EARTHSYS (EARTHSYS)

Courses

EARTHSYS 4. How to Build and Maintain a Habitable Planet: An Introduction to Earth System History. 4 Units.
Introduction to the history of the Earth, with a focus on processes that maintain or threaten habitability. Principles of stratigraphy, correlation, the geological timescale, the history of biodiversity, and the interpretation of fossils. The use of data from sedimentary geology, geochemistry, and paleontology to test theories for critical events in Earth history such as mass extinctions. One half-day field trip.
Same as: GS 4

EARTHSYS 9. Community-Based Internship Preparation Seminar. 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 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 all assignments for 1 unit of credit. Students planning to take a community-based internship in future years are welcome to enroll.
Same as: URBANST 101

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 12SC. Environmental and Geological Field Studies in the Rocky Mountains. 2 Units.
The Rocky Mountain area, ecologically and geologically diverse, is being strongly impacted by changing land-use patterns, global and regional environmental change, and societal demands for energy and natural resources. This three-week field program emphasizes coupled environmental and geological problems in the Rocky Mountains and will cover a broad range of topics including the geologic origin of the American West from three billion years ago to the recent; paleoclimatology and the glacial history of this mountainous region; the long- and short-term carbon cycle and global climate change; and environmental issues in the American West that are related to changing land-use patterns and increased demand for its abundant natural resources. These broad topics are integrated into a coherent field study by examining earth/environmental science-related questions in three different settings: 1) the three-billion-year-old rocks and the modern glaciers of the Wind River Mountains of Wyoming; 2) the sediments in the adjacent Wind River basin that host abundant gas and oil reserves and also contain the long-term climate history of this region; and 3) the volcanic center of Yellowstone National Park and mountainous region of Teton National Park, and the economic and environmental problems associated with gold mining and extraction of oil and gas in areas adjoining these national parks. Students will complete six assignments based upon field exercises, working in small groups to analyze data and prepare reports and maps. Lectures will be held in the field prior to and after fieldwork.
Note: This course involves one week of backpacking in the Wind Rivers and hiking while staying in cabins near Jackson Hole, Wyoming, and horseback riding in the Dubois area of Wyoming. Students must arrive in Salt Lake City on Monday, Sept. 1. (Hotel lodging will be provided for the night of Sept. 1, and thereafter students will travel as a Sophomore College group.) We will return to campus on Sunday, Sept. 21. Sophomore College Course: Application required, due noon, April 7, 2015. Apply at http://soco.stanford.edu.
Same as: ESS 12SC, GS 12SC

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 18. Promoting Sustainability Behavior Change at Stanford. 2 Units.
Stanford Green Living Council training course. Strategies for designing and implementing effective behavior change programs for environmental sustainability on campus. Includes methods from community-based social marketing, psychology, behavioral economics, education, public health, social movements, and design. Students design a behavior change intervention project targeting a specific environmental sustainability-related behavior. Lectures online and weekly sections/workshops.
EARTHSYS 30. Ecology for Everyone. 4 Units.
Everything is connected, but how? Ecology is the science of interactions and the changes they generate. This project-based course links individual behavior, population growth, species interactions, and ecosystem function. Introduction to measurement, observation, experimental design and hypothesis testing in field projects, mostly done in groups. The goal is to learn to think analytically about everyday ecological processes involving bacteria, fungi, plants, animals and humans. The course uses basic statistics to analyze data; there are no math prerequisites except arithmetic. Open to everyone, including those who may be headed for more advanced courses in ecology and environmental science.
Same as: ESS 42

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

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

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

EARTHSYS 41N. The Global Warming Paradox. 3 Units.
Preference to freshman. Focus is on the complex climate challenges posed by the substantial benefits of energy consumption, including the critical tension between the enormous global demand for increased human well-being and the negative climate consequences of large-scale emissions of carbon dioxide. 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.

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

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

EARTHSYS 46N. Exploring the Critical Interface between the Land and Monterey Bay: Elkhorn Slough. 3 Units.
Preference to freshmen. Field trips to sites in the Elkhorn Slough, a small agriculturally impacted estuary that opens into Monterey Bay, a model ecosystem for understanding the complexity of estuaries, and one of California's last remaining coastal wetlands. Readings include Jane Caffrey's Changes in a California Estuary: A Profile of Elkhorn Slough. Basics of biogeochemistry, microbiology, oceanography, ecology, pollution, and environmental management.
Same as: ESS 46N

EARTHSYS 46Q. Environmental Impact of Energy Systems: What are the Risks?. 3 Units.
In order to reduce CO2 emissions and meet growing energy demands during the 21st Century, the world can expect to experience major shifts in the types and proportions of energy-producing systems. These decisions will depend on considerations of cost per energy unit, resource availability, and unique national policy needs. Less often considered is the environmental impact of the different energy producing systems: fossil fuels, nuclear, wind, solar, and other alternatives. One of the challenges has been not only to evaluate the environmental impact but also to develop a systematic basis for comparison of environmental impact among the energy sources. The course will consider fossil fuels (natural gas, petroleum and coal), nuclear power, wind and solar and consider the impact of resource extraction, refining and production, transmission and utilization for each energy source.
Same as: GS 46Q

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

EARTHSYS 56Q. Changes in the Coastal Ocean: The View From Monterey and San Francisco Bays. 3 Units.
Preference to sophomores. Recent changes in the California current, using Monterey Bay as an example. Current literature introduces principles of oceanography. Visits from researchers from MBARI, Hopkins, and UCSC. Optional field trip to MBARI and Monterey Bay.
Same as: ESS 56Q
EARTHSYS 57Q. Climate Change from the Past to the Future. 3 Units. Preference to sophomores. Numeric models to predict how climate responds to increase of greenhouse gases. Paleoclimate during times in Earth's history when greenhouse gas concentrations were elevated with respect to current concentrations. Predicted scenarios of climate models and how these models compare to known hyperthermal events in Earth history. Interactions and feedbacks among biosphere, hydrosphere, atmosphere, and lithosphere. Topics include long- and short-term carbon cycle, coupled biogeochemical cycles affected by and controlling climate change, and how the biosphere responds to climate change. Possible remediation strategies. Same as: ESS 57Q

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

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

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

EARTHSYS 102. Renewable Energy Sources and Greener Energy Processes. 3 Units. The energy sources that power society are rooted in fossil energy although energy from the core of the Earth and the sun is almost inexhaustible; but the rate at which energy can be drawn from them with today's technology is limited. The renewable energy resource base, its conversion to useful forms, and practical methods of energy storage. Geothermal, wind, solar, biomass, and tidal energies; resource extraction and its consequences. Recommended: MATH 21 or 42. Same as: ENERGY 102

EARTHSYS 103. Understanding Energy. 3 Units. Energy is one of the world's main drivers of opportunity and development for human beings. At the same time, our energy system has significant consequences for our society, political system, economy, and environment. For example, energy production and use is the #1 source of greenhouse gas emissions. This course surveys key aspects of each energy resource, including significance and potential conversion processes and technologies, drivers and barriers, policy and regulatory environment, and social, economic, and environmental impacts. Both depletable and renewable energy resources are covered, including oil, natural gas, coal, nuclear, biomass, hydroelectric, wind, solar, photovoltaics, geothermal, and ocean energy, with cross-cutting topics including electricity, storage, climate change, sustainability, green buildings, energy efficiency, transportation, and the developing world. Understanding Energy is part of a trio of interrelated courses aimed at gaining an in-depth understanding of each energy resource - from fossil fuels to renewable energy. The other two classes are CEE107W/207W Understanding Energy - Workshop, and CEE 107F/207F Understanding Energy -- Field Trips. Note that this course was formerly called Energy Resources (CEE 173A/207A & Eartsys 103). Prerequisites: Algebra. May not be taken for credit by students who have completed CEE 107S. Same as: CEE 107A, CEE 207A

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

EARTHSYS 105. Food and Community: New Visions for a Sustainable Future. 3 Units. Through this course students will learn about the community and outreach component of the urban gardening movement. Over the quarter students will learn about urban farming, about projects that work to increase access of the most underserved to fresh and local food, and about the challenges surrounding these efforts. The theme of the course will be stories - stories of food and community, of innovation, and of service. Students will learn through engaging in conversation with different leaders in the local food movement. Additionally, through hands-on learning and participation, students will become familiar with different types of community food projects in the Bay Area, including urban farms, free food giveaways, food banks, and gleaning projects. Service Learning Course (certified by Haas Center). Limited enrollment. May be repeated for credit. Same as: ESS 105

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

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

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

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

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

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

EARTHSYS 113. Earthquakes and Volcanoes. 3 Units.
Is the “Big One” overdue in California? What kind of damage would that cause? What can we do to reduce the impact of such hazards in urban environments? Does “fracking” cause earthquakes and are we at risk? Is the United States vulnerable to a giant tsunami? The geologic record contains evidence of volcanic super eruptions throughout Earth's history. What causes these gigantic explosive eruptions, and can they be predicted in the future? This course will address these and related issues. For non-majors and potential Earth scientists. No prerequisites. More information at https://pangea.stanford.edu/research/CDFM/CourseDescriptions/ GP_113_announcement.pdf.
Same as: GEOPHYS 90

EARTHSYS 115. Wetlands Ecology of the Pantanal Prefield Seminar. 2-3 Units.
This seminar will prepare students for their overseas field experience in the Pantanal, Brazil, the largest wetland in the world, studying wetlands ecology and conservation in situ. Students will give presentations on specific aspects of the Pantanal and lay the groundwork for the presentations they will be giving during the field seminar where access to the internet and to other scholarly resources will be quite limited. Additional topics include: logistics, health and safety, cultural sensitivity, geography and politics, and basic language skills; also, post-field issues such as reverse culture shock, and ways in which participants can consolidate and build up their abroad experiences after they return to campus. Students will have the opportunity to participate in a pilot study aimed at developing a series of innovative online curriculum based upon their field experience.

EARTHSYS 115T. Island Biogeography of Tasmania Prefield Seminar. 3 Units.
Islands are natural laboratories for studying a wide variety of subjects including biological diversity, cultural diversity, epidemiology, geology, climate change, conservation, and evolution. This field seminar focuses on Island Biogeography in one of the most extraordinary and well-preserved ecosystems in the world: Tasmania. Tasmanian devils, wombats, and wallabies; the names conjure up images of an exotic faraway place, a place to appreciate the incredibly diversity of life and how such striking forms of life came to be. This course will prepare students for their overseas field experience 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 volcanoc activity, and hillslope stability conclude the course. Methods for monitoring and predicting eruptions, defining spatial changes in landform, landform stability, soil production rates, and measuring biogeochemical processes are covered throughout the course. This course is restricted to students accepted into the Earth Systems of Hawaii Program. Same as: EARTH 117, ESS 117

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

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

EARTHSYS 121. Building a Sustainable Society: New Approaches for Integrating Human and Environmental Priorities. 3 Units. "Building a Sustainable Society: New approaches to 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 the main drivers, core features and challenges of 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 measures, and 21st century leadership. Critical perspectives, lectures and student-led discussions guide analysis of innovations within public, private and civic sectors globally, with emphasis on Latin America.

EARTHSYS 122. Paleobiology. 4 Units. Introduction to the fossil record with emphasis on marine invertebrates. Major debates in paleontological research. The history of animal life in the oceans. Topics include the nature of the fossil record, evolutionary radiations, mass extinctions, and the relationship between biological evolution and environmental change. Fossil taxa through time. Exercises in phylogenetics, paleoecology, biostratigraphy, and statistical methods. Same as: GS 123, GS 223B

EARTHSYS 127. GIS for good: Applications of GIS for International Development and Humanitarian Assistance. 3-4 Units. This service-learning course exposes students to geographic information systems (GIS) as a tool for exploring alternative solutions to complex environmental and humanitarian issues in the international arena. The project-based, interdisciplinary structure of this class gives primary emphasis to the use of GIS for field data collection, mapping, analysis and visualization that allows for multi-criteria assessment of community development. Those with no prior GIS experience will be required to take an introductory GIS workshop hosted by the Geospatial Center in Branner Library during the first two weeks of class. Same as: ESS 122, ESS 222

EARTHSYS 128. Evolutionary History of Terrestrial Ecosystems. 4 Units. The what, when, and how do we know it regarding life on land including plants, fungi, invertebrates, and vertebrates (yes, dinosaurs); and 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. Same as: GS 128, GS 228

EARTHSYS 129. Geographic Impacts of Global Change: Mapping the Stories. 4 Units. Forces of global change (eg., climate disruption, biodiversity loss, disease) impact wide-ranging political, socioeconomic, and ecological impacts, creating an urgent need for science communication. Students will collect data for a region of the US using sources ranging from academic journals to popular media and create an interactive Story Map (http://stanford.maps.arcgis.com/apps/StorytellingText/index.html?appid=dace2393ad92e4aacc8b0a4e671d0b6d5) 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. Same as: BIO 128

EARTHSYS 135. Podcasting the Anthropocene. 3 Units. Identification and interview of Stanford researchers to be featured in an audio podcast. Exploration of interviewing techniques, audio storytelling, audio editing, and podcasting as a newly emerging media platform. Individual and group projects. Group workshops focused on preparation, review, and critiques of podcasts. Same as: EARTHSYS 235

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

EARTHSYS 140. The Energy-Water Nexus. 3 Units. Energy, water, and food are our most vital resources constituting a tightly intertwined network: energy production requires water, transporting and treating water needs energy, producing food requires both energy and water. The course is an introduction to learn specifically about the links between energy and water. Students will look first at the use of water for energy production, then at the role of energy in water projects, and finally at the challenge in figuring out how to keep this relationship as sustainable as possible. Students will explore case examples and are encouraged to contribute examples of concerns for discussion as well as suggest a portfolio of sustainable energy options. Same as: GEOPHYS 80
EARTHSYS 141. Remote Sensing of the Oceans. 3-4 Units. 
How to observe and interpret physical and biological changes in the 
oceans using satellite technologies. Topics: principles of satellite remote 
sensing, classes of satellite remote sensors, converting radiometric data 
into biological and physical quantities, sensor calibration and validation, 
interpreting large-scale oceanographic features.
Same as: EARTHSYS 241, ESS 141, ESS 241, GEOPHYS 141

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

EARTHSYS 144. Fundamentals of Geographic Information Science (GIS). 3-4 Units. 
Survey of geographic information including maps, satellite imagery, 
and census data, approaches to spatial data, and tools for integrating and 
examining spatially-explicit data. Emphasis is on fundamental concepts of 
geographic information science and associated technologies. Topics include 
geographic data structure, cartography, remotely sensed data, statistical 
analysis of geographic data, spatial analysis, map design, and geographic 
information system software. Computer lab assignments. All students are 
required to attend a weekly lab on Tuesdays or Thursdays from 6 pm to 9 

pm.
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 
mist 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: EARTHSYS 246A, ESS 146A, ESS 246A, GEOPHYS 146A, GEOPHYS 246A

EARTHSYS 146B. Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation. 3 Units. 
Introduction to the physics governing the circulation of the atmosphere 
and ocean and their control on climate with emphasis on the large-scale 
ocncean circulation. This course will give an overview of the structure 
and dynamics of the major ocean current systems that contribute to 
the meridional overturning circulation, the transport of heat, salt, and 
biogeochemical tracers, and the regulation of climate. Topics include the 
tropical ocean circulation, the wind-driven gyres and western boundary 
currents, the thermohaline circulation, the Antarctic Circumpolar Current, 
water mass formation, atmosphere-ocean coupling, and climate variability. 
Prerequisites: EESS 146A or EESS 246A, or CEE 164 or CEE 262D, or 
consent of instructor.
Same as: EARTHSYS 246B, ESS 146B, ESS 246B, GEOPHYS 146B, GEOPHYS 246B

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

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

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

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

EARTHSYS 156M. Marine Resource Economics and Conservation. 5 Units. 
Economic and ecological frameworks to understand the causes of and 
potential solutions to marine resource degradation. Focus on conservation 
of marine biodiversity and ecosystem-based management. Applications 
include: commercial and recreational fisheries, marine reserves, and 
ofshore energy production.
Same as: ECON 156, HUMBio 111M

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

EARTHSYS 160. Sustainable Cities. 4-5 Units. 
Service-learning course that exposes students to sustainability concepts 
and urban planning as a tool for determining sustainable outcomes in the 
Bay Area. Focus will be on the relationship of land use and transportation 
planning to housing and employment patterns, mobility, public health, 
and social equity. Topics will include government initiatives to counteract 
urban sprawl and promote smart growth and livability, political realities 
of organizing and building coalitions around sustainability goals, and 
increasing opportunities for low-income and communities of color to 
achieve sustainability outcomes. Students will participate in team-based 
projects in collaboration with local community partners and take part in 
significant off-site fieldwork. Prerequisites: consent of the instructor.
Same as: URBANST 164
EARTHSYS 163E. International Climate Negotiations: Unpacking the Road to Paris. 3 Units.
Interested in what's going on with international climate negotiations, why it has proven so difficult to reach a meaningful agreement? Wondering whether or not another UN agreement is even a meaningful part of climate policy in 2015? This course traces the history of climate negotiations from the very first awareness of the problem of climate change, through the Kyoto Protocol and Copenhagen Accord, to the current state of international negotiations in the lead-up to the 21st Conference of the Parties meeting in Paris in December 2015. The course covers fundamental concepts in climate change science and policy, international law and multilateral environmental agreements, as well as key issues of climate finance, climate justice, equity, adaptation, communication, and social movements that together comprise the subjects of debate in the negotiations. We will discuss all the key facets of what is being negotiated in Paris and prepare students to follow the outcome of the negotiation in detail. Students also participate in a three-day mock conference of the parties. By application only.
Same as: CEE 163E, ECE 263E, EARTHSYS 263E

EARTHSYS 163F. Groundwork for COP21. 1 Unit.
This course will prepare undergraduate and coterm students to participate in 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 graduate student mentors. Please note: Along with EARTHSYS/CEE 163E, this course is part of the required two-course-set in which undergraduate and co-terminal masters degree students must enroll to receive accreditation to the climate negotiations.
Same as: EARTHSYS 163F, CEE 263F, EARTHSYS 263F

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

EARTHSYS 168. The Evolving Sphere of Food Security. 2 Units.
This seminar develops into a comprehensive new volume on food security written by an all-Stanford team of nineteen faculty and researchers. It explores the interconnections of food security with energy, water, climate, health, and national security, and examines the role of food and agricultural policies and their consequences in countries at different stages of development. Led by the editor of the book, with participation of several of the authors from across many disciplines. Prerequisite: ECON 106. Admission is by application.
Same as: EARTHSYS 268

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

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

Can aquaculture feed billions of people without degrading aquatic ecosystems or adversely impacting local communities? Interdisciplinary focus on aquaculture science and management, international seafood markets, historical case studies (salmon farming in Chile, tuna ranching in the Mediterranean, shrimp farming in Vietnam), current federal/state legislation. Field trip to aquaculture farm and guest lectures. By application only - instructor consent required. Contact gerhart@stanford.edu or dikhlinger@stanford.edu prior to first day of class.
Same as: EARTHSYS 273, ESS 173, ESS 273

EARTHSYS 175. California Coast: Science, Policy, and Law. 3-4 Units.
Same as LAW 514. Interdisciplinary. The legal, science, and policy dimensions of managing California's coastal resources. Coastal land use and marine resource decision making. The physics, chemistry, and biology of the coastal zone, tools for exploring data from the coastal ocean, and the institutional framework that shapes public and private decision making. Primarily for graduate students; upper-level undergraduates may enroll with permission of instructor. Students will be expected to participate in field trips.
Same as: CEE 175A, CEE 275A, EARTHSYS 275

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

EARTHSYS 176A. Open Space Practicum Independent Study. 1-2 Unit.
Additional practicum units for students intent on continuing their projects from EARTHSYS 176. Students who enroll in 176A must have completed EARTHSYS 176: The Peninsula Open Space Practicum: Community-Based Environmental Research for Open Space Management, or have consent of the instructors.
EARTHSYS 177. Interdisciplinary Research Survival Skills. 2 Units.
Learning in interdisciplinary situations. Framing research questions. Developing research methods that benefit from interdisciplinary understanding. Writing for multiple audiences and effectively making interdisciplinary presentations. Discussions with interdisciplinary experts from across campus regarding interdisciplinary research projects.
Same as: EARTHSYS 277, ENVRINST 177, ENVRINST 277

EARTHSYS 177C. Specialized Writing and Reporting: Environmental Journalism. 4-5 Units.
(Graduate students register for COMM / ENVRES 277C.) Practical, collaborative, writing-intensive course in science-based environmental journalism. Science and journalism students learn how to identify and write engaging stories about environmental issues and science, how to assess the quality and relevance of environmental news, how to cover the environment and science beats effectively, and how to build bridges between the worlds of journalism and science. Limited enrollment: preference to journalism students and students in the natural and environmental sciences. Prerequisite: COMM 104, ENVRES 200 or consent of instructor. Admissions by application only, available from thayden@stanford.edu.
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 180B. Principles and Practices of Sustainable Agriculture. 3-4 Units.
Field-based training in ecologically sound agricultural practices at the Stanford Community Farm. Weekly lessons, field work, and group projects. Field trips to educational farms in the area. Topics include: soils, composting, irrigation techniques, IPM, basic plant anatomy and physiology, weeds, greenhouse management, and marketing.
Same as: ESS 280B

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 182. Ecological Farm Management. 1 Unit.
A project-based course emphasizing 'ways of doing' on-farm; in sustainable agricultural systems based at the new Stanford Educational Farm. Students will work individually and in small groups on farm projects of their choice facilitated and guided by the Educational Farm Director. Potential projects include: orchards, compost systems, pastured poultry, beekeeping, medicinal herbs, mushroom cultivation, native plants, etc.
Same as: ESS 282

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

EARTHSYS 184. Climate and Agriculture. 3-4 Units.
The effects of climate change on global agriculture and food security, and the effects of agriculture on climate change. An overview of different lines of evidence used to measure impacts and adaptations, and to quantify future impacts, risks, and adaptation needs for agro-ecosystems and society. Enrollment limited to 25; priority to juniors, seniors, and graduate students. Prerequisites: ECON 106/206 or permission of instructor.
Same as: EARTHSYS 284, ESS 184, ESS 284

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 187. FEED the Change: Redesigning Food Systems. 2-3 Units.
Introductory course in design thinking and food system analysis offered through the FEED Collaborative. Targeted at upper-class undergraduates, this course provides a series of diverse, primarily hands-on experiences (design projects, field work, and storytelling) in which students both learn and apply the process of human-centered design to projects of real consequence in the food system. Students will also develop knowledge and basic tools for working effectively in teams and for analyzing complex systems. The goal of this course is to develop the creative confidence of students and, in turn, to work collaboratively with thought leaders in the local food system to design innovative solutions to the challenges they face. Admission is by application: http://feedcollaborative.org/classes/.

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

EARTHSYS 191. Introduction to 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 range and scope of research and practice in environmental communication. Intended for senior undergraduates and above with a background in environmental science and policy. Prerequisite: Earth Systems core (EarthSys 111 and EarthSys 112) or equivalent.
Same as: EARTHSYS 291
EARTHSYS 195. Natural Hazards and Risk Communication. 3 Units. 
Introduction to the science behind natural hazards, the risks associated with 
these hazards, and effective methods of communicating them to a variety 
of audiences. Examination of methods of translation and communication. 
Investigation of the relative effectiveness of these methods for increasing 
preadparedness and resiliency to natural hazards. Satisfies the Earth Systems 
WM requirement.

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 199. Honors Program in Earth Systems. 1-9 Unit.

EARTHSYS 200. Sustaining Action: Research, Analysis and Writing 
for the Public. 3 Units.
Preference to graduate students and senior undergraduates in environmental, 
natural and social sciences, engineering, journalism. Students help produce 
and publish SAGE, an eco advice column, by choosing, researching, and 
answering questions about sustainable living submitted by Stanford alumni 
and the general public. Prerequisite: admission by application, available 
from instructor, thayden@stanford.edu. (Meets Earth Systems WM 
requirement).

EARTHSYS 205. Navigating Wicked Marine Problems. 3 Units. 
Commercial shipping is essential to international trade, consumer goods 
and the global economy, but can impact the marine environment. Vessel 
traffic schemes often overlap with important marine areas, creating 
unintended pressures and impacts to marine ecosystems, including whales. 
Ship strikes are a threat to endangered whales, and ship noise can affect 
important mating and feeding behavior. In this course, the issue of whale 
and vessel interactions will be used as a case study to help students identify 
threats, pressures, and policy responses of a complex, or “wicked,” ocean-
based problem. In project teams, students will complete a Pressure State 
Response analysis of the problem, with the goal of developing practical 
and professional skills necessary to participate in complex marine planning 
and decision-making in their post-graduate careers. Students will gain 
an opportunity to network with experts, scientists and professionals who 
have experience on the primary themes of the course. The deadline for 
enrollment for this course is Feb. 23. Contact lhgod@stanford.edu with 
interest.

EARTHSYS 206. World Food Economy. 5 Units.
The economics of food production, consumption, and trade. The micro-
and macro- determinants of food supply and demand, including the 
terrelationship among food, income, population, and public-sector 
decision making. Emphasis on the role of agriculture in poverty alleviation, 
economic development, and environmental outcomes. (graduate students 
enroll in 206).
Same as: EARTHSYS 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 207A. 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 207B. 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 207C. 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 207P. Earth Systems Capstone Project. 1 Unit. 
Students work independently or in groups to complete their Senior 
Capstone Projects. They will participate in regular advising meetings with 
the instructor(s), and will give a final presentation on their projects at the 
end of the quarter in a special Earth Systems symposium. Prerequisite: 
EARTHSYS 210A, B, or C.

EARTHSYS 211. Fundamentals of Modeling. 3-5 Units. 
Simulation models are a powerful tool for environmental research, if used 
properly. The major concepts and techniques for building and evaluating 
models. Topics include model calibration, model selection, uncertainty and 
sensitivity analysis, and Monte Carlo and bootstrap methods. Emphasis 
is on gaining hands-on experience using the R programming language. 
Prerequisite: Basic knowledge of statistics. 
Same as: ESS 211

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

EARTHSYS 235. Podcasting the Anthropocene. 3 Units. 
Identification and interview of Stanford researchers to be featured in an 
audio podcast. Exploration of interviewing techniques, audio storytelling, 
audio editing, and podcasting as a newly emerging media platform. 
Individual and group projects. Group workshops focused on preparation, 
review, and critiques of podcasts. 
Same as: EARTHSYS 135
EARTHSYS 238. Land Use. 3 Units.
(Same as LAW 338.) This course focuses on the pragmatic (rather than theoretical) aspects of contemporary land use law and policy, including: nuisance as a land use tool and foundation for modern land use law; use and abuse of the "police power" (the legal basis for land use control); zoning flexibility; vested property rights, development agreements, and takings; redevelopment; growth control; and direct democracy. 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.

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 246A. Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the 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: EARTHSYS 146A, ESS 146A, ESS 246A, GEOPHYS 146A, GEOPHYS 246A

EARTHSYS 246B. Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation. 3 Units.
Introduction to the physics governing the circulation of the atmosphere and ocean and their control on climate with emphasis on the large-scale ocean circulation. This course will give an overview of the structure and dynamics of the major ocean current systems that contribute to the meridional overturning circulation, the transport of heat, salt, and biogeochemical tracers, and the regulation of climate. Topics include the tropical ocean circulation, the wind-driven gyres and western boundary currents, the thermohaline circulation, the Antarctic Circumpolar Current, water mass formation, atmosphere-ocean coupling, and climate variability. Prerequisites: EESS 146A or EESS 246A, or CEE 164 or CEE 262D, or consent of instructor.
Same as: EARTHSYS 146B, ESS 146B, ESS 246B, GEOPHYS 146B, GEOPHYS 246B

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

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

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

EARTHSYS 255. Microbial Physiology. 3 Units.
Same as: BIO 180, ESS 255, GS 233A

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

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

EARTHSYS 260. Internship. 1-9 Unit.
Supervised field, lab, or private sector project. May consist of directed research under the supervision of a Stanford faculty member, participation in one of several off campus Stanford programs, or an approved non-Stanford program relevant to the student's Earth Systems studies. Required of and restricted to declared Earth Systems majors. Includes 15-page technical summary research paper that is subject to iterative revision.
EARTHSYS 263E. International Climate Negotiations: Unpacking the Road to Paris. 3 Units.
Interested in what's going on with international climate negotiations, why it has proven so difficult to reach a meaningful agreement? Wondering whether or not another UN agreement is even a meaningful part of climate policy in 2015? This course traces the history of climate negotiations from the very first awareness of the problem of climate change, through the Kyoto Protocol and Copenhagen Accord, to the current state of international negotiations in the lead-up to the 21st Conference of the Parties meeting in Paris in December 2015. The course covers fundamental concepts in climate change science and policy, international law and multilateral environmental agreements, as well as key issues of climate finance, climate justice, equity, adaptation, communication, and social movements that together comprise the subjects of debate in the negotiations. We will discuss all the key facets of what's at stake; being negotiated in Paris and prepare students to follow the outcome of the negotiation in detail. Students also participate in a three-day mock conference of the parties. By application only.
Same as: CEE 163E, CEE 263E, EARTHSYS 163E

EARTHSYS 263F. Groundwork for COP21. 1 Unit.
This course will prepare undergraduate and coterminal students to participate in 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 graduate student mentors. Please note: Along with EARTHSYS/CEE 163E, this class is part of the required two-course-set in which undergraduate and co-terminal masters degree students must enroll to receive accreditation to the climate negotiations.
Same as: CEE 163F, CEE 263F, EARTHSYS 163F

EARTHSYS 268. The Evolving Sphere of Food Security. 2 Units.
This seminar delves into a comprehensive new volume on food security written by an all-Stanford team of nineteen faculty and researchers. It explores the interconnections of food security with energy, water, climate, health, and national security, and examines the role of food and agricultural policies and their consequences in countries at different stages of development. Led by the editor of the book, with participation of several of the authors from across many disciplines. Prerequisite: ECON 106. Admission is by application.
Same as: EARTHSYS 168

EARTHSYS 272. Antarctic Marine Geology. 3 Units.
For upper-division undergraduates and graduate students. Intermediate and advanced topics in marine geology and geophysics, focusing on examples from the Antarctic continental margin and adjacent Southern Ocean. Topics: glaciers, icebergs, and sea ice as geologic agents (glacial and glacial marine sedimentology, Southern Ocean current systems and deep ocean sedimentation), Antarctic biostратigraphy and chronostratigraphy (continental margin evolution). Students interpret seismic lines and sediment core/well log data. Examples from a recent scientific drilling expedition to Prydz Bay, Antarctica. Up to two students may have an opportunity to study at sea in Antarctica during Winter Quarter.
Same as: ESS 242

Can aquaculture feed billions of people without degrading aquatic ecosystems or adversely impacting local communities? Interdisciplinary focus on aquaculture science and management, international seafood markets, historical case studies (salmon farming in Chile, tuna ranching in the Mediterranean, shrimp farming in Vietnam), current federal/state legislation in 2015? This course traces the history of climate negotiations from the very first awareness of the problem of climate change, through the Kyoto Protocol and Copenhagen Accord, to the current state of international negotiations in the lead-up to the 21st Conference of the Parties meeting in Paris in December 2015. The course covers fundamental concepts in climate change science and policy, international law and multilateral environmental agreements, as well as key issues of climate finance, climate justice, equity, adaptation, communication, and social movements that together comprise the subjects of debate in the negotiations. We will discuss all the key facets of what's at stake; being negotiated in Paris and prepare students to follow the outcome of the negotiation in detail. Students also participate in a three-day mock conference of the parties. By application only.
Same as: EARTHSYS 173, ESS 173, ESS 273

EARTHSYS 275. California Coast: Science, Policy, and Law. 3-4 Units.
Same as LAW 514. Interdisciplinary. The legal, science, and policy dimensions of managing California's coastal resources. Coastal land use and marine resource decision making. The physics, chemistry, and biology of the coastal zone, tools for exploring data from the coastal ocean, and the institutional framework that shapes public and private decision making. Primarily for graduate students; upper-level undergraduates may enroll with permission of instructor. Students will be expected to participate in field trips.
Same as: CEE 175A, CEE 275A, EARTHSYS 175

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

EARTHSYS 277. Interdisciplinary Research Survival Skills. 2 Units.
Learning in interdisciplinary situations. Framing research questions. Developing research methods that benefit from interdisciplinary understanding. Writing for multiple audiences and effectively making interdisciplinary presentations. Discussions with interdisciplinary experts from across campus regarding interdisciplinary research projects.
Same as: EARTHSYS 177, ENVIRINST 177, ENVIRINST 277

EARTHSYS 277C. Specialized Writing and Reporting: Environmental Journalism. 4-5 Units.
(Graduate students register for COMM / ENVRES 277C) Practical, collaborative, writing-intensive course in science-based environmental journalism. Science and journalism students learn how to identify and write engaging stories about environmental issues and science, how to assess the quality and relevance of environmental news, how to cover the environment and science beats effectively, and how to build bridges between the worlds of journalism and science. Limited enrollment: preference to journalism students and students in the natural and environmental sciences. Prerequisite: COMM 104, ENVRES 200 or consent of instructor. Admissions by application only, available from thayden@stanford.edu.
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 283. Food Matters: Agriculture in Film. 1 Unit.
Film series presenting historical and contemporary issues dealing with food and agriculture across the globe. Students discuss reactions and thoughts in a round table format. May be repeated for credit.
Same as: EARTHSYS 183, ESS 183, ESS 283

EARTHSYS 284. Climate and Agriculture. 3-4 Units.
The effects of climate change on global agriculture and food security, and the effects of agriculture on climate change. An overview of different lines of evidence used to measure impacts and adaptations, and to quantify future impacts, risks, and adaptation needs for agro-ecosystems and society. Enrollment limited to 25; priority to juniors, seniors, and graduate students. Prerequisites: ECON 106/206 or permission of instructor.
Same as: EARTHSYS 184, ESS 184, ESS 284

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

EARTHSYS 289A. FEED Lab: Innovating in the Local Food System. 3-4 Units.
Offered through the FEED Collaborative, this graduate-level course combines experiential learning in human-centered design, systems thinking and social entrepreneurship. Students will learn and apply these skills to projects that may include: sustainable food and farming technology, disruptive models of production and distribution, food justice, and/or the behavioral economics of eating. Students will benefit from close interaction with the teaching team, working on a multidisciplinary team of their peers, support from industry-leading project sponsors, and the varied perspectives of guest speakers. The goal of this course is to develop the creative confidence of students and, in turn, to work collaboratively with thought leaders in the local food system to design innovative solutions to the challenges they face. Admission is by application: http://feedcollaborative.org/classes/.

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

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

EARTHSYS 291. Introduction to 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 range and scope of research and practice in environmental communication. Intended for senior undergraduates and above with a background in environmental science and policy. Prerequisite: Earth Systems core (EarthSys 111 and EarthSys 112) or equivalent.
Same as: EARTHSYS 191

EARTHSYS 292. Multimedia Environmental Communication. 3 Units.
Theory and practice of effective, accurate and engaging use of photography and audio and web video production in environmental communication. Emphasis on group project work and peer critiquing in each modality, including some out-of-class work time. Limited class size, preference to Earth Systems Master’s students.

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

EARTHSYS 294. Environmental Communication Capstone. 5 Units.
Group-project based course focused on applying the skills and theoretical understanding gained through the Environmental Communication Master of Arts in Earth Systems course progression to a real-world communication challenge. Students design, plan, and implement an integrated communication strategy around a defined environmental topic or research program, such as the implementation of the new student farm; a specific research group; a laboratory or expedition work; or an activity or proposal of interest across research groups, such as climate change adaptation or marine conservation. Restricted to students enrolled in the Environmental Communication Master of Arts in Earth Systems, or by permission of the instructor.

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

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, EESS 323