ENGR 8990 - Nature-based Infrastructure Engineering and Design
Spring 2020

Time / location: **Mondays 1:30-4 pm in Boyd 146**

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Prerequisite: Permission of instructor

Text: No textbook is required. Electronic versions of the readings will be provided on eLC.

Course Description: Integration of engineering, ecological design, and economic perspectives in the planning, design, implementation, and adaptive management of nature-based infrastructure systems that work in harmony with conventional infrastructure. Innovative use of natural processes and systems to increase infrastructure performance, efficiency, and benefits (social, environmental, and economic) in upland, riverine, and coastal settings.

This course is appropriate for graduate students from multiple disciplines, including engineering, ecology, environmental design, biology, natural resources, marine science, anthropology, economics, and other disciplines. I strive for an interdisciplinary mix of students which makes for a dynamic and stimulating class environment. **This is a lecture course with practicum sessions and student-led discussions.** Discussion topics covered include definitions of natural infrastructure (NI) and nature-based solutions (NBS), resilience, benefits provided by NI, risk analysis, modeling tools, project planning, ecological engineering and ecosystem restoration, monitoring and adaptive management, and integration of conventional and natural infrastructure. The course makes use of case studies, including the instructors' own experiences in real-world application, planning, management and policy related to natural infrastructure engineering. Practicum sessions will focus on making substantive contributions to real world projects that utilize NBS in upland, riverine, and coastal settings.

Learning Objectives

1. Develop the capacity to serve as a productive and effective member of an interdisciplinary project delivery team for a large-scale headwater, riverine and/or coastal natural infrastructure project.
2. Define natural infrastructure and nature-based solutions.
3. Apply standard mathematical and computational models used to plan and design natural infrastructure.
4. Understand the planning process for large scale civil works projects that utilize nature-based solutions
5. Perform risk analysis for climate resilient infrastructure.
6. Garner experience in designing ecosystem restoration / natural infrastructure in upland, riverine, and coastal settings.

7. Identify pragmatic and specific examples of how natural infrastructure can be intentionally co-designed to work together with and strengthen conventional infrastructure.
8. Improved speaking, writing, and critical thinking skills in the context of interdisciplinary water and environmental management issues.
9. Exposure to the primary scientific literature and current themes in natural infrastructure research.

Grading System: Midterm 25%
Homework 30%
Project 30%
Discussion and Practicum 15%

Essential Computer Skills: Spreadsheets (formulas / Solver), word processing, web browser

Class Discussions: You will be assigned to lead the discussion on your assigned date. The purpose of the discussion section is to have a stimulating conversation, with the discussion leader(s) providing brief background information followed by discussion questions. The discussion leader(s) will each prepare at least 2 questions for discussion and give them to the instructor on the Tuesday preceding their discussion date. Students are responsible for reading the discussion material in advance of class and actively participating.

Project: You will be required to complete a research project on a topic of your choosing. You will select a project idea in February and will have to pitch your idea to classmates to get their feedback during discussion on February 10. These will be five-minute speed presentations accompanied by a 1-page abstract; each student will comment on the abstracts of the students in the class. The final products will be due the last day of class (April 27) and will be presented as an approximately 20-page (double-spaced) paper along with a 20 minute oral presentation (on April 13 and 20).

Policies: Homework submissions must be prepared in accordance with the guidance distributed in class and posted on the course web page. Acceptable excuses for missing an exam are limited and will require written, documented evidence. Late work will not be accepted and will be graded with a zero. Missed assignments will be graded with a zero. Non-participation due to unexcused absence will be graded with a zero. Unless stated otherwise, all assignments are due at the beginning of class. Please turn off cell phones in the classroom. I encourage students to discuss and collaborate on homework and other outside assignments but the final work you turn in should be distinctly your own.

Academic Honesty: All students are responsible for maintaining the highest standards of honesty and integrity in every phase of their academic careers. The penalties for academic dishonesty are severe and ignorance is not an acceptable defense. Students are reminded that the University's Academic Honesty Policy binds them. If you have misplaced your copy, the document for academic honesty may be found at the web site for The University of Georgia Office of Senior Vice President for Academic Affairs and Provost (https://honesty.uga.edu/Academic-Honesty-Policy/Student-Honor-Code/). UGA policies on academic integrity will be rigorously enforced in this course.

Tentative Schedule: The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary. Based on your specific interests, selected projects, and discussion questions, we will work together applying principles of self-organization and adaptive management to fill out the remainder of the schedule.

Date	**Lecture/Readings**
13-Jan	Lecture: Introduction to course, definitions, and factors limiting adoption and implementation of NI and NBS Organizing questions: What is natural infrastructure? How is it different from conventional "hard" infrastructure? Does it include existing, intact ecosystems, novel / created ecosystems, individual small-scale stormwater features (e.g., a rain garden in a city), farm soils, the atmosphere, etc.? Is NI inherently resilient--why? What are the major types of economic, social, and environmental benefits NI provides? What are the primary factors limiting broader adoption and implementation of natural infrastructure projects? What are the types and scale of actual natural infrastructure projects described in the USACE Engineering With Nature® Atlas and other initial readings? What are some pragmatic examples of how natural infrastructure can be intentionally co-designed to work together with and strengthen conventional infrastructure? Readings: ESSI Fact Sheet – Nature as Resilient Infrastructure: An Overview of Nature-Based Solutions https://www.eesi.org/files/FactSheet_Nature_Based_Solutions_1016.pdf This fact sheet is currently circulating around capitol hill in DC Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T., & Lange, G. M. (2019). Integrating Green and Gray. https://openknowledge.worldbank.org/handle/10986/31430 - Executive Summary and First Chapter (pp. 3-25) and peruse projects in Appendix pp. 85-121 The United Nations world water development report 2018: nature-based solutions for water (2018) https://unesdoc.unesco.org/ark:/48223/pf0000261424 - Executive Summary Sutton-Grier, A. E., Wowk, K., & Bamford, H. (2015). Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience

of our coastal communities, economies and ecosystems. *Environmental Science & Policy*, *51*, 137-148.

Gartner, T., Mehan III, G. T., Mulligan, J., Roberson, J. A., Stangel, P., & Qin, Y. (2014). Protecting forested watersheds is smart economics for water utilities. *Journal-American Water Works Association*, *106*(9), 54-64.

Bridges, T. S., E. M. Bourne, J. K. King, H. K. Kuzmitski, E. B. Moynihan, and B. C. Suedel. 2018. Engineering With Nature®: An Atlas, US Army Corps of Engineers ERDC/EL SR-18-8. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/27929. https://ewn.el.erdc.dren.mil/atlas.html - peruse the projects

ASCE Policy Statement 518 - Unified Definitions for Critical Infrastructure Resilience https://www.asce.org/issues-and-advocacy/public-policy/policy-statement-518---unified-definitions-for-critical-infrastructure-resilience/

27-Jan Lecture: Ecological engineering and foundations of NBS

Organizing questions: What are key similarities and differences between ecological engineering and nature-based infrastructure engineering?

Are natural infrastructure and nature-based solutions simply a repackaging of old ideas? Why or why not?

In your opinion, what are the essential principles for planning and designing nature based solutions? What is missing from the lists of principles in your readings?

Readings: Mitsch, W. J., & Jørgensen, S. E. (2003). Ecological engineering and ecosystem restoration. John Wiley & Sons, pp. 3-55, 94-102.

World Bank (2017). Implementing nature-based flood protection: Principles and implementation guidance. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/739421509427698706/pdf/120735-REVISED-PUBLIC-Brochure-Implementing-nature-based-flood-protection-web.pdf Chapter 1 pp. 1-13

Whelchel, A. W., Reguero, B. G., van Wesenbeeck, B., & Renaud, F. G. (2018). Advancing disaster risk reduction through the integration of science, design, and policy into eco-engineering and several global resource management processes. *International journal of disaster risk reduction*, 32, 29-41.

3-Feb	Lecture: Dr. Todd Bridges on USACE and Engineering With Nature® Dr. Todd Bridges is the U.S. Army's Senior Research Scientist for Environmental Science. His responsibilities include leading research, development and environmental initiatives for the U.S. Army and U.S. Army Corps of Engineers (USACE). Dr. Bridges is the National Lead for USACE's Engineering With Nature® initiative, which includes a network of research projects, field demonstrations, and communication activities to promote sustainable, resilient infrastructure systems. Organizing questions: TBD Readings: TBD
10-Feb	Lecture: Ecological engineering of upland and riverine systems Organizing questions: TBD Readings: TBD
17-Feb	Lecture: Ecological engineering of riverine and coastal systems, system level interactions Organizing questions: TBD Readings: TBD
24-Feb	Lecture: Risk analysis fundamentals Organizing questions: TBD Readings: TBD
2-Mar	Lecture: Risk and decision analysis – nonstationarity, uncertainty, MCDA, compounding effects Organizing questions: TBD Readings: TBD
16-Mar	Midterm Exam Lecture: Benefits, functions, and services Organizing questions: TBD Readings: TBD

23-Mar	Lecture: Tools – H&H models, economics, functional assessment
	Organizing questions: TBD
	Readings: TBD
30-Mar	Lecture: Project planning
	Organizing questions: TBD
	Readings: TBD
6-Apr	Lecture: O&M, monitoring and adaptive management
	Organizing questions: TBD
	Readings: TBD
13-Apr	**Student Presentations**
20-Apr	**Student Presentations**
27-Apr	Lecture: Prospectus for NI / NBS and hybrid infrastructure systems
	Organizing questions: TBD
	Readings: TBD
	Course wrap-up – last day of class

Engineering Professionalism Policy: Engineers make great contributions to society. Engineering is a very satisfying profession thatprovides many rewards but is demanding and requires hard work. The engineering profession is governed by a code of ethics. The following link will take you to the National Society of Professional Engineers, Engineering Code of Ethics website. http://www.nspe.org/resources/ethics/code-ethics. Engineering faculty at UGA expect students to act in a professional manner at all times and develop the work ethic required for a successful engineering career. Engineering students at UGA are responsible for maintaining the highest standards of professionalism and professional practice.

UGA College of Engineering Accreditation: The programs in the UGA College of Engineering are accredited through ABET, a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology. ABET accredits over 3,100 programs at more than 670 colleges and universities in 24 countries.*

Earning a degree from an ABET-accredited program:*

- Verifies that the quality of the educational experience you've received
- meets the standards of the profession.
- Increases and enhances employment opportunities.
- Permits and eases entry to a technical profession through licensure,
- registration, and certification.
- Establishes eligibility for many federal student loans, grants, and/or
- scholarships.

An ABET-accredited program assures students that:*

- the institution is committed to improving their educational experience
- the program is committed to using best practices and innovation in
- education
- the program is guided by its industry, government, and academic
- constituents through formal feedback
- the program considers the students' perspective as part of its continuous
- quality improvement process

See more at http://abet.org/why-accreditation-matters/
*from abet.org

As part of the accreditation process, you will asked for your assessment of UGA's Engineering Programs via an online survey. Your responses are much appreciated and will contribute toward the continuous improvement process.