

SOIL GEOMORPHOLOGY FIELD STUDY

Geography 408

Fall Semester, 2015

Instructor: Dr. Randall Schaetzl

Office: 128 Geography Bldg

soils@msu.edu I will always try to answer my email promptly.

Office Hours: 10:15-12:15 M, W, and by appointment, and after class

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Texts:

1. Schaetzl and Thompson. 2015. *Soils: Genesis and Geomorphology*. 2nd ed. Cambridge Univ. Press. 778 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, 105 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. Equivalent courses at other institutions will be acceptable. 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 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? We make good use of NRCS soils data in this class – both profile descriptions and in GIS forms, in this class. Rudimentary GIS skills/abilities are assumed.

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.

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 these. I expect everyone to have read the papers and text pages BEFORE the lecture for which they are assigned. Overachievers are especially invited to read regularly and repeatedly from the text and the papers.

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	100 pts
Final exam	150 pts
Take-home soil taxonomy assignment	50 pts
Soil landscape project	150 pts
Attitude, class and field trip participation, effort, brownie points, etc.	50 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 as well. The final exam is more lecture/text based in its approach. On the exams, student will have access to their class notebook, but not the text or the internet. 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.

Field trips: All of the field trips 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 sometimes tiring, but remain the best (perhaps the only) way to *really learn* this material. Do not waste this opportunity by partying at night such that you are dragging the next day, or by maintaining a lazy, negative or slipshod 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 for the long, 5-day trip. Likely amount: \$110 per person.

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

1. *Stay positive.* Keep smiling despite rain, cold, mud, and wet, cold, smelly feet, despite (apparently) dense, ditty, know-it-all, or obnoxious classmates, in spite of 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-chatting with your classmates, sleeping, or munching 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 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 best earned by:

- always being on time (or early) for field trips, both at the main departure from the MSU 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 and photography are encouraged.

Soil taxonomy project: Each student will be *randomly* assigned ten soil series from my list of all 24,645 US soil series. The student will have one week to write a report about each series. More detailed instructions will be given out at the time the project is assigned, but in general the student is expected to provide about a paragraph of information about (1) the types of horizons and parent materials in the soil, (2) the soil temperature and moisture regimes of the soil, (3) where the soil is typically found and what it is typically used for, (4) its relationship to neighboring soil on the landscape, and most importantly, (5) its genesis and geomorphology.

Soil-landscape project: In GEO 408, students will do research and write a report on a soil landscape of their choosing - with an area of soil about 2 km². The area will contain one or more soil associations. Reports on more complex landscapes will be graded more leniently; reports on simpler landscapes will be graded more rigorously. The project will be a step-wise journey, with me helping you along the way. The goal is to help you use and interpret NRCS SSURGO soils data, i.e., large-scale, digital, soil map data in a GIS environment. These kinds of data are widely used and are the best quality soils data out there. You need to be able to use and interpret them. Your project and data will be from an area in Michigan, for which we have all the data on the computers in Room 233. Note: all pages must be numbered.

Essentially, each project is an application of the skills learned in class, to a soil landscape. Each report will center on a *soil association*, sometimes as depicted on a block diagram in a NRCS county soil survey (see: http://soils.usda.gov/education/training/block_diagrams_map.html) but much expanded upon in the report. YOU choose the soil association, with my guidance and approval. In the project you are expected to:

(1) List and describe the soils: What soils comprise your area, your association? What are the major soil series *like*? What horizons do they have? What are their parent materials, classifications, drainage classes? KEY: How are the series “arranged” on the landscape? The taxonomic classification and drainage class must be given for every soil series mentioned in the paper.

(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 from each other (they *must* differ, or else they'd all be in the same series!). Why do the morphologies of these soils vary, one series from 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 a plus).
2. Typical profile descriptions and classifications for the major soils of the association; this is best done in Table format. Explain (in the text) the differences in the soil morphologies, and give the reasons why the soils have the morphologies that they do (why they are different from each other, etc).
3. Soil and/or topographic maps (DEMs are OK) of your landscape - the one 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 peaves 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 Tables 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. Other common writing mistakes

Since vs Because.

Since Soil X is on steep slopes, it is thinner. This sentence is an example - all too common nowadays - of the improper use of the word "since". "Since" is best used when referring to time. "Since I left, she has been crying." Almost all of the times that students use "since" in paper, they mean "because."

Because Soil X is on steep slopes, it is thinner.

Though vs Although

Though the soil is red, podzolization is not to blame. In modern society, we have gotten sloppy and now use "though" for "although." Be more exact and correct and use the proper word.

Although the soil is red, podzolization is not to blame.

While vs Although

While this soil is wet, it is not gleyed. While refers to a temporal (time) event and should only be used as such.

Although this soil is wet, it is not gleyed.

Most importantly, in this project 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, Room 233. 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,” “cobbley,” 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 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 MI. You can also use Google Earth to help with this project, using the Soilweb.kmz app. 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) 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) 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 (TEXT and PAPERS)
Sep 2	Introduction, soil characteristics and concepts Functional-factorial model of soil development	Chapter 1 (also browse Chapter 10) pp. 283-288 Bockheim et al. (2005)
Sep 9	Process-systems model of soil development, soil horizons and horizonation; lithologic discontinuities	Chapters 2 and 3 pp. 300-302
Sep 16	The first soil processes: melanization, leucinization, acidification <i>TRIP 1: Basic soil, soil-landscape and horizonation concepts: local (SUNDAY Sep 20)</i>	pp. 321-337
Sep 23	Clay translocation: forming the Bt horizon <i>TRIP 2: Soils of SW Michigan: loess, melanization, pedoturbation and polygenesis (SUNDAY Sep 27)</i>	pp. 337-349
Sep 30	Podzolization and associated processes	pp. 419-433
Oct 7	Gleization, redox processes, ferrollysis; soil drainage classes <i>TRIP 3: Podzolization and fragipan formation; soils and surfaces; soil geomorphology examples from northern lower MI through the eastern UP (THURSDAY through MONDAY Oct 8-12)</i>	pp. 356-363; 128-142 (txt only); 151-157; 477-490
Oct 14	Hydroconsolidation and fragipan formation, pedogenesis in dry environments	pp. 349-356; 375-398
Oct 21	Midterm exam	
Oct 28	Soil classification and mapping, use and interpretation of NRCS Soil Surveys <i>TRIP 4: Soil-landform relationships on and near the Saginaw lake Plain (SATURDAY, Oct 31)</i>	Chapter 8, but generally only skim the "thick" Tables
Nov 4	Soil geomorphology, geomorphic surfaces, soils-on-slopes Soil taxonomy project handed out <i>TRIP 5: Tbd (FRIDAY, Nov 6)</i>	pp. 465-486; 506-514
Nov 11	Dating of geomorphic surfaces; soil chronosequences; quantifying pedogenesis	Chapter 1
Nov 18	Catenas; the pedogenic effects of topography Soil taxonomy project due in class	452-477
Nov 24	(<i>Tuesday</i> of Thanksgiving week) Models of soil and landscape evolution	Chapter 12
Dec 2	Pedoturbation; stone lines and landscape evolution	Chapter 11; pp. 490-493
Dec 9	Paleopedology; use of soils in paleoenvironmental reconstruction SOIL LANDSCAPE PROJECT due in class	Chapters 15 and 16
Dec 16	FINAL EXAM (8:00 pm)	