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. Please check with your advisor for their recommendation after discussing your academic goals.

- 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 Land, Air and Water Resources (LAWR), 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: Calculus for Engineers (F, S, Su; 4 credits)
STATISTICS - The most broadly applicable quantitative method for ESS students. One of the following statistics courses is required.

- **BTRY 3010/STSCI 2200: Biological Statistics I** (F, 4 credits)
  This course is designed for ESS students and should be your first choice. If you plan to take two statistics courses, BTRY 3010 is the first of a two-semester sequence,

- **BTRY 3020/STSCI 3200: Biological Statistics II** (S, 4 credits) is the spring course.

- **STSCI 2150 (F, S, 4 credits): Introductory Statistics for Biology**
  A good choice for those with biological interests and intending only one statistics 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** (F, W, S, Su, 4 credits)
- **MATH 1710: Statistical Theory and Application in the Real World** (F, S, 4 credits)

THIRD COURSE - The most appropriate third course can vary depending on 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 is also 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 3020/STSCI 3200: Biological Statistics II** (S, 4 credits)
  Prerequisite: Biological Statistics I

- **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 the Social Sciences** (F, 4 credits)

**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 applications.

- **BIOEE 3620/MATH 3620: Dynamic Models in Biology** (S, 4 credits)
- **BIOMG 4810: Population Genetics** (F, 4 credits)
- **DSOC 4631: Using Statistics to Explore Social Policy and Development** (F, 3 credits)
- **EAS 4830: Environmental Biophysics** (F, alternate 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 used in 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.
- CRP 4080: Introduction to Geographic Information Systems (F, S, 4 credits)
- PLSCS 4110/CEE 4110: Applied Remote Sensing and GIS for Resource Inventory and Analysis (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