University Council

February 9, 2024

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Dear Colleagues:

The attached proposal from the College of Engineering to create a Graduate Certificate in Natural Infrastructure will be an agenda item for the February 16, 2024, Full University Curriculum Committee meeting.

Sincerely,

Susan Sanchez, Chair

cc: Provost S. Jack Hu
Dr. Marisa Pagnattaro

PROPOSAL FOR A CERTIFICATE PROGRAM

Date: November 21, 2023

School/College/Unit: College of Engineering

Department/Division: Institute for Resilient Infrastructure Systems (IRIS)

Certificate Title: Graduate Certificate in Natural Infrastructure

Effective Term: Fall 2024

CIP: 14.1401

Which campus(es) will offer this certificate? Athens

Level (Undergraduate, Graduate, or Post-Baccalaureate): Graduate

Program Abstract: The Graduate Certificate in Natural Infrastructure is designed for graduate students seeking in-depth knowledge and expertise in the field of natural infrastructure (NI). It offers a combination of required core courses, elective courses, and practical experiences, providing students with a well-rounded skill set in planning, developing, and implementing innovative natural infrastructure projects. This program also aims to prepare a diverse cadre of graduate students with specific competencies and practical experience to meet the unique workforce demands of effectively and equitably implementing natural infrastructure solutions. It integrates an interdisciplinary approach, drawing from various disciplines to provide a comprehensive understanding of natural infrastructure and its applications.

1. Purpose and Educational Objectives

State the purpose and educational objectives of the program. How does this program complement the mission of the institution?

Through a combination of required core courses, elective courses, and hands-on experiences, this certificate aims to equip graduate students with the skills and expertise needed to effectively address complex challenges and develop resilient solutions within the broader context of infrastructure systems. Through the certificate's emphasis on innovative and integrated problem-solving at the intersection of engineering, ecology, landscape design, and social science, students will be trained to acquire the skills and experiences they need to effectively plan, design, build, and manage natural infrastructure systems.

In tandem with the Institute for Resilient Infrastructure Systems' (IRIS) mission, the certificate contributes significantly to the broader objectives of the University of Georgia. By fostering interdisciplinary collaboration and promoting a comprehensive understanding of natural infrastructure, the certificate aligns with the university's commitment to academic excellence, research, and service to society. In addition, this certificate will help prepare students to address real-world challenges in an inclusive and holistic manner, aligning with the university's goal of producing graduates who are capable of effecting positive change.

Upon successful completion of this certificate, the student will be able to:

- Understand and implement natural infrastructure and nature-based solutions and their various applications in water resource management and engineering such as flood risk management, coastal erosion, effects of transportation networks on waterways, and water quality management.
- Understand and navigate the planning and regulatory processes for large-scale civil works projects utilizing nature-based solutions.
- Understand pragmatic and specific examples of how natural infrastructure can be intentionally co-designed to work together with and strengthen conventional infrastructure for sustainable urban development and resilience.
- Understanding the role of communities as stakeholders affecting and affected by natural infrastructure outcomes and be fluent in best practices for stakeholder engagement.
- Incorporate multi-scale spatial thinking for understanding natural infrastructure systems.
- Incorporate the key principles of sustainability and resilience as they apply to natural infrastructure into project planning and management.
- Perform risk and uncertainty analysis for climate-resilient infrastructure.
- Speak and write clearly and persuasively in the context of interdisciplinary water and environmental management issues.
- Function effectively in a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

2. Need for the Program

Explain why this program is necessary.

One of the most critical challenges plaguing present-day society is the rising social, ecological, and economic costs of natural disasters such as flooding and erosion, driven by both climate change and human development patterns. Despite the massive investments in conventional flood defenses such as levees, breakwaters, and seawalls, there is a need to explore more resilient and adaptive infrastructure systems that can meet the future challenge

of amplified flooding, rising sea levels, and increased wave action within a context of rapid social change.

Policymakers, practitioners, and the public are increasingly recognizing and understanding the roles of natural infrastructure in achieving the twin engineering objectives of sustainable development of the built environment and protecting the natural environment. Right now, in the U.S., there are broad calls for major investments in NI to support climate resilience and adaptation. Recent policies including the Infrastructure Investment and Jobs Act and the Water Resources Development Act explicitly require the inclusion of NI and "natural and nature-based features" in numerous types of civil works projects including hazard mitigation, transportation, and water resources infrastructure.

With increasing climate change impacts, mounting threats of habitat and biodiversity loss, and massive global infrastructure investments anticipated over the next few decades, there is an urgent need to train a workforce capable of delivering effective NI solutions at multiple scales. Therefore, this certificate will provide students with the right knowledge, skills, and experiences to effectively plan, design, build, and manage NI systems. Upon completion of this certificate, students will understand how natural and engineering processes can work together to deliver effective NI solutions that generate far-reaching social, economic, and ecological benefits.

Enrollment Information:

a. **Semester/Year of Program Initiation:** Fall 2024
b. **Semester/Year of Full Implementation of Program:** Fall 2024
c. **Semester/Year First Certificates will be awarded:** Spring 2025
d. **Annual Number of Graduates expected (once the program is established):** 20-30
e. **Projected Future Trends for number of students enrolled in the program:** It is anticipated that most students will take 1-2 years to complete the certificate. In the first year, at least 10 students are expected to earn the certificate, with up to 20 enrolled. After three years, an enrollment of 50-60 students, with 20-30 completing the certificate each year, is expected.

3. Student Demand

a. Provide documentation of evidence of student demand for this program, including a student survey.

Student interest in pursuing a certificate in Natural Infrastructure was assessed through a survey of 26 students. The results revealed that a significant majority of students, constituting 92% of the respondents, expressed their intent to pursue the certificate. Among

them, 69% indicated they were 'Very likely,' while 23% mentioned they were 'Somewhat likely.' These findings underscore a strong interest in specialized training in this field.

Here are a selected list of quotes from the survey responses:

"I want to pursue this as a full-time career, and I believe the certificate will make me competitive entering the workforce." - Master's student, College of Engineering.

"This is exactly what I want to devote my career to; I'd take any opportunity to expand my knowledge on it and also give it a little credibility on my resume!" - Doctoral student, College of Engineering.

"I believe this is a critical knowledge base for a landscape architect who wants to utilize natural systems in design." – Master's student, College of Environment and Design

"It's clear that nature-based infrastructure is part of the future of environmental and civil engineering, so it's worth it to master the related skills." – Master's student, College of Agricultural and Environmental Sciences

b. Provide evidence that demand will be sufficient to sustain reasonable enrollment.

Industry input provided during the formation of IRIS's Innovation Ecosystem for an NSF Engineering Research Center proposal, as well as feedback from an Industry Summit on Nature-Based Solutions indicate very strong and sustained demand for this certificate. With the passage of the Bipartisan Infrastructure Law and its investment of billions of dollars in nature-based solutions, faculty anticipate a sustained demand for upskilling and workforce development across the next decade and beyond.

c. To what extent will minority student enrollments be greater than, less than, or equivalent to the proportion of minority students in the total student body?

It is anticipated that the proportion of minority student enrollment in this program will be higher than that of the general student body in the College of Engineering. Faculty believe that this certificate's focus on solutions that are environmentally and economically sound and that include robust stakeholder engagement will be particularly attractive to underrepresented students.

4. Program of Study

Provide a detailed program of study for the certificate program, including:

a. Identify any new courses created for this program

The certificate in natural infrastructure is appropriate for graduate students from multiple disciplines including engineering, ecology, environmental design, biology, natural resources, marine science, anthropology, economics, and other related disciplines. The graduate certificate will be housed in the Institute for Resilient Infrastructure Systems (IRIS), operating under the jurisdiction of the College of Engineering. The certificate offers a blend of required core courses, elective courses, and practical experiences, providing students with a well-rounded skill set in planning, developing, and implementing innovative natural infrastructure projects. Some of the required courses for the certificate are currently being developed and will be submitted through the established faculty governance course approval process.

These newly developed courses are:

ENVE 8310, Fundamentals of Natural Infrastructure and Nature-Based Solutions (3 hours - required):

This course will introduce students to the concepts, theories, and applications of natural infrastructure at multiple scales, including the site level, watershed, and regional scales. Students will be presented with the best available information on 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 also provides students with knowledge on the 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.

ENVE 8320, Engineering Design of Natural and Hybrid Infrastructure (3 hours - elective):

This immersive engineering design course will equip students with natural infrastructure design concepts and their applications in riverine and coastal settings. Students will have access to state-of-the-art information, exploring the essence, relevance, and practical implementation of engineering and ecological design principles to enhance infrastructure performance, efficiency, and benefits across economic, environmental, and social dimensions. Design projects will be a core component of the course, offering students the opportunity to actively contribute to real-world projects that utilize natural infrastructure in both riverine and coastal contexts.

ENVE 8330, Field Experiences in Natural Infrastructure (1 hour - required):

The course will cover various topics related to the planning, design, and execution of nature-based solutions for water resource management. Students will explore these topics through

fieldwork components, engaging in hands-on activities and gaining practical experience. Field sites around Athens will be visited to observe and study the interaction of natural systems and infrastructure. These activities aim to deepen the understanding of concepts discussed in other UGA courses on natural infrastructure and bridge the gap between theoretical knowledge and real-world application. The course also offers a unique opportunity for students to collaborate with professionals, experts, and local stakeholders involved in diverse ecosystems.

ENVE 8340, Internship for Natural and Hybrid Infrastructure (1-9 hours – 3 hours required):

This internship course is a unique and immersive capstone course that offers students the opportunity to work directly with industry, agency, and nonprofit partners on real-world natural infrastructure design projects. This practicum provides students with valuable hands-on experience in designing and implementing solutions to enhance natural infrastructure systems. Under the supervision of experts and industry representatives, students work within a professional environment to develop their skills and competencies in natural infrastructure design. The course allows students to integrate theoretical knowledge with practical application, showcasing their abilities in addressing real-world challenges.

b. Program Content

All students will be required to complete the necessary coursework, with a minimum of 14 credit hours. This includes taking ECOL 8550, Skills for Collaborative Research; ENVE 8310, Fundamentals of Natural Infrastructure and Nature-Based Solutions; ENVE 8330, Field Experiences in Natural Infrastructure; ENVE 8340, Internship in Natural and Hybrid Infrastructure; and any two elective courses from the provided menu. The two electives must be chosen from different categories to ensure broad experience.

Required Coursework	**Course Prefix**	**Hours**
Skills for Collaborative Research	ECOL 8550	1
Fundamentals of Natural Infrastructure and Nature-Based Solutions	ENVE 8310	3
Field Experiences in Natural Infrastructure	ENVE 8330	1
Internship in Natural and Hybrid Infrastructure	ENVE 8340	3
Electives from a menu of approved options	(Choose 2)	5-6
TOTAL HOURS		**13 - 14**

Students must pick two electives from the list below. These courses must have different category codes (B, E, or S). Additional courses may be added to this list after consideration by the College of Engineering Executive Committee.

	Course Title	Course Prefix	Credit Hours
B	Foundations of Restoration Ecology	ECOL 6220	3 hours
B	Freshwater Ecosystems	ECOL(FISH)(WASR) 6310	3 hours
B	Stream Ecology	ECOL 8220	2 hours
B	Ecological Landscape Restoration	LAND 6390	3 hours
B	Wetland Management and Restoration	WASR 6400-6400L	3 hours
E	Environmental River Mechanics	CVLE 8110	3 hours
E	Engineering Design of Natural and Hybrid Infrastructure	ENVE 8320	3 hours
E	Advanced Topics in Engineering	ENGR 6990	3 hours
S	Social Science Research Applications	ANTH 7200	3 hours
S	Environmental Justice: Evidence and Impact	ENVE 6730	3 hours
S	Environmental Ethics	PHIL(EETH) 6220	3 credits

B = Biology/Ecology; E = Engineering; S = Social/Policy/Economics

5. Model Program and Accreditation

a. Identify any model programs, accepted disciplinary standards, and accepted curricular practices against which the proposed program could be judged. Evaluate the extent to which the proposed curriculum is consistent with these external points of reference and provide a rationale for significant inconsistencies and differences that may exist.

b. If program accreditation is available, provide an analysis of the ability of the program to satisfy the curricular standards of such specialized accreditation.

Not applicable.

6. Student Learning Outcomes

Upon successful completion of this certificate program, the student will be able to:

- Understand and implement natural infrastructure and nature-based solutions and their various applications in water resource management and engineering, such as flood risk management, coastal erosion, effects of transportation networks on waterways, and water quality management.
- Understand and navigate the planning and regulatory processes for large-scale civil works projects utilizing nature-based solutions.
- Understand pragmatic and specific examples of how natural infrastructure can be intentionally co-designed to work together with and strengthen conventional infrastructure for sustainable urban development and resilience.
- Understanding the role of communities as stakeholders affecting and affected by natural infrastructure outcomes and be fluent in best practices for stakeholder engagement.
- Incorporate multi-scale spatial thinking for understanding natural infrastructure systems.
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- Perform risk and uncertainty analysis for climate-resilient infrastructure.
- Speak and write clearly and persuasively in the context of interdisciplinary water and environmental management issues.
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7. Assessment and Admissions

Describe how the learning outcomes for the program will be assessed. Describe the process and criteria for how students will be admitted to and retained in the program.

Assessment

The certificate is designed to help students gain a comprehensive understanding of natural infrastructure through a combination of theoretical knowledge, practical experiences, and interdisciplinary collaboration. The courses are designed to provide complementary learning outcomes, but when completed together, they fulfill the eight sustainability competencies outlined by the United Nations (UN). These include: 1) Systems thinking competency, (2) Anticipatory competency, (3) Normative competency, (4) Strategic competency, (5) Collaboration competency, (6) Critical thinking competency, (7) Self-awareness competency and (8) Integrated problem-solving competency.

Students will be assessed by grades in courses, evaluation of the capstone project, and an exit survey to comprehensively gauge their learning outcomes and overall educational experience. All core courses will be reviewed each semester by the program coordinator against UGA-approved student learning outcomes, following UGA's Academic Affairs Policy No. 2.04-4. Per this policy, the College of Engineering has an assessment plan in place already and collects data on at least one of the student learning outcomes each semester.

Admissions

Students will apply to the certificate by submitting a letter of interest to the College of Engineering Executive Committee. Because these students will work with community members and professionals, they will be asked to demonstrate both their interest in natural infrastructure and their professionalism and ability to engage with stakeholders. Any student who wishes to attempt the certificate and shows appropriate motivation and aptitude will be invited to do so.

Documentation of Approval and Notification

Proposal: Graduate Certificate in Natural Infrastructure

College: College of Engineering

Department: School of Environmental, Civil, Agricultural, and Mechanical Engineering

Proposed Effective Term: Fall 2024

School/College:

- College of Engineering Assistant Dean for Academic and Faculty Affairs, Dr. Mable Fok, 1/29/24
- Graduate School Associate Dean, Dr. Anne Shaffer, 2/7/24

Use of Course Approvals:

- College of Environment and Design Dean, Dr. Sonia Hirt, 11/6/23
- Franklin College of Arts and Sciences Dean, Dr. Anna Stenport, 11/16/23
- Odum School of Ecology Associate Dean, Dr. Pejman Rohani, 11/9/23
- Warnell School of Forestry Interim Associate Dean, Dr. Rhett Jackson, 11/10/23
- Warnell School of Forestry Dean, Dr. Dale Greene, 11/10/23

Letters of Support:

- United States Department of the Army Engineering with Nature National Lead and Program Manager, Dr. Jeffrey King, 10/13/2023