SOIL GEOMORPHOLOGY FIELD STUDY

Geography 408

Fall Semester, 2011

Instructor: Dr. Randall Schaetzl
Office: 128 Geography Bldg
soils@msu.edu .... I will always answer my email.
Office Hours: 10:15-12:15 M, W, and by appointment, and after class
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Texts:

1. Schaetzl and Anderson. 2005. *Soils: Genesis and Geomorphology*. Cambridge Univ. Press. 832 pp. REQUIRED

2. Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., and W.D. Broderson. 2002. Field Book for Describing and Sampling Soils. USDA-NRCS, National Soil Survey Center, Lincoln, NE. RECOMMENDED

Lectures: 7:00 - 8:50 p.m. Wednesday, 120 Geography Bldg

Prerequisites …they will be enforced:

A grade of 2.0 or higher in any ONE or more of the following (or their equivalents elsewhere):

CSS 210 (Intro Soil Science), or
GEO 306 (Geomorphology), or
GLG 201 (Intro Geology), or
GLG 412 (Glacial Geology), or
ISP 203 (Geology of the Human Environment),
or permission of instructor.

This class is not open to freshmen or sophomores.

Course Goals: This course is intended for those students who have a basic background in physical geography, geology and/or soils, and who wish to advance their knowledge of soils, geomorphology and soil-environment interactions, *especially in a field-based setting*. GEO 408 is all about *soils and landscapes*. The major goal of GEO 408 is to provide students with the ability to differentiate soils as they view them on the landscape, and to be able to propose scientifically sound reasons for these differences in morphology and chemistry, both at a site and from place-to-place, *based primarily on landform-soil, stratigraphy-soil, and sediment-soil relationships*. The course is designed to include a weekly lecture/discussion meeting, and several *required* field trips; the field trips end by early November to allow time for work on individual projects. Topics to be examined in GEO 408 include: (1) soil profile concepts and horizonation, (2) soil stratigraphy, (3) soil genesis, (4) soil geomorphology and soils as dating tools, (5) paleopedology and landscape evolution, (6) soil classification and taxonomy, and (7) soil mapping and the use of soil surveys. Overall, though, the course focuses on soils in landscapes, why and how do soils vary across space?

The course has a regional focus on Michigan and the midwest. The student is reminded that, because lectures provide important background information on the upcoming trip AND summarize important concepts from the previous trip, missing even **one** lecture (or field trip) unnecessarily can be very detrimental. Therefore, regular attendance at lecture is absolutely essential.

Field trips: All **seven days** of field trip are required. Field trips are the most essential and important part of any field course, and GEO 408 is no exception. They are invigorating, vital learning experiences. Missing a field trip will result in a loss of exposure to vital course material, which will come back to haunt you on the exams. The trips are long, time-consuming and tiring, but remain the best (perhaps the only) way to *really* learn this material. Hence, you have the potential to get a great deal out of them; do not waste this opportunity by partying at night such that you are dragging the next day, or by maintaining a lazy, negative or slip-shod attitude. MSU will cover the transportation cost of the trips; at the end of the semester the students will be notified of the amount they must contribute to defray the lodging (and some of the meal) expenses. Likely amount: $125 per person.

Grading: A total of 500 points can be earned in this course. Final grades are based on a curve of the student's overall point total. Points are assigned as follows:

Midterm exam	90 pts
Final exam	140 pts
Three quizzes	60 pts
First soil landscape project	50 pts
Second soil landscape project	100 pts
Attitude, class and field trip participation, effort, brownie points, etc.	60 pts
TOTAL	500 points

Exams: There will be a midterm and final exam in GEO 408. The midterm will stress essential concepts covered in the field, with a notable component of material from lecture. The final exam is more lecture-text based in its approach. On the final exam only, students will have access to information they choose to write (not type) on *one side of a 4x6 inch notecard*. The final exam is cumulative. Both exams will be of essay/short answer format, with some objective questions or definitions. Exams *will* include material from the readings, and are mostly short answer and essay format.

Quizzes: Three quizzes will be given during the semester. Each will be announced the week previous, and will occur at the beginning of class. Makeup quizzes are not given.

Readings: Most of the readings will come from the text. Additionally, however, several research papers will (may) be read during the term; I will send you pdfs of the papers. I expect everyone to have read the papers and text pages BEFORE the lecture for which they are assigned. Overachievers[1] are especially invited to read regularly and repeatedly from the text and the papers.

1. Gross underachievers are not required to attend class or to read anything.

General **FIELD TRIP "RULES"** for GEO 408:

1. *Stay positive*. Keep smiling despite rain, cold, mud, wet feet, cold feet, smelly feet, (apparently) dense, ditty, know-it-all, or obnoxious classmates, long drive-times, boredom, impatience, etc. No sourpusses or fussbudgets, and especially no weenies. Adhering to the above instructions will not only make the course more enjoyable, but you will learn more and earn more brownie points (see **Grading** above). Participation and discussion is an important part of this class/field experience. Questions are not only encouraged----they are expected. I WILL be calling on you for questions during the field trips (translation: putting you on the spot in front of your peers). If you look dazed, bored or otherwise disinterested the likelihood that I will be calling on you increases substantially.

2. *Take diligent notes*. Taking good field notes is a talent that is easy to acquire; it does not take a 160 IQ, only hard work. It will require you to *work* in the vehicle, rather than chit-chat with your classmates, sleep, or munch on Fritos. If you think you can write your notes when you return to Lansing, or at night after the trip is over, you are sorely mistaken. I strongly encourage everyone to take notes in a *weatherproof field book*, obtainable from most book stores. The notebook might, for example, contain notes on soils, soil profile descriptions, stratigraphy, summary tables and other items. Within the notebook, basic soils data will be recorded. For example, soil series and taxonomic classification, topographic position, and drainage class, field textures of major soil horizons, depth to carbonates where appropriate, moist color of major horizons, including mottling where applicable, soil structure, evidence of erosion, current land use practice, landform, and other pertinent information. It is suggested that the student compile the views of the group regarding the genesis of the soil, and how the soil relates to similar soils (as in a catena or development sequence).

3. *Prepare for the worst possible weather conditions*, without bringing undue amounts of clothing. Better to have rain gear and not need it. Better to wear heavy shoes and stay dry than to take a chance with your new Reeboks and regret it. Bring a hat. When conditions are at their worst and you have NOT prepared adequately, refer back to rule #1.

4. *Brownie and attitude points* (see **Grading** above) can be earned by:

- always being on time (or early) for field trips, both at the main departure from the Stock Pavillion parking lot, and at each individual stop,
- paying for the field trips well before the stated deadline,
- volunteering to dig or turn the auger, drive (where appropriate), navigate, or pack and load the vehicle,
- maintaining a serious attitude about the field learning experience,
- cheerfully awakening in the morning and *not being the last one to be ready to depart*,
- (especially) not being “hung over” or so tired that that you are a liability to the class and yourself,
- assisting the professor in picking up or dropping off the vans, etc.

5. *Equipment*. Field notebook, pen/pencil are required. If you have a **non-folding** pocket knife, bring it. (Some will be provided.) Cameras are encouraged.

Soil-landscape projects: In GEO 408 students will do research and write a report on two soil landscapes (*aka* soil associations), using NRCS Soil Survey data as their main source of information. Essentially, each project is an application of the skills learned in class, to a soil landscape. Each report will center on a major soil association, initially depicted in a county soil survey but much expanded upon in the report. YOU choose the soil association (which cannot be from Michigan), with my guidance and approval. Working alone, each student will request a soil association to work on.

The purpose of the projects is threefold:

(1) List and describe the soils: What soils comprise your association? What are the major soil series like? What horizons do they have? What are their parent materials? What are their classifications? Drainage classes? How are the series "arranged" on the landscape? Etc, etc.

(2) Discuss how the state factors vary across the landscape, in this association. Answer the question: how has the spatial variation in the state factors caused these different soils to have formed in the arrangement that they did? What are the main state factor variants in this association? For most associations, usually only one or two factors change among the soils.

(2) Explain how and why the soils have developed the distinct morphologies that they have. What are their unique series morphologies, and how did they form? What major diagnostic horizons do they have, and why? How do the soils in the association differ (they must differ, or else they'd all be in the same series!). Why does soil morphology vary from one series to another? How have the pedogenic processes varied across space, such that different horizons have formed in these soils? Are there any special, unique minor soils in the association that are worthy of note and discussion?

Bottom line - how and why are these soils different?

Each project must contain at a minimum:

1. A block diagram of the soil association (using the one in the survey is acceptable; drafting a new one or editing an existing one is generally viewed as a plus).
2. Typical profile descriptions and classifications for the major soils of the association; this is best done in a Table. Explain the reasons why the soils have the morphology that they do (why they are different from each other, etc).
3. Soil and/or topographic maps (DEMs are OK) of typical landscapes in which this soil association dominates, appropriately annotated, labeled, and explained.
4. An in-depth discussion of the soil parent materials in the association, as well as the pedogenesis of the soils. Explain how the pedogenic state factors have come together to form this association.

Optional components of the projects that may enhance your grade:

1. Images of the landscape and/or soil profiles therein.
2. Land use information
3. Inclusion of references to scientific papers that have studied these soils, and discussion of said papers in the context of your soil association. This one is especially important.

Other notes, comments, suggestions, and pet peeves of the professor:

1. All tables, figures and graphics must be consecutively numbered, and have their sources clearly listed. Ideally, I'd like to see each Table or Figure shown on the page where it is first called-out, or immediately on the next page. All Figures must have a caption, and all Table must have a title.
2. Use of metric units only is allowed. Convert all English units to metric.
3. When you discuss a soil SERIES use the singular, e.g., The Schaetzl series has great water-holding capacity. When you discuss these types of SOILS, use the plural, e.g., Schaetzl soils are really great.
4. Deep vs thick. These are different words and their usage should not be mixed.
   "The base of the horizon was deep." OK
   "The loess was deep." Not OK, what was meant was that the loess was "thick."
5. A personal bias of mine: "create". Do not say that pedogenesis has "created" anything. God *creates*. Pedogenesis and surficial processes *form*. This usage applies in many, many other instances, e.g., "Plowing has formed a plowpan."
6. Textures. Do not say, "The A horizon is silt loam" or "The A horizon consists of silt loam." Instead, say that "The A horizon has a silt loam texture." Remember, "silt loam" and the other texture classes are *adjectives*, not nouns.

7. Soil orders. The taxonomic names of soils should be capitalized. Hapludalf, not hapludalf. Name of diagnostic horizons are not capitalized - mollic, not Mollic.
8. All pages must be numbered.
9. The taxonomic classification and drainage class must be given for every soil series mentioned in the paper.

Project 1 vs 2: What is described above is for Project 1, due in class on November 9. The details of Project 2 are described below.

Project 2 is intended to be an expanded and enhanced version of Project 1. Project 2 is due in class on Dec 9. report for Project 2 should be "better" and more in depth than for Project 1, because of the possible/likely addition of fieldwork to the project, but also because you will be better dirt people by then, and you will have been able to apply the skills you learned from Project 1 to Project 2. Most importantly, in Project 2 you will utilize digital spatial data, in a GIS. You can do it in ArcGIS 10, using data that I have loaded onto the computers in the PC lab upstairs. These data are for Wisconsin and Michigan, meaning that your soil association will need to be from one of these two states. Find an area that you wish to work with/on, and determine the major and minor soils therein. Many different data products are available to you, for this project; here are more details about them than you probably wanted to know:
1. Digital Raster Graphics coverage (scanned 7.5-minute topographic maps).
2. DEM and hillshade rasters, at 10-m resolution (USGS, 2009).
3. Local relief. From the digital elevation data, we derived a measure of local relief, by using map algebra to calculate the elevation range in a 250m circle for each output cell.
4. Surficial and bedrock geology maps, from the Michigan Geographic Data Library.
5. The 1:500,000 scale surficial/Quaternary deposits maps by Farrand and Bell (1982a; b), based in large part on the surface formations map by Martin (1955; 1957)
6. A glacial landsystems map, compiled by Lusch from the combination of the Farrand and Bell linework and the NRCS STATSGO soil texture data (1:250,000).
7. A variety of landform and geomorphic maps of within-state regions, e.g., a map of the surficial geology of the western Upper Peninsula (Peterson, 1985), NRCS digital landform maps – one for the entire Upper Peninsula and one for the northern Lower Peninsula, and landform maps of the northeastern Lower Peninsula (Burgis 1977) and the northwestern Lower Peninsula (Blewett 1990), both developed in conjunction with PhD dissertations.
8. Bedrock surface elevation data, and
9. Glacial deposits thickness map, both newly revised by Lusch, using 270,000 point observations of the bedrock surface elevation (149,427 points in the Lower Peninsula and 124,570 points in the Upper Peninsula).
10. A 2007 Cropland Data Layer (CDL) (USDA, 2007) for the state, produced by a partnership between the Land Policy Institute at MSU and the USDA, National Agriculture Statistics Service. Twenty-seven crops were mapped in this layer, including corn, soybeans, and winter wheat, representing the majority of the cropland in Michigan, as well as six non-crop covers (woodland, wetland, developed, shrubland, barren and water).
11. A 30-m satellite land cover classification from ca. 2000 (Michigan Department of Natural Resources, 2003), and ca. 2006 (NOAA, 2008), both of which contained natural land cover attributes to Anderson Levels II and III in some cases.
12. Soils data: NRCS SSURGO digital soils data, derived from large-scale county soil surveys, were downloaded from the NRCS Soil Data Mart web site (http://soildatamart.nrcs.usda.gov/). The 83 county soil surveys were merged into a statewide vector file and subsequently converted to a raster grid.

12a. Soil parent materials. We coded as many of the soil series as possible to a parent material category by first downloading the official series description from the NRCS web site (http://soils.usda.gov/technical/classification/osd/index.html) and noting the parent material that is written into the series description. The parent material description was copied verbatim, enabling us to code most of the series to one of several classes: till, outwash and glaciofluvial sediment, loess, lacustrine sediment, dune sand, and a few other, minor categories. For soils with loess as a parent material, the underlying material was also noted. Eventually, we were able to code 439 of the 624 mapped soil series in Michigan, to a parent material class.

12b. Surface texture. In a similar manner, we coded each series to the texture of the surface mineral (usually A) horizon.

12c. Parent material (lowest horizon) texture. This was done as in 12b.

12d. Graveliness. We also noted when the texture modifier on the lowest horizon contained the words "gravelly," cobbly," or "stony," allowing us to compile a data layer for soils that contain significant amounts of coarse fragments in their parent materials.

In the end, we had four large-scale data sets, each derived from the NRCS SSURGO soils data: parent material type, upper solum texture, lower solum texture, and graveliness.

12e. The Drainage Index (DI) of Schaetzl et al. (2009), which is a measure of the long-term, natural wetness of soils. We used the join file on the DI web site (http://www.drainageindex.msu.edu/), to assign each soil series in Michigan to its appropriate natural wetness (DI) value; the result was a map of landscape wetness.

13. Presettlement vegetation (Comer et al., 1995; http://web4.msue.msu.edu/mnfi/data/veg1800.cfm), from the original land Surveyor's notes.

14. Contemporary ecoregions (Albert, 1995).

Is that enough data for you? No? Then there's more….

15. Existing maps and databases on proglacial lakes in the state also exist. Using glacial rebound-adjusted DEMs, presented in Schaetzl et al. (2002) and refined by Drzyzga (2007), as guides, we have shapefiles that show the maximum and some of the intermediate extents of

a. Glacial Lake Algonquin, in the northern Lower and eastern Upper Peninsulas,

b. The highest shorelines of Glacial Lake Saginaw (Lusch et al. 2009), and

c. The uppermost shoreline(s) of Glacial Lake Chicago.

You can do this in Google Earth, using the Soilweb.kmz app. (I can email this file to you.)

You are to use these data, or subsets of the data, to fully understand and explain the soil variation across a soil association of your choice, in WI or MI. You can also use Google Earth to help with this project, using the Soilweb.kmz app. (I can email this file to you.) I reiterate, Project 2 is just like Project 1, but with a LOT more data, and now you have access to ALL the soils on the landscape, not just the ones in the block diagram. Do not let this project kill you, but do try to be inclusive and exhaustive. Use Tables to summarize data, rather than spelling it all out in paragraphs of text. Use figures to convey messages and information efficiently.

This project really has **two goals**:

(1) to determine what is important and what is not, on a soil landscape. That is, what are the most important soils and landscape attributes – you cannot discuss them all. Then, once you've determined that, you need

(2) to characterize and explain the major and minor soils on this landscape. (See text discussing Project #1 above – it's the same thing again…).

LECTURE AND *FIELD TRIP* OUTLINE

DATE	TOPICS	READINGS
Aug 31	Introduction, soil characteristics and concepts	Chapter 1
	Functional-factorial model of soil development	(also browse Chapter 8)
		pp. 295-300
Sep 7	Process-systems model of soil development, soil horizons and horizonation	Chapters 2 and 3
		pp. 320-323
Sep 14	The first soil processes: melanization, leucinization, acidification	pp. 347-361
TRIP 1: Soils of the SE Michigan interlobate area (FRIDAY Sep 16)		
Sep 13	Next: lessivage and Bt horizon formation	pp. 361-373
Sep 28	Podzolization and associated processes	pp. 440-453
TRIP 2: Miscellaneous soil-y things: Soil-landform relationships in the valley of the Red Cedar River, and on the outwash plains of SW Michigan (SATURDAY Oct 1)		
Oct 5	Gleization, redox processes, ferrolysis; soil drainage classes	pp. 380-385; 486-501
TRIP 3: Podzolization; soils and surfaces; soil geomorphology case study examples from northern lower Michigan through the eastern UP, and into northern Wisconsin (THURSDAY through MONDAY Oct 6-10)		
Oct 12	Hydroconsolidation and fragpian formation, pedogenesis in dry environments	pp. 373-380; 402-439
Oct 19	Midterm exam; Project 1 assigned	
Oct 26	Soil classification and mapping, use and interpretation of NRCS Soil Surveys	Chapter 7
Nov 2	Soil geomorphology, geomorphic surfaces, soils-on-slopes	pp. 465-486; 506-514
TRIP 4: Soil-landform relationships on and near the Saginaw lake Plain (SATURDAY, Nov 12)		
Nov 9	Dating of geomorphic surfaces; soil chronosequences; quantifying pedogenesis	pp. 460-461; Chapter 14
PROJECT 1 DUE in class		
Nov 16	Catenas and the pedogenic effects of topography	
Nov 22	(Tuesday of Thanksgiving week)	
	Models of soil and landscape evolution; Project 2 assigned	pp. 295-342; 456-460
Dec 2	Pedoturbation and lithologic discontinuities; stone lines and landscape evolution	Chapter 10; pp. 501-506
		pp. 516-546

Dec 9 Paleopedology; use of soils in paleoenvironmental reconstruction Chapters 15 and 16
PROJECT 2 DUE in class

Dec 12 FINAL EXAM (8:00 pm, in Rm 120)