Environmental Studies

Students interested in studying the environment can choose among three majors in the following academic departments: Biology; Earth and Planetary Sciences; and Political Science. The curriculum for these majors is integrated and interdisciplinary, drawing from many disciplines across Arts & Sciences and the university as a whole, and the majors thus capture the strengths of both the traditional academic departments and the interdisciplinary innovation necessary to explore fully the multiple issues and questions posed in the study of the environment. Please visit the Environmental Studies website (http://enst.wustl.edu) for more information.

Please visit the following Bulletin pages for more information on these majors:

Environmental Biology
Environmental Earth Sciences
Environmental Policy

Phone: (314) 935-7047
E-mail: bowinston@wustl.edu
Departmental website: http://enst.wustl.edu

Director
David Fike
Associate Professor, Director and Contact for Environmental Earth Science
PhD, Massachusetts Institute of Technology
(Earth and Planetary Sciences)

Associate Director
Eleanor Pardini
Lecturer and Research Scientist, and Associate Director of Environmental Studies and Contact for Environmental Biology
PhD, University of Georgia
(Biology)

Professor
William R. Lowry
Contact for Environmental Policy
PhD, Stanford University
(Political Science)

Additional Faculty
Karen DeMatteo
Lecturer
PhD, St. Louis University
(Environmental Studies, GIS)

Scott Krummenacher
Postdoctoral Research Associate
PhD, St. Louis University
(Political Science)

Maxine I. Lipeles
JD, Harvard University
(Law, Interdisciplinary Environmental Clinic)

Beth Martin
MS, Washington University
(Law and Environmental Studies)

John Parks
PhD, Washington University
(Environmental Studies and University College)

Eric Zencey
Lecturer
PhD, Claremont Graduate University
Political Philosophy/Science History

Majors
The Major in Environmental Studies

Students interested in studying the environment can choose among three majors in the following academic departments: Biology; Earth and Planetary Sciences; and Political Science. Please visit the following Bulletin pages for more information on these majors:

Environmental Biology
Environmental Earth Sciences
Environmental Policy

Minors
The Minor in Environmental Studies

Required Units: 19

Required Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPSc 201</td>
<td>Earth and the Environment</td>
<td>4</td>
</tr>
<tr>
<td>Biol 2950</td>
<td>Introduction to Environmental Biology</td>
<td>3</td>
</tr>
<tr>
<td>Pol Sci 201</td>
<td>Introduction to Environmental Policy</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total units</strong></td>
<td></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

Elective Courses: 9 units — one course from each of the three categories below

One advanced science course:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPSc 323</td>
<td>Biogeochemistry</td>
<td>3</td>
</tr>
<tr>
<td>Biol 372</td>
<td>Behavioral Ecology</td>
<td>4</td>
</tr>
</tbody>
</table>


Change examines: 1) the physical basis for climate change; 2) how climates are changing and how we know and assess that climates are changing; and 3) the effects of climate change on natural and human systems. The course is team-taught and involves participation by scholars across the university with expertise in specific subjects. This is a broad, introductory course for first year students and presumes no special subject matter knowledge on the part of the student.

Same as InterO 101
Credit 3 units. A&S: NS A&S IQ: NSM

L82 EnSt 109A Quantitative Reasoning in Environmental Science
Introduction to practical mathematical methods for understanding environmental aspects of our planet, particularly how the environment changes with time through human interactions. Emphasis on intuitive approaches in devising simple relationships for understanding quantitative outcomes of natural processes. Introduction to basic statistical methods, including hypothesis testing, and how statistics can be applied to environmental problems.

Same as EPSc 109A
Credit 3 units. A&S: NS, QA A&S IQ: NSM, AN Art: NSM BU: SCI

L82 EnSt 110 Environmental Issues
This course examines the science behind current environmental issues, with emphasis on ecology and Earth science. Students gain an understanding about the consequences of the way that humans currently interact with the natural environment and potential solutions that would allow long-term sustainability of the Earth. Topics include: human population growth, global climate change, energy use, challenges to feeding the world, the interaction between the environment and human health, sustainable design, and the relationship between biodiversity and ecosystem functioning.

Credit 3 units. A&S: NS A&S IQ: NSM BU: SCI

L82 EnSt 122 Freshman Seminar: A Sense of Place: Discovering the Environment of St. Louis
This seminar is designed to serve as an introductory science seminar course for freshmen. The goals of the course include: Providing students with an introduction to the environmental setting of St. Louis; introducing students to topics of interest in the local environment; providing students with opportunities to identify and critically analyze environmental issues from a local perspective; and aiding students in their major selection by introducing them to a wide degree of scientific and environmental disciplines and perspectives.

Credit 3 units. A&S: NS A&S IQ: NSM BU: SCI

L82 EnSt 201 Earth and the Environment
Introduction to the study of the Earth as a dynamic, evolving planet. Emphasis on how internal and surface processes combine to shape the environment. Themes: Earth’s interior as revealed by seismic waves; Earth history and global tectonics shown by changes to ocean floors, mountain-building, formation of continents, earthquakes and volcanism; climate history and global biogeochemical cycles, influenced by circulation of atmosphere and oceans, ice ages and human activity. Composition and structure of rocks and minerals. Part of the introductory sequence of courses for all Earth and Planetary Sciences and Environmental Studies majors. Three class hours and one two-hour lab a week.
**L82 EnSt 210 Undergraduate Teaching Assistant**
Credit 3 units.

**L82 EnSt 221A Human Use of the Earth**
Examination of the impacts of a growing population on the Earth, including habitat destruction, resource depletion, and air and water pollution. Population growth, landscape change, and the distribution and uses of the water, mineral, and energy-producing resources of the Earth.
Same as EPSc 221A
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

**L82 EnSt 222 Topics in Japanese Literature and Culture:**
**Environmental Consciousness in Modern Japanese Literature**
Same as Japan 221
Credit 3 units. A&S: TH A&S IQ: HUM, LCD BU: IS EN: H

**L82 EnSt 2431 Missouri’s Natural Heritage**
Missouri’s Natural Heritage is a multidisciplinary two-semester Freshman Focus course. The first semester of the sequence focuses on Missouri geology, climate, archaeology and native megafauna. This provides a foundation on which to examine the ecology, restoration and management of our diverse habitats (prairie, forest, glade and stream) and the biology of our diverse plant and animal wildlife (arthropods, mollusks, fish, salamanders, lizards, birds and mammals) in the second semester. We also introduce basic concepts in biodiversity and resource management with attention to resolution of conflicts of interest. In addition to weekly lecture and discussion, students in this class visit sites across the state during three weekend camping trips and a longer camping trip during winter break. Attendance on field trips is an essential component of the course and grade. Lab fee of $480 covers transportation and meals for all field trips.
Same as Focus 2431
Credit 3 units. A&S IQ: NSM BU: SCI

**L82 EnSt 272A Physics and Society**
Introduction to physics: its goals, methods, and relevance for society. Topics include energy as a unifying principle of physics and society’s use of energy: resources and costs. Nuclear energy; history, technology, radioactivity, nuclear energy, fusion, fission, safety, weapons. Global climate change: the greenhouse effect, the hole in the ozone layer. Science and government. Bad science, pseudoscience, antiscience. Intended for science and nonscience majors. Must be taken for a letter grade.
Same as Physics 171A
Credit 3 units. A&S: NS, QA A&S IQ: NSM, AN Art: NSM BU: SCI

**L82 EnSt 290 Sophomore Seminar in Sustainability and the Environment**
This course provides an opportunity for students to evaluate and explore potential paths in environmental studies, and learn presentation skills to carry forward in their careers. Students also get the opportunity to get out of the classroom and participate in environmental field trips and activities.
Credit 3 units. A&S: NS A&S IQ: NSM

**L82 EnSt 299 Directed Internship**
Internship with an environmental organization (commercial, not-for-profit, governmental, etc.) where the primary objective is to obtain professional experience outside of the classroom. Student must have a faculty sponsor and must file a Learning Agreement with the Career Center, the faculty sponsor and the site supervisor. A final written project is agreed upon between the student and faculty sponsor before work begins, and is evaluated by the faculty sponsor at the end of the internship. Detailed supervision of the intern is the responsibility of the site supervisor.
Credit variable, maximum 3 units.

**L82 EnSt 3053 Nomadic Strategies and Extreme Ecologies**
This course explores the archaeology and anthropology of nomadic pastoral societies in light of their ecological, political and cultural strategies and adaptation to extreme environments (deserts, mountains, the arctic). The aim of the course is to understand both the early development of pastoral ways of life, and how nomads have had an essential role in the formation and transfer of culture, language and power from prehistoric time to the current era.
Same as Anthro 3053
Credit 3 units. A&S: SS A&S IQ: SSC Art: SSC BU: BA, IS EN: S

**L82 EnSt 306B Africa: Peoples and Cultures**
An anthropological survey of Africa from the classic ethnographies to contemporary studies of development. Emphasis on the numerous social and economic changes African peoples have experienced from precolonial times to the present.
Same as Anthro 306B
Credit 3 units. A&S: SS, CD A&S IQ: LCD, SSC BU: HUM, IS

**L82 EnSt 310 Ecological Economics**
This course is designed to give students an appropriately advanced understanding of the fundamental assumptions, the conceptual novelties, and the distinctive tools of analysis that comprise the emerging discipline of ecological economics. Often the value of tools is best illustrated through use, so the course also aims to acquaint students with how the conceptual frame of Ecological Economics offers a distinctive approach to some of the most pressing problems our culture faces — problems that have their origin in our perpetual-growth economy which now strains against (and in many places has far transgressed) environmental limits to growth.
Credit 3 units. A&S: SS A&S IQ: SSC EN: S

**L82 EnSt 323 Biogeochemistry**
Survey of biogeochemical interactions among Earth’s crust, oceans and atmosphere, including perturbations due to human activities. Carbon, nitrogen, phosphorus and sulfur biogeochemical cycles. Greenhouse warming of atmosphere from carbon dioxide and chlorofluorocarbons: effects of inorganic and organic wastes in groundwater systems. Introductory course for students of environmental science and nonscience majors. Prerequisite: permission of instructor.
Same as EPSc 323
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI
L82 EnSt 332 Environmental and Energy Issues
This course considers the major issues in these increasingly important areas of public policy. We discuss the importance of political processes and actors on such phenomenon as pollution, global warming and wilderness protection. This course emphasizes the American experience but also considers international implications. Two lectures and one section meeting each week.
Same as Pol Sci 332B
Credit 3 units. A&S: SS A&S IQ: SSC Arch: SSC Art: SSC BU: ETH

L82 EnSt 332 Brave New Crops
This course introduces students to the major issues surrounding the development and use in genetically modified (GM) crops. Its focus is international, but with particular focus on the developing world. A variety of experts, available locally or through the internet, contribute perspectives. The course also includes field trips. For further information, see http://arts.wustl.edu/~anthro/courses/3322.
Same as Anthro 3322
Credit 3 units. A&S: SS A&S IQ: SSC Art: NSM BU: ETH

L82 EnSt 335F Introduction to Environmental Ethics
A general survey of current issues in environmental ethics, focusing on problems such as the obligation to future generations, protection of endangered species, animal rights, problems of energy and pollution, wilderness, global justice, and business obligations. Students also learn some ethical and political theory.
Same as Phil 235F
Credit 3 units. A&S: TH A&S IQ: HUM Art: HUM BU: ETH

L82 EnSt 350W Environmental Issues: Writing
For students interested in environmental issues — natural science, social science and policy. This course aims to provide students with the writing skills they need to be successful in the environmental field once they graduate. In doing so, students examine environmental issues and decision-making processes by examining data and facts underlying positions and decisions. They explore the role of audience, purpose and author angle of vision as they examine the role of multiple stakeholders in environmental issues and processes. Students also are exposed to different types of writing used in environmental studies professions. When the course includes a service learning component, students are exposed to the types of writing that are necessary in environmental careers and in environmental non-profits and governmental agencies in particular.
Credit 3 units. A&S: NS, WI A&S IQ: NSM, WI

L82 EnSt 361 Culture and Environment
An introduction to the ecology of human culture, especially how "traditional" cultural ecosystems are organized and how they change with population density. Topics include foragers, extensive and intensive farming, industrial agriculture, the ecology of conflict, and problems in sustainability.
Same as Anthro 361
Credit 3 units. A&S: SS A&S IQ: SSC Art: SSC BU: ETH

L82 EnSt 374 Social Landscapes in Global View
From the beginning of the human campaign, societies have socialized the spaces and places where they live. This socialization comes in many forms, including the generation of sacred natural places (e.g., Mt. Fuji) to the construction of planned urban settings where culture is writ large in overt and subtle contexts. Over the past two decades or so, anthropologists, archaeologists and geographers have developed a wide body of research concerning these socially constructed and perceived settings — commonly known as "landscapes." This course takes a tour through time and across the globe to trace the formation of diverse social landscapes, starting in prehistoric times and ending in modern times. We cover various urban landscapes, rural landscapes, nomadic landscapes (and others) and the intersection of the natural environment, the built environments and the symbolism that weaves them together. Chronologically, we range from 3000 BCE to 2009 CE and we cover all the continents. This course also traces the intellectual history of the study of landscape as a social phenomenon and investigates the current methods used to recover and describe social landscapes around the world and through time. Join in situating your own social map alongside the most famous and the most obscure landscapes of the world and trace the global currents of your social landscape!
Same as Anthro 374
Credit 3 units. A&S: SS A&S IQ: SSC Art: NSM BU: BA EN: S

L82 EnSt 375 Urban Ecology
Urban Ecology: a field of study within ecology that focuses on the urban environment as an ecosystem and attempts to understand how humans and nature can better coexist in these highly modified environments. The ultimate goal is to aid efforts for more sustainable cities through better urban planning and practices. The class format includes both lectures and discussions.
Credit 3 units. A&S: NS A&S IQ: NSM

L82 EnSt 379 Feast or Famine: Archaeology and Climate Change
This course examines the temporal, geographical and environmental aspects of past climate changes, and by using specific examples, explores how climate changes may have affected the evolution of human culture and the course of human history. Archaeological and documentary examples from the Americas, Africa, Asia, Europe and the Near East are used to explore if or how significant events in human history have been influenced by changes in climate.
Same as Anthro 379
Credit 3 units. A&S: SS A&S IQ: SSC Art: SSC BU: EN: S

L82 EnSt 380 Applications in GIS
This introductory course in Geographic Information Systems (GIS) is designed to provide basic knowledge of GIS theory and applications using the existing state-of-the-art GIS software. The course is taught using a combination of lectures, demonstrations and hands-on, interactive tutorials in the classroom. The first week of the course provides a broad view of how students can display and query spatial data and produce map products. The remainder of the course focuses on applying spatial analytical tools to address questions and solve problems. As the semester develops, more tools are added to students' GIS toolbox so that they can complete a final independent project that integrates material learned during the course. Students are encouraged to design individualized final projects using their own or other available data; however, some already-prepared final projects also are available.
Credit 3 units. A&S: NS A&S IQ: NSM
L82 EnSt 381 Introduction to Ecology
This course explores the science of ecology, including factors that control the distribution and population dynamics of organisms, the structure and function of biological communities, how energy and nutrients flow across ecosystems, and what principles govern ecological responses to global climatic and other environmental changes. The class format includes lectures, discussions and small group exercises. Assignments include quantitative data analysis, ecological modeling and scientific writing.
Same as Biol 381
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

L82 EnSt 390 Independent Study
Independent study for undergraduates, supervised by a faculty member. Prerequisite: permission of instructor.
Credit variable, maximum 6 units.

L82 EnSt 391 Directed Research in Environmental Studies
Research activities or project in environmental studies done under the direction of an instructor in the Program. Permission of an instructor and the chair of the program is required.
Credit variable, maximum 6 units.

L82 EnSt 392 Directed Fieldwork in Environmental Studies
Fieldwork carried out under the direction or supervision of an instructor in the Program. Permission of an instructor and of the chair of the program is required.
Credit variable, maximum 6 units.

L82 EnSt 393 Practical Skills in Environmental Biology Research
This course provides students with an interest in research in environmental biology and a broad overview of the skills and tools needed for a successful career. Topics covered include: (1) developing ideas/approaches for research projects, (2) experimental design and analyses, (3) using the primary literature effectively, (4) writing successful small grant and fellowship proposals, and (5) writing/reporting results. In addition, students learn other important field biology skills, including a variety of field methods, as well as coping with rough field conditions. Some Saturday and nighttime field trips required.
Grading is based primarily on class participation and take-home assignments. Prerequisites/corequisites: permission of Professor Knight and at least one of the following courses: EnSt 370, EnSt 373, Biol 2950, Biol 3501, Biol 372, Biol/EnSt 381, Biol/EnSt 4170, Biol/EnSt 419, Biol 4191, Biol/EnSt 4193.
Credit 2 units. A&S: NS A&S IQ: NSM

L82 EnSt 405 Sustainability Exchange: Community and University Practicums
The Sustainability Exchange brings together students working in trans-disciplinary teams to tackle real-world energy, environmental and sustainability problems through an experiential form of education. Students participate in projects with clients and partners on- or off-campus, developed with and guided by faculty advisers drawn from across the university, with the intention of delivering an applicable end-product that explores “wicked” problems requiring innovative methods and solutions. These projects matter to the client or partner. The team-based project is complimented by a seminar that explores the field of design and design-thinking through problem-solving strategies and methodologies drawn from a wide range of creative practices, including design, engineering and science, as well as contemporary topics in energy, environment and sustainability. Students draw on these topics to influence their projects. This course is open to all undergraduate juniors and seniors. An application is required; students will be accepted off the wait list following the application process. Complete the application here at the time of registration: http://tinyurl.com/sustainabilityexchange.
Same as InterD 405
Credit 3 units. A&S IQ: SSC EN: S

L82 EnSt 406 Urban Ecosystem Principles Integration
In today’s world, your discipline has grand challenges whose solutions often lay in other realms. How will you train yourself to leverage the interdisciplinary partnerships required to innovatively solve and evolve in a rapidly changing world? The mission of this interdisciplinary course is to “Advance the interrelationships of ecological and human systems toward creating a healthy, resilient, and biodiverse urban environment,” and bring together experts and students in ecology, urban design, architecture/landscape architecture, economics, social work and engineering, drawing from inside and outside the WU community. Building from our knowledge of ecosystem principles and function, a diverse group of leaders in their fields provides lectures, readings and student project leadership to understand and test Healthy Urban Ecosystems Principles among human and ecological (nonhuman) systems and the range of sociopolitical processes entailed with their implementation. Class content is developed by Washington University leaders in their disciplines as well as external organizations such as the Missouri Botanical Garden, the Field Museum in Chicago and others. This course builds upon a 1-unit fall seminar (not a prerequisite) that introduces challenges and solutions to achieving healthy urban ecosystems, and provides students an opportunity to more deeply engage and manipulate the interrelationships of symbolic urban systems, and apply those concepts in multidisciplinary project applications. Projects leverage student-defined challenges in the evolving laboratory of urban St. Louis using Healthy Urban Ecosystems Principles to develop multidisciplinary integrated solutions to challenges encountered in urban areas such as climate change and resilience, security of ecosystem services, social inequity, economic strife, and community vitality. Students present their work in a public forum at semester’s end.
Same as InterD 406
Credit 3 units. A&S IQ: SSC EN: S

L82 EnSt 408 Earth’s Atmosphere and Global Climate
Structure and dynamics of Earth’s atmosphere. Basic factors controlling global climate of Earth. Quantitative aspects of remote sensing of atmosphere. Remote sensing instrumentation. Prerequisites: Math 233 and Phys 117A (or Phys 197); or permission of instructor.
Same as InterD 408
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

L82 EnSt 413 Introduction to Soil Science
Physical, chemical and biological processes that occur within soil systems. Types of soils and how these relate to soil formation. Major components of soil, including soil water, minerals, organic matter and microorganisms. Soils in wetlands and arid regions. Cycling of nutrients and contaminants in soils. Soil quality, conservation and sustainability. Two one-day field trips required. Prerequisites: EPSc 323 or Chem 112A (or AP Chem score of 4) or permission of instructor.
L82 EnSt 419 Community Ecology
Basic principles of community ecology, including species interactions, spatial and temporal patterns of biodiversity, and ecosystem functioning. Analytical theory, statistical patterns, and experimental approaches are emphasized. Intended for students wanting a rigorous overview of ecological principles. Prerequisite: at least one of the following courses: Biol 3501, 372, 381, 4170, 4193, EnSt 370 or permission of instructor. Same as Biol 419
Credit 4 units. A&S: NS & A&S IQ: NSM Art: NSM

L82 EnSt 4193 Experimental Ecology Laboratory
Design and interpretation of ecological experiments, with an emphasis on hypothesis testing, sampling methodology, and data analyses. Sessions address fundamental ecological questions and include field, greenhouse, and laboratory (microcosm) studies on a variety of taxa and ecosystems. Generally work is done before dark (5-6 p.m.), although occasionally goes later (7 p.m.). Includes occasional required Saturday field trips to local sites (e.g., forests, wetlands, prairies, streams) for in-depth study. Assignments are primarily several written assignments, including final projects and in-class participation. Fulfills the upper-level laboratory requirement for the Biology major. One hour of lecture and 4 hours of laboratory per week. Prerequisite: permission of instructor and at least one of the following: Introduction to Ecology (Biol 381), Behavioral Ecology (Biol 372), Biological Conservation (EnSt 370), Population Ecology (Biol 4170), Community Ecology (Biol 419), or Evolution (Biol 419). Credit will not be awarded for both 4191 and 4193. Enrollment is limited to 15 students. Same as Biol 4193
Credit 4 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM

L82 EnSt 428 Hydrology
Survey of principles that govern the flow of water in river and groundwater systems in deep geologic environments. Basic equations of fluid flow, dynamics and the characteristics of drainage basins, rivers, floods and important aquifers. Exploitation of ground water systems. Prerequisites: EPSc 353, Physics 117A (or Physics 197), Math 233, or permission of instructor. Same as EPSc 428
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

L82 EnSt 432 Environmental Mineralogy
Topics connected with environmental mineralogy, some selected by students. Topics may include: mineral dust such as asbestos, containment materials for nuclear waste disposal, environmental ramifications of the processing and use of phosphate fertilizers, lead in the environment, acid mine drainage, microbial mediation of sulfide oxidation, minerals in the human body, weathering of building materials, materials engineering, and engineering of materials for more effective recycling. Three class hours and one two-hour laboratory a week. Participation in discussions, term paper, two field trips required. Most readings from primary sources. Prerequisite: EPSc 352 or permission of instructor. Same as EPSc 430
Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM

L82 EnSt 444 Environmental Geochemistry
Introduction to the geochemistry of natural waters and the processes that alter their composition. Key principles of aqueous geochemistry and their application to describe the main controls on the chemistry of pristine and polluted soil, surface, and ground water environments. Acids and bases, mineral solubility, carbonate chemistry, chemical speciation, redox reactions, adsorption and ion exchange, and the speciation, mobility and toxicity of metals. Prerequisites: EPSc 201 and Chem 112A (or AP Chem score of 4); or permission of instructor. Same as EPSc 444
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L82 EnSt 451 Environmental Policy
This course examines the relationship between environmental economics and environmental policy. The course focuses on air pollution, water pollution, and hazardous wastes, with some attention given to biodiversity and global climate change. The course examines critically two prescriptions that economics usually endorses: (1) "balancing" of benefits against costs (e.g., benefit-cost analysis) and the use of risk analysis in evaluating policy alternatives; (2) use of market incentives (e.g., prices, taxes or charges) or "property rights" instead of traditional command-and-control regulations to implement environmental policy. Prerequisite: Econ 1011. Same as Econ 451
Credit 3 units. A&S: SS A&S IQ: SSC Art: SSC BU: BA, ETH

L82 EnSt 490 Senior Seminar
Provides an opportunity for students majoring in environmental science and environmental social science to communicate across interdisciplinary boundaries. Topics of current interest to environmental studies are presented and discussed by students in weekly sessions. Efforts are made to communicate ideas from environmental science, biology, economics, anthropology, geology, political science, chemistry, and law in ways that are easily understood by all participants. Prerequisite: senior standing.
Credit 3 units. A&S: NS A&S IQ: NSM

L82 EnSt 4980 Undergraduate Research Seminar
Provides an opportunity for advanced undergraduates to synthesize many of the diverse subdisciplines of Earth and Planetary Sciences while focusing on a research topic. Subject changes each offering. Each subject is unique and timely, but broad enough to encompass wide-ranging interests among students. Students conduct original research, make written reports of the results, and make oral presentations of their projects in class. Prerequisite: senior standing or permission of instructor. Same as EPSc 498
Credit 3 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM

---

Same as EPSc 413
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

---

L82 EnSt 419 Community Ecology
Basic principles of community ecology, including species interactions, spatial and temporal patterns of biodiversity, and ecosystem functioning. Analytical theory, statistical patterns, and experimental approaches are emphasized. Intended for students wanting a rigorous overview of ecological principles. Prerequisite: at least one of the following courses: Biol 3501, 372, 381, 4170, 4193, EnSt 370 or permission of instructor. Same as Biol 419
Credit 4 units. A&S: NS & A&S IQ: NSM Art: NSM

---

L82 EnSt 4193 Experimental Ecology Laboratory
Design and interpretation of ecological experiments, with an emphasis on hypothesis testing, sampling methodology, and data analyses. Sessions address fundamental ecological questions and include field, greenhouse, and laboratory (microcosm) studies on a variety of taxa and ecosystems. Generally work is done before dark (5-6 p.m.), although occasionally goes later (7 p.m.). Includes occasional required Saturday field trips to local sites (e.g., forests, wetlands, prairies, streams) for in-depth study. Assignments are primarily several written assignments, including final projects and in-class participation. Fulfills the upper-level laboratory requirement for the Biology major. One hour of lecture and 4 hours of laboratory per week. Prerequisite: permission of instructor and at least one of the following: Introduction to Ecology (Biol 381), Behavioral Ecology (Biol 372), Biological Conservation (EnSt 370), Population Ecology (Biol 4170), Community Ecology (Biol 419), or Evolution (Biol 419). Credit will not be awarded for both 4191 and 4193. Enrollment is limited to 15 students. Same as Biol 4193
Credit 4 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM

---

L82 EnSt 428 Hydrology
Survey of principles that govern the flow of water in river and groundwater systems in deep geologic environments. Basic equations of fluid flow, dynamics and the characteristics of drainage basins, rivers, floods and important aquifers. Exploitation of ground water systems. Prerequisites: EPSc 353, Physics 117A (or Physics 197), Math 233, or permission of instructor. Same as EPSc 428
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

---

L82 EnSt 432 Environmental Mineralogy
Topics connected with environmental mineralogy, some selected by students. Topics may include: mineral dust such as asbestos, containment materials for nuclear waste disposal, environmental ramifications of the processing and use of phosphate fertilizers, lead in the environment, acid mine drainage, microbial mediation of sulfide oxidation, minerals in the human body, weathering of building materials, materials engineering, and engineering of materials for more effective recycling. Three class hours and one two-hour laboratory a week. Participation in discussions, term paper, two field trips required. Most readings from primary sources. Prerequisite: EPSc 352 or permission of instructor. Same as EPSc 430
Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM

---

L82 EnSt 444 Environmental Geochemistry
Introduction to the geochemistry of natural waters and the processes that alter their composition. Key principles of aqueous geochemistry and their application to describe the main controls on the chemistry of pristine and polluted soil, surface, and ground water environments. Acids and bases, mineral solubility, carbonate chemistry, chemical speciation, redox reactions, adsorption and ion exchange, and the speciation, mobility and toxicity of metals. Prerequisites: EPSc 201 and Chem 112A (or AP Chem score of 4); or permission of instructor. Same as EPSc 444
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

---

L82 EnSt 451 Environmental Policy
This course examines the relationship between environmental economics and environmental policy. The course focuses on air pollution, water pollution, and hazardous wastes, with some attention given to biodiversity and global climate change. The course examines critically two prescriptions that economics usually endorses: (1) "balancing" of benefits against costs (e.g., benefit-cost analysis) and the use of risk analysis in evaluating policy alternatives; (2) use of market incentives (e.g., prices, taxes or charges) or "property rights" instead of traditional command-and-control regulations to implement environmental policy. Prerequisite: Econ 1011. Same as Econ 451
Credit 3 units. A&S: SS A&S IQ: SSC Art: SSC BU: BA, ETH

---

L82 EnSt 490 Senior Seminar
Provides an opportunity for students majoring in environmental science and environmental social science to communicate across interdisciplinary boundaries. Topics of current interest to environmental studies are presented and discussed by students in weekly sessions. Efforts are made to communicate ideas from environmental science, biology, economics, anthropology, geology, political science, chemistry, and law in ways that are easily understood by all participants. Prerequisite: senior standing.
Credit 3 units. A&S: NS A&S IQ: NSM

---

L82 EnSt 4980 Undergraduate Research Seminar
Provides an opportunity for advanced undergraduates to synthesize many of the diverse subdisciplines of Earth and Planetary Sciences while focusing on a research topic. Subject changes each offering. Each subject is unique and timely, but broad enough to encompass wide-ranging interests among students. Students conduct original research, make written reports of the results, and make oral presentations of their projects in class. Prerequisite: senior standing or permission of instructor. Same as EPSc 498
Credit 3 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM

---