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 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, assignments, and two off-site field trips. Field trip offerings differ each fall (see syllabus for updated list), but may include Diablo Canyon nuclear power plant, Shasta dam, Tesla Gigafactory, NextEra wind farm, San Ardo oil field, Geyser’s geothermal power plants, etc. Students choose two field trips from approximately 8 that are offered.
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 Ginnebaugh. Open to all: pre-majors and majors, with any background! The course was formerly called Energy Resources. Website: http://web.stanford.edu/class/cee207a/ nFor a course that covers all of this but goes less in-depth into the technical aspects of each energy resource, check out CEE 107S/207S Understanding Energy: Essentials, offered spring and summer (cannot take both for credit). Prerequisites: Algebra. May not be taken for credit by students who have completed CEE 107S/207S or CEE 107E.
Same as: CEE 107A, CEE 207A

EARTHSYS 104. The Water Course. 3 Units.
The Central Valley of California provides a third of the produce grown in the U.S., but has a desert climate, thus raising concerns about both food and water security. The pathway that water takes from rainfall to irrigation and water security. The pathway that water takes rainfall to the irrigation of fields (the water course) determines the quantity and quality of the available water. Working with various data sources (remote sensing, gauges, wells) allows us to model the water budget in the valley and explore the way in which recent droughts and increasing demand are impacting freshwater supplies.
Same as: GEOPHYS 70

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

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

EARTHSYS 106. World Food Economy. 4 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). Applications for enrollment are due by December 7, 2018. The application can be found here: https://economics.stanford.edu/academics/undergraduate-program/forms.
Same as: EARTHSYS 206, ECON 106, ECON 206, ESS 106, ESS 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.
Our 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.
Prerequisites: 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 (8th 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 111. 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.
Prerequisite: CME 100 or MA TH 51, or co-registration in either.
Same as: GEOPHYS 110

EARTHSYS 111. Biology and Global Change. 4 Units.
The biological causes and consequences of anthropogenic and natural changes in the atmosphere, oceans, and terrestrial and freshwater ecosystems. Topics: glacial cycles and marine circulation, greenhouse gases and climate change, tropical deforestation and species extinctions, and human population growth and resource use. Prerequisite: Biology or Human Biology core or BIO 81 or graduate standing.
Same as: BIO 117, ESS 111

EARTHSYS 112. Human Society and Environmental Change. 4 Units.
Interdisciplinary approaches to understanding human-environment interactions with a focus on economics, policy, culture, history, and the role of the state. Prerequisite: ECON 1.
Same as: 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/zr8ar28efmuo5wtl6qg2jbxle76r4u.
Same as: GEOPHYS 90

EARTHSYS 114. Environmental Change and Emerging Infectious Diseases. 4-5 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 to be addressed 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 Sossusvlei (Sand Sea) World Heritage 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 imperialism of the early 20th century? How was sovereignty and Native Hawaiian identity been shaped by these forces? How has tourism and the leisure industry affected the natural environment? This course uses archaeological methods, ethnohistorical sources, and historical analysis in an exploration of contemporary Hawaiian social economic and political life.
Same as: ANTHRO 118, 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 119B. Will Work for Food: Designing Your Pathway to Impact in the Food System. 1-2 Unit.
Offered exclusively for juniors and seniors, the goal of this course is to help you align your Stanford experience with potential pathways for creating impact in the food system after Stanford. This course builds on the "paced education" model that emerged from the d.school's landmark exploration of education at Stanford known as Stanford 2025. It is comprised of three phases of learning, which will unfold over six to nine months, at a pace that is determined by the amount of time you need to move from one phase to the next. In the first phase (119A and/or 119B), you will assess your knowledge, experience, abilities, interests, and development opportunities, and you will broadly explore a systemic problem of interest in the food system. In the second phase (119B), you will deepen your knowledge on a specific problem by creating a personal learning plan, a series of experiments to explore the ways in your knowledge, experience, abilities, interests, and development opportunities align with solving your problem of interest, and by developing a board of advisors to support you along the journey. In the third phase (119C), you will scope, in collaboration with a project partner, a project of real-world consequence. You must enroll in either 119A or 119B to enroll in 119C and the expectation is that you complete four units of work in total. This is a highly selective and hands-on course led by a teaching team with deep professional connections in the food system and who will act as your coaches, mentors, and connectors. Please visit http://feedcollaborative.org/classes/ to apply. Applications will be reviewed on a rolling basis. Select applicants will be interviewed. Decisions will be made one week prior to the start of the quarter.

EARTHSYS 119C. Will Work for Food: Designing Your Pathway to Impact in the Food System. 1-2 Unit.
Offered exclusively for juniors and seniors, the goal of this course is to help you align your Stanford experience with potential pathways for creating impact in the food system after Stanford. This course builds on the "paced education" model that emerged from the d.school's landmark exploration of education at Stanford known as Stanford 2025. It is comprised of three phases of learning, which will unfold over six to nine months, at a pace that is determined by the amount of time you need to move from one phase to the next. In the first phase (119A and/or 119B), you will assess your knowledge, experience, abilities, interests, and development opportunities, and you will broadly explore a systemic problem of interest in the food system. In the second phase (119B), you will deepen your knowledge on a specific problem by creating a personal learning plan, a series of experiments to explore the ways in your knowledge, experience, abilities, interests, and development opportunities align with solving your problem of interest, and by developing a board of advisors to support you along the journey. In the third phase (119C), you will scope, in collaboration with a project partner, a project of real-world consequence. You must enroll in either 119A or 119B to enroll in 119C and the expectation is that you complete four units of work in total. This is a highly selective and hands-on course led by a teaching team with deep professional connections in the food system and who will act as your coaches, mentors, and connectors. Please visit http://feedcollaborative.org/classes/ to apply. Applications will be reviewed on a rolling basis. Select applicants will be interviewed. Decisions will be made one week prior to the start of the quarter.

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. This course is designed to provide students with education about the history of the environmental justice movement, the future being envisioned, and the strategies that are needed to get to the vision. It will draw on lectures, readings, guest presentations, case studies, and the instructor's more than 15 years of experience with organizing and social justice campaigns. Students will learn about the principles guiding the environmental justice movement, the vision and framework of how we achieve a just transition to a regenerative economy, the process of organizing and campaign work to advance a community agenda, and skills in collecting, analyzing, and communicating information.
Same as: ASNAMST 123

EARTHSYS 124. 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 environments. The course discusses the impact of race, ethnicity, and culture on environmental and health outcomes and the role of social movements in bringing about social change. Students will work with partner organizations to problem-solve around issues of access and diversity. This course is open to students from all disciplines.
Same as: CSRE 125E, EARTHSYS 225, URBANST 125

EARTHSYS 126. Perspectives in International Development. 3 Units.
In this course, we explore the context in which development occurs 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 sustainable. This course will focus on understanding the potential for development to achieve equitable and just outcomes and 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 course examines the evolution of terrestrial ecosystems 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: GEOLSCI 128, GEOLSCI 228

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

EARTHSYS 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: ENVRSES 201

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 guest speakers 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 and contested legacy 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 meat. In this course, we will apply 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.

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 to develop proposals for sustainable urban development projects. Limited enrollment via application; see internationalurbanization.org for details. Prerequisites: consent of the instructor(s).
Same as: CEE 126, INTL POL 274, URBANST 145

EARTHSYS 139. Ecosystem Services: Frontiers in the Science of Valuing Nature. 3 Units.
This advanced course explores the science of valuing nature, beginning with its historical origins, and then its recent development in natural (especially ecological), economic, psychological, and other social sciences. We will use the ecosystem services framework (characterizing benefits from ecosystems to people) to define the state of knowledge, core methods of analysis, and research frontiers, such as at the interface with biodiversity, resilience, human health, and human development. Intended for diverse students, with a focus on research and real-world cases. To apply, please email the instructor (gdaily@stanford.edu) with a brief description of your background and research interests.
Same as: BIO 138, BIO 238

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

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

EARTHSYS 141. Remote Sensing of the Oceans. 3-4 Units.
How to observe and interpret physical and biological changes in the oceans using satellite technologies. Topics: principles of satellite remote sensing, classes of satellite remote sensors, converting radiometric data into biological and physical quantities, sensor calibration and validation, interpreting large-scale oceanographic features.
Same as: EARTHSYS 241, ESS 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: BIO 83 and CHEM 35 or permission of the instructor.
Same as: BIO 142, ESS 143, ESS 243
EARTHSYS 144. Fundamentals of Geographic Information Science (GIS). 3-4 Units.
Survey of geographic information including maps, satellite imagery, and census data, approaches to spatial data, and tools for integrating and examining spatially-explicit data. Emphasis is on fundamental concepts of geographic information science and associated technologies. Topics include geographic data structure, cartography, remotely sensed data, statistical analysis of geographic data, spatial analysis, map design, and geographic information system software. Computer lab assignments. All students are required to attend a weekly lab session.
Same as: ESS 164

EARTHSYS 146A. Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the atmospheric circulation. Topics include the global energy balance, the greenhouse effect, the vertical and meridional structure of the atmosphere, dry and moist convection, the equations of motion for the atmosphere and ocean, including the effects of rotation, and the poleward transport of heat by the large-scale atmospheric circulation and storm systems. Prerequisites: MATH 51 or CME100 and PHYSICS 41.
Same as: CEE 161I, CEE 261I, 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 CEE 162A or CEE 101B or a graduate class in fluid dynamics or consent of the instructor.
Same as: CEE 162I, CEE 262I, ESS 246B

EARTHSYS 148. Grow it, Cook it, Eat it. An Experiential Exploration of How and Why We Eat What We Eat. 3 Units.
This course provides an introductory exploration of the social, cultural, and economic forces that influence contemporary human diets. Through the combination of interrelated lectures by expert practitioners and hands-on experience planting, tending, harvesting, cooking, and eating food from Stanford’s dining hall gardens, students will learn to think critically about modern agricultural practices and the relationship between cuisine and human and ecological health outcomes. Students will also learn and apply basic practices of human-centered design to develop simple frameworks for understanding various eating behaviors in Stanford’s dining halls and to develop and test hypotheses for how R&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 wilderness and why does it matter? In this course we will interrogate answers to this question articulated by influential and diverse American environmental thinkers of the 19th, 20th, and 21st centuries, who through their writing transformed public perceptions of wilderness and inspired such actions as the founding of the National Park System, the passage of the Wilderness Act and the Clean Air and Water Acts, the establishment of the Environmental Protection Agency, and the birth of the environmental and climate justice movements. Students will also develop their own responses to the question of what is wilderness and why it matters through a series of writing exercises that integrate personal narrative, wilderness experience, and environmental scholarship, culminating in a ~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. If you are interested in signing up for the course, complete this pre-registration form https://stanforduniversity.qualtrics.com/jfe/form/SV_9xQ2eZe5o366Wvop.
Same as: EARTHYS 249

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/EARTHYS 152/252). Prerequisites: BIO 43 and ESS 8 or equivalent.
Same as: EARTHYS 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/EARTHYS 151/251).
Same as: EARTHYS 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. Intermediate Writing: Stanford Science Podcast. 4 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 91 JS

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.
Service-learning course that exposes students to sustainability concepts and urban planning as a tool for determining sustainable outcomes in the Bay Area. Focus will be on the relationship of land use and transportation planning to housing and employment patterns, mobility, public health, and social equity. Topics will include government initiatives to counteract urban sprawl and promote smart growth and livability, political realities of organizing and building coalitions around sustainability goals, and increasing opportunities for low-income and communities of color to achieve sustainability outcomes. Students will participate in team-based projects in collaboration with local community partners and take part in significant off-site fieldwork. Prerequisites: consent of the instructor. (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/9LSZFl7IpKHaMx5D3. A permission code will be given to admitted students to register for the class.
Same as: CS 325B, EARTHSYS 262

EARTHSYS 164. Introduction to Physical Oceanography. 4 Units.
Formerly CEE 164. The dynamic basis of oceanography. Topics: physical environment; conservation equations for salt, heat, and momentum; geostrophic flows; wind-driven flows; the Gulf Stream; equatorial dynamics and ENSO; thermohaline circulation of the deep oceans; and tides. Prerequisite: PHYSICS 41 (formerly 53).
Same as: CEE 1620, CEE 2620, ESS 148

EARTHSYS 165I. 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 165I

EARTHSYS 170. Environmental Geochemistry. 4 Units.
Solid, aqueous, and gaseous phases comprising the environment, their natural compositional variations, and chemical interactions. Contrast between natural sources of hazardous elements and compounds and types and sources of anthropogenic contaminants and pollutants. Chemical and physical processes of weathering and soil formation. Chemical factors that affect the stability of solids and aqueous species under earth surface conditions. The release, mobility, and fate of contaminants in natural waters and the roles that water and dissolved substances play in the physical behavior of rocks and soils. The impact of contaminants and design of remediation strategies. Case studies. Prerequisite: 90 or consent of instructor.
Same as: GEOLSCI 170, GEOLSCI 270

EARTHSYS 172. Australian Ecosystems: Human Dimensions and Environmental Dynamics. 3 Units.
This cross-disciplinary course surveys the history and prehistory of human ecological dynamics in Australia, drawing on geology, climatology, archaeology, geography, ecology and anthropology to understand the mutual dynamic relationships between the continent and its inhabitants. Topics include anthropogenic fire and fire ecology, animal extinctions, aridity and climate variability, colonization and spread of Homo sapiens, invasive species interactions, changes in human subsistence and mobility throughout the Pliocene and Holocene as read through the archaeological record, the totemic geography and social organization of Aboriginal people at the time of European contact, the ecological and geographical aspects of the "Dreamtime", and contemporary issues of policy relative to Aboriginal land tenure and management.
Same as: ANTHRO 170, ANTHRO 270
EARTHSYS 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. All students must complete the course application and turn it into Rachel Engstrand (rco212@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 seema@yasminacademy.com. (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 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 12 for Autumn and March 10 for Spring. nnApplication: https://stanforduniversity.qualtrics.com/jfe/form/SV_6MDj7ndB1Ch93bT.
Same as: ESS 280

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

EARTHSYS 182A. Ecological Farm Systems. 1-2 Unit.
A project-based course emphasizing 'ways of doing' in sustainable agricultural systems based at the Stanford Educational Farm. Students will work individually and in small groups on projects at the Stanford Educational Farm. This winter the course will include orchard establishment and educational garden design in addition to other topics.

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_9SPufdULCh93bT.
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 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 those metrics be weighed against each other? What 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 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. nUsing 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? nHow 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/rDQq6B.

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 (EARTH SYS 111 and EarthSys 112) or equivalent. (Meets Earth Systems WIM requirement.).
Same as: EARTH SYS 291

EARTHSYS 194. Topics in Writing & Rhetoric: Introduction to Environmental Justice: Race, Class, Gender and Place. 4 Units.
Environmental justice means ensuring equal access to environmental benefits and preventing the disproportionate impacts of environmental harms for all communities regardless of gender, class, race, ethnicity or other social positions. This introductory 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 from Standing Rock to Flint, Michigan. 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.
Same as: CSRE 132E, PWR 194EP, URBANST 155EP

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 Emissions Reductions (IPER) by 2050 for a country, state, province, sector, or industry. 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 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: EARTH SYS 298

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

ASB Course. The course on nutrition, health and food insecurity is split into four projects: 1) Workshop a Story, in which students craft a personal narrative with input from the class, 2) Pose a Question, in which students in pairs attempt to educate the class on many sides of the same issue, 3) Create a Dish, in which students develop original dishes in support of local organizations, and 4) Teach a Class, in which students, in teams, develop a curriculum to be implemented in over the spring break trip. Furthermore, each section will expand the scope of the issue from the individual to the community and all the way up to national policies. The course will be a mix of some of the best lecturers and professors that we have 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, testing 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 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 resiliency and equity. Cardinal Course (certified by Haas Center). Limited enrollment. May be repeated for credit.

Same as: EARTHSYS 105

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.

Same as: SOC 105VP SOC 205VP

EARTHSYS 206. World Food Economy. 4 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). Applications for enrollment are due by December 7, 2018. The application can be found here: https://economics.stanford.edu/academics/undergraduate-program/forms.

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

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

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

Same as: BIO 208, LATINAM 207

EARTHSYS 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, HUMBIO 182

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

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

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

The Earth Systems Senior Capstone and Reflection, required of all seniors, provides students with opportunities to synthesize and reflect on their learning in the major. Students participate in guided career development and planning activities and initiate work on an independent or group capstone project related to an Earth Systems problem or question of interest. In addition, students learn and apply principles of effective oral communication through developing and giving a formal presentation on their internship. Students must also take EARTHSYS 210P Earth Systems Capstone Project, in the quarter following the Senior Capstone and Reflection Course. Prerequisite: Completion of an approved Earth Systems internship (EARTHSYS 260).
EARTHSYS 210P. Earth Systems Capstone Project. 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. Environmental Change and Emerging Infectious Diseases. 4-5 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 219. Will Work for Food. 1 Unit.
This is a speaker series class featuring highly successful innovators in the food system. Featured speakers will talk in an intimate, conversational manner about their current work, as well as about their successes, failures, and learnings along the way. Additional information can be found here: http://feedcollaborative.org/speaker-series/.
Same as: EARTHSYS 119

EARTHSYS 225. Shades of Green: Redesigning and Rethinking the Environmental Justice Movements. 3-5 Units.
Historically, discussions of race, ethnicity, culture, and equity in the environment have been relegated to the environmental justice movement, which often focuses on urban environmental degradation and remains separated from other environmental movements. This course will seek to break out of this limiting discussion. We will explore access to outdoor spaces, definitions of wilderness, who is and isn’t included in environmental organizations, gender and the outdoors, how colonialism has influenced ways of knowing, and the future of climate change. The course will also have a design thinking community partnership project. Students will work with partner organizations to problem-solve around issues of access and diversity. We value a diversity of experiences and epistemological beliefs, and therefore undergraduates and graduate students from all disciplines are welcome.
Same as: CSRE 125E, EARTHSYS 125, URBANST 125

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

EARTHSYS 235. Podcasting the Anthropocene. 3 Units.
The Anthropocene refers to the proposed geologic age defined by the global footprint of humankind. It’s an acknowledgement of the tremendous influence people and societies exert on Earth systems. 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 245. Quick Capture and Questions: Practicing Natural History Through Watercolor. 1 Unit.
This course makes space to use art as an entry point for closer observation, deeper curiosity, and better understanding of natural systems. With a series of guest experts in art, science, and the practice of natural history, we will investigate the Jasper Ridge Biological Preserve through a number of lenses, microscopic to macroscopic. In each session, we will venture into the preserve to explore how field journaling, quick capture watercolor, and expressive language can mediate insight and sense of connection. Come build a community of practice with us! Apply at https://tinyurl.com/earthsys24 and direct further questions to Freya Chay (frejac@stanford.edu) and Hannah Black (hmcblack@stanford.edu).

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.

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

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 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 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. For course requirements, please visit: https://pangea.stanford.edu/esys/earth-systems-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/9LSZf7IPkHAdix503. 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 coterm 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. All 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 the 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 seema@yasminacademy.com . (Meets Earth Systems WIM requirement.)
Same as: COMM 177C, COMM 277C, EARTHSYS 177C

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

EARTHSYS 286. Farm and Garden Environmental Education Practicum. 2 Units.
Farms and gardens provide excellent settings for place-based environmental education that emphasize human ecological relationships and experiential learning. The O’Onohue Family Stanford Educational Farm is the setting to explore the principles and practices of farm and garden-based education in conjunction with the farm’s new field trip program for local youth. The course includes readings and reflections on environmental education and emphasis on learning by doing, engaging students in the practice of team teaching. Application required. Deadline: March 14.nnnApplication: https://stanforduniversity.qualtrics.com/jfe/form/SV_9SPufdULCCh93BT.
Same as: EARTHSYS 186

How can we ensure that measures taken to mitigate global climate change don’t create larger social and environmental problems? What metrics should be used to compare potential climate solutions beyond cost and technical feasibility, and how should these metrics be weighed against each other? How can modeling efforts and stakeholder engagement be best integrated into climate decision making? What information are we still missing to make fully informed decisions between technologies and policies? Exploration of these questions, alongside other issues related to potential negative externalities of emerging climate solutions. Evaluation of energy, land use, and geoengineering approaches in an integrated context, culminating in a climate stabilization group project.
Same as: EARTHSYS 188
EARTHSYS 289. 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 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 master’s students. Reflection on the Earth Systems core curriculum and development of skills to clearly articulate interdisciplinary expertise to potential employers, graduate or professional schools, colleagues, business partners, etc. Hands-on projects to take students through a series of guided reflection activities. Individual and small group exercises. Required, self-chosen final project encapsulates each student’s MS expertise in a form relevant to his or her future goals (i.e. a personal statement, research poster, portfolio, etc.).

EARTHSYS 291. Concepts in Environmental Communication. 3 Units.
Introduction to the history, development, and current state of communication of environmental science and policy to non-specialist audiences. Includes fundamental principles, core competencies, and major challenges of effective environmental communication in the public and policy realms and an overview of the current scope of research and practice in environmental communication. Intended for graduate students and advanced undergraduates, with a background in 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. 1-5 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.

EARTHSYS 323. Stanford at Sea. 16 Units.

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

Same as: BIOHOPK 182H, BIOHOPK 323H, ESS 323

EARTHSYS 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 37N. Climate Change: Science & Society. 3 Units.

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

EARTHSYS 39N. The Carbon Cycle: Reducing Your Impact. 3 Units.

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

EARTHSYS 41N. The Global Warming Paradox. 3 Units.

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

EARTHSYS 42. The Global Warming Paradox II. 1 Unit.

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

Same as: ESS 42

EARTHSYS 44N. The Invisible Majority: The Microbial World That Sustains Our Planet. 3 Units.

Microbes are often viewed through the lens of infectious disease yet they play a much broader and undervalued 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
Earth Systems (EARTHSYS)

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

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

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

EARTHSYS 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 field trips to marine research centers in Bodega, Santa Cruz, Moss Landing, and Monterey. 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.

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: ARTSINST 40, EDUC 9, HUMBIO 9, PUBLPOL 74, URBANST 101

EARTHSYS 90. Introduction to Geochemistry. 3-4 Units.
The chemistry of the solid earth and its atmosphere and oceans, emphasizing the processes that control the distribution of the elements in the earth over geological time and at present, and on the conceptual and analytical tools needed to explore these questions. The basics of geochemical thermodynamics and isotope geochemistry. The formation of the elements, crust, atmosphere and oceans, global geochemical cycles, and the interaction of geochemistry, biological evolution, and climate. Recommended: introductory chemistry.
Same as: GEOLSCI 90

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/cbYX3gSGdHgHBjH3; 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