GEOGRAPHY 561

ECOHYDROLOGY

Dr. D. Scott Mackay, Instructor

Course Objectives

The general aim of this course is to examine the emerging interdisciplinary area that integrates the hydrologic and ecologic mechanisms underlying climate-soil-vegetation dynamics and land-water dynamics. The evolution of terrestrial ecosystems depends on the need of vegetation for inputs of light, water, and nutrients. These inputs are variable in time and space, and how they are assimilated depends on plant characteristics and ecosystem structure. Thus, vegetation plays an active role as both cause and effect of the space-time dynamics of soil water and climate. We will build on a set of fundamental topics as a basis for examining contemporary topics such as: Plants in water-limited environments; relationships between runoff, erosion and vegetation; aquatic and riparian interactions; disturbance and fire regimes; and global carbon cycling and climate; and prediction of water balance in ungaged basins.

Reference Materials

There is no required text for this course. Each topic we explore will be supported using a combination of important foundation papers and contemporary papers. Representative papers are described later. However, a number of reference texts are worth examining to increase one's familiarity with each topic. A list of reference texts, specific readings, and some representative papers for contemporary topics, appear at the end of this document.

Prerequisites

Graduate student status. Students should have a background and/or interest in science, or permission of instructor.

Grading

There are no exams in this class. We will run this course primarily as a seminar. Sometimes the instructor will lead discussion, and at other times each student will be given the opportunity to lead. For your grade you will submit a term paper (35%) on a contemporary topic in Ecohydrology, lead discussion on the general subject in which your paper falls (25%), lead discussion of a paper on a foundation topic (15%), give a brief presentation on your term paper (15%), and participate in discussion throughout the semester (10%). All evaluations will be by letter grade.

Term papers must be printed using a high quality printer (*e.g.*, laser printer), with a length of about 5000 words, not including references cited. Pages must be double-spaced and font should be 11 or 12 pt. References must follow a format acceptable in the scientific literature, be consistently applied throughout the paper, and must not include references taken from the World-Wide Web (WWW) or other "grey" literature. Papers that cite the WWW will be returned without grading.

It is important to note that plagiarism is a serious offence and will be handled according to University guidelines. We will apply a fairly broad definition here. Examples of plagiarism include whole or substantial copying of other work, failing to cite work used, using work from another student, colleague, etc, or substantial use of your own work from a paper in another course. If you are uncertain whether you are running the risk of plagiarizing other work it's best to ask the instructor.

Office Hours

Should you have any problem or question regarding the course, I will always be available in my office (113 Wilkeson Quad, Ellicott Complex) from 11:00 am to Noon on Mondays and Wednesdays. If you wish to make an appointment for some other time, my office number is 645-2722 ext. 64 and my email address is dsmackay@buffalo.edu.

Tentative Course Schedule

Class	Date		Module	Topic (*Discussion*)
1	12-Jan	*M*		Course overview
2	14-Jan	*W*	ET	Physics
3	21-Jan	*W*		Physiology
4	26-Jan	*M*		Scaling up
5	28-Jan	*W*		Play with models
6	*2-Feb*	*M*		*Discussion*
	4-Feb			No class
7	9-Feb	*M*	Budgets	Storage and flux in unsaturated media
8	11-Feb	*W*		Plant water uptake and limitation
9	16-Feb	*M*		Scaling up
10	18-Feb	*W*		Play with models
11	*23-Feb*	*M*		*Discussion*
12	25-Feb	*W*	BGC	Carbon cycling
13	1-Mar	*M*		Nutrients cycling
14	3-Mar	*W*		Integrated water and BGC
15	*8-Mar*	*M*		*Discussion*
16	10-Mar	*W*		Play with models
	15-Mar			Spring Recess
	17-Mar			Spring Recess
17	*22-Mar*	*M*		*Discussion*
18	*24-Mar*	*W*	*Cross-*	*Plants in water-limited environments*
19	*29-Mar*	*M*	*cutting*	*Runoff, erosion, and vegetation*
20	*31-Mar*	*W*	*Topics*	Disturbance, fire regimes
21	*5-Apr*	*M*		*Aquatic, riparian interactions*
22	*7-Apr*	*W*		*Global carbon and climate*
23	*12-Apr*	*M*		*Prediction of ungaged basins*
24	*14-Apr*	*W*		
25	19-Apr	*M*		Projects reports
26	21-Apr	*W*		Projects reports
27	26-Apr	*M*		Wrap-up; papers due

GEO561 – Ecohydrology - Readings

A. Reference Materials

Ecohydrology is a relatively new and growing subject. There currently is no comprehensive text on the subject, although the recent book by Peter Eagleson at MIT (Eagleson, 2002) is an excellent framework. Eagleson's thesis assumes that plant growth is not nutrient limitated. We will initially work within the bounds offered by Eagleson's thesis, but later relax his constraints to incorporate nutrient and carbon budgets. Foundation and contemporary readings will be drawn primarily from the primary literature, and used as a basis for discussion sessions. The following texts are suggested as representative of the topics we will be covering in the first part of the course, but they are by no means required reading:

Eagleson, Peter S. 2002. *Ecohydrology: Darwinian Expression of Vegetation Form and Function*, Cambridge University Press, Cambridge.

Grayson, R. and G. Blöschl (Eds.). 2000. *Spatial Patterns in Catchment Hydrology: Observations and Modelling*, Cambridge University Press, Cambridge, Chapters 2 and 3.

Schlesinger, William H. 1997. *Biogeochemistry: An Analysis of Global Change*, 2nd Edition, Academic Press, San Diego, CA.

A copy of Eagleson (2002) and of Schlesinger (1997) have been reserved in the Science and Engineering library. Chapters 2 and 3 from Grayson and Blöschl (2000) will be made available in electronic form.

B. Foundation Topics

The following are papers to be read while we are going over foundation topics (evapotranspiration, soil water, and biogeochemical cycling):

1. Evapotranspiration:

Leuning, R., F.M. Kelliher, D.G.G. De Pury, and E.-D. Schulze. 1995. Leaf nitrogen, photosynthesis, conductance, and transpiration: Scaling from leaves to canopies. *Plant, Cell and Environment*, 18, 1183-1200.

Mackay, D.S., D.E. Ahl, B.E. Ewers, S.T. Gower, S.N. Burrows, S. Samanta, and K.J. Davis. 2002. Effects of aggregated classifications of forest composition on estimates of evapotranspiration in a northern Wisconsin forest. *Global Change Biology*, 8, 1253-1265.

McNaughton, K. G. and P. G. Jarvis. 1991. Effects of spatial scale on stomatal control of transpiration. *Agricultural and Forest Meteorology*, 54(2-4): 279-302.

Oren, R., J.S. Sperry, G.G. Katul, D.E. Patako, B.E. Ewers, N. Phillips, and K.V.R. Schäfer. 1999. Survey and synthesis of intra- and interspecific variation in stomatal sensitivity to vapour pressure deficit. *Plant, Cell and Environment*, 22, 1515-1526.

Raupach, M.R. 1995. Vegetation-atmosphere interaction and surface conductance at leaf, canopy and regional scales. *Agricultural and Forest Meteorology*, 73, 151-179.

2. Soil Moisture:

Eagleson, P. S. 1982. Ecological optimality in water-limited natural soil-vegetation systems .1. Theory and hypothesis. *Water Resources Research*, 18(2): 325-340.

Grayson, R.B., A.W. Western, F.H.S. Chiew, and G. Blöschl. 1997. Preferred states in spatial soil moisture patterns: Local and nonlocal controls. *Water Resources Research*, 33(12), 2897-2908.

Nemani, R. R. and S. W. Running. 1989. Testing a theoretical climate soil leaf-area hydrologic equilibrium of forests using satellite data and ecosystem simulation. *Agricultural and Forest Meteorology*, 44(3-4): 245-260.

Rodriguez-Iturbe, I., A. Porporato, L. Ridolfi, V. Isham, and D.R. Cox. 1999. Probabilistic modeling of water balance at a point: The role of climate, soil and vegetation. *Proceedings of the Royal Society of London A*, 455, 3789-3805.

Seyfried, M.S. and B.P. Wilcox. 1985. Scale and the nature of spatial variability: Field examples having implications for hydrologic modeling. *Water Resources Research*, 31(1), 173-184.

3. Biogeochemical Cycling:

Band, L.E., P. Patterson, R.Nemani, and S.W. Running. 1993. Forest ecosystem processes at the watershed scale: Incorporating hillslope hydrology. *Agricultural and Forest Meteorology*, 63, 93-126.

Bonan, G.B., S. Levis, L. Kergoat, and K.W. Oleson. 2002. Landscapes as patches of plant functional types: An integrating concept for climate and ecosystem models. *Global Biogeochemical Cycles*, 16(2), 10.1029/2000GB001360.

Mackay, D.S. 2001. Evaluation of hydrologic equilibrium in a mountainous watershed: Incorporating forest canopy spatial adjustment to soil biogeochemical processes. *Advances in Water Resources*, 24, 1211-1227.

Porporato, A., P. D'Odorico, F. Laio, and I. Rodriguez-Iturbe. 2003. Hydrologic controls on soil carbon and nitrogen cycles. I. Modeling scheme. *Advances in Water Resources*, 26, 45-58.

Vertessy, R. A., T. J. Hatton, et al. .1996. Long-term growth and water balance predictions for a mountain ash (Eucalyptus regnans) forest catchment subject to clear- felling and regeneration. *Tree Physiology*, 16(1-2): 221-232.

C. Contemporary Topics (Some representative papers)

Bond, B.J., J.A. Jones, G. Moore, N. Phillips, D. Post, and J.J. McDonnell. 2002. The zone of vegetation influence on baseflow revealed by diel patterns of streamflow and vegetation water use in a headwater basin. *Hydrological Processes*, 16, 1671-1677.

Doyle, M.W., E.H. Stanley, and J.M. Harbor. 2003. Hydrogeomorphic controls on phosphorus retention in streams. *Water Resources Research*, 39(6), 1147, doi: 1029/2003WR002038.

Farmer, D., M. Sivapalan, and C. Jothityangkoon. 2003. Climate, soil, and vegetation controls upon the variability of water balance in temperate and semiarid landscapes: Downward approach to water balance analysis. *Water Resources Research*, 39(2), 1035, doi: 1029/2001WR000328.

Nemani, R., M. White, P. Thornton, K. Nishida, Swarna Reddy, J. Jenkins, and S. Running. 2002. Recent trends in hydrologic balance have enhanced the terrestrial carbon sink in the United States. *Geophysical Research Letters*, 2002GL014867.

Wilcox, B.P., D.D. Breshears, and C.D. Allen. 2003. Ecohydrology of a resource-conserving semiarid woodland: Effects of scale and disturbance. *Ecological Monographs*, 73(2), 223-239.

Van Wijk, M.T. and I. Rodriguez-Iturbe. 2002. Tree-grass competition in space and time: Insights from a simple cellular automata model based on ecohydrological dynamics. *Water Resources Research*, 38(9), 1179, doi: 10.1029/2001WR000768.