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 (http://bulletin.wustl.edu/undergrad/artsci/biology/#majors)

Environmental Earth Sciences (http://bulletin.wustl.edu/undergrad/artsci/earthplanetarysciences/#majors)

Environmental Policy (http://bulletin.wustl.edu/undergrad/artsci/politicalscience/#majors)

**Faculty**

**Director**

David Fike (http://eps.wustl.edu/people/dave_fike)
InCEES Associate Professor, Department of Earth & Planetary Sciences
Associate Director, International Center for Energy, Environment and Sustainability (InCEES)
Director, Environmental Studies Program
PhD, Massachusetts Institute of Technology (Earth and Planetary Sciences)

**Associate Director**

Eleanor Pardini (http://wubio.wustl.edu/people/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 (http://polisci.wustl.edu/William_Lowry)
Contact for Environmental Policy
PhD, Stanford University
(Political Science)

**Additional Faculty**

Karen DeMatteo (https://eggert.biology.missouri.edu/people/former-students/karen-dematteo)
Lecturer
PhD, Saint Louis University
(Environmental Studies; GIS)

Scott Krummenacher (http://polisci.wustl.edu/faculty/scott-krumenacher)
Lecturer
PhD, Saint Louis University
(Political Science)

Maxine I. Lipeles (http://law.wustl.edu/Faculty/pages.aspx?id=291)
Senior Lecturer
JD, Harvard University
(Law; Interdisciplinary Environmental Clinic)

Suzanne Loui (https://enst.wustl.edu/people/suzanneloui)
Lecturer
PhD, Saint Louis University
(Biology; Environmental Studies)

Beth Martin (https://enst.wustl.edu/people/f-elizabeth-martin)
Senior Lecturer
MS, Washington University
(Environmental Studies)

John Parks (http://enst.wustl.edu/people/john-parks)
Lecturer
PhD, Washington University
(Environmental Studies; University College)

Eric Zencey (http://www.uvm.edu/giee/?Page=zencey.html)
Lecturer
PhD, Claremont Graduate University
(Political Philosophy/Science History)

**Majors**

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 (http://bulletin.wustl.edu/undergrad/artsci/biology/#majors)

Environmental Earth Sciences (http://bulletin.wustl.edu/undergrad/artsci/earthplanetarysciences/#majors)
Environmental Policy (http://bulletin.wustl.edu/undergrad/artscl/politicalscience/#majors)

Minors

The Minor in Environmental Studies

Required Units: 19

Required Courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</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 2010</td>
<td>Introduction to Environmental Policy</td>
<td>3</td>
</tr>
<tr>
<td>Total Units</td>
<td>10</td>
<td></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>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 372</td>
<td>Behavioral Ecology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 381</td>
<td>Introduction to Ecology</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 375</td>
<td>Urban Ecology</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 323</td>
<td>Biogeochemistry</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 401</td>
<td>Earth Systems Science</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 413</td>
<td>Introduction to Soil Science</td>
<td>3</td>
</tr>
<tr>
<td>Total Units</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

One advanced political science or law course:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pol Sci 3240</td>
<td>The Political Economy of Public Goods</td>
<td>3</td>
</tr>
<tr>
<td>Pol Sci 331</td>
<td>Topics in Politics</td>
<td>3</td>
</tr>
<tr>
<td>Pol Sci 332B</td>
<td>Environmental and Energy Issues</td>
<td>3</td>
</tr>
<tr>
<td>Pol Sci 3752</td>
<td>Topics in American Politics: Globalization, Urbanization and Environment</td>
<td>3</td>
</tr>
<tr>
<td>Pol Sci 4043</td>
<td>Public Policy Analysis, Assessment and Practical Wisdom</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 539</td>
<td>Interdisciplinary Environmental Clinic</td>
<td>var.; max 6</td>
</tr>
<tr>
<td>Total Units</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

One advanced anthropology or ethics course:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthro 3322</td>
<td>Brave New Crops</td>
<td>3</td>
</tr>
<tr>
<td>Anthro 3472</td>
<td>Global Energy and the American Dream</td>
<td>3</td>
</tr>
<tr>
<td>Anthro 361</td>
<td>Culture and Environment</td>
<td>3</td>
</tr>
<tr>
<td>Anthro 4211</td>
<td>Paleoenvironment and Ethnobotany</td>
<td>3</td>
</tr>
</tbody>
</table>

EnSt 335F | Introduction to Environmental Ethics            | 3     |

Courses that are offered less frequently or have more prerequisites but that are preapproved substitutions for these requirement categories include:

Advanced science:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 4170</td>
<td>Earth's Atmosphere and Global Climate</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 408</td>
<td>Environmental Hydrogeology</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 429</td>
<td>Environmental Geochemistry</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 444</td>
<td>Paleoenvironmental Reconstruction</td>
<td>3</td>
</tr>
</tbody>
</table>

Advanced political science or law:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Econ 451</td>
<td>Environmental Policy</td>
<td>3</td>
</tr>
</tbody>
</table>

Advanced anthropology or ethics:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthro 3612</td>
<td>Population and Society</td>
<td>3</td>
</tr>
<tr>
<td>Anthro 4215</td>
<td>Anthropology of Food</td>
<td>3</td>
</tr>
</tbody>
</table>

Other advanced courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnSt 405</td>
<td>Sustainability Exchange: Community and University Practicums</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 406</td>
<td>Urban Ecosystem Principles Integration</td>
<td>3</td>
</tr>
</tbody>
</table>

The Minor in Interdisciplinary Environmental Analysis

Required Units: 18

Required Courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnSt 350W</td>
<td>Environmental Issues: Writing</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 357</td>
<td>Environmental Problem Solving</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 380</td>
<td>Applications in GIS</td>
<td>3</td>
</tr>
<tr>
<td>Total Units</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

One interdisciplinary environmental capstone course:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnSt 405</td>
<td>Sustainability Exchange: Community and University Practicums</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 406</td>
<td>Urban Ecosystem Principles Integration</td>
<td>3</td>
</tr>
</tbody>
</table>
The 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 115 Introduction to Conservation Biology
This course is introductory level and appropriate for both non-science majors as well as potential science majors who may be investigating their interests. Conservation Biology will focus on biodiversity, its preservation and current threats, as well as obstacles to its preservation for the future. We will examine the different levels of biodiversity present in nature as well as highlighting its importance, and why it matters to the human population. In studying Conservation Biology, students will also learn key concepts from related fields such as evolution and ecology that are necessary to understand concepts and concerns. Course topics include species and ecosystem management, restoration, strategies to combat threats, and past successes and failures relating to biodiversity conservation.

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

L82 EnSt 122 A&S Freshman Seminar: A Sense of Place: Discovering the Environment of St. Louis
Students go exploring in and around St. Louis. Rivers, prairies, urban landscapes and more. They'll learn about the St. Louis backyard and their "home" for the next four years. Through field trips, readings, interviews and discussion, they'll see first-hand what challenges face the environment and the people who live here. They will learn how to examine multiple perspectives, how to think critically and how to approach problems from an interdisciplinary and holistic approach. Students also learn why it is important to know a community at the local level if they're going to affect change on any level — state, national or international. In addition to weekly readings and discussion, this class includes several field trips.

Credit 3 units. 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.

Same as L19 EPSc 201
Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

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 L19 EPSc 221A
A&S: NS A&S IQ: NSM Art: NSM BU: SCI

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 L19 EPSc 323
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

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 L30 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 BU: SCI

L82 EnSt 357 Environmental Problem Solving
This course aims to provide students with the opportunity
to develop and apply problem-solving skills in the context of
environmental challenges. Students will learn basic frameworks
decision-making through readings and role-play. Through the
role-play, students will grapple with the perspectives of multiple stakeholders, the interplay of science and policy, and the
ambiguity and uncertainty inherent in decision-making processes.
Credit 3 units. A&S IQ: SSC Arch: SSC Art: SSC BU: BA EN: S

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. Fiji) to the construction of
planned urban settings where culture is writ large in
overt and subtle contexts. Over the past two decades or
more, 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 L48 Anthro 374
Credit 3 units. A&S: SS A&S IQ: LCD, SSC Art: SSC BU: BA EN:
S UColl: NW

L82 EnSt 375 Urban Ecology
Urban Ecology is 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. It is a multidisciplinary study including topics
from ecology, evolution and conservation biology, as well as
architecture, economics and business. The class format will
include both lectures and discussions.
Credit 3 units. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

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 L41 Biol 381
Credit 3 units. A&S A&S IQ: NSM Art: NSM BU: S

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.
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 405 Sustainability Exchange: Community and University Practicums
The Sustainability Exchange will bring together students working in transdisciplinary teams to tackle real-world energy, environmental, and sustainability problems through an experiential form of education. Students will 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 will be complemented by a seminar that will explore 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 will 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. CET (https://gephardtinstitute.wustl.edu/cec/college-of-arts-sciences) course.
Same as I50 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 inter disciplinary 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 Washington University 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 symbiotic 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. CET (https://gephardtinstitute.wustl.edu/cec/college-of-arts-sciences) course.
Same as I50 InterD 406
Credit 3 units. A&S IQ: SSC EN: S

L82 EnSt 408 Earth's Atmosphere & 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 L19 EPSc 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.
Same as L19 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 L41 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. Prerequisites: 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 3501). Credit will not be awarded for both 4191 and 4193. Enrollment is limited to 15 students.
Same as L41 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. Prerequisite: EPSc 353; or permission of instructor. 
Same as L19 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 L19 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 L19 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 L11 Econ 451
Credit 3 units. A&S: SS A&S IQ: SSC Art: SSC BU: BA, ETH

L82 EnSt 452 International Climate Negotiation Seminar
This course is a 3-credit advanced seminar for students who will represent Washington University at the annual United Nations Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). COP22 will be held in Marrakech, Morocco, in November of 2017. 
Credit variable, maximum 6 units. A&S IQ: SSC EN: S

L82 EnSt 461 Intro to Environmental Law and Policy
Survey of the most prominent federal laws governing environmental compliance and pollution control. Examines laws applicable to environmental impact statements, air pollution, water pollution, and hazardous waste. Addresses policy
Concerning the relative merits of using technological capabilities as compared with health risks in setting environmental standards. Discusses the need for environmental regulation to protect societal resources. 
Credit 3 units. A&S: SS A&S IQ: SSC EN: S

L82 EnSt 481 Advanced GIS
This course is designed to move beyond tools and skills learned in Applications in GIS (EnSt 380/580). Classes will feature hands-on exercises selected to help students master advanced GIS analysis tools and techniques, while providing experience in the planning and execution of real-world projects. Primary emphasis will be on applying fundamental GIS concepts, performing spatial analysis, developing proficiency with core ArcGIS software (e.g., Network Analyst extension), resolution of problems, and efficient delivery of results. Readings from books and scientific literature will introduce key concepts and provide real-world examples that will be reinforced in the hands-on exercises, assignments and projects. As the semester develops, students will gain a variety of new tools and techniques that will allow them to complete a final independent project that integrates the material learned during the course. 
Credit 3 units. 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 L19 EPSc 498
Credit 3 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM