C. Cation Exchange Reactions and Base Saturation	NPS, pp. 328-347
M Oct 14	***No Class – Fall Break***	
W Oct 16	D. Soil Acidity & Buffer Capacity	NPS, pp. 358-371
M Oct 21	Soil Acidity (continued)	
W Oct 23	**EXAM I**	
	Soil Biology & Ecology	
M Oct 28	A. Microbial Communities	NPS, ch. 11 pp. 443-455
W Oct 30	Microbial Communities (continued)	NPS, ch 11, pp. 455-491
M Nov 4	B. Analyses of Soil Microbial Communities	
W Nov 6	C. Microbial Interactions with Roots	
M Nov 11	Microbial Interaction with Roots (continued)	FE, ch 15 pp. 384-386
W Nov 13	D. Roots & Nutrient Acquisition	FE, ch 19 pp. 534-540
M Nov 18	Roots & Nutrient Acquisition (continued)	
	Ecosystem Dynamics & Soil Processes	
W Nov 20	A. Plant Litter	FE, ch 18 pp
M Nov 25	B. Litter Decay	FE, ch 19 pp. 547-557
W Nov 27	C. Organic Matter Decomposition	FE, ch 19 pp. 524-547
M Dec 2	Decomposition (continued)	FE, ch 19. pp 557-575
W Dec 4	D. Soil Nitrogen Dynamics	
M Dec 9	Nitrogen Dynamics (continued)	
W Dec 11	Course Synthesis & Summary	
W Dec 18	**EXAM II – 4:00 to 6:00 pm**	

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

Laboratory Schedule

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

Week	Date	Subject
1	Sep 2,4	**No Lab**
2	Sep 9, 10	Landforms, Soils, and Vegetation
3	Sep 16, 17	Soil Profile Descriptions - Saginaw Forest
4	Sep 23, 24	Radrick Forest – Mixed-Oak Ecosystem
5	Sep 30, Oct 1	Stinchfield Woods – Oak-Hickory Ecosystem
	Oct 5 (Saturday)	Northern Forest Ecosystems - Manistee Forest
6*	Oct 7, 8	Soil Texture *(Begin meeting indoors – 2556 Dana)*
7	Oct 14, 15	**No Lab – Fall Break**
8	Oct 21, 22	Soil Moisture and Bulk Density/**Field Presentations**
9	Oct 28, 29	Soil pH and Organic Matter
10	Nov 4, 5	Microbial Activity in Soil
11	Nov 11, 12	Cation Exchange Capacity and Base Saturation
12	Nov 18, 9	Ecosystem Biomass and Nutrient Pools
		Complete Microbial Activity Lab
13	Nov 25, 26	Summarize Data & Preparation for Final Presentations
14	Dec 2, 3	**Final Presentations, Summary, and Integration**
	Dec 11	**Term Paper Due by 5:00 pm**
		Hardcopy Placed on My Door or in Mailbox

Please Note: On Weeks 2 through 5, we will depart for our field trips promptly 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. Mosquito repellant is also advisable. **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 5** 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 clothes and rain gear! Please let us know at least two weeks in advance if you will not be able to make it.