

Soil Formation: Earth Surface Processes and Biogeochemistry

LAAS 5515

Fall 2021

<https://canvas.umn.edu/courses/267060>

Lecture: 01:55PM- 2:45 PM, M,W. McNeal 146

Discussion: 01:55PM-2:45 PM. F. McNeal 146

Office Hour: 3:00 PM-4:00 PM (or by appointment). F. 570 Borlaug Hall.

**INSTRUCTOR:**

Kyungsoo Yoo

Professor

Department of Soil, Water, and Climate

570 Borlaug Hall

Tel: 612-624-7784

Email: [kyoo@umn.edu](mailto:kyoo@umn.edu)

**COURSE OVERVIEW**

**LAAS 5515** is a course designed for graduate students and advanced undergraduate students. The course follows physical, biological, and chemical processes (1) that disintegrate rocks, form soils, and generate sediments and solutes, (2) that create soils as an integral part of landscape evolution and biogeochemical cycles, and (3) that create diverse soil landscapes in the natural and human-managed ecosystems.

**REQUIRED TEXTBOOKS**

**Amundson, Ronald. *Introduction to the Biogeochemistry of Soils*. New York, NY, USA: Cambridge University Press, 2021.**

This new textbook came out this summer and is now available for purchase in online bookstores (e-book is also available). It has not arrived at our libraries. This graduate-level textbook on soil formation uniquely provides a balanced perspective between theories and practices without overwhelming the readers with details and observations. Not all but many lectures will be provided using the materials in this textbook as a background.

**Soil Science Division Staff. 2017. *Soil survey manual*. C. Ditzler, K. Scheffe, and H.C. Monger (eds.). USDA Handbook 18. Government Printing Office, Washington, D.C.**

This book is freely available in PDF and in printed copy at:

[https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2\\_054262](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054262)

**Soil Survey Staff. 2015. *Illustrated guide to soil taxonomy*. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska.** This book is freely available in PDF at:

[https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2\\_053580](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580)

For a full version of soil taxonomy, you can consult **Soil Survey Staff. 2014. *Keys to Soil Taxonomy, 12th ed.* USDA-Natural Resources Conservation Service, Washington, DC.** This full and more technical version of soil taxonomy is available on the same website.

**COURSE STRUCTURE**

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**Lecture** (1:55 PM- 2:45 PM, M, W.): First five to ten minutes will be devoted to reflecting the materials covered in previous classes and placing the day's material in the larger context of learning objectives. We will then focus on new materials for about thirty minutes. The remaining five minutes will be used for summarizing the new materials. Powerpoint slides (not including the lecture notes) will be posted in pdf format to the Canvas site after each class.

**Friday Session** (1:55 PM- 2:45 PM, F.): Friday sessions will be devoted to student-led and group activities.

**Optional Field Trips:** Two full-day weekend field trips are planned this semester. We will visit (1) Minnesota Arboretum and (2) Southwest Research & Outreach Center at Lamberton, MN. Tentative dates are in the course schedule below. Dress appropriately for hiking and digging and bring field notes and bring your lunch, snack, and water.

### COURSE ASSIGNMENTS AND GRADING

**Problem Sets (40%):** There will be a total of 6 problem sets. Problem sets will be due in two weeks. Problems will be divided into two types. (1) Problems that remind students of key concepts and facts. (2) Exercises that encourage students to apply key concepts and simple models to real-world soils.

**Attendance/Quizzes (20%):** There will be quizzes during the class hours. They will not be graded but will be used as a basis for attendance. When you turn in quizzes, do not forget to include your name.

**Group presentation (20%):** Each student will participate in group activities. The learning objective, mode of collaboration, final outcomes, and assessment of the group work, and effective use of Discussion sessions will be the topic for the first two Friday Discussion sessions.

**Participation (20%):** Students earn participation grades by providing feedbacks to other group projects. The format of the feedback will be articulated during the first two Friday Discussion sessions.

**Late Assignments:** Unless you have received permission in advance from the Instructor to turn in an assignment past the due date, the grade on an Assignment posted to Canvas will be automatically reduced by 10% of the graded value if it is turned in late and further reduced by an additional 10% each day thereafter. For example, if your grade on an assignment was 80 but you turned it in two days late, your score would be  $80 \times 0.80 = 64$ . Failure to turn in an assignment within five days of the deadline will result in a grade of zero for that assignment. All deadlines will be posted on the Canvas site with the assignment.

**Additional / Extra Credit Assignments:** The instructor will not provide additional extra credit assignments for students seeking to improve their grade in the course. This practice is unfair to other students and creates an additional workload for the instructor. There are ample opportunities for students to earn grade points during regularly assigned coursework.

Course grades are based on the University's point scale. For information, please refer to <http://policy.umn.edu/education/gradingtranscripts>.

#### **Grading criteria (A-F):**

A	100%	to	93%
A-	< 93%	to	90%
B+	< 90%	to	87%
B	< 87%	to	83%
B-	< 83%	to	80%

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C+	< 80%	to	77%
C	< 77%	to	73%
C-	< 73%	to	70%
D+	< 70%	to	67%
D	< 67%	to	60%
F	< 60%	to	0%

### **COVID-19**

It is important to keep our learning community safe and healthy. All participants in the course must wear masks (covering both mouth and nose) while in classrooms and in cars (during the optional field trips) regardless of vaccination status.

Here are some useful guidelines related to Covid-19.

*Face Covering Protocol, Updated August 27, 2021*

<https://safe-campus.umn.edu/return-campus/face-coverings>

*Get the Vax 2.0*

<https://safe-campus.umn.edu/return-campus/get-the-vax>

*Steps for addressing non-compliance in the instructional environment*

<https://docs.google.com/document/d/1d4BVCODLFjU1ujl2GzXVkvXiJ3Fgg4q18gMbhZSsifs/edit?usp=sharing>

*Guidance on Student Positive Cases: Guidance for faculty, staff, and instructors on the Twin Cities campus for use in the classroom, advising, or other learning or student life settings. Updated September 2, 2021*

<https://provost.umn.edu/covid-19-response/guidance-student-positive-cases>

*Makeup Work for Legitimate Absences: Twin Cities, Crookston, Morris, Rochester*

<https://policy.umn.edu/education/makeupwork>

### **Teaching and Learning: Student Responsibilities**

Modified from <https://policy.umn.edu/education/studentresp>

**Responsibility for class work.** Students are responsible for knowing all information contained in the syllabus. Students are responsible for meeting all course requirements, observing all deadlines, examination times, and other course procedures.

#### **Attending class.**

Students are expected to attend all meetings of their courses. They may not be penalized for absence from class, however, to participate in religious observances, for approved University activities, and for other reasons in accordance with the policy on Makeup Work for Legitimate Absences. Students should notify instructors as soon as possible about such absences. (See Administrative Policy: [Makeup Work for Legitimate Absences: Twin Cities, Crookston, Morris, Rochester](#)).

Students must attend the first class meeting of every course in which they are registered unless (1) they obtain approval from the instructor before the first meeting or (2) they provide notice to the instructor they must miss class because of a recognized religious holiday (see the policy on Mandatory Attendance at First Class Session and Consequences for

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Absence). Otherwise, they may lose their places in class to other students. (See Administrative Policy: [Mandatory Attendance at First Class Session and Consequences for Absence: Twin Cities, Crookston, Morris, Rochester](#)).

Students are responsible for being on time and prepared for all class sessions.

### **Maintaining academic integrity.**

Students are expected to maintain academic integrity, including doing their own assigned work for courses. If it is determined that a student has engaged in scholastic dishonesty, the instructor may impose an academic consequence (e.g., giving the student a grade of "F" or an "N" for the course), and the student may face additional sanctions from the University. (See Board of Regents Policy: [Student Conduct Code](#), Section VI, Subd 1, Scholastic Dishonesty, and Administrative Policy: [Grading and Transcripts: Twin Cities, Crookston, Morris, Rochester](#)).

### **Seeking help and accommodation.**

Students are responsible for seeking academic help in a timely fashion.

Students who need special accommodations are responsible for working first with the relevant University offices and then with the instructor at the beginning of the course.

### **Respecting intellectual property.**

Students may not distribute instructor-provided notes or other course materials, except to other members of the same class or with the express (written) consent of the instructor. Instructors have the right to impose additional restrictions on course materials in accordance with copyright and intellectual property law and policy. Students may not engage in the widespread distribution or sale of transcript-like notes or notes that are close to verbatim records of a lecture or presentation.

### **Keeping classroom in good order.**

Students may be responsible for helping straighten up a classroom at the end of a class period, if requested to do so by the instructor. Keeping a classroom in good order includes taking away or disposing of everything one came in with, such as pop cans/bottles, food containers/wrappers, newspapers, etc. Students must also not deface or damage classrooms or classroom furniture or equipment.

### **Use of personal electronic devices in the classroom.**

Instructors determine if personal electronic devices (such as cell phones and laptops) are allowed in the classroom. Students may be directed to turn off personal electronic devices if the devices are not being used for class purposes. Students are not permitted to record any part of a class/lab/other session unless explicitly granted permission by the instructor. If the student does not comply, the student may be asked to leave the classroom.

**Guests may not be brought to class without permission from the instructor.**

## **Other University Policies**

***Makeup Work for Legitimate Absences:*** Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see: <http://policy.umn.edu/education/makeupwork>.

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**Sexual Harassment:** "Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy:

[https://regents.umn.edu/sites/regents.umn.edu/files/policies/Sexual\\_Harassment\\_Sexual\\_Assault\\_Stalking\\_Relationship\\_Violence.pdf](https://regents.umn.edu/sites/regents.umn.edu/files/policies/Sexual_Harassment_Sexual_Assault_Stalking_Relationship_Violence.pdf)

**Equity, Diversity, Equal Opportunity, and Affirmative Action:** This course draws students from a variety of scientific disciplines. In addition, students may come from widely diverse ethnic and cultural backgrounds and hold different values. Because a key to optimal learning is to hear, analyze, and draw from a diversity of views, the instructors expect collegial and respectful dialogue across disciplinary, cultural, and personal boundaries. The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy:

[http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity\\_Diversity\\_EO\\_AA.pdf](http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity_Diversity_EO_AA.pdf).

Please also see the Department of Soil, Water, and Climate Diversity, Equity, and Inclusivity Statement <https://www.swac.umn.edu/about-us/diversity>

**Disability Accommodations:** As a student, you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily activities. University of Minnesota services are available to assist you with addressing these and other concerns you may be experiencing. You can learn more about the broad range of confidential [mental health services](#) available on campus.

The University of Minnesota views disability as an important aspect of diversity and is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

- If you have, or think you have, a disability in any area such as mental health, attention, learning, chronic health, sensory, or physical, please contact the DRC office on your campus (UM Twin Cities - 612.626.1333) to arrange a confidential discussion regarding equitable access and reasonable accommodations.
- Students with short-term disabilities, such as a broken arm, can often work with instructors to minimize classroom barriers. In situations where additional assistance is needed, students should contact the DRC as noted above.
- If you are registered with the DRC and have a disability accommodation letter dated for this semester or this year, please contact your instructor early in the semester to review how the accommodations will be applied in the course.
- If you are registered with the DRC and have questions or concerns about your accommodations please contact your (access consultant/disability specialist).

Additional information is available on the [DRC website](#) or email [drc@umn.edu](mailto:drc@umn.edu).

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**Mental Health and Stress Management:** As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating, and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: <http://www.mentalhealth.umn.edu>.

**Academic Freedom and Responsibility:** Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.\*

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact your instructors, the Department Head of SWAC, your adviser, the associate dean of your college, or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost.

*\* Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".*

## Tentative Schedule (Fall 2021)

date	day	topic	Chapters in Soil Biogeochemistry	Chapters in Soil Survey Books	Other Readings
8-Sep	W	Review of syllabus			
10-Sep	F	Discussion (self-introduction)			
13-Sep	M	Geochemical context of soil formation	2. An overview of the Biogeochemistry of Soils		Railsback LB., 2003, An earth scientist's periodic table of the elements and their ions, GEOLOGY Volume: 31 Issue: 9 Pages: 737-740.
15-Sep	W				Virtual Museum of Minerals and Molecules: <a href="http://virtual-museum.soils.wisc.edu/">http://virtual-museum.soils.wisc.edu/</a> .
17-Sep	F	Discussion			
20-Sep	M	Geomorphic context of soil formation	6. Time and Soil Process	2. Landscapes, geomorphology, and site description in "Soil survey manual". P21-52.	Gilbert, G.K., 1909, The convexity of hilltops: Journal of Geology, v. 17, p. 344-350.
22-Sep	W				Fernandes, Nelson F., and William E. Dietrich. "Hillslope Evolution by Diffusive Processes: The Timescale for Equilibrium Adjustments." Water Resources Research 33, no. 6 (1997): 1307–18.
24-Sep	F	Discussion (Problem Set #1 Out)			
25-Sep	Sat	Optional Field Trip to MN Arboretum			
27-Sep	M	Field-based soil properties	4. Field-based properties of soils	Part 2—Horizon Nomenclature Used for Describing Soil Profiles in "Illustrated Guide to Soil Taxonomy."	
29-Sep	W	Soil biogeochemical measurements and data	5. Soil biogeochemical measurements and data	Appendix 3. NCSS soil characterization database in "Soil survey manual"	
1-Oct	F	Discussion			
4-Oct	M	Soil diversity: state factors and soil taxonomy	1. Introduction to Soils	Part 1, 3, and 4 in "Illustrated Guide to Soil Taxonomy."	
6-Oct	W			4. Soil mapping concepts (p.235-268) in "Soil survey manual"	
8-Oct	F	Discussion (Problem Set #2 Out, #1 Due)			
9-Oct	Sat	Optional Field Trip to Lamberton SWROC (This date may change depending on the situations at Lamberton SWROC)			
11-Oct	M	Tools 1: geochemical mass balance model	p. 142-151 in 8. Chemical and physical processes in soils		Resner et al., "Invasive Earthworms Deplete Key Soil Inorganic Nutrients (Ca, Mg, K, and P) in a Northern Hardwood Forest." <i>Ecosystems</i> 18, no. 1 (January 2015): 89–102. <a href="https://doi.org/10.1007/s10021-014-9814-0">https://doi.org/10.1007/s10021-014-9814-0</a> .

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13-0 ct	W	Tools 2: cosmogenic radio-nuclides			Dixon, J. L., and C. S. Riebe. "Tracing and Pacing Soil Across Slopes." <i>Elements</i> 10, no. 5 (October 1, 2014): 363–68. <a href="https://doi.org/10.2113/gselements.10.5.363">https://doi.org/10.2113/gselements.10.5.363</a> .  Fulajtar et al., <i>Use of <sup>137</sup>Cs for Soil Erosion Assessment / Emil Fulajtar, Lionel Mabit, Chris S. Renschler, Amelia Lee Zhi Yi.</i> , 2017.
15-0 ct	F	Discussion			
18-0 ct	M	Parent material as a soil-forming factor		2. <i>Landscapes, geomorphology, and site description in "Soil survey manual"</i> . P53-70.  Andisols / Vertisols in "Illustrated Guide to Soil Taxonomy"	Oh, N.-H. and D. D. Richter (2005). "Elemental translocation and loss from three highly weathered soil-bedrock profiles in the southeastern United States." <i>Geoderma</i> 126: 5-25.
20-0 ct	W				Fanning et al., 2010, An acid sulfate perspective on landscape-seascape soil mineralogy in the US Mid-Atlantic region. <i>Geoderma</i> , 154. 457-464.
22-0 ct	F	Discussion (Problem Set #3 Out, #2 Due)			
25-0 ct	M	Time as a soil-forming factor (Soil chronosequences)		Entisols / Inceptisols in Illustrated Guide to Soil Taxonomy"	Merritts et al., "The Mass Balance of Soil Evolution on Late Quaternary Marine Terraces, Northern California." <i>Geological Society of America Bulletin</i> 104, no. 11 (November 1992): 1456–70. <a href="https://doi.org/10.1130/0016-7606(1992)104&lt;1456:TMBOSE&gt;2.3.CO;2">https://doi.org/10.1130/0016-7606(1992)104&lt;1456:TMBOSE&gt;2.3.CO;2</a> .
27-0 ct	W				Jefferson et al., "Controls on the Hydrological and Topographic Evolution of Shield Volcanoes and Volcanic Ocean Islands." In <i>Geophysical Monograph Series</i> , edited by Harpp et al., 185–213. Hoboken, New Jersey: John Wiley & Sons, Inc, 2014. <a href="https://doi.org/10.1002/9781118852538.ch10">https://doi.org/10.1002/9781118852538.ch10</a> .
29-0 ct	F	Discussion			
1-No v	M	Climate as a soil-forming factor	8.3 Soil biogeochemical processs in dry environments	Aridisols / Gelisols / Oxisols / Ultisols in "Illustrated Guide to Soil Taxonomy"	Chadwick et al., "The Impact of Climate on the Biogeochemical Functioning of Volcanic Soils." <i>Chemical Geology</i> 202, no. 3–4 (December 2003): 195–223. <a href="https://doi.org/10.1016/j.chemgeo.2002.09.001">https://doi.org/10.1016/j.chemgeo.2002.09.001</a> .
3-No v	W				Muhs, D. R., E. A. Bettis, J. Been, and John P. McGeehin. "Impact of Climate and Parent Material on Chemical Weathering in Loess-Derived Soils of the Mississippi River Valley." <i>Soil Science Society of America Journal</i> 65, no. 6 (2001): 1761–77.  Ewing et al., "A Threshold in Soil Formation at Earth's Arid–Hyperarid Transition." <i>Geochimica et Cosmochimica Acta</i> 70, no. 21 (November 2006): 5293–5322. <a href="https://doi.org/10.1016/j.gca.2006.08.020">https://doi.org/10.1016/j.gca.2006.08.020</a> .
5-No v	F	Discussion (Problem Set #4 Out, #3 Due)			



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8-Nov	M				Jenny, Hans. "Role of the Plant Factor in the Pedogenic Functions." <i>Ecology</i> 39, no. 1 (January 1958): 5. <a href="https://doi.org/10.2307/1929960">https://doi.org/10.2307/1929960</a> .
10-Nov	W	Biology as a soil-forming factor (possibly zoom or video lectures due to Soil Science Society of America Meeting)	3. Biology in Soil Biogeochemistry	Mollisols in "Illustrated Guide to Soil Taxonomy"	Lucas, Y. "The Role of Plants in Controlling Rates and Products of Weathering: Importance of Biological Pumping." <i>Annual Review of Earth and Planetary Sciences</i> 29, no. 1 (May 2001): 135–63. <a href="https://doi.org/10.1146/annurev.earth.29.1.135">https://doi.org/10.1146/annurev.earth.29.1.135</a> .  Johnson et al., "Reflections on the Nature of Soil and Its Biomantle." <i>Annals of the Association of American Geographers</i> 95, no. 1 (March 2005): 11–31. <a href="https://doi.org/10.1111/j.1467-8306.2005.00448.x">https://doi.org/10.1111/j.1467-8306.2005.00448.x</a> .
12-Nov	F	Discussion			
15-Nov	M	Soils and hillslopes (Topography as a soil-forming factor)	9. Soil processes on sloping landscape	2. Landscapes, geomorphology, and site description in "Soil survey manual". P70-77.	Wackett et al., "Climate Controls on Coupled Processes of Chemical Weathering, Bioturbation, and Sediment Transport across Hillslopes: Climate, Weathering, Bioturbation and Sediment Transport on Hillslopes." <i>Earth Surface Processes and Landforms</i> , February 5, 2018. <a href="https://doi.org/10.1002/esp.4337">https://doi.org/10.1002/esp.4337</a> .
17-Nov	W				
19-Nov	F	Discussion (Problem Set #5 Out, #4 Due)			
22-Nov	M	Soil carbon 1	7. The soil Carbon Cycle	Histosols / Spodosols in "Illustrated Guide to Soil Taxonomy"	Eriksson, E. "Compartment Models and Reservoir Theory." <i>Annual Review of Ecology and Systematics</i> 2, no. 1 (November 1971): 67–84. <a href="https://doi.org/10.1146/annurev.es.02.110171.000435">https://doi.org/10.1146/annurev.es.02.110171.000435</a> .  Harden et al., "Dynamics of Soil Carbon during Deglaciation of the Laurentide Ice Sheet." <i>Science</i> 258 (1992): 1921–1921.
24-Nov	W	Thanksgiving Holiday			
26-Nov	F				
29-Nov	M	Soil carbon 2	7. The soil Carbon Cycle	Histosols / Spodosols in "Illustrated Guide to Soil Taxonomy"	p. 3-14 in Handley, W. R. C. <i>Mull and Mor Formation in Relation to Forest Soils</i> . HM Stationery Office, 1954. <a href="http://www.forestry.gov.uk/pdf/FCBU023.pdf/\$FILE/FCBU023.pdf">http://www.forestry.gov.uk/pdf/FCBU023.pdf/\$FILE/FCBU023.pdf</a> .  Kleber et al., "Dynamic Interactions at the Mineral–Organic Matter Interface." <i>Nature Reviews Earth &amp; Environment</i> , May 11, 2021. <a href="https://doi.org/10.1038/s43017-021-00162-y">https://doi.org/10.1038/s43017-021-00162-y</a> .
1-Dec	W	Soil pH		Alfisols / Ultisols in "Histosols / Spodosols in "Illustrated Guide to Soil Taxonomy""	Chadwick and Chorover. "The Chemistry of Pedogenic Thresholds." <i>Geoderma</i> 100, no. 3–4 (May 2001): 321–53. <a href="https://doi.org/10.1016/S0016-7061(01)00027-1">https://doi.org/10.1016/S0016-7061(01)00027-1</a> .  Slessarev et al., "Water Balance Creates a Threshold in Soil pH at the Global Scale." <i>Nature</i> 540, no. 7634 (December 2016): 567–69. <a href="https://doi.org/10.1038/nature20139">https://doi.org/10.1038/nature20139</a> .

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3-Dec	F	Discussion (Problem Set #6 Out, #3 Due)			
6-Dec	M	Soil phosphorus			Walker and Syers. "Fate of phosphorus during pedogenesis." <i>Geoderma</i> 15, no. 1 (1976): 1–19. <a href="https://doi.org/10.1016/0016-7061(76)90066-5">https://doi.org/10.1016/0016-7061(76)90066-5</a> .  Eger et al., "Does Soil Erosion Rejuvenate the Soil Phosphorus Inventory?" <i>Geoderma</i> 332 (December 2018): 45–59. <a href="https://doi.org/10.1016/j.geoderma.2018.06.021">https://doi.org/10.1016/j.geoderma.2018.06.021</a> .
8-Dec	W	Shifting cultivation and soil biogeochemistry	10. Humans and Soil Biogeochemistry		Jobbágy, Esteban G., and Robert B. Jackson. "THE UPLIFT OF SOIL NUTRIENTS BY PLANTS: BIOGEOCHEMICAL CONSEQUENCES ACROSS SCALES." <i>Ecology</i> 85, no. 9 (September 2004): 2380–89. <a href="https://doi.org/10.1890/03-0245">https://doi.org/10.1890/03-0245</a> .  Toky and Ramakrishnan. "Secondary Succession Following Slash and Burn Agriculture in North- Eastern India: II. Nutrient Cycling." <i>The Journal of Ecology</i> 71, no. 3 (November 1983): 747. <a href="https://doi.org/10.2307/2259590">https://doi.org/10.2307/2259590</a> .
10-Dec	F	Discussion			
13-Dec	M	A brief history of soil fertility	10. Humans and Soil Biogeochemistry	11. Human-altered and human-transported soils in "Soil survey manual."	Krausmann, Fridolin. "Milk, Manure, and Muscle Power. Livestock and the Transformation of Preindustrial Agriculture in Central Europe." <i>Human Ecology</i> 32, no. 6 (December 2004): 735–72. <a href="https://doi.org/10.1007/s10745-004-6834-y">https://doi.org/10.1007/s10745-004-6834-y</a> .  Ferguson, Dean T. "Nightsoil and the 'Great Divergence': Human Waste, the Urban Economy, and Economic Productivity, 1500–1900." <i>Journal of Global History</i> 9, no. 3 (November 2014): 379–402. <a href="https://doi.org/10.1017/S1740022814000175">https://doi.org/10.1017/S1740022814000175</a> .
15-Dec	W	Lands - Plows - Animal vs. Tractors - Human	10. Humans and Soil Biogeochemistry		White, Lynn. <i>Medieval Technology and Social Change</i> . Reprinted. London: Oxford Univ. Press, 1980. Chapter 2. The agricultural revolution of the early middle ages.  Pleasant, Jane Mt. "The Paradox of Plows and Productivity: An Agronomic Comparison of Cereal Grain Production under Iroquois Hoe Culture and European Plow Culture in the Seventeenth and Eighteenth Centuries." <i>Agricultural History</i> 85, no. 4 (January 1, 2011): 460–92. <a href="https://doi.org/10.3098/ah.2011.85.4.460">https://doi.org/10.3098/ah.2011.85.4.460</a> .



