Proposal to revise the Earth and Environmental Sciences major
prepared by Steven Goodbred, EES Chair

Overview
The Department of Earth and Environmental Science proposes a revision of its undergraduate curriculum to remain current with changes to the profession, career opportunities, student interests, and our faculty composition. The revisions would provide EES majors with flexibility in choosing an area of specialization within the earth and environmental sciences, where no such option has existed before. To ensure a coherent and rigorous program, the curriculum is anchored by a set of required courses taken by all students early in the major. In this way, there can be flexibility in the upper-level courses to accommodate varying student interests while maintaining a core experience shared by all majors. Once in place, the revised curriculum is expected to attract more majors, enhance student experience and training, and better prepare them for success in a rewarding profession and positive job market (Gonzales and Keane, 2010).

Motivation
The proposed revisions have roots with our 2007 name change to the Department of Earth and Environmental Sciences, after more than a century as Vanderbilt’s Geology department. This rebranding was made in concert with evolution of the greater geoscience profession, which has increasingly engaged allied fields such as ocean and atmospheric sciences, ecology and the biosciences, engineering, and their application to environmental challenges of the 21st century—including the prominent role of humans in governing conditions on our planet (National Research Council, 2012). Concurrent with the expanded scope of our faculty research, the department has also increased classroom emphasis on quantitative methods, analytical capabilities, and coupled-system interactions. These shifts in the structure and branding of our program over the last decade have paralleled those of the broader geoscience community, with similar actions repeated in departments across the nation.

For successful job placement and sustained careers of our undergraduate majors, the revised curriculum pivots from geology’s traditional emphasis on petroleum and mining-based industries to a broader “Earth and environmental” theme that reflects new career opportunities in these areas. Our graduates increasingly find employment in environmentally oriented jobs in water resources, contaminants, habitat restoration, resource management, climate and weather, among others. As well, the broad field of geohazards has opened opportunities in earthquake risk, coastal and river flooding, hillslope instability, storm effects, and drought management. Finally, the increasing intersection of humans and the natural environment have given rise to new geoscience-related careers in policy, law, health, and social development through government agencies, non-profits, and NGOs.

The change in curriculum has been motivated not only by external factors, but also by diversification of the student body through Opportunity Vanderbilt. The associated reduction in debt at graduation has encouraged students to pursue a major of their interest over its earning potential. In this new climate our number of majors continues to grow – however, feedback on what prompts student interest in the Earth and Environmental Sciences reveals several important messages: (1) students have highly varied interests across the discipline; (2) they seek flexibility to design a curriculum path that meets those interests, and (3) they value the department’s sense of community and its active engagement across disciplines and beyond the lecture hall. These goals are valued by our faculty and students alike and are consistent with national trends in the field.
Curriculum Plan

In our current curriculum there is just a single point of entry for the major, the course EES-1510 Dynamic Earth. After completing this course, the major proceeds with a set of six required 2000 to 3000-level courses, followed by a single elective that serves as the only decision point for students. In our revised curriculum, we adjust this approach at several points. At the introductory level, the course EES-1030 Oceanography will now also serve as an entry point to the major, allowing students with interest in Earth’s marine environments to begin the major upon completing that course. EES-1030 is taught both semesters with enrollments of 60-90 students, and we expect to draw several additional majors from this new entry point. We similarly hope to expand the entry course to include one of our atmosphere-based courses in the future.

Upon completing one of the two entry-level courses (1000 level), students would proceed to a set of three core-level courses (2000 level). The core courses are designed to teach students fundamental topics that can be applied to any area of specialization in the earth and environmental sciences. These courses include: one that is focused on the transport and motion of fluids, energy, and mass; another focused on material properties (i.e., physico-chemical attributes and behavior of materials); and the third on the integration of earth systems as viewed through Earth’s deep-time history. This triad of courses is intended to provide all majors with a core set of skills, knowledge, and experience that can be carried forward into their focus area, where each student chooses a specialization of interest (Maclodonald et al., 2005).

Once a student has completed at least one of the core courses, they are eligible to begin their focus-level courses (3000 level). For the focus, majors are required to take three out of six course offerings that are currently available. This set of courses defines a student’s focus area, for which they must prepare a brief written plan that explains their course choice in context of their goals and interests. The course plan is to be designed in consultation with the student’s advisor and must be approved by the DUS. Although the choice of courses for the focus area is flexible, guidance for particular areas are suggested in the catalog description. Beyond the focus courses, students must additionally complete three electives (mostly 4000 level) that may be chosen to give greater depth in their focus area or to add breadth and exposure to other sub-disciplines. Students must propose a set of electives in their initial course plan, but this can be modified at a later date should interests change. The major is capped by a one-credit hour Senior Seminar that aims to bring student cohorts back together to share knowledge gained in their focus area and elective courses.

Implementation

To implement the revised curriculum, we will establish two new courses and modify several others. Among the new courses, Prof. Jessica Oster is designing a focus-level option in Environmental Geochemistry (EES-3280) that she will teach in Fall 2017. The ORCA proposal for this course has been submitted. The other new offering will be one of the three core-level courses, Earth Dynamics (to be EES-2580), which will be taught by Prof. Dan Morgan. This course is intended to be taught in Spring 2018, at first as a special topics course and then with a formal course designation in Spring 2019. Among the modified courses, Prof. Jonathan Gilligan is revising his EES-2110 Global Climate Change to serve as one of the focus-level courses. An ORCA proposal has been submitted with a requested course number of EES-3310. The other course to be modified is Prof. Guil Gualda’s EES-3250 Earth Materials course, which will become the core-level offering of EES-2550. Prof. Gualda will be on leave in 2017-2018 and will be redesigning the course then. Overall, transition to the revised curriculum will not impose any significant problems to student progress toward completion of the major, and there are several places where exceptions or substitutions can be accommodated as needed. By Fall 2018 the new curriculum will be fully implemented. Finally, the current EES Assessment Plan remains appropriate for the revised curriculum and will not be changed.
Dropping the Environmental Sciences Minor

As part of our curriculum revision, we propose to discontinue the Environmental Sciences Minor for the following reasons:

- Our two recent DUSs report that no one has pursued this minor in the last 5 years, at least.
- In part, the minor relies on too many mid- to upper-level courses in other departments that have their own pre-requisites, making the minor too much work to be attractive.
- With our proposed curriculum changes, EES will have several new courses that will allow students interested in “environmental sciences” to develop a relevant course of study through the remaining Earth & Environmental Sciences Minor, making the other minor redundant.
- Lastly, as of 2012 there has been an Environmental and Sustainability Studies Minor available to students interested in environmental issues, providing another more humanities based option.

References


SUMMARY of FACULTY VOTE on REVISED CURRICULUM and CATALOG DESCRIPTION

Department faculty met on Thursday February 16, 2017 for a vote on the revised curriculum and catalog description presented herein.

The vote of the tenure-track faculty was:

10 for, 0 against, and 1 absent
Earth and Environmental Sciences

CHAIR Steven L. Goodbred
DIRECTOR OF UNDERGRADUATE STUDIES Lily L. Claiborne
DIRECTOR OF GRADUATE STUDIES Guilherme Gualda
PROFESSORS EMERITI Leonard P. Alberstadt, Molly Fritz Miller, Arthur L. Reesman, William G. Siesser, Richard G. Stearns
PROFESSORS John C. Ayers, Ralf Bennartz, James H. Clarke, David J. Furbish, Steven L. Goodbred, George M. Hornberger, Calvin F. Miller
ASSOCIATE PROFESSORS Jonathan M. Gilligan, Guilherme Gualda
ASSISTANT PROFESSORS Simon A. F. Darroch, Larisa R. G. DeSantis, Maria Luisa Jorge, Neil P. Kelley, Jessica L. Oster
SENIOR LECTURERS Lily L. Claiborne, Daniel J. Morgan, Garrett W. Tate

The Earth and Environmental Sciences are aimed at interpreting Earth’s dynamic history—its age and origin as recorded in rocks and the landscape—and at understanding how geological processes affect modern environmental and ecological systems. Understanding Earth’s governing processes—how they operate and interact—as well as interpreting Earth’s dynamic history—its age and origin as recorded in rocks and the landscape—and finally, at understanding how geological processes affect modern environmental and ecological systems, including humans. Among the natural sciences, ours is the quintessential interdisciplinary science, providing vital perspective on how Earth’s physical and geochemical template simultaneously sustains and threatens life, and influences human interactions with Earth.

The Department of Earth and Environmental Sciences (EES) offers an undergraduate major leading to the B.A. degree. Students majoring in EES participate in field and laboratory work. Students majoring in EES take a core set of lab science courses with field components, then propose a course plan that creates an area of concentration in solid earth, earth surface, or environmental science while maintaining breadth across the discipline. The comparatively small size of the faculty and student body allows many opportunities for faculty-student interaction. Students use the major as preparation for graduate study, for careers in environmental studies and resource exploration (petroleum, minerals), or for related careers in such fields as land use planning, teaching, law, or engineering.

Research programs in the department, which in many cases involve students, employ field, analytical, and experimental methods. A wide variety of Earth processes are investigated, ranging from the migration of fluids and generation of magmas in the Earth’s crust, to the evolution of rivers and landscapes, to the evolution of sedimentary and biological environments, to geological processes in the human environment, to the impacts of humans on the environment. Study areas, in addition to Middle Tennessee, include the southwestern United States, the Pacific northwest, the southern Appalachians, Florida, Antarctica, South Asia, Brazil, Peru, Namibia, the Bahamas, Australia, and New Zealand.

For students with primary interests in environmental issues, there are three degree options. A student may major in EES or may construct an individualized interdisciplinary major. Alternatively, a student may major in another conventional discipline and augment that with an Earth and Environmental Sciences minor.

NOTE: New course numbers took effect in fall 2015. Former course numbers are included in course descriptions in this catalog and at this website: registrar.vanderbilt.edu/faculty/course-renumbering/course-lookup/.

Program of Concentration in Earth and Environmental Sciences

Three options are available within the EES major. All provide a solid grounding in the Earth and environmental sciences. The differences are in requirements for supporting sciences and mathematics and for research. Option I provides a background for careers or post-graduate work in related fields such as teaching, law, or business and for some graduate programs and employment opportunities in earth and environmental sciences. Option II prepares students well for graduate work and careers in the earth and environmental sciences. Option III (Honors) is designed for excellent, highly motivated students who want to pursue research as undergraduates.

The EES major is designed to provide a solid grounding in the Earth and environmental sciences while...
allowing flexibility in the particular focus. The major is organized into five parts, beginning with one of two introductory courses that serve as entry points. The second part involves three core courses with labs that provide all majors with a common background. At least one core course must be completed before students may enroll in the more advanced focus courses of part three. Also, prior to taking any focus courses, students must complete submit a one-page course plan for parts three and four that explains their choice of advanced courses based on expressed goals and interests. The course plan should be designed in consultation with the faculty advisor and must be approved by the Undergraduate Studies. In most cases, students will also declare the major at this time. The third part of the major defines a focus in the general areas of solid earth, Earth Surface, or environmental science. A brief description of each focus and a list of most relevant courses are given below. The fourth part follows the focus and allows three qualified electives to pursue depth in the focus or broaden to include another area of concentration. The fifth component of the major is a 1 credit hour seminar that serves as a capstone for senior students. In addition to the major, qualified students may elect to participate in the Honors program designed for highly motivated students who want to pursue research as undergraduates. Opportunities for research may be available to other students outside of the Honors program.

Required EES courses — 32 credit hours toward major for all options

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>EES 1510/1510L</td>
<td>4</td>
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<tr>
<td>EES 2510 (or 1020 prior to fall 2011)</td>
<td>4</td>
</tr>
<tr>
<td>EES 3220 (or 3220W prior to fall 2012)</td>
<td>4</td>
</tr>
<tr>
<td>EES 3250</td>
<td>4</td>
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<tr>
<td>EES 3260</td>
<td>4</td>
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<td>EES 3330</td>
<td>4</td>
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<td>EES 3340</td>
<td>4</td>
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<tr>
<td>EES 4961</td>
<td>1</td>
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<tr>
<td>One additional course selected from the following: EES 2110, 4420, 4550, 4600, 4820, 4830, 6200, 6891</td>
<td>3</td>
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Option I. Provides students with a comprehensive background in geoscience. In addition to the courses listed above, students are required to take one course each from two of the following groups.

Group A: Physical World
- Physics I (Physics 1601/1601L 4 hr or Physics 1901 5 hr)
- Chemistry I (Chemistry 1601/1601L 4 hr)
- Astronomy (2110 3 hr)

Group B: Earth Life
- Biological Sciences (1100/1100L 4 hr or 1510/1510L 4 hr or 1103 4 hr or 2218 4 hr or 2219 4 hr or 2238/2238L 4 hr)

Group C: Quantitative Skills
- Calculus I (Math 1100 4 hr or 1200 3 hr or 1300 4 hr)
- Statistics (Math 1010 3 hr)

Total credit hours: 38–41

Option II. Provides students with most course work needed for a career or graduate studies in geoscience.
Students take the required EES courses and complete the following:

Physics I (1601/1601L 4 hr)
Chemistry I (1601/1601L 4 hr)
Calculus I (Math 1200 3 hr or 1300 4 hr)
Total credit hours: 43–44

In addition, the second semesters of Chemistry, Physics, and Calculus as well as one or more courses in Biological Sciences are highly recommended to complete courses commonly required for graduate school or employment. Recommended selections include:

- Physics II (1602/1602L 4 hr) or Chemistry II (1602/1602L 4 hr) or Calculus II (Math 1201 3 hr or 1301 4 hr)
- Biological Sciences (1100/1100L 4 hr or 1510/1510L 4 hr or 1103 or 2218 4 hr or 2219 4 hr or 2238/2238L 4 hr)
- Astronomy (2110 3 hr)

Option III. Honors. Provides research experience as well as coursework preparation for a career or graduate studies in earth or environmental sciences. Course work is the same as for Option II with the addition of EES 4998 and 4999 (4 credit hours).

Total credit hours: 47–48

Interested students should apply to the undergraduate adviser for entry into the Honors program before the end of fall semester, junior year. A minimum of a 3.3 grade point average both overall and in the major is required for entry into the Honors program.

Working closely with a faculty adviser, students in the Honors program complete a research project of interest to both the student and faculty member during the senior year. In order to graduate with honors in EES, a student must: (1) maintain a 3.3 average; (2) complete the required courses for Option II plus EES 4998 and 4999; (3) satisfactorily present the results of his/her research in written form as a senior thesis to two members of the faculty and orally to students and faculty of the department.

At least 37 credit hours toward the major are required as follows:

1. Introductory Course (3+1 credit hours each):
   - 1510/1510L or 1030/1030L 4

2. Core Courses with Lab (3 or 4 credit hours each):
   - 2510, 2550, and 2580 11
   - (2550 was formerly 3250)

   **Math Course:**
   - 1100, 1201, or 1301 3-4

   Note: Math 1100, 1201, or 1301 are pre-requisite or co-requisite for 2550 and 2580.
   Note: Math 1100 provides basic calculus skills required for the EES major but does not qualify students for any more advanced math courses at Vanderbilt. Math 1301 is recommended for students interested in taking additional math courses or calculus-based physics that may be suggested by some graduate programs.

3. Focus Courses with Lab (4 credit hours each).
   - Three of the following per the approved course plan:
     - 3220, 3260, 3280, 3310, 3330, or 3340 12

4. Three electives, at least two above-at 4000 level (3 or 4 credit hours each):
   - An additional 3000-level course, or 4420, 4550, 4600, 4650, 4680, 4750, 4760, 4820, 4830, or 4891 9-10
Note: Does not include Directed and Independent Studies: 3841, 3842, 3851, or 3852

5. Senior Seminar:
   4961

| TOTAL: | 37-38 (40-42 with Math 1100, 1201, 1301) |

Additional supporting science and math courses are highly recommended for the major. Courses in Chemistry, Physics, Math and possibly Biological Sciences are recommended, and may be required for admittance into graduate school or for employment. Recommended selections include:

- Chemistry I and II (1601/1601L and 1602/1602L)
- Physics I and II (1601/1601L and 1602/1602L)
- Calculus I and II (Math 1200/1201, 1300/1301, or higher)
- Biological Sciences (1100/1100L, 1103, 1510/1510L, 1511/1511L, 4403, 2218, 2219, or 2238/2238L)

Options for area of focus

In-depth Earth & Environmental Sciences courses can be chosen so as to define a focus area within EES. Students should consult with their major adviser about choosing a focus area and associated course options. Students may also formulate an individualized focus area that may incorporate components of several areas to maintain breadth. All parts of the Earth are interconnected, and students are encouraged to maintain some breadth in their plan to create a comprehensive understanding of the cycling of energy and materials through the Earth’s spheres. Further descriptions of these focus options and recommended courses can be found in the EES major handbook on the EES department homepage.

**Solid Earth Focus**

This focus area most closely reflects a traditional geology degree, focusing on the processes and history of the Earth as recorded in its rocks, how those rocks are formed and how they change with changing conditions. Focus and elective courses appropriate for Solid Earth include: 3260, 3340, 3330, 3220, 4420, 4550, 4600, 4830.

**Earth Surface Focus**

This focus area considers interactions between Earth’s land surface, oceans, and atmosphere, for example governing how rivers, mountains, coasts, or the climate operate and evolve with time. Earth surface systems also define the planet’s critical zone that supports life and its ecosystems. Focus and elective courses appropriate for Earth Surface systems include: 3330, 3220, 3280, 4420, 4600, 4550, 4650, 4680.

**Environmental Focus**

This focus considers aspects of the hydrosphere, biosphere, atmosphere, and coupled human-environment systems, both present and past. Life on Earth impacts and is impacted by Earth’s environments, and is therefore central to this focus. Focus and elective courses most appropriate for environmental systems include: 3220, 3280, 3310, 4650, 4680, 4820, 489, 4750, 4760.

**Honors in Earth and Environmental Sciences**

The EES Honors program provides research experience and mentoring in preparation for a career or graduate studies in Earth and Environmental Sciences. Interested students should apply to the undergraduate adviser for entry into the Honors program fall semester, junior year. A grade point average of 3.3 or higher both cumulatively and in courses that count toward the EES major is required for admission to the Honors program.

Working closely with a faculty adviser, students in the Honors program complete a research project of interest to both the student and faculty member during the senior year. In order to graduate with honors in EES, a student must: (1) maintain a 3.3 grade point average both in the EES major and cumulatively; (2) complete the required courses for the EES major; (3) complete Senior Honors Seminar (4996, 4997) and Senior Honors Research (4998, 4999); (4) satisfactorily present the results of his/her research in written form as a senior thesis to two members of the faculty and orally to students and faculty of the department.
Minor in Earth and Environmental Sciences

The minor in EES provides students with a broad background in Earth processes, systems, and history, and an introduction to environmental issues. This background is highly relevant to many different fields of endeavor. The minor does not, however, fully prepare students for graduate studies or employment as Earth scientists.

Students should consult with the director of undergraduate studies about how the minor in EES fits with their career or graduate school interests.

The minor consists of at least five courses (at least 17 credit hours; EES 1510/1510L and 1030/1030L each count as one course; EES 2150 does not count toward the minor). Although EES 1510 (with 1510L) and 1030 (with 1030L) are highly recommended, students are encouraged to choose courses based on their interests and career plans and to discuss course selection with the director of undergraduate studies. No more than two 1000-level courses count toward the minor. Two courses with labs are required; one must be numbered above 2000. No credit toward the minor is given for EES 3841–3842 or 3851–3852.

Minor in Environmental Science

The interdisciplinary minor in environmental science requires a minimum of 15 credit hours. Environmental science is the study of how the earth’s natural environmental processes work, how they have been or can be modified by humans and society, and how such modifications impact on the biosphere, at the levels of individuals through ecosystems. An environmental science minor provides students the opportunity to expand their education to include a coherent program in the scientific aspects of how we interact with and modify the earth’s environment.

Students who want to minor in environmental science must take a minimum of five courses chosen from the courses listed below and approved by an adviser. Two must be from the core environmental science list (A), and at least two others must be from either the environmental science list (C) or the core environmental science list (A). No more than one 1000-level course may be counted toward the minor. No more than two courses can come from the student’s major department, recognizing that such courses cannot be counted simultaneously for both a major and a minor.


D) ENVIRONMENTAL STUDIES: Philosophy: 3616, Philosophy and the Natural Sciences; 3611, Environmental Philosophy.

Licensure for Teaching

Candidates for teacher licensure in earth and space science at the secondary level should refer to the chapter on Licensure for Teaching in the Peabody College section of this catalog.

EES majors may choose a second major in Science Education which includes teaching licensure, a prudent choice if interested in teaching. Peabody offers a fifth-year Master's program for science majors interested in teaching. Upon graduating with a B.A. in EES, EES majors in the fifth year program would spend the next summer and academic year earning their M.Ed. and teaching licensure.

Students seeking teacher certification in science disciplines at the secondary level should refer to the chapter on Certification for Teaching in the Peabody College section of the Undergraduate Catalog. Please contact Professor Heather Johnson, Coordinator of Science Secondary Education, at heather.j.johnson@vanderbilt.edu for more information.

Course descriptions begin on page 152.