

# ENVIRONMENTAL SCIENCE (ENSCI)

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*Any experimental courses offered by ENSCI can be found at:*

registrar.iastate.edu/faculty-staff/courses/explisting/ (<http://www.registrar.iastate.edu/faculty-staff/courses/explisting/>)

**Courses primarily for undergraduates:**

## **ENSCI 110: Orientation to Environmental Science**

(1-0) Cr. 1. F.

*Prereq: Freshman classification in EnSci*

Overview of Environmental Science curriculum and discussion of professional opportunities. Offered on a satisfactory-fail basis only.

## **ENSCI 201: Introduction to Environmental Issues**

(Cross-listed with BIOL, ENV S). (2-0) Cr. 2. F.

Discussion of current and emerging environmental issues such as human population growth, energy use, loss of biodiversity, water resources, and climate change.

## **ENSCI 202: Exploration of Environmental and Sustainability Issues**

(1-0) Cr. 1. F.

*Prereq: Credit or enrollment in ENSCI 201*

Exploration of specific environmental and sustainability issues; designed to complement ENSCI 201. Offered on a satisfactory-fail basis only.

## **ENSCI 203: Exploration of Environmental Science**

(1-0) Cr. 1. S.

*Prereq: ENSCI 202.*

Continued exploration of specific environmental science issues developed in ENSCI 202. Topics may vary in different years. Offered on a satisfactory-fail basis only.

## **ENSCI 250: Environmental Geography**

(Cross-listed with ENV S). (3-0) Cr. 3. F.

The distribution, origins and functions of the earth's physical systems and the spatial relationship between human activity and the natural world.

## **ENSCI 251: Biological Processes in the Environment**

(Cross-listed with BIOL). (3-0) Cr. 3. S.

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.

## **ENSCI 270: Geospatial Technologies**

(Cross-listed with AGRON). Cr. 3. F.

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.

## **ENSCI 301: Natural Resource Ecology and Soils**

(Cross-listed with NREM). (3-3) Cr. 4. F.

*Prereq: BIOL 211, BIOL 211L; FOR 201 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.

## **ENSCI 312: Ecology**

(Cross-listed with A ECL, BIOL). (3-3) Cr. 4. F.SS.

*Prereq: BIOL 211, BIOL 211L, BIOL 212, and BIOL 212L*

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.

## **ENSCI 312L: Ecology**

(Cross-listed with A ECL, IA LL). Cr. 4. SS.

An introduction to the principles of ecology at the population, community and ecosystem level. Field studies of local lakes, wetlands and prairies are used to examine factors controlling distributions, interactions, and roles of plants and animals in native ecosystems.

## **ENSCI 324: Energy and the Environment**

(Cross-listed with ENV S, GEOL, MTEOR). (3-0) Cr. 3. S.

*Prereq: CHEM 163 or CHEM 177, MATH 140*

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.

**ENSCI 345: Natural Resource Photogrammetry and Geographic Information Systems**

(Cross-listed with NREM). (2-3) Cr. 3. S.

*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.

**ENSCI 360: Environmental Soil Science**

(Cross-listed with AGRON). (3-0) Cr. 3. S.

*Prereq: AGRON 182 (or equivalent) or ENSCI 250 or GEOL 201*

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.

**ENSCI 370: GIS for Ecology and Environmental Science**

(Cross-listed with BIOL). Cr. 1-6. Repeatable. F.S.

*Prereq: Six credits in biological and /or physical sciences, and 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.

**ENSCI 381: Environmental Systems I: Introduction to Environmental Systems**

(Dual-listed with ENSCI 581). (Cross-listed with BIOL, ENV S). Cr. 3-4. F.

*Prereq: 12 credits of natural science including biology and chemistry*

Introduction to the structure and function of natural environmental systems. Emphasis on the analysis of material and energy flows in natural environmental systems and the primary environmental factors controlling these systems.

**ENSCI 382: Environmental Systems II: Analysis of Environmental Systems**

(Dual-listed with ENSCI 582). (Cross-listed with BIOL). (2-2) Cr. 3. S.

*Prereq: ENSCI 381*

Continuation of EnSci 381. Systems approach to the analysis of material and energy flows in natural environmental systems and the primary environmental factors controlling these systems.

**ENSCI 384: Introduction to Ecosystems**

(3-0) Cr. 3. S.

*Prereq: 12 credits of natural science including biology and chemistry*

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.

**ENSCI 390: Internship in Environmental Science**

Cr. arr. Repeatable. F.S.SS.

*Prereq: Approval of the Environmental Science coordinator*

Supervised off-campus work experience in the field of environmental science. Offered on a satisfactory-fail basis only.

**ENSCI 391: Apprenticeship**

Cr. arr. Repeatable. F.S.SS.

*Prereq: Approval of the Environmental Science Coordinator*

Practical experience in an approved setting such as a research laboratory, government office, or private office. Offered on a satisfactory-fail basis only.

**ENSCI 402: Watershed Hydrology**

(Dual-listed with ENSCI 502). (Cross-listed with GEOL, MTEOR, NREM).

(2-3) Cr. 3. F.

*Prereq: Four courses in physical or biological sciences or engineering; junior standing*

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.

**ENSCI 404: Global Change**

(Dual-listed with ENSCI 504). (Cross-listed with AGRON, ENV S, MTEOR).

(3-0) Cr. 3. F.S.

*Prereq: Four courses in physical or biological sciences or engineering; junior standing*

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.

**ENSCI 405: Environmental Biophysics**

(Dual-listed with ENSCI 505). (Cross-listed with AGRON, MTEOR). (3-0) Cr.

3. Alt. S., offered odd-numbered years.

*Prereq: MATH 165 and some exposure to computer programming (any language)*

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.

**ENSCI 406: World Climates**

(Cross-listed with AGRON, MTEOR). (3-0) Cr. 3. S.

*Prereq: AGRON 206/MTEOR 206*

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.

**ENSCI 407: Watershed Management**

(Dual-listed with ENSCI 507). (Cross-listed with ENV S, NREM). (3-3) Cr. 4. S.

*Prereq: A course in general biology*

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.

**ENSCI 408: Aquatic Ecology**

(Dual-listed with ENSCI 508/ENSCI 408). (Cross-listed with IA LL). Cr. 4. SS.

*Prereq: Courses in ecology, chemistry, and physics*

Analysis of aquatic ecosystems; emphasis on basic ecological principles; ecological theories tested in the field; identification of common plants and animals.

**ENSCI 409: Field Methods in Hydrogeology**

(Dual-listed with ENSCI 509). (Cross-listed with GEOL). (0-4) Cr. 3. Alt. SS., offered even-numbered years.

*Prereq: GEOL/ENSCI 402 or GEOL/ENSCI 411 or C E 473*

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.

**ENSCI 411: Hydrogeology**

(Dual-listed with ENSCI 511). (Cross-listed with GEOL). (3-2) Cr. 4. F.

*Prereq: Four courses in biological or physical sciences*

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.

**ENSCI 412: Micropaleontology**

(Cross-listed with GEOL). Cr. 3. Alt. F., offered even-numbered years.

*Prereq: GEOL 102 and GEOL 102L*

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.

**ENSCI 413: Applied and Environmental Geophysics**

(Dual-listed with ENSCI 513). (Cross-listed with C E, GEOL). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: GEOL 100 or GEOL 201, algebra and trigonometry*

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.

**ENSCI 414: Applied Groundwater Flow Modeling**

(Dual-listed with ENSCI 514). (Cross-listed with GEOL). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: GEOL 411 or C E 473; MATH 165 or MATH 181*

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.

**ENSCI 415: Paleoclimatology**

(Dual-listed with ENSCI 515). (Cross-listed with GEOL). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: Four courses in biological or physical science*

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).

**ENSCI 416: Hydrologic Modeling and Analysis**

(Dual-listed with ENSCI 516). (Cross-listed with GEOL, MTEOR). (2-3) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: Four courses in Earth science, meteorology, or engineering; junior standing.*

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.

**ENSCI 418: Stream Ecology**

(Dual-listed with ENSCI 518). (Cross-listed with A ECL). (2-3) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: A ECL 486*

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.

**ENSCI 419: Aqueous and Environmental Geochemistry**

(Dual-listed with ENSCI 519). (Cross-listed with GEOL). (2-2) Cr. 3. S.

*Prereq: CHEM 178, CHEM 178L; 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.

**ENSCI 420: Environmental Engineering Chemistry**

(Dual-listed with ENSCI 520). (Cross-listed with C E). (2-3) Cr. 3. F.

*Prereq: C E 326, CHEM 178*

Principles of chemical and physical phenomena applicable to the treatment of water and wastewater and natural waters; including chemical equilibria, reaction kinetics, acid-base equilibria, chemical precipitation, redox reactions, and mass transfer principles. Individual laboratory practicals and group projects required.

**ENSCI 422I: Prairie Ecology**

(Cross-listed with IA LL). Cr. 4. SS.

*Prereq: Familiarity with basic principles in biological sciences and ecology*

Basic patterns and underlying physical and biotic causes of both regional and local distributions of plants and animals of North American prairies; field and laboratory analyses and projects.

**ENSCI 424: Air Pollution**

(Dual-listed with ENSCI 524). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 424A: Air Pollution: Air quality and effects of pollutants**

(Dual-listed with ENSCI 524A). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 424B: Air Pollution: Climate change and causes**

(Dual-listed with ENSCI 524B). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 424C: Air Pollution: Transportation Air Quality**

(Dual-listed with ENSCI 524C). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: C E 524A; PHYS 231 and PHYS 231L or CHEM 178; MATH 166 or 3 credits in statistics. Senior classification or above.*

**ENSCI 424D: Air Pollution: Off-gas treatment technology**

(Dual-listed with ENSCI 524D). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: C E 524A, C E 524B; Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

**ENSCI 424E: Air Pollution: Agricultural sources of pollution**

(Dual-listed with ENSCI 524E). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 426: Stable Isotopes in the Environment**

(Dual-listed with ENSCI 526). (Cross-listed with GEOL). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: Four courses in biological or physical science*

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.

**ENSCI 446: Integrating GPS and GIS for Natural Resource Management**

(Dual-listed with ENSCI 546). (Cross-listed with NREM). (2-3) Cr. 3. F.  
*Prereq: 12 credits in student's major at 300 level or above, NREM 345 or equivalent experience with ArcGIS*

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.

**ENSCI 452: GIS for Geoscientists**

(Dual-listed with ENSCI 552). (Cross-listed with AGRON, GEOL). (2-2) Cr. 3. F.S.

Introduction to geographic information systems (GIS) using ArcGIS Pro with particular emphasis on geoscientific data. Emphasizes typical GIS operations and analyses in the geosciences to prepare students for advanced GIS courses.

**ENSCI 459: Environmental Soil and Water Chemistry**

(Dual-listed with ENSCI 559). (Cross-listed with AGRON). (3-3) Cr. 4. F.  
*Prereq: Two semesters of college-level chemistry, MATH 140, AGRON 182 (or equivalent) or AGRON 360; GEOL 100 and AGRON 354 recommended*

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.

**ENSCI 461I: Introduction to GIS**

(Cross-listed with ENV S, IA LL, L A). Cr. 4. SS.

Descriptive and predictive GIS modeling techniques, spatial statistics, and map algebra. Application of GIS modeling techniques to environmental planning and resource management.

**ENSCI 463: Soil Formation and Landscape Relationships**

(Dual-listed with ENSCI 563). (Cross-listed with AGRON). (3-0) Cr. 3. F.  
*Prereq: AGRON 182 (or equivalent) or AGRON 260*

Relationships between soil formation, geomorphology, and environment. Soil description, classification, geography, mapping, and interpretation for land use. Two weekend field trips. Credit for one of AGRON 463 or AGRON 463I may be applied for graduation.

**ENSCI 464: Wetland Ecology**

(Dual-listed with ENSCI 564). (Cross-listed with BIOL). (3-0) Cr. 3. S.  
*Prereq: 15 credits in biological sciences.*

Ecology, classification, creation and restoration, and management of wetlands. Emphasis on North American temperate wetlands.

**ENSCI 466: Ecosystem Services**

(Dual-listed with ENSCI 566). (Cross-listed with NREM). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: 15 credits in natural science*

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.

**ENSCI 468: Applied Geostatistics for Geoscientists**

(Dual-listed with ENSCI 568). (Cross-listed with GEOL, MTEOR). Cr. 3. Alt. F., offered even-numbered years.

*Prereq: GEOL 452, C R P 351, C R P 452, NREM 345, or NREM 446*

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).

**ENSCI 477: Soil Physics**

(Dual-listed with ENSCI 577). (Cross-listed with AGRON). (3-0) Cr. 3. S.

*Prereq: AGRON 182 or equivalent and MATH 166 recommended*

The physical soil system: the soil components and their physical interactions; transport processes involving water, air, and heat.

**ENSCI 479: Surficial Processes**

(Dual-listed with ENSCI 579). (Cross-listed with GEOL). (2-3) Cr. 3. F.  
*Prereq: GEOL 100 and GEOL 100L; or GEOL 201; or equivalent experience.*

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.

**ENSCI 480: Engineering Analysis of Biological Systems**

(Cross-listed with A B E, GLOBE). (2-2) Cr. 3. F.

*Prereq: A B E 380 or permission of the instructor*

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 580 will be required to conduct additional learning activities.

**ENSCI 483: Environmental Biogeochemistry**

(Dual-listed with ENSCI 583). (Cross-listed with BIOL, GEOL). Cr. 3. Alt. S., offered odd-numbered years.

*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.

**ENSCI 484: Ecosystem Ecology**

(Cross-listed with BIOL). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*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.

**ENSCI 485: Soil and Environmental Microbiology**

(Dual-listed with ENSCI 585). (Cross-listed with AGRON, MICRO). (2-3) Cr. 3. F.

*Prereq: AGRON 182 or equivalent; MICRO 201 and MICRO 201L recommended*

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.

**ENSCI 486: Aquatic Ecology**

(Dual-listed with ENSCI 586). (Cross-listed with A ECL, BIOL). (3-0) Cr. 3. F.

*Prereq: Biol 312 or EnSci 381 or EnSci 402 or NREM 301*

Structure and function of aquatic ecosystems with application to fishery and pollution problems. Emphasis on lacustrine, riverine, and wetland ecology.

**ENSCI 486L: Aquatic Ecology Laboratory**

(Dual-listed with ENSCI 586L). (Cross-listed with A ECL, BIOL). (0-3) Cr. 1. F.

*Prereq: Concurrent enrollment in BIOL 486*

Field trips and laboratory exercises to accompany 486. Hands-on experience with aquatic research and monitoring techniques and concepts.

**ENSCI 487: Microbial Ecology**

(Dual-listed with ENSCI 587). (Cross-listed with BIOL, GEOL, MICRO). (3-0) Cr. 3. F.

*Prereq: Six 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.

**ENSCI 488: GIS for Geoscientists II**

(Dual-listed with ENSCI 588). (Cross-listed with AGRON, GEOL). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: GIS course, such as GEOL 452, CRP 451, CRP 452, NREM 345, NREM 446, AE 408 or equivalent*

GIS course with focus on the spatial analysis and modeling of raster data and triangulated irregular network (TIN) data. Uses ArcGIS and various extensions, such as Spatial Analyst, 3D Analyst, and ArcScene. Includes practical exercises during lectures, lab exercises, homework assignments, and (for GEOL 588) a class project.

**ENSCI 489: Survey of Remote Sensing Technologies**

(Dual-listed with ENSCI 589). (Cross-listed with E E, GEOL, MTEOR, NREM). (3-0) Cr. 3. F.

*Prereq: Four courses in physical or biological sciences or engineering*

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

**ENSCI 490: Independent Study**

Cr. arr. Repeatable. F.S.SS.

*Prereq: Permission of the instructor and approval of the Environmental Science coordinator*

**ENSCI 490H: Independent Study: Honors**

Cr. arr. Repeatable. F.S.SS.

Permission of instructor and approval of Environmental Science coordinator.

**ENSCI 495: Current Topics and Case Studies in Environmental Science**

Cr. 1-3.

*Prereq: Junior classification in Environmental Science, permission of instructor*

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

**ENSCI 496: Travel Course**

Cr. arr. Repeatable.

*Prereq: Permission of instructor*

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. A. International Tour B. Domestic Tour.

**ENSCI 496A: Travel Course: International Tour**

Cr. arr. Repeatable.

*Prereq: Permission of instructor*

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 496B: Travel Course: Domestic Tour**

Cr. arr. Repeatable.

*Prereq: Permission of instructor*

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 498: Cooperative Education**

Cr. R. Repeatable. F.S.SS.

*Prereq: Permission of Environmental Science Coordinator*

Required of all cooperative education students. Students must register prior to commencing each work period.

**Courses primarily for graduate students, open to qualified undergraduates:****ENSCI 502: Watershed Hydrology**

(Dual-listed with ENSCI 402). (Cross-listed with GEOL, MTEOR, NREM). (2-3) Cr. 3. F.

*Prereq: Four courses in physical or biological sciences or engineering; junior standing*

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.

**ENSCI 504: Global Change**

(Dual-listed with ENSCI 404). (Cross-listed with AGRON, MTEOR). (3-0) Cr. 3. F.S.

*Prereq: Four courses in physical or biological sciences or engineering; junior standing*

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.

**ENSCI 505: Environmental Biophysics**

(Dual-listed with ENSCI 405). (Cross-listed with AGRON, MTEOR). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: MATH 165 and some exposure to computer programming (any language)*

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.

**ENSCI 507: Watershed Management**

(Dual-listed with ENSCI 407). (Cross-listed with NREM). (3-3) Cr. 4. S.

*Prereq: A course in general biology*

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.

**ENSCI 508: Aquatic Ecology**

(Cross-listed with IA LL, NREM). Cr. 4. SS.

*Prereq: Courses in ecology, chemistry, and physics*

Analysis of aquatic ecosystems; emphasis on basic ecological principles; ecological theories tested in the field; identification of common plants and animals.

**ENSCI 509: Field Methods in Hydrogeology**

(Dual-listed with ENSCI 409). (Cross-listed with GEOL). (0-4) Cr. 3. Alt. SS., offered even-numbered years.

*Prereq: GEOL/ENSCI 402 or GEOL/ENSCI 411 or C E 473*

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.

**ENSCI 511: Hydrogeology**

(Dual-listed with ENSCI 411). (Cross-listed with GEOL). (3-2) Cr. 4. F.

*Prereq: Four courses in biological or physical sciences*

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.

**ENSCI 513: Applied and Environmental Geophysics**

(Dual-listed with ENSCI 413). (Cross-listed with C E, GEOL). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: GEOL 100 or GEOL 201, algebra and trigonometry*

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.

**ENSCI 514: Applied Groundwater Flow Modeling**

(Dual-listed with ENSCI 414). (Cross-listed with GEOL). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: GEOL 411 or C E 473; MATH 165 or MATH 181*

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.

**ENSCI 516: Hydrologic Modeling and Analysis**

(Dual-listed with ENSCI 416). (Cross-listed with GEOL, MTEOR). (2-3) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: Four courses in earth science, meteorology, or engineering; junior standing*

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.

**ENSCI 518: Stream Ecology**

(Dual-listed with ENSCI 418). (Cross-listed with A ECL). (2-3) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: A ECL 486*

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.

**ENSCI 519: Aqueous and Environmental Geochemistry**

(Dual-listed with ENSCI 419). (Cross-listed with GEOL). (2-2) Cr. 3. S.

*Prereq: CHEM 178, CHEM 178L; 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.

**ENSCI 520: Environmental Engineering Chemistry**

(Dual-listed with ENSCI 420). (Cross-listed with C E). (2-3) Cr. 3. F.

*Prereq: C E 326, CHEM 178*

Principles of chemical and physical phenomena applicable to the treatment of water and wastewater and natural waters; including chemical equilibria, reaction kinetics, acid-base equilibria, chemical precipitation, redox reactions, and mass transfer principles. Individual laboratory practicals and group projects required.

**ENSCI 521: Environmental Biotechnology**

(Cross-listed with C E). (2-2) Cr. 3. F.

*Prereq: C E 326*

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.

**ENSCI 522: Water Pollution Control Processes**

(Cross-listed with C E). (2-2) Cr. 3.

*Prereq: C E 421 or C E 521*

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 523: Physical-Chemical Treatment Process**

(Cross-listed with C E). (2-2) Cr. 3.

*Prereq: C E 520*

Material and energy balances. Principles and design of physical-chemical unit processes; including screening, coagulation, flocculation, chemical precipitation, sedimentation, filtration, lime softening and stabilization, oxidation, adsorption, membrane processes, ion exchange and disinfection; recovery of resources from residuals and sludges; laboratory exercises and demonstrations; case studies in mineral processing and secondary industries.

**ENSCI 524: Air Pollution**

(Dual-listed with ENSCI 424). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 524A: Air Pollution: Air quality and effects of pollutants**

(Dual-listed with ENSCI 424A). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 524B: Air Pollution: Climate change and causes**

(Dual-listed with ENSCI 424B). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 524C: Air Pollution: Transportation Air Quality**

(Dual-listed with ENSCI 424C). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: C E 524A; PHYS 231 and PHYS 231L or CHEM 178; MATH 166 or 3 credits in statistics. Senior classification or above.*

**ENSCI 524D: Air Pollution: Off-gas treatment technology**

(Dual-listed with ENSCI 424D). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: C E 524A, C E 524B; Either PHYS 231 and PHYS 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

**ENSCI 524E: Air Pollution: Agricultural sources of pollution**

(Dual-listed with ENSCI 424E). (Cross-listed with A B E, C E). (1-0) Cr. 1.

*Prereq: Either PHYS 231 and 231L or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*

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

**ENSCI 526: Stable Isotopes in the Environment**

(Dual-listed with ENSCI 426). (Cross-listed with GEOL). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: Four courses in biological or physical science*

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.

**ENSCI 528: Solid and Hazardous Waste Management**

(Cross-listed with C E). (3-0) Cr. 3.

*Prereq: C E 326 or background courses in both environmental chemistry and microbiology; 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 531: Design and Evaluation of Soil and Water Conservation Systems**

(Cross-listed with A B E). (2-3) Cr. 3. F.

*Prereq: E M 378 or CH E 356*

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.

**ENSCI 532: Nonpoint Source Pollution and Control**

(Cross-listed with A B E). (3-0) Cr. 3.

*Prereq: A B E 431 or C E 372*

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.

**ENSCI 533: Erosion and Sediment Transport**

(Cross-listed with A B E, NREM). (2-3) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: C E 372 or GEOL/ENSCI/MTEOR 402, MATH 166 or equivalent*

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.

**ENSCI 535: Restoration Ecology**

(Cross-listed with EEOB, NREM). (2-3) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: BIOL 366 or BIOL 474 or graduate standing*

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.

**ENSCI 535I: Restoration Ecology**

(Cross-listed with A ECL, EEOB, IA LL). Cr. 2. Alt. SS., offered even-numbered years.

*Prereq: A course in ecology*

Ecological principles for the restoration of native ecosystems; establishment (site preparation, selection of seed mixes, planting techniques) and management (fire, mowing, weed control) of native vegetation; evaluation of restorations. Emphasis on the restoration of prairie and wetland vegetation.

**ENSCI 537: Watershed Modeling and Policy**

(Cross-listed with A B E). (2-2) Cr. 3.

*Prereq: C E 372 or equivalent*

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.

**ENSCI 546: Integrating GPS and GIS for Natural Resource Management**

(Dual-listed with ENSCI 446). (Cross-listed with NREM). (2-3) Cr. 3. F.

*Prereq: 12 credits in student's major at 300 level or above, NREM 345 or equivalent experience with ArcGIS*

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.

**ENSCI 552: GIS for Geoscientists**

(Dual-listed with ENSCI 452). (Cross-listed with AGRON, GEOL). (2-2) Cr. 3. F.S.

Introduction to geographic information systems (GIS) using ArcGIS Pro with particular emphasis on geoscientific data. Emphasizes typical GIS operations and analyses in the geosciences to prepare students for advanced GIS courses.

**ENSCI 553: Soil-Plant Relationships**

(Cross-listed with AGRON). (3-0) Cr. 3. S.

*Prereq: AGRON 354*

Composition and properties of soils in relation to the nutrition and growth of plants.

**ENSCI 559: Environmental Soil and Water Chemistry**

(Dual-listed with ENSCI 459). (Cross-listed with AGRON). (3-3) Cr. 4. F.

*Prereq: Two semesters of college-level chemistry, MATH 140, AGRON 182 (or equivalent) or AGRON 360; GEOL 100 and AGRON 354 recommended*

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.

**ENSCI 563: Soil Formation and Landscape Relationships**

(Dual-listed with ENSCI 463). (Cross-listed with AGRON). (3-0) Cr. 3. F.

*Prereq: AGRON 182 (or equivalent) or AGRON 260*

Relationships between soil formation, geomorphology, and environment. Soil description, classification, geography, mapping, and interpretation for land use. Two weekend field trips. Credit for one of AGRON 463 or AGRON 463I may be applied for graduation.

**ENSCI 564: Wetland Ecology**

(Dual-listed with ENSCI 464). (Cross-listed with EEOB). (3-0) Cr. 3. S.

*Prereq: 15 credits in biological sciences.*

Ecology, classification, creation and restoration, and management of wetlands. Emphasis on North American temperate wetlands.

**ENSCI 564I: Wetland Ecology**

(Cross-listed with EEOB, IA LL). Cr. 4. SS.

*Prereq: IA LL 312I*

Ecology, classification, creation, restoration, and management of wetlands. Field studies will examine the composition, structure and functions of local natural wetlands and restored prairie pothole wetlands. Individual or group projects.

**ENSCI 566: Ecosystem Services**

(Dual-listed with ENSCI 466). (Cross-listed with NREM). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: 15 credits in natural science*

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.

**ENSCI 568: Applied Geostatistics for Geoscientists**

(Dual-listed with ENSCI 468). (Cross-listed with GEOL, MTEOR). Cr. 3. Alt. F., offered even-numbered years.

*Prereq: GEOL 452, C R P 351, C R P 452, NREM 345, or NREM 446*

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).

**ENSCI 571: Surface Water Hydrology**

(Cross-listed with C E). (3-0) Cr. 3. S.

*Prereq: C E 372*

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.

**ENSCI 572: Analysis and Modeling Aquatic Environments**

(Cross-listed with C E). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: C E 372*

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.

**ENSCI 573: Groundwater Hydrology**

(3-0) Cr. 3. F.

*Prereq: C E 372*

Principles of groundwater flow, hydraulics of wells, superposition, slug and pumping tests, streamlines and flownets, and regional groundwater flow. Contaminant transport. Computer modeling. Design project. Extra assignments required for graduate students.

**ENSCI 575: Soil Formation and Transformation**

(Cross-listed with AGRON). (1-0) Cr. 1. F.

*Prereq: AGRON 463 or equivalent*

A one-week intensive field class examining the pedology of Iowa under natural and transformed con.

**ENSCI 577: Soil Physics**

(Dual-listed with ENSCI 477). (Cross-listed with AGRON). (3-0) Cr. 3. S.

*Prereq: AGRON 182 or equivalent and MATH 166 recommended*

The physical soil system: the soil components and their physical interactions; transport processes involving water, air, and heat.

**ENSCI 578: Laboratory Methods in Soil Physics**

(Cross-listed with AGRON). (0-3) Cr. 1. S.

*Prereq: concurrent enrollment in AGRON 477 or AGRON 577*

Methods of measuring soil physical properties such as texture, density, and water content, and transport of heat, water, and gases.

**ENSCI 579: Surficial Processes**

(Dual-listed with ENSCI 479). (Cross-listed with GEOL). (2-3) Cr. 3. F.  
*Prereq: GEOL 100 and GEOL 100L; or GEOL 201; or equivalent experience.*

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.

**ENSCI 581: Environmental Systems I: Introduction to Environmental Systems**

(Dual-listed with ENSCI 381). (Cross-listed with EEOB). Cr. 3-4. F.

*Prereq: 12 credits of natural science including biology and chemistry*  
 Introduction to the structure and function of natural environmental systems. Emphasis on the analysis of material and energy flows in natural environmental systems and the primary environmental factors controlling these systems.

**ENSCI 582: Environmental Systems II: Analysis of Environmental Systems**

(Dual-listed with ENSCI 382). (Cross-listed with EEOB). (2-2) Cr. 3. S.

*Prereq: ENSCI 381*

Continuation of EnSci 381. Systems approach to the analysis of material and energy flows in natural environmental systems and the primary environmental factors controlling these systems.

**ENSCI 583: Environmental Biogeochemistry**

(Dual-listed with ENSCI 483). Cr. 3. Alt. S., offered odd-numbered years.

*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.

**ENSCI 584: Ecosystem Science**

(Cross-listed with EEOB). (3-0) Cr. 3. Alt. S., offered even-numbered years.

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

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.

**ENSCI 585: Soil and Environmental Microbiology**

(Dual-listed with ENSCI 485). (Cross-listed with AGRON, MICRO). (2-3) Cr. 3. F.

*Prereq: AGRON 182 or equivalent; MICRO 201 and MICRO 201L recommended*

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.

**ENSCI 586: Aquatic Ecology**

(Dual-listed with ENSCI 486). (Cross-listed with A ECL, EEOB). (3-0) Cr. 3. F.

*Prereq: Biol 312 or EnSci 381 or EnSci 402 or NREM 301*

Structure and function of aquatic ecosystems with application to fishery and pollution problems. Emphasis on lacustrine, riverine, and wetland ecology.

**ENSCI 586L: Aquatic Ecology Laboratory**

(Dual-listed with ENSCI 486L). (Cross-listed with A ECL, EEOB). (0-3) Cr. 1. F.

*Prereq: Concurrent enrollment in BIOL 486*

Field trips and laboratory exercises to accompany 486. Hands-on experience with aquatic research and monitoring techniques and concepts.

**ENSCI 587: Microbial Ecology**

(Dual-listed with ENSCI 487). (Cross-listed with EEOB, GEOL, MICRO).

(3-0) Cr. 3. F.

*Prereq: Six 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.

**ENSCI 588: GIS for Geoscientists II**

(Dual-listed with ENSCI 488). (Cross-listed with AGRON, GEOL). (2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: GIS course, such as GEOL 452, CRP 451, CRP 452, NREM 345, NREM 446, AE 408 or equivalent*

GIS course with focus on the spatial analysis and modeling of raster data and triangulated irregular network (TIN) data. Uses ArcGIS and various extensions, such as Spatial Analyst, 3D Analyst, and ArcScene. Includes practical exercises during lectures, lab exercises, homework assignments, and (for GEOL 588) a class project.

**ENSCI 589: Survey of Remote Sensing Technologies**

(Dual-listed with ENSCI 489). (Cross-listed with E E, GEOL, MTEOR, NREM). (3-0) Cr. 3. F.

*Prereq:* Four courses in physical or biological sciences or engineering

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

**ENSCI 590: Special Topics**

Cr. arr. Repeatable. F.S.SS.

*Prereq:* Permission of major professor in Environmental Science faculty

Literature reviews and conference in accordance with needs and interest of the student.

**ENSCI 599: Creative Component**

Cr. arr. Repeatable. F.S.SS.

*Prereq:* Permission of major professor in Environmental Science faculty

Creative component for nonthesis master of science degree.

**Courses for graduate students:****ENSCI 698: Seminar in Environmental Science**

Cr. 1-3. Repeatable. S.

Reports and discussion of recent research and literature.

**ENSCI 699: Research**

Cr. arr. Repeatable. F.S.SS.