ENTM 258. Seminar in Insect Pest Management (2) W Seminar, 2 hours. Prerequisite(s): consent of instructor. Selected topics in insect pest management. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes. **Perring**

ENTM 261. Seminar in Genetics, Genomics, and Bioinformatics (1) W, S Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Oral reports by visiting scholars, faculty, and students on current research topics in Genetics, Genomics, and Bioinformatics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with BCH 261, BIOL 261, BPSC 261, GEN 261, and PLPA 261.

ENTM 262. Seminar in Molecular Biology and Genomics of Disease Vectors (1) Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Seminar series, sponsored by the Center for Disease-Vector Research at the Institute for Integrative Genome Biology, provides an opportunity for graduate students to discuss current issues of molecular biology and genomics of vector insects and pathogens they transmit with guest speakers. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with MCBL 262.

ENTM 271. Research Seminar in Management of Vegetable Crop Pests (1) W Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in management of vegetable crop pests. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Trumble**

ENTM 272. Research Seminar in Insect Communication and Behavior (1) F, W, S Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in insect communication and behavior. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Carde, Millar, Visscher**

ENTM 276. Research Seminar in Medical, Urban, and Veterinary Entomology (1) F, S Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in medical, urban, and veterinary entomology. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Mullens, Rust, Walton**

ENTM 277. Research Seminar in Insect Biochemistry and Toxicology (1) F, W, S Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in insect biochemistry and toxicology. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Gill**

ENTM 289. Special Topics in Neuroscience (2) F, W, S Seminar, 2 hours. Prerequisite(s): graduate standing or consent of instructor. An interdisciplinary seminar consisting of student presentations and discussion of selected topics in neuroscience. Content and instructor(s) vary each time course is offered. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. Cross-listed with BCH 289, BIOL 289, CHEM 289, NRSC 289, and PSYC 289. **Hatton**

ENTM 290. Directed Studies (1-6) F, W, S Literature studies on special topics under direction of a member of the staff. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENTM 291. Individual Study in Coordinated Areas (1-6) F, W, S Prerequisite(s): graduate standing. Faculty assisted programs of individual study for candidates who are preparing for examinations. The following rules apply: 1) Up to 6 units may be taken prior to award of the Master's degree, such units to be in addition to minimum unit requirements for the degree; 2) Up to 12 additional units may be taken prior to advancement to candidacy for the Ph.D.; 3) The course may be repeated within these limits. Graded Satisfactory (S) or No Credit (NC).

ENTM 297. Directed Research (1-6) F, W, S Exploratory research toward the development of the dissertation problem or other research not specifically for thesis or dissertation. Graded Satisfactory (S) or No Credit (NC).

ENTM 299. Research for Thesis or Dissertation (1-12) F, W, S Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

ENTM 301. Teaching Entomology at the College Level (1) F, W, S Seminar, 1 hour. Prerequisite(s): graduate standing in Entomology. A program of weekly meetings and individual formative evaluation required of new entomology Teaching Assistants. Covers instructional methods and classroom/section activities most suitable for teaching Entomology. Conducted by departmental faculty or the Teaching Assistant Development Program. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENTM 302. College Teaching Practicum (1-4) F, W, S practicum/consultation, 3-12 hours. Prerequisite(s): graduate standing and consent of instructor. Supervised teaching in college level classes under supervision of the course instructor. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Environmental Engineering

See Chemical and Environmental Engineering

Environmental Sciences

Subject abbreviation: ENSC
College of Natural and Agricultural Sciences

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Professors
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Michael A. Anderson, Ph.D. *Environmental Chemistry*
Janet T. Arey, Ph.D. *Atmospheric Chemistry*
Roger Atkinson, Ph.D. *Atmospheric Chemistry*
David E. Crowley, Ph.D. *Soil Microbiology*
Ariel Dinar, Ph.D., *Environmental Economics*
William T. Frankenberger, Jr., Ph.D. *Soil Microbiology*
Jianying "Jay" Gan, Ph.D. *Environmental Chemistry*
Robert C. Graham, Ph.D. *Soil Mineralogy and Pedology*
Keith C. Knapp, Ph.D. *Natural Resource Economics*
David R. Parker, Ph.D. *Soil Biogeochemistry*
Roberto Sánchez-Rodriguez, Ph.D. *Environmental Policy*
Daniel Schlenk, Ph.D. *Aquatic Ecotoxicology*
Jiri Simunek, Ph.D. *Hydrology*
Laosheng Wu, Ph.D. *Soil Physics*
Marylynn V. Yates, Ph.D. *Environmental Microbiology*
Paul J. Ziemann, Ph.D. *Atmospheric Science*

Professors Emeriti
Andrew C.-S. Chang, Ph.D. *Agricultural Engineering*
Walter J. Farmer, Ph.D. *Soil Chemistry*
William A. Jury, Ph.D. *Soil Physics*
John Letey, Jr., Ph.D. Soil Physics
Lanny J. Lund, Ph.D. *Soil Morphology, Genesis, and Classification*
Albert L. Page, Ph.D. *Soil Chemistry*
Henry J. Vaux, Jr., Ph.D. *Natural Resource Economics*

Associate Professors
Kenneth A. Baerenklau, Ph.D. *Resource and Environmental Economics*
David M. Crohn, Ph.D. *Biosystems Engineering*
Linda Fernandez, Ph.D. *Resource and Environmental Economics*
Kurt A. Schwabe, Ph.D. *Resource and Environmental Economics*

Assistant Professors
James Sickman, Ph.D. *Watershed Hydrology and Biogeochemistry*

**

Adjunct Assistant Professors
W. Bowman Cutter, Ph.D. *Resource and Environmental Economics*
Brian Lanoil, Ph.D. *Environmental Microbiology*
Lisa Stein, Ph.D. *Environmental Microbiology*

Major

The Department of Environmental Sciences offers B.A. and B.S. degrees in Environmental Sciences. Students can choose to concentrate their studies in one of three options: Natural Science, Social Science, or Environmental Toxicology.

The necessity of maintaining an acceptable level of environmental quality is placing increasing demands upon governments and industries locally, nationally, and worldwide. To help meet those demands, the Environmental Sciences program is designed to provide training for students intending to enter environmental professions or for students preparing for graduate study in law, research, or teaching in a capacity that utilizes a background in the science of the human environment.

The structure of the Environmental Sciences curriculum provides a broad scope of instruction that enables students to explore the various disciplines and professions involved with solving environmental problems as well as opportunities for students to focus their training in accordance with their own educational and career objectives. All students majoring in Environmental Sciences

must complete a set of "core requirements" consisting of courses that provide a basic understanding of the physical, biological, and social sciences and their application to the analysis of environmental processes and issues. In addition to the core requirements, students must complete the required courses and an appropriate number of elective courses as designated in the option they select. Students are not expected to select an option during the freshman year so that they can be introduced to dimensions of the environmental sciences about which they may have no previous knowledge. Those wishing to change their selection of an option may do so at any time as long as they are able to complete the requirements for the bachelor's degree within the 216-unit limit specified by the College of Natural and Agricultural Sciences.

Joint Degree Program with California State University, Fresno

The B.S. degree in Environmental Sciences can also be earned by enrolling in the Environmental Sciences Joint Degree Program offered by UCR and California State University, Fresno. Students who are eligible for admission to both universities can enter the program by concurrently enrolling at both campuses. The general catalogs of both campuses stipulate the degree requirements. Students based at the CSU Fresno campus must spend two quarters at UCR and complete 24 units. Students based at UCR must spend one semester at CSU Fresno and complete 15 units. To gain the maximum benefit of courses in agriculture and industrial hygiene, which are unique to CSU Fresno, students based at UCR should consult their academic advisor for specific course selection.

Environmental Internship Program

The Environmental Internship Program offers students opportunities to work with government agencies, private firms, and nonprofit organizations involved in environmental affairs. As excursions into professional life, internships provide "hands-on" experience in applying the principles presented in courses. Beyond the highly specialized training associated with on-the-job activities, students can gain insights into their aptitudes, aspirations and work habits that enable them to clarify their academic and career objectives. Professional acquaintances established during internships can continue to serve as important contacts for students after the internship is completed.

Although most internships are part-time (12–15 hours per week) positions in the Riverside area, organizations that host student interns are located throughout the United States and in Washington, D.C. Students working as interns may receive stipends, hourly wages, or serve as volunteers, depending upon the specific appointment. Up to 16 units of credit toward the bachelor's degree may be earned by developing an academic component of the internship in consultation with a faculty supervisor and enrolling in ENSC 198-I.

Undergraduate Research

Students interested in enhancing the status of knowledge about environmental processes or seeking new solutions to environmental problems may gain training and experience as part-time employees in the department's research laboratories and other research facilities, such as the Air Pollution Research Center and the U.S. Department of Agriculture Soil and Water Research Service, located on campus. Those wishing to conduct their own research under faculty supervision may earn academic credit by enrolling in ENSC 197. Expenses for both laboratory and field experiments are eligible for funding by the campus mini-grant program which supports undergraduate research and creative activity.

Environmental Toxicology Option

As a curriculum that emphasizes the chemistry and biochemistry of toxic substances in the environment, this option prepares students for careers dealing with the control of toxics in the environmental media of air, water, soil, and ecosystems and in such related fields as public health and industrial hygiene. Qualified students completing this option may enter UCR's graduate program in Environmental Toxicology without significant deficiencies in their undergraduate curriculum.

Natural Science Option

As a general curriculum emphasizing the natural sciences, this option is suitable for students wishing to maintain a broad range of choices in technically oriented environmental professions such as air and water pollution control, hazardous materials management, public health, natural resource management, and environmental impact analysis. The Natural Science option is also appropriate as background for graduate study in such disciplines as ecology, forestry, air and water science, and environmental engineering. Students may earn either the B.A. or B.S. degree by completing the requirements specified by the College of Natural and Agricultural Sciences.

Social Science Option

Developed for students whose interests are oriented toward the social context of the environmental sciences, this option is appropriate preparation for careers dealing with environmental regulation, land use planning, environmental impact analysis and administration of environmental protection programs. The Social Science option is also suitable for those intending to continue their education in such areas as natural resource economics, urban planning, and environmental law. Both the B.A. and B.S. degrees are available to students in the Social Science option.

California Teach-Science/Mathematics Initiative (CaTEACH-SMI) California Teach-Science Mathematics Initiative (CaTEACH-SMI) has a goal of addressing the critical need of highly qualified K-12 science and mathematics teachers in California. With an economy increasingly reliant on science, technology, engineering, and mathematics (STEM) and the anticipated large scale retirement of qualified teachers, this is an essential time to explore and prepare for a career in teaching science or mathematics.

CaTEACH-SMI at UCR offers undergraduate students paid/unpaid opportunities to explore STEM teaching as a career option. Through CaTEACH-SMI, students receive advising and mentoring to prepare for entrance into an intern teaching credential program while diligently coordinating with academic advisors to ensure completion of STEM degree requirements. The CaTEACH-SMI Resource Center provides future STEM teachers with material and financial resources to promote planning and professional development towards a science/mathematics education career.

For more information about the CaTEACH-SMI program, please visit http://smi.ucr.edu or at the Resource Center at 1104 Pierce Hall.

University Requirements

See Undergraduate Studies section.

College Requirements

See College of Natural and Agricultural Sciences, Colleges and Programs section.

Some of the following requirements for the major may also fulfill some of the College's breadth requirements. Consult with a department advisor for course planning.

Major Requirements

The major requirements for both the B.A. and the B.S. degrees in Environmental Sciences are as follows: Students must fulfill the core courses listed under the lower-division and upper-division requirements with a grade point average of 2.0 or better and no grade lower than a C-. If a grade of D or F is received in 2 or more core courses required for the major, either in separate courses or repetitions of the same course, the student may be dismissed from the major. Students must, under such circumstances, petition to remain in the major. Students are also required to choose one of the the options and satisfactorily complete the option requirements.

Note To gain maximum benefit from participating in the Undergraduate Research and Environmental Internship Programs, students intending to enroll in ENSC 197 and ENSC 198-I should contact their advisor during the quarter prior to enrollment in these courses.

Core Requirements

1. Lower-division requirements (33 units)
   a) ENSC 001, ENSC 002
   b) CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC
   c) MATH 005
   d) POSC 010

2. Upper-division requirements (14 units): ENSC 100/SWSC 100, ENSC 101, ENSC 102, ENSC 191

Environmental Toxicology Option
(83-92 units)

1. BIOL 005A, BIOL 05LA, BIOL 005B
2. CHEM 005 or BIOL 005C; CHEM 112A, CHEM 112B, CHEM 112C
3. ENTX 101, ENTX 154
4. MATH 008B or MATH 009A, MATH 009B
5. PHYS 002A, PHYS 002B, PHYS 002C
6. PHYS 02LA, PHYS 02LB, PHYS 02LC are recommended
7. ENSC 006/ECON 006 or ENSC 143A/ ECON 143A (ECON 003 prerequisite)
8. BCH 100 or both BCH 110A and BCH 110B; BIOL 102 or BIOL 121/ MCBL 121; BCH 110C or BIOL 107A
9. STAT 100A and STAT 100B
10. Elective Courses: At least one course from ENSC 127/SWSC 127, ENSC 133/MCBL 133/SWSC 133, ENSC 135/CHEM 135/ENTX 135, ENSC 136/CHEM 136/ENTX 136/ SWSC 136, ENSC 140/SWSC 140, ENSC 141/MCBL 141/SWSC 141, ENSC 142, ENSC 144/ENVE 144, ENSC 155, ENSC 163, BPSC 134/ ENSC 134/SWSC 134, ENSC 104/SWSC 104, ENSC 107/SWSC 107, ENSC 138/ GEO 138/SWSC 138, CBNS 150/ ENTX 150, ENSC 197, ENSC 198-I

Natural Science Option (78–84 units)

1. BIOL 005A, BIOL 05LA, BIOL 005B
2. PHYS 002A, PHYS 002B, PHYS 002C
3. PHYS 02LA, PHYS 02LB, PHYS 02LC are recommended
4. MATH 008B or MATH 009A, MATH 009B
5. CHEM 112A, CHEM 112B
6. GEO 001 or GEO 002
7. ENSC 006/ECON 006 or ENSC 143A/ ECON 143A (ECON 003 prerequisite)
8. STAT 100A and STAT 100B
9. Elective Courses:
   a) At least one course from BIOL 005C, CHEM 005, CHEM 112C, MATH 009C
   b) A total of at least five courses from the following (at least three must be Environmental Sciences or Soil and Water Sciences)

   ENSC 120/NEM 120/SWSC 120, ENSC 127/SWSC 127, ENSC 133/MCBL 133/SWSC 133, ENSC 135/ CHEM 135/ENTX 135, ENSC 136/ CHEM 136/ENTX 136/SWSC 136, ENSC 140/SWSC 140, ENSC 141/ MCBL 141/SWSC 141, ENSC 142, ENSC 144/ENVE 144, ENSC 155, ENSC 163, ENSC 174, BPSC 134/ENSC 134/SWSC 134, ENSC 104/SWSC 104, ENSC 107/ SWSC 107, ENSC 138/GEO 138/ SWSC 138, ENSC 197, ENSC 198-I, BIOL 117, BIOL 121/MCBL 121, BIOL 121L/MCBL 121L, BIOL 124/MCBL 124, BIOL 160, BIOL 163, BPSC 104/BIOL 104, CHEM 109, ENTX 101, GEO 157, GEO 162, GEO 167, GEO 168

Social Science Option (85–90 units)

1. BIOL 002, BIOL 003
2. MATH 022
3. GEO 001 or GEO 002
4. ECON 003
5. ENSC 143A/ECON 143A, ENSC 143B/ ECON 143B, ENSC 143C/ECON 143C, ENSC 172, ENSC 174
6. ECON 101 or ECON 107
7. STAT 100A and STAT 100B
8. Elective Courses:
   a) At least one course from ENSC 133/MCBL 133/SWSC 133, ENSC 140/ SWSC 140, ENSC 141/MCBL 141/ SWSC 141, ENSC 142, ENSC 144/ ENVE 144, ENSC 155, ENSC 163, BPSC 134/ENSC 134/SWSC 134, ENSC 104/SWSC 104, ENSC 107/ SWSC 107, ENSC 138/GEO 138/ SWSC 138, ENSC 197, ENSC 198-I
   b) A total of at least six courses from the following:

   Economics: ECON 102A, ECON 102B, ECON 146, ECON 148, ECON 156, ECON 160/BUS 160

   Society and culture: ANTH 132, ANTH 134, ANTH 135, ANTH 186/LNST 166, PHIL 117, SOC 137, SOC 143/URST 143, SOC 182/URST 182, SOC 184

   Regulation and law: POSC 101, POSC 166, POSC 181, POSC 182, POSC 183

   Management: BUS 104/STAT 104, BUS 122, GEO 157, GEO 167, MATH 120

Minor

The minor in Environmental Sciences consists of the following.

1. Lower-division requirements (23 units)
   a) ENSC 002 or ENSC 017; ENSC 006/ECON 006
   b) CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC
2. Upper-division requirements (20 units)
   a) ENSC 100/SWSC 100, ENSC 101, ENSC 102
   b) Eight (8) units of additional upper-division courses in Environmental Sciences, no more than 4 units of which are in courses numbered 190-198

Of the specified upper-division units, a minimum of 16 units must be unique to the minor and may not be used to satisfy major requirements.

See Minors under the College of Natural and Agricultural Sciences in the Colleges and Programs section of this catalog for additional information on minors.

Concentration Areas

Students wishing to specialize in a particular science or discipline may do so by working with an advisor to select an appropriate sequence of elective courses within one of the required options. Sample areas of concentration and suggested courses are:

1. Water science: ENSC 136/CHEM 136/ ENTX 136/SWSC 136, ENSC 140/SWSC 140, ENSC 141/MCBL 141/SWSC 141, ENSC 142, ENSC 163
2. Environmental chemistry: ENSC 104/SWSC 104, ENSC 135/CHEM 135/ENTX 135, ENSC 136/CHEM 136/ENTX 136/ SWSC 136, CHEM 109, CHEM 125, CHEM 140, GEO 137
3. Soil science: ENSC 104/SWSC 104, ENSC 107/SWSC 107, ENSC 120/SWSC 120/NEM 120, ENSC 127/SWSC 127, ENSC 134/SWSC 134/BPSC 134, ENSC 138/SWSC 138/GEO 138
4. Environmental economics: ENSC 143A/ECON 143A, ENSC 143B/ECON 143B, ENSC 143C/ECON 143C, ECON 146, ECON 148, ECON 156

Graduate Program

Subject abbreviation: ENSC
College of Natural and Agricultural Sciences

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The Environmental Sciences Graduate Program offers the M.S. and Ph.D. degrees in Environmental Sciences.

Advanced training in Environmental Sciences is becoming increasingly necessary to address complex problems involving natural resources and environmental quality. Although this task frequently requires specialized knowledge in various fields of science, it also requires understanding and integration of a wide variety of interacting physical, chemical, biological, and societal influences. This interaction makes graduate study in environmental sciences distinct from many other scientific fields.

We have designed our program to offer advanced training in a number of specialized field areas within environmental sciences,

operating within a single graduate degree program administered by the Department of Environmental Sciences. Students trained in the Environmental Sciences Graduate Program can fill many areas of expertise needed in the state and nation. Potential career opportunities exist at regulatory agencies, consulting firms, government and academic research institutions, and industrial research facilities.

Admission Entry to the program requires completion of a baccalaureate degree in a field appropriate as preparation for graduate study in environmental sciences. Students normally will come to the program from an environmental sciences related discipline such as atmospheric science, aquatic science, earth science, environmental chemistry, hydrology, or soil science; a basic science such as biology, chemistry, or physics; or in a social science discipline such as economics, political science, geography, or sociology. Students may conduct research under the supervision of a sponsoring faculty member in any of the following field areas. Students must specify a field area for entry into the program.

In addition to the following requirements, all applicants must meet the general requirements as set forth in this catalog under the Graduate Studies section.

Environmental Chemistry and Ecotoxicology The Environmental Chemistry and Ecotoxicology field area focuses on the sources, physical and chemical transformations, and removal processes of chemicals in soil, water, and air, and their impacts on ecological systems.

Entrance requirements There are no entrance requirements for the Environmental Chemistry area beyond the general requirements for admission to the ESGP. For Ecotoxicology, prospective students would be expected to have had courses in General Biology/Zoology and Organic Chemistry. Students who do not have sufficient background to take the core course or specific elective courses may, however, need to first take prerequisite courses.

Environmental Microbiology The Environmental Microbiology field area encompasses the study of microbial processes in natural and agricultural ecosystems and the effects of microorganisms on environmental processes and environmental quality. Research topics include fundamental research on microbial physiology, genetics, and ecology as related to the environment, applied research on microbial effects on the fate and transport of pollutants, anthropogenic effects on microbial communities, fate and transport of human pathogenic microorganisms in the environment, and the application of microorganisms and microbial assays as indicators of soil and water quality.

Entrance requirements Students admitted to the Environmental Microbiology field area are expected to have a baccalaureate degree in biology, microbiology, or closely related field or demonstration of extensive background in biology and microbiology. Recommended prior course work includes chemistry (general, organic, and biochemistry), biology (general and advanced course work), microbiology (general), and statistics (general). Deficiencies in these areas must be remedied during the first year of graduate school.

Environmental and Natural Resource Economics and Policy The economics and policy field area focuses on the human aspects of environmental problems. Coursework emphasizes training in the traditional areas of environmental and natural resource economics, including welfare theory, externalities, pollution control, resource extraction, and non-market valuation, but also in sustainability, environmental management, and environmental policy. Research topics could include the environmental impacts of agriculture, transportation and urbanization, land use in poor and industrialized countries, international trade and the environment, climate change, and methodological advances in non-market valuation, to name just a few. Training in this field enables a student to analyze and address a wide variety of environmental policy issues.

Entrance requirements Students admitted to the Environmental and Natural Resource Economics and Policy field area normally will have completed a baccalaureate degree in the natural sciences, social sciences, or engineering. At least two undergraduate courses in economics and statistics are recommended. Students who do not have sufficient background to take the core courses or field courses may need to first take prerequisite courses.

Soil and Water Sciences The Soil and Water Science field area offers comprehensive training in the chemistry, physics, biology, and ecology of soils, surface waters and wetlands. Students can specialize in a variety of areas, including soil and aquatic chemistry, hydrology, limnology, soil-plant relations, biogeochemistry, bioremediation, geomicrobiology, contaminant fate and transport, water resources management, hillslope processes, soil genesis, soil mineralogy and geomorphology, and related areas.

Entrance requirements Admission to the Soil and Water Sciences field area requires a baccalaureate degree with preparation in both physical and life sciences. It is recommended that students have completed one year of general chemistry, as well as courses in general physics, organic chemistry, calculus through integrals, general biology, statistics, and physical geology or physical geography.

Environmental Sciences and Management The Environmental Sciences and Management field area is designed to serve students seeking interdisciplinary training in environmental research. Students enrolled in this field area will be expected to pursue a rigorous research plan that involves research in one or more of the following areas: science, management, or policy. Students will have the opportunity to select study committees from a spectrum of environmental disciplines.

Entrance requirements There are no additional entrance requirements for this field area beyond those to enter the graduate program.

Course Work The Ph.D. and M.S. degree programs both require completion of the courses given below, which are specific to each field area. Students with a M.S. objective may need to take additional courses to fulfill the requirements of the **Plan I (Thesis)** or **Plan II (Comprehensive Examination)** options. Upon acceptance to the program, the student will select an Advisory Committee made up of three members of the participating faculty in the ESGP to assist in the planning of the individualized curriculum. Electives are chosen in consultation with the Advisory Committee. Students also must attend a seminar each quarter (to be chosen in consultation with the major advisor). There is no foreign language requirement for the program.

Environmental Chemistry and Ecotoxicology
All students must complete one core course: ENSC 200/ENTX 200/CHEM 246.

Students focusing on **Environmental Chemistry** must complete 4 electives from the following list, of which at least 2 must be at the graduate level:

ENSC 104, ENSC 127/SWSC 127, ENSC 133/SWSC 133/MCBL 133, ENSC 135/ENTX 135/CHEM 135,ENSC 136/ENTX 136/CHEM 136/SWSC 136, ENSC 214/SWSC 214, ENSC 217/SWSC 217, ENSC 224/SWSC 224, ENSC 225/SWSC 225, ENSC 232/SWSC 232, ENTX 200L, ENTX 244/CHEM 244, ENTX 245/CHEM 245/SWSC 245, SWSC 203, SWSC 204.

Students focusing on **Ecotoxicology** must complete: ENTX 201 and ENTX 208 and take at least two electives from the following list, one of which must be at the graduate level: ENSC 214/SWSC 214, ENSC 217/SWSC 217, ENSC 224/SWSC 224, ENSC 225/SWSC 225, ENSC 232/SWSC 232, ENTX 200L, ENTX 244/CHEM 244, ENTX 245/CHEM 245 /SWSC 245, SWSC 203, SWSC 204, ENTX 154, ENTX 205.

Environmental Microbiology Students must complete the following core courses: MCBL 201, MCBL 221, MCBL 211, and at least 4 elective courses (or 12 credit hours), three of which must be at the graduate level.

Environmental and Natural Resource Economics and Policy Course requirements include: core course sequences consisting of ECON 200A, ECON 200B, ECON 200C and ECON 205A, ECON 205B, ECON 205C; field course sequence consisting of ECON 207, ECON 208, ECON 209; and three elective courses comprised of upper division undergraduate courses and/or graduate courses approved by their advisor. Students must earn a satisfactory score on the doctoral cumulative examination in microeconomic theory, attain a "B" average in each of the core and field course sequences, and pass the doctoral qualifying examination with written and oral components.

No student will be given more than three attempts to achieve a satisfactory grade on the microeconomic theory cumulative examination. Any unexcused absences from the required examinations will be regarded as a failure.

Soil and Water Sciences Students must complete one course in each of the following core course groups.

Chemistry

ENSC 104/SWSC 104
CHEM 136/ENSC 136/ENTX 136/SWSC 136

Physics

ENSC 107/SWSC 107
ENSC 163

Biology

ENSC/MCBL/SWSC 133
BPSC 134/ENSC 134/SWSC 134
ENSC 141/MCBL 141/SWSC 141

Natural Structure and Diversity

ENSC 138/GEO 138/SWSC 138
ENSC 140/SWSC 140

Students may have completed these prior to admission or they may take them early in their graduate program. Students must present a departmental seminar summarizing results of their thesis or dissertation or internship during the final quarter of matriculation.

Environmental Sciences and Management Because students enrolled in this field area may carry out interdisciplinary research for their advanced degree, the graduate course plan will be individualized. It is expected that the student and his/her Advisory Committee will design a course plan that includes graduate environmental science, management, and/or policy courses. The student will be required to take 6 courses (24 units), 3 of which must be at the graduate level.

Master's Degree

The Department of Environmental Sciences offers the M.S. degree in Environmental Sciences under the Plan I (Thesis) and Plan II (Comprehensive Examination) options. The general requirements for the M.S. degree are found in the Graduate Studies section of the General Catalog. All students are required to give a presentation annually at the Environmental Sciences Graduate Program Student Symposium.

Plan I (Thesis) Plan I (Thesis) Students must complete a minimum of 36 quarter units of graduate and upper-division undergraduate courses in, or significantly related to, Environmental Sciences. These must include the course requirements given above for the specific field area. At least 24 of the 36 units must be in graduate courses. A maximum of 12 of these units may be in graduate research for the thesis. No more than 4 units of ENSC 290 and 2 units of graduate seminar courses may be applied toward the degree. A thesis must be written and accepted by the M.S. thesis committee members, and a final oral defense of the thesis must be passed.

Plan II (Comprehensive Examination) Students must complete a minimum of 36 quarter units of graduate and upper-division undergraduate courses in, or significantly related to, Environmental Sciences. These must include the course requirements given above for the specific field area. At least 18 units must be in graduate courses. Students may count no more than 2 units of graduate seminar courses and 6 units of graduate internship courses toward the required 18 units and no units from graduate research for thesis or dissertation.
Students must take a comprehensive written examination that covers fundamental topics in environmental sciences. The written examination, which is three to four hours long, is prepared and evaluated by a committee appointed by the field director. The examination is taken during the latter part of the final quarter in the M.S. program. Students must wait at least eight weeks before retaking a failed examination. Students failing the examination twice are dismissed from the program.

Normative Time to Degree 2 years

Doctoral Degree

The Department of Environmental Sciences offers the Ph.D. degree in Environmental Sciences. The general requirements for the Ph.D. degree are found in the Graduate Studies section of the General Catalog.

Course Work Students must complete the course requirements given above for the specific field area. All students are required to give a presentation annually at the Environmental Sciences Graduate Program Student Symposium.

Ph.D. Written Qualifying Examination Following completion of all course work prescribed by the student's Advisory Committee, a Ph.D. Written Qualifying Examination will be prepared and administered to the student by a Ph.D. Written Qualifying Examination Committee. The Ph.D. Written Qualifying Examination Committee will consist of at least three faculty members with interests in the student's line of research. The purpose of this examination is to determine that the student has gained sufficient knowledge in the chosen field to perform professionally and competently. This exam may be attempted only twice. If this exam is failed twice, the student may be redirected to the M.S. degree if the student does not already hold an M.S. in Environmental Sciences or terminated from the program.

Ph.D. Oral Qualifying Examination A student who satisfactorily passes the Ph.D. Written Qualifying Examination may proceed with the Ph.D. Oral Qualifying Examination, which will focus on the dissertation proposal. This examination is conducted before the Oral Qualifying Examination Committee, consisting of five faculty members, one of whom must be from outside the ESGP. This examination may be attempted only twice. If this exam is failed twice, the student will be redirected to the M.S. degree if the student does not already hold an M.S. in Environmental Sciences or terminated from the program. The Ph.D. Written and Oral Qualifying Examinations will normally be taken at the end of the second year of graduate study and before the start of the third year.

Dissertation All Ph.D. students must write a doctoral dissertation, which must be read and accepted by all members of the Doctoral Dissertation Committee, comprised of at least three faculty members from the ESGP. A final oral dissertation defense in front of at least three Doctoral Dissertation Committee members may be required.

Relationship between Master's and Doctoral Programs The M.S. and Ph.D. programs are separate. Students who enter the Ph.D. program do not need to acquire a M.S. degree first, although students may elect to take both.

Normative Time to Degree 5 years

Lower-Division Courses

ENSC 001. Introduction to Environmental Science: Natural Resources (4) F Lecture, 3 hours; discussion, 1 hour. An introduction to environmental science, focusing on natural resource description, management, and conservation. Topics covered include ecosystem characteristics and function; material and energy flows; population dynamics and influence of population on the environment; energy resources and conservation; and mineral and soil resources and their management. Credit is awarded for only one of ENSC 001 or ENSC 001H.

ENSC 001H. Honors Introduction to Environmental Science: Natural Resources (4) F Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): admission to the University Honors Program or consent of instructor. Honors course corresponding to ENSC 001. An introduction to environmental science, focusing on natural resource description, management, and conservation. Topics covered include ecosystem characteristics and function; material and energy flows; population dynamics and influence of population on the environment; energy resources and conservation; and mineral and soil resources and their management. Satisfactory (S) or No Credit (NC) grading is not available. Credit is awarded for only one of ENSC 001 or ENSC 001H.

ENSC 002. Introduction to Environmental Science: Environmental Quality (4) W Lecture, 3 hours; discussion, 1 hour. An introduction to environmental science, focusing on the impact of human development and technology on the quality of natural resources and living organisms. Topics covered include soil, water, and air pollution; water, land, and food resources; wildlife management and species endangerment; toxicology and risk management; and solid and hazardous waste management. Credit is awarded for only one of ENSC 002 or ENSC 002H. **Amrhein**

ENSC 002H. Honors Introduction to Environmental Science: Environmental Quality (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): admission to the University Honors Program or consent of instructor. Honors course corresponding to ENSC 002. An introduction to environmental science, focusing on the impact of human development and technology on the quality of natural resources and living organisms. Topics covered include soil, water, and air pollution; water, land, and food resources; wildlife management and species endangerment; toxicology and risk

management; and solid and hazardous waste management. Satisfactory (S) or No Credit (NC) grading is not available. Credit is awarded for only one of ENSC 002 or ENSC 002H. **Amrhein**

ENSC 003. Contemporary Issues in the Environmental Sciences (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): none. An issue-oriented approach to understanding the scientific principles behind environmental issues. Case studies of environmental issues appearing in the mass media provide the context for assessing the status of scientific knowledge and its role in human decision making. Credit awarded for only one of ENSC 003 or ENSC 003H.

ENSC 003H. Honors Contemporary Issues in the Environmental Sciences (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): admission to the University Honors Program or consent of instructor. Honors course corresponding to ENSC 003. An issue-oriented approach to understanding the scientific principles behind environmental issues. Case studies of environmental issues appearing in the mass media provide the context for assessing the status of scientific knowledge and its role in human decision making. Satisfactory (S) or No Credit (NC) grading is not available. Credit is awarded for only one of ENSC 003 or ENSC 003H.

ENSC 006. Introduction to Environmental Economics (4) F, S Lecture, 3 hours; discussion, 1 hour. An introduction to the basic principles of economics and their application to problems of environmental quality and natural resource utilization. Emphasis is on the failure of markets as a cause of environmental degradation and the role of government in resolving problems of resource scarcity. Does not satisfy the Natural Science breadth requirement for the College of Humanities, Arts, and Social Sciences. Cross-listed with ECON 006.

ENSC 017. Environmental Impacts of Urbanization (4) Lecture, 2 hours; discussion, 2 hours. Prerequisite(s): none. Lectures and simulation exercises illustrating applications of principles from the physical and biological sciences to the analysis of urban systems and their impact on air and water quality, ecosystems, and reciprocal impacts at the urban-rural interface. Opportunities and constraints for mitigating the environmental impacts of urbanization.

ENSC 092. Exploring Environmental Sciences (1) Seminar, 1 hour. Familiarizes students with the fields of natural resource conservation, environmental regulation, and environmental restoration. Examines employment opportunities in government, university, and private business settings to participate in the development of sustainable interactions between humans and the environment. Graded Satisfactory (S) or No Credit (NC).

Upper-Division Courses

ENSC 100. Introduction to Soil Science (4) F Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC; GEO 001 is recommended. Explores the fundamental principles of soil science and soils as a natural resource. An introduction to the morphology, physics, chemistry, microbiology, fertility, classification, development, and management of soils in relation to the environment. Cross-listed with SWSC 100. Credit is awarded for only one of ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H. **Amrhein**

ENSC 100H. Honors Introduction to Soil Science (4) F Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): admission to the University Honors Program or consent of instructor; both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC ; GEO 001 is recommended. Honors course corresponding to ENSC 100. Explores the fundamental principles of soil science and soils as a natural resource. An introduction to the morphology, physics, chemistry, microbiology, fertility, classification, development, and management of soils in relation to the environment. Satisfactory (S) or No Credit (NC) grading is not available. Cross-listed with SWSC 100H. Credit is awarded for only one of ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H. **Amrhein**

ENSC 101. Water Resources (4) F Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ENSC 001 or ENSC 001H, ENSC 002 or ENSC 002H; or consent of instructor. An introduction to the hydrologic cycle; water sources, distribution, and transfer; and the physical, chemical, and biological properties of water. Discussion of water management and policy issues. **Wu**

ENSC 102. Introductory Atmospheric Science (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC . Covers the structure of the atmosphere and the impact of humans on it, including the causes and consequences of air pollution, air quality standards, and stratospheric and tropospheric ozone. Introduces the chemistry of air pollution and air pollution control strategies. **Arey**

ENSC 104. Environmental Soil Chemistry (4) F Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 005 or ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H or consent of instructor. Quantitative study of the chemistry of the solid, liquid, and gas phases in soils and sediments. Topics include solid and solution speciation, mineral solubility, ion exchange and adsorption reactions, oxidation-reduction, and the chemistry of organic contaminants and toxic trace elements in soils. Cross-listed with SWSC 104. **Parker**

ENSC 107. Soil Physics (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B or MATH 09HB; PHYS 002A; or consent of instructor. Topics include physical properties of soils and methods of evaluation. Emphasis is on movement of water, heat, gases, and chemicals through soil. Cross-listed with SWSC 107. **Simunek**

ENSC 120. Soil Ecology (3) S Lecture, 3 hours. Prerequisite(s): BIOL 002 or both BIOL 005A and BIOL 05LA; both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC. Examination of soil biota and their relationships with plants and the soil environment. Emphasis is on soil biotic interactions that influence soil fertility, plant disease, and plant growth. Examines the importance of the different microbial and faunal groups from the rhizosphere to the ecosystem level. Cross-listed with NEM 120 and SWSC 120. **Crowley, DeLey**

ENSC 127. Fate and Transport of Contaminants in Soil (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC; ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H; MATH 009B or MATH 09HB. Topics include interactions of environmental conditions with abiotic and biotic transformation and transport of major organic and inorganic contaminants in soil. Cross-listed with SWSC 127. **Gan**

ENSC 133. Environmental Microbiology (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C; or consent of instructor. Introduction to nonpathogenic microorganisms in the environment. Topics include an introduction to microbial biology and microbial and metabolic genetic diversity; methods; symbiotic interactions; biofilms; and geomicrobiology and biogeochemistry. Explores life in extreme environments and the effects of the physical and chemical environment on microbes. Cross-listed with MCBL 133 and SWSC 133.

ENSC 134. Soil Conditions and Plant Growth (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 104/BPSC 104, ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H; or consent of instructor. A study of the chemical, physical, and biological properties of soils and their influence on plant growth and development. Topics include soil-plant water relations; fundamentals of plant mineral nutrition; soil nutrient pools and cycles; soil acidity, alkalinity, salinity, and sodicity; root symbioses and rhizosphere processes. Cross-listed with BPSC 134 and SWSC 134. **Crowley**

ENSC 135. Chemistry of the Clean and Polluted Atmosphere (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 112A, CHEM 112B, or consent of instructor; ENSC 102 recommended. Structure of the troposphere and stratosphere; formation of atmospheric ozone; tropospheric NOx chemistry; methane oxidation cycle; phase distributions of chemicals; wet and dry deposition; chemistry of volatile organic compounds; formation of photochemical air pollution; modeling of air pollution and control strategies; stratospheric ozone depletion and global warming. Cross-listed with CHEM 135 and ENTX 135. **Ziemann**

ENSC 136. Chemistry of Natural Waters (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 005 with a grade of "C-" or better or ENSC 104/SWSC 104 with a grade of "C-" or better or consent of instructor. Introduction to processes controlling the chemical composition of natural waters. Topics include chemical equilibria, acid-base and coordination chemistry, oxidation-reduction reactions, precipitation-dissolution, air-water exchange, and use of equilibrium and kinetic models for describing marine nutrient, trace metal, and sediment chemistry. Cross-listed with CHEM 136, ENTX 136, and SWSC 136.

ENSC 138. Soils of Natural Ecosystems and Landforms (4) S Lecture, 3 hours; laboratory, 4 hours per quarter; one half-day field trip and three 1-day field trips. Prerequisite(s): ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H; GEO 001 or GEO 002; or consent of instructor. The study of soils in diverse natural environments. Examines how soils form and their roles in ecosystem function and landscape processes. Includes causes of soil variability, fundamentals of soil classification, and indicators of current and past environmental conditions. Field trips emphasize the description and interpretation of soils. Cross-listed with GEO 138 and SWSC 138. **Graham**

ENSC 140. Limnology (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC; ENSC 101. Study of surface waters. Considers in detail the physical and chemical processes in surface waters, aquatic biology, ecosystem dynamics, and aspects of surface water quality and modeling. Cross-listed with SWSC 140. **Anderson**

ENSC 141. Public Health Microbiology (4) F Lecture, 4 hours. Prerequisite(s): BIOL 002 or both BIOL 005A and BIOL 05LA; BIOL 003 or BIOL 005B; upper-division standing; or consent of instructor. Introduction to transmission of human pathogenic microorganisms through environmental media, including drinking water, wastewater, and air. Topics include characterization of environmentally transmitted pathogens, microbial risk assessment, sampling and detection methods for microorganisms in environmental samples, waterborne disease outbreaks, recycling or re-use of wastewater, microbial regulations and standards, and indoor air microbiology. Cross-listed with MCBL 141 and SWSC 141. **Yates**

ENSC 142. Water Quality (4) Lecture, 4 hours. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC; ENSC 101; upper-division standing or consent of instructor. Topics include principles and practices of water pollution control; basic concepts of water quality management; and the chemistry and physics of water purification processes.

ENSC 143A. Environmental Economics (4) F Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ECON 003 or ECON 004 or equivalent, MATH 022 or equivalent; or consent of instructor. Introduction to economic analysis of natural resources and the environment with emphasis on environmental quality. Topics include environment-economy interactions and social choice theory; source control costs, damage valuation, and efficient pollution control; and design of efficient and equitable environmental policy. Cross-listed with ECON 143A. **Baerenklau**

NSC 143B. Natural Resource Economics (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ECON 143A/ENSC 143A or consent of instructor. Considers the extraction and use of natural resources. Topics include land use and natural capital economics and valuation; economics of mineral and nonrenewable resources including recycling; and managing biological and renewable resources, including common property, efficient usage, and regulation. Cross-listed with ECON 143B. **Fernandez**

ENSC 143C. Ecological Economics and Environmental Valuation (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ECON 143A/ENSC 143A or consent of instructor. Survey of environmental valuation and economy-wide, long time-scale issues. Valuation methods covered include hedonic pricing, weak complements, contingent valuation, and ecosystem services. Environmental macroeconomic topics include population growth, biophysical constraints to economic growth, intertemporal welfare and sustainability, and sustainable development. Cross-listed with ECON 143C.

NSC 144. Solid Waste Management (4) S Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 002 or both BIOL 005A and BIOL 05LA; both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC; either both ENSC 001 (or ENSC 001H) and ENSC 002 (or ENSC 002H) or ENVE 171; MATH 009B (or MATH 09HB) or MATH 022; or consent of instructor. A study of the characterization, collection, transportation, processing, disposal, recycling, and composting of municipal solid waste. Emphasizes accepted management strategies and design procedures for recovering or disposing solid wastes while protecting public and environmental well-being. Cross-listed with ENVE 144. **Crohn**

ENSC 155. Principles and Applications of Bioremediation (4) F Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 002, BIOL 003, or equivalents; ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H. A study of the principles, applications, and case histories of biological treatment in the cleanup of hazardous chemicals. Topics include remediation of contaminated soils, sediments, sludges, groundwater, and vapors. **Frankenberger**

ENSC 163. Hydrology (4) W Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): MATH 009B or MATH 09HB; STAT 100B; or consent of instructor. Introduction to the scientific study of the hydrologic cycle. Covers the measurement and evaluation of hydrologic phenomena, including the use of statistical methods. Explores computer techniques in hydrology with applications to water resource development and water quality problems, particularly those in California. The laboratory includes field and computer assignments. **Sickman**

ENSC 172. Principles of Environmental Impact Analysis (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ECON 006/ENSC 006; ENSC 001 or ENSC 001H; ENSC 002 or ENSC 002H. Principles and theories of analyzing environmental interactions. Critical analysis of methodologies for assessing the physical, biological and social impacts on the environment by human activities. Synthesis of the subject matter through preparation of an environmental impact report.

ENSC 174. Law, Institutions, and the Environment (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ENSC 001 or ENSC 001H; ENSC 002 or ENSC 002H; or consent of instructor. Introduction to the important and complex issues of natural resource ownership, protection, and regulation in the institutional environment of local, state, and federal laws, implementing agencies, and competing interests in environmental protection. Decision making is examined in the context of the rights and limits of both private parties and the broad public interest in the use and protection of natural resources.

ENSC 190. Special Studies (1-5) F, W, S variable hours. Prerequisite(s): upper-division standing and consent of instructor. Special studies as a means of meeting special curricular problems. Graded Satisfactory (S) or No Credit (NC); however, students may petition the instructor for a letter grade. Course is repeatable.

ENSC 191. Seminar in Professional Development in Environmental Sciences (2) F, W, S Seminar, 2 hours. Prerequisite(s): upper-division standing in Environmental Sciences or consent of instructor. Lectures and discussions on scientific writing, critical analysis in reading, public speaking, job interview and resume preparation, and professional conduct. Students make both written and oral presentations on topics in Environmental Sciences.

ENSC 197. Research for Undergraduates (1-4) F, W, S variable hours. Prerequisite(s): upper-division standing and consent of instructor. Individual research on a problem relating to environmental science to be conducted under the guidance of an instructor. Graded Satisfactory (S) or No Credit (NC); however, students may petition the instructor for a letter grade. Course is repeatable.

ENSC 198-I. Internship in Environmental Sciences (1-12) F, W, S Field, 3-36 hours. Prerequisite(s): upper-division standing; ENSC 001 or ENSC 001H or equivalent; ENSC 002 or ENSC 002H or equivalent. An academic internship, involving participation in a functional capacity in the enhancement or maintenance of environmental quality, conducted under the joint supervision of an off-campus sponsor and a faculty member in Environmental Sciences. A final written report based on the internship experience is required. One unit of credit for every three hours per week spent in internship. Graded Satisfactory (S) or No Credit (NC), but in exceptional cases student may petition for a letter grade. Course is repeatable to a maximum of 16 units.

Graduate Courses

ENSC 200. Fate and Transport of Chemicals in the Environment (4) S Lecture, 4 hours. Prerequisite(s): CHEM 109 or CHEM 110B; CHEM 112A, CHEM 112B, CHEM 112C; or consent of instructor. Covers the identification of toxicants and their sources in the environment; equilibrium partitioning of chemicals in the environment (between air, water, soil, sediment, and biota) using physico-chemical properties; and the transport and chemical transformations of chemical compounds in air, water, and soil media. Includes case studies of fate and transport of selected toxic chemicals. Cross-listed with CHEM 246 and ENTX 200. **Atkinson**

ENSC 201. Environmental Management (4) S, Even Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ECON 003 or consent of instructor. An introduction to economic instruments used to make environmental policy to address pollution control and natural resource protection on local and international scales. Investigates public and private incentives for single and multiple polluters to reduce pollution and conserve exhaustible and renewable resources.

ENSC 202. Principles and Applications of Environmental Modeling (4) W, Alternate Even Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Introduction to the principles of transport modeling, including mass balance and flux laws, boundary conditions, and rate processes. Discusses and demonstrates the use of compartmental and differential models of specific environmental processes. Also examines case studies and environmental modeling software applications. May be taken Satisfactory (S) or No Credit (NC) by students advanced to candidacy for the Ph.D. **Simenuk**

ENSC 205. Functional Diversity of Prokaryotes (3) Lecture, 3 hours. Prerequisite(s): BCH 110A, BCH 110B, BIOL 121/MCBL 121; or equivalents; or consent of instructor. In-depth coverage of bacterial and archaeal bioenergetics, cell structure, diversity of metabolism, regulation of metabolism, growth, and biosynthesis, and cell-cell interactions between prokaryotes and eukaryotes. Project involves analysis of metabolic pathways from complete, annotated, prokaryotic genome sequences. Cross-listed with MCBL 201 and PLPA 201.

ENSC 206. Environmental Policy and Law (4) S, Even Years Seminar, 3 hours; extra reading, 3 hours. Prerequisite(s): graduate standing, POSC 010 or POSC 010H, POSC 020 or POSC 020H; or consent of instructor. An introduction to the process and politics of environmental regulation in the United States and the negotiation and implementation of international environmental accords. Uses social scientific methods of analysis to investigate specific issues such as air quality, energy, and biodiversity. Cross-listed with POSC 206. **Allison**

ENSC 207. Surface Water Quality Modeling (4) W, Odd Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Introduction to the principles of surface water quality modeling. Explores mathematical representations of surface water systems. Reviews theory and develops analytical and numerical solutions to describe hydrodynamics and mixing in surface waters, surface water quality, eutrophication, and the cycling and fate of contaminants in lake and river ecosystems. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. **Anderson**

ENSC 208. Ecotoxicology (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005A, BIOL 005B, CHEM 112A, CHEM 112B; or consent of instructor. Introduction to the impact of chemicals upon ecological systems. Examination of the fate and effects of environmental chemicals in various hierarchies of biological organization to learn how to carry out precise and accurate assessments of ecological risk. Cross-listed with ENTX 208 and SWSC 208. **Schlenk**

ENSC 214. Soil and Water Chemistry Laboratory (2) Laboratory, 6 hours. Prerequisite(s): concurrent enrollment in ENSC 104/SWSC 104 or consent of instructor. A series of advanced laboratory exercises involving modern analytical methods for soils, sediments, and surface waters. Topics include trace metal speciation, isotope exchange kinetics, mineral solubility, adsorption isotherms, redox couples, and partitioning and biodegradation of organic contaminants. Cross-listed with SWSC 214. **Parker**

ENSC 217. Vadose Zone Processes (4) W, Even Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B or MATH 09HB, ENSC 107/SWSC 107; or consent of instructor. A study of physical and mathematical descriptions of transient flow and transport processes in the vadose zone. Emphasis is on numerical solutions to equations describing the movement of water, gas, contaminants and heat, including chemical and biological reactions. Explores mathematical models for direct and inverse solutions, spatial heterogeneity, and determination of soil hydraulic properties. Cross-listed with SWSC 217. **Simunek**

ENSC 218. Isotopes in Ecology and Environmental Science (4) F, Odd Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC . Explores the principles and techniques of isotope tracer fractionation and mixing commonly used in ecology and environmental science. Introduces isotope notation, mixing models, and kinetic and equilibrium fractionation concepts. Includes case studies involving stable- and radioisotopes of carbon, nitrogen, oxygen, and sulfur. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable to a maximum of 4 units. **Sickman**

ENSC 227. Global Change and the Earth System (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor; ENSC 232/SWSC 232 is recommended. Examines the fundamental principles of earth system science in the context of global change. Emphasizes contemporary research on the relationship between humans and the Earth's environment. Topics include the earth system prior to human influence; the Anthropocene era (1850 to present); the responses of the Earth's support machinery to human activities; consequences of global change for human well-being; and pathways towards global sustainability. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ENSC 232. Biogeochemistry (4) W, Odd Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; consent of instructor. A study of the biogeochemical cycling and exchange of carbon and important nutrients (N, S, base cations) between the lithosphere, hydrosphere, and atmosphere. Quantitatively describes processes at scales ranging from local to global. Addresses modern concerns about water and atmospheric quality, including global climate change. Cross-listed with SWSC 232. **Parker**

ENSC 265. Special Topics in Earth and Environmental Sciences (1-3) F, W, S Seminar, 1-3 hours. Prerequisite(s): graduate standing. Involves oral presentations and small-group discussions of selected topics in the areas of biogeochemistry, global climate change, geomicrobiology, earth surface processes, and interplanetary life. Graded Satisfactory (S) or No Credit (NC). Course is repeatable as content changes to a maximum of 10 units. Cross-listed with GEO 265.

ENSC 275. Research Seminar in Environmental Sciences (1) Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Involves seminars by faculty, visiting scholars, environmental professionals, and advanced graduate students on current research topics in Environmental Sciences. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENSC 290. Directed Studies (1-6) Consultation, 1-3 hours; individual study, 1-15 hours. Prerequisite(s): graduate standing; consent of instructor and graduate advisor. Individual study of selected topics in Environmental Sciences under faculty direction. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENSC 297. Directed Research (1-6) Outside research, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor. Individual research performed under the direction of a faculty member. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENSC 299. Research for the Thesis or Dissertation (1-12) Outside research, 3-36 hours. Prerequisite(s): graduate standing; consent of instructor. Research in environmental sciences for the M.S. thesis or Ph.D. dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Course

ENSC 302. Teaching Practicum (1-4) Practicum, 3-12 hours. Prerequisite(s): graduate standing. Supervised teaching in Environmental Sciences or related courses. Required of all teaching assistants in Environmental Sciences. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Environmental Toxicology

Subject abbreviation: ENTX
College of Natural and Agricultural Sciences

Yinsheng Wang, Ph.D.,
Chair and Program Director
Program Office, 1001 Batchelor Hall North
(800) 735-7017 or (951) 827-4116
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Professors

Michael E. Adams, Ph.D. *Neurosciences* (Entomology/Cell Biology and Neuroscience)
Michael F. Allen, Ph.D. *Plant Pathology/Biology* (Plant Pathology)
Janet T. Arey, Ph.D. *Atmospheric Chemistry* (Environmental Sciences)
Roger Atkinson, Ph.D. *Atmospheric Chemistry* (Environmental Sciences)
Nancy E. Beckage, Ph.D. *Biochemistry and Endocrinology* (Entomology/Cell Biology and Neuroscience)
Wilfred Chen, Ph.D., *Chemical Engineering* (Chemical and Environmental Engineering)
Carl F. Cranor, Ph.D. *Regulation of Toxic Substances* (Philosophy)
David E. Crowley, Ph.D. *Environmental Microbiology* (Environmental Sciences)
David A. Eastmond, Ph.D. *Toxicology* (Cell Biology and Neuroscience)
Jianying "Jay" Gan, Ph.D. *Water Quality* (Environmental Sciences)
Sarjeet S. Gill, Ph.D. *Toxicology* (Cell Biology and Neuroscience)
Cynthia K. Larive, Ph.D. *Analytical Chemistry* (Chemistry)
Xuan Liu, Ph.D. *Transcription Regulation* (Biochemistry)
Ernest Martinez, Ph.D. *Molecular Biology* (Biochemistry)
Ashok K. Mulchandani, Ph.D. *Biosensors* (Chemical and Environmental Engineering)
David R. Parker, Ph.D. *Biogeochemistry* (Environmental Sciences)
Daniel Schlenk, Ph.D. *Aquatic Ecotoxicology* (Environmental Sciences)
Frances M. Sladek, Ph.D. *Transcriptional Regulation* (Cell Biology and Neuroscience)
Prudence Talbot, Ph.D. *Cell Biology* (Cell Biology and Neuroscience)
Yinsheng Wang, Ph.D. *Biological Mass Spectrometry* (Chemistry)
Yushan Yan, Ph.D. *Environmental Engineering* (Chemical and Environmental Engineering)
Marylynn V. Yates, Ph.D. *Environmental Microbiology* (Environmental Sciences)
Paul J. Ziemann, Ph.D. *Atmospheric Chemistry* (Environmental Sciences)

Associate Professors

Quan "Jason" Cheng, Ph.D. *Analytical Materials* (Chemistry)
Margarita C. Currás-Collazo, Ph.D. *Neurosciences* (Cell Biology and Neuroscience)
Mihri Ozkan, Ph.D. *Nanoelectronics and Nanoprobes* (Electric Engineering)

Assistant Professors

Jeffrey B. Bachant, Ph.D. *Chromosome Segregation* (Cell Biology and Neuroscience)
Constance Nugent, Ph.D. *Telomere Replication* (Cell Biology and Neuroscience)
Sharon Walker, Ph.D. *Environmental Engineering* (Chemical and Environmental Engineering)
Nicole I. zur Nieden, Ph.D. *Embryonic Stem Cells* (Cell Biology and Neuroscience)
Wenwan Zhong, Ph.D. *Analytical Chemistry* (Chemistry)

**

Lecturer

Robert Krieger, Ph.D. *Pesticide Toxicology* (Entomology)

Graduate Program

The program offers the M.S. and Ph.D. degrees in Environmental Toxicology.

The interdepartmental graduate program in Environmental Toxicology has participating faculty from the departments of Biochemistry, Cell Biology and Neuroscience, Chemical and Environmental Engineering, Chemistry, Entomology, Environmental Sciences, Philosophy, Plant Pathology and Microbiology, as well as scientists from the Air Pollution Research Center.

The goal of the program is to train toxicologists capable of directing research in areas of environmental toxicology. Areas of specialization include biochemical toxicology and chemical toxicology. To attain this goal, a three-tiered curriculum has been designed whereby students must complete