(06/14/2016)

Environmental and Sustainability Sciences (ESS)

The curriculum in Environmental and Sustainability Sciences (ESS) seeks to advance students' ability to understand and address real-world environmental problems, manage social-ecological systems in a sustainable manner, and affect decisions involving environmental policy, resource management, biodiversity conservation, and human health. Such a challenging goal requires an interdisciplinary and integrated undergraduate experience that provides both breadth and depth about the causes, consequences, and management or remediation of environmental problems ranging from local to global. The curriculum comprises an intensive foundation in biological sciences, physical-chemical sciences and social sciences, as well as the integration of these areas of study. Although demanding, the curriculum leaves students flexibility to pursue greater depth in specific areas of environmental and sustainability sciences, and to expand their knowledge outside the major by taking advantage of Cornell's diverse range of courses and study-abroad opportunities.

CURRICULUM FOR 2016-2017 ACADEMIC YEAR

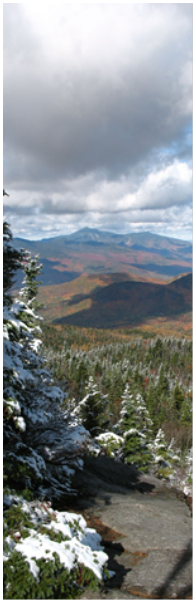

Photo courtesy of Eugene Madsen

The ESS major comprises a required set of core courses and completion of a selected concentration. All ESS students are required to take the core courses outlined in Table 1. In addition, all students must select one of five concentrations, each consisting of five additional courses. The concentrations are Environmental Biology and Applied Ecology (EBAE), Environmental Economics (EE), Environmental Policy and Governance (EPG), Land, Air and Water Resources (LAWR) (formerly Biogeochemical Sciences (BGCS)) and the Individual Student-Designed Concentration (ISD). Descriptions of the concentrations, their course requirements and lists of electives follow the quantitative proficiency guidelines.

Students should familiarize themselves as freshmen with the requirements of concentrations in which they may be interested. **Some requirements within the core curriculum include different course options depending on which concentration you select.** Four of the five concentrations require or recommend that students select specific courses among those options listed. This approach prepares students so that, in their junior and senior years, they can specialize in disciplines ranging from the social sciences (EPG and EE concentrations) to biology (EBAE concentration) to chemistry/physics (LAWR concentration). Regardless of the concentration chosen, all students are encouraged to engage in a variety of educational experiences beyond the classroom. Completing an integrative independent study/project or internship, or a research honors thesis takes advanced planning initiated by early discussion of options with an academic advisor or research mentor.

Many courses within the ESS core curriculum can simultaneously satisfy CALS distribution requirements and, depending on the concentration, some courses within the concentrations also meet CALS distribution requirements. ***However, no course may be double-counted as meeting both ESS core curriculum requirements and ESS concentration requirements.***

CORE CURRICULUM

The ESS Core Curriculum (Table 1) is required of all students. The curriculum provides fundamental knowledge of the biological, chemical and physical sciences, mathematics and quantitative analysis, and social sciences and humanities. These are essential to upper-level courses in environmental and sustainability sciences. The curriculum prepares students during their freshmen and sophomore years to pursue a concentration in-depth. Fundamental knowledge of all dimensions of the interdisciplinary curriculum, allows students to understand where their selected concentration fits together with the larger set of disciplinary skills needed to derive sustainable solutions to environmental challenges.

TABLE 1. Summary of Requirements within the ESS Core Curriculum
(Those courses also meeting CALS distribution requirements are indicated with an asterisk*)

REQUIRED CATEGORY	**COURSE(S) required or to select from in each category** Semester Key: F=Fall, S=Spring, Su=Summer
FRESHMEN, SOPHOMORE, JUNIOR YEARS	
Introduction to biotic/abiotic environmental science (freshmen only)	NTRES 1101: Introduction to Environmental Science and Sustainability (F)
Introduction to environmental social sciences (typically taken first year)	NTRES 2201: Society and Natural Resources* (S)
Biology (2 courses) (**Note:** BIOEE 1780 lecture conflicts with NTRES 1101 lab) (Note: BIOSM options are ~2.5 week intensive courses at Shoals Marine Lab that fully satisfy this requirement. Visit http://www.sml.cornell.edu)	BIOEE 1610: Ecology and the Environment* (F, S) **or** BIOSM 1610: Ecology and the Marine Environment (Su) **and** BIOEE 1780: Evolution and Diversity* (F, S) **or** BIOSM 1780: Evolution and Marine Diversity (Su) Pre-med, pre-vet students should consult with their advisor about meeting this requirement. AP Biology credits are accepted but do not exempt students from the above courses. **Note: Pre-med/dent students should visit** http://www.career.cornell.edu/paths/health/index.cfm
Quantitative Proficiency (3 courses)	**One calculus course:** MATH 1106: Calculus for the Life and Social Sciences* (S) MATH 1110: Calculus I* (F, S, Su) MATH 1910: Calculus for Engineers* (F, S, Su) **or** AP Calculus: AB score of 4, 5 or BC score of 3 = Calculus I; BC score of 4, 5 = Calculus I and II **One statistics course:** AEM 2100: Introductory Statistics* (F) BTRY 3010: Biological Statistics I (F) MATH 1710: Statistical Theory and Application in the Real World* (F, S) STSCI 2100: Introductory Statistics* (F, S, Su) STSCI 2150: Introductory Statistics for Biology (F, S) **or** AP Statistics score of 5 For more detailed guidance, see Quantitative Proficiency Guidelines, p. 10. **Plus 1 other highly quantitative course:** For more detailed guidance, see Quantitative Proficiency Guidelines.
Chemistry (2 courses)	CHEM 1560: Introduction to General Chemistry* (F, Su) CHEM 1570: Introduction to Organic and Biological Chemistry* (S, Su) CHEM 2070: General Chemistry I* (F, Su) CHEM 2080: General Chemistry II* (S, Su) CHEM 2150: Honors General and Inorganic Chemistry (F) {see Courses of Study for prerequisites} AP Chemistry score of 5 = 4 credits (one course)

REQUIRED CATEGORY	COURSE(S) required or to select from in each category Semester Key: F=Fall, S=Spring, Su=Summer
Physics (1 course)**	EAS 1600: Environmental Physics* (S) **Or** any of the following: PHYS 1101: General Physics I* (F, Su) PHYS 2207: Fundamentals of Physics I* (F) **Or** AP Physics B score of 5* **Note:** AP Physics C *does not* meet requirement
Ethics (1 course)	NTRES 3320: Introduction to Ethics and Environment* (F) **Alternative:** BSOC 2061/STS 2061/PHIL 2460: Ethics and the Environment* (F)
Economics (1 course)	AEM 1500: An Introduction to the Economics of Environmental and Natural Resources* (S, SU) **or** AEM 2500: Environmental and Resource Economics* (F) (prerequisite: ECON 1110)
Field experience (1 course)	NTRES 2100: Introductory Field Biology (F)
Sustainability Science Colloquium (1 course)	ESS 2000: Environmental and Sustainability Sciences Colloquium (F) BEE 2000: Perspectives on the Climate Change Challenge (S)
JUNIOR AND SENIOR YEARS	
Sustainability Science (1 course)	NTRES 3301: Sustainability Science (F) **or** **Alternative:** BEE 3299: Sustainable Development* (F, S)
Natural Sciences (2 courses)	Choose 1 course **each** in biotic and abiotic processes. See Lists A and B.
Social Science and Humanities (1 course)	Choose **one course from** List C.
Concentration (5 courses)	Students will choose and declare their concentration by the start of pre-enrollment of their sophomore year. See concentration descriptions and course requirements for each option.
Other courses required as part of CALS distribution requirements	
WRITTEN & ORAL EXPRESSION REQUIREMENTS (minimum 9 credits): **At least one course in Oral Expression is required by the ESS major**	
Written Expression (2 courses)	First-Year Writing Seminars (F, S) **or** AP English score of 4,5; refer to list of courses under CALS Distribution requirements: http://cals.cornell.edu/academics/registrar/degree-requirements/distribution/
Oral Expression (1 course)	COMM 2010: Oral Communication* (F, S, Su) ENTOM 3350: Naturalist Outreach Practicum* (F) ILRLR 2300: Argumentation and Debate* (Su) ILRLR 3300: Argumentation and Debate* (F, S)

List A. Environmental Natural Sciences -- Courses focused on biotic processes

BIOEE 3610	Advanced Ecology (F)
BIOMI/PLSCS 2790	Microbial Life and Processes that Rule Our Dynamic Planet (S)
NTRES 2830	DNA, Genes and Genetic Diversity (S)
NTRES 3100	Applied Population Ecology (F)

OR a class centered on a particular ecosystem

BIOEE/EAS 3500	Dynamics of Marine Ecosystems in a Changing Ocean (F, alternate years)
BIOEE 4570	Limnology: Ecology of Lakes, Lectures (F, alternate years)
BIOEE/EAS 4620	Marine Ecosystem Sustainability (F, alternate years)
BIOEE 4780	Ecosystem Biology and Global Change (S)
EAS 4830	Environmental Biophysics (F, alternate years)
ENTOM/PLHRT 4730	Ecology of Agricultural Systems (F)
NTRES 3220	Global Ecology and Management (F)
NTRES 3240	Sustainable, Ecologically Based Management of Water Resources (S)
NTRES 4200	Forest Ecology (F)
NTRES/BIOEE 4560	Stream Ecology (F, alternate years)
PLSCS 3210	Soil and Crop Management for Sustainability (S)
PLSCS 4660	Soil Ecology (S)

List B. Environmental Natural Sciences -- Courses focused on abiotic processes

BEE 3710	Physical Hydrology for Ecosystems (S, alternate years)
BEE 4270	Water Measurement and Analysis Methods (F)
BEE/EAS 4710	Introduction to Groundwater (S, alternate years)
BEE/EAS 4800	Our Changing Atmosphere: Global Change and Atmospheric Chemistry (S)
EAS 1310	Basic Principles of Meteorology (F)
EAS 2250	The Earth System (S)
EAS 2680	Climate and Global Warming (S)
EAS 3050	Climate Dynamics (F)
EAS 3340	Microclimatology (F, alternate years)
EAS 3530	Physical Oceanography (S, alternate years)
NTRES/EAS 3030	Introduction to Biogeochemistry (F)
PLSCS 2600	Soil Science (F)
PLSCS 3210	Soil and Crop Management for Sustainability (S)
PLSCS 3650	Environmental Chemistry: Soil, Air, and Water (S)
PLSCS/EAS 4830	Environmental Biophysics (F, alternate years)

List C. Environmental Social Sciences and Humanities

(*course meets CALS distribution requirement for CA, SBA, KCM, HA, or D)

AEM 2000	Contemporary Controversies in the Global Economy (S)
AEM 3380	Social Entrepreneurs, Innovators, and Problem Solvers (F)
AEM 4330	Devolution, Privatization, and the New Public Management (F)
AEM/NS 4450*	Toward a Sustainable Global Food System: Food Policy for Developing Countries* (SBA) (F
AEM 4500*	Resource Economics* (SBA) (F)
AEM 4510*	Environmental Economics* (SBA) (S)
AIIS/ANTHR 3422*	Culture, Politics, and Environment in the Circumpolar North* (CA, D) (S)
AMST/ENGL 3675*	The Environmental Imagination in American Literature* (LA) (S)
AMST/GOVT 4061*	Politics of Slow-Moving Crisis* (SBA) (S, next offered 2017-2018)
ANTHR 4410*	Indigenous Peoples, Ecological Sciences, and Environmentalism* (CA) (S, next offered 2017-2018))
BSOC/HIST/STS 3181*	Living in an Uncertain World: Science, Technology, and Risk* (HA) (S)
BSOC/HIST/STS 4131*	Comparative Environmental History* (HA) (F)
BSOC/AMST/HIST 2581*	Environmental History* (HA) (S)
CEE/TOX 5970	Risk Analysis and Management (S)
COML 6185	Introduction to Systems Theory (F)

COMM 2850/STS 2851*	Communication, Environment, Science and Health (SBA) (S)
COMM 3210	Communication and the Environment (SBA) (F) (Offered odd years)
COMM 4560*	Community Involvement in Decision Making* (SBA) (F) (Offered even years)
COMM/STS 4660*	Public Communication of Science and Technology* (SBA) (S)
COMM 4860*	Risk Communication* (SBA) (F)
CRP 3840	Green Cities (S)
CRP 5080	Introduction to Geographic Information Systems (GIS) (F, S)
CRP 5540	Introduction to Environmental Planning (F)
CRP 5460	Introduction to Community and Environment Dispute Resolution (F, S)
DEA 1500	Introduction to Environmental Psychology (S, Su)
DEA 4220/ARCH 4601	Ecological Literacy and Design (F)
DEA 6610	Environments and Health (S, alternate years)
DSOC 2010/SOC 2202*	Population Dynamics* (CA) (F)
DSOC 2030	Global Garbage (F, next offered 2017-2018)
DSOC 2050*	International Development* (D, HA, SBA) (S)
DSOC 3010*	Theories of Society and Development* (KCM, SBA) (F)
DSOC 3140	Spatial Thinking, GIS, and Related Methods (F)
DSOC 3200	Rethinking Global Development: New Frameworks for Understanding Poverty, Inequality and Growth in 21C (F, next offered 2017-2018)
DSOC 3240*	Environment, Society, and Land* (SBA) (S)
DSOC 3400	Agriculture, Food, Sustainability and Social Justice (F)
DSOC 4380	Population and Development (F, next offered 2017-2018)
HIST 2581*	Environmental History (HA) (F)
IARD/DSOC 2020	Perspectives on International Agriculture and Rural Development (F)
NTRES 3300*	Planning for Environmental Conservation and Sustainability (SBA) (F)
NTRES/BSOC/DSOC/STS 3311*	Environmental Governance* (SBA) (F)
NTRES 2320*	Nature and Culture* (CA, HA) (S, Su)
NTRES 3330*	Ways of Knowing: Indigenous and Local Ecological Knowledge* (F) (CA, D, KCM, SBA)
NTRES 4300	Environmental Policy Processes (S)
NTRES 4320*	Human Dimensions of Coupled Social-Ecological Systems* (SBA) (S)
NTRES 4330*	Applied Environmental Philosophy* (KCM) (S, alternate years, next offered 2017-2018)
NTRES/CRP 4440	Resource Management and Environmental Law (S)
NTRES/FDSC/IARD 4800	Global Seminar: Building Sustainable Environments and Secure Food Systems for a Modern World (S)
PLHRT 2240*	Urban Ecosystems* (HA, SBA) (S)
PLHRT 3600	Climate Change and the Future of Food (F)
PLHRT/BIOEE 4730	Ecology of Agricultural Systems (F)

Quantitative Proficiency Guidelines

The ESS major has the following learning outcomes related to quantitative proficiency:

- Ability to analyze, interpret, reason, and judge the quality and meaning of biological, ecological, and social-science data using appropriate mathematical, statistical, graphical, and other quantitative and qualitative methods, and to apply these methods to environmental and conservation issues.
- Ability to critically assess the rigor and relevance of data and other forms of evidence used to solve environmental problems, and to identify new and creative solutions.

The ESS major requires a minimum of three courses emphasizing quantitative analysis to achieve these outcomes: one calculus course, one statistics course, and a choice among several options for gaining greater proficiency in quantitative analysis. Skills with quantitative analysis are essential in many careers related to this major. Students should gain both specific analytical skills and the logical reasoning involved in quantitative methods. Some concentrations within ESS strongly recommend more than the minimum, or require specific choices for meeting ESS requirements for quantitative proficiency. All ESS students are advised to take courses emphasizing quantitative analysis to the highest level of their ability. Students may have greater success in entering graduate school and in obtaining employment with more than the required minimum.

Guidelines within each of the three required categories follow.

CALCULUS, including both differentiation and integration, is used in environmental physics, statistics, some economics courses, and some advanced courses in ecology. Thus, one university-level calculus course is required for all ESS majors.

An AP score of 4 or 5 on the MATHEMATICS BC exam earns 8 credits and may be used to fulfill the calculus requirement. Either score places you out of MATH 1106, MATH 1110, MATH 1120, MATH 1220, AND MATH 1910 and allows enrollment in MATH 2210, MATH 2230, MATH 2130 and MATH 2310, as well as MATH 1920.

An AP score of 4 or 5 on the MATHEMATICS AB or AB sub-score of the BC exam earns 4 credits and may be used to fulfill the calculus requirement. Either score places you out of MATH 1106 and MATH 1110 and allows enrollment in MATH 1120, MATH 1220, MATH 1910, or MATH 2310.

If you do not have a minimum AP calculus score of 4, start with either Math 1106 or Math 1110. (Those students planning to concentrate in Environmental Economics (EE), Environmental Biology and Applied Ecology (EBAE), or Biogeochemical Sciences (BGCS), or who are planning to take more advanced mathematics beyond calculus, should consider the Math 1110 option.)

- MATH 1106: Calculus for the Life and Social Sciences (S, 3 credits). This course is the best choice for most students as it covers the basics with life-science examples, or
- MATH 1110: Calculus I (F, S, Su, 4 credits). In addition to differentiation and integration, this course includes trigonometry, which has limited use in the environmental sciences.

If you do have a minimum AP AB or BC calculus score of 4 and would like to focus on the practical application of the subject you might also consider Math 2310: Linear Algebra with Applications.

Students with strong interests in climate or atmospheric dynamics may wish to consider MATH 1920.

These courses will give you more advanced skills than are developed in beginning calculus courses:

- MATH 2130: Calculus III (S, 4 credits)
- MATH 1920: Multivariate Calculus for Engineers (F, S, S; 4 credits)

STATISTICS is the most broadly applicable quantitative method for ESS students.
One statistics course is required.

- NTRES 3130 (same as STSCI 2200 and BTRY 3010): Biological Statistics I (F, 4 credits)
  This course is designed for ESS students and should be your first choice. Also, if you plan on taking two stats courses, NTRES 3130 is the first of a two-semester sequence.

- STSCI 2150 (F, S, 4 credits): Introductory Statistics for Biology
  A good choice for those with biological interests and intending only one stats course.

- AEM 2100: Introductory Statistics (F, 4 credits)
  A good choice for those with more social science or policy interests.

These courses can substitute for statistics courses above, if scheduling the above courses is difficult.
- ILRST 2100/STSCI 2100: Introductory Statistics (S, S, Su, 4 credits)
- MATH 1710: Statistical Theory and Application in the Real World (F, S, 4 credits)

THIRD COURSE. Choosing the most appropriate third quantitative course depends upon your area of interest. Most ESS specializations will benefit from additional experience with statistics (see below for more advanced courses). You may prefer to expand your quantitative skills in environmental science courses that use quantitative analyses in a major way. It also would be reasonable to gain skills with computer programming both to diversify your skill set and for specializations where computer-intensive analyses are common, such as using large databases or ecological modeling. See below for many options available to meet the requirement for a third course emphasizing quantitative proficiency.

Statistics:
(Recommended for those looking at research-based careers or graduate school in the sciences.)

- BTRY 3080/STSCI 3080: Probability Models and Inference (F, S, 4 credits)

- BTRY 3100/ILRST 3100/STSCI 3100: Statistical Sampling (F, 4 credits)
  Prerequisite: two semesters of statistics

- BTRY 4090/STSCI 4090: Theory of Statistics (S, 4 credits)
  Prerequisite BTRY 3080 and one statistics course

- ECON 3110/ILRST 3110/STSCI 3110: Probability Models and Inference for Social Sciences (F, 4 credits)

- NTRES 4130/BTRY 3020/STSCI 3200: Biological Statistics II (S, 4 credits)
  Prerequisite: Biological Statistics I

Courses that develop quantitative skills:

(Recommended for those interested in developing modeling skills or seeking experience in how quantitative analyses are used in the context of specific academic interests.)

- BIOEE 3620/MATH 3620: Dynamic Models in Biology (S, 4 credits)
- BIOMG 4810: Population Genetics (F, 4 credits)
- DSOC 3140: Spatial Thinking, GIS, and Related Methods (F, 4 credits)
- DSOC 4631: Using Statistics to Explore Social Policy and Development (F, 3 credits)
- EAS 4830: Environmental Biophysics (F, alt years)
- NTRES 3100: Applied Population Ecology (F, 3 credits)
- NTRES 4100: Advanced Conservation Biology: Concepts and Techniques (F, 4 credits)
- NTRES 4110: Quantitative Ecology and Management of Fisheries Resources (S, 4 credits)
- NTRES 4120: Wildlife Population Analysis: Techniques and Models (S, 4 credits)

Computer Programming:
(Recommended for students who want basic skills underlying developing environmental models, manipulating large data sets, developing some statistical analyses.)

- CS 1110: Introduction to Computing Using Python (F, S, Su, 4 credits)
- CS 1112: Introduction to Computing Using MATLAB (F, S, 4 credits)
- EAS 2900: Computer Programming and Meteorology Software (S, 3 credits)

Geographical Information Systems (GIS):
(These techniques can be essential for gathering and analyzing spatial data. Many public and planning agencies use GIS routinely. Applicable to many types of research.)

- PLSCS 4110/CEE 4110: Remote Sensing for Environmental Resource Inventory (F, 3 credits)
- PLSCS 4200: Geographic Information Systems (S, 3 credits)

For additional development of basic mathematical skills:

- MATH 1105: Finite Mathematics for the Life and Social Sciences (F, 3 credits)
- MATH 1120: Calculus II (F, S, 4 credits)
- MATH 1920: Multivariable Calculus for Engineers (F, S, Su, 4 credits)
- MATH 2310: Linear Algebra with Applications (F, S, 3 credits)

Additional guidance in math can be found at:
http://courses.cornell.edu/preview_program.php?catoid=12&poid=3421#courseselectionguidance

First Steps in Mathematics
Answers to the most frequently asked questions concerning freshman-sophomore mathematics courses can be found here: http://www.math.cornell.edu/m/first-steps-in-math

DESCRIPTION OF ESS CONCENTRATIONS

Environmental Biology and Applied Ecology Concentration (EBAE)

The EBAE concentration provides students with the scientific basis for understanding the sustainability of various ecological systems. Students will learn advanced principles of biology and ecology, and their application to problems of environmental management. Students with interests in any of a suite of topics will undertake this concentration, for example, wildlife and fisheries management; forest, wetland and aquatic ecology; environmental microbiology; conservation science; endangered and invasive species; biological and ecological consequences of pollutants in the environment.

Learning Goals: The students in the EBAE concentration will gain an in-depth understanding of the biological and ecological dimensions of environmental and sustainability sciences, and of the methods by which knowledge in this area of scholarship is acquired, analyzed, interpreted, evaluated, and used in natural and human-managed ecosystems. Students who complete the EBAE course of study will be able to apply fundamental current understanding of ecology and environmental biology to complex interdisciplinary environmental issues.

Course Requirements: Five courses beyond the ESS core requirements taken from approved lists -1 Advanced Ecology **(either BIOEE 3610 or NTRES 3100)**, 1 Ecosystems course **(from EBAE List 1)**, 1 Organismal course **(from EBAE List 2)**, and 2 other upper level courses (**from either EBAE List 1 or 2)**, one of which must be at the 4000 level. Approved courses are listed below. Students in this concentration **are required to take** a genetics-focused class for their "biotic" choice course in the ESS core, either NTRES 2830: DNA, Genes and Genetic Diversity or BIOMG 2800 and 2801: Genetics and Genomics, lecture/lab.
I**t is highly recommended that students take two semesters of calculus (Table 1)** or calculus and a calculus-based physics course (PHYS 2207).

Course Examples:
NTRES 2830: DNA, Genes and Genetic Diversity, to be taken within the core requirements;
NTRES 3100: Applied Population Ecology; BIOEE 3610: Advanced Ecology; NTRES 4110: Quantitative Ecology and Management of Fisheries Resources; BIOEE 4760: Biology of Fishes; NTRES/BIOEE 4560: Stream Ecology

EBAE Elective Lists

EBAE List 1: Ecosystems – The physical and biological environment

BIOEE/EAS 3500	Dynamics of Marine Ecosystems (F, alternate years)
BIOEE/EAS 3510	Conservation Oceanography (S)
BIOEE 3610	Advanced Ecology (F)
BIOEE/BIONB/ ENTOM 3690	Chemical Ecology (S)
BIOEE 4570	Limnology Ecology of Lakes (S, alternate years)
BIOEE/EAS 4620	Marine Ecology (F, alternate years)
BIOEE 4690	Food, Agriculture, and Society (F)
BIOEE 4780	Ecosystem Biology (S, alternate years)
EAS 4830	Environmental Biophysics (F, alternate years)
EAS/NTRES 3030	Introduction to Biogeochemistry (F)
EAS/BIOEE 3500	Dynamics of Marine Ecosystems (F, alternate years)
LA 3170	Design and Environmental Systems (F)
NTRES/BIOEE 2670	Introduction to Conservation Biology (F)
NTRES/EAS 3030	Introduction to Biogeochemistry (F)
NTRES 3220	Global Ecology and Management (F)
NTRES 3240	Sustainable, Ecologically Based Management of Water Resources (S)
NTRES 3250	Forest Management and Maple Syrup Production (S, alternate years)
NTRES 4200	Forest Ecology (F)
NTRES/BIOEE 4560	Stream Ecology (F, alternate years)
PLHRT 3600	Climate Change and the Future of Food (F)
PLHRT 4400	Restoration Ecology (F)
PLHRT/BIOEE 4730	Ecology of Agricultural Systems (F)
PLSCS 3210	Soil and Crop Management for Sustainability (S)
PLSCS 4660	Soil Ecology (S)

EBAE List 2: Organisms – plants, animals, microbes

BIOEE 2740	The Vertebrates: Structure, Function, and Evolution (S)
BIOEE 3610	Advanced Ecology (F)
BIOEE 3611	Field Ecology (F)
BIOEE/MATH 3620	Dynamic Models in Biology (S, alternate years)
BIOEE/BIONB 4460	Plant Behavior: Induced Plant Response to Biotic Stresses (S, alternate years)
BIOEE 4500	Mammalogy, Lecture/Laboratory (F, alternate years)
BIOEE 4580	Community Ecology (S, alternate years)
BIOEE 4660	Physiological Plant Ecology, Lectures (S, alternate years)
BIOEE 4700/4701	Herpetology, Lectures (S, alternate years)
BIOEE 4750	Ornithology (S, alternate years)
BIOEE 4760	Biology of Fishes (F, alternate years)
BIOMI/PLSCS 2790	Microbial Life and Processes that Rule Our Dynamic Planet (S)
BIOMI 2900	General Microbiology Lectures (F, S, Su)
BIOMI 3500/EAS 3555	Biological Oceanography and Ocean Biogeochemistry (S)
BIOMI 4140	Prokaryotic Diversity (S)
BIOMI/PLPPM 4480	Symbiotic Associations: Evolution and Ecology (S)
BIOSM 3210	Anatomy and Function of Marine Vertebrates (Su)
BIOSM 3730	Biodiversity and Biology of Marine Invertebrates (F)
BIOSM 3740	Field Ornithology (Su)
BIOSM 4650	Sharks: The Biology, Evolution and Conservation of Sharks and Their Allies (Su)
ENTOM 2120	Insect Biology (F)
ENTOM/TOX 3070	Pesticides, the Environment and Human Health (F, alternate years)
ENTOM 3150	Spider Biology (F)
ENTOM 3440	Insect Conservation Biology (F, alternate years)
ENTOM/PLSCS 4440	Integrated Pest Management (S)
ENTOM/BIOEE 4550	Insect Ecology (F, alternate years)
NTRES 3100	Applied Population Ecology (F)
NTRES 3110	Fish Ecology, Conservation and Management (S, alternate years)
NTRES 3260	Applied Conservation Ecology (S)
NTRES 4100	Advanced Conservation Biology: Concepts and Techniques (F)
NTRES 4110	Quantitative Ecology and Management of Fisheries Resources (F)
NTRES 4120	Wildlife Population Analysis: Techniques and Models (S)
NTRES 4280	Principles and Practices of Applied Wildlife Science (S, alternate years)
PLBIO 2410	Introductory Plant Biodiversity and Evolution (F)
PLBIO 2450	Plant Biology (Su)
PLBIO 3420	Plant Physiology, Lectures (S)
PLBIO 3590	Biology of Grasses (S, alternate years)
PLPPM 3010	Biology and Management of Plant Diseases (F)
PLPPM 4010	Microbial Pathogens vs. Plants (S)
PLPPM 4020	Biology of Plant Pathogens (S)
PLPPM 4330	Infectious Disease Ecology and Evolution (F)
PLSCS/BSOC/IARD/STS/GOVT 4303	The GMO Debate: Science and Society (F)
PLSCS 3150	Weed Biology and Management (F)
PLSCS 4130	Physiology and Ecology of Yield (S)

Environmental Economics Concentration (EE)

ESS students with a concentration in Environmental Economics will study how society allocates scarce natural resources and disposes of residuals that affect environmental quality and climate.

Learning Goals: Students will learn (1) how and why markets fail, (2) how optimization models and other economic methods might be used to promote the optimal, sustainable use of renewable resources, and (3) how taxes and cap-and-trade programs can improve environmental quality by employing taxes or markets to correct for negative externalities or generate tax revenues to conserve natural environments.

Course Requirements: Five courses beyond the ESS core requirements -- AEM 2500: Environmental and Resource Economics, to be taken within the core curriculum; ECON 1110: Introductory Microeconomics, ECON 1120: Introductory Macroeconomics, ECON 3030: Intermediate Microeconomics, AEM 4500: Resource Economics and AEM 4510: Environmental Economics.

Environmental Policy and Governance Concentration (EPG)

ESS students with a concentration in Environmental Policy and Governance will study the design, construction, implementation and evaluation of environmental policy and management.

Learning Goals: Students will gain an understanding of the mechanisms, strategies and constraints to securing social and ecological well-being through conservation of ecosystems at scales from local to global. Building on students' knowledge of natural resources, social and environmental sciences, and strengthening their knowledge in the social sciences, the concentration emphasizes critical reasoning, communication skills and capacity to integrate narrative, statistical and technical information. These skills will allow students to work with government agencies, commercial firms and civil society organizations and to address cross-cutting contemporary debates regarding conservation and the role of environment in politics, economic development and security.

Course Requirements: Five courses beyond the ESS core requirements -- CRP/NTRES 4440: Resource Management and Environmental Law, DSOC 3240: Environment, Society, and Land, NTRES 3311: Environmental Governance, NTRES 4300: Environmental Policy Processes, and one elective from List C that is offered at the 3000-level or higher.

Land, Air and Water Resources (LAWR)

(formerly Biogeochemical Sciences Concentration (BGCS))

Studies in Biogeochemical Sciences provide students with a sound foundation in physical and chemical processes and how these interact in ecosystems to control the transport and fate of naturally-occurring elements and pollutants in the environment. The concentration emphasizes viewing ecosystems as integrated systems in requiring at least one course in ecosystem ecology and one course in environmental information systems. Students with interests in toxicology, hydrology, climate change, soil and air pollution, for example, are encouraged to concentrate in the Biogeochemical Sciences.

Learning Goals: The overarching goals are to provide students with in-depth understanding of the chemical, physical, geological, and biological processes that govern the composition of natural and managed ecosystems, and with experience in the methods used to obtain, analyze, interpret, and evaluate biogeochemical information. Students who complete the Biogeochemical Sciences concentration will have knowledge sufficient to describe cycles of biologically and geochemically important chemical elements within and through ecosystems.

Course Requirements: Five courses beyond the ESS core requirements taken from approved lists – Either PLSCS 3650: Environmental Chemistry: Soil, Air, and Water OR EAS/NTRES 3030: Introduction to Biogeochemistry to be taken within the core curriculum, **AND** five courses beyond the ESS core requirements: One course from BGCS List 1, one course from BGCS List 2, one course from BGCS List 3, plus two additional courses selected from BGCS Lists 1, 2, or 3.

Other Cornell University courses similar in content and level (3000-level or above) but not on these lists may be chosen in consultation with the advisor. Note that some of the courses in this concentration require more than the minimum math and physics; thus **we recommend that students in the BGCS concentration take two semesters of calculus and two semesters of physics.**

LAWR Elective List

LAWR List 1: Chemical/Physical environmental science

Water management/hydrology

BEE 3500	Biological and Bioenvironmental Transport Processes (F, Su)
BEE 3710	Physical Hydrology for Ecosystems (S, alternate years)
BEE 4270	Water Measurement and Analysis Methods (F)
BEE/EAS 4710	Introduction to Groundwater (S)
CEE 3310	Fluid Mechanics (F)
CEE 4320	Hydrology (S)
EAS 3530	Physical Oceanography (F)
EAS/BIOEE 3500	Dynamics of Marine Ecosystems (F)

Atmosphere/climate

BEE/EAS 4800	Our Changing Atmosphere: Global Change and Atmospheric Chemistry (F)
EAS 1310	Basic Principles of Meteorology (F)
EAS 2680	Climate and Global Warming (S)
EAS 3050	Climate Dynamics (F)
EAS 3340	Microclimatology (S, alternate years)
EAS 3420	Atmospheric Dynamics (S)

Terrestrial/soil science/geology

EAS 2250	The Earth System (S)
EAS 3010	Evolution of the Earth System (F)
EAS/NTRES 3030	Introduction to Biogeochemistry (F)
EAS/PLSCS 4830	Environmental Biophysics (F, alternate years)
PLSCS 2600	Soil Science (F)
PLSCS 3210	Soil and Crop Management for Sustainability (S)
PLSCS 3630	Soil Genesis, Classification, and Survey (F)
PLSCS 3650	Environmental Chemistry: Soil, Air, and Water

LAWR List 2: Environmental informatics

CEE/PLSCS 4110	Applied Remote Sensing and GIS for Resource Inventory and Analysis (F)
CRP 4080	Introduction to GIS (F, S)
EAS 2900	Computer Programming and Meteorology Software (S)
PLSCS 4200	Geographic Information Systems (S)

LAWR List 3: Integrated ecosystems / ecology

BEE 3299	Sustainable Development (F, Su)
BIOEE 4570	Limnology: Ecology of Lakes, Lectures (S)
BIOEE/EAS 4620	Marine Ecosystem Sustainability (F)
BIOEE/PLHRT 4730	Ecology of Agricultural Systems (F)
BIOEE 4780	Ecosystem Biology (S)
NTRES 3220	Global Ecology and Management (F)
NTRES 4200	Forest Ecology, Lectures (F)
NTRES/BIOEE 4560	Stream Ecology (F, alternate years)
PLHRT 4400	Restoration Ecology (F)
PLHRT/PLSCS 4660	Soil Ecology (S)

Individual Student-Designed Concentration (ISD)

The complex and interdisciplinary nature of environmental and sustainability sciences means that the number of potential combinations of relevant disciplines and courses is large. The ISD concentration provides students the opportunity to work closely with their advisors to imagine and create a unique combination of courses to meet their own personal interests and explore domains outside of the other specified concentrations in ESS. It allows students to pursue much greater depth in a specific area of environment and sustainability, or design a more synthetic approach to understanding and participating in (re)structuring the interactions between society and environment. Both of these approaches emphasize developing an ability to think critically about and the myriad ways in which humans interact with the environment.

Learning Goals: Each student will work with their faculty advisor to design a cohesive sequence of five upper-division courses, at least one of which is a 4000-level course, that constitutes a theme relevant to ESS, and to prepare a one-paragraph rationale for their theme and choice of courses. These five courses should ensure development of specific competencies linked to personal and professional ambitions of the individual student.

Required Courses: Five courses beyond the ESS core requirements. No specific courses are required but at least one of the five courses in the concentration must be a 4000-level course. Students wishing to design an individual concentration must complete an application before beginning the courses in their theme. The rationale and list of courses selected should be completed no later than spring pre-enrollment of their sophomore year. An electronic copy of the requisite form is available by contacting Suzanne Wapner at sw38@cornell.edu. The form will need to be completed and signed by the student and her/his advisor, and should be submitted electronically to Suzanne Wapner. The application will be reviewed and the student notified of approval of their ISD Concentration.

Examples of themes: Environmental Health, Environmental Informatics, Marine Science, Sustainable Agriculture, Sustainable Development, Water Resource Management, Wildlife Conservation.

Using AP credit to fulfill a requirement

AP Credit Guidelines: Students vary in how they will choose to apply their AP credits toward their degree requirements. You will need to meet with your faculty advisor to review your best options given your academic goals. Below is a direct link to AP Guidelines; a link is also available in D.U.S.T. **https://dust.cals.cornell.edu/**

http://cals.cornell.edu/sites/cals.cornell.edu/files/shared/documents/academics/Advanced-Placement.pdf

Using S/U for requirements within the major

The ESS Curriculum Committee agreed that requirements for the major may be taken S/U provided all other CALS rules are followed and the course offers the S/U option.
The S/U System: http://cals.cornell.edu/academics/advising/faculty-staff/grading/

Alongside the letter-grade system stands an S-U system, in which S means satisfactory, as defined by performance that would be graded C- or higher and U means unsatisfactory, as defined by performance that would be graded below C-. Grades of S and U are not given grade-point values or taken into account in computing grade-point averages. The purpose of the S-U system is to encourage students to venture into courses outside their main areas of familiarity without great risk to their academic record. The border between S and U is not the same, however, as that between pass and fail in the letter-grade system. Credits toward the fulfillment of graduation requirements are earned for courses evaluated S but not for those graded U. The various schools and colleges differ in the restrictions they place on the election of SU grading over letter grading. But in those courses where college rules and course procedures allow it, the election is a student option that must be exercised within the first seven weeks of the beginning of the term. Students may not defer the decision in the hope of first seeing the letter grade they are likely to earn.

Environmental & Sustainability Sciences Requirement Checklist

Refer to Table 1: Summary of Requirements that lists acceptable course choices.

Check box	Course count	ESS Core Curriculum (All ESS Students)
☐	1	NTRES 1101: Intro to ESS – limited to freshmen only; transfers exempt
☐	1	NTRES 2201: Society and Natural Resources
☐	2	Biology: BIOEE 1610: Introductory Biology: Ecology and the Environment **AND** BIOEE 1780: An Introduction to Evolutionary Biology and Diversity
☐	2	Calculus and one additional Math or math-intensive course List courses 1 _____ 2 _____
☐	2	Chemistry courses List courses 1 _____ 2 _____
☐	1	Physics List course _____
☐	1	Statistics List course _____
☐	1	Oral Expression (COMM 2010, ENTOM 3350, ILRLR 2300) List course _____
☐	1	NTRES 3320: Introduction to Ethics and Environment. Alternative: BSOC 2061/STS 2061/ PHIL 2460: Ethics and the Environment List course: _____
☐	1	Economics: AEM 1500: Intro to the Economics of Environmental and Natural Resources **OR** AEM 2500: Environmental and Resource Economics List course _____
☐	1	NTRES 2100: Introductory Field Biology
☐	1	ESS 2000: Environmental and Sustainability Sciences Colloquium **OR** BEE 2000: Perspectives on the Climate Change Challenge
☐	1	NTRES 3301: Sustainability Science **OR** BEE 3299: Sustainable Development (online course)
☐	2	Environmental Natural Sciences (one from List A and one from List B) List courses 1 _____ 2 _____
☐	1	Environmental Social Sciences or Humanities course (from List C) List course _____

5 courses required in each concentration		**ESS Concentrations** **Concentration selection to be entered in D.U.S.T. no later than the end of pre-registration spring semester of student's sophomore year.** (See requirements for each concentration below)
	☐	**Environmental Biology and Applied Ecology Concentration (EBAE)** Either NTRES 2830: DNA, Genes and Genetic Diversity **OR** BIOMG 2800: Lectures in Genetics and Genomics **AND** BIOMG 2801: Laboratory in Genetics and Genomics List course(s) _____ Plus 5 upper-level courses beyond the ESS core requirements, taken from approved lists. One advanced ecology: NTRES 3100: Applied Population Biology or BIOEE 3610: Advanced Ecology List course _____ One ecosystem (EBAE List 1) _____ One organism (EBAE List 2) _____ Two other upper level courses (EBAE Lists 1, 2) (one must be at 4000-level) List courses 1 _____ 2 _____
	☐	**Environmental Policy and Governance Concentration (EPG)** 5 courses beyond the ESS core requirements, as outlined below: CRP/NTRES 4440: Resource Management and Environmental Law DSOC 3240: Environment, Society, and Land NTRES 3311: Environmental Governance NTRES 4300: Environmental Policy Processes One upper level course from List C (Environmental Social Sciences and Humanities) List course _____
	☐	**Environmental Economics Concentration (EE)** 5 courses beyond the ESS core requirement, as outlined below: ECON 1110: Introductory Microeconomics ECON 1120: Introductory Macroeconomics ECON 3030: Intermediate Microeconomic Theory AEM 4500: Resource Economics AEM 4510: Environmental Economics
	☐	**Land, Air and Water Resources (LAWR)** **Formerly: Biogeochemical Sciences Concentration (BGCS)** PLSCS 3650: Environmental Chemistry **OR** NTRES/EAS 3030: Introduction to Biogeochemistry (from ESS core requirements) List course _____ Plus 5 courses: One from each of the categories below, taken from lists : Chemical/Physical Science (LAWR List 1), list course _____ Environmental Informatics (LAWR List 2), list course _____ Integrated Ecosystems/Ecology (LAWR List 3), list course _____ Two additional electives from the above-listed categories, List courses 1 _____ 2 _____
	☐	**Individual Student-Designed Concentration (ISD)** An integrated set of 5 advisor-approved courses beyond the ESS core, preferred to be 3000 - 4000-level courses. The ISD Concentration must also be approved by the ISD Chair.