Marine and Environmental Sciences

Website (http://www.northeastern.edu/mes/)

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The academic programs of the Department of Marine and Environmental Sciences provide students a deep, multidisciplinary understanding of the chemical, physical, geological, and biological processes that shape Earth’s myriad ecosystems. This fundamental understanding, coupled with a focus on the many environmental challenges facing our planet, seeks to yield knowledge and solutions that promote sustainability. Our graduates leave Northeastern prepared to address diverse issues including collapsing fisheries, the impacts of climate change (e.g., sea level rise), coastal erosion, and pollution. To address and solve today’s complex environmental problems, environmental professionals are expected to work effectively as part of a multidisciplinary team containing natural and social scientists, engineers, and policymakers. Hence, our undergraduate program emphasizes experiential education in addition to traditional classroom learning. This approach better prepares students to engage in collaborative work and enhances their employment opportunities after Northeastern.

Our Bachelor of Science in Environmental and Sustainability Science degree is organized for students who seek a comprehensive understanding of the scientific implications of environmental problems and the multidisciplinary solutions that environmental scientists can produce to solve them. All students take foundational courses in Earth science, ecology, and sustainability. They then choose from one of four concentrations for deeper learning. For students interested in understanding how physical and geochemical processes shape existing and emerging environmental threats, they can concentrate in earth, oceans, and environmental change. If students are interested in how ecological and evolutionary processes influence our ability to conserve, restore, and manage ecosystems, they can focus on our conservation, restoration, and management concentration. Our concentration in sustainable planning and development is designed for students who want to examine how science informs the nexus of food, water, and energy to promote greater sustainability. Lastly, students who are interested in leveraging a strong scientific foundation to study coupled human and natural systems in search of solutions most threatened by environmental change can focus on our concentration in environment and society.

Students interested in the intersection of environmental science and the humanities can participate in our interdisciplinary Bachelor of Arts in Environmental Studies (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-studies-ba/).

Our Bachelor of Science in Marine Biology degree is designed to provide a strong foundation in marine biology and related disciplines. This major is offered through Northeastern University’s Marine Science Center (MSC) in Nahant, though many courses that satisfy this major are also offered on Northeastern’s main campus in Boston. Students in this major study all aspects of marine systems from invertebrate zoology to oceanography. For those students seeking a broader foundation that is not focused on marine systems, we also offer a Bachelor of Science in Ecology and Evolutionary Biology (EEB). Students majoring in EEB develop a strong theoretical foundation in ecology and evolution while also building practical skills in data science, genomics, and other areas at the cutting edge of science. Our core curriculum for both marine biology and EEB satisfy the vast majority of requirements for prehealth fields including veterinary sciences and medical fields.

We offer a number of combined majors in both the BA track and the BS track. Students are also able to create their own combined majors with approval from faculty committees in both departments.

Fieldwork is a critical component of training in our programs, and many of our courses use field sites throughout New England to explore environmental processes or problems in their full complexity. In addition to sponsoring local trips, our students also participate in longer field excursions to places like Iceland, Antarctica, the Florida Keys, the Cascade Mountains of Washington, and many others. Students also have the option to complete undergraduate research experiences with a faculty member. Undergraduate research projects can involve fieldwork and/or lab work guided by faculty mentors, and many projects evolve into senior and honors theses.

Our graduates work across a wide range of disciplines. Student training in the foundations of each major, coupled with extensive training in data science and scientific communication, allows our students to succeed in a range of positions from hydrology to public policy to oceanography. We have graduates working as environmental lawyers; lobbyists; consultants; planners; data analysts; educators; soil, air, and water quality technicians; veterinarians; foresters; geneticists; bioinformaticians; research divers; aquaculturists; and many more fascinating fields.

Three Seas Program

Three Seas is an accelerated, research-focused, graduate-level program that allows advanced undergraduate and beginning graduate students in marine biology and related areas to spend a year of field study in three distinct marine environments. As a prime example of Northeastern University’s innovative teaching initiative, Three Seas emphasizes experiential learning by providing students with hands-on research experience to develop the critical skills needed to succeed in a career in science.

The program begins with students spending a semester studying the classic rocky intertidal and salt marsh ecosystems at Northeastern University’s Marine Science Center (MSC) in Nahant, 12 miles north of the main campus. The following semester, the program travels abroad to both the University of Washington’s Friday Harbor Laboratories (FHL) and to the Smithsonian Tropical Research Institute (STRI).

FHL, located on San Juan Island, is 70 miles north of Seattle and part of an archipelago that lies between the mainland and Vancouver Island. In the cold and well-mixed waters of the Puget Sound, students study rocky shores, mudflats, sand beaches, kelp forests, and a range of subtidal environments.

STRI is located in the town of Bocas del Toro, on Isla Colon, an island on the northern Caribbean side of Panama. Students study Panama’s tropical ecosystem on both the Caribbean and Pacific coasts, which includes fringing coral reefs, seagrass, and mangrove habitats.
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For more information, visit the Three Seas Program website at www.northeastern.edu/threeseas (http://www.northeastern.edu/threeseas/).

**Marine Science Center Summer Internship Program in Marine Science**

The summer program allows students to participate in intensive research at the Marine Science Center (MSC). Students conduct independent research at the MSC laboratory primarily in the summer, but these experiences can also extend throughout the year.

**Academic Progression Standards**

Same as college standards.

**Programs**

**Bachelor of Arts (BA)**

- Environmental Studies (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-studies-ba/)
- Environmental Studies and History (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-studies-history-ba/)
- Environmental Studies and International Affairs (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-studies-international-affairs-ba/)
- Environmental Studies and Philosophy (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-studies-philosophy-ba/)
- Environmental Studies and Political Science (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-studies-political-science-ba/)
- Sociology and Environmental Studies (http://catalog.northeastern.edu/undergraduate/social-sciences-humanities/sociology-anthropology/sociology-environmental-studies-ba/)

**Bachelor of Science (BS)**

- Environmental and Sustainability Sciences (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-sustainability-sciences-bs/)
- Environmental Science (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-science-bs/)
- Environmental Science and Landscape Architecture (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/environmental-science-landscape-architecture-bs/)
- Ecology and Evolutionary Biology (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/ecology-evolutionary-biology-bs/)
- Marine Biology (http://catalog.northeastern.edu/undergraduate/science/marine-environmental/marine-biology-bs/)
- Computer Science and Environmental Science (http://catalog.northeastern.edu/undergraduate/computer-information-science/computer-information-science-combined-majors/computer-environmental-science-bs/)
- Data Science and Environmental Science (http://catalog.northeastern.edu/undergraduate/computer-information-science/computer-information-science-combined-majors/data-science-environmental-science-bs/)
- Data Science and Ecology and Evolutionary Biology (http://catalog.northeastern.edu/undergraduate/computer-information-science/)

**Courses**

**Marine Studies Courses**

Search MARS Courses using FocusSearch (http://catalog.northeastern.edu/class-search/?subject=MARS)

**MARS 3210. Marine Mammals. 4 Hours.**

Designed to familiarize students with biology and conservation of marine mammals. The course content is primarily scientific, but the goal of the course is to consider how scientific knowledge is used as a tool of conservation. Topics include the evolution and taxonomy of whales, seals, and other marine mammals, adaptations to the ocean environment, feeding and social behavior, and population ecology. Issues include whaling and sealing, environmental contaminants, entanglements in fishing gear, tuna/dolphin interactions, and the decline of Stellar Sea lions.

**MARS 3310. Water Resources Policy and Management. 4 Hours.**

Explores the ways in which water has affected our bodies, our planet, our history, our culture, and the danger posed by increasing demand, waste, and pollution on our limited supply of usable fresh water. Considers water through scientific, historical, and cultural viewpoints. Surveys contemporary water problems in all their dimensions-political, economic, and technological.

**MARS 3315. Wetlands: Ecology and Hydrology. 4 Hours.**

Investigates the vital role of wetlands in the hydrology and ecology of global landscapes. Topics include function of inland and coastal marshes, and swamps and bogs in water and nutrient cycles, and in support of biodiversity from microbes to vertebrates. Examines biological links between wetlands and human activities, such as agriculture, coastal development, and fisheries. Also covers legal framework for the protection and restoration of endangered wetlands.

**MARS 3325. Coastal Zone Management. 4 Hours.**

Focuses on outstanding issues in coastal environment affairs. Discusses scientific, legal, economic, and technical aspects of coastal issues and integrates them into problem-solving exercises.
MARS 3425. Biology of Fishes. 4 Hours.
Covers the evolution, systematics, anatomy, physiology, and behavior of freshwater, marine, and anadromous fishes from temperate to tropical environments. Examines the diversity of fish interactions in aquatic communities; predator/prey relationships, host/symbiont interactions, and the various roles of fishes as herbivores. Studies interspecific and intraspecific predator-prey relationships among fish populations in aquatic communities and integrates principles of ecology. Provides access to the collection of the New England Aquarium resulting in an extraordinary opportunity to understand principles of ichthyology through the study of living fish. Hosted each year by a consortium member institution, this Massachusetts Bay Marine Studies Consortium is an intermediate-level survey course.

MARS 3430. Biology of Whales. 4 Hours.
Offers a comprehensive review of the biology, ecology, and management of cetaceans. A thorough grounding in cetacean mammalogy and population biology seeks to prepare students to understand conservation problems presented as case histories. Requires students to complete an independent research project on a topic related to cetacean biology. Hands-on activities may include the dissection of a small cetacean and a shore-based whale watch in Cape Cod Bay. Hosted each year by a consortium member institution (at Northeastern University’s Boston campus), this is a Massachusetts Bay Marine Studies Consortium course.

Ecology, Evolution, and Marine Biology Courses
Search EEMB Courses using FocusSearch (http://catalog.northeastern.edu/class-search/?subject=EEMB)

EEMB 1101. Foundations in Ecology and Evolutionary Biology. 4 Hours.
Introduces students to the foundational principles of ecology and evolutionary biology. Merges traditional lectures on foundational topics in ecology and evolutionary biology (adaptation, mechanisms of evolution, community and ecosystems ecology) with explorations of local field sites and an introduction to field ecology. Students spend several weeks of the semester designing and implementing independent field research projects, through which they are exposed to the foundation of scientific inquiry, including hypothesis testing, collecting, managing, and analyzing data, and presenting their findings.

EEMB 1102. Lab for EEMB 1101. 1 Hour.
Accompanies EEMB 1101. Covers topics from the course through various experiments.

EEMB 1105. Foundations in Ecological and Evolutionary Genomics. 4 Hours.
Introduces students to the foundational principles of molecular ecology with an emphasis on applications of high-throughput sequencing techniques to answer questions in ecology and evolutionary biology. Covers foundational topics in ecological and evolutionary genomics (central dogma, structure of nucleic acids, genetic variation, tools in molecular ecology, understanding genomes, and genomics). Practical skills development includes clean technique and proper bench skills; basic command line programming; understanding, quantifying, and analyzing sequence variation; and visualizing genomic data for formal scientific presentations.

EEMB 1106. Lab for EEMB 1105. 1 Hour.
Accompanies EEMB 1105. Covers topics from the course through various experiments. Focuses on providing firsthand experience using tools from molecular ecology to test ecological and/or evolutionary hypotheses.

EEMB 1145. Beginning Scuba. 1 Hour.
Focuses on basic skin diving and scuba diving skills, with emphasis on safety. Requires lab fee. Requires ability to pass a swim test and basic comfort in the water.

EEMB 1450. Introduction to Marine Biology. 4 Hours.
Surveys the tremendous diversity of marine organisms in the context of the major marine ecosystems in which they are found. Explores interactions among organisms and how the physical and chemical environment influence marine organisms. Links changes on land to declines in organism numbers and diversity and explores the benefits humans gain from our relationship with the marine environment. Offers opportunities to investigate recent advances and understanding of marine organisms and their environments.

EEMB 1900. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

EEMB 2290. Ecology and Evolution of Behavior. 4 Hours.
Studies fundamental biological principles at behavioral, ecological, and evolutionary levels. Covers ethology, ecology, genetics, and comparative psychology, all within the conceptual framework of evolutionary theory. Explores both scientific practice and progress through readings, discussion, and projects. Illustrates the process by which biologists study questions about the evolutionary origin of behavior through a series of in-class activities, computer modeling assignments, interpretation of graphical data, collection and statistical analyses of behavioral data, as well as the generation and presentation of research. Does not focus on the neurological basis of behavior. Offers students an opportunity to become critical thinkers, critical readers, and to attain tools to interpret the world in a unique way. Requires permission of advisor.

EEMB 2302. Ecology. 4 Hours.
Offers students an opportunity to learn about the environmental and biological processes that control the distribution and abundance of species and controlling factors that operate on individuals, populations, and communities. The lecture and laboratory introduce a set of generalizable concepts that are of fundamental importance to plant and animal life on the land and in the sea and provide hands-on experiential learning that reinforce concepts covered in lecture. Offers students an opportunity to become proficient in the following: (a) understanding research results the primary literature; (b) conducting a research experiment; (c) interpreting the results of in-class research; (d) communicating results as manuscript.

EEMB 2303. Lab for EEMB 2302. 1 Hour.
Accompanies EEMB 2302. Covers topics from the course through various experiments.

EEMB 2400. Introduction to Evolution. 4 Hours.
Introduces evolutionary thinking, including contemporary examples of evolution. To understand the evolution of Charles Darwin’s “endless forms most beautiful,” the course adopts an integrative approach that includes information from ecology, genetics, molecular biology, biogeography, and paleobiology. Considers mechanisms of evolutionary change—how does it happen? Examines adaptation, the process by which attributes of an organism change to enhance fitness and the evolutionary history of life on our planet—what was the first living thing, how does speciation occur, what have we learned about evolution of life in the distant past, and how did humans evolve. Includes student presentations and analysis of scientific literature.
EEMB 2420. Fisheries Biology, Policy, and Conservation. 4 Hours.
Focuses on the study and management of economically valuable fish species. Studies the basic biology and ecology of fisheries species, quantifying and modeling their population biology to their interactions with each other and the environment. Requires students to read and analyze the scientific literature, to complete worksheets and writing assignments, and to develop and present research projects. Covers traditional stock assessment methods as well as how fisheries science and management has evolved more recently to integrate community- and ecosystem-level information. Reviews fisheries and how fishers are managed, their involvement in the management process, and the future fisheries in the United States and elsewhere.

EEMB 2616. Invertebrate Zoology. 4 Hours.
Surveys the tremendous diversity of invertebrates, emphasizing their form and function in ecological and evolutionary contexts. Explores functional morphology, systematics, phylogenetic relationships, ecology, and economic importance of the major invertebrate phyla. Discusses comparisons among phyla to enhance understanding of evolutionary relationships.

EEMB 2617. Lab for EEMB 2616. 1 Hour.
Accompanies EEMB 2616. Covers topics from the course through various experiments.

EEMB 2618. Vertebrate Zoology. 4 Hours.
Explores functional morphology, systematics, ecology, and phylogenetic relationships of the major vertebrate phyla.

EEMB 2619. Lab for EEMB 2618. 1 Hour.
Accompanies EEMB 2618. Covers topics from the course through various experiments.

EEMB 2700. Marine Biology. 4 Hours.
Examines biological aspects of natural ocean ecosystems and the physical processes that regulate them. Covers distributions, abundances, and interactions of marine organisms; interactions between organisms and the transformation and flux of energy and matter in marine ecosystems; and aspects of physiology related to marine species distributions, abundances, and roles. Students generate, evaluate, discuss, and present data from primary research and apply their knowledge of the scientific method and biological concepts through the creation of a written grant proposal.

EEMB 2701. Lab for EEMB 2700. 1 Hour.
Accompanies EEMB 2700. Covers topics from the lecture course through discussions and experiments.

EEMB 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

EEMB 3120. Physical Biology of Marine Organisms. 4 Hours.
Introduces principles from the physical sciences (fluid and solid mechanics, mass and heat transfer theory) applied to the analysis of form, function, ecology, and evolution of marine organisms. Topics covered include suspension and deposit feeding in invertebrates, allometry of metabolic processes, drag and lift in sessile organisms, locomotion of nekton (fishes, marine mammals) and plankton, diffusive limitations to metabolic transactions in marine invertebrates and algae, thermal transactions in intertidal organisms, the biology of the benthic boundary layer, and the properties of biomaterials and biological structures. Presents engineering methods and measurement techniques applicable to biomechanical investigations.

EEMB 3450. Physiological Adaptations to the Environment. 4 Hours.
Explores the evolutionary mechanisms by which organisms adapt physiologically to survive, and thrive, in diverse, often seemingly "hostile," habitats. Examines paleo- and modern examples of adaptation with the goal of predicting species success or failure as our planetary environment changes rapidly. Topics include adaptation of cellular metabolism, adaptations to variable oxygen availability and to changes in pH, the roles of water and microsolutes in regulation of the internal environment of cells, and the effects of temperature on cellular function and the biogeographic distribution of organisms. Includes student presentations and analysis of scientific literature. Requires junior or senior standing; sophomores admitted by permission of instructor; EEMB 2400 or ENVR 2400 recommended but not required.

EEMB 3455. Ecosystems Ecology. 4 Hours.
Focuses on the foundational principles of ecosystems ecology, examines the flow of energy and materials through both the biosphere (plants, animals, and microbes) and the geosphere (soils, atmospheres, and oceans) and the role that humans are playing in altering these key fluxes. Studies elemental cycles that are critically important for human and environmental sustainability—including carbon, nitrogen, and phosphorus—and examines similarities and differences in these cycles and flows while drawing on examples from both terrestrial and marine systems. Seeks to understand how changes in ecosystem structure ultimately affect ecosystem function and how this translates into the important services ecosystems provide.

EEMB 3460. Conservation Biology. 4 Hours.
Explores conservation biology, an interdisciplinary science that focuses on conservation of biological diversity at multiple levels. Emphasizes the causes and consequences of biodiversity loss and demonstrates how ecological and evolutionary principles are applied to conservation problems. Covers sustainability; climate change; introduced species; conservation of threatened and endangered species; and pollution, disease, and habitat restoration using examples from marine, aquatic, and terrestrial systems. Offers students an opportunity to read, discuss, evaluate, and present data from primary research through written assignments and oral debates and to apply this knowledge to conservation issues. Emphasizes critical thinking, problem solving, and recognizing multiple perspectives.

EEMB 3465. Ecological and Conservation Genomics. 4 Hours.
Offers an overview of ecological and conservation genetics, an interdisciplinary science that focuses on understanding the processes that determine genetic diversity at the individual to population level. Focuses on fundamental concepts in evolutionary ecology and population and quantitative genetics, then applies those concepts to solving real-world problems in conservation science. Covers harvested populations, inbreeding, climate change, introduced species, conservation of threatened and endangered species, adaptation, and habitat restoration. Exposes students to multiple sides of these issues and the science that underpins them. Offers students an opportunity to develop the R programming skills required to analyze the complex data sets that often emerge when addressing cutting-edge questions in genetics. Includes writing and coding exercises and mathematical derivations. Emphasizes critical thinking and problem solving.
EEMB 3466. Disease Ecology. 4 Hours.
Covers the fundamentals of disease ecology and evolution. Focuses on how disease can impact the physiology of organisms and how this can, in turn, alter communities and ecosystems. Topics include mathematical theory on host-pathogen interactions; empirical studies of human, wildlife, insect, and plant host populations; emerging infectious diseases; effects on host behavior; host-parasite coevolution; multihost and multipathogen systems; and anthropogenic effects on disease. Includes writing exercises, with a special emphasis on critical thinking and problem solving.

EEMB 3470. Coastal Ecology and Sustainability. 4 Hours.
Designed to provide an integrated exposure to issues surrounding the ecology and sustainability of coastal and estuarine systems, with a particular focus on urban harbors. Exposes students to both the diversity and complexity of coastal habitats that exist both locally (salt marshes and seagrass beds) and globally (mangroves) and the mechanisms of estuarine and coastal functioning (geomorphology, biogeochemistry, microbial ecology, food webs, fisheries). Considers the ecosystem services provided by coastal systems and how those services are altered through human pressures.

EEMB 3471. Lab for EEMB 3470. 1 Hour.
Accompanies EEMB 3470. Emphasizes hands-on experience in monitoring water quality in the greater metropolitan Boston area. Specifically focuses on "one outfall pipe per student" where students select a different combined storm water drainage pipe that delivers water into Boston area rivers. Exposes students to a suite of different water quality measurements typically used in coastal monitoring, including measuring nutrients, studying indicators of fecal contamination, and quantifying bacterial loads. Operates in partnership with the Massachusetts Water Resources Authority, local municipalities, and watershed associations so that the data students generate can be used to enhance ongoing monitoring efforts.

EEMB 3475. Wildlife Ecology. 4 Hours.
Focuses on wildlife ecology and management, with an emphasis on terrestrial species. Introduces habitat use, behavior, wildlife conservation, parasites and pathogens, wildlife sampling, wildlife management, food and nutrition, population viability, and conservation genetics. Offers students an opportunity to engage in analyzing primary literature, collection, interpretation, and wildlife data and using basic mathematical models.

EEMB 3555. Networks and Natural Systems. 4 Hours.
Covers the properties of diverse biological networks and explores foundational computational methods for analyzing, visualizing, and performing statistical investigations of networked data. From social networks and cities to ecosystems and evolution, methods from network science provide powerful tools for understanding and investigating the natural and modern world. Moving beyond description, a key objective of the course is to synthesize the diversity of biological networks and investigate how scientists have uncovered remarkable regularities in networked systems by applying approaches from scaling theory to biological networks. Based on a series of case-studies, focuses on how to elucidate the structure and function of biological networks using empirical data. Requires scientific programming.

EEMB 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

EEMB 4000. Applied Conservation Biology. 4 Hours.
Studies landscape-scale conservation in Transylvania and the Carpathian Mountains of Romania. Working intensively with Foundation Conservation Carpathia, explores efforts to build Europe's largest national park. Offers students an opportunity to learn from local conservation leaders, collect data, and develop plans to help launch the "Yellowstone of Europe." Focuses on large carnivore conservation (brown bears, lynx, and wolves); sustainable agriculture; resource management in a country formerly under communist rule; and balancing urban and rural conservation needs. Explores Romania's rich cultural heritage in Sighisoara, a UNESCO World Heritage Site, and Vacaresti Nature Park, a constructed urban wetland in the heart of Bucharest. Requires prior completion of one laboratory science course or permission of instructor.

EEMB 4001. Landscape and Restoration Ecology. 4 Hours.
Topics include ecosystem processes, spatial patterns, disturbance, species distributions, invasive species, and habitat loss. Offers students an opportunity to participate in activities in which they look at and interpret spatial data. Course format includes group work, analyzing the scientific literature, and in-class activities.

EEMB 4010. Biology of Mammals. 4 Hours.
Surveys the mammals of the world, including their evolution, morphology, physiology, behavior, and ecology. Students conduct a research project in which they investigate the morphology, evolution, ecology, and behavior of a species and present their findings to the class. Includes reading and analyzing the scientific literature and conducting in-class activities.

EEMB 4548. Sociobiology. 4 Hours.
Studies sociobiology, a field of biology that strives to understand the biological basis of social behavior in animals. Sociobiology is a multidisciplinary science, meshing together ethology (animal behavior), ecology, genetics, population biology, and comparative psychology, all within the conceptual framework of evolutionary theory. Why do animals live in societies? Why do animals cooperate and sometimes show extreme forms of altruism? What are the costs and benefits of group living? Reviews studies on nonhuman animals that demonstrate sociobiological principles by using a series of in-class activities, computer-modeling assignments, interpretation of graphical and tabulated data, collection and statistical analyses of behavioral data, as well as the generation and presentation of research.

EEMB 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

EEMB 4992. Directed Study. 1-4 Hours.
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

EEMB 5130. Ecological Dynamics. 4 Hours.
Offers a comprehensive overview of mathematical and computational concepts needed to construct (meta)population, (meta)community, and (meta)ecosystem models. Focuses on how to mathematically derive and model processes (growth, trophic and nontrophic species interactions, dispersal, and environmental variability) to understand patterns of population abundance and species diversity. Emphasizes the mathematical tools required to analyze the dynamical behavior of ecological models (stability, invasion, graphical, and numerical analyses) and validate model predictions using empirical data (via maximum likelihood and optimization methods). Sophomores admitted by permission of instructor.
EEMB 5131. Lab for EEMB 5130. 1 Hour.
Accompanies EEMB 5130. Offers supervised lab sessions designed to show how the topics covered in the lectures can be addressed in industry-standard programming environments.

EEMB 5303. Marine Biology Careers Seminar. 1 Hour.
Covers the information and tools needed to begin pursuing career opportunities in marine biology. Encourages students to explore a variety of career paths, construct résumés, contact potential employers for their internship and permanent positions. Presents invited speakers from state and federal agencies, and from private consulting firms, to talk about their work and career track.

EEMB 5504. Biology of Corals. 3 Hours.
Focuses on the biology of Scleractinian reef-building corals and associated anthozoans found in coral reef ecosystems. Topics include systematics, anatomy, physiology, and population biology of corals, with an emphasis on the latest techniques employed by coral molecular biologists and physiologists.

EEMB 5506. Biology and Ecology of Fishes. 3 Hours.
Provides an examination of the systematics, functional morphology, and behavioral, larval, and community ecology of reef fishes through lectures. Field and laboratory experiments focus on morphology, behavior, and community ecology of reef fishes.

EEMB 5508. Marine Birds and Mammals. 2 Hours.
Studies principles of classification, anatomy, physiology, behavior, and evolution of seabirds and marine mammals. Also addresses conservation and protection of animals and essential habitat. Includes field trips to observe local species.

EEMB 5509. Lab for EEMB 5508. 1 Hour.
Accompanies EEMB 5508. Covers topics from the course through various experiments.

EEMB 5512. Tropical Terrestrial Ecology. 1 Hour.
Studies the animals, plants, and ecosystems of the new world tropics, with the community structure and diversity of terrestrial Jamaican habitats as an example. Includes field trips to lowland forests, carbonate caves, and the Blue Mountain mist-montane forest. The issue of land use and development vs. conservation is a recurring theme.

EEMB 5516. Oceanography. 4 Hours.
Offers an integrated overview of physical, chemical, and biological processes operating in the world ocean. Seamingly unrelated topics like plate tectonics, oscillating currents and waves in the atmosphere, the activities of microbes and phytoplankton, and land-use practices in the middle of the continent have global reach and interact with each other in surprising yet understandable ways. Examines how new technologies have allowed stunning insights into global weather and climate, the deep sea, biodiversity, and how the biogeochemistry of the oceans can be measured and understood. Presents data use and analysis and formal reasoning used in marine science. Views the ocean as a “system of systems” where integration of experience from disparate disciplines is key.

EEMB 5517. Lab for EEMB 5516. 1 Hour.
Accompanies EEMB 5516. Offers experiential field and laboratory exercises in oceanography. The New England rocky intertidal, subtidal, wetlands, barrier islands, and dunes provide opportunities for field exercises in marine geology, physical oceanography, and marine ecology. Investigates processes affecting changes in the global ocean, such as ocean acidification; temperature stress in organisms; hydrodynamic drag and lift; suspension feeding; and the ecophysiology of reef corals, boreal invertebrates, and macroalgae.

EEMB 5518. Ocean and Coastal Processes. 2 Hours.
Examines the coupling between physical and biological processes on coral reefs and adjacent habitats. Focuses on biophysical, oceanographic, and benthic-pelagic processes acting in coral reef and associated nearshore ecosystems. Specific topics include oceanographic forcing mechanisms, organismal biomechanics, hydrodynamics, and nutrient dynamics.

EEMB 5520. Coral Reef Ecology. 2 Hours.
Examines the ecology and paleoecology of coral reefs. This course highlights the ecological importance of coral reefs and associated nearshore communities, ecosystem function, changes in reef biotas through geologic time, and the causes and consequences of reef degradation worldwide.

EEMB 5522. Experimental Design Marine Ecology. 4 Hours.
Includes introduction to and application of observational methods in three local marine habitats, experimental design, statistical analysis, R statistical computing and graphics software, and principles of marine ecology. Combines lecture, hand-on research experience, and computer laboratory and includes reading and analyzing the scientific literature and developing research projects. At the end of the semester, students are expected to demonstrate an integrative mastery of course topics by writing a scientific manuscript about a class experiment. Seeks to prepare students for practicing ecology in new environments and to provide students with the foundational knowledge necessary for pursuing more complex concepts in experimental design, statistical analysis, and marine ecology.

EEMB 5523. Lab for EEMB 5522. 1 Hour.
Accompanies EEMB 5522. Covers topics from the course through various experiments.

EEMB 5528. Marine Conservation Biology. 3 Hours.
Examines several critical issues facing marine ecosystems, including invasive species, marine pollution and eutrophication, fisheries impacts, physical alteration of habitats, and global climate change. Offers students an opportunity to spend field time surveying intertidal and subtidal habitats within the San Juan Islands and Friday Harbor Marine Reserve and to conduct independent research projects.

EEMB 5532. Physiological and Molecular Marine Ecology. 3 Hours.
Explores the physiological responses of marine organisms to variations in environmental factors. Uses complementary techniques, including molecular and physiological approaches, to determine genetic relationships at the species and population level and elucidate the mechanistic basis of organismic responses to environmental conditions at the level of genes and gene products.

EEMB 5534. Marine Invertebrate Zoology and Botany. 4 Hours.
Surveys the major groups of marine invertebrates, algae, and plants, in addition to their ecological roles and relationships. Offers students an opportunity to learn to identify these groups and understand the mechanisms they use to survive and adapt to changing oceans. Topics include ecological and evolutionary importance, ecosystem engineering, adaptive physiology, and climate change effects. Emphasizes interrelationships among major taxa. Hands-on learning includes field identification; visits to intertidal and subtidal marine environments; and specimen dissection, preparation, and cataloging. Offers students an opportunity to improve skills in reading and discussing scientific literature, experimental design, and scientific communication. Restricted to three seas students only; not open to students who have taken EEMB 5500 or EEMB 5502.

EEMB 5535. Lab for EEMB 5534. 1 Hour.
Accompanies EEMB 5534. Covers topics from the course through various experiments.
EEMB 5536. Ocean and Coastal Sustainability. 3 Hours.
Offers students advanced training in the expanding field of sustainability, with a combined focus on the practical aspects of systems management and the theoretical understanding of whole-systems design and resiliency. Seeks to train future leaders capable of creating innovative solutions to sustainability issues at local and global levels. Key interdisciplinary themes discussed include the social and political aspects of ocean and coastal sustainability (i.e., education and communication), sustainable development and ecosystem stability, the impacts of climate change on ocean and coastal resilience, and the economic and entrepreneurial possibilities in the field of sustainability. Restricted to Three Seas students only.

EEMB 5589. Diving Research Methods. 2 Hours.
 Presents experimental design, sampling methodology, statistical analysis, techniques, and the use of underwater equipment to conduct subtidal research.

Earth and Environmental Sciences Courses
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ENVR 1000. Marine and Environmental Sciences at Northeastern. 1 Hour.
Intended for first-year students in the College of Science. Introduces students to liberal arts; familiarizes them with their major; develops the academic skills necessary to succeed (analytical ability and critical thinking); provides grounding in the culture and values of the University community; and helps to develop interpersonal skills—in short, familiarizes students with all skills needed to become a successful university student.

ENVR 1101. Environmental Science. 4 Hours.
Focuses on the complex array of topics that collectively form the discipline of environmental science. Emphasizes the problems facing today's natural, human-managed, and coupled human/natural ecosystems and the solutions to those problems. Studies the human dimensions of environmental science, including culture, politics, worldviews, ethics, and economics, particularly within the context of global climate change. Offers students an opportunity to learn how to analyze data as a means of exploring relationships among societal and ecological drivers affecting economic, ecological, and socioeconomic stability; to learn how the scientific method is used to separate fact and data from opinion; and to apply these methods to explore the causes and solutions to global climate change.

ENVR 1103. Age of Dinosaurs. 4 Hours.
Utilizes evidence from the sedimentary rock record to evaluate and to interpret significant biological and physical events in Mesozoic earth history. Changes in the Earth's landscape due to variations in climate, plate tectonics, and sea level provide the background for detailed consideration of Mesozoic life. Emphasizes the evolutionary history of dinosaurs and provides detailed data for testing hypotheses of evolutionary mechanisms, paleobiogeography, functional anatomy, ecology and community structure, and extinction and extinction models.

ENVR 1104. Natural Disasters and Catastrophes. 4 Hours.
Provides an overview of what we know about the causes, locations, and effects of some of the most important natural disasters such as earthquakes, floods, and hurricanes. Also examines how loss of life and property damage can be minimized by implementing geologic knowledge. Briefly examines less common but possibly more devastating catastrophes such as large volcanic eruptions, large meteorite impacts, and rapid climate change.

ENVR 1110. Global Climate Change. 4 Hours.
Analyzes Earth's modern climate system and natural climate change over Earth's 4.5-billion-year history. Examines ongoing and future climate change. Includes expected impacts of the predicted climate changes as well as mitigation and adaptation options.

ENVR 1112. Environmental Geology. 4 Hours.
Investigates geologic processes such as flooding, volcanic eruptions, and earthquakes, as well as strategies for safer land use incorporating geologic information. Exercises completed and discussed in class offer hands-on experience with evaluating geologic factors that impact land use and formulating hazards mitigation strategies. Offers students an opportunity to increase their understanding of problems resulting from the interaction of humans with the geologic environment and how we can more appropriately interact with it.

ENVR 1120. Oceans and Coasts. 4 Hours.
Explores the marine and coastal realm and the problems that arise from the human-marine relationship. Begins by studying the history of the ocean and ends with how to create a more sustainable marine world. Topics covered include ocean and estuarine circulation, climate change and ocean response, and the plant and animal life thriving in different parts of the ocean. Includes reading and analyzing the scientific literature, developing and presenting research projects, and group work.

ENVR 1201. Lab for ENVR 1200. 1 Hour.
Accompanies ENVR 1200. Covers exercises pertaining to mineral and rock identification and topographic and geologic map interpretation. Required for environmental geology and geology majors.

ENVR 1202. History of Earth and Life. 4 Hours.
Traces biological and environmental development of the earth over the past 4.6 billion years using evidence preserved in the rock record. A primary goal is to understand how geoscientists interpret earth history by learning how to test hypotheses and develop explanations for events that occurred far in the geologic past. Examination of major earth systems, the biosphere, lithosphere, atmosphere and hydrosphere, reveals how they interact to control the origin of earth, the origin and evolution of life, the causes and effects of extinction, plate tectonics and mountain building, and climate change over earth history.

ENVR 1203. Interpreting Earth History. 1 Hour.
Focuses on students using sedimentary rocks, fossils, and geologic maps and stratigraphic sections to record and to interpret events in earth history.

ENVR 1400. Foundations in Environmental and Sustainability Sciences. 4 Hours.
Presents a series of lectures and case studies focused on the problems facing today's natural, human-managed, and coupled human/natural ecosystems. Integrates the underlying science with the human dimensions of environmental challenges. These include an understanding of the basic chemistry, physics, and ecology of environmental change and how this science is informed and altered by culture, politics, worldviews, ethics, and economics. Examines quantitative techniques to analyze data as a means of exploring relationships among societal and ecological drivers affecting economic, ecological, and socioeconomic stability. Studies how the scientific method is used to separate facts and data from opinion and applies these methods to explore the causes and solutions to global climate change and other environmental challenges.
ENVR 1401. Lab for ENVR 1400. 1 Hour.
Accompanies ENVR 1400. Offers supervised lab/discussion sessions for students to develop the tools needed to tackle environmental problem solving at the interface of human and natural systems.

ENVR 1450. Introduction to Sustainability Science. 4 Hours.
Explores the fundamental concepts of sustainability by breaking down the supporting science. Offers students an opportunity to understand the interactions among social and environmental systems by focusing on six major themes: dignity, people, prosperity, planet, justice, and partnership. Discusses topical ideas including pollution and health, water resources, food production, and energy. Integrates the interdisciplinary nature of sustainability science by applying best practices to your field of study. Uses case studies to exemplify the core principles of the course. Pulls knowledge from local examples of sustainability in practice in New England and garners an appreciation for how these principles are researched and applied across the globe. Students who do not meet course restrictions may seek permission of instructor.

ENVR 1500. Introduction to Environmental, Social, and Biological Data. 4 Hours.
Introduces the fundamental concepts in the fields of environmental, social, and biological science. Studies the expertise needed in each discipline to organize and manage data in sustainability science. The first half of the course covers data collection relevant to pressing issues in sustainability, database organization, coding, and finding errors in data sets. The second half of the course covers basic principles in the statistical analysis of data sets used in conservation and sustainability, including simulating data, machine learning, and errors in analysis. Offers hands-on experience through students' own data collection projects. Appropriate for students interested in biology, marine biology, environmental science, and ecology and evolutionary biology. Designed to prepare students for co-ops and upper-level classes in these fields.

ENVR 1501. Lab for ENVR 1500. 1 Hour.
Accompanies ENVR 1500. Offers supervised lab sessions demonstrating how topics covered in the lectures can be addressed using a variety of platforms, including Excel, R, and Python.

ENVR 1990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ENVR 2200. Earth's Changing Cycles. 4 Hours.
Introduces the biological, chemical, and physical interactions that shape our environment and how industrial emission of gases and black carbon, the use of fertilizers and plastics, and the expansion of cities are altering Earth's systems at rates unprecedented in the recent geological record. Offers students an opportunity to build a fundamental understanding of major issues in environmental science, including climate change, eutrophication, loss of biodiversity, and urbanization. Considers how we might build a more sustainable future.

ENVR 2310. Earth Materials. 4 Hours.
Describes the physical and chemical characteristics of common rock-forming minerals and geologic processes that form rock and soils in the igneous, sedimentary, and metamorphic environments. Focuses on commonly encountered minerals, soil, and rock types and how these are used to interpret past and present earth processes. This is a writing-intensive course with a required term paper.

ENVR 2311. Lab for ENVR 2310. 1 Hour.
Accompanies ENVR 2310. Cover topics from the course through various experiments.

ENVR 2330. Field Methods in Global Change. 4 Hours.
Endeavors to teach basic field methods in global change science through a suite of hands-on field projects based in the Emerald Necklace park system adjacent to Northeastern's Boston campus. Offers students an opportunity to learn basic skills in generating primary scientific data (i.e., abstracting data directly from nature), thereby functioning as a pillar for higher-level course work and research within the MES majors. Exposes students to fundamental content (e.g., fluvial geomorphology, biogeochemistry of natural waters, environmental pollution, sedimentology/stratigraphy) and skills (e.g., hypothesis generation and testing, topographic survey, map making, sedimentary coring, sampling and analysis of natural waters, producing scientific illustrations/graphs/videos, scientific writing) in global change science.

ENVR 2340. Earth Landforms and Processes. 4 Hours.
Focuses on the origin and evolution of landscape features by processes operating at or near the earth's surface. Exercises introduce interpretation of air photos, topographic maps, remotely sensed data, and digital elevation models.

ENVR 2341. Lab for ENVR 2340. 1 Hour.
Accompanies ENVR 2340. Covers topics from the course through various experiments.

ENVR 2500. Biostatistics. 4 Hours.
Offers an overview of traditional and modern statistical methods used to analyze biological data using the free and open-source R programming environment. Lectures describe core statistical approaches and discuss their suitability for understanding patterns that arise at different levels of biological organization, from cellular processes to whole ecosystems. Supervised lab sessions offer students an opportunity to develop the R programming skills required to analyze the complex datasets that often emerge when addressing cutting-edge questions in biology. Topics include basic probability and sampling theory, experimental design, null hypothesis significance testing, t-tests and ANOVA, correlation and regression, Monte Carlo simulations, likelihood, generalized linear models, model selection, and information theory.

ENVR 2501. Lab for ENVR 2500. 1 Hour.
Accompanies ENVR 2500. Offers supervised lab sessions demonstrating how topics covered in the lectures can be addressed in the R programming environment.

ENVR 2515. Sustainable Development. 4 Hours.
Focuses on the principles and practice of sustainable development, both as a way of looking at the interconnected world and an overarching framework for promoting economic development, social inclusion, and environmental stewardship. Students will study decades of local and global efforts aimed at developing economies, eradicating hunger and disease, and restoring and sustaining ecosystems for a large, and growing, population living on an increasingly altered planet and facing a changing climate. Along with lectures and discussions on core concepts, students will critically dissect the toughest questions and challenges of sustainable development through an online class blog and semester-long group projects.

ENVR 2900. Special Topics in Environmental Studies. 4 Hours.
Studies various topics on environmental issues. May be repeated without limit.

ENVR 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
ENVR 3125. Global Oceanic Change. 4 Hours.
Explores major changes in physical, biological, and chemical properties of the ocean over geological and human timescales. Includes origin and early evolution of the oceans; sea-level change; global warming; ocean acidification; the role of plate tectonics in driving long-term oceanic change; the role of atmospheric carbon dioxide in driving short-term oceanic change; tipping points in the oceans; snowball earth theory; marine pollution; oil exploration; and social, economic, and political implications of global oceanic change. Themes include differentiating drivers of change across multiple temporal and spatial scales; evaluating change from different and sometimes conflicting perspectives (social, economic, political, environmental); differentiating local and global change; and establishing linkages between physical, chemical, and biological processes in the ocean. Requires prior completion of one laboratory science course or permission of instructor.

ENVR 3150. Food Security and Sustainability. 4 Hours.
Discusses the science of sustainable agriculture, fisheries, and aquaculture. Examines the issues related to nutrition and hunger, food safety, and food production in the face of a changing climate with a scientific lens. Using the FAO Global Food Security and Strategy document and other peer-reviewed literature, compares the food issues in the United States with those in the developing world, including sub-Saharan Africa and Southeast Asia. Explores the many issues related to food production and environmental sustainability—including fertilizer use, GMOs, and pollution—and local examples of sustainable food production. Discusses the ways in which we can potentially remedy many of the issues involved in providing food for more than 7 billion people worldwide.

ENVR 3151. Food Sustainability in the Mediterranean - Abroad. 4 Hours.
Focuses on the Mediterranean diet, which serves as the framework for this course. Discusses the scientific evidence supporting/refuting this diet, then observes the food systems that comprise the diet. Uses museum evidence to deduce the composition of ancient diets and compares this to dietary changes over time using interviews with village locals. Explores production of olive oil, vegetables, and grains and discusses how industrial farming affects traditional agriculture and human health. Also focuses on fish and shellfish production with visits to aquaculture and marine research facilities to discuss how best to include seafood in the human diet while preserving a diverse marine environment. Through comprehensive writing and discussion, offers students an opportunity to more clearly understand the history of food in this region.

ENVR 3200. Water Resources. 4 Hours.
Offers students who wish to work in the area of water resources an opportunity to understand the issues related to water’s availability and behavior at the Earth’s surface. Topics covered include (1) the hydrologic cycle, including global and regional patterns of water movement; (2) characteristics of surface and groundwater systems, including the linkage between streams, rivers, lakes, wetlands, groundwater, and the sea; (3) water management issues and regulations that have been enacted to control the use of water as a resource; (4) water quality measures for surface water and groundwater; and (5) examples of water use conflicts and emerging water issues. Case studies include examples from California, New England, New York, the southwestern United States, China, Africa, and the Middle East.

ENVR 3201. Coastal Sustainability: Ecology and Coupled Human-Natural Systems in Southeast Asia. 4 Hours.
Accompanies ENVR 3202. The majority of the Earth’s population now lives in coastal cities, where people not only depend on ocean resources but are also experiencing ever-increasing threats from the ocean environment, especially global climate change. Explores the mechanisms by which coastal communities in Southeast Asia (Hong Kong and Malaysia) are facing these expanding challenges, including their impacts on coastal ecosystems. Using a comparative approach, explores the diverse challenges facing coastal societies. Offers students an opportunity to gain an in-depth understanding of coupled human-natural systems in Southeast Asia. Prior completion of an introductory course in ecology or environmental sciences is recommended.

ENVR 3202. Coastal Sustainability: The Blue Economy of the Gulf of Maine. 4 Hours.
Accompanies ENVR 3201. Examines the status of the Gulf of Maine (GOM) and its future trajectory from a scientific and societal perspective. The GOM is the heart of the Blue Economy in New England and the Canadian Maritime provinces. Historically, cod drove the economies of GOM communities. Now lobster, coastal development, international shipping, wild scallops, aquacultured salmon and mussels, and coastal technology are transforming the region. But the GOM is under threat from global warming, sea-level rise, eutrophication, and invasive species, as coastal cities like Boston, Portland, and Halifax seek resilient sustainable solutions to these challenges. Prior completion of an introductory course in ecology or environmental sciences is recommended.

ENVR 3300. Geographic Information Systems. 4 Hours.
Studies how to use a geographic information system (GIS). Explores the practical application of GIS to support scientific and social inquiry, analysis, and decision making. Topics include spatial data collection, data accuracy and uncertainty, cartographic principles, and data visualization, geographic analysis, and legal, economic, and ethical issues associated with using GIS. Investigates case studies from geology, environmental science, urban planning, architecture, social studies, and engineering. Provides extensive hands-on experience with a leading commercial GIS software package. Offers students an opportunity to conceive their own research problem that can be addressed using GIS and reach conclusions that are summarized in a professional report. Students who do not meet course prerequisites may seek permission of instructor.

ENVR 3301. Lab for ENVR 3300. 1 Hour.
Accompanies ENVR 3300. Covers topics from the course through various experiments.

ENVR 3410. Environmental Geochemistry. 4 Hours.
Offers students who wish to work in the geosciences or environmental science and engineering fields, including on the land, in freshwater, or the oceans, an opportunity to understand the geochemical principles that shape the natural and managed environment. Seeks to provide a context for understanding the natural elemental cycles and environmental problems through studies in atmospheric, terrestrial, freshwater, and marine geochemistry. Topics include fundamental geochemical principles; environmental mineralogy; organic and isotope geochemistry; the global carbon, nitrogen, and phosphorous cycles; atmospheric pollution; environmental photochemistry; and human-natural climate change feedbacks. ENVR 3410 and CHEM 3410 are cross-listed.
ENVR 3415. Environmental Pollution: Fate and Transport. 4 Hours.
Offers a systematic approach to analyzing the fate and transport of pollutants within natural systems. Uses equilibrium modeling and reactive transport modeling to assess the predominant processes that control the movement and persistence of pollutants in water, soil, and air. Topics include mass transfer across multiple phases; physical, chemical, and biological transformations of substances; transport processes (diffusion, dispersion, advection, interphase mass transport); eutrophication of lakes; conventional pollutants in rivers and estuaries; groundwater contamination; and atmospheric deposition.

ENVR 3418. Geophysics. 4 Hours.
Studies the basic techniques of reflection and refraction seismology and earthquake analysis; gravity and magnetic surveying methods; radioactive decay principles and Earth's heat flow; and how information from these methods are used to interpret the nature and age of the Earth's surface and interior. Emphasizes near-surface exploration, data collection methods, data analysis, and using data to constrain mathematical models of the subsurface distribution of geologic units.

ENVR 3600. Oceanography. 4 Hours.
Presents an integrated overview of biological, chemical, physical, and geological processes operating in the world's oceans. Emphasizes understanding the fragility and resilience of marine systems in the face of human-driven perturbations such as habitat fragmentation, elevated sea surface temperature and acidification, non-native species, nonsustainable fishing and aquaculture, and coastal land use. Offers students an opportunity to prepare for further work in both marine biology and in earth, oceans, and environmental change.

ENVR 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ENVR 4000. Science Communication and Professional Development. 4 Hours.
Covers professional skills such as writing cover letters, crafting resumes, interviewing, creating a biographical sketch, and developing overall confidence by connecting to audiences. Science communication focuses on connecting with nontechnical audiences to convey complex scientific concepts and engaging diverse stakeholders to solve pressing societal problems using scientific approaches. Covers general principles of messaging, based on an understanding of how people learn and make decisions, using techniques such as narrative storytelling, visualizations, and theatrical improvisation and other art forms. Offers students an opportunity to develop tools to highlight their strengths, market their skills, explore potential jobs and career paths, and understand how to best prepare for those positions. Designed to integrate with ENVR 4050.

ENVR 4050. Solving Emerging Environmental Challenges through Capstone. 4 Hours.
Gathers students from across the various environmental and sustainability sciences concentrations to solve environmental problems that are of concern to various stakeholders. Students perform service-learning with a number of not-for-profit and government agencies to identify specific environmental challenges to tackle. Students work in teams that unite social scientists, sustainability experts, conservation biologists and ecologists, and physical scientists to bring the specific expertise gained during their concentration studies together to tackle pressing environmental challenges. Offers students an opportunity to provide solutions to the problems proposed by our stakeholders, as well as to learn leadership and communication skills needed to head up a large project and to thrive in a transdisciplinary environment.

ENVR 4500. Applied Hydrogeology. 4 Hours.
Covers the origin, distribution, and flow of groundwater in permeable sediments and bedrock; hydrological and geological characteristics of aquifers; regional flow systems emphasizing rock structure, stratigraphy, and other aspects of the geological environment; principles of hydrogeologic mapping and analysis; and introduces well testing and well hydraulics. Uses methods of collecting data about the physical distribution and properties of water and its interaction with geologic materials in the subsurface, including its chemical composition, and mathematical models to interpret the direction and velocity of groundwater flow. Considers remediation strategies for dealing with contaminated water in the subsurface.

ENVR 4501. Lab for ENVR 4500. 1 Hour.
Accompanies ENVR 4500. Covers topics from the course through various experiments.

ENVR 4504. Environmental Pollution. 4 Hours.
Describes models and methods for predicting fate and transport of organic contaminants within and between environmental media, including molecular diffusion, transport across boundaries, and box models. Uses chemical structure and thermodynamic properties to predict physical processes that control the distribution of contaminants between the atmosphere, fresh and marine surface waters, groundwater, soils, sediments, and biota. Introduces concepts linking environmental chemistry with ecotoxicology, including bioaccumulation, food web models, and risk assessment. Uses case studies and real-world scenarios to illustrate important concepts. Offers students an opportunity to develop the tools and skills necessary to determine the fate of organic chemicals released to the environment.

ENVR 4505. Wetlands. 4 Hours.
Presents an interdisciplinary overview of the physical, biological, and cultural aspects of wetlands. Topics covered include definitions, classification systems, origins, human use, and natural processes of wetland environments. Offers students an opportunity to learn about wetland hydrology, soils, and vegetation and their relationship to ecosystem processes, societal values, and management. Includes reading and analyzing the scientific literature and conducting in-class activities.

ENVR 4900. Earth and Environmental Science Capstone. 1 Hour.
Designed for students enrolled in concert with an approved 500–600-level environmental studies course (check with department office for up-to-date listings). Faculty help students to identify topics for individual research tailored to students' interests and the course content. Provides an opportunity for reflection about what the student has learned in the major, in their NU Core course work, and experiential learning. Required components include writing with revision and an oral presentation at a departmentwide capstone seminar late in the semester.

ENVR 4970. Junior/Senior Honors Project 1. 4 Hours.
Focuses on in-depth project in which a student conducts research or produces a product related to the student's major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8-credit honors project. May be repeated without limit.

ENVR 4971. Junior/Senior Honors Project 2. 4 Hours.
Focuses on second semester of in-depth project in which a student conducts research or produces a product related to the student’s major field. May be repeated without limit.

ENVR 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
ENVR 4992. Directed Study. 1-4 Hours.
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

ENVR 4993. Independent Study. 1-4 Hours.
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

ENVR 4996. Experimental Education Directed Study. 4 Hours.
Draws upon the student's approved experiential activity and integrates it with study in the academic major. Restricted to those students who are using the course to fulfill their experiential education requirement. May be repeated without limit.

ENVR 4997. Senior Thesis. 4 Hours.
Offers students an opportunity to prepare an undergraduate thesis under faculty supervision.

ENVR 5115. Advanced Topics in Environmental Geology. 4 Hours.
Examines selected topics in geology through an understanding of the basic processes, materials, and evolution. Topics include basin analysis, landform evolution, volcanology, or regional geology. May be repeated without limit.

ENVR 5150. Climate and Atmospheric Change. 4 Hours.
Offers an in-depth view of the processes that drive change in Earth's climate system. Examines the modern climate system and how and why climate changes through time. Introduces the tools used to explore past climates and changes, and explores the long-term and short-term controls on the climate system. Also introduces the application of climate models to develop future climate projections. Offers students an opportunity to obtain hands-on experience analyzing and interpreting climate data and model output.

ENVR 5190. Soil Science. 4 Hours.
Provides a description and evaluation of the physical, chemical, and biological properties of soils. Includes soil formation, soil types, and processes that occur in soil including the importance of these processes for the soil productivity and management of soil. Also covers sources, reactions, transports, and fates of chemical species in soils and associated water and air environments, as well as the chemical behavior of elements and compounds and the phenomena affecting natural and anthropogenic materials in soils.

ENVR 5201. Geologic Field Seminar. 4 Hours.
Studies aspects of geology/environmental science associated with a particular field setting, in the classroom, followed by an intensive field investigation. Examples include carbonate petrology and reef ecology, then field studies in the Bahamas; glacial geology and volcanology, followed by field studies in Iceland; or stratigraphy of the U.S. Southwest, with field studies in the Grand Canyon. Focuses on using field observations and field data to interpret modern and ancient geologic processes. May be repeated without limit.

ENVR 5202. Environmental Science Field Seminar Abroad. 4 Hours.
Offers an intensive environmental science field study experience associated with a particular off-campus geographic setting, such as Iceland, Newfoundland, Bahamas, etc. Offers students an opportunity to learn the principles of field study, to learn to recognize and record significant data, and to reach conclusions about a range of field-based problems being studied. May be repeated without limit.

ENVR 5210. Environmental Planning. 4 Hours.
Examines aspects of surface runoff from geomorphic and hydrologic perspectives. Develops methods for description and calculation of major river and drainage basin processes and applies the results to the planning process. Examines human modification of these systems—including urbanization, dams, and channelization—and applies this information to an understanding of regulatory processes. This is a writing-intensive course.

ENVR 5220. Ecosystem-Based Management. 4 Hours.
Introduces the principles and practice of ecosystem-based management. Covers how ecosystem-based management draws from social, economic, and ecological principles, as well as how these principles are fundamentally coupled. Begins by covering the evolution of resource management, from single-species to ecosystem-based approaches, including the strengths and challenges of each approach. Focuses on how ecosystem-based management has been applied to terrestrial, freshwater aquatic, and marine ecosystems, including challenges and successes of adopting this approach. Draws from a wide range of examples, including marine protected areas, terrestrial and marine spatial planning, and habitat restoration. Designed for upper-intermediate or advanced undergraduates and graduate students in environmental science and related fields.

ENVR 5240. Sedimentary Basin Analysis. 4 Hours.
Presents the analysis of sedimentary basins based on detailed study of sedimentary petrology, sedimentary structures, and stratigraphic sequences and fossils.

ENVR 5241. Lab for ENVR 5240. 1 Hour.
Accompanies ENVR 5240. Lab work uses geologic sections, suites of sedimentary rocks and thin sections, and drill cores and bore hole logs to interpret and analyze the geologic history and environmental and economic potential of sedimentary basins.

ENVR 5242. Ancient Marine Life. 4 Hours.
Begins with a survey of major events, processes, and important invertebrate phyla preserved in the fossil record. This knowledge of paleontology is then utilized to evaluate evolutionary principles and the nature of function and adaptation in the history of life. Organization of populations into paleocommunities and their relationships to changes in environments through time permit the assessment and evaluation of paleoecology in Earth history.

ENVR 5243. Lab for ENVR 5242. 1 Hour.
Accompanies ENVR 5242. Introduces invertebrate fossil morphology by study of fossil specimens of all major groups. Principles of paleoecology and evolutionary theory are illustrated by analysis of suites of fossil specimens.

ENVR 5260. Geographical Information Systems. 4 Hours.
Examines geographical information systems (GIS), a way to input, store, analyze, and display spatial data (data with a geographic location). Introduces the major components and applications of this exciting new tool. Consists of two lectures and one laboratory period a week. Laboratory exercises introduce methods of data analysis as well as practical issues of how to manipulate various GIS software packages.

ENVR 5270. Glacial and Quaternary History. 4 Hours.
Examines the environmental conditions conducive to forming glaciers, the processes of ice movement, glacial erosion, modes of deposition, and the resulting landforms created under and around glaciers. Introduces the natural climate change of the ice age cycles and the major events of the Quaternary period.

ENVR 5271. Lab for ENVR 5270. 1 Hour.
Accompanies ENVR 5270. Covers topics from the course through various experiments.
ENVR 5350. Sustainable Energy and Climate Solutions. 4 Hours.
Examines the role of sustainable energy on emissions from energy production and the resulting impacts on climate changes. Introduces current observations, predictions of future climate change, and the resulting impacts on ecological and human systems. Assesses past and current sources of U.S. energy-related and non-energy-related sources of greenhouse gases. Reviews sustainable energy alternatives and emission reduction strategies with a focus on comparing moderate and deep decarbonization strategies and the overall goal of reaching zero net emissions.

ENVR 5450. Applied Social-Ecological Systems Modeling. 4 Hours.
Covers the key frameworks, theories, and approaches for conducting social-ecological systems (SES) research. Involves topic and paper discussions focused on developing detailed knowledge and agility at describing the theoretical and applied foundations of interdisciplinary SES research. Includes semester-long projects to develop hands-on skills for conducting robust, methodologically sound studies of social-ecological systems. Particularly emphasizes participatory modeling as a tool for both scientific inquiry and stakeholder engagement. Students complete a participatory modeling project, including all steps of the scientific process, and have an opportunity to gain experience with research design, data collection, analysis, interpretation, and communication.

ENVR 5563. Advanced Spatial Analysis. 4 Hours.
Offers an in-depth evaluation of theoretical, mathematical, and computational foundations of geographic information systems (GIS). Examines advanced concepts and techniques in GIS analysis and spatial statistics methods. Topics include spatial information theory, database theory, mathematical models of spatial objects, and GIS-based representation.

ENVR 5984. Research. 1-4 Hours.
Offers an opportunity to conduct research under faculty supervision. May be repeated without limit.

Environmental Studies Courses
Search ENVS Courses using FocusSearch (http://catalog.northeastern.edu/class-search/?subject=ENVS)

ENVS 1990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ENVS 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ENVS 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ENVS 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ENVS 4991. Research. 4 Hours.
Offers an opportunity to conduct research under faculty supervision.

ENVS 4997. Senior Thesis. 4 Hours.
Offers students an opportunity to prepare an undergraduate thesis under faculty supervision.