Bringing soil science to non-science university students and visa versa

Ray R. Weil[A]

[A]Department of Environmental Science and Technology, University of Maryland, College Park, MD 2782, USA, Email rweil@umd.edu

Abstract
Knowledge of environmental sciences in general and soil science in particular, is very limited among the public in the US. To reach people beyond the traditional audience for natural sciences, a course in Soil and Environmental Quality was developed for students in non science 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 non science majors involves unusual challenges, but is rewarded by reaching an audience with whom natural scientists need to communicate, but rarely do.

Key Words
Liberal arts, environmental education, soil science majors, university teaching.

Introduction
Despite well over 30 years of environmental education in the U.S. schools, surveys (Coyle 2005) suggest that fewer than 32% of adult Americans can correctly answer nine out of 12 simple but substantive questions about the environment. Only 28% could identify non-point run-off as the leading cause of water pollution. Only 33% knew that burning coal and oil was the main source of electric power generation in the U.S. The good news is that the number correct on this environmental knowledge quiz improved substantially with increasing levels of education. These survey results highlight the necessity of continuing environmental education efforts at all levels. Certainly soil science has a role to play in this effort. University courses that provide introductions to natural resource or agricultural subjects (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 who may never give any thought to soils or other natural resources. Furthermore, students majoring in business or humanities will eventually make decisions and cast votes on environmental issues in their various adult roles in society, yet few will have an understanding of soils or the basic facts about the environment and may have very little understanding of what science is and what scientists do.

Fortunately, many public universities in the U.S. require *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 we developed an introductory level course entitled "*Soil and Environmental Quality*" as a vehicle to address an audience not usually reached by soil scientists.

Purposes and objectives of the course
The course was developed to serve three main purposes:
To reach out to an audience that does not normally hear about soil science and that has only the vaguest idea of the scientific method. This outreach includes bringing these students some awareness of the connections between soils and the environmental issues that affect their lives. Therefore a major theme throughout the course is the inter-connectedness of all parts of the environment.
To cultivate in students an excitement about soils that may lead further study in soils related fields. That is, the course is used as a tool for recruiting new students to soil science.

To serve as a vehicle by which the Department of Environmental Science and Technology can make render a valued service to the general student body and the larger campus community. The course gives students some exposure to science, helping them round out their education and meet the University requirements. The course presents soil science as something interesting to study for people who do *not* intend to pursue a soils-related career.

Student backgrounds

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.* The latter, provides a rigorous survey of the field of soil science and requires at least one course in University level chemistry as a prerequisite. 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 in order 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 which contribute large numbers of students to this course are Letters and Sciences, Business, Government, Journalism, Computer Science, History, Accounting Art, and Criminal Justice; less than 10% of the students come from the College of Agriculture and Natural Resources. Teaching this mix of students is very different from teaching a relatively homogeneous group of students who all are majoring in some soils-related field. In *Soils and Environmental Quality* the range of student backgrounds and interest levels is extreme. In my 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 non-lab science requirement at a convenient time and show little interest. Teaching this type of group requires a deal of energy on the part of the instructor than because of the need to challenge the first group, while stimulating interest among the second, and managing to keep the third group from disrupting or dispiriting the class.

Course Format

The class as a whole meets for two 50-minute lecture hall sessions per week, breaking into smaller groups for an additional 50-minute discussion section each week. Although up to 175 students may be enrolled in the class, the "lectures" are very informal and interactive. Frequent use of rhetorical questions with five or six students contributing elements to each answer works well if even wrong answers are respected and used to build the discussion. This technique takes advantage of the great diversity of academic backgrounds represented in the class, turning this potential handicap into an advantage.

In the discussion sections, post- graduate teaching assistants review and explain topics form 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 Maryland farmland) and not-so-local (e.g. competition between urban uses and farmers for water resources in the Platte River basin, Nebraska) environmental controversies in which students role-play the various protagonists. Some discussion sessions include simple hands-on demonstrations and brief forays on campus to auger a soil profile, measure water infiltration rates and take a walking tour of campus hydrology. These activities provide students with some experience in gathering and interpreting quantitative data.

Unique mix of course content

Soil and Environmental Quality is very much a non-agricultural type soils course with very little discussion of agricultural production topics. Instead, most of the topics are of immediate relevance to suburban and urban residents who make up the bulk of the students in the course. The course consists of three main units: The Soil System, World Soil Resources, and Environmental Problems Involving Soils. The specific topics covered under the latter are partially determined by a questionnaire administered to the class in the first lecture session. Although most of the students are relatively uninformed about the possibilities at that stage, maintaining this flexibility gives the class some ownership of the course content and provides the instructor with valuable information on students' interests.

The soil system
The first five week unit provides an introduction to the Earth system in general and the soil system, in particular. The organizing concept is that of the six fundamental ecological functions of soils, namely the support of plant growth, the partitioning and conditioning of water in the hydrologic cycle, recycling of nutrients and organic wastes, provision of habitat for soil organisms, the modification of the atmosphere, and service as an engineering medium (Brady and Weil 2008). 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 physical, chemical, and biological properties of the soil system are described. The soil system is then integrated in terms of pedology to discuss soils as natural bodies in the field and the different kinds 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 they 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 bio-diversity. One of the first issues discussed is energy conservation and production. This issue helps to set the impress upon students the wide range of issues that involve soils directly or indirectly. The last part of this unit focuses on the degradation of the soil resource, itself, especially though soil erosion by wind and water and through chemical and ecological degradation by various forms of soil misuse. Degradation and mismanagement of soils is shown to be linked to degradation of the environment in general. Among the examples discussed are as such large scale problems as global warming, ozone depletion, human hunger, habitat degradation, desertification of the Aral Sea region in Kazakhstan, and preservation of bio-diversity in the rain forest region of the Amazon.

Environmental problems involving soils
The third and most extensive unit of the course focuses on pollution problems associated with soil, particularly water resources and their relation to soils. The concept of groundwater is given particular attention, including confined and unconfined aquifers and the dynamics of groundwater movement. Problems discussed concerning soil-groundwater interactions include excessive groundwater 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 with in various ecological settings is an important soil-water resource issue since irrigation remains the major consumptive water user in the United States and in most of the countries of the world.

Point sources, non-point sources, and the relation of water pollution to soil management are taken up next. Students see that most water pollution problems have their origins on land, and are greatly affected by soil management. Students learn why sediments are the principle pollutant problem in most rivers and nutrients are the principle pollutants in most lakes and estuaries. The nutrient cycles of nitrogen and phosphorus are briefly discussed in relation to leakage from terrestrial ecosystems into aquatic ecosystems. Concern about 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 programs that various political units have developed to try to turn the situation around. 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 of natural wetlands, their roles in the hydrologic cycle and in nutrient pollution abatement. Some time is also 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, PAH's and PCB's are discussed. The emphasis here is on how these substances may become pollutants because of management practices on both agricultural and non-agricultural land. Students also learn about steps that can be taken to control the use and movement of these substances once they are spread out into the environment. This leads into chemical pollution of soils and their bioremediation in which biological processes decontaminate soils that have been polluted by accidental spills or misapplications.

Every day soil impacts

The final section of the course focuses on the role of soils in the immediate life of a homeowner or even an apartment dweller. Students are asked to examine their own lifestyles for impacts on the environment and soils. They document their own generation of solid wastes and their ecological and economic impacts, including recycling efforts and management of sanitary landfills. Students learn about the various roles of soils and soil properties in the functioning of both containment-type and natural attenuation landfills. Students then consider their own bodily wastes and the sanitary systems in their own homes, leading to a discussion of on-site sewage disposal and the general issue of wastewater treatment. This leads into a fairly detailed discussion of septic filter field systems and the issues involved with the management of black water vs. gray water. Gray water systems, composting toilets and other alternatives to the ubiquitous (and enormously wasteful) flush toilet are considered. Other types of homeowner waste management that interface with soils are then discussed. Here the focus is on compost, at both the back yard and commercial scales.

The final homeowner oriented topics taken up are problems of wet basements, poor drainage and radon movement into indoor living spaces. The home drainage topic presents an opportunity to reemphasize the principles of soil water movement discussed earlier in the, but in a way that highlight 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 construction on less well drained soils. The final day of class is reserved for students to join in to review the many ways in which soils impact their daily lives and in which their own life styles impact the nation's and the world's soil resources.

Conclusion

To sum up, the course introduces students to environmental issues and the roles that soils play in them. It presents a scientific view point without being highly quantitative and without requiring a previous background in formal science education. For all three types of 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. Students express the opinion that the course is worthwhile, both on formal evaluations and by the fact that "word of mouth" has keep the enrolment in this non-required course at about 125 to 150 for the past 15 years. The small, but steady stream of students who are motivated to change their majors to a soils related program and the occasional feedback from former students and advisors in other colleges suggest that the extra effort required in teaching this type of "service" course is a worthwhile investment in reaching a non science-oriented segment of the public.

References

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