Agronomy 575
Soil Morphology, Genesis, and Classification
Fall 2007

Lecture Time and Location: Monday and Wednesday 3:10 -4:30 pm., 1026 Agronomy Hall
Instructor: Jon Sandor, 1013 Agronomy Hall, phone: 294-2209, email: jasandor@iastate.edu
Reading: Soils: Genesis and Geomorphology, Schaetzl and Anderson, 2005, and other readings from pedology literature. Also see the website list for additional soil information resources.

Evaluation (letter grading on ± basis):	2 exams	25%
	Discussion and Class Participation; Study Questions	25%
	Written Reports and Presentations	25%
	Paper	25%

Course Content

Topic (emphasis and topic sequence may vary!)	Text Reading (also see literature reading list by topic)
Tools for Observing and Interpreting Soils in the Field. Review and explore:	
Soil morphology	Chapters 2, 3
Soil classification (U.S. Soil Taxonomy and other systems)	Ch. 7 (p.106-146)
Models/Theories of Soil Formation & Soil-Landscape-Ecosystem Relationships	Ch. 11
Science History and Philosophy of Soil Formation and Soil Geomorphology	Ch. 1, 7 (p.107-115), 13 (p.465-466)
Soil Geomorphology and the Time Factor of Soil Formation	
Soil-parent material-landscape relationships	Ch. 8, 13
Catenas (soil – topographic sequences)	Ch. 13 (p.469-486)
Soil age, rates of soil formation and change, and soil chronosequences	Ch. 11 (p.300-302), Ch. 14
Complex, polygenetic soils	Ch. 11 (p.338-9) & text index
Paleosols and paleoenvironmental reconstruction	Ch. 15
Hydrology and Soil Formation (mostly incorporate into other topics)	Ch. 5 (p.82-87), Ch. 13
Chemistry & Mineralogy of Soil Formation (mostly incorporate into other topics)	Ch. 4, 8 (p.179-184), Ch. 9, Ch. 15 (p.636-641)
Soil Formation Processes and Environments (several optional/special topics):	
Organic matter and soil formation; organic horizons; soil-ecosystem relationships	Ch. 3 (p.37-48), 6, 10 (p.239-263), 12 (354-357)
Clay accumulation and argillic horizons	Ch. 12 (p.361-373)
Wetland soils	Ch. 12 (p.380-385), Ch. 13 (p.486-501)
Spodosol formation (under coniferous and other acidic vegetation)	Ch. 12 (p.440-454)
Soils formed in volcanic ash (Andisols)	Ch. 8 (p.207-210)
Highly weathered soils of the tropics (Oxisols)	Ch. 12 (p.385-401)
Soils of arid regions (Aridisols)	Ch. 12 (p.400-440)
Soils of cold regions (Gelisols)	Ch. 10 (p.263-277)
Pedoturbation (Vertisols, animal and plant effects)	Ch. 10
Cemented and dense soil horizons	Ch. 12 (e.g., p.373-380, 412-414, 422-424)
Soil Maps and Spatial Variation; Tools and Technology for Analyzing Soil Properties and Landscapes (GIS; Pedometrics and Pedotransfer Functions)	Ch. 7 (p.106-107, 146-163)
Soil Survey Applications to Land Use and Management	See reading list
Soils in land management (agriculture, engineering-urban, environmental quality)	
Soil risks and hazards	
Human impacts on soil formation and landscapes	Ch. 10 (p.292-293)
Kinds and processes anthropogenic soil change	Ch. 11 (p.317- 320)
Soil degradation	Also see reading list
Soil resistance to change; soil resilience and recovery	

Soils and global climate change
Soil resource protection

Learning Objectives for Students:

- Develop perspectives on soil as a complex natural resource that humans and other life depend on for sustenance and physical support. An understanding of soil is essential for sustainable land use and environmental conservation.
- Gain working knowledge and advanced skills in soil observation, description, and classification.
- Understand physical, chemical, and biological processes involved in soil formation, and the environmental and time factors that determine these processes.
- Recognize landforms and the geological basis of soils and ecosystems. Predict soil and ecosystem characteristics and productivity through an understanding of soil-landscape relationships.
- Interpret soil morphology and soil map information for agriculture, engineering, and other land uses.
- Explore human impacts on soil formation, and relationships of soil anthropogenic change, land use and management, and environmental quality issues.

Student Background and Preparation

This is an advanced graduate course in soil formation. The official prerequisite for the course is Agronomy/Environmental Science 473, an upper undergraduate course in soil formation that is also often taken by graduate students for non-major graduate credit. It is alright to take 575 without 473, but if so, you need to have some background preparation from other courses and reading. Check the website for 473 (http://www.agron.iastate.edu/courses/agron473/) for the syllabus on course content. We are using the same text in 575 and 473, and assume you have basic knowledge about soil formation. We will incorporate some review as a starting point for covering each topic in more depth, and will be glad to provide you with help. However, this will still require some background preparation on your part. You should especially have a basic understanding of the following topics:

- Factors of soil formation model (soil formation and properties as function of climate, organisms, topography, parent material, and time).
- Soil morphology and field description of soils (review 473 handout).
- Soil classification, including basics of U.S. Soil Taxonomy system (review 473 handout). Familiarity with the 12 soil orders and association of certain soil orders with the world's major ecoregions.
- Soil-landscape relationships, especially concepts of soil-geomorphic relationships and common landforms. Familiarity with basic hillslope model (text p. 470).
- Other geology-soil basics: Quaternary stratigraphy, soil weathering processes, primary minerals, and secondary minerals (clay minerals and iron and aluminum oxides), soil parent materials (see handout).
- Major soil formation processes of the world: clay accumulation (argillic horizon), wetland (aquic/hydric) soils, organic-Fe, Al complex accumulation (Spodosols), highly-weathered tropical soils (Oxisols and related soils), and desert soils (Aridisols).
- Soil Surveys: familiarity with the content and use of soil survey reports. You should know how to read soil maps, and know what information is available in the reports and how to access this information.

Student Learning Activities

We want to tailor the course to help you learn important material and gain skills in pedology in a way that is most effective and enjoyable to you, so that you can apply this knowledge in your areas of interest. Your active participation is essential in acquiring useful knowledge and skills. There are many ways to approach the course topics in terms of student learning activities. Here are some ideas for student-based activities that we can choose from, depending on interest, topics, and time.

- Study questions to guide class discussions and lecture.
- Student-led presentations and discussions on certain topics and readings, including development of visual presentation materials. Presentations may be done individually or in groups. Tentative topics planned are: models of soil formation, biosketch of key people and advances in the history of pedology, soil catena (soil-landscape sequence), soil chronosequence, and soil environmental risks or hazards.
- Visualizing soil formation and geomorphology (students view and interpret soil and landscape images, aerial photos, and other graphics).
- Potential lab and field activities:
  - Soil field description, plus some field trips to study soils and geomorphology.
  - Web Soil Survey and other internet sites to access soils information.
  - U.S. Soil Taxonomy to classify and interpret soils for land use.
  - Soil micromorphology and mineralogy.
  - Soil mapping exercise-exploring human alteration of soil morphology and spatial distribution
- Quantitative exercises: calculate soil properties (e.g., organic carbon) on weight/volume basis, clay translocation mass balance, soil development indices; isotope (carbon, oxygen, etc.) calculations in soil analyses and environmental reconstruction, redox conditions, geostatistics and other tools for analyzing soil spatial distribution and variation.

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Reading List (besides text) for Discussion by Topic

Tools for Observing and Interpreting Soils in the Field. Review and Exploration:
Soil morphology
Schoeneberger, P.J., D.J. Wysocki, E.C. Benham, and W.D. Broderson, (ed.). 2002. Field book for describing and sampling soils, Version 2.0. USDA-Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE. We will work with this in class.
Soil classification (U.S. Soil Taxonomy and other systems)
Spaargaren, O.C. 2000. Other systems of soil classification. In M.E. Sumner (ed.) Handbook of soil science. CRC Press, Boca Raton, FL.

Models and Theories Soil Formation and Soil-Landscape-Ecosystem Relationships
Dijkerman, J.C. 1974. Pedology as a science: the role of data, models and theories in the study of natural ecosystems. Geoderma 11:73-93.

Science History and Philosophy of Soil formation and Soil Geomorphology
Brown, David J. 2006. A historical perspective on soil-landscape modeling. p. 61-103. In S. Grunwald (ed.) Environmental soil-landscape modeling. CRC Press, Boca Raton, Florida.

Soil Geomorphology and the Time Factor of Soil Formation
Daniels, R.B., E.E. Gamble, and J.G. Cady. 1971. The relation between geomorphology and soil morphology and genesis. Advances in Agronomy 23:51-88.
Vreeken, W.J. 1975. Principal kinds of chronosequences and their significance in soil history. Journal of Soil Science 26:378-394.

Paleosols, Paleoenvironment, and Complex, Polygenetic Soils
Ruhe, R.V., and C.G. Olson. 1980. Soil welding. Soil Science 130:132-139.

Soil Formation Processes and Environments – mainly use Schaetzl and Anderson 2005 textbook.

Soil Maps and Spatial Variation; Tools and Technology for Analyzing Soil Properties and Landscapes (GIS; Pedometrics and Pedotransfer Functions)
Webster, R. 2000. Is soil variation random? Geoderma 97:149-163.

Pedology and Hydrology (incorporation into other topics)
Lin, H.S., K.J. McInnes, L.P. Wilding, and C.T. Hallmark. 1999. Effects of soil morphology on hydraulic properties: I. Quantification of soil morphology. Soil Science Society of America Journal 63:948-961.

Soil Survey Applications to Land Use and Management
Bouma, J. 1989. Using soil survey data for quantitative land evaluation. Advances in Soil Science 9:177-213.
Huddleston, J.H. 2003. That soil survey is no darn good! Soil Survey Horizons 44:126-128.
Soils in Land Management and Environmental Quality
Hall, G.F., T.J. Logan, and K.K. Young. 1985. Criteria for determining tolerable erosion rates. *In* R. F. Follett and B. A. Stewart (ed.). Soil erosion and crop productivity. American Society of Agronomy, Madison, WI.
Soil risks and hazards
Web site on Soil risks, hazards, degradation: http://soils.usda.gov/use/risks.html (this site links to pdf)

Human Impacts on Soil Formation and Landscapes
Sandor, J., C.L. Burras, and M. Thompson. 2005. Factors of soil formation: human impacts, p. 520-532. *In* D. Hillel (ed.) Encyclopedia of soils in the environment, Vol. 1. Elsevier Ltd., Oxford, U.K.
Effland, W.R., and R.V. Pouyat. 1997. The genesis, classification, and mapping of soils in urban areas. Urban Ecosystems 1:217-228.
Tugel, A.J., J.E. Herrick, J.R. Brown, M.J. Mausbach, W. Puckett, and K. Hipple. 2005. Soil change, soil survey, and natural resources decision making: a blueprint for action. Soil Science Society of America Journal 69:738-747.
Soil Resource Protection and Sustainable Land Use
Amundson, R. 2000. Are soils endangered? p. 144-153. *In* J. Schneiderman (ed.) The Earth around us, maintaining a livable planet. W.H. Freeman, New York.
Amundson, R., Y. Guo, and P. Gong. 2003. Soil diversity and land use in the United States. Ecosystems 6:470-482.
Bouma, J. 1994. Sustainable land use as a future focus for pedology. Soil Science Society of America J. 58:645-646.

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Term Paper

Each student will write a paper on some aspect of soil formation that will count for 25% of the final grade. Submit a general topic either of your own choosing or from suggestions listed below by September 21. A specific topic will be decided upon in consultation with the instructor by September 28. Guidelines to help with paper preparation will be provided. The suggested length is 15-20 pages. A draft of the paper is due by November 9. After consulting with the instructor about revisions, if necessary, the final version is due by December 6. The paper can be related to your graduate research, but should not be part of the thesis/dissertation itself.

Some Ideas for Topics

Soil Formation (Pedology), Classification, and Mapping

Soils of certain geographical areas or ecological regions (e.g., tropics, deserts, mountains, etc.)
Genesis, characteristics, and distribution of one of the world's soil orders or horizons
Clay mineral formation in soils or theories on the role of clay in the origin of life
Use of micromorphology in soil genesis studies
Rates of soil formation or soil development with time
How is soil age determined?
Anthrosols (highly human influenced soils)
Paleosols (soils formed in past geologic time)
Influences of climate, vegetation, animals, topography, or parent material on soils
Soil classification systems other than U.S. system (Soil Taxonomy)
Use of remote sensing in soil survey
Statistical methods in soil mapping (e.g. geostatistics) or soil classification

Applications of Soil Science in Agriculture, Natural Resource Management, and Climatology

Use of soil survey information in agriculture, forestry, wildlife, and other natural resource management
Effects of agricultural practices on soil properties
Soil in relation to precision agriculture
Soil quality and sustainable agriculture
Soil erodibility and soil loss tolerance
Effects of soil erosion or other degradation on productivity
Salt-affected soils (saline/sodic soils) and their reclamation
Plant roots and soil
Vegetation as a soil indicator, or influences of soils on vegetation and vice versa
Wetland soils
Applications of soil isotope studies and other soil information to climate and vegetation change
Interactions of animals or other organisms in soil environments

Applications of Soil Science in Engineering, Geology, Anthropology, Business/Economics, and other Disciplines

Reclamation of mine land or other highly disturbed soils
Use of soil survey information in engineering
Use of soil survey information in land appraisal, valuation, and tax assessment
Soils in the urban environment
Application of soil information in waste disposal
Soils and archaeology
Knowledge of soils in different cultures
Dating past earthquakes and other geologic hazards (e.g., tsunamis, etc.) using soils
Soils as geochemical indicators
Soils and human/animal nutrition problems or soils and health (geomedicine)
Use of soil information in criminal investigations (forensic soil science and geology)
Extraterrestrial "soils" (e.g., soils on Mars or the moon, or artificial soils)
Soil risks, hazards, and degradation

Soils and Environmental Quality Problems (role of soils or effects on soils, and possible solutions)

Erosion and sedimentation
Soil contamination, and related groundwater and surface water contamination
Acid rain
Global warming and climate change; soil carbon sequestration
Desertification
Tropical forest loss
Loss of soils to urban development

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Websites

Agronomy 473 Web Site

http://www.agron.iastate.edu/courses/agron473/

Information, photos, and other graphics on soils, geomorphology, and soil-land use relationships are available for most parts of the course, including all lectures and labs.

Other Photos of Soils and Landscapes Available on the Internet

- Photos of soil orders, maps, and other resources: http://soils.ag.uidaho.edu/soilorders/
- U.S. soil geography: http://soils.usda.gov/survey/geography/
- U.S. state soils (one major soil per state): http://soils.stanford.edu/StateSoils/StateSoilFrm.htm
- Color landform atlas of the U.S.: http://fermi.jhuapl.edu/states/
- Earth Science World ImageBank: http://www.earthscienceworld.org/imagebank/
- Canada landscape photos: http://gsc.nrcan.gc.ca/landscapes/index_e.php
- Arid land soils: http://ag.arizona.edu/OALS/oals/alic/resources/resources.html
- Soils and Substrates: http://www.metla.fi/info/vlib/soils/old.htm
- Illinois soils: http://www.gis.uiuc.edu/nrcs/profile.htm
- Wind erosion/dust storms: http://www.weru.ksu.edu/pics/nasa/index.html

Other Useful Sites

- USDA-Natural Resources Conservation Service: http://soils.usda.gov/ (including World Soil Resources section at http://soils.usda.gov/use/worldsoils/)
- Soil Series (United States) and Soil Taxonomy: http://soils.usda.gov/technical/classification/osd/index.html
- Soil data from USDA-NRCS: http://soildatamart.nrcs.usda.gov/
- Soil survey and map data from USDA-NRCS: http://websoilsurvey.nrcs.usda.gov/app/
- Iowa topographic maps and aerial photos: http://ortho.gis.iastate.edu/
- Iowa soil and land use information: http://extension.agron.iastate.edu/soils/
- Soil texture triangle calculator: http://nowlin.css.msu.edu/software/triangle_form.html
- Soil micromorphology and mineralogy: http://www.soils.org/divs/s9/micromorph/micro.html
- Soil mineral and organic molecule models: http://www.soils.wisc.edu/virtual_museum/index.html
- USDA- NRCS Wetland Science Institute: http://www.pwrc.usgs.gov/wli/
- Aquic/wetland soils: http://edafologia.ugr.es/hidro/indexw.htm
- Soil Quality Information: http://soils.usda.gov/sqi/
- Soil risks, hazards, degradation: http://soils.usda.gov/use/risks.html
- World Soils Information (International Soil Reference and Information Centre at Wageningen University, The Netherlands): http://www.isric.org/
- World geographic information: http://earth.google.com/
- History of Soil Science & Pedology: http://chiron.valdosta.edu/ecbrevik/HistoryMainPage.htm

Please let me know if you find other sites or site changes.
This list was checked and updated August 6, 2007.