

ENVIRONMENTAL SCIENCE (ENSCI)

Courses primarily for undergraduates:

ENSCI 1100: Orientation to Environmental Science

Credits: 1. Contact Hours: Lecture 1.

Overview of Environmental Science curriculum and discussion of professional opportunities. Offered on a satisfactory-fail basis only. (Typically Offered: Fall)

ENSCI 2010: Introduction to Environmental Issues

(Cross-listed with BIOL 2010/ ENVS 2010).

Credits: 2. Contact Hours: Lecture 2.

Discussion of current and emerging environmental issues such as human population growth, energy use, loss of biodiversity, water resources, and climate change. (Typically Offered: Fall)

ENSCI 2020: Exploration of Environmental and Sustainability Issues

Credits: 1. Contact Hours: Lecture 1.

Exploration of specific environmental and sustainability issues; designed to complement ENSCI 2010. (Typically Offered: Fall)

ENSCI 2030: Exploration of Environmental Science

Credits: 1. Contact Hours: Lecture 1.

Continued exploration of specific environmental science issues developed in ENSCI 2020. Topics may vary in different years. (Typically Offered: Spring)

ENSCI 2500: Environmental Geography

(Cross-listed with AGRON 2500/ ENVS 2500/ NREM 2500).

Credits: 3. Contact Hours: Lecture 3.

The distribution, origins and functions of the earth's physical systems and the spatial relationship between human activity and the natural world. (Typically Offered: Fall)

ENSCI 2510: Biological Processes in the Environment

(Cross-listed with BIOL 2510).

Credits: 3. Contact Hours: Lecture 3.

Principles of Biology from the level of macromolecules to the biosphere. Biological processes that affect environmental systems: including metabolism, energy pathways, biochemical reactions in cells, plant and microbial structure and function, element and water cycles. (Typically Offered: Spring)

ENSCI 2700: Geospatial Technologies

(Cross-listed with AGRON 2700).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Concepts and tools for acquiring, managing, analyzing, and displaying geographic information, including GIS, remote sensing, spatial analysis, and cartography. Focus on applications in biological, ecological, environmental, and agricultural sciences. (Typically Offered: Spring)

ENSCI 3010: Natural Resource Ecology and Soils

(Cross-listed with NREM 3010).

Credits: 4. Contact Hours: Lecture 3, Laboratory 3.

Prereq: BIOL 2110, BIOL 2110L; FOR 2010 *or a second course in biology*
Effects of environmental factors on ecosystem structure and function using forest, prairie and agricultural ecosystems as models. Special emphasis is given to soil-forming factors and the role of soil in nutrient and water cycling and ecosystem dynamics. Additional emphasis is given to human influences on natural ecosystems and the role of perennial plant communities in agricultural landscapes. (Typically Offered: Fall)

ENSCI 3120: Ecology

(Cross-listed with AECL 3120/ BIOL 3120).

Credits: 4. Contact Hours: Lecture 3, Laboratory 3.

Prereq: BIOL 2110; (BIOL 2120 *or* BIOL 2510)

Fundamental concepts and principles of ecology dealing with organisms, populations, communities, and ecosystems. Laboratory and field exercises examine ecological principles and methods as well as illustrate habitats. (Typically Offered: Fall, Summer)

ENSCI 3180: Introduction to Ecosystems

(Cross-listed with AGRON 3180/ BIOL 3180/ NREM 3180).

Credits: 3. Contact Hours: Lecture 3.

Prereq: 12 credits in AECL, AGRON, BIOL, CHEM, FOR, GEOL, NREM

Biological and physical processes affecting material and energy flows in natural and managed ecosystems. Understanding and predicting climate and management impacts on ecosystem services and sustainability. (Typically Offered: Spring)

ENSCI 3190: Analysis of Environmental Systems

(Cross-listed with BIOL 3190/ ENVS 3190).

Credits: 3. Contact Hours: Lecture 3.

Prereq: ENSCI 3120; *junior classification*

Systems approach to the analysis and modeling of material and energy flows in natural and managed environmental systems and the primary environmental factors controlling these systems. Applications in hydrology, biogeochemistry, and population dynamics. (Typically Offered: Spring)

ENSCI 3240: Energy and the Environment

(Cross-listed with GEOL 3240/ ENVS 3240/ MTEOR 3240).

Credits: 3. Contact Hours: Lecture 3.

Prereq: CHEM 1630, CHEM 1670, or CHEM 1770

Exploration of the origin of Earth's energy resources and the environmental and climatic impacts of energy acquisition and consumption. Renewable and non-renewable energy resources within an Earth-system context. Various environmentally-relevant topics such as water quality and availability, habitat destruction, greenhouse-gas emissions, and health and safety hazards to wildlife and human communities. (Typically Offered: Spring)

ENSCI 3450: Natural Resource Photogrammetry and Geographic Information Systems

(Cross-listed with NREM 3450).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: Junior classification

Measurement and interpretation of aerial photos in resource management. Introduction to Geographic Information Systems (GIS) using ArcGIS including digitizing, development and query of attribute tables, georeferencing, and use of multiple GIS layers in simple spatial analyses. (Typically Offered: Spring)

ENSCI 3600: Environmental Soil Science

(Cross-listed with AGRON 3600).

Credits: 3. Contact Hours: Lecture 3.

Application of soil science to contemporary environmental problems; comparison of the impacts that different management strategies have on short- and long-term environmental quality and land development. Emphasis on participatory learning activities. AGRON 1820 or ENSCI 2500 or GEOL 1010 recommended. (Typically Offered: Spring)

ENSCI 3700: GIS for Ecology and Environmental Science

(Cross-listed with BIOL 3700).

Credits: 1-6. Repeatable.

Prereq: 6 credits BIOL; permission of instructor

Introduction to geographic information systems (GIS) with emphasis on ecological and environmental applications. No prior GIS experience required. Guided, individualized study of topics based on student background and interest. For students with prior experience, topics and activities are selected to build upon any previous experience and minimize duplication to previous GIS coursework. Potential topics include: basic concepts of GIS, data structures, database management, spatial analysis, modeling and visualization of ecological and environmental data. Case studies in ecological and environmental applications using ArcGIS. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring)

ENSCI 3750: Marine Ecology and Ecosystems Dynamics

(Cross-listed with AECL 3750/ BIOL 3750).

Credits: 3. Contact Hours: Lecture 3.

Prereq: BIOL 2110

Overview of the ecological processes, ecosystems, and biodiversity in marine environments. Ever-changing dynamics caused by environmental disturbances, internal forces, or by human impacts on species and ecosystems. (Typically Offered: Spring)

ENSCI 3900: Internship in Environmental Science

Credits: 1-30. Repeatable.

Prereq: Instructor Permission for Course

Supervised off-campus work experience in the field of environmental science. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring, Summer)

ENSCI 3910: Apprenticeship

Credits: 1-30. Repeatable.

Prereq: Instructor Permission for Course

Practical experience in an approved setting such as a research laboratory, government office, or private office. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring, Summer)

ENSCI 4020: Watershed Hydrology

(Dual-listed with GEOL 5020/ ENSCI 5020/ MTEOR 5020/ NREM 5020).

(Cross-listed with GEOL 4020/ MTEOR 4020/ NREM 4020).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Examination of watersheds as systems, emphasizing the surface components of the hydrologic cycle. Combines qualitative understanding of hydrological processes and uncertainty with quantitative representation. Laboratory emphasizes field investigation and measurement of watershed processes. (Typically Offered: Fall)

ENSCI 4040: Global Change

(Dual-listed with MTEOR 5040/ AGRON 5040/ ENSCI 5040). (Cross-listed with AGRON 4040/ MTEOR 4040/ ENVS 4040).

Credits: 3. Contact Hours: Lecture 3.

Recent changes in global biogeochemical cycles and climate; models of future changes in the climate system; impacts of global change on agriculture, water resources and human health; ethical issues of global environmental change. (Typically Offered: Fall, Spring)

ENSCI 4050: Soil-Plant-Animal-Atmosphere Physics

(Dual-listed with AGRON 5050/ ENSCI 5050/ MTEOR 5050). (Cross-listed with AGRON 4050/ MTEOR 4050).

Credits: 3. Contact Hours: Lecture 3.

Prereq: MATH 1600 or MATH 1650

The movement of energy and mass among the soil, vegetation, and atmosphere. The heat and water budget of humans, other animals, plants, and plant communities. Relevance to weather and climate, the effect of climate change on organisms, and remote sensing. Some exposure to computer programming (any language) recommended. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4060: World Climates

(Cross-listed with AGRON 4060/ MTEOR 4060).

Credits: 3. Contact Hours: Lecture 3.

Prereq: AGRON 2060 or MTEOR 2060

Distribution and causes of different climates around the world. Effects of climate and climate variations on human activities including society, economy and agriculture. Current issues such as climate change and international efforts to assess and mitigate the consequences of a changing climate. Semester project and in-class presentation required. Meets International Perspectives Requirement. (Typically Offered: Spring)

ENSCI 4070: Watershed Management

(Dual-listed with NREM 5070/ ENSCI 5070). (Cross-listed with NREM 4070/ ENVS 4070).

Credits: 4. Contact Hours: Lecture 3, Laboratory 3.

Prereq: 1 course in BIOL

Managing human impacts on the hydrologic cycle. Field and watershed level best management practices for modifying the impacts on water quality, quantity and timing are discussed. Field project includes developing a management plan using landscape buffers. (Typically Offered: Spring)

ENSCI 4090: Field Methods in Hydrogeology

(Dual-listed with GEOL 5090/ ENSCI 5090). (Cross-listed with GEOL 4090).

Credits: 3. Contact Hours: Laboratory 4.

Prereq: GEOL 4020/ENSCI 4020, GEOL 4110/ENSCI 4110 or CE 4730

Introduction to field methods used in groundwater investigations. In-field implementation of pumping tests, slug tests, monitoring well installation and drilling techniques, geochemical and water quality sampling, seepage meters, minipiezometers, stream gaging, and electronic instrumentation for data collection. Field trips to investigate water resource, water quality, and remediation projects. Offered even-numbered years. (Typically Offered: Summer)

ENSCI 4110: Hydrogeology

(Dual-listed with GEOL 5110/ ENSCI 5110). (Cross-listed with GEOL 4110).

Credits: 4. Contact Hours: Lecture 3, Laboratory 2.

Physical principles of groundwater flow, nature and origin of aquifers and confining units, well hydraulics, groundwater modeling, and contaminant transport. Lab emphasizes applied field and laboratory methods for hydrogeological investigations. (Typically Offered: Spring)

ENSCI 4120: Micropaleontology

(Dual-listed with GEOL 5120). (Cross-listed with GEOL 4120).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: GEOL 1020 and GEOL 1020L

Evolution, identification and utility of major microfossil groups from the Mesozoic to present. Focus on Cenozoic applications including biostratigraphy, paleoclimate, and paleothermometry using assemblages, stable isotopes, Mg/Ca, and molecular fossils. Laboratory includes processing and analysis of specific microfossils. Major groups covered include foraminifera, calcareous nanofossils, sponge spicules, diatoms, radiolarians, and silicoflagellates. Offered even-numbered years. (Typically Offered: Fall)

ENSCI 4130: Applied and Environmental Geophysics

(Dual-listed with GEOL 5130/ CE 5130/ ENSCI 5130). (Cross-listed with CE 4130/ GEOL 4130).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Seismic, gravity, magnetic, resistivity, electromagnetic, and ground-penetrating radar techniques for shallow subsurface investigations and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with seismic - and resistivity-imaging systems and radar. Introductory geology, algebra, and trigonometry recommended. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4140: Applied Groundwater Flow Modeling

(Dual-listed with GEOL 5140/ ENSCI 5140). (Cross-listed with GEOL 4140).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: (GEOL 4110 or CE 4730); MATH 1650

Introduction to the principles of modeling groundwater flow systems. Finite-difference and analytic-element methods, spreadsheet models, boundary conditions, calibration, sensitivity analysis, parameter estimation, particle tracking, and post-audit analysis. Application of MODFLOW to regional flow-system analysis. Computer laboratory emphasizes assigned problems that illustrate topics discussed in the course. Offered even-numbered years. (Typically Offered: Spring)

ENSCI 4150: Paleoclimatology

(Dual-listed with GEOL 5150/ ENSCI 5150). (Cross-listed with GEOL 4150).

Credits: 3. Contact Hours: Lecture 3.

Introduction to mechanisms that drive climate, including the interplay between oceanic and atmospheric circulation and fluctuation in Earth's orbital parameters. Examination and analysis of past climate records ranging from historical documentation to ecological and geochemical proxies (e.g. tree ring analysis; O and C isotopes of skeletal carbonates and soils). Dating methods used to constrain and correlate climatic periods; utility of computer models to reconstruct past climates and predict future climate change. Emphasis placed on paleoclimatology and paleoecology of the late Quaternary (last ~1 million years). Offered even-numbered years. (Typically Offered: Fall)

ENSCI 4160: Hydrologic Modeling and Analysis

(Dual-listed with GEOL 5160/ ENSCI 5160/ MTEOR 5160). (Cross-listed with GEOL 4160/ MTEOR 4160).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Study of the basic principles of hydrologic modeling, including rainfall-runoff analysis, lumped and distributed modeling, conceptual and physical models, parameter estimation and sensitivity analysis, input and validation data, uncertainty analysis, and the use of models in surface water hydrology. A range of common models are applied to study hydrologic topics such as flood forecasting and land use change impacts. Previous experience with Matlab or other programming language is needed. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4180: Stream Ecology

(Dual-listed with AECL 5180/ ENSCI 5180). (Cross-listed with AECL 4180).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: AECL 4860

Biological, chemical, physical, and geological processes that determine the structure and function of flowing water ecosystems. Current ecological theories as well as applications to stream management for water quality and fisheries. Offered odd-numbered years. (Typically Offered: Fall)

ENSCI 4190: Aqueous and Environmental Geochemistry

(Dual-listed with GEOL 5190/ ENSCI 5190). (Cross-listed with GEOL 4190).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: CHEM 1780, CHEM 1780L and *Junior classification*

Geochemistry of natural waters and water-rock interactions. Acid-base equilibria, carbonate chemistry and buffer systems, mineral dissolution and precipitation, sorption, ion exchange, and redox reactions. Introduction to thermodynamics and kinetics. Laboratory emphasizes chemical analysis of waters and computer modeling. Offered even-numbered years. (Typically Offered: Spring)

ENSCI 4200: Environmental Engineering Chemistry

(Dual-listed with CE 5200/ ENSCI 5200). (Cross-listed with CE 4200).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: CE 3260, CHEM 1780

Geology and geochemistry of non-metallic and metallic ore deposits. Major processes that concentrate metals in the Earth. Geochemical conditions of ore formation using stable-isotope and fluid-inclusion studies. Laboratory emphasizes the study of metallic ores. Offered even-numbered years. (Typically Offered: Fall)

ENSCI 4240A: Air Pollution: Air Quality and Effects of Pollutants

(Dual-listed with CE 5240A/ ABE 5240A/ ENSCI 5240A). (Cross-listed with ABE 4240A/ CE 4240A).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); *Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

ENSCI 4240B: Air Pollution: Climate Change and Causes

(Dual-listed with CE 5240B/ ABE 5240B/ ENSCI 5240B). (Cross-listed with ABE 4240B/ CE 4240B).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); *Senior classification or above*

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

ENSCI 4240C: Air Pollution: Transportation Air Quality

(Dual-listed with CE 5240C/ ABE 5240C/ ENSCI 5240C). (Cross-listed with ABE 4240C/ CE 4240C).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); *Senior classification or above*

ENSCI 4240D: Air Pollution: Off-Gas Treatment Technology

(Dual-listed with CE 5240D/ ABE 5240D/ ENSCI 5240D). (Cross-listed with ABE 4240D/ CE 4240D).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); Senior classification or above

ENSCI 4240E: Air Pollution: Agricultural Sources of pollution

(Dual-listed with CE 5240E/ ABE 5240E/ ENSCI 5240E). (Cross-listed with ABE 4240E/ CE 4240E).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); Senior classification or above

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

ENSCI 4260: Stable Isotopes in the Environment

(Dual-listed with GEOL 5260/ ENSCI 5260). (Cross-listed with GEOL 4260).

Credits: 3. Contact Hours: Lecture 3.

Introduction to the theory, methods and applications of stable isotopes.

Primary focus on the origin, natural abundance, and fractionation of carbon, hydrogen, oxygen, nitrogen isotopes. Applications of isotopic occurrence for elucidation of physical, chemical, biological, and environmental processes. Effects of plant physiology, photosynthesis, trophic structure, diffusion, evaporation, chemical precipitation, soil and atmospheric processes, and environmental factors on isotope abundance. Offered odd-numbered years. (Typically Offered: Fall)

ENSCI 4460: Integrating GPS and GIS for Natural Resource Management

(Dual-listed with NREM 5460/ ENSCI 5460). (Cross-listed with NREM 4460).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: 12 credits in student's major (AECL/FOR) at 3000 level or above

Emphasis on the use of GPS as a data collection tool for GIS. Basic theory of GPS. Use of Global Positioning System technology for spatial data collection and navigation. Post-processing and real-time correction of GPS data. GPS data transfer to GIS for mapping applications. Use of GIS to construct waypoints for use in GPS navigation. (Typically Offered: Fall)

ENSCI 4520: Intro GIS for Geoscientists

(Dual-listed with GEOL 5520/ AGRON 5520/ ENSCI 5520). (Cross-listed with AGRON 4520/ GEOL 4520).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Introduction to geographic information systems (GIS) using ArcGIS Pro with particular emphasis on geoscientific data. Teaches typical GIS operations and analyses in the geosciences to prepare students for practical use of GIS in industry and academia. Includes a class project for GEOL 5520. Sophomore classification or above recommended. (Typically Offered: Fall, Spring)

ENSCI 4590: Environmental Soil and Water Chemistry

(Dual-listed with AGRON 5590/ ENSCI 5590). (Cross-listed with AGRON 4590).

Credits: 4. Contact Hours: Lecture 3, Laboratory 3.

Prereq: 6 credit of CHEM; (AGRON 1820 or AGRON 3600); MATH 1400 or higher

An introduction to the chemical properties of soils, chemical reactions and transformations in soils and surface waters, and their impact on the environment. Topics include solution chemistry in soils and surface waters, solid-phase composition of soils, reactions at the solid-solution interface, and applications to contemporary environmental issues. AGRON 3540; GEOL 1000 recommended. (Typically Offered: Fall)

ENSCI 4630: Soil Formation and Landscape Relationships

(Dual-listed with AGRON 5630/ ENSCI 5630). (Cross-listed with AGRON 4630).

Credits: 3. Contact Hours: Lecture 3.

Relationships between soil formation, geomorphology, and environment. Soil description, classification, geography, mapping, and interpretation for land use. Two weekend field trips. AGRON 1820 or ENSCI 2500 recommended. Graduation Restriction: Credit for one of AGRON 4630 or AGRON 4630L may be applied for graduation. (Typically Offered: Fall)

ENSCI 4640: Wetland Ecology

(Dual-listed with EEOB 5640/ ENSCI 5640). (Cross-listed with BIOL 4640).

Credits: 3. Contact Hours: Lecture 3.

Prereq: 15 credits in BIOL

Ecology, classification, creation and restoration, and management of wetlands. Emphasis on North American temperate wetlands. (Typically Offered: Fall, Spring, Summer)

ENSCI 4660: Ecosystem Services

(Dual-listed with ENSCI 5660/ NREM 5660). (Cross-listed with NREM 4660).

Credits: 3. Contact Hours: Lecture 2, Discussion 1.

Prereq: 15 credits in AECL, AGRON, BIOL, CHEM, FOR, GEOL, NREM

Ecosystem services are the societal benefits provided by natural and managed ecosystems. Benefits such as provision of food, purification of air and water, and regulation of climate are essential to human survival and prosperity, but rely upon maintenance of healthy ecosystems. This course will cover the science, policy, and practice of ecosystem services assessment and management, with a special focus on biodiversity, water quality, food production, and climate. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4680: Applied Geostatistics for Geoscientists

(Dual-listed with GEOL 5680/ ENSCI 5680/ MTEOR 5680). (Cross-listed with GEOL 4680/ MTEOR 4680).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: GEOL 4520; CRP 3510; CRP 4520; (NREM 3450 or NREM 4470)

Introduction to geospatial data collection, analysis, interpretation, and presentation. Geospatial techniques including geographic information systems (GIS), remote sensing (RS), and global positioning systems (GPS). Study of applied geostatistical analysis (e.g., interpolation and spatial regression). Offered even-numbered years. (Typically Offered: Fall)

ENSCI 4770: Soil Physics

(Dual-listed with AGRON 5770/ ENSCI 5770). (Cross-listed with AGRON 4770).

Credits: 3. Contact Hours: Lecture 3.

The physical soil system: the soil components and their physical interactions; transport processes involving water, air, and heat. AGRON 1820 recommended. (Typically Offered: Spring)

ENSCI 4790: Surficial Processes

(Dual-listed with GEOL 5790/ ENSCI 5790). (Cross-listed with GEOL 4790).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

The study of physical processes that shape Earth's surface. Topics include weathering, sediment transport, and landform genesis with emphasis on fluvial, glacial, hillslope, eolian, and coastal processes. Applications to engineering and environmental problems. Laboratory includes topographic map interpretation and local field trips. An introductory course in geology is recommended as background. (Typically Offered: Fall)

ENSCI 4800: Engineering Analysis of Biological Systems

(Dual-listed with ABE 5800). (Cross-listed with ABE 4800/ GLOBE 4800).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: ABE 3800 or Permission of Department

Systems-level quantitative analysis of various biological systems, including applications in foods, feeds, biofuels, bioenergy, and other bio-based systems. Introduction to techno-economic analysis and life-cycle assessment of these systems at multiple production scales. Applying these tools to evaluate and improve cost and sustainability performance. Students enrolled in ABE 5800 will be required to conduct additional learning activities. (Typically Offered: Fall)

ENSCI 4830: Environmental Biogeochemistry

(Dual-listed with ENSCI 5830). (Cross-listed with BIOL 4830/ GEOL 4830).

Credits: 3. Contact Hours: Lecture 3.

Prereq: Combined 12 credits in biology, chemistry, and physics

An exploration of biological, physical and geochemical impacts on the structure and function of ecosystems from local to global scales. Emphasis on the cycles of carbon, nitrogen, phosphorus, sulfur, and metals, and how these have been impacted by human activity. Topics may include biological feedbacks to climate change, microbial physiology and redox reactions, plant/soil feedbacks, terrestrial/aquatic linkages, early Earth processes and the origins of life. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4840: Ecosystem Ecology

(Cross-listed with BIOL 4840).

Credits: 3. Contact Hours: Lecture 3.

Prereq: Combined 12 credits in biology, chemistry, and physics

Introduction of the study of ecosystems and the biological and physical factors that influence their properties and dynamics. Conceptual foundations for ecosystem studies. Interactions among organisms, biological diversity, and ecosystem attributes. Quantitative analyses of accumulations, transformations, and fluxes of nutrients, water, and energy within and among ecosystems. Global change issues. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4850: Soil and Environmental Microbiology

(Dual-listed with AGRON 5850/ ENSCI 5850/ MICRO 5850). (Cross-listed with AGRON 4850/ MICRO 4850).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: AGRON 1820

The living organisms in the soil and what they do. Emphasis on soil biota composition, the carbon cycle and bioremediation, soil-plant-microbial relationships, and environmental issues. MICRO 2010; MICRO 2010L recommended. (Typically Offered: Fall)

ENSCI 4860: Aquatic Ecology

(Dual-listed with AECL 5860/ EEOB 5860/ ENSCI 5860). (Cross-listed with AECL 4860/ BIOL 4860).

Credits: 3. Contact Hours: Lecture 3.

Prereq: BIOL 3120 or ENSCI 3190 or ENSCI 4020 or NREM 3010

Structure and function of aquatic ecosystems with application to fishery and pollution problems. Emphasis on lacustrine, riverine, and wetland ecology. (Typically Offered: Fall)

ENSCI 4860L: Aquatic Ecology Laboratory

(Dual-listed with AECL 5860L/ EEOB 5860L/ ENSCI 5860L). (Cross-listed with AECL 4860L/ BIOL 4860L).

Credits: 1. Contact Hours: Laboratory 3.

Prereq: Concurrent enrollment in BIOL 4860

Field trips and laboratory exercises to accompany 4860. Hands-on experience with aquatic research and monitoring techniques and concepts. (Typically Offered: Fall)

ENSCI 4870: Microbial Ecology

(Dual-listed with EEOB 5870/ ENSCI 5870/ GEOL 5870/ MICRO 5870).

(Cross-listed with BIOL 4870/ GEOL 4870/ MICRO 4870).

Credits: 3. Contact Hours: Lecture 3.

Prereq: 6 credits in Biology and 6 credits in Chemistry

Introduction to major functional groups of autotrophic and heterotrophic microorganisms and their roles in natural and environmental systems. Consequences of microbial activity on water chemistry, weathering, and precipitation/dissolution reactions will be emphasized. (Typically Offered: Fall)

ENSCI 4880: Raster GIS for Geoscientists

(Dual-listed with GEOL 5880/ AGRON 5880/ ENSCI 5880). (Cross-listed with AGRON 4880/ GEOL 4880).

Credits: 3.

GIS course with focus on the spatial analysis and modeling of raster and triangulated irregular network (TIN) data using ArcGIS Pro. Includes practical exercises during lectures, lab exercises, homework assignments, and (for GEOL 5880) a class project. Basic knowledge of ArcGIS Pro is a plus but not required. Course can be taken concurrently to any other Intro GIS course. Sophomore classification or above recommended. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 4890: Survey of Remote Sensing Technologies

(Dual-listed with MTEOR 5890/ EE 5890/ ENSCI 5890/ GEOL 5890/ NREM 5890). (Cross-listed with EE 4890/ MTEOR 4890/ GEOL 4890/ NREM 4890).

Credits: 3. Contact Hours: Lecture 3.

Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S. (Typically Offered: Fall)

ENSCI 4900: Independent Study

Credits: 1-30. Repeatable.

Prereq: Instructor Permission for Course

(Typically Offered: Fall, Spring, Summer)

ENSCI 4900H: Independent Study: Honors

Credits: 1-30. Repeatable.

Prereq: Instructor Permission for Course

Permission of instructor and approval of Environmental Science coordinator. (Typically Offered: Fall, Spring, Summer)

ENSCI 4950: Current Topics and Case Studies in Environmental Science

Credits: 1-3. Contact Hours: Lecture 2, Laboratory 2.

Current topics and case studies related to the analysis and management of environmental systems. Individual and/or group projects.

ENSCI 4960A: Travel Course: International Tour

Credits: 1-30. Repeatable.

Extended field trips to study environmental topics in varied locations. Location and duration of trips will vary. Trip expenses paid by students. Check with department for current offerings.

ENSCI 4960B: Travel Course: Domestic Tour

Credits: 1-30. Repeatable.

Extended field trips to study environmental topics in varied locations. Location and duration of trips will vary. Trip expenses paid by students. Check with department for current offerings.

ENSCI 4980: Cooperative Education

Credits: Required. Repeatable.

Required of all cooperative education students. Students must register prior to commencing each work period. (Typically Offered: Fall, Spring, Summer)

Courses primarily for graduate students, open to qualified undergraduates:**ENSCI 5020: Watershed Hydrology**

(Dual-listed with GEOL 4020/ ENSCI 4020/ MTEOR 4020/ NREM 4020).

(Cross-listed with GEOL 5020/ MTEOR 5020/ NREM 5020).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Examination of watersheds as systems, emphasizing the surface components of the hydrologic cycle. Combines qualitative understanding of hydrological processes and uncertainty with quantitative representation. Laboratory emphasizes field investigation and measurement of watershed processes. (Typically Offered: Fall)

ENSCI 5040: Global Change

(Dual-listed with ENVS 4040/ MTEOR 4040/ AGRON 4040/ ENSCI 4040).
(Cross-listed with AGRON 5040/ MTEOR 5040).

Credits: 3. Contact Hours: Lecture 3.

Recent changes in global biogeochemical cycles and climate; models of future changes in the climate system; impacts of global change on agriculture, water resources and human health; ethical issues of global environmental change. (Typically Offered: Fall, Spring)

ENSCI 5050: Soil-Plant-Animal-Atmosphere Physics

(Dual-listed with AGRON 4050/ ENSCI 4050/ MTEOR 4050). (Cross-listed with AGRON 5050/ MTEOR 5050).

Credits: 3. Contact Hours: Lecture 3.

Prereq: MATH 1600 or MATH 1650

The movement of energy and mass among the soil, vegetation, and atmosphere. The heat and water budget of humans, other animals, plants, and plant communities. Relevance to weather and climate, the effect of climate change on organisms, and remote sensing. Some exposure to computer programming (any language) recommended. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 5070: Watershed Management

(Dual-listed with ENVS 4070/ NREM 4070/ ENSCI 4070). (Cross-listed with NREM 5070).

Credits: 4. Contact Hours: Lecture 3, Laboratory 3.

Managing human impacts on the hydrologic cycle. Field and watershed level best management practices for modifying the impacts on water quality, quantity and timing are discussed. Field project includes developing a management plan using landscape buffers. (Typically Offered: Spring)

ENSCI 5090: Field Methods in Hydrogeology

(Dual-listed with GEOL 4090/ ENSCI 4090). (Cross-listed with GEOL 5090).

Credits: 3. Contact Hours: Laboratory 4.

Introduction to field methods used in groundwater investigations. In-field implementation of pumping tests, slug tests, monitoring well installation and drilling techniques, geochemical and water quality sampling, seepage meters, minipiezometers, stream gaging, and electronic instrumentation for data collection. Field trips to investigate water resource, water quality, and remediation projects. Offered even-numbered years. (Typically Offered: Summer)

ENSCI 5110: Hydrogeology

(Dual-listed with GEOL 4110/ ENSCI 4110). (Cross-listed with GEOL 5110).

Credits: 4. Contact Hours: Lecture 3, Laboratory 2.

Physical principles of groundwater flow, nature and origin of aquifers and confining units, well hydraulics, groundwater modeling, and contaminant transport. Lab emphasizes applied field and laboratory methods for hydrogeological investigations. (Typically Offered: Fall)

ENSCI 5120: Micropaleontology

(Dual-listed with GEOL 4120). (Cross-listed with GEOL 5120).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Evolution, identification and utility of major microfossil groups from the Mesozoic to present. Focus on Cenozoic applications including biostratigraphy, paleoclimate, and paleothermometry using assemblages, stable isotopes, Mg/Ca, and molecular fossils. Laboratory includes processing and analysis of specific microfossils. Major groups covered include foraminifera, calcareous nannofossils, sponge spicules, diatoms, radiolarians, and silicoflagellates. Offered even-numbered years. (Typically Offered: Fall). (Typically Offered: Fall)

ENSCI 5130: Applied and Environmental Geophysics

(Dual-listed with GEOL 4130/ CE 4130/ ENSCI 4130). (Cross-listed with CE 5130/ GEOL 5130).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Seismic, gravity, magnetic, resistivity, electromagnetic, and ground-penetrating radar techniques for shallow subsurface investigations and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with seismic - and resistivity-imaging systems and radar. Introductory geology, algebra, and trigonometry recommended. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 5140: Applied Groundwater Flow Modeling

(Dual-listed with GEOL 4140/ ENSCI 4140). (Cross-listed with GEOL 5140).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Introduction to the principles of modeling groundwater flow systems. Finite-difference and analytic-element methods, spreadsheet models, boundary conditions, calibration, sensitivity analysis, parameter estimation, particle tracking, and post-audit analysis. Application of MODFLOW to regional flow-system analysis. Computer laboratory emphasizes assigned problems that illustrate topics discussed in the course. Offered even-numbered years. (Typically Offered: Spring)

ENSCI 5150: Paleoclimatology

(Dual-listed with GEOL 4150/ ENSCI 4150). (Cross-listed with GEOL 5150).

Credits: 3. Contact Hours: Lecture 3.

Introduction to mechanisms that drive climate, including the interplay between oceanic and atmospheric circulation and fluctuation in Earth's orbital parameters. Examination and analysis of past climate records ranging from historical documentation to ecological and geochemical proxies (e.g. tree ring analysis; O and C isotopes of skeletal carbonates and soils). Dating methods used to constrain and correlate climatic periods; utility of computer models to reconstruct past climates and predict future climate change. Emphasis placed on paleoclimatology and paleoecology of the late Quaternary (last ~1 million years). Offered even-numbered years. (Typically Offered: Fall)

ENSCI 5160: Hydrologic Modeling and Analysis

(Dual-listed with GEOL 4160/ ENSCI 4160/ MTEOR 4160). (Cross-listed with GEOL 5160/ MTEOR 5160).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Study of the basic principles of hydrologic modeling, including rainfall-runoff analysis, lumped and distributed modeling, conceptual and physical models, parameter estimation and sensitivity analysis, input and validation data, uncertainty analysis, and the use of models in surface water hydrology. A range of common models are applied to study hydrologic topics such as flood forecasting and land use change impacts. Previous experience with Matlab or other programming language is needed. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 5180: Stream Ecology

(Dual-listed with AECL 4180/ ENSCI 4180). (Cross-listed with AECL 5180).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: AECL 4860; or graduate standing

Biological, chemical, physical, and geological processes that determine the structure and function of flowing water ecosystems. Current ecological theories as well as applications to stream management for water quality and fisheries. Offered odd-numbered years. (Typically Offered: Fall)

ENSCI 5190: Aqueous and Environmental Geochemistry

(Dual-listed with GEOL 4190/ ENSCI 4190). (Cross-listed with GEOL 5190).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Geochemistry of natural waters and water-rock interactions. Acid-base equilibria, carbonate chemistry and buffer systems, mineral dissolution and precipitation, sorption, ion exchange, and redox reactions. Introduction to thermodynamics and kinetics. Laboratory emphasizes chemical analysis of waters and computer modeling. Offered even-numbered years. (Typically Offered: Spring)

ENSCI 5200: Environmental Engineering Chemistry

(Dual-listed with CE 4200/ ENSCI 4200). (Cross-listed with CE 5200).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: CE 3260, CHEM 1780 OR Graduate classification

Geology and geochemistry of non-metallic and metallic ore deposits. Major processes that concentrate metals in the Earth. Geochemical conditions of ore formation using stable-isotope and fluid-inclusion studies. Laboratory emphasizes the study of metallic ores. Offered even-numbered years. (Typically Offered: Fall)

ENSCI 5210: Environmental Biotechnology

(Cross-listed with CE 5210).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: CE 3260 OR Graduate classification

Fundamentals of biochemical and microbial processes applied to environmental engineering processes, role of microorganisms in wastewater treatment and bioremediation, bioenergetics and kinetics, metabolism of xenobiotic compounds, waterborne pathogens and parasites, and disinfection. Term paper and oral presentation. (Typically Offered: Fall)

ENSCI 5220: Water Pollution Control Processes

(Cross-listed with CE 5220).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: (CE 4210 or CE 5210)

Fundamentals of biochemical processes, aerobic growth in a single CSTR, multiple events in complex systems, and techniques for evaluating kinetic parameters; unit processes of activated sludge system, attached growth systems, stabilization and aerated lagoon systems, biosolids digestion and disposal, nutrient removal, and anaerobic treatment systems.

ENSCI 5230: Physical-Chemical Treatment Process

(Cross-listed with CE 5230).

Credits: 3.

Prereq: CE 5200

Mass balances. Principles and design of physical-chemical unit processes including ideal and realistic reactors; heterogeneous process including gas transfer, sorption, precipitation, and dissolution; redox; flocculation/coagulation; gravity separations; filtration; and membrane processes, electro dialysis, fouling, and scaling. Emphasis on water and wastewater treatment for environmental, health, and aesthetic ends. Case studies in secondary industries.

ENSCI 5240A: Air Pollution: Air Quality and Effects of Pollutants

(Dual-listed with CE 4240A/ ABE 4240A/ ENSCI 4240A). (Cross-listed with ABE 5240A/ CE 5240A).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); Senior classification or above

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

ENSCI 5240B: Air Pollution: Climate Change and Causes

(Dual-listed with CE 4240B/ ABE 4240B/ ENSCI 4240B). (Cross-listed with ABE 5240B/ CE 5240B).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); Senior classification or above

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

ENSCI 5240C: Air Pollution: Transportation Air Quality

(Dual-listed with CE 4240C/ ABE 4240C/ ENSCI 4240C). (Cross-listed with ABE 5240C/ CE 5240C).

Credits: 1. Contact Hours: Lecture 1.

Prereq: CE 5240A; CHEM 1780 or PHYS 2310 and PHYS 2310L; MATH 1660 or 3 credits in statistics. Senior classification or above.

ENSCI 5240D: Air Pollution: Off-Gas Treatment Technology

(Dual-listed with CE 4240D/ ABE 4240D/ ENSCI 4240D). (Cross-listed with ABE 5240D/ CE 5240D).

Credits: 1. Contact Hours: Lecture 1.

Prereq: CE 5240A, CE 5240B; Either PHYS 2310L or CHEM 1780 and either MATH 1660 or 3 credits in statistics. Senior classification or above

ENSCI 5240E: Air Pollution: Agricultural Sources of pollution

(Dual-listed with CE 4240E/ ABE 4240E/ ENSCI 4240E). (Cross-listed with ABE 5240E/ CE 5240E).

Credits: 1. Contact Hours: Lecture 1.

Prereq: (CHEM 1780 or [PHYS 2310; PHYS 2310L]); (MATH 1660 or 3 credits in STAT); Senior classification or above

1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

ENSCI 5260: Stable Isotopes in the Environment

(Dual-listed with GEOL 4260/ ENSCI 4260). (Cross-listed with GEOL 5260).

Credits: 3. Contact Hours: Lecture 3.

Introduction to the theory, methods and applications of stable isotopes.

Primary focus on the origin, natural abundance, and fractionation of carbon, hydrogen, oxygen, nitrogen isotopes. Applications of isotopic occurrence for elucidation of physical, chemical, biological, and environmental processes. Effects of plant physiology, photosynthesis, trophic structure, diffusion, evaporation, chemical precipitation, soil and atmospheric processes, and environmental factors on isotope abundance. Offered odd-numbered years. (Typically Offered: Fall)

ENSCI 5280: Solid and Hazardous Waste Management

(Cross-listed with CE 5280).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Prereq: CE 3260; junior or higher standing

Evaluation, characterization, assessment, planning and design of solid and hazardous waste management systems, regulatory requirements, material characterization and collection, minimization and recycling, energy and materials recovery, composting, off-gas treatment, incineration, stabilization, and landfill design. Design of treatment and disposal systems, including physical, chemical, and biological treatment, solidification, incineration, secure landfill design, and final disposal site closure plus restoration.

ENSCI 5310: Design and Evaluation of Soil and Water Conservation Systems

(Dual-listed with ABE 4310). (Cross-listed with ABE 5310).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Hydrology and hydraulics in agricultural and urbanizing watersheds. Design and evaluation of systems for the conservation and quality preservation of soil and water resources. Use and analysis of hydrologic data in engineering design; relationship of topography, soils, crops, climate, and cultural practices in conservation and quality preservation of soil and water for agriculture. Small watershed hydrology, water movement and utilization in the soil-plant-atmosphere system, agricultural water management, best management practices, and agricultural water quality. (Typically Offered: Fall)

ENSCI 5320: Nonpoint Source Pollution and Control

(Dual-listed with ABE 4320). (Cross-listed with ABE 5320).

Credits: 3.

Characteristics and mechanisms of non-point source (NPS) pollution in agricultural and urban watersheds, modeling of NPS pollution for terrestrial and aquatic systems, statistical tools to assess environmental datasets, strategies to control and manage NPS pollution of water bodies, and integrated watershed management. Graduate students are required to develop/deliver lecture models on assigned topics and/or complete additional assignments. Offered irregularly. (Typically Offered: Spring)

ENSCI 5330: Erosion and Sediment Transport

(Cross-listed with ABE 5330/ NREM 5330).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Soil erosion processes, soil loss equations and their application to conservation planning, sediment properties, initiation of sediment motion and over land flow, flow in alluvial channels and theory of sediment transport, channel stability, reservoir sedimentation, wind erosion, BMPs for controlling erosion. Offered even-numbered years. (Typically Offered: Fall)

ENSCI 5350: Restoration Ecology

(Cross-listed with EEOB 5350/ NREM 5350).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Theory and practice of restoring animal and plant diversity, structure and function of disturbed ecosystems. Restored freshwater wetlands, forests, prairies and reintroduced species populations will be used as case studies. Offered even-numbered years. (Typically Offered: Fall)

ENSCI 5370: Watershed Modeling and Policy

(Dual-listed with ABE 4370). (Cross-listed with ABE 5370).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

A project-based course on watershed-scale models for improving water quality. Legislative and judicial basis of the Total Maximum Daily Load (TMDL) program; approaches to TMDL development; principles and techniques for implementation; stakeholder engagement strategies. Hands-on experiences with GIS-interfaced models, data sources, calibration/validation, statistical assessment of model results, and simulation using multiple tools. In addition to other assignments, graduate students will present case studies of TMDLs using different modeling tools. Offered irregularly. (Typically Offered: Fall)

ENSCI 5460: Integrating GPS and GIS for Natural Resource Management

(Dual-listed with NREM 4460/ ENSCI 4460). (Cross-listed with

NREM 5460).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Emphasis on the use of GPS as a data collection tool for GIS. Basic theory of GPS. Use of Global Positioning System technology for spatial data collection and navigation. Post-processing and real-time correction of GPS data. GPS data transfer to GIS for mapping applications. Use of GIS to construct waypoints for use in GPS navigation. (Typically Offered: Fall)

ENSCI 5520: Intro GIS for Geoscientists

(Dual-listed with GEOL 4520/ AGRON 4520/ ENSCI 4520). (Cross-listed with AGRON 5520/ GEOL 5520).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Introduction to geographic information systems (GIS) using ArcGIS Pro with particular emphasis on geoscientific data. Teaches typical GIS operations and analyses in the geosciences to prepare students for practical use of GIS in industry and academia. Includes a class project for GEOL 5520. Sophomore classification or above recommended. (Typically Offered: Fall, Spring)

ENSCI 5530: Soil-Plant Relationships

(Cross-listed with AGRON 5530).

Credits: 3. Contact Hours: Lecture 3.

Prereq: AGRON 3540 or graduate standing

Composition and properties of soils in relation to the nutrition and growth of plants. (Typically Offered: Spring)

ENSCI 5590: Environmental Soil and Water Chemistry

(Dual-listed with AGRON 4590/ ENSCI 4590). (Cross-listed with

AGRON 5590).

Credits: 4. Contact Hours: Lecture 3, Laboratory 3.

An introduction to the chemical properties of soils, chemical reactions and transformations in soils and surface waters, and their impact on the environment. Topics include solution chemistry in soils and surface waters, solid-phase composition of soils, reactions at the solid-solution interface, and applications to contemporary environmental issues. AGRON 3540; GEOL 1000 recommended. (Typically Offered: Fall)

ENSCI 5630: Soil Formation and Landscape Relationships

(Dual-listed with AGRON 4630/ ENSCI 4630). (Cross-listed with AGRON 5630).

Credits: 3. Contact Hours: Lecture 3.

Relationships between soil formation, geomorphology, and environment. Soil description, classification, geography, mapping, and interpretation for land use. Two weekend field trips. AGRON 1820 or ENSCI 2500 recommended. Graduation Restriction: Credit for one of AGRON 4630 or AGRON 4630L may be applied for graduation. (Typically Offered: Fall)

ENSCI 5640: Wetland Ecology

(Dual-listed with BIOL 4640/ ENSCI 4640). (Cross-listed with EEOB 5640).

Credits: 3. Contact Hours: Lecture 3.

Ecology, classification, creation and restoration, and management of wetlands. Emphasis on North American temperate wetlands. (Typically Offered: Spring)

ENSCI 5660: Ecosystem Services

(Dual-listed with ENSCI 4660/ NREM 4660). (Cross-listed with NREM 5660).

Credits: 3. Contact Hours: Lecture 2, Discussion 1.

Ecosystem services are the societal benefits provided by natural and managed ecosystems. Benefits such as provision of food, purification of air and water, and regulation of climate are essential to human survival and prosperity, but rely upon maintenance of healthy ecosystems. This course will cover the science, policy, and practice of ecosystem services assessment and management, with a special focus on biodiversity, water quality, food production, and climate. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 5680: Applied Geostatistics for Geoscientists

(Dual-listed with GEOL 4680/ ENSCI 4680/ MTEOR 4680). (Cross-listed with GEOL 5680/ MTEOR 5680).

Credits: 3. Contact Hours: Lecture 2, Laboratory 2.

Introduction to geospatial data collection, analysis, interpretation, and presentation. Geospatial techniques including geographic information systems (GIS), remote sensing (RS), and global positioning systems (GPS). Study of applied geostatistical analysis (e.g., interpolation and spatial regression). Offered even-numbered years. (Typically Offered: Fall)

ENSCI 5710: Surface Water Hydrology

(Cross-listed with CE 5710).

Credits: 3. Contact Hours: Lecture 3.

Prereq: CE 3720

Analysis of hydrologic data including precipitation, infiltration, evapotranspiration, direct runoff and streamflow; theory and use of frequency analysis; theory of streamflow and reservoir routing; use of deterministic and statistical hydrologic models. Fundamentals of surface water quality modeling, point and non-point sources of contamination. (Typically Offered: Spring)

ENSCI 5720: Analysis and Modeling Aquatic Environments

(Cross-listed with CE 5720).

Credits: 3. Contact Hours: Lecture 3.

Prereq: CE 3720

Principles of surface water flows and mixing. Introduction to hydrologic transport and water quality simulation in natural water systems. Advection, diffusion and dispersion, chemical and biologic kinetics, and water quality dynamics. Applications to temperature, dissolved oxygen, primary productivity, and other water quality problems in rivers, lakes and reservoirs. Deterministic vs. stochastic models. Offered even-numbered years. (Typically Offered: Fall)

ENSCI 5730: Groundwater Hydrology

(Dual-listed with CE 4730). (Cross-listed with CE 5730).

Credits: 3. Contact Hours: Lecture 3.

Prereq: CE 3720 OR Graduate classification

Principles of groundwater flow, hydraulics of wells, super-position, slug and pumping tests, streamlines and flownets, and regional groundwater flow. Contaminant transport. Computer modeling. Individual and group projects. (Typically Offered: Fall)

ENSCI 5750: Soil Formation and Transformation

(Cross-listed with AGRON 5750).

Credits: 1. Contact Hours: Lecture 1.

A one-week intensive field class examining the pedology of Iowa under natural and transformed con. (Typically Offered: Fall)

ENSCI 5770: Soil Physics

(Dual-listed with AGRON 4770/ ENSCI 4770). (Cross-listed with AGRON 5770).

Credits: 3. Contact Hours: Lecture 3.

The physical soil system: the soil components and their physical interactions; transport processes involving water, air, and heat. AGRON 1820 recommended. (Typically Offered: Spring)

ENSCI 5780: Laboratory Methods in Soil Physics

(Cross-listed with AGRON 5780).

Credits: 1. Contact Hours: Laboratory 3.

Prereq: concurrent enrollment in AGRON 4770 or AGRON 5770

Methods of measuring soil physical properties such as texture, density, and water content, and transport of heat, water, and gases. (Typically Offered: Spring)

ENSCI 5790: Surficial Processes

(Dual-listed with GEOL 4790/ ENSCI 4790). (Cross-listed with GEOL 5790).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

The study of physical processes that shape Earth's surface. Topics include weathering, sediment transport, and landform genesis with emphasis on fluvial, glacial, hillslope, eolian, and coastal processes. Applications to engineering and environmental problems. Laboratory includes topographic map interpretation and local field trips. An introductory course in geology is recommended as background. (Typically Offered: Fall)

ENSCI 5830: Environmental Biogeochemistry

(Dual-listed with ENSCI 4830).

Credits: 3. Contact Hours: Lecture 3.

An exploration of biological, physical and geochemical impacts on the structure and function of ecosystems from local to global scales. Emphasis on the cycles of carbon, nitrogen, phosphorus, sulfur, and metals, and how these have been impacted by human activity. Topics may include biological feedbacks to climate change, microbial physiology and redox reactions, plant/soil feedbacks, terrestrial/aquatic linkages, early Earth processes and the origins of life. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 5840: Ecosystem Science

(Cross-listed with EEOB 5840).

Credits: 3. Contact Hours: Lecture 3.

Advanced studies of ecosystems and the biological and physical factors that influence their properties and dynamics. Conceptual foundations and modern approaches to ecosystem studies. Interactions among organisms, biological diversity, and ecosystem attributes. Quantitative analyses of accumulations, transformations, and fluxes of nutrients, water, and energy within and among ecosystems. Global change issues. Offered even-numbered years. (Typically Offered: Spring)

ENSCI 5850: Soil and Environmental Microbiology

(Dual-listed with AGRON 4850/ ENSCI 4850/ MICRO 4850). (Cross-listed with AGRON 5850/ MICRO 5850).

Credits: 3. Contact Hours: Lecture 2, Laboratory 3.

Prereq: AGRON 1820 or graduate standing

The living organisms in the soil and what they do. Emphasis on soil biota composition, the carbon cycle and bioremediation, soil-plant-microbial relationships, and environmental issues. MICRO 2010; MICRO 2010L recommended. (Typically Offered: Fall)

ENSCI 5860: Aquatic Ecology

(Dual-listed with AECL 4860/ BIOL 4860/ ENSCI 4860). (Cross-listed with AECL 5860/ EEOB 5860).

Credits: 3. Contact Hours: Lecture 3.

Prereq: BIOL 3120 or ENSCI 3810 or ENSCI 4020 or NREM 3010 or graduate classification

Structure and function of aquatic ecosystems with application to fishery and pollution problems. Emphasis on lacustrine, riverine, and wetland ecology. (Typically Offered: Fall)

ENSCI 5860L: Aquatic Ecology Laboratory

(Dual-listed with AECL 4860L/ BIOL 4860L/ ENSCI 4860L). (Cross-listed with AECL 5860L/ EEOB 5860L).

Credits: 1. Contact Hours: Laboratory 3.

Prereq: Concurrent enrollment in BIOL 4860

Field trips and laboratory exercises to accompany 4860. Hands-on experience with aquatic research and monitoring techniques and concepts. (Typically Offered: Fall)

ENSCI 5870: Microbial Ecology

(Dual-listed with BIOL 4870/ ENSCI 4870/ GEOL 4870/ MICRO 4870).

(Cross-listed with EEOB 5870/ GEOL 5870/ MICRO 5870).

Credits: 3. Contact Hours: Lecture 3.

Introduction to major functional groups of autotrophic and heterotrophic microorganisms and their roles in natural and environmental systems. Consequences of microbial activity on water chemistry, weathering, and precipitation/dissolution reactions will be emphasized. (Typically Offered: Fall)

ENSCI 5880: Raster GIS for Geoscientists

(Dual-listed with GEOL 4880/ AGRON 4880/ ENSCI 4880). (Cross-listed with AGRON 5880/ GEOL 5880).

Credits: 3.

Qualified Undergrad Prereq: GEOL 4520; CRP 4510; CRP 4520; NREM 3450; NREM 4460; AE 4080 or graduate standing

GIS course with focus on the spatial analysis and modeling of raster and triangulated irregular network (TIN) data using ArcGIS Pro. Includes practical exercises during lectures, lab exercises, homework assignments, and (for GEOL 5880) a class project. Basic knowledge of ArcGIS Pro is a plus but not required. Course can be taken concurrently to any other Intro GIS course. Sophomore classification or above recommended. Offered odd-numbered years. (Typically Offered: Spring)

ENSCI 5890: Survey of Remote Sensing Technologies

(Dual-listed with MTEOR 4890/ EE 4890/ ENSCI 4890/ GEOL 4890/ NREM 4890). (Cross-listed with EE 5890/ MTEOR 5890/ GEOL 5890/ NREM 5890).

Credits: 3. Contact Hours: Lecture 3.

Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S. (Typically Offered: Fall)

ENSCI 5900: Special Topics

Credits: 1-30. Repeatable.

Prereq: Instructor Permission for Course

Literature reviews and conference in accordance with needs and interest of the student. (Typically Offered: Fall, Spring, Summer)

ENSCI 5990: Creative Component

Credits: 1-30. Repeatable.

Creative component for nonthesis master of science degree. (Typically Offered: Fall, Spring, Summer)

Courses for graduate students:

ENSCI 6980: Seminar in Environmental Science

Credits: 1-3. Contact Hours: Lecture 3.

Repeatable.

Reports and discussion of recent research and literature. (Typically Offered: Spring)

ENSCI 6990: Research

Credits: 1-30. Repeatable.

Prereq: Instructor Permission for Course

(Typically Offered: Fall, Spring, Summer)