EARTH SYSTEMS (EARTHSYS)

EARTHSYS 10. Introduction to Earth Systems. 4 Units.
For non-majors and prospective Earth Systems majors. Multidisciplinary approach using the principles of geology, biology, engineering, and economics to describe how the Earth operates as an interconnected, integrated system. Goal is to understand global change on all time scales. Focus is on sciences, technological principles, and sociopolitical approaches applied to solid earth, oceans, water, energy, and food and population. Case studies: environmental degradation, loss of biodiversity, and resource sustainability.

EARTHSYS 100. Environmental and Geological Field Studies in the Rocky Mountains. 3 Units.
Three-week, field-based program in the Greater Yellowstone/Teton and Wind River Mountains of Wyoming. Field-based exercises covering topics including: basics of structural geology and petrology; glacial geology; western cordillera geology; paleoclimatology; chemical weathering; aqueous geochemistry; and environmental issues such as acid mine drainage and changing land-use patterns.
Same as: ESS 101, GS 101

EARTHSYS 101. Energy and the Environment. 3 Units.
Energy use in modern society and the consequences of current and future energy use patterns. Case studies illustrate resource estimation, engineering analysis of energy systems, and options for managing carbon emissions. Focus is on energy definitions, use patterns, resource estimation, pollution. Recommended: MATH 21 or 42.
Same as: ENERGY 101

EARTHSYS 102. Fundamentals of Renewable Power. 3 Units.
Do you want a much better understanding of renewable power technologies? Did you know that wind and solar are the fastest growing forms of electricity generation? Are you interested in hearing about the most recent, and future, designs for green power? Do you want to understand what limits power extraction from renewable resources and how current designs could be improved? This course dives deep into these and related issues for wind, solar, biomass, geothermal, tidal and wave power technologies. We welcome all student, from non-majors to MBAs and grad students. If you are potentially interested in an energy or environmental related major, this course is particularly useful.
Recommended: Math 21 or 42.
Same as: ENERGY 102

EARTHSYS 103. Understanding Energy. 3-5 Units.
Energy is a fundamental driver of human development and opportunity. At the same time, our energy system has significant consequences for our society, political system, economy, and environment. For example, energy production and use is the number one source of greenhouse gas emissions. In taking this course, students will not only understand the fundamentals of each energy resource – including significance and potential, conversion processes and technologies, drivers and barriers, policy and regulation, and social, economic, and environmental impacts – students will also be able to put this in the context of the broader energy system and think critically about how and why society has chosen particular energy resources. Both depletable and renewable energy resources are covered, including oil, natural gas, coal, nuclear, biomass and biofuel, hydroelectric, wind, solar thermal and photovoltaics (PV), geothermal, and ocean energy, with cross-cutting topics including electricity, storage, climate change, sustainability, green buildings, energy efficiency, transportation, and the developing world. The course is 4 units, which includes lecture and in-class discussion, readings and videos, assignments, and two off-site field trips. Enroll for 5 units to also attend the Workshop, an interactive discussion section on cross-cutting topics that meets once per week for 80 minutes (timing TBD based on student schedules). The 3-unit option requires instructor approval - please contact Diana Ginnebaugh. Website: http://web.stanford.edu/class/cee207a/ Course was formerly called Energy Resources. Prerequisites: Algebra. May not be taken for credit by students who have completed CEE 107S.
Same as: CEE 107A, CEE 207A

EARTHSYS 103F. Understanding Energy -- Field Trips. 1 Unit.
This course is only for students who have already taken CEE 107A/207A/ Earyshs 103 -- Understanding Energy. Please contact Kirsten Stasio (kstasio@stanford.edu) for instructor consent code.
Same as: CEE 107F, CEE 207F

EARTHSYS 104. The Water Course. 3 Units.
The pathway that water takes from rainfall to the tap using student home towns as an example. How the geological environment controls the quantity and quality of water; taste tests of water from around the world. Current U.S. and world water supply issues.
Same as: GEOPHYS 70

EARTHSYS 105. Food and Community: Creating Change through Education and Outreach. 3 Units.
In this community-engaged learning course, students will learn about local efforts to bring about positive change in the Bay Area food system, with a particular focus on nutrition and garden-based education and outreach programs designed to encourage healthy and sustainable behaviors. Through field trips, readings, and work with community partner organizations, students will develop familiarity with diverse organizations and engagement strategies, and gain practical, hands-on experience designing and carrying out community-oriented projects. Cardinal Course (certified by Haas Center). Limited enrollment. May be repeated for credit.

EARTHSYS 105A. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units.
Formerly 96A - Jasper Ridge Docent Training. First of two-quarter sequence training program to join the Jasper Ridge education/docent program. The scientific basis of ecological research in the context of a field station, hands-on field research, field ecology and the natural history of plants and animals, species interactions, archaeology, geology, hydrology, land management, multidisciplinary environmental education; and research projects, as well as management challenges of the preserve presented by faculty, local experts, and staff. Participants lead research-focused educational tours, assist with classes and research, and attend continuing education classes available to members of the JRBP community after the course.
Same as: BIO 105A
EARTHSYS 105B. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units. 
Formerly 96B - Jasper Ridge Docent Training. First of two-quarter sequence training program to join the Jasper Ridge education/docent program. The scientific basis of ecological research in the context of a field station, hands-on field research, field ecology and the natural history of plants and animals, species interactions, archaeology, geology, hydrology, land management, multidisciplinary environmental education; and research projects, as well as management challenges of the preserve presented by faculty, local experts, and staff. Participants lead research-focused educational tours, assist with classes and research, and attend continuing education classes available to members of the JRBP community after the course. 
Same as: BIO 105B

EARTHSYS 106. World Food Economy. 5 Units. 
The economics of food production, consumption, and trade. The micro- and macro-determinants of food supply and demand, including the interrelationship among food, income, population, and public-sector decision making. Emphasis on the role of agriculture in poverty alleviation, economic development, and environmental outcomes. (graduate students enroll in 206). 
Same as: EARTHSYS 206, ECON 106, ECON 206, ESS 106, ESS 206

EARTHSYS 107. Control of Nature. 3 Units. 
Think controlling the earth's climate is science fiction? It is when you watch Snowpiercer or Dune, but scientists are already devising geoengineering schemes to slow climate change. Will we ever resurrect the woolly mammoth or even a T. Rex (think Jurassic Park)? Based on current research, that day will come in your lifetime. Who gets to decide what species to save? And more generally, what scientific and ethical principles should guide our decisions to control nature? In this course, we will examine the behind ways that people alter and engineer the earth, critically examining the positive and negative consequences. We'll explore these issues first through popular movies and books and then, more substantively, in scientific research. 
Same as: ESS 107

EARTHSYS 108. U.S. Environmental Law in Transition. 1 Unit. 
This course offers an accessible survey of timely topics in environmental law and policy as the United States transitions presidential administrations. Taught by two practicing lawyers, the class introduces students from any background to the interactions between local, state, and federal environmental law as they apply to prominent policy issues. We will analyze major changes in federal policy, providing historical context for the transformations now underway in the laws and institutions that help shape environmental outcomes in the United States. 
Same as: EARTHSYS 208

EARTHSYS 109. Creating a Green Student Workforce to Help Implement Stanford's Sustainability Vision. 2 Units. 
Examination of program-based local actions that promote resource conservation and an educational environment for sustainability. Examination of building-level actions that contribute to conservation, lower utility costs, and generate understanding of sustainability consistent with Stanford's commitment to sustainability as a core value. Overview of operational sustainability including energy, water, buildings, waste, and food systems. Practical training to enable students to become sustainability coordinators for their dorms or academic units. 
Same as: CEE 109, ENVIRNIST 109

EARTHSYS 110. Introduction to the foundations of contemporary geophysics. 3 Units. 
Introduction to the foundations of contemporary geophysics. Topics drawn from broad themes in: whole Earth geodynamics, geohazards, natural resources, and environment. In each case the focus is on how the interpretation of a variety of geophysical measurements (e.g., gravity, seismology, heat flow, electromagnetics, and remote sensing) can be used to provide fundamental insight into the behavior of the Earth. Prerequisite: CME 100 or MA TH 51, or co-registration in either. 
Same as: GEOPHYS 110

EARTHSYS 111. Biology and Global Change. 4 Units. 
The biological causes and consequences of anthropogenic and natural changes in the atmosphere, oceans, and terrestrial and freshwater ecosystems. Topics: glacial cycles and marine circulation, greenhouse gases and climate change, tropical deforestation and species extinctions, and human population growth and resource use. Prerequisite: Biology or Human Biology core or graduate standing. 
Same as: BIO 117, ESS 111

EARTHSYS 112. Human Society and Environmental Change. 4 Units. 
Interdisciplinary approaches to understanding human-environment interactions with a focus on economics, policy, culture, history, and the role of the state. Prerequisite: ECON 1. 
Same as: ESS 112, HISTORY 103D

EARTHSYS 113. Earthquakes and Volcanoes. 3 Units. 
Is the "Big One" overdue in California? What kind of damage would that cause? What can we do to reduce the impact of such hazards in urban environments? Does "fracking" cause earthquakes and are we at risk? Is the United States vulnerable to a giant tsunami? The geologic record contains evidence of volcanic super eruptions throughout Earth's history. What causes these gigantic explosive eruptions, and can they be predicted in the future? This course will address these and related issues. For non-majors and potential Earth scientists. No prerequisites. More information at: https://stanford.box.com/s/zr8ar28efmuo5wtlj6gj2jbxle76r4lu. 
Same as: GEOPHYS 90

EARTHSYS 115. Wetlands Ecology of the Pantanal Prefield Seminar. 2-3 Units. 
This seminar will prepare students for their overseas field experience in the Pantanal, Brazil, the largest wetland in the world, studying wetlands ecology and conservation in situ. Students will give presentations on specific aspects of the Pantanal and lay the groundwork for the presentations they will be giving during the field seminar where access to the internet and to other scholarly resources will be quite limited. Additional topics include: logistics, health and safety, cultural sensitivity, geography and politics, and basic language skills; also, post-field issues such as reverse culture shock, and ways in which participants can consolidate and build up their abroad experiences after they return to campus. Students will have the opportunity to participate in a pilot study aimed at developing a series of innovative online curriculum based upon their field experience.
EARTHSYS 115T. Island Biogeography of Tasmania Prefield Seminar. 3 Units.
Islands are natural laboratories for studying a wide variety of subjects including biological diversity, cultural diversity, epidemiology, geology, climate change, conservation, and evolution. This field seminar focuses on Island Biogeography in one of the most extraordinary and well-preserved ecosystems in the world: Tasmania. Tasmanian devils, wombats, and wallabies—the names conjure up images of an exotic faraway place, a place to appreciate the incredibly diversity of life and how such striking forms of life came to be. This course will prepare students for their overseas seminar in Tasmania. Students will give presentations on specific aspects of the Tasmania and will lay the groundwork for the presentations they will be giving during the field seminar where access to the internet and to other scholarly resources will be quite limited. Additional topics to be addressed include: logistics, health and safety, group dynamics, cultural sensitivity, history, and politics. We will also address post-field issues such as reverse culture shock, and ways to consolidate and build up abroad experiences after students return to campus.

EARTHSYS 116. Ecology of the Hawaiian Islands. 4 Units.
Terrestrial and marine ecology and conservation biology of the Hawaiian Archipelago. Taught in the field in Hawaii as part of quarter-long sequence of courses including Earth Sciences and Anthropology. Topics include ecological succession, plant-soil interactions, conservation biology, biological invasions and ecosystem consequences, and coral reef ecology. Restricted to students accepted into the Earth Systems of Hawaii Program.
Same as: BIO 116

EARTHSYS 117. Earth Sciences of the Hawaiian Islands. 4 Units.
Progression from volcanic processes through rock weathering and soil-ecosystem development to landscape evolution. The course starts with an investigation of volcanic processes, including the volcano structure, origin of magmas, physical-chemical factors of eruptions. Factors controlling rock weathering and soil development, including depth and nutrient levels impacting plant ecosystems, are explored next. Geomorphic processes of landscape evolution including erosion rates, tectonic/volcanic activity, and hillslope stability conclude the course. Methods for monitoring and predicting eruptions, defining spatial changes in landform, landform stability, soil production rates, and measuring biogeochemical processes are covered throughout the course. This course is restricted to students accepted into the Earth Systems of Hawaii Program.
Same as: EARTH 117, ESS 117

EARTHSYS 118. Heritage, Environment, and Sovereignty in Hawaii. 4 Units.
This course explores the cultural, political economic, and environmental status of contemporary Hawaiians. What sorts of sustainable economic and environmental systems did Hawaiians use in prehistory? How was colonization of the Hawaiian Islands informed and shaped by American economic interests and the nascent imperialism of the early 20th century? How was sovereignty and Native Hawaiian identity been shaped by these forces? How has tourism and the leisure industry affected the natural environment? This course uses archaeological methods, ethnohistorical sources, and historical analysis in an exploration of contemporary Hawaiian social economic and political life.
Same as: ANTHRO 118

EARTHSYS 119. Will Work for Food. 1 Unit.
This is a speaker series class featuring highly successful innovators in the food system. Featured speakers will talk in an intimate, conversational manner about their current work, as well as about their successes, failures, and learnings along the way. Additional information can be found here: http://feedcollaborative.org/speaker-series/.
Same as: EARTHSYS 219

EARTHSYS 11Q. Sustainability And Social Justice. 3 Units.
At its core, sustainability is a conversation about equity. Equity between people today and people tomorrow. Equity between the many diverse people today who are all trying to pursue their hopes and dreams. Equity between human beings and the myriad other living creatures we share this planet with. Movements for environmental sustainability and social justice share a concern for equity, but have largely evolved in parallel. Mounting evidence however shows that environmental and social change are almost always inextricably linked, and the climate crisis is pushing together these two areas of study like never before. That is good news, but tough questions remain. What happens when the environmental costs of personal freedom can no longer be sustained? Should the needs of the many always outweigh the needs of the few? Are we responsible for repairing the injustices of our parents’ and grandparents’ generations? Where are the win-win solutions? In this interdisciplinary seminar, we will explore the theory and practice of sustainability and social justice, examining case studies where they have intersected, and where they have not. Readings will draw from sustainability science, environmental justice, environmental ethics, religious studies, social psychology, and ecological economics. Through weekly readings, discussions, and journal writing, students will develop a personal sustainability manifesto and analyze a policy, technology, or social movement through the lens of social and environmental sustainability.
Same as: ETHICSOC 11Q

EARTHYS 121. Building a Sustainable Society: New Approaches for Integrating Human and Environmental Priorities. 3 Units.
"Building a Sustainable Society: New approaches for integrating human and environmental priorities" draws on economics, natural resources management, sociology and leadership science to examine theoretical frameworks and diverse case studies that illustrate challenges as well as effective strategies in building a sustainable society where human beings and the natural environment thrive. Themes include collaborative consumption, the sharing economy, worker-owned cooperatives, community-corporate partnerships, cradle to cradle design, social entrepreneurship, impact investing, "beyond GDP", and transformative leadership. Critical perspectives, lectures and student-led discussions guide analysis of innovations within public, private and civic sectors globally. Students explore their personal values and motivations and develop their potential to become transformative leaders.

EARTHYS 122. Evolution of Marine Ecosystems. 3-4 Units.
Life originally evolved in the ocean. When, why, and how did the major transitions occur in the history of marine life? What triggered the rapid evolution and diversification of animals in the Cambrian, after more than 3.5 billion years of Earth’s history? What caused Earth’s major mass extinction events? How do ancient extinction events compare to current threats to marine ecosystems? How has the evolution of primary producers impacted animals, and how has animal evolution impacted primary producers? In this course, we will review the latest evidence regarding these major questions in the history of marine ecosystems. We will develop familiarity with the most common groups of marine animal fossils. We will also conduct original analyses of paleontological data, developing skills both in the framing and testing of scientific hypotheses and in data analysis and presentation.
Same as: GS 123, GS 223B
EARTHSYS 123. Asian Americans and Environmental Justice. 3-5 Units.
One central tenet of the environmental justice movement is centering the leadership of frontline communities. Unfortunately, the struggles of Asian Americans on the frontlines of corporate environmental pollution and extraction are less visible and less well-known. In this course, we will explore the Asian American voices that have contributed to the development of the environmental justice movement and the leadership that is shaping the future of this movement. This course is designed to provide students with education about the history of the environmental justice movement, the future being envisioned, and the strategies that are needed to get to the vision. It will draw on lectures, readings, guest presentations, case studies, and the instructor’s more than 15 years of experience with organizing and social justice campaigns. Students will learn about the principles guiding the environmental justice movement; the vision and framework of how we achieve a just transition to a regenerative economy; the process of organizing and campaign work to advance a community agenda; and skills in collecting, analyzing, and communicating information.

Same as: ASNAMST 123

EARTHSYS 124. D^3: Disasters, Decisions, Development. 3-5 Units.
This class connects the science behind natural disasters with the real-world constraints of disaster management and development. In each iteration of this class we will focus on a specific, disaster-prone location as case study. By collaborating with local stakeholders we will explore how land-use change, engineering, and policy can make a difference in reducing disaster risk in the future. Offered every other year.

Same as: ESS 118, ESS 218, GEOPHYS 118, GEOPHYS 218, GS 118, GS 218

EARTHSYS 125. Shades of Green: Redesigning and Rethinking the Environmental Justice Movements. 3-5 Units.
Historically, discussions of race, ethnicity, culture, and equity in the environment have been relegated to the environmental justice movement, which often focuses on urban environmental degradation and remains separated from other environmental movements. This course will seek to break out of this limiting discussion. We will explore access to outdoor spaces, definitions of wilderness, who is and isn’t included in environmental organizations, gender and the outdoors, how colonialism has influenced ways of knowing, and the future of climate change. The course will also have a design thinking community partnership project. Students will work with partner organizations to problem-solve around issues of access and diversity. We value a diversity of experiences and epistemological beliefs, and therefore undergraduates and graduate students from all disciplines are welcome.

Same as: CSRE 125E, EARTHSYS 225

EARTHSYS 128. Evolution of Terrestrial Ecosystems. 4 Units.
The what, when, where, and how do we know it regarding life on land through time. Fossil plants, fungi, invertebrates, and vertebrates (yes, dinosaurs) are all covered, including how all of those components interact with each other and with changing climates, continental drift, atmospheric composition, and environmental perturbations like glaciation and mass extinction. The course involves both lecture and lab components. Graduate students registering at the 200-level are expected to write a term paper, but can opt out of some labs where appropriate.

Same as: GS 128, GS 228

EARTHSYS 129. Geographic Impacts of Global Change: Mapping the Stories. 4 Units.
Forces of global change (eg., climate disruption, biodiversity loss, disease) impart wide-ranging political, socioeconomic, and ecological impacts, creating an urgent need for science communication. Students will collect data for a region of the US using sources ranging from academic journals to popular media and create an interactive Story Map (http://stanford.maps.arcgis.com/apps/StorytellingTextLegend/index.html?appid=dafe2393fd2e4acc8b0a4e6e71d0b6d5) that merges the scientific and human dimensions of global change. Students will interview stakeholders as part of a community-engaged learning experience and present the Map to national policy-makers. Our 2014 Map is being used by the CA Office of Planning & Research.

EARTHSYS 12SC. Environmental and Geological Field Studies in the Rocky Mountains. 2 Units.
The ecologically and geologically diverse Rocky Mountain area is being strongly impacted by changing land use patterns, global and regional environmental change, and societal demands for energy and natural resources. This field program emphasizes coupled environmental and geological problems in the Rocky Mountains, covering a broad range of topics including the geologic origin of the American West from three billion years ago to the present; paleoclimatology and the glacial history of this mountainous region; the long- and short-term carbon cycle and global climate change; and environmental issues in the American West related to changing land-use patterns and increased demand for its abundant natural resources. In addition to the science aspects of this course we will also investigate the unique western culture of the area particularly in regards to modern ranching and outfitting in the American West. These broad topics are integrated into a coherent field-study as we examine earth/ environmental science-related questions in three different settings: 1) the three-billion-year-old rocks and the modern glaciers of the Wind River Mountains of Wyoming; 2) the sediments in the adjacent Wind River basin that host abundant gas and oil reserves and also contain the long-term climate history of this region; and 3) the volcanic center of Yellowstone National Park and the mountainous region of Teton National Park. Students will complete six assignments based upon field exercises, working in small groups to analyze data and prepare reports and maps. Lectures will be held in the field prior to and after fieldwork. The students will read two required books prior to this course that will be discussed on the trip.

EARTHSYS 131. Pathways in Sustainability Careers. 1 Unit.
Interactive, seminar-style sessions expose students to diverse career pathways in sustainability. Professionals from a variety of careers discuss their work, their career development and decision-points in their career pathways, as well as life style aspects of their choices.

Same as: EARTHSYS 131

EARTHSYS 132. Evolution of Earth Systems. 4 Units.
This course examines biogeochemical cycles and how they developed through the interaction between the atmosphere, hydrosphere, biosphere, and lithosphere. Emphasis is on the long-term carbon cycle and how it is connected to other biogeochemical cycles on Earth. The course consists of lectures, discussion of research papers, and quantitative modeling of biogeochemical cycles. Students produce a model on some aspect of the cycles discussed in this course. Grades based on class interaction, student presentations, and the modeling project.

Same as: EARTHSYS 232, ESS 132, ESS 232
EARTHSYS 133. Social Entrepreneurship Collaboratory. 4 Units.
Interdisciplinary student teams create and develop U.S. and international social entrepreneurship initiatives. Proposed initiatives may be new entities, or innovative projects, partnerships, and/or strategies impacting existing organizations and social issues in the U.S. and internationally. Focus is on each team’s research and on planning documents to further project development. Project development varies with the quarter and the skill set of each team, but should include: issue and needs identification; market research; design and development of an innovative and feasible solution; and drafting of planning documents. In advanced cases, solicitation of funding and implementation of a pilot project. Enrollment limited to 20. May be repeated for credit.
Same as: URBANST 133

EARTHSYS 135. Podcasting the Anthropocene. 3 Units.
The Anthropocene refers to the proposed geologic age defined by the global footprint of humankind. It’s an acknowledgement of the tremendous influence people and societies exert on Earth systems. Students taking the course will identify a subject expert, workshop story ideas with fellow students and instructors, conduct interviews, iteratively write audio scripts, and learn the skills necessary to produce final audio podcast as their final project. Our expectation is that the final projects will be published on the award-winning Generation Anthropocene podcast, with possible opportunities to cross post in collaboration with external media partners. Students taking EARTHSYS 135/235 are strongly encouraged to take EARTHSYS 135A/235A beforehand. Meets Earth Systems WIM requirement. (Cardinal Course certified by the Haas Center).
Same as: EARTHSYS 235

EARTHSYS 135A. Podcasting the Anthropocene 1.0. 1-2 Unit.
The Anthropocene refers to the proposed geologic age defined by the global footprint of humankind. It’s an acknowledgement of the tremendous influence people and societies exert on Earth systems. In this course, students research, prepare, and conduct audio interviews related to the Anthropocene with experts of their choosing. Instructors will help facilitate interviews and prepare student for the experience. Throughout the quarter students will participate in group workshops. This is a project-based course resulting in two long-form interviews. The expectation at the end of the quarter is to publish interviews via the Generation Anthropocene podcast, with possible opportunities to cross post in collaboration with external media partners. Students taking EARTHSYS 135/235 are strongly encouraged to take EARTHSYS 135A/235A beforehand. Meets Earth Systems WIM requirement. (Cardinal Course certified by the Haas Center).
Same as: EARTHSYS 235A

EARTHSYS 136. The Ethics of Stewardship. 2-3 Units.
What responsibilities do humans have to nonhuman nature and future generations? How are human communities and individuals shaped by their relationships with the natural world? What are the social, political, and moral ramifications of drawing sustenance and wealth from natural resources? Whether we realize it or not, we grapple with such questions every time we turn on the tap, fuel up cars, or eat meals and they are key to addressing issues like global climate change and environmental justice. In this class, we consider several perspectives on this ethical question of stewardship: the role of humans in the global environment. In addition to reading written work and speaking with land stewards, we will practice stewardship at the Stanford Educational Farm. This course must be taken for a minimum of 3 units and a letter grade to be eligible for Ways credit.
Same as: EARTHSYS 236

EARTHSYS 138. International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development. 4-5 Units.
Comparative approach to sustainable cities, with focus on international practices and applicability to China. Tradeoffs regarding land use, infrastructure, energy and water, and the need to balance economic vitality, environmental quality, cultural heritage, and social equity. Student teams collaborate with Chinese faculty and students partners to support urban sustainability projects. Limited enrollment via application; see internationalurbanization.org for details. Prerequisites: consent of the instructor(s).
Same as: CEE 126, IPS 274, URBANST 145

EARTHSYS 13SC. People, Land, and Water in the Heart of the West. 2 Units.
Salmon River. Sun Valley. Pioneer Mountains. The names speak of powerful forces and ideas in the American West. Central Idaho - a landscape embracing snow-capped mountains, raging rivers, sagebrush deserts, farms, ranches, and resort communities - is our classroom for this field-based seminar led by David Freyberg, professor of Civil and Environmental Engineering, and David Kennedy, professor emeritus of History. This course focuses on the history and future of a broad range of natural resource management issues in the western United States. We will spend a week on campus preparing for a two-week field course in Idaho exploring working landscapes, private and public lands, water and fisheries, conservation, and the history and literature of the relationship between people and the land in the American West. After the first week spent on campus, we will drive to Idaho to begin the field portion of our seminar. In Idaho, we will spend time near Twin Falls, at Lava Lake Ranch near Craters of the Moon National Monument, in Custer County at the Upper Salmon River, and near Stanley in the Sawtooth National Forest. No prior camping experience is required, but students should be comfortable living outdoors in mobile base camps for periods of several days. Students will investigate specific issues in-depth and present their findings at the end of the course.

EARTHSYS 140. The Energy-Water Nexus. 3 Units.
Energy, water, and food are our most vital resources constituting a tightly intertwined network: energy production requires water, transporting and treating water needs energy, producing food requires both energy and water. The course is an introduction to learn specifically about the links between energy and water. Students will look first at the use of water for energy production, then at the role of energy in water projects, and finally at the challenge in figuring out how to keep this relationship as sustainable as possible. Students will explore case examples and are encouraged to contribute examples of concerns for discussion as well as suggest a portfolio of sustainable energy options.
Same as: GEOPHYS 80

EARTHSYS 141. Remote Sensing of the Oceans. 3-4 Units.
How to observe and interpret physical and biological changes in the oceans using satellite technologies. Topics: principles of satellite remote sensing, classes of satellite remote sensors, converting radiometric data into biological and physical quantities, sensor calibration and validation, interpreting large-scale oceanographic features.
Same as: EARTHSYS 241, ESS 141, ESS 241, GEOPHYS 141

EARTHSYS 142. Remote Sensing of Land. 4 Units.
The use of satellite remote sensing to monitor land use and land cover, with emphasis on terrestrial changes. Topics include pre-processing data, biophysical properties of vegetation observable by satellite, accuracy assessment of maps derived from remote sensing, and methodologies to detect changes such as urbanization, deforestation, vegetation health, and wildfires.
Same as: EARTHSYS 242, ESS 162, ESS 262
EARTHSYS 144. Fundamentals of Geographic Information Science (GIS). 3-4 Units.
Survey of geographic information including maps, satellite imagery, and census data, approaches to spatial data, and tools for integrating and examining spatially-explicit data. Emphasis is on fundamental concepts of geographic information science and associated technologies. Topics include geographic data structure, cartography, remotely sensed data, statistical analysis of geographic data, spatial analysis, map design, and geographic information system software. Computer lab assignments. All students are required to attend a weekly lab session.
Same as: ESS 164

EARTHSYS 146A. Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the atmospheric circulation. Topics include the global energy balance, the greenhouse effect, the vertical and meridional structure of the atmosphere, dry and moist convection, the equations of motion for the atmosphere and ocean, including the effects of rotation, and the poleward transport of heat by the large-scale atmospheric circulation and storm systems. Prerequisites: MATH 51 or CME100 and PHYSICS 41.
Same as: CEE 161I, CEE 261I, EARTHSYS 246A, ESS 146A, ESS 246A, GEOPHYS 146A, GEOPHYS 246A

EARTHSYS 146B. Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the large-scale ocean circulation. This course will give an overview of the structure and dynamics of the major ocean current systems that contribute to the meridional overturning circulation, the transport of heat, salt, and biogeochemical tracers, and the regulation of climate. Topics include the tropical ocean circulation, the wind-driven gyres and western boundary currents, the thermohaline circulation, the Antarctic Circumpolar Current, water mass formation, atmosphere-ocean coupling, and climate variability. Prerequisites: EESS 146A or EESS 246A, or CEE 162D or CEE 262D, or consent of instructor.
Same as: CEE 162I, CEE 262I, EARTHSYS 246B, ESS 146B, ESS 246B

EARTHSYS 148. Grow it, Cook it, Eat it. An Experiential Exploration of How and Why We Eat What We Eat. 3 Units.
This course provides an introductory exploration of the social, cultural, and economic forces that influence contemporary human diets. Through the combination of interrelated lectures by expert practitioners and hands-on experience planting, tending, harvesting, cooking, and eating food from Stanford's dining hall gardens, students will learn to think critically about modern agricultural practices and the relationship between cuisine and human and ecological health outcomes. Students will also learn and apply basic practices of human-centered design to develop simple frameworks for understanding various eating behaviors in Stanford's dining halls and to develop and test hypotheses for how R&D at Stanford Dining might influence eating behaviors to effect better health outcomes for people and the planet. This class, which is offered through the FEED Collaborative in the School of Earth, Energy and Environmental Sciences, requires an application. For more information about the FEED Collaborative, application procedures and deadlines, and other classes we teach, please visit our website at http://feedcollaborative.org.

EARTHSYS 149. Wild Writing. 3 Units.
What is wilderness and why does it matter? In this course we will interrogate answers to this question articulated by influential and diverse American environmental thinkers of the 19th, 20th, and 21st centuries, who through their writing transformed public perceptions of wilderness and inspired such actions as the founding of the National Park System, the passage of the Wilderness Act and the Clean Air and Water Acts, the establishment of the Environmental Protection Agency, and the birth of the environmental and climate justice movements. Students will also develop their own responses to the question of what is wilderness and why it matters through a series of writing exercises that integrate personal narrative, wilderness experience, and environmental scholarship, culminating in a ~300-word narrative nonfiction essay. This course will provide students with knowledge, tools, experience, and skills that will empower them to become more persuasive environmental storytellers and advocates.
Same as: EARTHSYS 249

EARTHSYS 15. Gender, Land Rights, and Climate Change: An International Perspective. 1 Unit.
For decades, numerous and far-reaching consequences of anthropogenic climate change have disproportionately affected women, from poverty, to land rights, to education, to food security, and everything in between. As a result, mitigating climate change has massive implications for women's rights worldwide, and yet few national or International policies address this critical and worsening intersection. This weekly seminar will examine in depth the relationship between gender and climate change, with a particular focus on land rights, resource use, and international policy in the era of the Sustainable Development Goals and the Paris Agreement. The course will feature guest speakers, reading discussions, and tools to persuasively communicate about gender and climate change.

EARTHSYS 151. Biological Oceanography. 3-4 Units.
Required for Earth Systems students in the oceans track. Interdisciplinary look at how oceanic environments control the form and function of marine life. Topics include distributions of planktonic production and abundance, nutrient cycling, the role of ocean biology in the climate system, expected effects of climate changes on ocean biology. Local weekend field trips. Designed to be taken concurrently with Marine Chemistry (EESS/EARTHSYS 152/252). Prerequisites: BIO 43 and EESS 8 or equivalent.
Same as: EARTHSYS 251, ESS 151, ESS 251

EARTHSYS 152. Marine Chemistry. 3-4 Units.
Introduction to the interdisciplinary knowledge and skills required to critically evaluate problems in marine chemistry and related disciplines. Physical, chemical, and biological processes that determine the chemical composition of seawater. Air-sea gas exchange, carbonate chemistry, and chemical equilibria, nutrient and trace element cycling, particle reactivity, sediment chemistry, and diagenesis. Examination of chemical tracers of mixing and circulation and feedbacks of ocean processes on atmospheric chemistry and climate. Designed to be taken concurrently with Biological Oceanography (EESS/EARTHSYS 151/251).
Same as: EARTHSYS 252, ESS 152, ESS 252
EARTHSYS 154. Intermediate Writing: Communicating Climate Change: Navigating the Stories from the Frontlines. 4 Units.
In the next two decades, droughts and famine caused by climate change will displace more than 250 million people around the world. In this course, students will develop an increased understanding of how different stakeholders including scientists, aid organizations, locals, policy makers, activists, and media professionals communicate the climate change crisis. They will select a site experiencing the devastating effects and research the voices telling the stories of those sites and the audiences who are (or are not) listening. Students might want to investigate drought-ridden areas such as the Central Valley of California or Darfur, Sudan; Alpine glaciers melting in the Alps or in Alaska; the increasingly flooded Pacific islands; the hurricane ravaged Gulf Coast, among many others. Data from various stakeholders will be analyzed and synthesized for a magazine-length article designed to bring attention to a region and/or issue that has previously been neglected. Students will write and submit their article for publication. For further work in developing writing abilities, especially within discipline-specific contexts and nonfiction genres. Individual conferences with instructor and peer workshops. Prerequisite: first two levels of the writing requirement or equivalent transfer credit. For more information, see https://undergrad.stanford.edu/programs/pwr/explore/notion-science-writing.
Same as: PWR 91EP

EARTHSYS 155. Science of Soils. 3-4 Units.
Physical, chemical, and biological processes within soil systems. Emphasis is on factors governing nutrient availability, plant growth and production, land-resource management, and pollution within soils. How to classify soils and assess nutrient cycling and contaminant fate. Recommended: introductory chemistry and biology.
Same as: ESS 155

EARTHSYS 156. Soil and Water Chemistry. 1-4 Unit.
(Graduate students register for 256.) Practical and quantitative treatment of soil processes affecting chemical reactivity, transformation, retention, and bioavailability. Principles of primary areas of soil chemistry: inorganic and organic soil components, complex equilibria in soil solutions, and adsorption phenomena at the solid-water interface. Processes and remediation of acid, saline, and wetland soils. Recommended: soil science and introductory chemistry and microbiology.
Same as: EARTHSYS 256, ESS 156, ESS 256

EARTHSYS 158. Geomicrobiology. 3 Units.
How microorganisms shape the geochemistry of the Earth's crust including oceans, lakes, estuaries, subsurface environments, sediments, soils, mineral deposits, and rocks. Topics include mineral formation and dissolution; biogeochemical cycling of elements (carbon, nitrogen, sulfur, and metals); geochemical and mineralogical controls on microbial activity, diversity, and evolution; life in extreme environments; and the application of new techniques to geomicrobial systems. Recommended: introductory chemistry and microbiology such as CEE 274A.
Same as: EARTHSYS 258, ESS 158, ESS 258

EARTHSYS 160. Sustainable Cities. 4-5 Units.
Service-learning course that exposes students to sustainability concepts and urban planning as a tool for determining sustainable outcomes in the Bay Area. Focus will be on the relationship of land use and transportation planning to housing and employment patterns, mobility, public health, and social equity. Topics will include government initiatives to counteract urban sprawl and promote smart growth and livability, political realities of organizing and building coalitions around sustainability goals, and increasing opportunities for low-income and communities of color to achieve sustainability outcomes. Students will participate in team-based projects in collaboration with local community partners and take part in significant off-site fieldwork. Prerequisites: consent of the instructor.
Same as: URBANST 164

EARTHSYS 161. Introduction to Physical Oceanography. 4 Units.
Formerly CEE 164. The dynamic basis of oceanography. Topics: physical environment; conservation equations for salt, heat, and momentum; geostrophic flows; wind-driven flows; the Gulf Stream; equatorial dynamics and ENSO; thermohaline circulation of the deep oceans; and tides. Prerequisite: PHYSICS 41 (formerly 53).
Same as: CEE 162D, CEE 262D, ESS 148

EARTHSYS 16SC. Water and Power in the Pacific Northwest: The Columbia River. 2 Units.
This seminar will explore the nature of and coupling between water and energy resources in the Pacific Northwest, using the Columbia River as our case study. We will explore the hydrologic, meteorologic, and geologic basis of water and energy resources, and the practical, social, environmental, economic, and political issues surrounding their development in the West. The Columbia River and its watershed provide a revealing prototype for examining these issues. A transnational, multi-state river with the largest residual populations of anadromous salmonids in the continental US, it provides a substantial fraction of the electrical energy produced in the Northwest (the Grand Coulee dam powerhouse on the Columbia is the largest-capacity hydropower facility in the US), it is a major bulk commodity transportation link to the interior West via its barge navigation system, it provides the water diversions supporting a large area of irrigated agriculture in Washington and Idaho, and its watershed is home to significant sources of solar and wind energy. We will use the Columbia to study water and energy resources, and especially their coupling, in the context of rapid climate change, ecosystem impacts, economics, and public policy.
We will begin with a week of classroom study and discussion on campus, preparing for the field portion of the seminar. We will then travel to the Columbia basin, spending approximately 10 days visiting a number of water and energy facilities across the watershed, e.g., solar, wind, and natural gas power plants; dams and reservoirs with their powerhouses, fish passage facilities, navigation locks, and flood-mitigation systems; an irrigation project; operation centers; and offices of regulatory agencies. We will meet with relevant policy experts and public officials, along with some of the stakeholders in the basin.
Over the summer students will be responsible for assigned readings from several sources, including monographs, online materials, and recent news articles. During the trip, students will work in small groups to analyze and assess one aspect of the coupling between water and energy resources in the Northwest. The seminar will culminate in presentations on these analyses.
Travel expenses during the seminar will be provided (except incidentals) by the Bill Lane Center for the American West and Sophomore College.
Same as: CEE 17SC, ENERGY 12SC, POLISCI 14SC

EARTHSYS 16SI. Environmental Justice in the Bay Area. 2 Units.
Hands-on, discussion-based course that seeks to expose students to the intersectionality of social justice and environmental well being. Through student-led talks and field trips around the Bay, the course pushes participants to think about connections between issues of privilege, race, health, gender equality, and class in environmental issues. Students from all experiences and fields of study are encouraged to join to gain a sense of place, engage critically with complex challenges, and learn about environmental justice in and out of the classroom.
Same as: URBANST 16SI
EARTHSYS 170. Environmental Geochemistry. 4 Units.
Solid, aqueous, and gaseous phases comprising the environment, their natural compositional variations, and chemical interactions. Contrast between natural sources of hazardous elements and compounds and types and sources of anthropogenic contaminants and pollutants. Chemical and physical processes of weathering and soil formation. Chemical factors that affect the stability of solids and aqueous species under earth surface conditions. The release, mobility, and fate of contaminants in natural waters and the roles that water and dissolved substances play in the physical behavior of rocks and soils. The impact of contaminants and design of remediation strategies. Case studies. Prerequisite: 90 or consent of instructor. Same as: GS 170, GS 270

EARTHSYS 172. Australian Ecosystems: Human Dimensions and Environmental Dynamics. 3 Units.
This cross-disciplinary course surveys the history and prehistory of human ecological dynamics in Australia, drawing on geology, climatology, archaeology, geography, ecology and anthropology to understand the mutual dynamic relationships between the continent and its inhabitants. Topics include anthropogenic fire and fire ecology, animal extinctions, aridity and climate variability, colonization and spread of Homo sapiens, invasive species interactions, changes in human subsistence and mobility throughout the Pleistocene and Holocene as read through the archaeological record, the totemic geography and social organization of Aboriginal people at the time of European contact, the ecological and geographical aspects of the "Dreamtime", and contemporary issues of policy relative to Aboriginal land tenure and management. Same as: ANTHRO 170, ANTHRO 270

EARTHSYS 175. California Coast: Science, Policy, and Law. 3-4 Units.
This interdisciplinary course integrates the legal, scientific, and policy dimensions of how we characterize and manage resource use and allocation along the California coast. We will use this geographic setting as the vehicle for exploring more generally how agencies, legislatures, and courts resolve resource-use conflicts and the role that scientific information and uncertainty play in the process. Our focus will be on the land-sea interface as we explore contemporary coastal land-use and marine resource decision-making, including coastal pollution, public health, ecosystem management; public access; private development; local community and state infrastructure; natural systems and significant threats; resource extraction; and conservation, mitigation and restoration. Students will learn the fundamental physics, chemistry, and biology of the coastal zone, tools for exploring data collected in the coastal ocean, and the institutional framework that shapes public and private decisions affecting coastal resources. There will be 3 to 4 written assignments addressing policy and science issues during the quarter, as well as a take-home final assignment. Special Instructions: In-class work and discussion is often done in interdisciplinary teams of students from the School of Law, the School of Engineering, the School of Humanities and Sciences, and the School of Earth, Energy, and Environmental Sciences. Students are expected to participate in class discussion and field trips. Elements used in grading: Participation, including class session and field trip attendance, writing and quantitative assignments. Cross-listed with Civil & Environmental Engineering (CEE 175A/275A), Earth Systems (EARTHSYS 175/275), Law (LAW514), and Public Policy (PUBLPOL 175/275). Open to graduate students and to advanced undergraduates with instructor consent. Same as: CEE 175A, CEE 275A, EARTHSYS 275, PUBLPOL 175, PUBLPOL 275

EARTHSYS 176. Open Space Management Practicum. 3-4 Units.
The unique patchwork of urban-to-rural land uses, property ownership, and ecosystems in our region poses numerous challenges and opportunities for regional conservation and environmental stewardship. Students in this class will address a particular challenge through a faculty-mentored research project engaged with the Peninsula Open Space Trust, Acterra, or the Amah Mutsun Land Trust that focuses on open space management. By focusing on a project driven by the needs of these organizations and carried out through engagement with the community, and with thorough reflection, study, and discussion about the roles of scientific, economic, and policy research in local-scale environmental decision-making, students will explore the underlying challenges and complexities of what it means to actually do community-engaged research for conservation and open space preservation in the real world. As such, this course will provide students with skills and experience in research design in conservation biology and ecology, community and stakeholder engagement, land use policy and planning, and the practical aspects of land and environmental management. Same as: EARTHSYS 276

EARTHSYS 176A. Open Space Practicum Independent Study. 1-2 Unit.
Additional practicum units for students intent on continuing their projects from EARTHSYS 176. Students who enroll in 176A must have completed EARTHSYS 176: Open Space Management Practicum, or have consent of the instructors.

EARTHSYS 177C. Specialized Writing and Reporting: Environmental Journalism. 4-5 Units.
Advanced reporting and writing course in the specific practices and standards of environmental journalism. This course begins with the assumption that students already know how to research and relay the essential facts of almost any environmental story. Students will go beyond the basics of journalistic practice, both as reporters and storytellers. Emphasis on magazine-style writing, with the goal of producing stories that stand on fact but move like fiction, that have protagonists and antagonists, that create suspense, that reveal character through dialogue and action, and that pay off with resonant finales. Limited enrollment: preference to students in the Earth Systems Master of Arts, Environmental Communication Program and the Graduate Journalism Program. Prerequisite: COMM 104, or EarthSys 191, or consent of instructor. Admission by application only, available from thayden@stanford.edu. Applications due Nov. 30, 2016. (Meets Earth Systems WIM requirement.) Same as: COMM 177C, COMM 277C, EARTHSYS 277C

EARTHSYS 179S. Seminar: Issues in Environmental Science, Technology and Sustainability. 1-2 Unit.
Invited faculty, researchers and professionals share their insights and perspectives on a broad range of environmental and sustainability issues. Students critique seminar presentations and associated readings. Same as: CEE 179S, CEE 279S, ESS 179S

EARTHSYS 18. Promoting Sustainability Behavior Change at Stanford. 2 Units.
Stanford Green Living Council training course. Strategies for designing and implementing effective behavior change programs for environmental sustainability on campus. Includes methods from community-based social marketing, psychology, behavioral economics, education, public health, social movements, and design. Students design a behavior change intervention project targeting a specific environmental sustainability-related behavior. Lectures online and weekly sections/ workshops.

EARTHSYS 180. Principles and Practices of Sustainable Agriculture. 3-4 Units.
Field-based training in ecologically sound agricultural practices at the Stanford Community Farm. Weekly lessons, field work, and group projects. Field trips to educational farms in the area. Topics include: soils, composting, irrigation techniques, IPM, basic plant anatomy and physiology, weeds, greenhouse management, and marketing. Same as: ESS 280
EARTHSYS 181. Urban Agriculture in the Developing World. 3-4 Units.
In this advanced undergraduate course, students will learn about some of the key social and environmental challenges faced by cities in the developing world, and the current and potential role that urban agriculture plays in meeting these challenges. This course provides an opportunity for students to meet and work with thought-leading innovators, to gain meaningful field experience, and to develop connections with faculty, students, and others working to create impact in the food system. Students in the course will develop creative confidence by learning and using the basic principles and methodologies of human-centered design, storytelling, and media design. Students will also learn basic tools for working effectively in teams and for analyzing complex social systems. FEED the Change is taught at the d.school and is offered through the FEED Collaborative in the School of Earth. This class meets over lunch time and, therefore, lunch will be provided during each class session. This class requires an application. For application information and more information about our work and about past class projects, please visit our website at http://feedcollaborative.org/classes/.
Same as: EARTHSYS 281, ESS 181, ESS 281, URBANST 181

EARTHSYS 182. Designing Educational Gardens. 2 Units.
A project-based course emphasizing ‘ways of doing’ sustainable agricultural systems based at the new Stanford Educational Farm. Students will work individually and in small groups on the design of a new educational garden and related programs for the Stanford Educational Farm. The class will meet on 6 Fridays over the course of winter quarter. Class meetings will include an introduction to designing learning gardens and affiliated programs, 3 field trips to exemplary educational gardens in the bay area that will include tours and discussions with garden educators, and work sessions for student projects. By application only.
Same as: ESS 282

EARTHSYS 183. Food Matters: Agriculture in Film. 1 Unit.
Film series presenting historical and contemporary issues dealing with food and agriculture across the globe. Students discuss reactions and thoughts in a round table format. May be repeated for credit.
Same as: EARTHSYS 283, ESS 183, ESS 283

EARTHSYS 185. Feeding Nine Billion. 4-5 Units.
Feeding a growing and wealthier population is a huge task, and one with implications for many aspects of society and the environment. There are many tough choices to be made—on fertilizers, groundwater pumping, pesticide use, organics, genetic modification, etc. Unfortunately, many people form strong opinions about these issues before understanding some of the basics of how food is grown, such as how most farmers currently manage their fields, and their reasons for doing so. The goal of this class is to present an overview of global agriculture, and the tradeoffs involved with different practices. Students will develop two key knowledge bases: basic principles of crop ecology and agronomy, and familiarity with the scale of the global food system. The last few weeks of the course will be devoted to building on this knowledge base to evaluate different future directions for agriculture.

EARTHSYS 186. Farm and Garden Educational Practicum. 2 Units.
Farms and gardens provide excellent settings for place-based environmental education that emphasize human ecological relationships and experiential learning. The O’Donohue Family Stanford Educational Farm is the setting to explore the principles and practices of farm and garden-based education in conjunction with the farm’s new field trip program for local youth. The course includes readings and reflections on environmental education and emphasis on learning by doing, engaging students in the practice of team teaching.
Same as: EARTHSYS 286

EARTHSYS 187. FEED the Change: Redesigning Food Systems. 2-3 Units.
FEED the Change is a project-based course focused on solving real problems in the food system. Targeted at upper-class undergraduates, this course provides an opportunity for students to meet and work with thought-leading innovators, to gain meaningful field experience, and to develop connections with faculty, students, and others working to create impact in the food system. Students in the course will develop creative confidence by learning and using the basic principles and methodologies of human-centered design, storytelling, and media design. Students will also learn basic tools for working effectively in teams and for analyzing complex social systems. FEED the Change is taught at the d.school and is offered through the FEED Collaborative in the School of Earth. This class meets over lunch time and, therefore, lunch will be provided during each class session. This class requires an application. For application information and more information about our work and about past class projects, please visit our website at http://feedcollaborative.org/classes/.

EARTHSYS 188. Social and Environmental Tradeoffs in Climate Decision-Making. 1-2 Unit.
How can we ensure that measures taken to mitigate global climate change don’t create larger social and environmental problems? What metrics should be used to compare potential climate solutions beyond cost and technical feasibility, and how should these metrics be weighed against each other? How can modeling efforts and stakeholder engagement be best integrated into climate decision making? What information are we still missing to make fully informed decisions between technologies and policies? Exploration of these questions, alongside other issues related to potential negative externalities of emerging climate solutions. Evaluation of energy, land use, and geoengineering approaches in an integrated context, culminating in a climate stabilization group project.
Same as: EARTHSYS 288

EARTHSYS 191. Concepts in Environmental Communication. 3 Units.
Introduction to the history, development, and current state of communication of environmental science and policy to non-specialist audiences. Includes fundamental principles, core competencies, and major challenges of effective environmental communication in the public and policy realms and an overview of the current scope of research and practice in environmental communication. Intended for graduate students and advanced undergraduates, with a background in environmental science and/or policy studies. Prerequisite: Earth Systems core (EarthSys 111 and EarthSys 112) or equivalent. (Meets Earth Systems WIM requirement.).
Same as: EARTHSYS 291

EARTHSYS 196. Implementing Climate Solutions at Scale. 3 Units.
Climate change is the biggest problem humanity has ever faced, and this course will teach students about the means and complexity of solving it. The instructors will guide the students in the application of key data and analysis tools for their final project, which will involve developing integrated plans for eliminating greenhouse gas emissions (100% reductions) by 2050 for a country, state, province, sector, or industry.
Same as: EARTHSYS 296

EARTHSYS 199. Honors Program in Earth Systems. 1-9 Unit.
EARTHSYS 20. The Cuisine of Change: Promoting Child Health and Combating Food Insecurity. 1 Unit.

ASB Course. The course on nutrition, health and food insecurity is split into four projects: 1) Workshop a Story, in which students craft a personal narrative with input from the class, 2) Pose a Question, in which students in pairs attempt to educate the class on many sides of the same issue, 3) Create a Dish, in which students develop original dishes in support of local organizations, and 4) Teach a Class, in which students, in teams, develop a curriculum to be implemented in over the spring break trip. Furthermore, each section will expand the scope of the issue from the individual to the community and all the way up to national policies. The course will be a mix of some of the best lecturers and professors that were encountered in our time at Stanford as well as a smattering of community challenges. Come with a willingness to push your comfort zone, as some of the activities include creative presentations, taking a no added sugar challenge, get vulnerable, and developing an intelligent attitude toward healthy eating.

EARTHSYS 200. Environmental Communication in Action: The SAGE Project. 3 Units.

This course is focused on writing about sustainability for a public audience through an ongoing project, SAGE (Sound Advice for a Green Earth), that is published by Stanford Magazine. Students contribute to SAGE, an eco advice column, by choosing, researching, and answering questions about sustainable living submitted by Stanford alumni and the general public. (Meets Earth Systems WIM requirement).

EARTHSYS 201. Editing for Publication. 2 Units.

Most student writing experiences end with a “final” written draft, but that leaves out crucial steps in the publication process. In this course, advanced students take responsibility for final editing and publication of the environmental advice column SAGE, starting with answers researched and written by students in EARTHSYS 200. Topics include developmental editing and project management for the SAGE project, structural editing for overall organization and impact of individual pieces, line editing for clarity and style, and fact checking and copy editing for accuracy and consistency.

EARTHSYS 206. World Food Economy. 5 Units.

The economics of food production, consumption, and trade. The micro- and macro- determinants of food supply and demand, including the interrelationship among food, income, population, and public-sector decision making. Emphasis on the role in agriculture in poverty alleviation, economic development, and environmental outcomes. (graduate students enroll in 206).

Same as: EARTHSYS 106, ECON 106, ECON 206, ESS 106, ESS 206

EARTHSYS 207. Spanish in Science/Science in Spanish. 2 Units.

For graduate and undergraduate students interested in the natural sciences and the Spanish language. Students will acquire the ability to communicate in Spanish using scientific language and will enhance their ability to read scientific literature written in Spanish. Emphasis on the development of science in Spanish-speaking countries or regions. Course is conducted in Spanish and intended for students pursuing degrees in the sciences, particularly disciplines such as ecology, environmental science, sustainability, resource management, anthropology, and archeology.

Same as: BIO 208, LATINAM 207

EARTHSYS 208. U.S. Environmental Law in Transition. 1 Unit.

This course offers an accessible survey of timely topics in environmental law and policy as the United States transitions presidential administrations. Taught by two practicing lawyers, the class introduces students from any background to the interactions between local, state, and federal environmental law as they apply to prominent policy issues. We will analyze major changes in federal policy, providing historical context for the transformations now underway in the laws and institutions that help shape environmental outcomes in the United States.

Same as: EARTHSYS 108

EARTHSYS 21. Peopling of the Globe: Changing Patterns of Land Use and Consumption Over the Last 50,000 Years. 3-5 Units.

Fossil, genetic and archaeological evidence suggest that modern humans began to disperse out of Africa about 50,000 years ago. Subsequently, humans have colonized every major landmass on earth. This class introduces students to the data and issues regarding human dispersal, migration and colonization of continents and islands around the world. We explore problems related to the timing and cause of colonizing events, and investigate questions about changing patterns of land use, demography and consumption. Students are introduced to critical relationships between prehistoric population changes and our contemporary environmental crisis.

Same as: ANTHRO 18, ARCHLGY 12, HUMBIO 182

EARTHSYS 210A. Senior Capstone and Reflection. 3 Units.

The Earth Systems Senior Capstone and Reflection, required of all seniors, provides students with opportunities to synthesize and reflect on their learning in the major. Students participate in guided career development and planning activities and initiate work on an independent or group capstone project related to an Earth Systems problem or question of interest. In addition, students learn and apply principles of effective oral communication through developing and giving a formal presentation on their internship. Students must also take EARTHSYS 210P, Earth Systems Capstone Project, in the quarter following the Senior Capstone and Reflection Course. Prerequisite: Completion of an approved Earth Systems internship (EARTHSYS 260).

EARTHSYS 210B. Senior Capstone and Reflection. 3 Units.

The Earth Systems Senior Capstone and Reflection, required of all seniors, provides students with opportunities to synthesize and reflect on their learning in the major. Students participate in guided career development and planning activities and initiate work on an independent or group capstone project related to an Earth Systems problem or question of interest. In addition, students learn and apply principles of effective oral communication through developing and giving a formal presentation on their internship. Students must also take EARTHSYS 210P, Earth Systems Capstone Project, in the quarter following the Senior Capstone and Reflection Course. Prerequisite: Completion of an approved Earth Systems internship (EARTHSYS 260).

EARTHSYS 210P. Earth Systems Capstone Project. 1 Unit.

Students work independently or in groups to complete their Senior Capstone Projects. They will participate in regular advising meetings with the instructor(s), and will give a final presentation on their projects at the end of the quarter in a special Earth Systems symposium. Prerequisite: EARTHSYS 210A, B, or C.

EARTHSYS 211. Fundamentals of Modeling. 3-5 Units.

Simulation models are a powerful tool for environmental research, if used properly. The major concepts and techniques for building and evaluating models. Topics include model calibration, model selection, uncertainty and sensitivity analysis, and Monte Carlo and bootstrap methods. Emphasis is on gaining hands-on experience using the R programming language. Prerequisite: Basic knowledge of statistics.

Same as: ESS 211

EARTHSYS 219. Will Work for Food. 1 Unit.

This is a speaker series class featuring highly successful innovators in the food system. Featured speakers will talk in an intimate, conversational manner about their current work, as well as about their successes, failures, and learnings along the way. Additional information can be found here: http://feedcollaborative.org/speaker-series/. Same as: EARTHSYS 119
EARTHSYS 225. Shades of Green: Redesigning and Rethinking the Environmental Justice Movements. 3-5 Units.
Historically, discussions of race, ethnicity, culture, and equity in the environment have been relegated to the environmental justice movement, which often focuses on urban environmental degradation and remains separated from other environmental movements. This course will seek to break out of this limiting discussion. We will explore access to outdoor spaces, definitions of wilderness, who is and isn’t included in environmental organizations, gender and the outdoors, how colonialism has influenced ways of knowing, and the future of climate change. The course will also have a design thinking community partnership project. Students will work with partner organizations to problem-solve around issues of access and diversity. We value a diversity of experiences and epistemological beliefs, and therefore undergraduates and graduate students from all disciplines are welcome.
Same as: CSRE 125E, EARTHSYS 125

EARTHSYS 232. Evolution of Earth Systems. 4 Units.
This course examines biogeochemical cycles and how they developed through the interaction between the atmosphere, hydrosphere, biosphere, and lithosphere. Emphasis is on the long-term carbon cycle and how it is connected to other biogeochemical cycles on Earth. The course consists of lectures, discussion of research papers, and quantitative modeling of biogeochemical cycles. Students produce a model on some aspect of the cycles discussed in this course. Grades based on class interaction, student presentations, and the modeling project.
Same as: EARTHSYS 132, ESS 132, ESS 232

EARTHSYS 235. Podcasting the Anthropocene. 3 Units.
The Anthropocene refers to the proposed geologic age defined by the global footprint of humankind. It’s an acknowledgement of the tremendous influence people and societies exert on Earth systems. This course examines biogeochemical cycles and how they developed through the interaction between the atmosphere, hydrosphere, biosphere, and lithosphere. Emphasis is on the long-term carbon cycle and how it is connected to other biogeochemical cycles on Earth. The course consists of lectures, discussion of research papers, and quantitative modeling of biogeochemical cycles. Students produce a model on some aspect of the cycles discussed in this course. Grades based on class interaction, student presentations, and the modeling project.
Same as: EARTHSYS 132, ESS 132, ESS 232

EARTHSYS 235A. Podcasting the Anthropocene 1.0. 1-2 Unit.
The Anthropocene refers to the proposed geologic age defined by the global footprint of humankind. It’s an acknowledgement of the tremendous influence people and societies exert on Earth systems. In this course, students research, prepare, and conduct audio interviews related to the Anthropocene with experts of their choosing. Instructors will help facilitate interviews and prepare student for the experience. Throughout the quarter students will participate in group workshops. This is a project-based course resulting in two long-form interviews. The expectation at the end of the quarter is to publish interviews via the Generation Anthropocene podcast, with possible opportunities to cross post in collaboration with external media partners. Students taking EARTHSYS 135/235 are strongly encouraged to take EARTHSYS 135A/235A beforehand. Meets Earth Systems WIM requirement. (Cardinal Course certified by the Haas Center).
Same as: EARTHSYS 135

EARTHSYS 236. The Ethics of Stewardship. 2-3 Units.
What responsibilities do humans have to nonhuman nature and future generations? How are human communities and individuals shaped by their relationships with the natural world? What are the social, political, and moral ramifications of drawing sustenance and wealth from natural resources? Whether we realize it or not, we grapple with such questions every time we turn on the tap, fuel up cars, or eat meals -and they are key to addressing issues like global climate change and environmental justice. In this class, we consider several perspectives on this ethical question of stewardship: the role of humans in the global environment. In addition to reading written work and speaking with land stewards, we will practice stewardship at the Stanford Educational Farm. This course must be taken for a minimum of 3 units and a letter grade to be eligible for Ways credit.
Same as: EARTHSYS 136

EARTHSYS 238. Land Use Law. 3 Units.
(Same as LAW 2505.) This course focuses on the pragmatic (more than theoretical) aspects of contemporary land use law and policy, including: the tools and legal foundation of modern land use law; the process of land development; vested property rights, development agreements, and takings; growth control, sprawl, and housing density; and direct democracy over land use. We explore how land use decisions affect environmental quality and how land use decision-making addresses environmental impacts. Special Instructions: All graduate students from other departments are encouraged to enroll, and no pre-requisites apply. Student participation is essential. Roughly two-thirds of the class time will involve a combination of lecture and classroom discussion. The remaining time will engage students in case studies based on actual land use issues and disputes. Elements used in grading: Attendance, class participation, writing assignments, and final exam. Elements used in grading: Attendance, Class Participation, Final Exam.

EARTHSYS 241. Remote Sensing of the Oceans. 3-4 Units.
How to observe and interpret physical and biological changes in the ocean using satellite technologies. Topics: principles of satellite remote sensing, classes of satellite remote sensors, converting radiometric data into biological and physical quantities, sensor calibration and validation, interpreting large-scale oceanographic features.
Same as: EARTHSYS 141, ESS 141, ESS 241, GEOPHYS 141

EARTHSYS 242. Remote Sensing of Land. 4 Units.
The use of satellite remote sensing to monitor land use and land cover, with emphasis on terrestrial changes. Topics include pre-processing data, biophysical properties of vegetation observable by satellite, accuracy assessment of maps derived from remote sensing, and methodologies to detect changes such as urbanization, deforestation, vegetation health, and wildfires.
Same as: EARTHSYS 142, ESS 162, ESS 262

EARTHSYS 243. Environmental Advocacy and Policy Communication. 3 Units.
Although environmental science suggests that coordinated policy action is critically necessary to address a host of pressing issues - from global climate change to marine pollution to freshwater depletion - governments have been slow to act. This course focuses on the translation of environmental science to public discourse and public policy, with an emphasis on the causes of our current knowledge-to-action gap and policy-sphere strategies to address it. We will read classic works of environmental advocacy, map our political system and the public relations and lobbying industries that attempt to influence it, grapple with analytical perspectives on effective and ethical environmental policy communication, engage with working professionals in the field, learn effective strategies for written and oral communication with policymakers, and write and workshop op-eds.
EARTHSYS 246A. Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the large-scale ocean circulation. This course will give an overview of the structure and dynamics of the major ocean current systems that contribute to the meridional overturning circulation, the transport of heat, salt, and biogeochemical tracers, and the regulation of climate. Topics include the tropical ocean circulation, the wind-driven gyres and western boundary currents, the thermohaline circulation, the Antarctic Circumpolar Current, water mass formation, atmosphere-ocean coupling, and climate variability. Prerequisites: EESS 146A or ESS 246A, or CEE 162D or CEE 262D, or consent of instructor.
Same as: CEE 161I, CEE 261I, EARTHSYS 146A, ESS 146A, ESS 246A, GEOPHYS 146A, GEOPHYS 246A

EARTHSYS 246B. Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the large-scale ocean circulation. This course will give an overview of the structure and dynamics of the major ocean current systems that contribute to the meridional overturning circulation, the transport of heat, salt, and biogeochemical tracers, and the regulation of climate. Topics include the tropical ocean circulation, the wind-driven gyres and western boundary currents, the thermohaline circulation, the Antarctic Circumpolar Current, water mass formation, atmosphere-ocean coupling, and climate variability. Prerequisites: EESS 146A or ESS 246A, or CEE 162D or CEE 262D, or consent of instructor.
Same as: CEE 162I, CEE 262I, EARTHSYS 146B, ESS 146B, ESS 246B

EARTHSYS 249. Wild Writing. 3 Units.
What is wilderness and why does it matter? In this course we will interrogate answers to this question articulated by influential and diverse American environmental thinkers of the 19th, 20th, and 21st centuries, who through their writing transformed public perceptions of wilderness and inspired such actions as the founding of the National Park System, the passage of the Wilderness Act and the Clean Air and Water Acts, and inspired such actions as the founding of the National Park System, the establishment of the Environmental Protection Agency, and the birth of the environmental and climate justice movements. Students will also develop their own responses to the question of what is wilderness and why it matters through a series of writing exercises that integrate personal narrative, wilderness experience, and environmental scholarship, culminating in a ~3000 word narrative nonfiction essay. This course will provide students with knowledge, tools, experience, and skills that will empower them to become more persuasive environmental storytellers and advocates.
Same as: EARTHSYS 149

EARTHSYS 250. Directed Research. 1-9 Unit.
Independent research related to student’s primary track, carried out after the junior year, during the summer, and/or during the senior year. Student develops own project with faculty supervision. 10-15 page thesis. May be repeated for credit.

EARTHSYS 251. Biological Oceanography. 3-4 Units.
Required for Earth Systems students in the oceans track. Interdisciplinary look at how oceanic environments control the form and function of marine life. Topics include distributions of planktonic production and abundance, nutrient cycling, the role of ocean biology in the climate system, expected effects of climate changes on ocean biology. Local weekend field trips. Designed to be taken concurrently with Marine Chemistry (EESS/EARTHSYS 152/252). Prerequisites: BIO 43 and EESS 8 or equivalent.
Same as: EARTHSYS 151, ESS 151, ESS 251

EARTHSYS 252. Marine Chemistry. 3-4 Units.
Introduction to the interdisciplinary knowledge and skills required to critically evaluate problems in marine chemistry and related disciplines. Physical, chemical, and biological processes that determine the chemical composition of seawater. Air-sea gas exchange, carbonate chemistry, and chemical equilibria, nutrient and trace element cycling, particle reactivity, sediment chemistry, and diageneis. Examination of chemical tracers of mixing and circulation and feedbacks of ocean processes on atmospheric chemistry and climate. Designed to be taken concurrently with Biological Oceanography (EESS/EARTHSYS 151/251).
Same as: EARTHSYS 152, ESS 152, ESS 252

EARTHSYS 255. Microbial Physiology. 3 Units.
Introduction to the physiology of microbes including cellular structure, transcription and translation, growth and metabolism, mechanisms for stress resistance and the formation of microbial communities. These topics will be covered in relation to the evolution of early life on Earth, ancient ecosystems, and the interpretation of the rock record. Recommended: introductory biology and chemistry.
Same as: BIO 180, ESS 255, GS 233A

EARTHSYS 256. Soil and Water Chemistry. 1-4 Unit.
(Graduate students register for 256.) Practical and quantitative treatment of soil processes affecting chemical reactivity, transformation, retention, and bioavailability. Principles of primary areas of soil chemistry: inorganic and organic soil components, complex equilibria in soil solutions, and adsorption phenomena at the solid-water interface. Processes and remediation of acid, saline, and wetland soils. Recommended: soil science and introductory chemistry and microbiology.
Same as: EARTHSYS 156, ESS 156, ESS 256

EARTHSYS 258. Geomicrobiology. 3 Units.
How microorganisms shape the geochemistry of the Earth’s crust including oceans, lakes, estuaries, subsurface environments, sediments, soils, mineral deposits, and rocks. Topics include mineral formation and dissolution; biogeochemical cycling of elements (carbon, nitrogen, sulfur, and metals); geochemical and mineralogical controls on microbial activity, diversity, and evolution; life in extreme environments; and the application of new techniques to geomicrobial systems. Recommended: introductory chemistry and microbiology such as CEE 274A.
Same as: EARTHSYS 158, ESS 158, ESS 258

EARTHSYS 260. Internship. 1-9 Unit.
Supervised field, lab, or private sector project. May consist of directed research under the supervision of a Stanford faculty member, participation in one of several off campus Stanford programs, or an approved non-Stanford program relevant to the student’s Earth Systems studies. Required of and restricted to declared Earth Systems majors. Includes 15-page technical summary research paper that is subject to iterative revision.

EARTHSYS 263F. Groundwork for COP21. 1 Unit.
This course will prepare undergraduate and coterm students to observe the climate change negotiations (COP 21) in Paris in November/December 2015. Students will develop individual projects to be carried out before and during the negotiation session and be paired with mentors. Please note: Along with EARTHSYS 163E/CEE 163E, this course is part of the required two-course-set in which undergraduate and coterminal masters degree students must enroll to receive accreditation to the climate negotiations.
EARTHSYS 272. Antarctic Marine Geology. 3 Units.
For upper-division undergraduates and graduate students. Intermediate and advanced topics in marine geology and geophysics, focusing on examples from the Antarctic continental margin and adjacent Southern Ocean. Topics: glaciers, icebergs, and sea ice as geologic agents (glacial and glacial marine sedimentology, Southern Ocean current systems and deep ocean sedimentation), Antarctic biostratigraphy and chronostratigraphy (continental margin evolution). Students interpret seismic lines and sediment core/well log data. Examples from a recent scientific drilling expedition to Prydz Bay, Antarctica. Up to two students may have an opportunity to study at sea in Antarctica during Winter Quarter.
Same as: ESS 242

EARTHSYS 275. California Coast: Science, Policy, and Law. 3-4 Units.
This interdisciplinary course integrates the legal, scientific, and policy dimensions of how we characterize and manage resource use and allocation along the California coast. We will use this geographic setting as the vehicle for exploring more generally how agencies, legislatures, and courts resolve resource-use conflicts and the role that scientific information and uncertainty play in the process. Our focus will be on the land-sea interface as we explore contemporary coastal land-use and marine resource decision-making, including coastal pollution, public health, ecosystem management; public access; private development; local community and state infrastructure; natural systems and significant threats; resource extraction; and conservation, mitigation and restoration. Students will learn the fundamental physics, chemistry, and biology of the coastal zone, tools for exploring data collected in the coastal ocean, and the institutional framework that shapes public and private decisions affecting coastal resources. There will be 3 to 4 written assignments addressing policy and science issues during the quarter, as well as a take-home final assignment. Special Instructions: In-class work and discussion is often done in interdisciplinary teams of students from the School of Law, the School of Engineering, the School of Humanities and Sciences, and the School of Earth, Energy, and Environmental Sciences. Students are expected to participate in class discussion and field trips. Elements used in grading: Participation, including class session and field trip attendance, writing and quantitative assignments. Cross-listed with Civil & Environmental Engineering (CEE 175A/275A), Earth Systems (EARTHSYS 175/275), Law (LAW14), and Public Policy (PUBLPOL 175/275). Open to graduate students and to advanced undergraduates with instructor consent.
Same as: CEE 175A, CEE 275A, EARTHSYS 175, PUBLPOL 175, PUBLPOL 275

EARTHSYS 276. Open Space Management Practicum. 3-4 Units.
The unique patchwork of urban-to-rural land uses, property ownership, and ecosystems in our region poses numerous challenges and opportunities for regional conservation and environmental stewardship. Students in this class will address a particular challenge through a faculty-mentored research project engaged with the Peninsula Open Space Trust, Acterra, or the Amah Mutsun Land Trust that focuses on open space management. By focusing on a project driven by the needs of these organizations and carried out through engagement with the community, and with thorough reflection, study, and discussion about the roles of scientific, economic, and policy research in local-scale environmental decision-making, students will explore the underlying challenges and complexities of what it means to actually do community-engaged research for conservation and open space preservation in the real world. As such, this course will provide students with skills and experience in research design in conservation biology and ecology, community and stakeholder engagement, land use policy and planning, and the practical aspects of land and environmental management.
Same as: EARTHSYS 176

EARTHSYS 276A. Open Space Practicum Independent Study. 1-2 Unit.
Additional practicum units for students intent on continuing their projects from EARTHSYS 276. Students who enroll in 276A must have completed EARTHSYS 276: Open Space Management Practicum, or have consent of the instructors.

EARTHSYS 277C. Specialized Writing and Reporting: Environmental Journalism. 4-5 Units.
Advanced reporting and writing course in the specific practices and standards of environmental journalism. This course begins with the assumption that students already know how to research and relay the essential facts of almost any environmental story. Students will go beyond the basics of journalistic practice, both as reporters and storytellers. Emphasis on magazine-style writing, with the goal of producing stories that stand on fact but move like fiction, that have protagonists and antagonists, that create suspense, that reveal character through dialogue and action, and that pay off with resonant finales. Limited enrollment: preference to students in the Earth Systems Master of Arts, Environmental Communication Program and the Graduate Journalism Program. Prerequisite: COMM 104, or EarthSys 191, or consent of instructor. Admission by application only, available from thayden@stanford.edu. Applications due Nov. 30, 2016. (Meets Earth Systems WIM requirement).
Same as: COMM 177C, COMM 277C, EARTHSYS 177C

EARTHSYS 281. Urban Agriculture in the Developing World. 3-4 Units.
In this advanced undergraduate course, students will learn about some of the key social and environmental challenges faced by cities in the developing world, and the current and potential role that urban agriculture plays in meeting (or exacerbating) those challenges. This is a service-learning course, and student teams will have the opportunity to partner with real partner organizations in a major developing world city to define and execute a project focused on urban development, and the current or potential role of urban agriculture. Service-learning projects will employ primarily the student's analytical skills such as synthesis of existing research findings, interdisciplinary experimental design, quantitative data analysis and visualization, GIS, and qualitative data collection through interviews and textual analysis. Previous coursework in the aforementioned analytical skills is preferred, but not required. Admission is by application.
Same as: EARTHYS 181, ESS 181, ESS 281, URBANST 181

EARTHSYS 283. Food Matters: Agriculture in Film. 1 Unit.
Film series presenting historical and contemporary issues dealing with food and agriculture across the globe. Students discuss reactions and thoughts in a round table format. May be repeated for credit.
Same as: EARTHYS 183, ESS 183, ESS 283

EARTHSYS 286. Farm and Garden Environmental Education Practicum. 2 Units.
Farms and gardens provide excellent settings for place-based environmental education that emphasize human ecological relationships and experiential learning. The O'Onohue Family Stanford Educational Farm is the setting to explore the principles and practices of farm and garden-based education in conjunction with the farm's new field trip program for local youth. The course includes readings and reflections on environmental education and emphasis on learning by doing, engaging students in the practice of team teaching.
Same as: EARTHYS 186
How can we ensure that measures taken to mitigate global climate change don’t create larger social and environmental problems? What metrics should be used to compare potential climate solutions beyond cost and technical feasibility, and how should these metrics be weighed against each other? How can modeling efforts and stakeholder engagement be best integrated into climate decision making? What information are we still missing to make fully informed decisions between technologies and policies? Exploration of these questions, alongside other issues related to potential negative externalities of emerging climate solutions. Evaluation of energy, land use, and geoengineering approaches in an integrated context, culminating in a climate stabilization group project.
Same as: EARTHSYS 188

EARTHSYS 289A. FEED Lab: Food System Design & Innovation. 3-4 Units.
FEED Lab is a 3-4 unit introductory course in design thinking and food system innovation offered through the FEED Collaborative. Targeted at graduate students interested in food and the food system, this course provides a series of diverse, primarily hands-on experiences (design projects with industry-leading thinkers, field work, and collaborative leadership development) in which students both learn and apply the process of human-centered design to projects of real consequence in the food system. The intention is to develop students’ creative confidence, collaborative leadership ability, and skills in systems thinking to prepare them to be more effective as innovators and leaders in the food system. This course is mandatory for any student wishing to qualify for the FEED Collaborative’s summer Leadership and Innovation Program, in which select students participate in full-time, paid, externship roles with collaborating thought-leaders in the industry. Admission is by application: http://feedcollaborative.org/classes/.

EARTHSYS 289B. FEED Lab: Food System Design & Innovation. 3-4 Units.
Primarily a follow-on course to EARTHSYS 289A, this course is an experiential education platform that enables students already experienced in design thinking to collaborate with faculty and industry thought-leaders on projects of real consequence in the local food system. A select cohort of students will work in small, diverse teams and will interact closely with the teaching team in an intentionally creative and informal classroom setting. Students will deepen their skills in design thinking and social entrepreneurship by working on projects sponsored by leading innovators in the FEED Collaborative’s network. Some projects may turn into summer internships or research projects for students interested in continuing their work. Admission is by application: http://feedcollaborative.org/classes/.

EARTHSYS 290. Master's Seminar. 2 Units.
Required of and open only to Earth Systems master’s students. Reflection on the Earth Systems coterm experience and development of skills to clearly articulate interdisciplinary expertise to potential employers, graduate or professional schools, colleagues, business partners, etc. Hands-on projects to take students through a series of guided reflection activities. Individual and small group exercises. Required, self-chosen final project encapsulates each student’s MS expertise in a form relevant to his or her future goals (ie. a personal statement, research poster, portfolio, etc.).

EARTHSYS 291. Concepts in Environmental Communication. 3 Units.
Introduction to the history, development, and current state of communication of environmental science and policy to non-specialist audiences. Includes fundamental principles, core competencies, and major challenges of effective environmental communication in the public and policy realms and an overview of the current scope of research and practice in environmental communication. Intended for graduate students and advanced undergraduates, with a background in environmental science and/or policy studies. Prerequisite: Earth Systems core (EarthSys 111 and EarthSys 112) or equivalent. (Meets Earth Systems WIM requirement.).
Same as: EARTHSYS 191

EARTHSYS 292. Multimedia Environmental Communication. 3 Units.
Introductory theory and practice of effective, accurate and engaging use of photography and web video production in communicating environmental science and policy concepts to the public. Emphasis on fundamental technique and process more than gear. Includes group project work, instructor and peer critiquing of work, and substantial out-of-class project work. Limited class size, preference to Earth Systems Master’s students. No previous photography or video experience necessary.

EARTHSYS 293. Environmental Communication Practicum. 1-5 Unit.
Students complete an internship or similar practical experience in a professional environmental communication setting. Potential placements include environmental publications, NGOs, government agencies, on-campus entities, and science centers and museums. Restricted to students enrolled in the Environmental Communication Master of Arts in Earth Systems. Can be completed in any quarter.

EARTHSYS 294. Environmental Communication Capstone. 1-5 Unit.
Project-based course focused on applying the skills and theoretical understanding gained through the Earth Systems Master of Arts, Environmental Communication course progression to a real-world communication challenge. Students design, plan, and implement an integrated communication strategy around a defined environmental topic or research program; a specific research group’s laboratory or expedition work; or a topic or concept of interest across research groups, such as climate change adaptation or marine conservation. Restricted to students enrolled in the Earth Systems Master of Arts, Environmental Communication Program, or by permission of the instructor. May also be completed as an independent project, in consultation with the Earth Systems Master of Arts, Environmental Communication Director.

EARTHSYS 296. Implementing Climate Solutions at Scale. 3 Units.
Climate change is the biggest problem humanity has ever faced, and this course will teach students about the means and complexity of solving it. The instructors will guide the students in the application of key data and analysis tools for their final project, which will involve developing integrated plans for eliminating greenhouse gas emissions (100% reductions) by 2050 for a country, state, province, sector, or industry. Same as: EARTHSYS 196

EARTHYS 297. Directed Individual Study in Earth Systems. 1-9 Unit.
Under supervision of an Earth Systems faculty member on a subject of mutual interest.

EARTHYS 298. Earth Systems Book Review. 2 Units.
For Earth Systems master’s students and advanced undergraduates only. Analysis and discussion of selected literary nonfiction books relevant to Earth systems topics. Examples of previous topics include political presentations of environmental change in the popular press, review of the collected works of Aldo Leopold, disaster literature, and global warming.

EARTHYS 299. M.S. Thesis. 1-9 Unit.
EARTHSYS 30. Ecology for Everyone. 4 Units.
Everything is connected, but how? Ecology is the science of interactions and the changes they generate. This project-based course links individual behavior, population growth, species interactions, and ecosystem function. Introduction to measurement, observation, experimental design and hypothesis testing in field projects, mostly done in groups. The goal is to learn to think analytically about everyday ecological processes involving bacteria, fungi, plants, animals and humans. The course uses basic statistics to analyze data; there are no math prerequisites except arithmetic. Open to everyone, including those who may be headed for more advanced courses in ecology and environmental science. Same as: BIO 30

EARTHSYS 323. Stanford at Sea. 16 Units.
(Graduate students register for 323H.) Five weeks of marine science including oceanography, marine physiology, policy, maritime studies, conservation, and nautical science at Hopkins Marine Station, followed by five weeks at sea aboard a sailing research vessel in the Pacific Ocean. Shore component comprised of three multidisciplinary courses meeting daily and continuing aboard ship. Students develop an independent research project plan while ashore, and carry out the research at sea. In collaboration with the Sea Education Association of Woods Hole, MA. Only 6 units may count towards the Biology major. Same as: BIOHOPK 182H, BIOHOPK 323H, ESS 323

EARTHSYS 36N. Life at the Extremes: From the Deep Sea to Deep Space. 3 Units.
Preference to freshmen. Microbial life is diverse and resilient on Earth; could it survive elsewhere in our solar system? This seminar will investigate the diversity of microbial life on earth, with an emphasis on extremophiles, and consider the potential for microbial life to exist and persist in extraterrestrial locales. Topics include microbial phylogenetic and physiological diversity, biochemical adaptations of extremophiles, ecology of extreme habitats, and apparent requirements and limits of life. Format includes lectures, discussions, lab-based activities and local field trips. Basics of microbiology, biochemistry, and astrobiology.

EARTHSYS 37N. Climate Change: Science & Society. 3 Units.
Preference to freshmen. How and why do greenhouse gases cause climate to change? How will a changing climate affect humans and natural ecosystems? What can be done to prevent climate change and better adapt to the climate change that does occur? Focus is on developing quantitative understanding of these issues rooted in both the physical and social sciences. Exercises based on simple quantitative observations and calculations; algebra only, no calculus.

EARTHSYS 38N. The Worst Journey in the World: The Science, Literature, and History of Polar Exploration. 3 Units.
This course examines the motivations and experiences of polar explorers under the harshest conditions on Earth, as well as the chronicles of their explorations and hardships, dating to the 1500s for the Arctic and the 1700s for the Antarctic. Materials include The Worst Journey in the World by Aspley Cherry-Garrard who in 1911 participated in a midwinter Antarctic sledding trip to recover emperor penguin eggs. Optional field trip into the high Sierra in March. Same as: ESS 38N, GS 38N

EARTHSYS 39N. The Carbon Cycle: Reducing Your Impact. 3 Units.
Preference to freshmen. Changes in the long- and short-term carbon cycle and global climate through the burning of fossil fuels since the Industrial Revolution. How people can shrink their carbon footprints. Long-term sources and sinks of carbon and how they are controlled by tectonics and short-term sources and sinks and the interaction between the biosphere and ocean. How people can shrink their carbon footprints. Held at the Stanford Community Farm.

EARTHSYS 4. Coevolution of Earth and Life. 4 Units.
Earth is the only planet in the universe currently known to harbor life. When and how did Earth become inhabited? How have biological activities altered the planet? How have environmental changes affected the evolution of life? Are we living in a sixth mass extinction? In this course, we will develop and use the tools of geology, paleontology, geochemistry, and modeling that allow us to reconstruct Earth’s 4.5 billion year history and to reconstruct the interactions between life and its host planet over the past 4 billion years. We will also ask what this long history can tell us about life’s likely future on Earth. We will also use One half-day field trip. Same as: GS 4

EARTHSYS 41N. The Global Warming Paradox. 3 Units.
Preference to freshman. Focus is on the complex climate challenges posed by the substantial benefits of energy consumption, including the critical tension between the enormous global demand for increased human well-being and the negative climate consequences of large-scale emissions of carbon dioxide. Topics include: Earth’s energy balance; detection and attribution of climate change; the climate response to enhanced greenhouse forcing; impacts of climate change on natural and human systems; and proposed methods for curbing further climate change. Sources include peer-reviewed scientific papers, current research results, and portrayal of scientific findings by the mass media and social networks.

EARTHSYS 42. The Global Warming Paradox II. 1 Unit.
Further discussion of the complex climate challenges posed by the substantial benefits of energy consumption, including the critical tension between the enormous global demand for increased human well-being and the negative climate consequences of large-scale emissions of carbon dioxide. Discussions of topics of student interest, including peer-reviewed scientific papers, current research results, and portrayal of scientific findings by the mass media and social networks. Focus is on student engagement in on-campus and off-campus activities. Prerequisite: EESS 41N or EARTHSYS 41N or consent of instructor. Same as: ESS 42

EARTHSYS 44N. The Invisible Majority: The Microbial World That Sustains Our Planet. 3 Units.
Microbes are often viewed through the lens of infectious disease yet they play a much broader and underappreciated role in sustaining our Earth system. From introducing oxygen into the Earth’s atmosphere over 2 billion years ago to consuming greenhouse gases today, microbial communities have had (and continue to have) a significant impact on our planet. In this seminar, students will learn how microbes transformed the ancient Earth environment into our modern planet, how they currently sustain our Earth’s ecosystems, and how scientists study them both in the present and in the past. Students will be exposed to the fundamentals of microbiology, biogeochemistry, and Earth history.

EARTHSYS 46N. Exploring the Critical Interface between the Land and Monterey Bay: Elkhorn Slough. 3 Units.
Preference to freshmen. Field trips to sites in the Elkhorn Slough, a small agriculturally impacted estuary that opens into Monterey Bay, a model ecosystem for understanding the complexity of estuaries, and one of California’s last remaining coastal wetlands. Readings include Jane Caffrey’s Changes in a California Estuary: A Profile of Elkhorn Slough. Basics of biogeochemistry, microbiology, oceanography, ecology, pollution, and environmental management. Same as: ESS 46N
EARTHSYS 46Q. Environmental Impact of Energy Systems: What are the Risks?. 3 Units.
In order to reduce CO2 emissions and meet growing energy demands during the 21st Century, the world can expect to experience major shifts in the types and proportions of energy-producing systems. These decisions will depend on considerations of cost per energy unit, resource availability, and unique national policy needs. Less often considered is the environmental impact of the different energy producing systems: fossil fuels, nuclear, wind, solar, and other alternatives. One of the challenges has been not only to evaluate the environmental impact but also to develop a systematic basis for comparison of environmental impact among the energy sources. The course will consider fossil fuels (natural gas, petroleum and coal), nuclear power, wind and solar and consider the impact of resource extraction, refining and production, transmission and utilization for each energy source.
Same as: GS 46Q

EARTHSYS 49N. Multi-Disciplinary Perspectives on a Large Urban Estuary: San Francisco Bay. 3 Units.
This course will be focused around San Francisco Bay, the largest estuary on the Pacific coasts of both North and South America as a model ecosystem for understanding the critical importance and complexity of estuaries. Despite its uniquely urban and industrial character, the Bay is of immense ecological value and encompasses over 90% of California's remaining coastal wetlands. Students will be exposed to the basics of estuarine biogeochemistry, microbiology, ecology, hydrodynamics, pollution, and ecosystem management/ restoration issues through lectures, interactive discussions, and field trips. Knowledge of introductory biology and chemistry is recommended.
Same as: CEE 50N, ESS 49N

EARTHSYS 56Q. Changes in the Coastal Ocean: The View From Monterey and San Francisco Bays. 3 Units.
Preference to sophomores. Recent changes in the California current, using Monterey Bay as an example. Current literature introduces principles of oceanography. Visits from researchers from MBARI, Hopkins, and UCSC. Optional field trip to MBARI and Monterey Bay.
Same as: ESS 56Q

EARTHSYS 57Q. Climate Change from the Past to the Future. 3 Units.
Preference to sophomores. Numeric models to predict how climate responds to increase of greenhouse gases. Paleoclimate during times in Earth's history when greenhouse gas concentrations were elevated with respect to current concentrations. Predicted scenarios of climate models and how these models compare to known hyperthermal events in Earth history. Interactions and feedbacks among biosphere, hydrosphere, atmosphere, and lithosphere. Topics include long- and short-term carbon cycle, coupled biogeochemical cycles affected by and controlling climate change, and how the biosphere responds to climate change. Possible remediation strategies.
Same as: ESS 57Q

EARTHSYS 61Q. Food and security. 3 Units.
The course will provide a broad overview of key policy issues concerning agricultural development and food security, and will assess how global governance is addressing the problem of food security. At the same time the course will provide an overview of the field of international security, and examine how governments and international institutions are beginning to include food in discussions of security.
Same as: ESS 61Q, INTNLREL 61Q