University of Montana

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Syllabi

Course Syllabi

Spring 2-1-2017

GEO 560.01: Fluvial Geomorphology

Andrew C. Wilcox

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Geosciences 560: Fluvial Geomorphology Spring 2017

Course Information

- Instructor Name: Andrew Wilcox
- Office: CHCB 357
- Email: andrew.wilcox@umontana.edu
- Class meetings: MW 3:30-4:50, CHCB 333
    - CLASS WILL NOT MEET AT THE REGULAR TIME THE FIRST WEEK. INSTEAD WE WILL MEET FRIDAY, JAN. 27 FROM 3:30-5 PM IN CHCB 333
- Office Hours: T 3-4pm, or by appointment
- Website: Moodle umonline.umt.edu

Overview

Fluvial Geomorphology provides an investigation of the processes that determine the form and evolution of rivers and streams. The course combines lectures, discussions, field data collection, and modeling activities. Active learning and student participation are an essential component.

Our inquiries this semester will be guided by several related questions / themes:

- What processes determine the form and evolution of rivers and streams?
- How can we infer process from form and vice versa?
- How do river form and process vary spatially and temporally?
- How can we apply knowledge about fluvial geomorphic processes to river restoration and management?

Course Objectives

To provide students with:

- a strong understanding of river channel processes and of the linkages between river channel form and process
- fundamental knowledge about fluvial geomorphic processes needed to manage and restore rivers
- experience collecting and analyzing field data
- opportunities for developing scientific writing skills
- experience in interpreting and analyzing literature about fluvial geomorphology from both secondary and primary sources
- practice in using models, data, and logical reasoning to critically evaluate and connect information about river processes
- experience communicating an understanding of the interrelationships among fluvial geomorphic concepts and theories to peers and others
- experience working as members of productive, collaborative teams

Assessment

35% Homework assignments and labs
25% Field project report
10% Midterm
10% Final exam

20% Class participation: 1) in-class activities testing and applying material from readings and lectures; 2) leadership of a paper discussion; 3) active participation in paper discussions, 4) questions and other participation during class activities

Exams: Exams will be open book / note.

Consistent productivity is essential to your grade. Don't miss any assignments; keep up with the lectures, the labs, and the reading; complete all in-class work; and ask questions.

Course Information, Guidelines and Policies

Field Trips

There is one required field trip. The date is Saturday, March 11. We need to do the trip relatively early, despite the challenges of spring semester weather, because data collected on this trip will be used in the main class field project. Our field data will be used for various geomorphic calculations, modeling, and analyses. We may do a 2nd field trip later in the semester (but not a 2nd field project).

Prerequisites

Graduate standing or the consent of the instructor are prerequisites. Some background in calculus, physics, and river processes is expected. In lectures, the textbook, and journal papers, you will see derivatives, integrals, and physics concepts such as force, stress, and Newton's Laws. What I would consider extensive manipulation of equations will not be required. A degree of computer literacy is also required. Assignments will be given involving the use of spreadsheets, retrieval of data over the internet, and basic computer tools. If you are not proficient in these types of tasks, assignments will take longer to complete (but you'll become more proficient!).

Readings

There is no required textbook. We will draw heavily on:

Wilcock, P., J. Pitlick, and Y. Cui (2009), Sediment transport primer: Estimating bed-material transport in gravel-bed rivers, U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. RMRS-GTR-226. Fort Collins, CO. (posted on Moodle)

Other useful references that I encourage you to draw on (and in some cases will assign readings from):

Dingman, S.L. (2009) *Fluvial Hydraulics.* (In the past I've used this as a textbook, but no longer required)

Parker, G. *1D Sediment Transport Morphodynamics with Application to Rivers and Turbidity Currents* (free download: http://vtchl.uiuc.edu/people/parkerg/morphodynamics_e-book.htm)

Wohl, E. (2010), *Mountain Rivers Revisited*, 573 pp., American Geophysical Union Water Resources Monograph Vol.19, Washington DC, doi:10.1029/WM019.

Paper readings and discussion: Most weeks, we will read 1-2 journal papers each week and spend a portion of one class section discussing them. Discussion leadership will rotate among students; please read the "Guidelines for discussion leadership" posted on Moodle. These discussions will be designed to encourage critical thinking about primary literature and broad participation. A partial list of discussion papers is on the last page of the syllabus; we will develop a more specific discussion schedule early in the semester.

Course website
Please check the course website (Moodle) regularly, especially before class, for announcements, notes, readings, assignments, and schedule updates. Some of the class lecture notes will be posted.

Email
Feel free to communicate with me by email. Keep in mind: 1) I'm likely to read your email fairly soon after I receive it but I may not respond immediately; 2) if you have questions that others are also likely to have, please save them for class; 3) if you need to miss class for any reason, please let me know in advance by email. Assignments submitted electronically (whether by email or via Moodle) must be well organized, consolidated into at most 2 files, and contain your last name in the file name.

Late Policy
No credit allowed for assignments handed in > 1 week after due date or after answer key / grading rubric posted, whichever comes first.

Student Conduct Code
The Student Conduct Code at the University of Montana embodies and promotes honesty, integrity, accountability, rights, and responsibilities associated with constructive citizenship in our academic community. This Code describes expected standards of behavior for all students, including academic conduct and general conduct, and it outlines students' rights, responsibilities, and the campus processes for adjudicating alleged violations. [Full student conduct code.](http://www.umt.edu/vpsa/policies/student_conduct.php)
http://www.umt.edu/vpsa/policies/student_conduct.php

Course Withdrawal
Students may use Cyberbear to drop courses through the first 15 instructional days of the semester. Beginning the 16th instructional day of the semester through the 45th instructional day, students use paper forms to drop, add and make changes of section, grading option or credit. GEO560 may not be taken as credit/no-credit.

Disability Modifications
The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. https://www.umt.edu/dss/default.php
If you think you may have a disability adversely affecting your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or call 406.243.2243. I will work with you and Disability Services to provide an appropriate modification.

Schedule (next page)
- Class meeting topics are subject to change
- Readings will be announced each week and must be completed before the following class.
- Updates to the syllabus will be announced in class and posted on Moodle

Topics covered (updates will be announced in class and posted on Moodle)

1. Introduction: Overview of river processes, dichotomies in approaches (Week 1; 1/27)
2. River hydraulics / Flow mechanics (Weeks 2-4; 1/30-2/15)
    a. Overview of open-channel flow
    b. Conservation equations (mass, momentum, energy)
    c. Types of flow (Steady uniform flow, super vs subcritical, turbulent vs laminar)
    d. Flow resistance and shear stress partitioning
    e. Velocity profiles
3. Sediment transport (Weeks 5-8; 2/20-3/15)
    a. Forces on particles
    b. Incipient motion & critical shear stress
    c. Estimating transport rates
    d. Armoring, supply effects
    e. Sediment transport and channel change
    f. Conservation of mass
4. Channel morphology (Weeks 9-12; 3/27-4/19)
    a. The bankfull channel
        i. Hydraulic geometry
        ii. Flow regimes and dominant discharge
    b. Bars and meandering
    c. Multi-thread channels, avulsions
    d. Floodplains
    e. River long profiles: Graded streams, base level, downstream fining
    f. Channel classification
    g. Interpreting channel conditions
    h. Bedrock rivers
        i. Morphology, erosion processes, role in landscape evolution
5. Ecogeomorphology; River management and restoration (Weeks 13-14; 4/24-5/3)
    a. Riparian vegetation, large woody debris, beaver
    b. Dams and dam removal
    c. Linking process knowledge to restoration

Other topics that may be covered as time permits:

- River basin morphology (drainage networks, runoff processes)
- Climate change and river processes
- Modeling tools (computational, physical, remote sensing)
- Topics of particular student interest

Labs

We will spend portions of several class session doing labs to gain experience with various forms of hands-on, computational, fluvial geomorphic inquiry. These will include:

- HEC-RAS 1-D modeling
- HEC-GeoRAS
- BAGS sediment transport
- IRIC 2-D modeling
- Other tools as time permits

Journal papers for readings and discussion (in approximate order of when they may be discussed, rather than alphabetically; we will modify this list depending on student interest**)**

Walter, R.C. and D.J. Merritts. 2008. Natural streams and the legacy of water-powered mills. *Science* 319:299-304.
Comments by Bain et al, Wilcock, and Response by authors, *Science* 2008
Montgomery, D. R. 2008. Dreams of natural streams, *Science*, *319*(5861), 291-292.

Mueller, E. R., and J. Pitlick (2013), Sediment supply and channel morphology in mountain river systems: 1. Relative importance of lithology, topography, and climate, J. Geophys. Res. Earth Surf., 118, doi:10.1002/2013JF002843.

O'Connor, J. E., J. F. Mangano, S. W. Anderson, J.R. Wallick, K.L. Jones, and M.K. Keith. 2014. Geologic and physiographic controls on bed-material yield, transport, and channel morphology for alluvial and bedrock rivers, western Oregon. *GSA Bulletin*; March/April 2014; v. 126; no. 3/4; p. 377–397; doi:10.1130/B30831.1;

Dean, D. J., D. J. Topping, J. C. Schmidt, R. E. Griffiths, and T. A. Sabol (2016), Sediment supply versus local hydraulic controls on sediment transport and storage in a river with large sediment loads, J. Geophys. Res. Earth Surf., 121, doi:10.1002/2015JF003436.

Montgomery, D.R. and J.M. Buffington. 1997. Channel reach morphology in mountain drainage basins. *GSA Bulletin* 109.

Buffington, J. M., and D. R. Montgomery. 1999. Effects of hydraulic roughness on surface textures of gravel-bed rivers. *Water Resources Research* 35:3507-3521.
Comments by Wilcock, Millar and Rennie, and Reply to comments by authors

Church, M. 2006. Bed material transport and the morphology of alluvial river channels. *Annual Review of Earth and Planetary Sciences* 34: 325-354.

Dietrich, W.E., J.W. Kirchner, H. Ikeda, and F. Iseya. 1989. Sediment supply and the development of the coarse surface layer in gravel-bedded rivers. *Nature* 340: 215-217.

Wolman, M.G. and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *Journal of Geology* 68: 54-74.

Andrews, E.D. 1983. Entrainment of gravel from naturally sorted riverbed material. *Geological Society of America Bulletin* 94:1225-1231.

Finnegan, N. J., R. Schumer, and S. Finnegan (2014), A signature of transience in bedrock river incision rates over timescales of 10^4-10^7 years, *Nature*, *505*(7483), 391-394, doi: 10.1038/nature12913

DiBiase, R. A. (2014), Earth science: River incision revisited, *Nature*, *505*(7483), 294-295, doi: 10.1038/505294a.

Willett, S. D., S. W. McCoy, J. T. Perron, L. Goren, and C.-Y. Chen (2014), Dynamic Reorganization of River Basins, *Science*, *343*(6175).

Murphy, B.P., Johnson, J.P.L., Gasparini, N.M., Sklar, L.S., 2016. Chemical weathering as a mechanism for the climatic control of bedrock river incision. Nature, 532(7598), 223-227.

Riebe, C.S., Sklar, L.S., Lukens, C.E., Shuster, D.L., 2015. Climate and topography control the size and flux of sediment produced on steep mountain slopes. Proceedings of the National Academy of Sciences, 112(51), 15574-15579.

Scheingross, J. S., E. W. Winchell, M. P. Lamb, and W. E. Dietrich (2013), Influence of bed patchiness, slope, grain hiding, and form drag on gravel mobilization in very steep streams, *J. Geophys. Res. Earth Surf*.,118, doi:10.1002/jgrf.20067.

May, C.L., Pryor, B., Lisle, T.E., Lang, M., 2009. Coupling hydrodynamic modeling and empirical measures of bed mobility to predict the risk of scour and fill of salmon redds in a large regulated river. Water Resources Research, 45, W05402.

McKean, J., and D. Tonina (2013), Bed stability in unconfined gravel bed mountain streams: With implications for salmon spawning viability in future climates, J. Geophys. Res. Earth Surf., 118, 1227–1240, doi:10.1002/jgrf.20092

Bätz, N., Colombini, P., Cherubini, P., Lane, S.N., 2016. Groundwater controls on biogeomorphic succession and river channel morphodynamics. Journal of Geophysical Research: Earth Surface, 121, doi: 10.1002/2016jf004009.

Braudrick, C.A., W.E. Dietrich, G.T. Leverich, and L.S. Sklar. 2009. Experimental evidence for the conditions necessary to sustain meandering in coarse-bedded rivers. *Proceedings of the National Academy of Sciences* 106(40): 16936-16941.

Lauer, J. W., and G. Parker. 2008, Modeling framework for sediment deposition, storage, and evacuation in the floodplain of a meandering river: Application to the Clark Fork River, Montana*, Water Resour. Res*., 44, W08404, doi:10.1029/2006WR005529.

Nittrouer, J. A., J. L. Best, C. Brantley, R. W. Cash, M. Czapiga, P. Kumar, and G. Parker (2012), Mitigating land loss in coastal Louisiana by controlled diversion of Mississippi River sand, *Nature Geosci*, *5*(8), 534-537, doi: http://www.nature.com/ngeo/journal/v5/n8/abs/ngeo1525.html#supplementary-information.

Kim, W. (2012), Geomorphology: Flood-built land, *Nature Geosci*, *5*(8), 521-522.

Schmidt, J.C. and P.R. Wilcock. 2008. Metrics for assessing the downstream impacts of dams. *Water Resources Research* 44,W04404, doi:10.1029/2006WR005092.

Beechie, T.J., Sear, D.A., Olden, J.D., Pess, G.R., Buffington, J.M., Moir, H., Roni, P., and Pollock, M.M., 2010, Process-based principles for restoring river ecosystems: BioScience, v. 60, p. 209-222, 10.1525/bio.2010.60.3.7.

Wohl, E., S.N. Lane, and A.C. Wilcox. 2015. "The science and practice of river restoration." *Water Resources Research* 51, doi:10.1002/2014WR016874.

Wohl, E., B. Bledsoe, R. B. Jacobson, N. L. Poff, S.L. Rathburn, D. Walters, A.C. Wilcox. 2015. "The natural sediment regime in rivers: Broadening the foundation for ecosystem management." *Bioscience* 65(4): 358-371, doi:10.1093/biosci/biv002.