Soil and Environmental Quality: A Course for Nonmajors

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ABSTRACT

The public's knowledge of environmental sciences in general, and soil science in particular, is very limited. To reach people beyond the traditional audience for natural resource courses, a course in Soil and Environmental Quality was developed for students in nonscience majors at the University of Maryland. This course is distinct from the more rigorous Fundamentals of Soil Science course that is aimed at students majoring in natural resource sciences. The course presents scientific principles, but requires only rudimentary quantitative skills. It includes two weekly lectures and a weekly discussion session. About one-third of the semester is devoted to studying the basic nature of the soil systems and world soil resources. Most of the remainder of the semester focuses on environmental issues involving soils, including nonpoint water pollution, waste disposal, homeowner problems, and soil bioremediation. Students are actively engaged in learning through role-playing, mini-field trips, demonstrations, interactive lectures, and a choice of semester-long writing projects. Teaching soil and environmental science to nonscience majors involves unusual challenges, but is rewarded by reaching an audience with whom natural scientists need to communicate, but rarely do.

DESPITE some 30 yr of environmental education in the nation's schools, a recent survey (NEETF, 2001) found that fewer than 33% of adult Americans could correctly answer at least 9 out of 12 simple, substantive questions about the environment. Only 28% could identify "surface water running off yards, city streets, paved lots, and farm fields" as the leading cause of water pollution. Such survey results underscore the importance of continuing environmental education efforts at all levels. Most introductory natural resource or agricultural courses (such as Introductory Soils) enroll primarily students for whom the course is a requirement for their major curriculum. Most of the students in such introductory courses have their academic home in colleges of agriculture and natural resources or related colleges. Consequently, most soil scientists (or other natural resource scientists) have relatively few opportunities to reach a more general audience of people, many who may never have given a thought to soils or other natural resources. Furthermore, students majoring in business or humanities may have very little understanding of what science is and what scientists do.

Fortunately, many public universities attempt to assure a broad education by requiring *all* their students to take at least *some* courses in natural sciences as well as in social sciences and humanities. At the University of Maryland, a freshman-level course entitled Soil and Environmental Quality was developed as an option for students to fulfill the University's general liberal arts CORE curriculum requirements and to reach an audience that normally is not exposed to natural resource sciences and scientists.

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PURPOSES AND OBJECTIVES OF THE COURSE

In 1976, then University of Maryland professors John Foss (recently retired from the University of Tennessee) and Fred Miller (currently with Ohio State University) started team-teaching a course (then called Soil and Environment) in response to an upsurge in public interest in ecology and environmental quality. I assumed responsibility for the course when I came to the University of Maryland in 1979. Although initially offered only once per year, the course has been offered twice per year since 1995, when several faculty members volunteered to take turns teaching it in spring. Over the past 25 yr, the course has evolved to serve these three purposes:

1. To reach out to an audience that does not normally hear about natural resource sciences and that has only the most vague idea of the scientific method. This outreach includes helping these students understand some of the connections between soils and environmental issues that affect their lives. Therefore, a major theme throughout the course is the interconnectedness of all parts of the environment.
2. To excite in students a curiosity about soils so they may become interested in further study and perhaps declare a major in a soils-related field. In other words, the course is used as a recruiting tool.
3. To serve as a vehicle by which the Department of Natural Resource Sciences and Landscape Architecture (formerly the agronomy and horticulture departments) can impact the larger campus community and render a service to the general student body. The course gives students exposure to science and the scientific method, helping them round out their education and meet the university requirements. In this regard, the course serves much the same purpose as, say, an introductory astronomy course, which also is aimed primarily at nonmajors. Now entitled Soil and Environmental Quality, the course presents soil science as a subject of interest for people who do *not* intend to pursue a career related to soils.

The backgrounds and interests of students who take this course are typically very different from those of students who enroll in our professional gateway to soil science, Fundamentals of Soil Science, which is taught at the sophomore level. Fundamentals of Soil Science provides a rigorous introduction to and survey of the field of soil science. It is designed to prepare students either for more advanced soils courses or for related courses that depend on basic soils principles. On the other hand, Soil and Environmental Quality is taught at a much less rigorous level to be accessible to students whose math skills are often underdeveloped and who may have taken no other college science courses (some have not had much science in high school, either). Among the majors that contribute large numbers of students to this course are letters and sciences, general studies, business, journalism, and criminal justice; fewer than 10% of the students come from the College of Agriculture and Natural Resources (Fig. 1).

Teaching this mix of students is a very different experience than teaching a relatively homogeneous group of students who all are majoring in some soils-related field and have a professional interest in the subject. In Soil and Environmental Quality, the range of student backgrounds and interest levels is extreme. In my informal estimation, about one-third of the students choose to enroll in the course because they have a genuine interest in environmental issues. Another third of the students bring a neutral attitude and only become interested occasionally when a topic seems to have particular relevance to their lives. The final third of the students are clearly taking the course mainly because it fulfilled their CORE nonlab science requirement at a convenient time. Many in this last group openly act as if they wish it were over already. Teaching this course takes more of my energy than other courses because of the need for challenging the first group, while stimulating interest among the second, and managing to keep the third group from disrupting or dispiriting the class (and the instructor). My personal observation suggests that it is more difficult to achieve high student evaluations with this type of class when compared with classes in which students bring a greater degree of shared interest in the subject and identify more strongly with the instructor's professional discipline (Table 1), a factor that instructors seeking tenure may wish to consider. Although, student evaluations may also be influenced by grading, I use a normative grading system (Weil and Kroontje, 1977) in this course that consistently assigns a grade of C or lower to between 40 and 50% of the class. Nonetheless, enrollments have consistently been near the capacity of 25 students in each of six discussion sections.

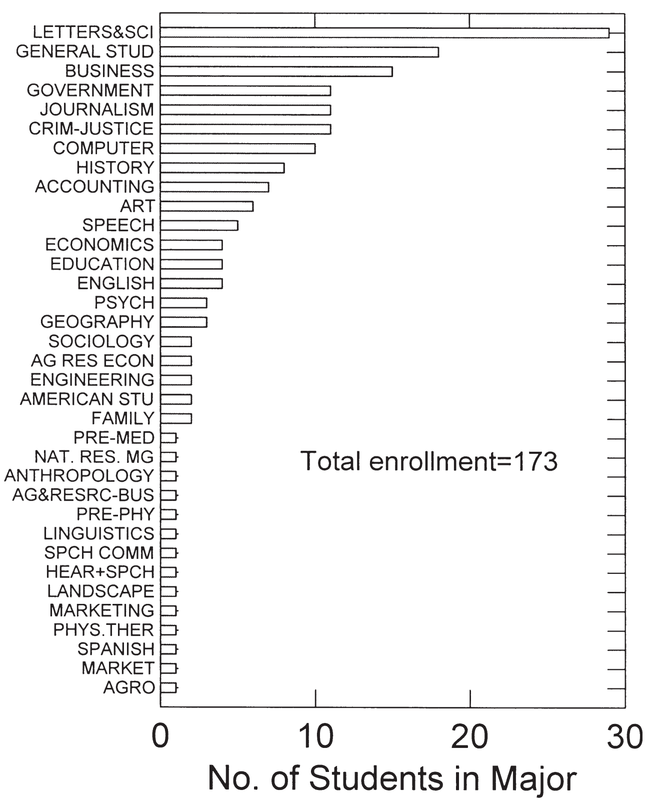

Fig. 1. Academic majors of students enrolled in Soil and Environmental Quality. Data for fall 1999.

COURSE FORMAT

The format of the course is different from that of most science courses: it is a 3 credit hour course in which the class as a whole meets for two 50-min lecture hall sessions and breaks into small groups for an additional 50-min discussion section each week. There are no science or math prerequisites. Although up to 175 students may be enrolled in the class, I treat the lectures in a very informal and interactive manner, so that they sometimes resemble a large-scale group discussion. I make frequent use of rhetorical questions, seeking to have five or six students contribute elements to each answer. This approach works well once the class realizes that I will not belittle any answer and will use even wrong answers to build the discussion. I find this technique takes advantage of the great diversity of academic backgrounds represented in the class and turns this potential handicap into an advantage.

The discussion sections each enroll about 20 to 25 students. In these sections, graduate teaching assistants have the opportunity to review and explain topics from lecture. However, most discussion section time is spent on activities that amplify and expand on lecture topics. These activities include case studies of local (e.g., sludge application to Maryland farmland) and not-so-local (e.g., forest protection regulations in Africa) environmental controversies in which students role-play as the various protagonists. Early in the fall semester, the discussion sections' activities are similar to laboratory sessions. These activities include simple hands-on demonstrations and brief forays outdoors to auger a soil profile or to measure water infiltration rates on campus. One aim of the latter is to give the students some introductory experience in gathering, analyzing, and interpreting quantitative data.

UNIQUE MIX OF COURSE CONTENT

Soil and Environmental Quality includes several unique features that make it particularly effective for the special roles

Table 1. Student evaluations of selected aspects of Soil and Environmental Quality compared with other courses taught by the author and all courses offered by the Department of Natural Resource Sciences and Landscape Architecture. Mean scores for fall 1999 and 2000 on standard departmental student evaluation forms.

Evaluation question	Soil and Environmental Quality taught by author		Other courses taught by author		All courses offered by NRSL Dep.	
	score†	*N*	score	*N*	score	*N*
Overall, this was an excellent course on this subject.	3.85	136	4.36	83	4.13	1311
I learned things useful to my professional, intellectual, or academic interests.	3.48	136	4.45	83	4.08	1311
Topics were organized in a logical sequence.	3.98	136	4.12	83	4.02	1311
Hands-on or real-life experience and skills were developed.	3.71	136	ND‡	ND	3.94	790
Time required for study and assignments was appropriate for a course of this nature.	3.66	136	3.89	83	3.92	1311
Instructor encouraged class involvement.	4.02	136	4.31	83	4.17	1311

† Score based on 0 (poor or strongly disagree) to 5 (excellent or strongly agree).
‡ Data not available.

just described. The first is the nature of the covered topics. The specific topics covered are partially determined by a questionnaire administered to the class during the first lecture session (Fig. 2). Although most of the students at that stage are relatively uninformed about the possibilities, maintaining this flexibility gives the students some ownership of the course content and provides the instructor with valuable information on students' interests. I attempt to include, and give extra emphasis to, those topics receiving the most votes on the questionnaire.

Unlike most soils courses, this course includes very little discussion of agricultural issues. Instead, most of the topics are of immediate relevance to suburban and urban residents who comprise the bulk of the students. The course consists of three main units: The Soil System, World Soil Resources, and Environmental Problems Involving Soils. For the first section, I have tried several very elementary soil science textbooks (e.g., Harpstead et al., 2002; Dubbin, 2001). For the remaining two-thirds of the course, I assign readings from a 300-page anthology of articles I assembled from such sources as *Scientific American*, *The Washington Post*, the *Bay Journal*, extension publications from several states, and Chapters 1 (The Soils Around Us) and 18 (Chemical Pollution of Soils) from Brady and Weil (2002). This anthology is printed locally and sold in the campus bookstore for about $30, which includes the cost of copyright permissions.

The Soil System

The first 5-wk unit introduces the Earth system in general and the soil system in particular. The organizing concept is the five fundamental ecological functions of soils, namely: the support of plant growth; the partitioning and conditioning of water in the hydrologic cycle; cycling of nutrients and organic wastes; provision of habitat for soil organisms; and service as an engineering medium (Brady and Weil, 2002). After a brief introduction to the hydrosphere, lithosphere, atmosphere, and biosphere, a few basic principles of ecology are explained with common real-life examples. Then, the properties of the soil system are described, using approximately six lectures to discuss first physical, then chemical, and finally biological properties of soils. The soil system is integrated in terms of pedology to present soils as natural bodies in the field and the different types of soils in the world. The latter involves what I call *a worm's eye tour* of the world's soils, and the ecosystems and cultural systems in which soils are found. This leads into a discussion of world soil resources as a major part of the global environment.

World Soil Resources

The second unit goes on to describe the roles that soils play in contributing to and in resolving such global problems as world food production, hunger, the greenhouse effect, and loss of biodiversity. One of the first issues discussed is energy conservation and production. This topic helps to impress the students with the wide range of issues that involve soils directly or indirectly. In particular, the use of fossil fuels is discussed, both in terms of the greenhouse effect and in terms of various types of air pollution. The use of contemporary photosynthesis to provide fuels such as vegetable oils (e.g., biodiesel), wood, and other biomaterials (e.g., biopolymers) is compared with the use of fossil fuels in terms of the impact on atmospheric composition and sustainability. It becomes clear during the discussions that soil will have an increasingly important roll to play in helping provide biofuels and biofeedstocks to industry once fossil fuels reserves eventually are depleted.

The last part of this unit focuses on the degradation of the soil resource, itself, especially through wind and water-caused erosion, and through chemical and ecological degradation by various forms of soil misuse. Degradation and mismanagement of soils are linked to degradation of the environment in general. Among the examples discussed are such large-scale problems as global warming, ozone depletion, human hunger, habitat degradation, desertification of the Aral Sea region in Kazakhstan, and preservation of biodiversity in the rain forests of the tropics.

Environmental Problems Involving Soils

Ground Water. The third and longest unit of the course focuses on pollution problems associated with soil, particularly water resources and their relationships to soils. The first topic discussed is the soil's role in the hydrologic cycle, which highlights the soil as provider and purifier of water, and as a major influence on the partitioning and movement of water through the hydrologic cycle. In this section, hydrologic processes such as infiltration, percolation, ground water movement, and saturated and unsaturated flow are introduced. The concept of ground water is given particular attention, including confined and unconfined aquifers and the dynamics of

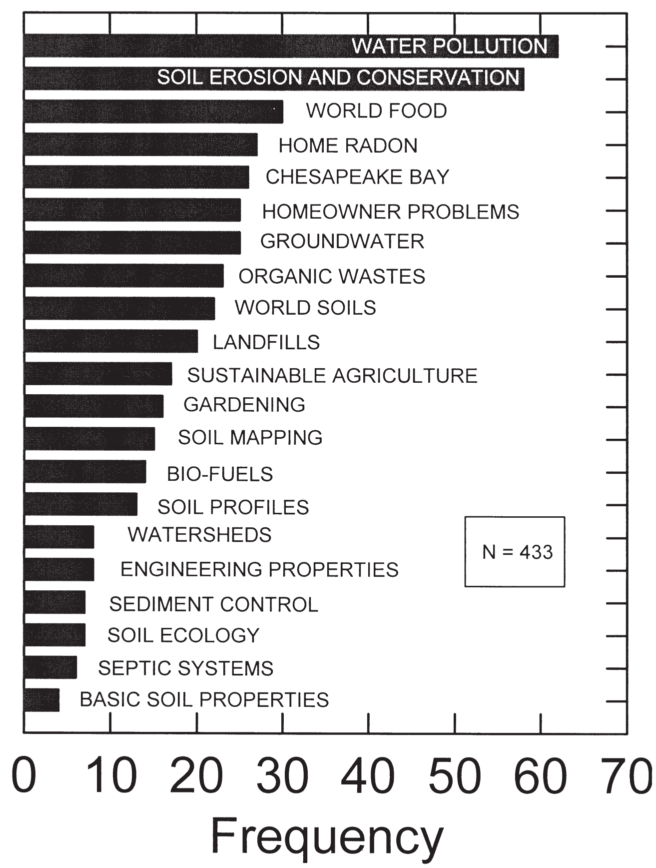

Fig. 2. Topics that students indicated they would most like to learn about, as of the first day of class. Total of 433 respondents in 1998–2000.

ground water movement. Problems discussed concerning soil–ground water interactions include excessive ground water pumping, the resulting development of cones of depression in the water table, and the infiltration of salt water into coastal aquifers. The importance of soil management—especially in aquifer recharge areas—is discussed, as is the importance of water use efficiency in irrigation. Appropriate use of irrigation within various ecological settings is an important soil–water resource issue since irrigation remains the largest consumptive water use in most countries, including the USA.

Soil and Water Pollution. Water pollution is the second topic discussed in this unit. Point sources, nonpoint sources, and the relation of water pollution to soil management are stressed. The main types of water pollutants; the extent to which they impact on rivers, lakes, and estuaries; and the negative effects they have on aquatic life and on the value of the aquatic resources are all topics included. Students see that most water pollution problems have their origins on land, and that these problems are significantly influenced by soil management. Students learn why sediments are the principle pollutant problem in most rivers and why nutrients are the principle pollutants in most lakes and estuaries. The nutrient cycles of N and P are briefly discussed in relation to leakage from terrestrial ecosystems into aquatic ecosystems.

Consideration of nutrients as pollutants leads into a discussion of the principles of eutrophication. Lectures focus on the Chesapeake Bay as a case study, highlighting the history of declining fisheries and worsening water quality, as well as the historic interstate agreements that have developed programs to turn the situation around. Here students learn that control of most point source pollution was accomplished early on in the history of water quality efforts, leading to the current focus on nonpoint source pollution, which now causes most remaining water pollution problems. The Nutrient Management Program in Maryland is highlighted, as are the concepts of nutrient balance in a watershed and on a farm.

One or two lecture periods are devoted to wetlands, including the properties and soil processes of natural wetlands, their roles in the hydrologic cycle, and in nutrient pollution abatement. Some time also is spent on the related topics of buffer strips and other types of land management aimed at reducing nutrient pollution and land use impacts on water. Finally, organic and inorganic toxins such as heavy metals, pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) are discussed. The emphasis here is on how these substances may become pollutants because of management practices on both agricultural and nonagricultural land. Students also learn about steps that can be taken to control the use of these substances and their movement once they have been introduced into the environment. This leads to chemical pollution of soils themselves and the relatively new field of bioremediation, in which biological processes are used to decontaminate soils polluted by accidental spills or misapplications of toxic chemicals.

Everyday Soil Impacts

The final section of the course focuses on more personal aspects of soil–environmental issues, specifically the roles soils play in the life of a homeowner or even an apartment dweller. In this section, students examine their lifestyles for impacts on the environment and soils. Students consider their own generation of solid wastes and the ecological and economic aspects of materials recycling. The consideration of wastes and recycling leads to a discussion of sanitary landfills. Students learn how soils are involved in the functioning of both containment-type and natural attenuation landfills. The two main functions of landfills—safekeeping of wastes and protection of ground water—are related to soil properties, as are the gaseous emissions from landfills that contribute both to safety problems and to greenhouse and other atmospheric effects. The class speculates about the environmental and social problems that would be associated with attempting to site a new landfill in suburban Washington, DC.

Next, students consider the subject of their own bodily wastes and home sanitary facilities, leading to onsite sewage disposal and the general issue of wastewater treatment. First municipal wastewater treatment is discussed, with the emphasis on what is done with the effluent and the sludge, both of which can be used as soil amendments. The degree to which current wastewater treatment systems are or are not based on ecological principles is discussed. Advantages and hazards of these systems are also addressed. Many of the students grew up in homes located outside of the municipal sewage system; therefore, whether they were aware of it or not, their families were responsible for their own onsite waste management. This leads into a detailed discussion of how septic tanks and filter field systems operate, how they are regulated, and how soil properties affect the abilities of these systems to treat human waste.

Students consider the management of black water vs. gray water. Gray water systems, composting toilets, and other alternatives to the ubiquitous (enormously wasteful) flush toilet are among the more ecologically sound approaches considered for the treatment and reuse of these wastes. The interface of soils and homeowner waste management leads to a discussion of the biological and physical principles of composting, and the use of compost as a soil amendment. Both back yard and commercial scale composting are discussed (I usually have the students feel and smell a sample of the finished product from my own back yard compost pile).

The making of compost and cycling of nutrients or organic matter within a home site leads to a general discussion of gardening and soil fertility, which takes about one class period. The final homeowner-oriented topics are problems of wet basements, poor drainage, and radon movement into indoor living spaces. Home drainage presents an opportunity to reemphasize the principles of soil water movement discussed earlier in the semester, but in a way that highlights the relevance to individual students and possible impacts on their current or future homes. Students come away with information that they feel may help them choose an appropriate house site, or at least recognize the need for a drainage system if a house is constructed on less well-drained soils.

A full class period is devoted to the radon problem—the hazards of radon toxicity, where radon originates, how it can be detected, how it moves through soils and rocks into houses, and how houses can be designed or retrofitted to minimize the indoor concentration of radon. The final day of class is ideally reserved for students to reflect together on the many ways in which soils impact their daily lives, and in which their own life styles impact on the quality of our soil resources.

Table 2. Components of three term project assignments and criteria used to grade the final product. Students submit all previous work with each new portion of the assignment so that the instructor can judge the progress made and response to earlier suggestions. Students choose one of the three assignments.

	Letter	Illustrated investigative report	Group presentation
Preliminary components due 2nd week of semester.	For 10 points: A one-page typed outline. 1. The specific problem in question (if legislation, cite a specific bill number and name; if a local problem, cite its specific nature and location). 2. Complete citations for 3 (not in-class information). 3. Name, title, and address of addressee.	For 5 points: A brief outline of the project. 1. Media you plan to use. 2. Type of environmental site you plan to investigate.	For 5 points: Brief outline. 1. One sentence topic. 2. List of names, contact numbers, and responsibilities for all group members.
Components due 4th to 6th week of semester	Due Week 4 for 20 points: Four-page (double spaced) background paper including: 1. History and nature of the problem. 2. One or two paragraphs on your position concerning the issue. 3. Proposed solution to the problem and what facts that support your position. 4. Complete citations for all references. Due Week 6 for 20 points: First draft of complete letter stating your position on the specific issue, giving substantive reasons for your position, and citing scientific findings and media reports to support your argu ment.	For 15 points: One-page background. 1. Describe the topic of the project 2. Include the location(s) and date(s) you plan to shoot the slides/scenes. 3. Name a contact person involved with the site(s) (e.g., the manager of a landfill). • Submit final slide/script or video, due 3 weeks before end of the semester.	For 15 points: One-page progress report. 1. Production schedule. 2. One paragraph describing the topic. 3. One paragraph describing the presentation's educational message on the environment. • Presentations are scheduled during the last week of discussion sections.
Grading criteria for final product	• 30%—Writing quality (grammar, spelling, punctuation, transitions, vocabulary, neatness, etc.). • 40%—Substantiality of your argument (do you have your facts straight, and is your argument logical, complete, and persuasive?). • 30%—Appropriateness of topic and addressee.	• 20%—Originality and thoughtfulness. • 25%—Quality of photography or visuals. • 25%—Documentation and information. • 5%—Professional appearance of the project. • 25%—Quality of writing (grammar, composition).	• 20%—Creativity, originality, and thoughtfulness. • 30%—Documentation and substantive information given. • 20%—Quality of photography or visuals. • 10%—Logic and accuracy. • 10%—Professional appearance of the presentation. • 10%—Individual performance.

TERM PROJECT ASSIGNMENTS

Grading for the course is based on three to four 1-h exams (part multiple-choice and part short essay), a comprehensive final exam, class participation in discussion sections (as indicated by attendance, participation in discussions, and completion of short hand-in assignments), and a term project. The term project accounts for about 20% of the course grade. Objectives for the term project in this course are twofold: (i) to meet the writing requirement for the liberal arts education CORE program of the University of Maryland, and (ii) to enable students to delve deeper into a particular aspect of soil and environmental quality. Students are given a choice of doing one of three possible term projects (Table 2).

The Letter

The first choice is perhaps the simplest assignment and its description in the syllabus is accompanied by a warning to students that this assignment is actually more challenging and time-consuming than it might appear to them at first glance. The assignment is to write a one-page letter to an individual who is in a position of responsibility concerning an environmental situation that needs action. The letter must be written to a real person about a real environmental situation involving principles of soils discussed in the course. The student is not to indicate in the letter that he or she is writing this as a class assignment, but should write the letter as an informed, concerned citizen.

The first challenge of this assignment is finding an appropriate environmental situation that needs to be addressed. This could be a situation that the student can observe in the local area, such as soil erosion on campus, pollution in a nearby river, dangerously stored toxic waste, a flood plain in need of a buffer strip, sediment control on a construction site, or poor manure handling on local farms. Other topics could include broader issue of government policy, such as support or criticism of a particular bill before the U.S. Congress or state legislature. The instructions are to write a letter of only one page in length because busy people in positions of authority do not generally have time to read more than that.

Early in the semester, students submit an outline that includes the topic, a one- to two-page background paper highlighting the nature of the problem, the responsible person to whom the letter will be addressed, and that person's address and official title. This assignment requires students to use library and Internet resources to find people in authority. Typically, students will write to legislators, city or county officials, newspaper editors, corporate departments of environmental compliance, or possibly the physical plant operations on campus.

I consider the letter to be a serious writing assignment. Students who consider themselves good writers may become chagrined to find they need to go through two, three, or more drafts before an acceptable letter is achieved. Finally, the letter is mailed and responses are shared with the class if they are received before the end of the semester. In its original form, this assignment required three separate letters, one per month, with the results to be shared with the class. However, I soon learned that for these letters to be good enough to actually mail without embarrassment, it was more productive to assign three (or more) drafts of a single letter. Even so, many students find it challenging to produce a concise, well written, well argued, and well informed one-page letter. Nonetheless, students report that they feel quite proud and empowered when they receive responses (as they usually do) from real-world public figures, especially when the response goes beyond a form letter or indicates that they have stimulated some new actions.

The Group Presentation

The second assignment choice is a group project, which allows a great deal of leeway for creativity. Groups of three to four students self-organize around a topic of mutual interest. The assignment is to make a presentation on this topic in discussion section using any format or medium that the group desires. The only requirement is that the topic be on a soil-and-environment issue and that the presentation be informative as well as possibly entertaining.

This option is very popular with students, especially among those who have friends in the class. Examples of past projects include production of an onsite video showing soil erosion processes in the Chesapeake Bay watershed, presentation of a skit on deforestation, and creation of a TV-style quiz show using nonpoint source pollutants as the topic for a pool of questions. A brief background paper on the topic, which is also part of this assignment, helps organize the groups' ideas and assists the instructor in grading. However, most of the grading is done during the actual in-class presentation, which is limited to 5 min per participant or up to 20 min per presentation. Several sessions of the discussion sections are scheduled for this purpose.

The Illustrated Onsite Investigative Report

The third assignment choice involves individual investigative journalism. Specifically, the student must find a site that involves a soil and environment issue, either a problem where something has gone wrong or an example of proper management of a soil environmental situation. Sites that have been subjects for this investigative journalism assignment include a local sanitary landfill, sewage treatment plant, sewage sludge composting facility, tree nursery and erosion control company, and a stream bank stabilization project. The student is to find out who is in charge of the chosen project site, get permission to visit with a camera, and take photographs detailing the situation. Additional visuals must be created to present facts and data about the site. The next step is to organize the visuals into a logical sequence and write a script to explain them. The illustrated report can take the form of a slide set and script or a computer image presentation with narration. Thus, in essence, the student prepares an original, highly illustrated investigative report. Students turning in the best reports are invited (but not required) to present them to their discussion sections.

For all three types of term assignments, students report that they have had very eye-opening experiences. They express excitement about getting out in the real world and seeing how soils actually affect the environment.

CONCLUSION

To summarize, a course has been developed to introduce nonscience students to environmental issues and the roles that soils play in them. It presents a scientific viewpoint without being highly quantitative and without requiring previous college-level science course work. Student response to the course has been consistently positive, both in terms of comments on formal course evaluations and in terms of word of mouth, which has kept the enrollment in this nonrequired course at about 125 to 150/yr (80–105% of seats offered) for the past 10 fall semesters. Other positive feedback includes a small, but steady stream (3–5/yr) of students who are motivated to change their majors to a soils-related program, and the occasional letters or emails (4–5/yr) from former students and advisors in other colleges. I therefore believe that the extra effort required to teach this type of *service* course is a worthwhile investment in communicating with a nonscience-oriented segment of the public that we in natural resources education rarely reach.

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