K. Teaching Experience.
L. Extension Internship.
M. Immature Insects.
N. Insect Genetics.

Courses for graduate students

Ent 600. Seminar. Cr. 1. F.S.SS. Presentation of research results.

Ent 671. Insect Ecology. (2-3) Cr. 3. Alt. F., offered 2006. *Prereq: 370, Biol 312, Stat 401.* Concepts of insect population dynamics, emphasizing sampling, outbreaks, analysis, and bioeconomics.

Ent 675. Insecticide Toxicology. (Same as Tox 675.) (2-3) Cr. 3. Alt. F., offered 2005. *Prereq: 555 or Tox 501.* Coats. Principles of insecticide toxicology; classification, mode of action, metabolism, and environmental effects of insecticides.

Ent 699. Research. Cr. var.

Entrepreneurial Studies

(Interdepartmental Undergraduate Minor)

Supervisory Committee: Kay Palan (Business), Chair; D. Draper (Vet Med); Eric O. Hoiberg (Ag); Pat Patterson (Engineering); Linda Niehm (Family & Cons. Science); Kate Schwensen (Design); Peter Orazem (LAS); Roger A. Smith (Education).

Entrepreneurial Studies is an interdisciplinary program that provides opportunities to students to learn about entrepreneurship—the starting of new business ventures. It serves to complement the student's major area of study, whether it be electrical engineering, horticulture, textiles and clothing, or veterinary medicine, by offering a means of putting theory and science into practice. The goal of the Entrepreneurial Studies program is to provide the knowledge and skills needed to start and manage new ventures. In addition to feasibility analysis and business planning, the program deals with the topics of innovation, technology transfer, industry analysis, and competitive strategy. Although the program introduces some fundamental concepts from accounting, finance, marketing, and management, it does not attempt to substitute for any business courses in these areas.

A minor in entrepreneurial studies is available to all undergraduate students at ISU. Students must follow college specific rules in selecting courses and must consult with the representative of that college to the Entrepreneurial Studies Supervisory Committee. The college representatives to the supervisory committee will be responsible for advising students in their college, and will inform students about the details of the college rules.

Minor

A student seeking a minor in entrepreneurial studies must successfully complete a minimum of 15 credits in courses approved for use in the entrepreneurial studies program, including the two required courses, Management 310 and 313. Management 310, *Entrepreneurship and Innovation*, is the introductory course and provides an overview of the entire field. Management 313, *Feasibility Analysis and Business Planning*, emphasises developing an idea for a new venture, conducting a feasibility study, researching the potential market, analyzing the competition, and preparing a formal business plan. Up to six of the 15 credits required for the minor may also be used in the student's required program of study. Interested students should see a representative of the Entrepreneurial Studies Supervisory Committee in the college of their primary major for the list of approved courses.

Environmental Science

www.ensci.iastate.edu

(Interdepartmental Program)

William G. Crumpton: Coordinator

Environmental Science provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems. The magnitude and complexity of environmental problems are creating a growing need for scientists with rigorous, interdisciplinary training in environmental science. The Environmental Science program is designed to prepare students for positions of leadership in this rapidly changing discipline. Environmental Science graduates have a solid foundation in biological and physical natural sciences and the specialized training necessary for integrated analysis of environmental systems.

Undergraduate Study

The Environmental Science undergraduate major is offered through both the College of Agriculture and the College of Liberal Arts and Sciences. Environmental Science majors complete foundation courses in biology, chemistry, earth science, geology, physics and mathematics, plus a major consisting of an integrated core of Environmental Science courses and additional advanced course work in Environmental Science. Scientific rigor is stressed throughout the program, beginning with the foundation courses in the first two years of the curriculum. The upper level core courses emphasize a dynamic systems approach that provides a framework for integrating physical, chemical, and biological aspects of environmental systems.

Students seeking an Environmental Science major complete the following: (1) A foundation of approved supporting courses in science and mathematics including biology, chemistry, earth science, physics, calculus, and statistics, (2) 27 credits of course work in the major, including the Environmental Science core (EnSci 295, 381, 402, 483 and 495) and 12 additional credits of approved course work in Environmental Science. A combined average grade of C or higher is required in courses applied in the major.

English proficiency requirement: Beyond first-year composition (Engl 104 and 105) Environmental Science majors must demonstrate proficiency in written communication by completing an approved advanced course and maintaining a portfolio of term papers and other major writing assignments for departmental evaluation.

Graduate Study

Environmental Science offers a university-wide, interdisciplinary graduate program leading to the M.S. and Ph.D. degrees with a major in Environmental Science. Faculty from the colleges of Agriculture, Engineering, and Liberal Arts and Sciences cooperate to offer courses and research opportunities covering a broad array of environmental topics.

Applicants should have completed an undergraduate or masters degree in one of the biological, chemical, physical, or engineering sciences or should have equivalent preparation.

The Environmental Science graduate program emphasizes fundamental concepts and research, which at the same time address major environmental issues. The curriculum is designed to provide the interdisciplinary approach needed in Environmental Science education and research. In addition to work in their chosen area of specialization, students are afforded a broad exposure to the biological, chemical and physical aspects of environmental systems and the specialized training necessary for integrated analysis of these systems.

Courses open for nonmajor graduate credit: 301, 345, 381, 402, 402l, 404, 406, 411, 414, 415, 419, 420, 422l, 426, 434, 451, 452, 461l, 473, 473l, 479, 483, 485, 486, 486L, 487.

Courses primarily for undergraduate students

EnSci 290. Apprenticeship. Cr. Var. Staff. *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 grading basis only.

EnSci 295. Sophomore Seminar. (1-0) Cr. 1. F. Burras. *Prereq: Sophomore classification in EnSci.* Discussion of current issues in Environmental Science. Offered on a satisfactory-fail grading basis only.

EnSci 301. Forest Ecology and Soils. (Same as NREM 301.) See *Natural Resource Ecology and Management.* Nonmajor graduate credit.

EnSci 304l. Physical Geology. (Same as Ia LL 304l.) See *Iowa Lakeside Laboratory.*

EnSci 312. Ecology. (Same as Biol 312.) See *Biology.*

EnSci 312l. Ecology. (Same as Ia LL 312l.) See I*owa Lakeside Laboratory.*

EnSci 345. Natural Resource Photogrammetry and Geographic Information Systems. (Same as NREM 345.) (2-3) Cr. 3. F. *Prereq: Junior classification.* Use of aerial photos and remotely sensed imagery in resource management. Training in techniques of photo measurement, interpretation, and use of Geographic Information Systems (GIS). Principles of remote sensing. Nonmajor graduate credit.

EnSci 360. Environmental Soil Science. (Same as Agron 360.) (2-3) Cr. 3. S. *Prereq: Agron 260 or Geol 100 or 201.* Burras, Killorn. 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 381. Environmental Systems. (Dual-listed with 581, Same as Biol 381, Env S 381, Micro 381.) (2-4) Cr. 4. F. *Prereq: Biol 212 or Micro 201, Chem 164, 167 or 178, Math 160, 165 or 181.* Crumpton. Introduction to the dynamics of metabolic and biogeochemical processes in environmental systems, emphasizing microbial processes. Environmental factors controlling major autotrophic and heterotrophic processes of microbes and higher organisms. Laboratory emphasizes mass balance analysis and environmental simulation modeling. Nonmajor graduate credit.

EnSci 390. Internship in Environmental Science. Cr. var. *Prereq: Approval of the Environmental Science coordinator.* Supervised off-campus work experience in the field of environmental science. Offered on a satisfactory-fail grading basis only.

EnSci 402. Watershed Hydrology and Surficial Processes. (Dual-listed with 502, Same as Agron 402, Geol 402, NREM 402.) (3-3) Cr. 4. F. *Prereq: Credit or enrollment in EnSci 381 or Geol 100 or 201, Math 165 or 181.* Burras, Simpkins. Examination of watersheds as systems wherein biological and physical factors control hydrology, soil formation, and nutrient transport. Laboratory emphasizes field investigation of watershed-scale processes. Nonmajor graduate credit.

EnSci 402l. Watershed Hydrology and Surficial Processes. (Same as Ia LL 402l.) See *Iowa Lakeside Laboratory*. Nonmajor graduate credit.

EnSci 404. Global Change. (Dual-listed with 504, Same as Agron 404, Env S 404, Mteor 404.) (3-0) Cr. 3. S. P*rereq: 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. Nonmajor graduate credit.

EnSci 406. Climate of the Continents. (Same as Agron 406, Mteor 406.) (2-0) Cr. 2. F. *Prereq: Agron/ Mteor 206.* Arritt. The major climate controls and how they affect the world climate. Climate classification. Combining controls and classification to explain the pattern or climates of different continents and the world. Semester project and in-class presentation required. Nonmajor graduate credit.

EnSci 407. Watershed Management. (Dual-listed with 507, same as Env S 407, NREM 407.) (3-3) Cr. 4. S. *Prereq: A course in general biology.* Managing human impacts on the hydrologic cycle. Field and watershed landscape 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. GIS and Natural Resources Management. (Dual-listed with 508, Same as A E 408.) (2-2) Cr. 3. F. *Prereq: Working knowledge of computers and Windows environment.* Introduction to fundamental concepts and applications of GIS in natural resources management with specific focus on watersheds. Topics include: basic GIS technology, data structures, database management, spatial analysis, and modeling; visualization and display of natural resource data. Case studies in watershed and natural resource management using ArcView GIS. .

EnSci 409. Field Methods in Hydrogeology. (Dual-listed with 509, same as Geol 409.) (0-4) Cr. 2. Alt. SS., offered 2006. *Prereq: 402 or 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, electronic instrumentation for data collection, geophysics. Local field trips to investigate water resource, water quality, and remediation projects.

EnSci 411. Hydrogeology. (Dual-listed with 511, Same as Geol 411.) (3-2) Cr. 4. F. *Prereq: Geol 100 or 201; Math 165 or 181; Phys 111 or 221.* Physical principles of groundwater flow, nature and origin of aquifers and confining units, well hydraulics, and containment transport. Lab emphasizes applied field and laboratory methods for hydrogeological investigations. Nonmajor graduate credit.

EnSci 414. Applied Groundwater Flow Modeling. (Dual-listed with 514, same as Geol 414.) (2-2) Cr. 3. Alt. S., offered 2006. *Prereq: 411 or C E 473; Math 165 or 181.* Introduction to the principles of modeling groundwater flow systems. Finite-difference, finite-element, and analytic element techniques, spreadsheet models, appropriate boundary conditions in geological environments, verification, calibration, sensitivity analysis, parameter estimation techniques, and post-audit analysis. Emphasis on application of the USGS groundwater-flow model, MODFLOW, to regional flow system analysis. Computer laboratory emphasizes assigned problems and projects that illustrate topics discussed in the course. Nonmajor graduate credit.

EnSci 415. Paleoclimatology. (Dual-listed with 515, same as Geol 415.) (3-0) Cr. 3. Alt. S., offered 2007. *Prereq: Four courses in the biological or physical science at the 200 level or higher.* 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). Nonmajor graduate credit.

EnSci 419. Environmental Geochemistry. (Dual-listed with 519, Same as Geol 419.) (2-2) Cr. 3. F. *Prereq: 402 or 411 or equivalent.* Geochemistry of natural waters, including inorganic and organic constituents and water-rock interactions. Interpretation of water quality data. Geochemical equilibrium modeling and introduction to kinetics. Laboratory emphasizes chemical analysis of waters and computer modeling. Nonmajor graduate credit.

EnSci 422I. Prairie Ecology. (Same as Ia LL 422I.) See *Iowa Lakeside Laboratory.* Nonmajor graduate credit.

EnSci 426. Stable Isotopes in the Environment. (Dual-listed with 526, same as Geol 426.) (3-0) Cr. 3. Alt. F., offered 2005. *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. Nonmajor graduate credit.

EnSci 434. Contaminant Hydrogeology. (Dual-listed with 534, Same as Geol 434.) (3-0) Cr. 3. S. *Prereq: 411 or equivalent.* Brief review of organic and inorganic contaminants in industrial and agricultural settings. Geochemical interactions with porous media. Process-oriented approach to abiotic and biological fate and transport of contaminants. Investigation of coupled processes (diffusion, advection, dispersion, sorption, biodegradation) using computer models. Groundwater remediation strategies. Nonmajor graduate credit.

EnSci 446. Integrating GPS and GIS for Natural Resource Management. (Dual-listed with 546, Same as NREM 446.) (2-3) Cr. 3. S. *Prereq: 12 credits in student's major at 300 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.

EnSci 451. Applied and Environmental Geophysics. (Dual-listed with 551, same as Geol 451.) (2-2) Cr. 3. S. *Prereq: Geol 100 or 201, Math 165 or equivalent experience.* 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. Nonmajor graduate credit.

EnSci 452. GIS for Geoscientists. (Dual-listed with 552, same as Agron 452, Geol 452.) (2-4) Cr. 4. *Prereq: Geol 100, Geol 201 or equivalent.* Introduction to geographic information systems (GIS) with particular emphasis on geoscientific data. Uses ESRI;s ArcGIS Desktop Software and extension modules. Emphasizes typical GIS operations and analyses in the geosciences to prepare students for advanced GIS courses. Nonmajor graduate credit.

EnSci 459. Environmental Soil Chemistry. (Dual-listed with 559, Same as Agron 459.) (2-3) Cr. 3. FS *Prereq: 483 or Agron 354, Chem 178L or 211.* An introduction to the chemical properties of soils, chemical reactions and transformations occurring in the soils and their impact on the environment. Topics include composition of soils, acid-base equilibria, buffer systems, mineral dissolution and precipitation, speciation, ion exchange, redox reactions, absorption phenomena, soil pollution and chemical-equilbria computer programs.

EnSci 461I. Introduction to GIS. (Same as Ia LL 461I.) See *Iowa Lakeside Laboratory.* Nonmajor graduate credit.

EnSci 473. Soil Genesis and Landscape Relationships. (Same as Agron 473.) (2-3) Cr. 4. S. *Prereq: 402 or Agron 154.* Sandor. Relationships between soil formation, geomorphology, and environment. Soil description, classification, geography, mapping, and interpretation for land use. Two weekend field trips. Credit for 473 or 473I may be applied for graduation, not both. Nonmajor graduate credit.

EnSci 473I. Soil Genesis and Landscape Relationships. (Same as Ia LL 473I.) See *Iowa Lakeside Laboratory.* Nonmajor graduate credit.

EnSci 479. Surficial Processes. (Dual-listed with 579, Same as Geol 479.) (2-2) Cr. 3. F. *Prereq: Geol 100 or 201 or equivalent experience.* Study of surficial processes in modern and ancient geological environments. 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 emphasizes aerial photo and topographic map interpretation. Nonmajor graduate credit.

EnSci 483. Environmental Biogeochemistry. (Dual-listed with 583, Same as Biol 483, Geol 483.) (3-2) Cr. 4. S. *Prereq: EnSci 381 and 402 or 402I.* Fang, Raich. Biological, chemical, and physical phenomena controlling material, energy, and elemental fluxes in the environment. Human interactions with and effects on environmental systems. Nonmajor graduate credit.

EnSci 485. Soil Microbial Ecology. (Dual-listed with 585, Same as Agron 485, Micro 485.) (2-3) Cr. 3. F. *Prereq: 402 or Agron 154, Micro 201 (Micro 203 recommended).* Loynachan. 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. Nonmajor graduate credit.

EnSci 486. Aquatic Ecology. (Dual-listed with 586, Same as A Ecl 486, Biol 486.) (3-0) Cr. 3. F. *Prereq: 312 and 381, 301, 402, or 402I.* Structure and function of aquatic ecosystems with application to fishery and pollution problems. Emphasis on lacustrine, riverine and wetland ecology. Nonmajor graduate credit.

EnSci 486L. Aquatic Ecology Laboratory. (Dual-listed with 586L, Same as A Ecl 486L, Biol 486L.) (0-3) Cr. 1. F. *Prereq: Concurrent enrollment in 486.* Field trips and laboratory exercises to accompany 486. Hands-on experience with aquatic research and monitoring techniques and concepts. Nonmajor graduate credit.

EnSci 487. Aquatic and Wetland Microbial Ecology. (Dual-listed with 587, Same as Biol 487, Micro 487.) (3-0) Cr. 3. S. *Prereq: Six credits in biology and 6 credits in chemistry.* Crumpton. Introduction to major functional groups and their roles in aquatic and wetland ecosystems. Emphasis on energy flow and nutrient dynamics. Nonmajor graduate credit.

EnSci 490. Independent Study. Cr. Var. *Prereq: Permission of the instructor and approval of the Environmental Science coordinator.*

EnSci 495. Current Topics and Case Studies in Environmental Science. (1-3) Cr. 2. F. *Prereq: Senior classification in Environmental Science.* Schultz. Current topics and case studies related to the analysis and management of environmental systems. Will include field trips and cooperative group projects to assess environmental problems in heavily impacted landscapes and develop alternative management plans.

Courses primarily for graduate students, open to qualified undergraduate students

EnSci 502. Watershed Hydrology and Surficial Processes. (Dual-listed with 402.) (3-3) Cr. 4. F. *Prereq: Credit or enrollment in EnSci 381 or Geol 100 or 201, Math 165 or 181.* Burras, Simpkins. Examination of watersheds as systems wherein biological and physical factors control hydrology, soil formation, and nutrient transport. Laboratory emphasizes field investigation of watershed-scale processes.

EnSci 504. Global Change. (Dual-listed with 404, same as Agron 504, Mteor 504.) (3-0) Cr. 3. S. *Prereq: Four courses in physical or biological sciences or*

engineering; junior, senior, or graduate 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. Biometeorology. (Same as Agron 505, Mteor 505.) (3-0) Cr. 3. Alt. S., offered 2005. *Prereq: Agron/Mteor 206.* Hornbuckle. Energy, mass and momentum exchange near the ground. Radiation, turbulence, conductance and evaporation as components of the heat balance. Temperature, wind and humidity conditions in the microclimate. Modification of the microclimate. Computer modeling of biophysical processes. Semester project required.

EnSci 505l. Watershed Modeling and GIS. (Same as Ia LL 505l.) See *Iowa Lakeside Laboratory*.

EnSci 507. Watershed Management. (Dual-listed with 407, same as NREM 507.) (3-3) Cr. 4. S. *Prereq: A course in general biology.* Managing human impacts on the hydrologic cycle. Field and landscape 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. GIS and Natural Resource Management. (Dual-listed with 408, same as A E 508.) (2-2) Cr. 3. F. *Prereq: Working knowledge of computers and Windows environment.* Introduction to fundamental concepts and applications of GIS in natural resources management with specific focus on watersheds. Topics include: basic GIS technology, data structures, database management, spatial analysis, and modeling; visualization and display of natural resource data. Case studies in watershed and natural resource management using ArcView GIS. In addition ot other assignments, graduate students will prepare literature reviews on topics covered in class and develop enterprise applications.

EnSci 508l. Aquatic Ecology. (Same as Ia LL 508l.) See *Iowa Lakeside Laboratory.*

EnSci 509. Field Methods in Hydrogeology. (Dual-listed with 409, same as Geol 509.) (0-4) Cr. 2. Alt. SS., offered 2006. *Prereq: 402 or 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, electronic instrumentation for data collection, and geophysics. Local field trips to investigate water resource, water quality, and remediation projects.

EnSci 511. Hydrogeology. (Dual-listed with 411, same as Geol 511.) (3-2) Cr. 4. F. *Prereq: Geol 100 or 201; Math 165 or 181; Phys 111 or 221.* Physical principles of groundwater flow, nature and origin of aquifers and confining units, well hydraulics and contaminant transport. Lab emphasizes applied field and laboratory methods for hydrogeological investigations.

EnSci 514. Applied Groundwater Flow Modeling. (Dual-listed with 414, same as Geol 514.) (2-2) Cr. 3. Alt. S., offered 2006. *Prereq: 411 or C E 473; Math 165 or 181.* Introduction to the principles of modeling groundwater flow systems. Finite-difference, finite-element, and analytic element techniques, spreadsheet models, appropriate boundary conditions in geological environments, verification, calibration, sensitivity analysis, parameter estimation techniques, and post-audit analysis. Emphasis on application of the USGS groundwater-flow model, MODFLOW, to regional flow sysetm analysis. Computer laboratory emphasizes assigned problems and projects that illustrate topics discusses in the course.

EnSci 515. Paleoclimatology. (Dual-listed with 415, same as Geol 515.) (3-0) Cr. 3. Alt. S., offered 2007. *Prereq: Four courses in the 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 518. Stream Ecology. (Same as A Ecl 518.) (3-0) Cr. 3. Alt. S., offered 2006. *Prereq: 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. Environmental Geochemistry. (Dual-listed with 419, same as Geol 519.) (2-2) Cr. 3. F. *Prereq: 511 or equivalent.* Geochemistry of natural waters, including inorganic and organic constituents and water-rock interactions. Interpretation of water quality data. Geochemical equilbrium modelig and introduction to kinetics. Laboratory emphasizes chemical analysis of waters and computer modeling.

EnSci 520. Environmental Engineering Chemistry. (Same as C E 520.) (2-3) Cr. 3. *Prereq: Chem 177 and 178, Math 166.* Principles of chemical and physical phenomena applicable to the treatment of water and wastewater and natural waters; including chemical equilbria, reaction kinetics, acid-base equilibria, chemical precipitation, redox reactions, and mass transfer principles. Individual and group projects required. Additional term paper and oral presentation. Extensive laboratory practicals.

EnSci 521. Environmental Biotechnology. (Same as C E 521.) (2-2) Cr. 3. *Prereq: C E 326.* Fundamentals of biochemical and microbial processes applied to environmental engineering processes, role of microorganisms in wastewater treatment and bioremedication, bioenergetics and kinetics, metabolism of xenobiotic compounds, waterborne pathogens and parasites, and disinfection. Additional term paper and oral presentation.

EnSci 522. Water Pollution Control Processes. (Same as C E 522.) See *Civil Engineering.*

EnSci 523. Physical-Chemical Treatment Process. (Same as C E 523.) See *Civil Engineering.*

EnSci 524. Air Pollution. (Same as C E 524.) See *Civil Engineering.*

EnSci 525. Industrial Wastewater and Resource Recovery. (Same as C E 525.) See *Civil Engineering.*

EnSci 526. Stable Isotopes in the Environment. (Dual-listed with 426, same as Geol 526.) (3-0) Cr. 3. Alt. F., offered 2005. *Prereq: Four courses in biological or physical sciences.* 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 527. Solid Waste Management. (Same as C E 527.) See *Civil Engineering.*

EnSci 529. Hazardous Waste Management. (Same as C E 529.) See *Civil Engineering.*

EnSci 530. Agricultural Water Quality Engineering. (Same as A E 530.) (3-0) Cr. 3. Alt. S., offered 2006. *Prereq: Chem 163 or 167, Agron 154 or Geol 201, AST 324 or Agron 402 or C E 372.* Physical and chemical properties and processes that affect the transport and fate of chemicals that occur in crop and livestock production. Methods of measurement of chemical concentrations and loading on the environment. Modeling of chemical movement and fate. Methods of control of nonpoint pollution in agriculture.

EnSci 531. Natural Resource Conservation Engineering. (Same as A E 531.) (2-3) Cr. 3. F. *Prereq: E M 378 or Ch E 356.* Planning and design of systems to conserve and utilize natural resources in the agricultural environment. Small watershed hydrology, water movement and utilization in the soil-plant-atmosphere system, agricultural water management, best management practices for control of erosion, and agricultural water quality. Students will prepare several research literature reviews on topics covered in the class in addition to the other assignments.

EnSci 533. Erosion and Sediment Transport. (Same as A E 533.) (3-0) Cr. 3. Alt. F., offered 2005. *Prereq: A E 422 or C E 372, Math 266.* Erosion processes. Initiation of motion and overland flow. Erosion models. Flow in alluvial channels and theory of transport. Surface soil and channel stability. Wind erosion.

EnSci 534. Contaminatn Hydrogeology. (Dual-listed with 434, same as Geol 534.) (3-0) Cr. 3. S. *Prereq: 511 or their equivalent.* Brief review of organic and inorganic contaminants in industrial and agricultural settings. Geochemical interactions with porous media. Process-oriented approach to abiotic and biological fate and transport of contaminants. Investigation of coupled processes (diffusion, advection, dispersion, sorption, and biodegradation) using computer models. Groundwater remediation strategies.

EnSci 535. Restoration Ecology. (Same as EEOB 535, NREM 535.) (2-3) Cr. 3. F. *Prereq: Biol 366 or 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 in case studies.

EnSci 535l. Restoration Ecology. (Same as Ia LL 535l.) See *Iowa Lakeside Laboratory.*

EnSci 544. Aquatic Toxicology. (Same as A Ecl 544, Tox 544.) (3-0) Cr. 3. Alt. F., offered 2006. *Prereq: Biol 486.* Environmental chemistry and the biochemical, physiological, behavioral and populations level effects of contaminants on aquatic organisms.

EnSci 546. Integrating GPS and GIS for Natural Resource Management. (Dual-listed with 446, same as NREM 546.) (2-3) Cr. 3. S. *Prereq: 12 credits in student's major at 300 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.

EnSci 551. Applied and Environmental Geophysics. (Dual-listed with 451, same as Geol 551.) (2-2) Cr. 3. S. *Prereq: 100 or 201, Math 165 or equivalent experience.* 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 552. GIS for Geoscientists. (Dual-listed with 452, same as Agron 552, EnSci 552, Geol 552.) (2-4) Cr. 4. *Prereq: Geol 100, Geol 201 or equivalent.* Introduction to geographic information systems (GIS) with particular emphasis on geoscientific data. Uses ESRI's ArcGIS Desktop Software and extension modules. Emphasizes typical GIS operations and analyses in the geosciences to prepare students for advanced GIS courses.

EnSci 553. Soil-Plant Relationships. (Same as Agron 553.) (3-0) Cr. 3. F. *Prereq: Agron 354.* Blackmer. Composition and properties of soils in relation to the nutrition and growth of plants.

EnSci 558. Laboratory Methods in Soil Chemistry. (Same as Agron 548.) (2-3) Cr. 3. Alt. F., offered 2005. *Prereq: Agron 354 and Chem 210 or 211.* Tabatabai. Experimental and descriptive inorganic and organic analyses. Operational theory and principles of applicable instruments, including spectrophotometry, atomic and molecular absorption and emission spectroscopy, mass spectrometry, x-ray diffraction

and fluorescence, gas and ion chromatography, and ion-selective electrodes.

EnSci 559. Environmental Soil Chemistry. (Dual-listed with 459, same as Agron 559.) (3-0) Cr. 3. S. *Prereq: Agron 354, Chem 178L or 210* Thompson. An introduction to the chemical properties of soils, chemical reactions and transformations occurring in the soils and their impact on the enviornment. Topics include composition of soils, acid-base equilibria, buffer systems, mineral dissolution and precipitation, speciation, ion exchange, redox reactions, absorption phenomena, soil pollution and chemical-equilibria computer programs.

EnSci 564. Wetland Ecology. (Same as EEOB 564.) (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 564l. Wetland Ecology. (Same as Ia LL 564l.) See *Iowa Lakeside Laboratory.*

EnSci 571. Surface Water Hydrology. (Same as C E 571.) (3-0) Cr. 3. *Prereq: 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. Design project.

EnSci 572. Analysis and Modeling of Aquatic Environments. (Same as C E 572.) (3-0) Cr. 3. *Prereq: 571.* 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 biological 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. (Same as C E 573.) (3-0) Cr. 3. *Prereq: C E 372.* 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.

EnSci 574. Environmental Impact Assessment. (Same as C E 574.) (3-0) Cr. 3. *Prereq: Four courses in natural, biological, or engineering sciences and senior or above classification.* Review of federal and state requirements for environmental impact assessment, requirements of the National Environmental Policy Act and Council on Environmental Quality, methods of evaluating the environmental impacts on the physical, biological, socioeconomic, cultural/historical, human health and psychological environments, public participation in EIS, review and evaluate project environmental impact statements. An environmental impact assessment of a proposed project will be completed in small teams.

EnSci 577. Soil Physics. (Same as Agron 577.) (3-0) Cr. 3. S. *Prereq: 354. Recommended: Math 166.* Horton. 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. (Same as Agron 578.) (3-0) Cr. 3. S. *Prereq: 577 concurrent.* Horton. 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 479, same as Geol 579.) (2-2) Cr. 3. F. *Prereq: Geol 100 or 201 or equivalent experience.* Study of surficial processes in modern and ancient geological environments. 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 emphasizes aerial photo and topographic map interpretation.

EnSci 580. Engineering Quantification of Biological Processes. (Same as A E 580.) (2-2) Cr. 3. S. *Prereq: Math 266; Biol 101 or 211; M E 330.* Prediction of biological systems behavior by computer simulation of mathematical system models. Focus on mathematical representation of biological processes including population dynamics, growth, development, diffusion, bioenergetics, enzyme kinetics. Flow diagrams for representing systems and constructing mathematical models. Finite difference techniques for continuous system simulation including examples of plant growth and soil water balances. Students enrolled in A E 580 will be required to answer an additional final exam question, to report on two journal articles, and to complete a more comprehensive class project than students enrolled in A E 480.

EnSci 581. Environmental Systems. (Dual-listed with 381, same as EEOB 581.) (2-4) Cr. 4. F. *Prereq: Biol 212 or Micro 201, Chem 164, 167, or 178, Math 165 or 181.* Crumpton. Introduction to the dynamics of metabolic and biogeochemical processes in environmental systems, emphasizing microbial processes. Environmental factors controlling major autotrophic and heterotrophic processes of microbes and higher organisms. Laboratory emphasizes mass balance analysis and environmental simulation modeling.

EnSci 583. Environmental Biogeochemistry. (Dual-listed with 483, same as EEOB 583, Geol 583.) (3-2) Cr. 4. S. *Prereq: EnSci 381 and 402 or 402l.* Fang, Raich. Biological, chemical, and physical phenomena controlling material, energy, and elemental fluxes in the environment. Human interactions with and effects on environmental systems.

EnSci 584. Ecosystem Ecology. (Same as EEOB 584.) (3-0) Cr. 3. Alt. S., offered 2006. *Prereq: Combined 12 credits in biology and chemistry.* Survey of the structure and functioning of major terrestrial ecosystems. Nutrient cycles, energy flows, and biotic and abiotic controls over ecosystem structure and composition.

EnSci 585. Soil Microbial Ecology. (Dual-listed wtih 485, same as Agron 585, Micro 585.) (2-3) Cr. 3. F. *Prereq: 402 or Agron 154, Micro 201 (Micro 203 recommended).* Loynachan. 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 486, same as EEOB 586.) (3-0) Cr. 3. F. *Prereq: 301, 312, or 381.* 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 486L, same as EEOB 586L.) (0-3) Cr. 1. F. *Prereq: Concurrent enrollment in 586.* Field trips and laboratory exercises to accompany 586. Hands-on experience with aquatic research and monitoring techniques and concepts.

EnSci 587. Aquatic and Wetland Microbial Ecology. (Dual-listed with 487, same as EEOB 587, Micro 587.) (3-0) Cr. 3. S. *Prereq: 6 credits in biology and 6 credits in chemistry.* Crumpton. Introduction to major functional groups of autotrophic and heterotrophic microorganisms and their roles in aquatic and wetland ecosystems. Emphasis on energy flow and nutrient dynamics.

EnSci 590. Special Topics. Cr. var. *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. var. *Prereq: Permission of major professor in Environmental Science faculty.* Creative component for nonthesis master of science degree.

Courses for graduate students

EnSci 690. Seminar in Environmental Science. (1-0) Cr. R. F.S. Reports and discussion of recent research and literature.

EnSci 699. Research.

Environmental Studies

www.envs.iastate. edu

(Interdepartmental Undergraduate Program)

William G. Crumpton: Coordinator

The Environmental Studies Program deals with the relationship between humans and nature, or between humans and natural systems. The curriculum is designed to give students an understanding of regional and global environmental issues and an appreciation of different perspectives regarding these issues. Courses are provided for students pursuing careers related to the environment and for others who simply want to know more about environmental issues. In addition, students in any college may elect to take a secondary major or minor in Environmental Studies.

Secondary Major

The Environmental Studies secondary major is taken in addition to one's first major and provides the breadth of preparation and integrated perspective necessary to understand environmental issues. Students seeking a major in Environmental Studies complete 24 credits of Env S coursework including (1) at least one general survey course chosen from Env S 101, 120, 173, and 201, (2) at least one integrative/issues course chosen from Env S 304, 324, 342, 404, 424, and 450, and (3) at least two human/societal perspectives courses chosen from Env S 303, 320, 334, 345, 380, 382, 384, 442, 472, 482, 484, and 491. Beyond these three requirements, any Environmental Studies course and up to six credits of approved departmental coursework may be applied toward the 24 credit total for the major. Regardless of their home college, Environmental Studies majors must complete 12 credits of approved coursework in natural science including coursework from life sciences and physical sciences. Since Environmental Studies is a secondary major, courses used in the major may also be used to satisfy general education and other requirements of departments and colleges. A combined average grade of C or higher is required in courses applied to the major.

Regardless of their primary major, Environmental Studies graduates have a broad foundation in science and humanities, an understanding of major regional and global environmental issues, and an appreciation of the varied and sometimes opposing perspectives regarding these issues.

Minor

Students seeking a minor in Environmental Studies complete 15 credits in Environmental Studies courses including (1) at least one general survey course chosen from Env S 101, 120, 173, and 201, (2) at least one integrative/ issues course chosen from Env S 304, 324, 342, 404, 424, and 450, and (3) at least two human/societal perspectives course chosen from
Env S 303, 334, 345, 380, 382, 384, 442, 472, 482,484, and 491. Beyond these three requirements, any Environmental Studies course may be applied toward the 15 credit total for the minor. A combined average grade of C or higher is required in courses applied to the minor, and the minor must include at least 9 credits that are not used to meet any other department, college, or university requirement.

Courses open for nonmajor graduate credit: 303, 334, 342, 381, 384, 404, 460, 461l, 472, 480l, 482.

Courses primarily for undergraduate students

Env S 101. Environmental Geology: Earth in Crisis. (Same as Geol 101.) (3-0) Cr. 3. F.S. An introduction to geologic processes and the consequences of human