UG FOR 415 **Environmental Soils** **Spring 2009**

Time: T/TR 12:40 – 2:00 pm, DHC 120

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Course Web Site: Blackboard (http://umonline.umt.edu/)

Office hours: T 2:00 – 3:00 pm in SC 464 and by appointment

Course Description: Healthy soils provide the foundation for all healthy terrestrial ecosystems. They provide us with the food, fuel and fiber that fuel the human enterprise, filter water, store carbon, cycle nutrients, and perform countless other critical ecosystem functions. However, when people till intensively till fields, clearcut or burn forests, mine for energy or minerals, etc, they can damage or destroy topsoil that took centuries to accumulate.

In this course, we will examine the physical, chemical and biological properties of soils and how they function. After a brief look at these basic properties, we will take a closer look at a number of soil processes and how they affect, and are affected by global change. In addition, we will consider a number of contemporary topics including the potential effects of climate change on soils, plant-soil interactions, and the consequences of large-scale biofuel production from biomass on soil processes, among others. The course will involve some lecture, discussion and presentations by both me and you.

Prerequisites: U FOR 210 N or equivalent (for undergraduates). Graduate students should also have completed an equivalent introductory soils course at another institution. If you have not, please come talk to me.

Textbooks: Unfortunately, there is not a single textbook that adequately covers this class, but there are two that I will draw from heavily, and that you should consider purchasing.

An Introduction to Soils for Environmental Professionals by Duane Winegardner, Lewis Publishers, 1995.

Soil Microbiology, Ecology and Biochemistry by Eldor A. Paul, Academic Press, 2007.

Both of these books should be available at the UM Bookstore, and on reserve in the library.

In addition, the textbook reading will be supplemented by readings from other sources, including the primary literature. These readings will be available as .pdf files on the course web site. You should print them out, read them, and bring them with you to class every day.

I will expect a lot from each of you in this class. The course will include some lecture, but also plenty of discussion of key topics. Thus, we will work from the both the *texts and from the primary scientific literature*. We will focus on the *fundamentals* of soil science in the first 1/3 of the class, and spend the remainder of the course covering a variety of key environmental issues that affect – and are affected by – soil processes. **Finally, note that part of everyone's grade is determined by class participation. These are easy points to get – come to class, come to class prepared, ask questions, and participate in discussions. While we are on the subject of *preparation*…**

Class Preparation: This is a senior/graduate-level class. That means the course will consist of a mix of lectures and some discussion. **The only way that works is if YOU COME TO CLASS PREPARED EVERY DAY, and you are willing and able to participate!** First and foremost, that means you must keep up with the reading. For undergraduate students, I will assign virtually NO additional homework, but you should treat the reading as formal (*i.e.*, graded) assignments. There may be quizzes periodically to encourage you to come prepared.

Grading:

Undergraduate students:
Midterm exam: 25%
Final exam: 25%
Final paper: 25%
Class presentation: 15%
Class participation: 10%

Graduate students:
Midterm exam: 25%
Final exam: 25%
Final paper: 25%
Final presentation: 10%
Class participation: 15%

Finally, the usual rules concerning academic honesty apply here. As per University rules, academic misconduct is subject to penalty by the course instructor (me) and or disciplinary sanction by the University. Familiarize yourself with the Student Honor Code, and make sure that you adhere to all aspects of it:

http://ordway.umt.edu/SA/VPSA/index.cfm/name/StudentConductCode.

Class #	Date	Topic	Required Reading	Class Leader
1	1/27	Course Introduction & Overview	Winegardner Ch. 1	CC
		The Soil Environment		
2	1/29	The Soil Environment: Mineralogy	Winegardner Ch. 3, Richter & Markewitz 1995	CC
3	2/3	The Soil Environment: Soil Physics	Winegardner Ch. 4 & 5	CC
4	2/5	The Soil Environment: Chemistry	Winegardner Ch. 6	CC
5	2/10	The Soil Environment: Biology	Winegardner Ch. 7, Paul Ch. 5, 6 & 7	CC
		Soil Ecology & Biogeochemistry		
6	2/12	Soil Ecology	Paul Ch. 8 & 9	CC
7	2/17	Soil Biogeochemistry: Carbon	Paul (2007) Ch. 12	CC
8	2/19	Soil Biogeochemistry: Nitrogen (Campus Climate Exchange)	Paul (2007) Ch. 13 & 14	CC
9	2/24	Soil Biogeochemistry: Phosphorus et al.	Paul (2007) Ch. 15, Walker and Syers (1976)	CC

		Global Change & Soils	**Suggested References**	**Class Leader**
10	2/26	Soil & Ecosystem Development: The State Factors	Amundson & Jenny (1991); Amundson & Jenny (1997)	CC
11	3/3	Climate Change and Soil Processes I: Temperature	Paul Ch. 2, Davidson & Janssens (2006), Melillo et al. (2002), Groffman et al. (2001)	
12	3/5	Climate Change and Soil Processes II: Precipitation	Davidson et al. (2004)	
13	3/10	Plant Species – Soil Interactions	Paul Ch. 10, Wardle et al. (2004), Hooper et al. (2000)	
14	3/12	Invasive Species and Soil Processes	Vitousek et al. (1987), Reinhart & Callaway (2006)	
15	3/17	Humans: Land use change and soils	Richter (2007)	
16	3/19	Humans: Land use change & erosion I: Water	Montgomery (2007), National Geographic (Sept 2008)	
17	3/24	Humans: Land use change & erosion II: Wind	Reynolds et al. (2001)	
		Contemporary Issues in Soil Science		
18	3/26	Atmospheric Deposition: N	Aber et al. (1998) Bowman et al. (2008)	
19	3/31	**Spring Break**		
20	4/2	**Spring Break**		
21	4/7	Atmospheric Deposition: N & P interactions	Gress et al. (2007), Menge and Field (2007)	
22	4/9	Elevated CO_2	Hungate et al. (2004), deGraaff et al. (2006)	
23	4/14	Soils Under Fire	Certini et al. (2005), DeLuca and Sala (2007), Erickson & White (2008)	
24	4/16	Logging & Soils	Harmon et al. (1990), Ares et al. (2007), Cullen et al. (1991)	
25	4/21	Soils & Ecological Restoration	Seastedt et al. (2008); Gundale et al. (2006), Baer et al. (2005)	

26	4/23	Soils as C Sinks	Robertson et al. (2000); Lal (2004a, 2004b)
27	4/28	Biofuels: What's Happening Underground?	Fargione et al (2008); Searchinger et al. (2008); Field et al. (2008)
28	4/30	Soils and Remediation	Chaney et al. (1997), Giller et al. (1998)
29	5/5	TBA	
30	5/7	TBA	

Required and Suggested References (Available as PDFs for download on Blackboard):

Aber, J. 1998. Nitrogen saturation in temperate forests- Hypotheses revisited. BioScience **48**: 921-934

Amundson, R., and H. Jenny. 1997. On a state factor model of ecosystems. BioScience **47**:536-543.

Amundson, R., and H. Jenny. 1991. The place of humans in the state factor theory of ecosystems and their soils. Soil Science 151: 99-109.

Ares, A., T. Terry, C. Harrington, W. Devine, D. Peter, and J. Bailey. 2007. Biomass removal, soil compaction, and vegetation control effects on five-year growth of Douglas-fir in coastal Washington. Forest Science **53**:600-610.

Baer, S. G., S. L. Collins, J. M. Blair, A. K. Knapp, and A. K. Fiedler. 2005. Soil heterogeneity effects on tallgrass prairie community heterogeneity: An application of ecological theory to restoration ecology. Restoration Ecology **13**:413-424.

Bowman, W. D., C. C. Cleveland, L. Halada, J. Hresko, and J. S. Baron. 2008. Negative impact of nitrogen deposition on soil buffering capacity. Nature Geoscience **1**:767-770.

Certini, G. 2005. Effects of fire on properties of forest soils: a review. Oecologia **143**:1-10.

Chaney, R. L., M. Malik, Y. M. Li, S. L. Brown, E. P. Brewer, J. S. Angle, and A. J. M. Baker. 1997. Phytoremediation of soil metals. Current Opinion in Biotechnology **8**:279-284.

Cullen, S. J., C. Montagne and H. Ferguson. 1991. Timber harvest trafficking and soil compaction in western Montana. Soil Science Society of America Journal 55: 1416-1421.

Davidson, E. A., F. Y. Ishida, and D. C. Nepstad. 2004. Effects of an experimental drought on soil emissions of carbon dioxide, methane, nitrous oxide, and nitric oxide in a moist tropical forest. Global Change Biology **10**:718-730.

Davidson, E. A., and I. A. Janssens. 2006. Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. Nature **440**:165-173.

de Graaff, M. A., K. J. van Groenigen, J. Six, B. Hungate, and C. van Kessel. 2006. Interactions between plant growth and soil nutrient cycling under elevated CO2: a meta-analysis. Global Change Biology **12**:2077-2091.

DeLuca, T. H., and A. Sala. 2006. Frequent fire alters nitrogen transformations in ponderosa pine stands of the inland northwest. Ecology **87**:2511-2522.

Erickson, H. E. and R. White. 2008. Soils under fire: soils research and the Joint Fire Sciences Program. USDA.

Fargione, J., J. Hill, D. Tilman, S. Polasky, and P. Hawthorne. 2008. Land clearing and the biofuel carbon debt. Science **319**:1235-1238.

Field, C., J. Campbell, and D. Lobell. 2007. Biomass energy: the scale of the potential resource. TREE **23**:65-72.

Giller, K. E., E. Witter, and S. P. McGrath. 1998. Toxicity of heavy metals to microorganisms and microbial processes in agricultural soils: A review. Soil Biology & Biochemistry **30**:1389-1414.

Gress, S. E., T. D. Nichols, C. C. Northcraft, and W. T. Peterjohn. 2007. Nutrient limitation in soils exhibiting differing nitrogen availabiltiies: What lies beyond nitrogen saturation. Ecology **88**:119-130.

Groffman, P. M., C. T. Driscoll, T. J. Fahey, J. P. Hardy, R. D. Fitzhugh, and G. L. Tierney. 2001. Colder soils in a warmer world: A snow manipulation study in a northern hardwood forest ecosystem. Biogeochemistry **56**:135-150.

Gundale, M. J., K. L. Metlen, C. E. Fiedler, and T. H. DeLuca. 2006. Nitrogen spatial heterogeneity influences diversity following restoration in a Ponderosa Pine Forest, Montana. Ecological Applications **16**:479-489.

Harmon, M., W. Ferrell, and J. Franklin. 1990. Effects on carbon storage of conversion of old-growth forests to yound forests. Science **247**:699-702**,**

Hooper, D. U. et. al. 2000. Interactions between aboveground and belowground biodiversity in terrestrial ecosystems: Patterns, mechansims, and feedbacks. BioScience **50**:1049-1061.

Hungate, B. A., P. D. Stiling, P. Dijkstra, D. W. Johnson, M. E. Ketterer, G. J. Hymus, C. R. Hinkle, and B. G. Drake. 2004. CO2 elicits long-term decline in nitrogen fixation. Science **304**:1291.

Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science **304**:1623-1627.

Lal, R. 2004. Soil carbon sequestration to mitigate climate change. Geoderma 123: 1-22.

Melillo, J. M., P. A. Steudler, J. D. Aber, K. Newkirk, H. Lux, F. P. Bowles, C. Catricala, A. Magill, T. Ahrens, and S. Morrisseau. 2002. Soil warming and carbon-cycle feedbacks to the climate system. Science **298**:2173-2176.

Menge, D. N. L., and C. B. Field. 2007. Simulated global changes alter phosphorus demand in annual grassland. Global Change Biology **13**:2582-2591.

Montgomery, D. R. 2007. Is agriculture eroding civilization's foundation? GSA Today 17: 4-9.

National Geographic, September 2008
http://ngm.nationalgeographic.com/2008/09/soil/bourne-text
http://ngm.nationalgeographic.com/2008/09/soil/mann-text

Reinhart, K. O., and R. M. Callaway. 2006. Soil biota and invasive plants. New Phytologist **170**:445-457.

Reynolds, R., J. Belnap, M. Reheis, P. Lamothe, and F. Luiszer. 2001. Aeolian dust in Colorado Plateau soils: Nutrient inputs and recent change in source. Proceedings Of The National Academy Of Sciences Of The United States Of America **98**:7123-7127.

Richter, D., and D. Markewitz. 1995. How deep is soil? BioScience **45**:600-609.

Richter, D. D. 2007. Humanity's transformation of Earth's soil: Pedology's new frontier. Soil Science **172**:957-967.

Robertson, G. P., E. A. Paul, and R. R. Harwood. 2000. Greenhouse gases in intensive agriculture: Contributions of individual gases to the radiative forcing of the atmosphere. Science **289**:1922-1925.

Searchinger, T., R. Heimlich, R. A. Houghton, F. X. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T. H. Yu. 2008. Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change. Science **319**:1238-1240.

Seastedt, T. R., R. J. Hobbs and K. N. Suding. Management of novel ecosystems: are novel approaches required? Frontiers in Ecology and Environment. In Press.

Vitousek, P. M., L. R. Walker, L. D. Whiteaker, D. Mueller-Dombois, and P. A. Matson. 1987. Biological invasion by Myrica faya alters ecosystem development in Hawaii. Science **238**:802-804.

Walker, T. W., and J. K. Syers. 1976. The fate of phosporus during pedogenesis. Geoderma **15**:1-19.

Wardle, D. A., R. D. Bardget, J. N. Klironomos, H. Setala, W. H. van der Putten, and D. H. Wall. 2004. Ecological linkages between aboveground and belowground biota. Science **304**:1629-1633.