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

EARTHSYS 100A. Data Science for Geoscience. 3 Units.
This course provides an overview of the most relevant areas of data science to address geoscientific challenges and questions as they pertain to the environment, earth resources & hazards. The focus lies on the methods that treat common characters of geoscientific data: multivariate, multi-scale, compositional, geospatial and space-time. In addition, the course will treat those statistical method that allow a quantification of the human dimension by looking at quantifying impact on humans (e.g. hazards, contamination) and how humans impact the environment (e.g. contamination, land use). The course focuses on developing skills that are not covered in traditional statistics and machine learning courses.
Same as: GEOLSCI 6

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 the number one contributor to climate change and has significant consequences for our society, political system, economy, and environment. Energy is also a fundamental driver of human development and opportunity. 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. 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 and greenhouse gas emissions (GHG), 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, homework assignments, virtual field trips, and a small-group discussion section once a week for 50 minutes (live participation is required, many different times will be offered). Lectures will be recorded and available on Canvas. No in-person field trips will be offered for AY 2020-2021 ¿ but alumni of the class can optionally attend field trips in future quarters. 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). The 3-unit option requires instructor approval - please contact Diana Gragg. Open to all: pre-majors and majors, with any background! Website: https://energy.stanford.edu/understanding-energy. CEE 107S/207S Understanding Energy: Essentials is a shorter (3 unit) version of this course, offered summer quarter. Students should not take both for credit. Prerequisites: Algebra.
Same as: CEE 107A, CEE 207A

EARTHSYS 104. The Water Course. 4 Units.
The Central Valley of California provides a third of the produce grown in the U.S., but recent droughts and increasing demand have raised concerns about both food and water security. The pathway that water takes from rainfall to the irrigation of fields or household taps (¿the water course¿) determines the quantity and quality of the available water. Working with various data sources (measurements made on the ground, in wells, and from satellites) allows us to model the water budget in the valley and explore the recent impacts on freshwater supplies.
Same as: EARTHSYS 204, GEOPHYS 104, GEOPHYS 204

EARTHSYS 105. Food and Community: Food Security, Resilience and Equity. 2-3 Units.
What can communities do to bolster food security, resiliency, and equity in the face of climate change? This course aims to respond to this question, in three parts. In Part 1, we will explore the most current scientific findings on trends in anthropogenic climate forcing and the anticipated impacts on global and regional food systems. Specifically, Part I will review the anticipated impact of climate change on severe weather events, crop losses, and food price volatility and the influence of these impacts on global and regional food insecurity and hunger. In Part II, we will consider what communities can do to promote food security and equity in the face of these changes, by reviewing the emerging literature on food system resiliency. Finally, we will facilitate a conference in which multi-disciplinary teams from around the country will gather to initiate regional planning projects designed to enhance food system resilience and equity. Cardinal Course (certified by Haas Center). Limited enrollment. May be repeated for credit.
Same as: EARTHSYS 205

EARTHSYS 105A. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units.
Ecology and Natural History of Jasper Ridge Biological Preserve an upper-division course, aims to help student learn ecology and natural history using a ¿living laboratory¿, the Jasper Ridge Preserve. The course¿s central goal is that, as a community of learning, we examine ¿via introductory discussions, followed by hands-on experiences in the field¿ the scientific basis of: ecological research, archaeology, edaphology, geology, hydrology, species interactions, land management, and multidisciplinary environmental education. The 10 sessions that compose the academic program are led by the instructors, faculty (world-experts on the themes of each session), and JRBP staff. In addition, this class trains students to become JRBP Docents that therefore join the Jasper Ridge education affiliates community. nnAfter completing this course and as new affiliates of Jasper Ridge, participants will be able to lead research-focused educational tours, assist with classes and research, and attend continuing education activities available to members of the JRBP community.
Same as: BIO 105A

EARTHSYS 105B. Ecology and Natural History of Jasper Ridge Biological Preserve. 4 Units.
Ecology and Natural History of Jasper Ridge Biological Preserve an upper-division course, aims to help student learn ecology and natural history using a ¿living laboratory¿, the Jasper Ridge Preserve. The course¿s central goal is that, as a community of learning, we examine ¿via introductory discussions, followed by hands-on experiences in the field¿ the scientific basis of: ecological research, archaeology, edaphology, geology, hydrology, species interactions, land management, and multidisciplinary environmental education. The 10 sessions that compose the academic program are led by the instructors, faculty (world-experts on the themes of each session), and JRBP staff. In addition, this class trains students to become JRBP Docents that therefore join the Jasper Ridge education affiliates community. nnAfter completing this course and as new affiliates of Jasper Ridge, participants will be able to lead research-focused educational tours, assist with classes and research, and attend continuing education activities available to members of the JRBP community.
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. Grades based on mid-term exam and group modeling project and presentation. Enrollment is by application only and will be capped at 25, with priority given to upper level undergraduates in Economics and Earth Systems and graduate students (graduate students enroll in 206). Application found at https://economics.stanford.edu/academics/undergraduate-program/forms.
Same as: EARTHSYS 206, ECON 106, ECON 206, ESS 106, ESS 206

EARTHSYS 106B. Sustainable and Equitable Water Management. 3-4 Units.
California has committed itself to sustainable groundwater management, with passage of the Sustainable Groundwater Management Act in 2014, and safe drinking water access for all, with California's Human Right to Water Act in 2012. Yet, groundwater overdraft continues while over 1 million residents lack access to safe drinking water. Working with a water agency in the San Joaquin Valley, we will explore feedback loops between the two Acts and develop a plan for water management that meet the co-equal objectives of sustainable and equitable resource governance. We will work with "big" and "small" data, exploring the possibilities but also the limitations of using publicly available data for assessment and monitoring. The course will include guest speakers and interaction with public agencies and other key stakeholders.nThis is a Cardinal Course certified by the Haas Center.
Same as: EARTHSYS 206B, GEOPHYS 106, GEOPHYS 206

EARTHSYS 106C. Why are Scientists Engineering Our Food?. 2 Units.
This lecture and discussion course will review the scientific evidence on the use and impacts of genetic engineering in global food and agricultural systems. The class will cover the history and details of crop genetic improvement, ranging from primitive domestication to CRISPR technologies. We will examine the risks and benefits of crop genetic technologies in agriculture with regards to productivity, farm incomes, food safety, human health and nutrition, and environmental impacts. We will also discuss the current and future use of genetic engineering techniques for enhancing climate resilience and nutritional outcomes in agricultural systems worldwide. Finally, we will discuss the ethics of using modern genetic approaches for crop improvement, and the policy environment surrounding the use of these genetic techniques.nnOur expectation is that students enrolled in the course will attend all class sections and participate actively in the discussions. Students will be asked to identify peer-reviewed, scientific papers on the impacts of specific crop genetic improvements. Depending on the class size, students will also be asked to help lead class discussions. At the end of the course, students will work in groups to debate a selected topic on the use of genetic engineering in agriculture, to be announced during the course.nnPrerequisites: One course in biology and one course in economics are suggested. Completion of "Feeding Nine Billion" and "The World Food Economy" classes would also be helpful, as would a class in genetics, but there are no strict course requirements.

EARTHSYS 106D. New meat: The Science Behind Scalable Alternatives to Animal Products. 2 Units.
Plant-based meat products and the technologies used to produce them have increased in complexity from tofu (~200 BC) and wheat gluten-based meat replacements (6th century AD) to the Beyond Burger and the Impossible Burger (both 2016), which use mechanically extracted plant proteins and genetically engineered yeast producing soy leghemoglobin, respectively. This course will cover the scientific challenges and processes used to create convincing and marketable plant-based and clean meats, including the biological and chemical processes used to produce plant-based meat and clean meat; the environmental and economic drivers behind the market for meat replacements; and the dietary roles of plant- and animal-based proteins. This course is intended for undergraduates interested in learning about the technical and scientific developments involved in the production of clean and plant-based meat. Students should be familiar with introductory biology and chemistry.

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 science 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 11. Introduction to Geology. 5 Units.
Why are earthquakes, volcanoes, and natural resources located at specific spots on the Earth surface? Why are there rolling hills to the west behind Stanford, and soaring granite walls to the east in Yosemite? What was the Earth like in the past, and what will it be like in the future? Lectures, hands-on laboratories, in-class activities, and one field trip will help you see the Earth through the eyes of a geologist. Topics include plate tectonics, the cycling and formation of different types of rocks, and how geologists use rocks to understand Earth's history.
Same as: GEOLSCI 1

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. The course will include a weekend field trip. Prerequisite: CME 100 or MATH 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 BIO 81 or graduate standing.
Same as: BIO 117, EARTHSYS 217, 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: EARTHSYS 212, 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 114. Global Change and Emerging Infectious Disease. 3 Units.
The changing epidemiological environment. How human-induced environmental changes, such as global warming, deforestation and land-use conversion, urbanization, international commerce, and human migration, are altering the ecology of infectious disease transmission, and promoting their re-emergence as a global public health threat. Case studies of malaria, cholera, hantavirus, plague, and HIV.
Same as: EARTHSYS 214, ESS 213, HUMBIO 114

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 115N. Desert Biogeography of Namibia Prefield Seminar. 3 Units.
Desert environments make up a third of the land areas on Earth, ranging from the hottest to the coldest environments. Aridity leads to the development of unique adaptations among the organisms that inhabit them. Climate change and other processes of desertification as well as increasing human demand for habitable and cultivatable areas have resulting in increasing need to better understand these systems. Namibia is a model system for studying these processes and includes the Sossuvlei (Sand Sea) World Heritable Site. This seminar will prepare students for their overseas field experience in Namibia. The seminar will provide an introduction to desert biogeography and culture, using Namibia as a case study. During the seminar, students will each give two presentations on aspects of desert biogeography and ecology, specific organisms and their adaptations to arid environments, cultural adaptations of indigenous peoples and immigrants, ecological threats and conservation efforts, and/or national and international policy towards deserts. Additional assignments include a comprehensive dossier and a final exam. Students will also carry out background research for the presentations they will be giving during the field seminar where access to the internet and to other scholarly resources will be limited. In addition, we will cover logistics, health and safety, cultural sensitivity, geography, and politics. We will deal with 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.
Same as: AFRICAST 114N

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 imperialsm of the early 20th centrury? 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: CSRE 118E, NATIVEAM 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 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.

EARTHSYS 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: BIO 119, GEOLSCI 123, GEOLSCI 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.nThis 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 123A. Biosphere-Atmosphere Interactions. 3-4 Units.
How do ecosystems respond to climate, and how do ecosystems influence climate? Covers the role of the terrestrial land surface in earth's climate system, including among others photosynthesis, transpiration, greenhouse gasses, radiation, and atmospheric water vapor. For each of these topics, attention is paid to both the underlying processes and how they can be mathematically represented in earth system models. Instruments and techniques used to measure these processes are also discussed, and, where appropriate, demonstrated.
Same as: EARTHSYS 223, ESS 123, ESS 223

EARTHSYS 124. Measurements in Earth Systems. 3-4 Units.
A classroom, laboratory, and field class designed to provide students familiarity with techniques and instrumentation used to track biological, chemical, and physical processes operating in earth systems, encompassing upland, aquatic, estuarine, and marine environments. Topics include gas and water flux measurement, nutrient and isotopic analysis, soil and water chemistry determination. Students will develop and test hypotheses, provide scientific evidence and analysis, culminating in a final presentation.
Same as: ESS 212

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, URBANST 125

EARTHSYS 126. Perspectives in International Development. 3 Units.
In this course, we explore the contested nature of development as a concept, goal, intervention, project, and policy. Because development is often associated with ideas surrounding poverty and well-being it is used as a tool by government agencies, multilateral organizations, and non-governmental organizations to achieve livelihood improvement and biodiversity/natural resource conservation. Development projects have the potential to achieve goals that are socially, ecologically, and economically focused while providing a just distribution of benefits. What does ¿development¿ really mean? What does it include (and not include)? And who? When (under what conditions) does development work? How do we measure? Who decides? Who benefits from development, and who pays the costs? We will try to answer these questions and more like them, each week exploring themes related to development while drawing from various disciplines and contexts.

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: BIO 148, BIO 228, GEOLSCI 128, GEOLSCI 228

EARTHSYS 130. Designing and Evaluating Community Engagement Programs for Social and Environmental Change. 3 Units.
Non-profit organizations seeking to achieve social and environmental change often run outreach and education programs to engage community members in their cause. Effective application of social science theory and methods may improve the design and evaluation of such community engagement programs. In this class, we partner with environmental and social justice organizations in the Bay Area to explore two questions: 1) How can recent findings from the social sciences be applied to design more effective community engagement programs ? 2) How can we rigorously evaluate outreach and education programs to ensure they are achieving the desired objectives? The course will include an overview of key theories from psychology, sociology, and education, field trips to partnering organizations, and a term-long community-engaged research project focused on designing and/or evaluating a local outreach or educational program that is meant to achieve social and environmental change.
Same as: ENVRES 201

EARTHSYS 130A. Ecosystems of California. 4 Units.
California is home to a huge diversity of ecosystem types and processes. This course provides an introduction to the natural history, systematics, and ecosystem ecology of California ecosystems, based on a combination of lectures, student-led projects, and weekend field trips. Ecosystems to be explored will range from coasts to mountains and from desert to wetlands. Requirements include three essays and participation in three field trips (of six options).
Same as: BIO 130

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: EARTH 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, GEOLSCI 132, GEOLSCI 232

EARTHSYS 133. Social Enterprise Workshop. 4 Units.
Social Enterprise Workshop: A team based class to design solutions to social issues. In the class students will identify issues they are interested in, such as housing, food, the environment, or college access. They will join teams of like-minded students. Working under the guidance of an experienced social entrepreneur, together they will develop a solution to one part of their issue and write a business plan for that solution. The class will also feature guests who are leaders in the field of social entrepreneurship who will share their stories and help with the business plans. The business plan exercise can be used for both nonprofits and for-profits. Previous students have started successful organizations and raised significant funds based on the business plans developed in this class. There are no prerequisites, and students do not need to have an idea for a social enterprise to join the class. Enrollment limited to 20. May be repeated for credit.
Same as: URBANST 133

EARTHSYS 135B. Waste Politics: Contesting Toxicity, Value, and Power. 3 Units.
Waste is increasingly central as an object and medium of political contestation in the contemporary world, from struggles over garbage, labor, and dignity in Senegal; to explosive remnants of war acting as rogue infrastructure in the Korean demilitarized zone. In response, waste has also become a productive concept in the environmental humanities and humanistic social sciences. In this course we will read a selection of foundational texts focused on waste, many of which draw on case studies from different parts of the world. The case of China will be emphasized, however, since China has emerged in the last few decades as a center not only of global industrial production, but also for processing the world¿s waste, contesting pollution, and fighting for environmental justice. By pairing key theoretical texts with texts dealing with waste-related issues in China and elsewhere, we will ultimately ask how contemporary global waste politics disrupts western understandings of waste, recycling, value, and more.
Same as: ANTHRO 135B, ANTHRO 235B

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 137. Concepts and Analytic Skills for the Social Sector. 4 Units.
How to develop and grow innovative not-for-profit organizations and for-profit enterprises which have the primary goal of solving social and environmental problems. Topics include organizational mission, strategy, market/user analysis, communications, funding, recruitment and impact evaluation. Perspectives from the field of social entrepreneurship, design thinking and social change organizing. Opportunities and limits of using methods from the for-profit sector to meet social goals. Focus is on integrating theory with practical applications, including several case exercises and simulations.One-day practicum where students advise an actual social impact organization. Enrollment limited to 20. Prerequisite:consent of instructor. Email lalitvak@stanford.edu.
Same as: URBANST 132

EARTHSYS 138. International Urbanization Seminar: Cross-Cultural Collaboration for Sustainable Urban Development. 4-5 Units.
(formerly IPS 274) 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, INTLPOL 274, URBANST 145

EARTHSYS 139. Ecosystem Services: Frontiers in the Science of Valuing Nature. 3 Units.
This course explores the science of valuing nature, beginning with its historical origins and then a primary focus on its recent development and frontiers. The principal aim of the course is to enable new research and real-world applications of InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) tools and approaches. We will discuss the interconnections between people and nature and key research frontiers, such as in the realms of biodiversity, resilience, human health, poverty alleviation, and sustainable development. The science we¿ll explore is in the service of decisions, and we will use examples from real life to illustrate why this science is so critical to informing why, where, how, and how much people need nature. Prerequisite. Basic to intermediate GIS skills are required (including working with raster, vector and tabular data; loading and editing rasters, shapefiles, and tables into a GIS; understanding coordinate systems; and performing basic raster math).
Same as: BIO 138, BIO 238, EARTHSYS 239

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. nnThis 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 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 143. Molecular Geomicrobiology Laboratory. 3-4 Units.
In this course, students will be studying the biosynthesis of cyclic lipid biomarkers, molecules that are produced by modern microbes that can be preserved in rocks that are over a billion years old and which geologist use as molecular fossils. Students will be tasked with identifying potential biomarker lipid synthesis genes in environmental genomic databases, expressing those genes in a model bacterial expression system in the lab, and then analyzing the lipid products that are produced. The overall goal is for students to experience the scientific research process including generating hypotheses, testing these hypotheses in laboratory experiments, and communicating their results through a publication style paper. Prerequisites: BIO83 and CHEM 121 or permission of the instructor.
Same as: BIO 142, ESS 143, ESS 243

EARTHSYS 143H. Quantitative methods for marine ecology and conservation. 4 Units.
The goal of this course is to learn the foundations of ecological modelling with a specific (but not exclusive) focus on marine conservation and sustainable exploitation of renewable resources. Students will be introduced to a range of methods ¿ from basic to advanced ¿to characterize population structure, conduct demographic analyses, estimate extinction risk, identify temporal trends and spatial patterns, quantify the effect of environmental determinants and anthropogenic pressures on the dynamics of marine populations, describe the potential for adaptation to climate change. This course will emphasize learning by doing, and will rely heavily on practical computer laboratories, in R and/or Phyton, based on data from our own research activities or peer reviewed publications. Students with a background knowledge of statistics, programming and calculus will be most welcome.
Same as: BIOHOPK 143H, BIOHOPK 243H, CEE 164H, CEE 264H, EARTHSYS 243H

EARTHSYS 144. Fundamentals of Geographic Information Science (GIS). 1-4 Unit.
"Everything is somewhere, and that somewhere matters." The rapid growth and maturity of spatial data technologies over the past decade represent a paradigm shift in the applied use of location data from high-level overviews of administrative interests, to highly personalized location-based services that place the individual at the center of the map, at all times. The use of spatial data and related technology continues to grow in fields ranging from environmental sciences to epidemiology to market prediction. This course will present an overview of current approaches to the use of spatial data and its creation, capture, management, analysis and presentation, in a research context. Topics will include modeling of geographic objects and associated data, modeling of geographic space and the conceptual foundations of "spatial thinking," field data collection, basic spatial statistical analysis, remote sensing & the use of satellite-based imagery, "Big Data" and machine learning approaches to spatial data, and cartographic design and presentation including the use of web-based "Storymap" platforms.n nThe course will consist of weekly lectures, guest speakers, computer lab assignments and an individual final project requirement. nnThis course must be taken for a minimum of 3 units and a letter grade to be eligible for Ways credit. In AY 2020-21, a letter grade or `CR' grade satisfies the Ways requirement.
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, ESS 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: MATH 51 or CME100; and PHYSICS 41; and a course that introduces the equations of fluid motion (e.g. ESS 246A, ESS 148, or CEE 101B).
Same as: CEE 162I, CEE 262I, ESS 246B

EARTHSYS 147. Ecosystem Ecology and Biogeochemistry. 3 Units.
An introduction to ecosystem ecology and terrestrial biogeochemistry. This course will focus on the dynamics of carbon and other biologically essential elements in the Earth System, on spatial scales from local to global. Prerequisites: Biology 117, Earth Systems 111, or graduate standing.
Same as: BIO 147, BIO 240, EARTHSYS 247

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&DE 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 the wild? What is our relationship to nature, and why does this relationship matter? We will interrogate these questions through the work of influential, diverse, primarily American environmental writers who have given voice to many ways of knowing the wonder, fragility, complexity, and power of the natural world and have inspired readers to act on behalf of social-environmental causes. This course centers the work of diverse voices, including Indigenous, Black, and Chicana writers, enabling us to consider some of the many ways that people have understood and experienced nature throughout history and the relevance of these manifold ways of knowing to our conceptualizations of nature today. Students will develop their responses to the question of what is the wild and why it matters through a series of synchronous and asynchronous in-the-field writing exercises that integrate personal narrative 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.nIf you are interested in signing up for the course, complete this pre-registration form:nhttps://stanforduniversity.qualtrics.com/jfe/form/SV_9XqZeZs036WIvop.
Same as: EARTHSYS 249

EARTHSYS 150B. Fire: Social and Ecological Contexts of Conflagration. 3 Units.
Over 1 million acres burned from California wildland fires in 2018, yet conservative estimates suggest that four times as many acres burned annually in California preceding European colonialism. In this course we will explore how climate, land management, urban development, and human social institutions contribute to contrasts in wild and prescribed (intentional anthropogenic) fire patterns worldwide. We will investigate the socio-ecological values and harms associated with different fire and land-use policies and practices, ranging from Indigenous and small-scale contexts, conservation projects, and large-scale fire suppression efforts.
Same as: ANTHRO 150B

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 (ESS/EARTHSYS 152/252). Prerequisites: BIO 43 and ESS 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 (ESS/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 floods, 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.nnFor students who have completed the first two levels of the writing requirement and want 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/notation-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 157. Stanford Science Podcast. 3 Units.
In this course, students will explore how podcasts can be used as a tool for effective science communication. Through a series of workshops and guest speakers, students in this course will learn the necessary journalistic and technical skills to produce high quality podcast episodes, from interviewing and storytelling to audio editing and digital publishing. Podcast episodes will highlight the cutting edge research being done at Stanford, and students will choose specific stories based on their own interests, from earth sciences to public health to big data. Final podcast episodes will be published on iTunes.
Same as: PWR 91JS

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 159. Economic, Legal, and Political Analysis of Climate-Change Policy. 5 Units.
This course will advance students understanding of economic, legal, and political approaches to avoiding or managing the problem of global climate change. Theoretical contributions as well as empirical analyses will be considered. It will address economic issues, legal constraints, and political challenges associated with various emissions-reduction and adaptation strategies, and it will consider policy efforts at the local, national, and international levels. Specific topics include: interactions among overlapping climate policies, the strengths and weaknesses of alternative policy instruments, trade-offs among alternative policy objectives, and decision making under uncertainty. Prerequisites: Econ 50 or its equivalent.
Same as: ECON 159, ECON 209, PUBLPOL 159

EARTHSYS 160. Sustainable Cities. 4-5 Units.
Community-engaged learning course that exposes students to sustainability concepts and urban planning as a tool for determining sustainable outcomes in the Bay Area. The focus will be on 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 remote team-based projects in collaboration with Bay Area community partners. Prerequisites: Consent of the instructor. (Cardinal Course certified by the Haas Center.).
Same as: URBANST 164

EARTHSYS 162. Data for Sustainable Development. 3-5 Units.
The sustainable development goals (SDGs) encompass many important aspects of human and ecosystem well-being that are traditionally difficult to measure. This project-based course will focus on ways to use inexpensive, unconventional data streams to measure outcomes relevant to SDGs, including poverty, hunger, health, governance, and economic activity. Students will apply machine learning techniques to various projects outlined at the beginning of the quarter. The main learning goals are to gain experience conducting and communicating original research. Prior knowledge of machine learning techniques, such as from CS 221, CS 229, CS 231N, STATS 202, or STATS 216 is required. Open to both undergraduate and graduate students. Enrollment limited to 24. Students must apply for the class by filling out the form at https://goo.gl/forms/9LSZF7lPkHadix5D3. A permission code will be given to admitted students to register for the class.
Same as: CS 325B, EARTHSYS 262

EARTHSYS 163. Tribal Economic Development and Sustainability. 3-5 Units.
Native Americans, Alaska Natives and Inuit are disproportionately on the forefront of climate change and are being forced to adapt to climate change now. One of the biggest challenges Indigenous Nations face is building sustainable businesses that respect the environment while providing for current and future generations. This course will survey environmental, regulatory, political and financing issues associated with economic development on tribal, Alaska Native and Inuit lands. We will examine Indigenous business success stories as well as an overview of major challenges to building sustainable businesses. We will engage with Indigenous leaders and industry experts to discuss the challenges of building businesses that provide jobs and economic opportunities for Indigenous communities now while also taking into account the responsibilities Indigenous leadership has to future generations.
Same as: NATIVEAM 162

EARTHSYS 164. Introduction to Physical Oceanography. 4 Units.
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.
Same as: CEE 162D, CEE 262D, ESS 148

EARTHSYS 16SI. Environmental Justice in the Bay Area. 2 Units.
Hands-on, discussion-based class 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 176. Open Space Management Practicum. 4-5 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 East Bay Regional Parks District. Grass Roots Ecology 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.nnAll students must complete the course application and turn it into Rachel Engstrand (rce212@stanford.edu) and Briana Swette (bswette@stanford.edu) by email. To receive priority consideration and an enrollment code, please submit the application by Monday September 10th, 2018. The course application consists of a short paragraph about your background and interest in and preparation for working on a real-world community-engaged earth systems project. The total course enrollment is necessarily limited by the project-based nature of the class.
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: Health and Science Journalism. 4-5 Units.
Practical, collaborative, writing-intensive advanced journalistic reporting and writing course in the specific practices and standards of health and science journalism. Science and journalism students learn how to identify and write engaging stories about medicine, global health, science, and related environmental issues; how to assess the quality and relevance of science news; how to cover the health and science beats effectively and efficiently; and how to build bridges between the worlds of journalism and science. Instructed Winter Quarter 2019 by Dr. Seema Yasmin, http://www.seemayasmin.com. nnnLimited enrollment: preference to students enrolled in or considering the Earth Systems Master of Arts, Environmental Communication Program and the Graduate Journalism Program. Prerequisite: EarthSys 191/291, COMM 104w, or consent of instructor. Admission by application only, available from dr.yasmin@stanford.edu (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. Application required. Deadline: September 10 for Autumn and March 10 for Spring. nnApplication: https://stanforduniversity.qualtrics.com/jfe/form/SV_244JnBoEP7zs8Dz.
Same as: ESS 280

EARTHSYS 181. Urban Agroecology. 3 Units.
The United Nations estimates that up to 15% of the world's food is produced in and around cities. Urban populations are projected to continue rising and urban agriculture in its many forms has been shown to provide multiple benefits to urban communities. This class will survey urban agriculture around the world while training you in small-scale food production practices. The emphasis will be on ecological approaches to the design and stewardship of urban farms and gardens. nnnIf permitted, given the challenges of COVID-19, the course will be taught in-person, outdoors at the Stanford Educational Farm. nn nThis is a 3-unit, Earth Systems practicum course that meets on Wednesdays from noon to 3pm. Space is limited and applications are due by Friday 8/28. Students will be notified if they are admitted to the course by 9/4. For the course application go to: https://stanforduniversity.qualtrics.com/jfe/form/SV_86udp8aEuWUCnNH.
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 's 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 182A. Ecological Farm Systems. 1-2 Unit.
An in-person, outdoor, project-based course in sustainable agricultural systems. Students will work individually or in small groups on projects at the Stanford Educational Farm. Potential projects this fall include building educational gardens, orchard establishment and management, and seedling propagation for plant donations for low-income families in partnership with Valley Verde in San Jose. Students are also encouraged to develop their own sustainable agriculture projects based on their interests.nn nnThe class will meet in-person, outdoors at the Stanford Educational Farm. Students will be required to follow farm and University COVID-19 protocols. By application only. The Winter 2021 application can be found here (Deadline Dec. 28): https://stanforduniversity.qualtrics.com/jfe/form/SV_abKbQxC1Q2cCC2h.
Same as: EARTHSYS 282A

EARTHSYS 183. Adaptation. 3 Units.
Adaptation is the process by which organisms or societies become better suited to their environments. In this class, we will explore three distinct but related notions of adaptation. Biological adaptations arise through natural selection, while cultural adaptations arise from a variety of processes, some of which closely resemble natural selection. A newer notion of adaptation has emerged in the context of climate change where adaptation takes on a highly instrumental, and often planned, quality as a response to the negative impacts of environmental change. We will discuss each of these ideas, using their commonalities and subtle differences to develop a broader understanding of the dynamic interplay between people and their environments. Topics covered will include, among others: evolution, natural selection, levels of selection, formal models of cultural evolution, replicator dynamics, resilience, rationality and its limits, complexity, adaptive management.
Same as: ESS 185

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 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'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. Application required. Deadline: March 14.nnApplication: https://stanforduniversity.qualtrics.com/jfe/form/SV_9SPufdULCh93rbT.
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 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 187A. The Future of Food & Farming Technology. 1 Unit.
"How are we going to feed X billion people by the year ____?" A historical refrain from corporate agribusiness, academia, national policy makers and, increasingly today, investors and technologists in innovation hotspots like Silicon Valley. But with only 60 global harvests remaining due to soil degradation, the compounding feedback loop between agriculture and climate change, and nearly a billion of our current population starving or undernourished and another billion of them overweight or obese, it begs the question of whether this is the right problem for which our food system should be solving. Some even argue, including the designers of this course, that this question is responsible for the various existential crises we face today.nnThis course will examine the history of agricultural innovation and technology to look for insights as to why our food system has gone so far off the rails. We will utilize the Stanford Educational Farm as a scaled-down model of our agricultural systems, where each student will step into the role of a modern, large scale farmer under simulated conditions. Through gamified scenarios based on real-world challenges faced by farmers, students will gain a deeper understanding of the problems facing our agriculture. Based on this nuanced understanding, students will propose new and novel uses of existing and/or emerging technologies to solve these problems. These ideas will be circulated in the marketplace of your peer farmers, where ideas will either be adopted, modified and built upon, or abandoned. This process will tap into, challenge, and hone your creative problem solving abilities. In the end, we will see who has what it takes to fundamentally shift the course of our food system,nnThis class is for students who are (a) aspiring ag-tech entrepreneurs (b) generally interested in emerging technologies or (c) seeking a deeper understanding of how large scale agriculture works.nnThe application for this course can be found on the d.school¿s website: https://dschool.stanford.edu/classes/nnCourse meets : Saturday May 4th, 10 am to 3pm, Saturday May 11th, 10am to 3pm, Saturday May 25th, 10am to 3pm.

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 190. The Multimedia Story. 2-3 Units.
Stories are how we understand ourselves and the world. This course will teach how to plan, research, report and produce a long-form, rich-media science/environment feature story. Students will work in groups or individually to master the blending of text with data visualization, photos, audio, and video. Teachers are experienced digital journalists at leading national and international publications with a close eye on trends and innovations in online, investigative, and data journalism. nnUsing the landmark New York Times story "Snow Fall" (http://nyti.ms/1eTyf2Y) as a departure point, the course will examine the questions: how do we engage and inform the public around critical environmental topics? nnHow do we explain complex and sometimes hidden factors shaping the future of our world? Students are asked to express interest through this form: http://goo.gl/rDQogB.

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 Earth or environmental science and/or policy studies, or in communication or journalism studies with a specific interest in environmental and science communication. Prerequisite: Earth Systems core (EarthSys 111 and EarthSys 112) or equivalent. (Meets Earth Systems WIM requirement.).
Same as: EARTHSYS 291

EARTHSYS 193. Natural Perspectives: Geology, Environment, and Art. 1 Unit.
Multi-day field trip that combines exploration of regional geology, ecology, and environmental history with guided drawing exercises in the Eastern Sierra Nevada of California. We¿ll visit several sites of geologic and environmental interest, discuss their formation and significance, and use drawing as tool for close observation. Students will gain an understanding of the natural processes shaping California, acquire new skills and techniques for artistic expression, and gain an appreciation for how scientific and aesthetic perspectives complement and enhance one another in the study of nature. No previous scientific or artistic experience is required. Preference for freshmen and sophomores.
If you are interested in signing up for the course, complete this pre-registration form: https://stanforduniversity.qualtrics.com/SE/?SID=SV_9RF2rDopROzwOxf.
Same as: EARTH 193

EARTHSYS 194. Topics in Writing & Rhetoric: Introduction to Environmental Justice: Race, Class, Gender and Place. 4 Units.
This course examines the rhetoric, history and key case studies of environmental justice while encouraging critical and collaborative thinking, reading and researching about diversity in environmental movements within the global community and at Stanford, including the ways race, class and gender have shaped environmental battles still being fought today. We center diverse voices by bringing leaders, particularly from marginalized communities on the frontlines to our classroom to communicate experiences, insights and best practices. Together we will develop and present original research projects which may serve a particular organizational or community need, such as racialized dispossession, toxic pollution and human health, or indigenous land and water rights, among many others. Prerequisite: PWR 2.
Same as: ENVRES 223, PWR 194EP

EARTHSYS 194A. Environmental Justice Colloquium. 1 Unit.
This colloquium brings the voices and vision of leading Environmental Justice (EJ) advocates to the Stanford community, in order to educate, inspire, and transform our understanding of environmental science. Environmental Justice advances a positive vision for policies and actions that fight environmental racism. EJ approaches involve centering the voices and leadership of marginalized communities in 1) ensuring equitable access to environmental benefits, and 2) preventing or mitigating the disproportionate impacts of environmental harms for all communities, regardless of gender, class, race, ethnicity, or other social positions. This colloquium highlights the work of leading EJ thinkers and practitioners, speaking from frontline organizations on a wide range of topics. These topics include acting on toxic exposures and health disparities for community resilience, climate justice and youth action, Indigenous land and water rights, green cities and Afrofuturism, food justice and intersecting social movements, queer ecologies, and more. The colloquium will host a weekly speaker, and final symposium at the end of the quarter. nnThe first meeting for this course will take place during WEEK 3.
Same as: HUMRTS 194A, URBANST 155A

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 196A. Environmental Justice and Human Rights Lab. 1 Unit.
The Environmental Justice and Human Rights Lab is an intellectual hub and supportive learning community for students engaging in environmental justice and human rights work of any kind. Environmental justice (EJ) advances a positive vision for policies and actions that fight environmental racism, and human rights (HR) center on the notion that all people, by virtue of their existence and regardless of any given status or classification, are equally entitled to fundamental rights and protections. Our semi-structured weekly sessions will foster an open learning environment for students and peer-to-peer learning connections. Sessions will include giving and receiving feedback on capstone or community-based projects, independent research, or other relevant coursework or extracurricular activity. We also welcome students who are new to these topics and would like to learn more. We are open to students of all backgrounds and disciplines at any stage of their research or project work. Following EJ and HR principles, we seek to center local, contextualised knowledge and leadership through ethical research partnerships with community members. To do so, we follow community-based participatory research approaches and decolonizing methodologies. Examples of our work to date include 1) enabling graduate students to effectively bring EJ and HR approaches into dissertation research, 2) supporting campus leaders and directly participating in diversity, equity, and inclusion (DEI) initiatives, and 3) educating and learning from one another about critical EJ and HR scholarship and anti-racist approaches to our work. Lab interests include addressing inequitable impacts of climate change, advancing decolonial approaches to land and water management, promoting food justice, combatting human trafficking and labor exploitation, promoting fair and just immigration policies, and additional EJ and HR research topics. Note that this lab is intended as an open space for engagement. If you are unable to enroll for credit, but would still like to participate, please email humanrights@stanford.edu.
Same as: HUMRTS 196

EARTHSYS 197. Directed Individual Study in Earth Systems. 1-9 Unit.
Under supervision of an Earth Systems faculty member on a subject of mutual interest.

EARTHSYS 198. Seminar on Philosophy, Politics, and the Environment. 1 Unit.
Much public discourse that touches upon the relationship of human society to the natural environment acknowledges the fundamental connection between people and the environment, but avoids or simplifies discussion of broader philosophical and political views of what this relationship is, has been, and ought to be. Expansive conceptual categories of the study of politics, economics, and society, such as capitalism, socialism, democracy, human welfare, and distribution, are often left out entirely, or used quickly and not defined clearly. In thinking big about human society and the natural world, what is ideal, and what is possible? This once-weekly seminar aims to help students develop the breadth and depth of their thinking about the relationship of human society to nature at the level of political, social, and economic philosophy. It will provide an organized setting for the understanding and critical discussion of these abstract but sometimes world-shaping ideas. Particular attention will be paid to the wide range of such views put forth in recent history, the various assumptions built into each view, and to the differing levels of influence and political effectiveness achieved by each. Discussions will be based on a weekly reading from a philosophically oriented work about humanity and the environment, such as a book chapter or a piece of long-form journalism. Grading/credit based on weekly participation and a short reflective paper.
Same as: EARTHSYS 298

EARTHSYS 199. Honors Program in Earth Systems. 1-9 Unit.
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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 we¿ve 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 204. The Water Course. 4 Units.
The Central Valley of California provides a third of the produce grown in the U.S., but recent droughts and increasing demand have raised concerns about both food and water security. The pathway that water takes from rainfall to the irrigation of fields or household taps (¿the water course¿) determines the quantity and quality of the available water. Working with various data sources (measurements made on the ground, in wells, and from satellites) allows us to model the water budget in the valley and explore the recent impacts on freshwater supplies.
Same as: EARTHSYS 104, GEOPHYS 104, GEOPHYS 204

EARTHSYS 205. Food and Community: Food Security, Resilience and Equity. 2-3 Units.
What can communities do to bolster food security, resiliency, and equity in the face of climate change? This course aims to respond to this question, in three parts. In Part 1, we will explore the most current scientific findings on trends in anthropogenic climate forcing and the anticipated impacts on global and regional food systems. Specifically, Part I will review the anticipated impact of climate change on severe weather events, crop losses, and food price volatility and the influence of these impacts on global and regional food insecurity and hunger. In Part II, we will consider what communities can do to promote food security and equity in the face of these changes, by reviewing the emerging literature on food system resiliency. Finally, we will facilitate a conference in which multi-disciplinary teams from around the country will gather to initiate regional planning projects designed to enhance food system resilience and equity. Cardinal Course (certified by Haas Center). Limited enrollment. May be repeated for credit.
Same as: EARTHSYS 105

EARTHSYS 205A. Fundamentals of Geobiology. 3 Units.
Lecture and discussion covering key topics in the history of life on Earth, as well as basic principles that apply to life in the universe. Co-evolution of Earth and life; critical intervals of environmental and biological change; geomicrobiology; paleobiology; global biogeochemical cycles; scaling of geobiological processes in space and time.
Same as: ESS 205, GEOLSCI 205

EARTHSYS 205VP. Contested markets in the Brazilian Amazon Rainforest. 2-3 Units.
Strategies of environmental movements to contain domestic and foreign corporations that are viewed as major perpetrators of rainforest devastation and the socio-economic degradation of this vast region. Topics: Origins, roles and inter-relations among corporations (zero deforestation agreements in soybean agriculture and cattle ranching), the development of environmental law and the efficacy of government and NGO movements¿ strategies, and whether this emerging economy shapes social classes, groups, tribes, family life to further embed inequality and immobility. This course must be taken for a minimum of 3 units and a letter grade to be eligible for Ways credit.
Same as: SOC 105VP, SOC 205VP

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 of agriculture in poverty alleviation, economic development, and environmental outcomes. Grades based on mid-term exam and group modeling project and presentation. Enrollment is by application only and will be capped at 25, with priority given to upper level undergraduates in Economics and Earth Systems and graduate students (graduate students enroll in 206). Application found at https://economics.stanford.edu/academics/undergraduate-program/forms.
Same as: EARTHSYS 106, ECON 106, ECON 206, ESS 106, ESS 206

EARTHSYS 206B. Sustainable and Equitable Water Management. 3-4 Units.
California has committed itself to sustainable groundwater management, with passage of the Sustainable Groundwater Management Act in 2014, and safe drinking water access for all, with California's Human Right to Water Act in 2012. Yet, groundwater overdraft continues while over 1 million residents lack access to safe drinking water. Working with a water agency in the San Joaquin Valley, we will explore feedback loops between the two Acts and develop a plan for water management that meet the co-equal objectives of sustainable and equitable resource governance. We will work with "big" and "small" data, exploring the possibilities but also the limitations of using publicly available data for assessment and monitoring. The course will include guest speakers and interaction with public agencies and other key stakeholders.nThis is a Cardinal Course certified by the Haas Center.
Same as: EARTHSYS 106B, GEOPHYS 106, GEOPHYS 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 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

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. 2 Units.
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 212. 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: EARTHSYS 112, ESS 112, HISTORY 103D

EARTHSYS 214. Global Change and Emerging Infectious Disease. 3 Units.
The changing epidemiological environment. How human-induced environmental changes, such as global warming, deforestation and land-use conversion, urbanization, international commerce, and human migration, are altering the ecology of infectious disease transmission, and promoting their re-emergence as a global public health threat. Case studies of malaria, cholera, hantavirus, plague, and HIV.
Same as: EARTHSYS 114, ESS 213, HUMBIO 114

EARTHSYS 217. 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 BIO 81 or graduate standing.
Same as: BIO 117, EARTHSYS 111, ESS 111

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 22. Introduction to Landscape Architecture: Urban Ecology and Environmental Design. 1 Unit.
This 1 unit, nine-week course provides an introduction to landscape architecture, covering a brief history of the field, making connections between science and sustainable and resilient urban ecosystems, and exploring a range of projects and topics that landscape architects touch. From public spaces and streetscapes to shorelines and trails, landscape architecture projects combine art and science in the pursuit of connecting and engaging humans with built and natural environments. The practice can be used to contribute to and achieve complex goals such as climate resilience, environmental restoration, habitat creation, green infrastructure planning, and aesthetic appeal. Through targeted readings, lectures, thoughtful discussions, and foundational assignments encouraging students to get outside and observe their surrounding landscapes, students will receive an introduction to landscape architecture and engage with a creative application of earth systems science. This course begins during Week 2 of fall quarter and will invite practicing landscape architects and urban designers to give biweekly guest lectures. Students of all class years and majors are encouraged to enroll. Guest lectures will be open to the Stanford community.

EARTHSYS 223. Biosphere-Atmosphere Interactions. 3-4 Units.
How do ecosystems respond to climate, and how do ecosystems influence climate? Covers the role of the terrestrial land surface in earth's climate system, including among others photosynthesis, transpiration, greenhouse gasses, radiation, and atmospheric water vapor. For each of these topics, attention is paid to both the underlying processes and how they can be mathematically represented in earth system models. Instruments and techniques used to measure these processes are also discussed, and, where appropriate, demonstrated.
Same as: EARTHSYS 123A, ESS 123, ESS 223

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, URBANST 125

EARTHSYS 227. Decision Science for Environmental Threats. 3-5 Units.
Decision science is the study of how people make decisions. It aims to describe these processes in ways that will help people make better or more well-informed decisions. It is an interdisciplinary field that draws upon psychology, economics, political science, and management, among other disciplines. It is being used in a number of domain areas and for a variety of applications, including managing freshwater resources, designing decision support tools to aid in coastal adaptation to sea-level rise, and creating "nudges" to enhance energy efficiency behaviors. This course covers behavioral theories of probabilistic inference, intuitive prediction, preference, and decision making. Topics include heuristics and biases, risk perceptions and attitudes, strategies for combining different sources of information and dealing with conflicting objectives, and the roles of group and emotional processes in decision making. This course will introduce students to foundational theories of decision science, and will involve applying these theories to understand decisions about environmental threats.
Same as: ESS 227

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, GEOLSCI 132, GEOLSCI 232

EARTHSYS 233. Mitigating Climate Change through Soil Management. 2 Units.
Climate change is one of the greatest crises facing our world. Increasing soil organic carbon storage may be a key strategy for mitigating global climate change, with the potential to offset approximately 20% of annual global fossil fuel emissions. In this course, we will learn about soil carbon cycling, its contribution to the global carbon cycle, how carbon is stored in soil, and land management practices that can increase or decrease soil carbon stocks, thereby mitigating or exacerbating climate change. Although the content is centered on soil carbon, the processes and skills learned in this course can be applied to design solutions to any environmental problem.nnPrerequisites: Some knowledge of soils, introductory chemistry, and introductory biology would be useful but not necessary. Please email the instructor if you have any concerns or questions.
Same as: ESS 233

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. 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).

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 239. Ecosystem Services: Frontiers in the Science of Valuing Nature. 3 Units.
This course explores the science of valuing nature, beginning with its historical origins and then a primary focus on its recent development and frontiers. The principal aim of the course is to enable new research and real-world applications of InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) tools and approaches. We will discuss the interconnections between people and nature and key research frontiers, such as in the realms of biodiversity, resilience, human health, poverty alleviation, and sustainable development. The science we¿ll explore is in the service of decisions, and we will use examples from real life to illustrate why this science is so critical to informing why, where, how, and how much people need nature. Prerequisite. Basic to intermediate GIS skills are required (including working with raster, vector and tabular data; loading and editing rasters, shapefiles, and tables into a GIS; understanding coordinate systems; and performing basic raster math).
Same as: BIO 138, BIO 238, EARTHSYS 139

EARTHSYS 240. Data science for geoscience. 3 Units.
This course provides an overview of the most relevant areas of data science (applied statistics, machine learning & computer vision) to address geoscience challenges, questions and problems. Using actual geoscientific research questions as background, principles and methods of data scientific analysis, modeling, and prediction are covered. Data science areas covered are: extreme value statistics, multi-variate analysis, factor analysis, compositional data analysis, spatial information aggregation models, spatial estimation, geostatistical simulation, treating data of different scales of observation, spatio-temporal modeling (geostatistics). Application areas covered are: process geology, hazards, natural resources. Students are encouraged to participate actively in this course by means of their own data science research challenge or question.
Same as: ENERGY 240, ESS 239, GEOLSCI 240

EARTHSYS 241. 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 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.nnApplication required. Deadline Dec. 1. nApply here: https://stanforduniversity.qualtrics.com/jfe/form/SV_4IuQC5BcQdn3j6Z¿.

EARTHSYS 243H. Quantitative methods for marine ecology and conservation. 4 Units.
The goal of this course is to learn the foundations of ecological modelling with a specific (but not exclusive) focus on marine conservation and sustainable exploitation of renewable resources. Students will be introduced to a range of methods ¿ from basic to advanced ¿to characterize population structure, conduct demographic analyses, estimate extinction risk, identify temporal trends and spatial patterns, quantify the effect of environmental determinants and anthropogenic pressures on the dynamics of marine populations, describe the potential for adaptation to climate change. This course will emphasize learning by doing, and will rely heavily on practical computer laboratories, in R and/or Phyton, based on data from our own research activities or peer reviewed publications. Students with a background knowledge of statistics, programming and calculus will be most welcome.
Same as: BIOHOPK 143H, BIOHOPK 243H, CEE 164H, CEE 264H, EARTHSYS 143H

EARTHSYS 247. Ecosystem Ecology and Biogeochemistry. 3 Units.
An introduction to ecosystem ecology and terrestrial biogeochemistry. This course will focus on the dynamics of carbon and other biologically essential elements in the Earth System, on spatial scales from local to global. Prerequisites: Biology 117, Earth Systems 111, or graduate standing.
Same as: BIO 147, BIO 240, EARTHSYS 147

EARTHSYS 249. Wild Writing. 3 Units.
What is the wild? What is our relationship to nature, and why does this relationship matter? We will interrogate these questions through the work of influential, diverse, primarily American environmental writers who have given voice to many ways of knowing the wonder, fragility, complexity, and power of the natural world and have inspired readers to act on behalf of social-environmental causes. This course centers the work of diverse voices, including Indigenous, Black, and Chicana writers, enabling us to consider some of the many ways that people have understood and experienced nature throughout history and the relevance of these manifold ways of knowing to our conceptualizations of nature today. Students will develop their responses to the question of what is the wild and why it matters through a series of synchronous and asynchronous in-the-field writing exercises that integrate personal narrative 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.nIf you are interested in signing up for the course, complete this pre-registration form:nhttps://stanforduniversity.qualtrics.com/jfe/form/SV_9XqZeZs036WIvop.
Same as: EARTHSYS 149

EARTHSYS 250. Directed Research. 1-9 Unit.
Independent research. Student develops own project with faculty supervision. 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 (ESS/EARTHSYS 152/252). Prerequisites: BIO 43 and ESS 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 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 (ESS/EARTHSYS 151/251).
Same as: EARTHSYS 152, ESS 152, ESS 252

EARTHSYS 254. Environmental Governance. 3 Units.
How do we work together to solve environmental problems? Across the globe, who has a voice, and who ultimately decides how to balance conservation and development? How do we build governance institutions that facilitate both environmental sustainability and social equity? This seminar on environmental governance will focus on the challenges and opportunities for managing common-pool resources, like fisheries, forests, and water. Because managing environmental resources is often about managing people, we will explore the motivations underlying human behavior towards the environment. We will discuss how institutions encode our cultural values and beliefs, and how we can reshape these institutions to achieve more sustainable outcomes. Coursework includes foundational readings and a pragmatic exploration of case studies. Teaching cases address topics in community-based conservation, international protected areas, market-based approaches, coping with environmental risk, and other themes. Interested undergraduate and graduate students from any discipline are welcome.
Same as: ENVRES 250

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, GEOLSCI 233A

EARTHSYS 256. Soil and Water Chemistry. 3 Units.
(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: 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 26. Sustainability in Athletics. 1 Unit.
This interactive, seminar-style course explores the intersection of environmental sustainability and athletics. Athletic teams and organizations provide a unique lens to analyze environmental sustainability due to their global reach, enormous fan bases and widely recognized sport icons. At the same time, the athletics industry produces an enormous environmental footprint with its travel, gear, competitive fueling, events, venue construction and maintenance. Because of this position, the sports industry has the opportunity and responsibility to create meaningful change in support of a sustainable future. We will explore the many ways that the athletics industry can make this change by inviting weekly speakers from a multitude of sports realms to share their expertise, vision and advice. There will be six learning modules addressing sustainability in terms of athletic gear and equipment, sports nutrition, facilities and stadiums, game days and events, the national and international stage, and individual sustainability superstars. Through taking this course, students will develop an understanding for the current state of athletic sustainability as well as future directions for the industry in this space.

EARTHSYS 260. Internship. 1 Unit.
Supervised field, lab, or public/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 or opportunity relevant to the student's Earth Systems studies. Required of and restricted to declared Earth Systems majors. This is a 1 unit, credit/no credit course, consisting of at least 270 hours of work. Course can be fulfilled any quarter. For more course requirements, please visit: https://earth.stanford.edu/esys/undergrad/internship.

EARTHSYS 262. Data for Sustainable Development. 3-5 Units.
The sustainable development goals (SDGs) encompass many important aspects of human and ecosystem well-being that are traditionally difficult to measure. This project-based course will focus on ways to use inexpensive, unconventional data streams to measure outcomes relevant to SDGs, including poverty, hunger, health, governance, and economic activity. Students will apply machine learning techniques to various projects outlined at the beginning of the quarter. The main learning goals are to gain experience conducting and communicating original research. Prior knowledge of machine learning techniques, such as from CS 221, CS 229, CS 231N, STATS 202, or STATS 216 is required. Open to both undergraduate and graduate students. Enrollment limited to 24. Students must apply for the class by filling out the form at https://goo.gl/forms/9LSZF7lPkHadix5D3. A permission code will be given to admitted students to register for the class.
Same as: CS 325B, EARTHSYS 162

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 co-terminal masters degree students must enroll to receive accreditation to the climate negotiations.

EARTHSYS 272. Antarctic Marine Geology and Geophysics. 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.
Same as: ESS 242

EARTHSYS 276. Open Space Management Practicum. 4-5 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 East Bay Regional Parks District. Grass Roots Ecology 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.nnAll students must complete the course application and turn it into Rachel Engstrand (rce212@stanford.edu) and Briana Swette (bswette@stanford.edu) by email. To receive priority consideration and an enrollment code, please submit the application by Monday September 10th, 2018. The course application consists of a short paragraph about your background and interest in and preparation for working on a real-world community-engaged earth systems project. The total course enrollment is necessarily limited by the project-based nature of the class.
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: Health and Science Journalism. 4-5 Units.
Practical, collaborative, writing-intensive advanced journalistic reporting and writing course in the specific practices and standards of health and science journalism. Science and journalism students learn how to identify and write engaging stories about medicine, global health, science, and related environmental issues; how to assess the quality and relevance of science news; how to cover the health and science beats effectively and efficiently; and how to build bridges between the worlds of journalism and science. Instructed Winter Quarter 2019 by Dr. Seema Yasmin, http://www.seemayasmin.com. nnnLimited enrollment: preference to students enrolled in or considering the Earth Systems Master of Arts, Environmental Communication Program and the Graduate Journalism Program. Prerequisite: EarthSys 191/291, COMM 104w, or consent of instructor. Admission by application only, available from dr.yasmin@stanford.edu (Meets Earth Systems WIM requirement.).
Same as: COMM 177C, COMM 277C, EARTHSYS 177C

EARTHSYS 281. Urban Agroecology. 3 Units.
The United Nations estimates that up to 15% of the world's food is produced in and around cities. Urban populations are projected to continue rising and urban agriculture in its many forms has been shown to provide multiple benefits to urban communities. This class will survey urban agriculture around the world while training you in small-scale food production practices. The emphasis will be on ecological approaches to the design and stewardship of urban farms and gardens. nnnIf permitted, given the challenges of COVID-19, the course will be taught in-person, outdoors at the Stanford Educational Farm. nn nThis is a 3-unit, Earth Systems practicum course that meets on Wednesdays from noon to 3pm. Space is limited and applications are due by Friday 8/28. Students will be notified if they are admitted to the course by 9/4. For the course application go to: https://stanforduniversity.qualtrics.com/jfe/form/SV_86udp8aEuWUCnNH.
Same as: EARTHSYS 181, ESS 181, ESS 281, URBANST 181

EARTHSYS 282A. Ecological Farm Systems. 1-2 Unit.
An in-person, outdoor, project-based course in sustainable agricultural systems. Students will work individually or in small groups on projects at the Stanford Educational Farm. Potential projects this fall include building educational gardens, orchard establishment and management, and seedling propagation for plant donations for low-income families in partnership with Valley Verde in San Jose. Students are also encouraged to develop their own sustainable agriculture projects based on their interests.nn nnThe class will meet in-person, outdoors at the Stanford Educational Farm. Students will be required to follow farm and University COVID-19 protocols. By application only. The Winter 2021 application can be found here (Deadline Dec. 28): https://stanforduniversity.qualtrics.com/jfe/form/SV_abKbQxC1Q2cCC2h.
Same as: EARTHSYS 182A

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'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. Application required. Deadline: March 14.nnApplication: https://stanforduniversity.qualtrics.com/jfe/form/SV_9SPufdULCh93rbT.
Same as: EARTHSYS 186

EARTHSYS 288. 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 188

EARTHSYS 289. FEED Lab: Food System Design & Innovation. 3-4 Units.
FEED Lab is a course in which entrepreneurial and motivated students, engaged industry-thought leaders, and deeply experienced and connected faculty work together to design solutions to some of the food system's most consequential problems. Whether you're passionate about transforming the food system, or merely curious explore it, all students in this course will leave with practical design skills, enhanced leadership abilities, and confidence that their work will leave a lasting impact on the organizations with whom we collaborate. Students who complete this course gain access to the broad network of the FEED Collaborative, whose mission is to equip and inspire the next generation of leaders in the food system, and to connect them to meaningful opportunities after Stanford. To learn more about the FEED Collaborative, visit https://feedcollab.stanford.edu/. This course requires an application, which can be found here: https://forms.gle/5Rd93yVg8XjRCig26.
Same as: SUST 231

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 intent of this course 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 co-terminal MS and MA students. This remote course has several elements, including, skill building through experiential learning and reflection and professional development. Students will either work in teams with a community partner in the Bay area on a predetermined project, or select a self-designed project with a partner anywhere in the world. The idea is to complete a well-defined, manageable, but important project to a high standard under significant time constraints. Our community partners have requested help with achieving their missions and seminar students will utilize their backgrounds in social/environmental problem solving to deliver a final product. Our partners have requested help with such efforts as grant and report writing, data analysis, curriculum development, symposium organizing, presentation research and preparation and communications to raise awareness about an environmental challenge. If you choose to design your own project, the instructor will help you to create this opportunity. Students will give oral presentations on their project progress throughout the quarter, culminating in a final presentation at a symposium with our partners. Students will also explore how best to communicate their interdisciplinary skills and goals through their resumes, cv¿s or cover letters, portfolios or linkedIn profiles in preparation for the next phase of their career. Guest speakers and in class workshops will complement these activities.

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 Earth or environmental science and/or policy studies, or in communication or journalism studies with a specific interest in environmental and science communication. 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, audio and video production in communicating environmental science and policy concepts to the public. Emphasis on fundamental techniques, storytelling and workflow more than technical how to or gear. Includes extensive instructor and peer critiquing of work and substantial out-of-class group project work. Limited class size, preference to Earth Systems master's students. No previous multimedia 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, environmental or outdoor education placements, NGOs, government agencies, on-campus departments, programs, or centers, and science centers and museums. Restricted to students admitted to the Earth Systems Master of Arts, Environmental Communication Program. Can be completed in any quarter.

EARTHSYS 294. Environmental Communication Capstone. 1-3 Unit.
The Earth Systems Master of Arts, Environmental Communication capstone project provides students with an opportunity to complete an ambitious independent project demonstrating mastery of an area of environmental communication. Capstone projects are most often applied communication projects such as writing, photography, or video projects; expressive or artistic works; or student-initiated courses, workshops, or curriculum materials. Projects focused on academic scholarship or communication theory research may also be considered. Restricted to students enrolled in the Earth Systems Master of Arts, Environmental Communication Program.

EARTHSYS 295. Environmental Communication Seminar. 1 Unit.
Weekly seminar for students enrolled in the Earth Systems Master of Arts, Environmental Communication Program, to be taken twice for credit during degree progress. Includes discussion of and reflection on current topics in environmental communication, skills and professional development workshop sessions, and mentoring and peer support for MA capstone projects.

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

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

EARTHSYS 298. Seminar on Philosophy, Politics, and the Environment. 1 Unit.
Much public discourse that touches upon the relationship of human society to the natural environment acknowledges the fundamental connection between people and the environment, but avoids or simplifies discussion of broader philosophical and political views of what this relationship is, has been, and ought to be. Expansive conceptual categories of the study of politics, economics, and society, such as capitalism, socialism, democracy, human welfare, and distribution, are often left out entirely, or used quickly and not defined clearly. In thinking big about human society and the natural world, what is ideal, and what is possible? This once-weekly seminar aims to help students develop the breadth and depth of their thinking about the relationship of human society to nature at the level of political, social, and economic philosophy. It will provide an organized setting for the understanding and critical discussion of these abstract but sometimes world-shaping ideas. Particular attention will be paid to the wide range of such views put forth in recent history, the various assumptions built into each view, and to the differing levels of influence and political effectiveness achieved by each. Discussions will be based on a weekly reading from a philosophically oriented work about humanity and the environment, such as a book chapter or a piece of long-form journalism. Grading/credit based on weekly participation and a short reflective paper.
Same as: EARTHSYS 198

EARTHSYS 299. M.S. Thesis. 1-9 Unit.
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EARTHSYS 301. CURRICULAR PRACTICAL TRAINING - CPT. 1 Unit.
CPT course required for international students completing degree.

EARTHSYS 308. Carbon Dioxide and Methane Removal, Utilization, and Sequestration. 1 Unit.
This is a seminar on carbon dioxide and methane removal, utilization, and sequestration options, and their role in decarbonizing the global energy system. This course will cover topics including the global carbon balance, utilizing atmospheric carbon in engineered solutions, recycling and sequestering fossil-based carbon, and enhancing natural carbon sinks. The multidisciplinary lectures and discussions will cover elements of technology, economics, policy and social acceptance, and will be led by a series of guest lecturers. Short group project on carbon solutions.
Same as: ENERGY 308, ENVRES 295, ESS 308, ME 308

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. 2020-21 academic year offering of this course is dependent on COVID-19 regulations.
Same as: BIOHOPK 182H, BIOHOPK 323H, ESS 323

EARTHSYS 332. Theory and Practice of Environmental Education. 3 Units.
Foundational understanding of the history, theoretical underpinnings, and practice of environmental education as a tool for addressing today's pressing environmental issues. The purpose, design, and implementation of environmental education in formal and nonformal settings with youth and adult audiences. Field trip and community-based project offer opportunities for experiencing and engaging with environmental education initiatives.
Same as: EDUC 332

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 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 sledging trip to recover emperor penguin eggs. Optional field trip into the high Sierra in March.
Same as: ESS 38N, GEOLSCI 38N

EARTHSYS 39Q. Talking about Earthquakes, Volcanoes, and Floods: Science Communication and Natural Hazards. 4 Units.
In an age of fake news, how do we communicate the importance of scientific facts? How do we compel action from an individual to a national level when the facts alone aren¿t enough? In this class you will learn the basic tools of science communication through the lens of natural hazards such as earthquakes, volcanoes, and extreme weather. You will learn the basics of the science that drives these hazards, and how to communicate that science to different audiences. Recent research has shown that relaying scientific knowledge alone to potentially vulnerable populations does not have a significant impact on increasing their resilience to those hazards. Therefore, it is increasingly important to train a new generation of science communicators and translators who can effectively relay complex information in engaging and understandable ways. This will be a hands-on course where you will be working individually and in small groups to discuss class topics, share, and peer review each other¿s writing each week. This course satisfies the Write 2 requirement for undergraduates.

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: GEOLSCI 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 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: GEOLSCI 46Q

EARTHSYS 55Q. Am I a Part of Earth? Understanding of Rock, Water, and Time. 3 Units.
Am I a part of Earth? Not only is this a question of personal meaning, but also a complex question that shapes how we interact with the natural world. Answering it calls for both scientific and experiential understanding of Earth processes, as well as how geologic thinking and our individual thinking about nature have changed through time. By connecting Earth processes and rates of transformations to personal experience, we can rigorously interrogate our relationship to and/or separation from Earth.nnIn this course, you will think like a philosopher and a geochemist. You will commune with nature and calculate the history of rocks. You will use real data analysis of Earth processes to understand the limits of our knowledge about Earth history (Deep Time). You will explore your interactions with Earth materials through mindfulness activities and discuss different views of humans relative to nature through history. You will have autonomy in a course-long project that synthesizes your growing understanding of your relationship to and/or separation from Earth.nnThis course welcomes all, from rock collectors to hikers and ecofeminists to meditators. No prior experience with philosophy or Earth science is required, though an introductory high school chemistry and algebra course will be helpful. The only requirement is a willingness to examine your personal relationship with Earth from scientific and humanistic perspectives.

EARTHSYS 58Q. Understanding Our Oceans: Scientific Toys, Tools, & Trips. 3 Units.
In popular science magazines we read about deep ocean critters recently discovered or the latest threats coral reefs face. But what is it actually like to do science in the ocean-to research ocean life in the various ocean ecosystems? In this course, we will explore the latest advances in marine science-what technologies are allowing scientists to explore and investigate the ocean and what are we discovering. We will have 2 one-day fieldtrips (on Fridays) to marine research centers in Moss Landing, Monterey, and institutions in the Bay Area. This course will also expose students to what life as a marine biology/science graduate student is like.

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

EARTHSYS 8. The Oceans: An Introduction to the Marine Environment. 4 Units.
The course will provide a basic understanding of how the ocean functions as a suite of interconnected ecosystems, both naturally and under the influence of human activities. Emphasis is on the interactions between the physical and chemical environment and the dominant organisms of each ecosystem. The types of ecosystems discussed include coral reefs, deep-sea hydrothermal vents, coastal upwelling systems, blue-water oceans, estuaries, and near-shore dead zones. Lectures, multimedia presentations, group activities, and tide-pooling day trip.
Same as: ESS 8

EARTHSYS 801. TGR Project. 0 Units.
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EARTHSYS 9. Public Service Internship Preparation. 1 Unit.
Are you prepared for your internship this summer? This workshop series will help you make the most of your internship experience by setting learning goals in advance; negotiating and communicating clear roles and expectations; preparing for a professional role in a non-profit, government, or community setting; and reflecting with successful interns and community partners on how to prepare sufficiently ahead of time. You will read, discuss, and hear from guest speakers, as well as develop a learning plan specific to your summer or academic year internship placement. This course is primarily designed for students who have already identified an internship for summer or a later quarter. You are welcome to attend any and all workshops, but must attend the entire series and do the assignments for 1 unit of credit.
Same as: EDUC 9, HUMBIO 9, PUBLPOL 74, URBANST 101

EARTHSYS 91. Earth Systems Writers Collective. 1 Unit.
Come join a community of environmental writers, publish your work, and get course credit at the same time! Are you currently working on an article, an op-ed, translating your class projects into publishable pieces or pursuing a new writing project? Are you interested in publishing your work in the quarterly Earth Systems newsletter and the annual Earth Systems magazine? In this weekly seminar, you will collaborate with others and get constructive feedback from a community of peer writers. You can enroll in the Earth Systems Writers Collective for 1 unit, or just join without signing up for course credit. May be repeated for credit.

EARTHSYS 95. Liberation Through Land: Organic Gardening and Racial Justice. 2 Units.
Through field trips, practical work and readings, this course provides students with the tools to begin cultivating a relationship to land that focuses on direct engagement with sustainable gardening, from seed to harvest. The course will take place on the O'Donohue Family Stanford Educational Farm, where students will be given the opportunity to learn how to sow seeds, prepare garden beds, amend soils, build compost, and take care of plants. The history of forced farm labor in the U.S., from slavery to low-wage migrant labor, means that many people of color encounter agricultural spaces as sites of trauma and oppression. In this course we will explore the potential for revisiting a narrative of peaceful relation to land and crop that existed long before the trauma occurred, acknowledging the beautiful history of POC coexistence with land. Since this is a practical course, there will be a strong emphasis on participation. Application available at https://goo.gl/forms/cbYX3gSGdrHgHBJH3; deadline to apply is September 18, 2018, at midnight. The course is co-sponsored by the Institute for Diversity in the Arts (IDA) and the Earth Systems Program.
Same as: AFRICAAM 95, CSRE 95

EARTHSYS 96. Land Justice: Unearthing Histories & Seeding Liberation. 2 Units.
Through readings, class discussions, direct interviews, peer reviews, and blog posts, this course grounds students in United States land histories, explores contemporary efforts towards food and land justice, and equips students with the frameworks to envision and work towards an equitable and just food and land management system and greater environmental movement. Teams of students will have the opportunity to delve deeper into course concepts through direct engagement with our community partners. This course acknowledges the ways that historical and contemporary colonial violence, racism, and systemic injustice shape our food and land systems, while empowering students to envision and help build an equitable, just, sovereign, and healthy land future. Although this is an online course, there will be a strong emphasis on community engagement and in-class participation.