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Attracting (young) people to a soils career

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Attracting bright students to pursue studies in soil science: A case study

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Abstract
A major challenge facing soil science education is responding to insufficient enrollment in undergraduate programs. This issue has prompted many institutions of higher education to discontinue soil science offerings. The objective of this research was to evaluate a case study highlighting recent changes in a traditional undergraduate soil science degree program designed to increase enrollment and participation through a new environmental science curriculum. The case study details the addition of an environmental science program within a traditional soil science department at the University of Missouri. In 2004, a new environmental science curriculum was developed and offered for entering freshmen students. Over the next few years, five new required courses were developed by Soil Science Faculty for environmental science students. The effect of this offering has been to increase undergraduate departmental majors by approximately 45 to 50, with slight increases in incoming test scores. Participation by these students in soil science courses, soil judging activities, and other departmental offerings has enhanced soil science and increased the number of graduates with Bachelor of Science degrees pursuing careers related to soil science.

Key Words
Education, environmental science, soil science curriculum, undergraduate enrolment.

Introduction
Challenges with enrollment in soil science classes at the undergraduate level have caused many institutions of higher education to discontinue offerings of traditional soil science (Arnalds 2006; Baveye 2006; Baveye *et al.* 2006). These issues have occurred due to low interest of enrolling secondary school seniors in soil science, since they are unaware of opportunities in this significant discipline. Many students who wish to pursue careers in science do not understand how soil science can provide them with excellent career options.

How do soil science educators develop curriculum to attract secondary school seniors? One major area related to soil science to which secondary school seniors are attracted is the study of environmental science. These students need to be provided with the opportunity to see the advantages of studying the earth system as a way to develop their credentials and allow them to pursue their interests in helping to solve environmental challenges that face society today. If soil science educators participate in the development and offering of Environmental Science curricula, more students will have opportunities to study soil science. Many disciplines may wish to develop programs that cater to the interests of secondary school students in environmental issues. As a result, disagreements among different University colleges and departments can erupt over who “owns” Environmental Science and is permitted to develop environmental science programs. Such campus politics may stymie the active participation of Soil Science faculty in the development of environmental science programs.

The University of Missouri began offering a new Environmental Science undergraduate degree program in 2004. This program was established as an emphasis area in the Department of Soil, Environmental and Atmospheric Sciences due in part to this department being under the umbrella of the School of Natural Resources. In order to develop depth as well as breadth, the Environmental Science program at Missouri has three tracks: Land Management, Water Quality, and Air Quality. The objective of this paper is to present a case study on how a traditional undergraduate soil science degree program was re-designed to increase enrollment and participation through integration into a new environmental science curriculum.

History of soil science at the University of Missouri
The teaching of soil science at the University of Missouri began in the College of Agriculture and Mechanic Arts which was established in 1870 (Mumford, 1944). The Department of Agronomy was formed in 1904 and was split into the Departments of Soils, Farm Crops, and Agricultural Engineering in 1914 (Mitchell, 2004). The Department of Soils first employed an atmospheric scientist in 1949 (Woodruff, 1990). In 1967, a separate Department of Atmospheric Science was formed and the Departments of Field Crops and Soils were

re-combined that year into the Department of Agronomy (Mitchell, 2004). In 2005, the Departments of Agronomy, Entomology, Horticulture, and Plant Pathology were dissolved and joined together in the Division of Plant Sciences. Soil Science teaching and research faculty had previously transferred from the Department of Agronomy to the School of Natural Resources in 1990. The Department of Atmospheric Science joined them in 1992, and the name changed to the Department of Soil and Atmospheric Sciences. After some challenges in 2002, a new Department of Soil, Environmental and Atmospheric Sciences were formed in 2003 in the School of Natural Resources.

Environmental science curriculum

Since Soil Science faculty were part of the School of Natural Resources, proposals were made to develop an Environmental Science curriculum. The new Environmental Science curriculum was instituted as an emphasis area within the Department of Soil, Environmental and Atmospheric Sciences and offered in 2004. The curriculum is shown in Table 1 and features a strong emphasis in basic science courses and new environmental science courses (Table 2). Three tracks are offered in the degree program: land management, water quality, and air quality. The land management track prepares students to pursue careers related to soil science; other faculty within the School of Natural Resources assist in offering the water quality track; and the Atmospheric Science faculty offer a track in air quality.

The curriculum was developed with input from representatives of state and federal agencies. A required three credit hour internship gives students real-world experiences. Part-time employment as a field or laboratory technician assessing land management and water quality or conducting environmental monitoring can fulfill this requirement. These internships provide valuable experience for students pursuing professional careers. State and federal agencies likely to recruit environmental science interns include the Missouri Department of Conservation, the Missouri Department of Natural Resources, the U.S. Department of Agriculture-Natural Resources Conservation Service, and the U.S. Geological Survey. Private groups, such as environmental consulting firms and a diverse selection of industries and environmental advocacy groups, also provide internship opportunities. In addition to the Environmental Science major, a dual degree in Environmental Science and Biochemistry is offered. This is a very challenging curriculum with excellent employment opportunities for students pursuing this option. Students may also choose an undergraduate minor in Environmental Science.

New courses developed for environmental science

Several new courses have been developed for the new curriculum. These courses are listed in Table 2 and are taught by Soil Science faculty. These classes are in addition to the regular undergraduate Soil Science courses which include: Introduction to Soil Science, Soil Science Laboratory, Environmental Soil Physics, Environmental Soil Physics Laboratory, Soil Conservation, Environmental Soil Microbiology, Soil Fertility and Plant Nutrition, Soil Fertility and Plant Nutrition Laboratory, Environmental Soil Chemistry, and Genesis of Soil Landscapes. During the past couple of years, Environmental Science students have taken Soil Science courses selected within the track-specific options. Thus, by offering Environmental Science courses, Soil Science Faculty have also slightly increased enrollment in Soil Science courses.

Undergraduate enrollment levels

Undergraduate student enrollment numbers within the Department of Soil, Environmental and Atmospheric Sciences for the past 20 years are shown in Figure 1. Data in Figure 1 from 1990 through 1999 were obtained from the School of Natural Resources, University of Missouri; data from 2000 through 2009 were obtained from the Registrar, University of Missouri.

These numbers reflect several changes over the past 20 years. In 1990, all students shown were enrolled in Atmospheric Science, since Soil Science faculty taught courses to undergraduates in the Department of Agronomy for the prior 23 years. In 1992, a curriculum was developed for Soil Science undergraduates that were offered in the new Department of Soil and Atmospheric Sciences. This curriculum, which is still being offered, attracted between five and ten undergraduates within a given year. The Atmospheric Science curriculum experienced a significant increase in enrollment from 26 in 1992 to 90 in 2003 (97 total, including 7 Soil Science students). Beginning in 2004, subsequent enrollment increases in the department were due to the new Environmental Science curriculum. Thus, enrollment at present for the department has increased to 140 with about 45 to 50 undergraduates in Environmental Science. Growth in Environmental Science was gradual since it was offered as an emphasis area and interest spread due to word of mouth.

Table 1. Required semester courses for Environmental Science Program at the University of Missouri.

Requirements	Course Titles	Required Credit Hours
General Requirements		
English	Exposition and Argumentation	3
History or Political Science	US History or Political Science	3
Mathematics	College Algebra, Calculus, Statistics	9
Social Sciences	Economics, Sociology, Communications, Policy	12
Humanistic Studies & Fine Arts	Humanities, Fine Arts, Language	9
Science Requirements		
Biological Science	Biological Systems, Botany, Ecology	15
Chemistry	General Chemistry (Recommend Organic Chemistry)	8
Geology	Principles of Geology or Environmental Geology	4
Physics	Physics or Environmental Physics	4
Departmental Requirements[A]		
Atmospheric Science	Meteorology	3
Soil Science	Introduction to Soils, Soil Science Laboratory	5
Environmental Science	Introduction to Environmental Science, Soils and the Environment, Pollutant Fate and Transport, Hydrologic and Water Quality Modeling	12
Computer Science	Computing and Information Systems or Introduction to GIS	3
Track Specific	Land Use Management or Water Quality & Natural Resource Management or Atmospheric Physics & Weather Briefing	3
	Environmental Science Internship	3
	Five courses in Environmental Science or related areas (includes Soil Science courses)	15
Capstone Experience	Natural Resources Practicum	3
Electives		
Elective Courses	Other courses	14

[A]Two courses in the curriculum must be designated Writing Intensive.

Table 2. New courses developed by Soil Science Faculty and offered for the Environmental Science Program at the University of Missouri.

Course Number	Course Title	Year First Offered
1100	Introduction to Environmental Science	2006
3290	Soils and the Environment[A]	2000
3330	Environmental Land Use Management	2009
3500	Pollutant Fate and Transport	2009
4320	Hydrologic and Water Quality Modeling[A]	2002
4940	Environmental Science Internship	2006

[A]Courses offered in Soil Science prior to formation of the Environmental Science Program.

Comparison of entering freshmen average test scores (American College Testing, ACT) indicates the School of Natural Resources has increased 5.5% over 10 years relative to the campus which remained unchanged. Department scores have increased 5.3% over 5 years relative to the School. Despite these small score differences, more bright students are graduating with interests in soil science compared to 10 years ago.

Effects on soil science

A direct impact of the new program on soil science is the participation of environmental science students in traditional soil science courses (~3 current soil science undergraduates but about 30% higher enrollment in courses than 10 years ago). Traditionally, students in environmentally-related disciplines (forestry, fisheries and wildlife, geology, etc.) have taken the Introductory Soil Science course. However, environmental science students are now taking additional soils courses beyond the introductory course. In addition, the soil judging team is now composed primarily of environmental science students. Graduates from this program have been hired by the USDA-Natural Resources Conservation Service as well as consulting firms who have traditionally hired soil science graduates.

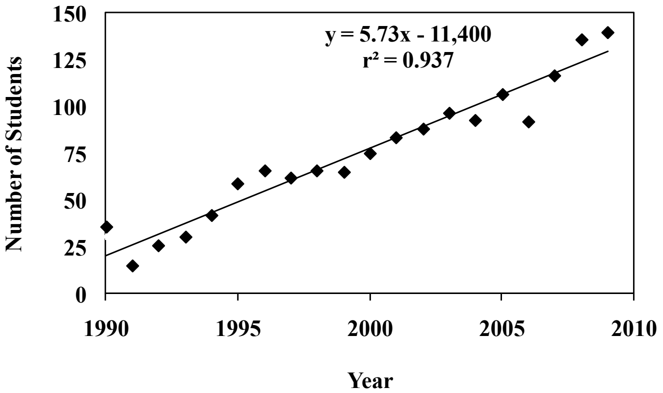

Figure 1. Number of undergraduate students in the Department of Soil, Environmental and Atmospheric Sciences at the University of Missouri as a function of year. Student numbers include Atmospheric Science, Soil Science and Environmental Science (beginning in 2004).

Conclusion

Low enrollment is a significant challenge facing undergraduate soil science programs today. This paper suggests that offering an environmental science undergraduate program can address the challenge. The case study concerns the addition of an environmental science program within a traditional soil science department at the University of Missouri. In 2004, a new Environmental Science curriculum was developed and offered for entering freshmen students at the University of Missouri. Five new courses required for environmental science students were developed by Soil Science faculty. The effect of this offering has been to increase undergraduate departmental majors by approximately 45 to 50. Participation by these students in soil science courses, soil judging activities, and other departmental offerings has enhanced soil science and increased the number of graduates with Bachelor of Science degrees pursuing careers in soil science (0 BS graduates pursuing graduate degrees 10 years ago vs. 6 BS graduates currently pursuing graduate degrees). Attracting students into environmental science with exposure to soil science has increased the number of students pursuing careers in soil science. Development of environmental science programs may help enhance enrollment in soil science programs at institutions of higher education.

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

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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.

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Can making soils more entertaining to encourage young people's interest in soils?

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Abstract
Soil is often ill-considered and attention to its importance has lagged behind that of air and water. It is a complex system, it is mostly unseen and in the everyday experience of some public can be even be seen as a nuisance that dirties their clothes and cars. This paper describes some novel approaches that have been developed in Scotland to increase public awareness of soils and aimed at young people. An underlying theme is to draw on similarities and contrasts between humans and soils and to use those relationships through a number of different communication mechanisms. Given that we are competing for their attention we have sought to entertain our audience through the use of interesting facts, glamour and humour whilst trying to ensure that the underlying scientific messages are robust and can be mapped to the science at different levels of understanding. Soil scientists do need to leave our comfort zone and engage in more novel techniques to ensure that societies are aware of the fundamental relevance of soils to their enduring existence.

Key Words
Public engagement, soil health, soil characters, soil forensics, games.

Introduction and Rationale
Soils provide the basis of life on earth underpinning many of the key provisioning and regulating ecosystem services but why is its importance not fully reconised? Is it because we have failed to engage? What motivate young people to engage in soils? Our experience is that young people want to be doing something important for the future as well as being interesting and it helps if it is also glamorous. So soils are important and we have no doubt but do they and how we tell me them about it?

There are a number of interconnected global issues such as food supply, population growth, climate change and energy provision; in all of these, soil plays a key role either directly or indirectly. The current generation of soil scientists have a responsibility to raise awareness of the importance of soils to young people to convince them that a career in soil science is not just interesting but also of fundamental importance to societies around the world. Novel approaches that employ different types of imagery and language interspersed with humour are likely to reach beyond that of conventional methods particularly for the younger generation.

Unlike many other science disciplines such as biology or chemistry, soil science can be a difficult subject to translate into publicly accessible material either through use of appropriate language, iconic imagery or through things that people see or use in everyday life. This issue is recognised widely and indeed is now finding its way into policy. For example the pending European Soil Framework Directive will require member states in the EU to have an awareness raising campaign (EC 2006). It is therefore an issue confronting soil scientists that is unlikely to go away and is relevant to all potential audience groups.

Guiding principles
Awareness raising and engagement with soils are beginning to become mainstream and there are a number of successful high profile initiatives such as the Smithsonian in Washington DC, the Soil Museum in Osnabruck in Germany and the Soil of the Year again from Germany and these are excellent examples of the type of activity needed. We have drawn on these examples and others that use non standard communication techniques (in the context of soil science) and with communication professionals we have been guided by some key principals in communication planning, objectives and techniques. These include

- Being aware of your key audiences and their specific needs;
- Appreciating the purpose of communicating i.e. what do we want the audience to do as a result of the communication?

- Making informed choices about the appropriate communication channels;
- Seeing communication as an opportunity for our own learning and improvement. We can learn what interests and stimulates the public and develop new ideas from that feedback.
- Creating interest and attention by being provocative, then relating and telling your story;
- Showing and not exclusively telling;
- It is their story, not yours, you want them to remember it so they need to understand;
- Tell your stories in the context of a bigger picture

We sought to apply the principles above as we developed a series of exhibits and materials built around the central theme of soil health and its varied characteristics. We attempted to relate soil to what interested people not what interested soil scientists. In this context we have also taken the opportunity to engage with the public on issues, such as crime investigation, that are also glamorous in the eyes of the young, have a wide public interest and profile and where soil is important.

Soils and human health: One of the same?
While there are many philosophical aspects to the relationships between soil and humanity as well as direct links between soils and human health, our approach was more pragmatic in that the more analogies to human health, condition and human self awareness we can make the more these similarities would be appreciated. For example similarities include:
- Just as are there are many human personalities so there "is not one soil but many" each with their own personality and way of behaving.
- As humans breathe so do soils - "Soils are living, breathing things"
- Other analogies to body functions can be made e.g. as a human kidney filters toxins; soils perform this function for the environment
- As humans can become unwell and sometimes even die, so can soils so "soils need care and attention"
- As humans can be injured and can be repaired, so can "soil be made better by our actions"

We used these analogies between humans and soils to develop the theme of the "Dirt Doctor" (www.macaulay.ac.uk/news/dirtdoctors/index.php) in which a number of techniques to illustrate soil and human health have been developed. There are several demonstrations within this theme from x–rays (of soil DNA fingerprints) to health and fitness checks. We have also produced a small A5 booklet that expands on the similarities outlined above. One of our most successful components is the development of a 'soil breathing kit'. In essence, this comprises a simple Infra-red gas analyser connected to a PC with appropriate software and a rubber tube to breathe into. A child (or willing adult!) is asked to blow into the tube to check they are breathing and their breath signal is then seen on the screen in just a few seconds. This immediately makes a personal connection to the experiment and at the same time proves the method to them. Next the tube is placed in a sealed Perspex cylinder containing soil and the respiratory pulse from the soil is recorded on the same graphical display on the PC screen. A relatively simple mechanism that illustrates a fundamentally important message about soils being living systems and which genuinely engages the public who try it out and lead into discussions of soil C release from soil and climate change.

Soil characters
The theme of connecting soils and humans in a practical sense was continued in the development of soil characters. We are all well aware we all have different personalities, strengths and weaknesses, live in different preferred places, do different jobs, and need to be managed differently to ensure that the best is brought out of each of us. It is innate in us that we are very diverse and belong to different races, creeds, families and even though we possess similarities we are fundamentally unique at different levels.
We have developed this idea into the development of different soil characters. We have given eight important Scottish soil types human names that reflect their personalities and appearance e.g. colour (for example, Rusty, a brown earth), their texture (Sandy, a regosol), what grows on them (Heather (*Calluna vulgaris*), a humus-iron podzol, see Figure 1), where they are found (Monty, an alpine podzol of Scottish mountains) or some other pedological feature (for example Rocky, a ranker).

We have described them against a set of common criteria and derived a soil "health profile" for each of them. The criteria are age, address, preferred occupation height/weight, personality, notes and health advice. Clearly these are attributes that are normally used to describe people but they are equally suited to soils.

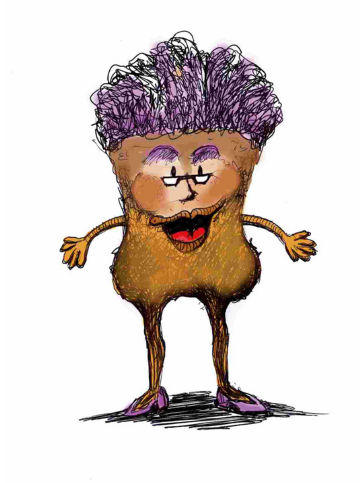

Figure 1 Heather, one of our soil characters.

The soil characters have been successful at a number of levels, primarily, we believe, because we have incorporated humour. We also specifically adopted a 'Pixar'-like of approach in which the character cartoon captures the children's attention and imagination whereas the text is more subtle and is designed to appeal to the inevitable accompanying parent, elder sibling or grand-parent. This conforms with the principles of provoking, relating and revealing outlined above. In this way the adult is used hopefully to reinforce the child's understanding through dialogue because they have understood it on a different level and want to engage in the fun and education of the child..

The characters have also been introduced to hard-bitten scientific peers and politicians and been well received showing that simplifying the message and making it fun works at more than one level.. The education sector, both in Scotland and Ireland, have recognised that this approach is a valuable teaching tool as the health profiles have been designed to describe soils in a consistent way to that required by the curricula in both countries. Teachers have also told us that it is much more fun teaching soils using the characters. Interestingly, modern education curricula (for example in Scotland, http://www.ltscotland.org.uk/curriculumforexcellence/index.asp) are looking for this cross-curricular topics, not just in the sciences and can also address connected learning outcomes such as looking after our environment, community stewardship and even promoting entrepreneurship though local food marketing initiatives.

Soils, crime and forensics (exploiting the "CSI factor")
This initiative is different from those examples relating soil and human health to each other, rather than relating soil to a topic that in which there is high public interest – death, crime and mystery. Crime, fiction and fact pervade the media and is also amongst the most popular topics in film, novels and television. We have recently been evaluating the use of soil evidence in crime situations and this lead to a successful research programme (SoilFit, www.macaulay.ac.uk/soilfit) with several partners in the UK and worldwide through a network initiative (GIMI, www.macaulay.ac.uk/geoforensic).

Based on this experience we developed the "Murder, Mystery and Microscopes" initiative which seeks to 'Unearth the Science behind the Crime Fiction' (http://www.macaulay.ac.uk/mmm/techfest09.php) Institute scientists have appeared on stage with well-known Scottish crime writers who read excerpts out of their crime novels and along with other forensic experts reveal the science behind these stories. It has been highly successful and the Institute has won further funding to visit venues across Scotland. Engaging with high profile UK crime writers such as Ian Rankin has helped raise awareness of the initiative and we have had full houses (up to 250 paying public) at all our events. An interesting aspect of this engagement has been that the crime writers (and there are many) are keen to engage not only because they can promote their own work but they are also looking for new ideas and sound science to illustrate future stories. The place a body is buried, soil on the murder weapon or spade used for concealment or found on a vehicle wheel arch are all examples of soil evidence and the science is fundamental to ensuring the right verdict is reached. By describing how soils vary in the landscape due to vegetation and depth it is possible to build a story that illustrates soil properties and differences. This approach has been very successful winning prizes but one of the main audience groups interested has been young undergraduates who are very attracted the topic as it combines science with high profile problem solving with a glamorous image. In offering project for MSc projects our soil forensic projects are always the first to be taken up.

Concluding remarks

Knowledge exchange and awareness raising activities such as those described are a very important part of modern science. A number of our colleagues remain uncomfortable with these approaches and clearly one of our key audiences must still be our scientific peers. However we all benefit from raising awareness as long as we ensure we stick to sound scientific principles and benefit from the experience of communication professionals. There is an even more fundamental reason for doing this type of outreach; we are duty bound to make society aware of the global issues that we face and more importantly the place that soil plays within them. It is at times difficult to engage the public and young people in particular in soils but this is often our problem and not theirs and more importantly we can do something about it. Whilst we still produce more conventional material in our outreach activities, we have learned that we have to think a little more radically about public engagement; work with communication professionals; innovate and experiment with novel approaches and seek to entertain people in making the all important initial connection. Only when that connection has been made will they be willing to listen to the serious messages. In our experience this type of work has added a new dimension to our own thinking, forced us to think about what we are doing in a different way and what we are contributing to society and its understanding of global issues as well as being a lot of fun, satisfying and fulfilling.

Acknowledgements

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Digital resources to excite students about soil science

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Abstract
The Soil Science courses at Purdue University have been a great recruiting tool for the department and have encouraged many students to select careers in soil science. Placement of soil science students after graduation has been approximately 95%. In recent years, new instructional technologies such as Student Response Devices and Adobe Acrobat Connect Pro® (Adobe Connect®) have allowed instructors to increase the students' engagement in the learning process. Individual Student Response Devices are used in lectures to assess learning. Based on input by each student, the class immediately discusses topics that are not clear resulting in enhanced learning. Adobe Connect® provides a way for instructors to tutor students via the Internet. Faculty arranges a time to be available at a specified Website to help students with homework assignments or exam preparation. The student simply accesses the Website and is immediately in the instructor's "meeting room" where students chat using text boxes and faculty can be seen and heard as they discuss the course material. Student reaction to the Student Response Devices and the On-line Tutoring has been positive and it has increased students' ratings of our courses, improved course grades, and enhanced student interest in Soil Science.

Key Words
Student response device, on-line tutoring, interactive learning, active learning.

Introduction
At Purdue University, there has been a long commitment to engaging students in the study of Soil Science by providing students a Soils Resource Center (open 40 hours per week) that utilizes a multitude of computer directed activities, individual tutoring, collaborative projects, and interactive lectures and discussions. Since the late 1970's, when students in the Introductory Soil Science course at Purdue University first began to use personal computers, technology and a team approach to instruction by the faculty have played major roles in helping students learn about soils (McFee *et al.* 1980). Today, students conduct their weekly lessons in a Soils Resource Center equipped with Internet-based lessons and surrounded with a multitude of displays and experiments directly related to each unit's instructional objectives (Figure 1). In addition to the many opportunities for collaborative, active learning in the Soils Resource Center, students in the Soil Science (230 students annually), Forest Soils (45 students annually), Soil Fertility (65 students annually), and Soil Ecology (25 students annually) courses have a new instructional technology tool for the course lectures. All students enrolled in these courses have an *e*Instruction classroom performance system (CPS)® pad or "clicker" that allows them to respond to the instructor's questions individually. When the instructor poses a question in lecture, each student answers using his or her clicker. Immediately, a histogram is projected that tells the class and instructor how well the students understood the concept (Figure 2). This encourages the lecturer to focus on helping those students who did not understand the concept rather than assuming students are understanding and keeping up with the lecture because one or two students responded correctly.

Students in our soil science courses also have the ability to access the instructor via the Internet through Adobe Connect® to seek help with homework and/or prepare for exams. The use of Adobe Connect® makes the instructor available to the students from home (or anywhere) at a point in time when the students are most interested in learning – usually late at night before the homework is due or before an exam. Regular face-to-face help sessions and tutoring sessions are still offered but many students have schedules that do not permit them to come to these sessions. Late at night, on weekends, or at anytime convenient to the students, the instructor can use Adobe Connect® from a location of choice. The interactive sessions may be recorded and made available via the Web to students who cannot attend the face-to-face help sessions or the synchronous Adobe Connect® sessions. This access to the recorded "meetings" allows all students to learn from the instructor's and the other students' comments at a time and place of their choosing. In the Soil Fertility course, approximately one tutoring session is offered every two weeks depending on course assignments and the exam schedule. On-line tutoring has only been recently introduced in the other courses.

However, because of the effectiveness of this technique in the Soil Fertility course it has been used College-wide to tutor students in math and chemistry the last two years with approximately 100 students participating annually.

Methods

The Student Response Devices (clickers) used for engaging the students during lecture are *e*Instruction® units, model number KGEN2EL from Denton, TX, USA; ISBN number 978-1-881483-71-1. The cost is $25.95 and can be used in multiple courses. The hand-held device uses infrared (IR) or radio frequency (RF) to transmit student responses to questions during a lecture (Educase 2007). Most clickers in use today are RF because they are faster and require only one receiver to be mounted in the classroom (Simpson and Oliver 2007). Many of the response devices allow for multiple choice responses (A through E), true/false, and numeric answers on a 10 digit numeric pad, which consists of a power switch, serial number and send button (Caldwell 2007; Simpson and Oliver 2007). The student must register their clickers with the unique serial number that each clicker carries and student ID (Duncan 2007). The clicker transmits the student responses to a portable receiving unit which transmits the student answers to a computer in the lecture room. Results from the entire class are displayed as a histogram on the projection screen. The histogram maintains the anonymity of the students. There are grading tools associated with the *e*Instruction® software which allow the instructor to specify the correct answer so student responses can be graded and the information sent directly to an electronic grade book (Caldwell 2007), if desired.

These devices work well at Purdue University because they are easy to use and are supported by the University with receivers and software in every classroom. During a typical lecture from three to six questions are posed about the lecture material and every student responds to each question. Often, students are encouraged to have discussion with other students as they develop answers to multiple choice questions or questions requiring calculations and numerical responses. Histograms of their answers are shown to the class immediately following all of their responses. Presenting the answers immediately engages the students in lively discussions.

For On-line Tutoring, Adobe Acrobat Connect Pro® (Adobe Connect®) is the interactive software which allows the instructor to be seen and heard by the students over the Internet and allows the students to see PowerPoint® presentations, Word® or Excel® documents, video clips, websites or white boards on which the instructor can write using a Tablet PC. Students ask questions and discuss topics with other students and the instructor by typing in a chat box. Both the clickers and On-line Tutoring activities provide opportunities for active, collaborative learning and stimulate interest in the course material. Students do not need special software because all of the support is provided through the software used by the instructor. The only requirement for the student is an Internet connection and a computer that has speakers.

Results

Many efforts in recent years have focused on improving science education. In most cases, however, the lecture and textbooks remain a one-way communication of material. Despite the effort put into organizing an excellent lecture, research conducted by MacManaway (1970) showed that for 84% of his students, 20 to 30 minutes was the extent of their ability to concentrate in lecture. Clearly, the success of an exemplary lecture is limited by the passive role that students take in lecture (Duncan 2007; Elliot 2003). An interactive system such as personal response devices, colloquially known as “clickers”, can promote student-centered learning and maintain a high level of active involvement by each student, which results in more learning and classroom enjoyment (Elliott 2003; Wood 2004; Duncan 2007; Caldwell 2007; Educase 2007).

Clickers address two fundamental challenges in teaching: how to engage students and how to assess whether or not they are learning what you are teaching (Duncan 2007; Stowell and Nelson 2007). In a traditional lecture, the instructor may get an answer or two to a question or possibly a brave student asking for clarification. In our classrooms where clickers are being used, all students are required to participate in the question posed by the instructor and can do so anonymously and avoid risk of embarrassment. They become active participants and not merely passive listeners. Clickers give students and instructors immediate feedback concerning student understanding of the material being presented (Duncan 2007). A quick look at the summary of responses may encourage the instructor to present the information in a new way and provide a catalyst to trigger further discussion.

The overall trend found in the research literature indicates a positive attitude toward the use of clickers in the classroom. When students were asked whether they enjoyed using clickers, if they were helpful, and if they should be used again, over 70% responded positively (Elliott 2003; Simpson and Oliver 2006). Caldwell (2007) found about 88% of the students enrolled in an introductory non-majors freshman biology course at West Virginia University enjoyed using clickers in the classroom. Features the students liked most about the computer response system and the resulting class improvements included its anonymity, improved discussion and interactivity, reinforced learning, increased awareness of student comprehension and increased teacher insight into student difficulties (Roschelle *et al.* 2004). Wood (2004) also found that through the use of clickers students could better retain and apply concepts learned in lecture. In our soil science classes, we have found that 84 to 100% of the students felt the use of clickers was valuable to their learning experience and that 75 to 100% felt using the clickers kept them more engaged in the lecture. Variation in these responses was due to course, semester, and class size. To our surprise, students in a class of 25 students usually rated the use of the clickers the highest. We have also used them in classes of over 75 students.

Students learn most easily when they are receptive to learning. As they do homework or study for exams, the opportunity to access the instructor at a point in time when they have the most questions is extremely valuable. The Adobe Connect® On-line Tutoring (Figure 3) provides a tool that puts the instructor in contact with the students in their residence hall, library, or in their apartment while allowing the instructor to be in his/her office at the University or at home (or at any other location). The collaborative nature of both of these activities exposes students to the thought processes of the other students and helps them see how their responses and understanding of the material match those of their peers.

As seen in Figure 3, students are "chatting" with the instructor and are engaged in the learning process. Use of Adobe Connect® for On-line Tutoring was rated extremely high by the students – 4.5 out of 5.0. All students in the Soil Fertility course indicated that On-line Tutoring should be continued. Student comments included "very beneficial and convenient, easy to use, encourage other instructors to do this," and "audio very clear and easy to see PowerPoints® and other documents**.**" Use of Adobe Connect® for On-line Tutoring allowed the instructor to bring up slides, websites, and homework documents with the added advantage of being able to write on these visuals or on a white board (Figure 3). In addition, the students see the instructor and hear his/her voice which has been noted by the students to be important. As pointed out by one of the students, "it's like the instructor is right there with you."

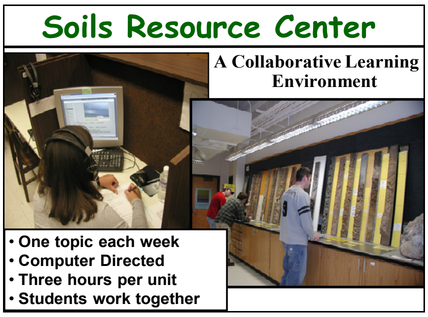

Figure 1. Soils Resource Center where students are actively engaged in learning.

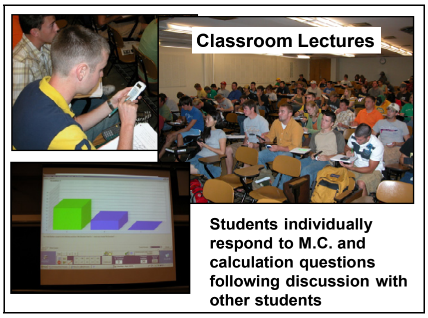

Figure 2. Using clickers in the classroom with a summary of student answers displayed on the screen following each student's response.

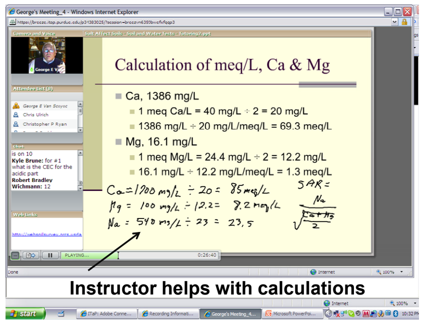

Figure 3. Computer screen showing On-line Tutoring using Adobe Connect® where students can see and hear the instructor and students chat via a text box to the left.

Conclusions

Instructional technologies like *e*Instruction® and Adobe Connect® allow instructors to engage students in the learning process and motivate them to excel in learning. In the Soil Fertility course where both clickers and Adobe Connect® On-line Tutoring were used, grades increased (A and B grades increased from 59%, a three year average, to an average of 75% for 2007 and 2008.) Course evaluations indicated that the quality of the course went from a rating of 4.4 out of 5.0 to 4.9 out of 5.0, and instructor quality and accessibility to the instructor went from 4.7 out of 5.0 to 5.0 out of 5.0. Students obviously liked using these instructional technologies and truly benefitted from them. Student interest in the soil science courses has remained high and post graduate placement of students (approximately 48 annually) in the soil and crop sciences is exceptionally good (95% had positions within six months after graduation).

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Problem-based learning and e-learning approach to teaching introductory soil science course

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Abstract
In most faculties of agriculture, the Introduction to Soil Science course is traditionally taught using a combination of lecture and laboratory formats. To promote engagement, improve comprehension, and enhance retention of content by students, Introduction to Soil Science was developed and delivered on-line using Blackboard® and Moodle® (Course Management Platforms), and employing a problem-based learning (PBL) approach to teaching the course. Delivering the course using PBL shifts the focus to student-centered learning by assigning student teams to work and report on a number of current soil science themes. Teams of students are responsible for problem investigation and definition, for identifying and obtaining the information and skills they will need for development of a satisfactory solution. Each of the problems undertaken by student teams concludes with student presentations and the preparation and submission of a professional quality work product. Teams work semi-competitively on the same problems so that students can learn from the experience of other students that are reflected in the oral reports. The construction approach of this online course is presented, including new teaching approaches, assessment tools and mapping of course outcomes to program outcomes.

Key Words
Active learning, student-center learning, project-oriented, team-based learning

Introduction
The Introduction to Soil Science course has a lecture and laboratory component. The main expected outcome of the course is problem-solving skills, which make student (1) be able in individual and team/group settings to use the scientific method to solve problems related to soil resource management; (2) be able to identify and treat problem causes, rather than effects; (3) be able to see the whole of a problem, including the social and economic aspects, along with the soil resource management aspects; (4) be able to make logical decisions based on available information and (5) be able, when appropriate, to include the personal values of those involved in decision-making. Problem-based learning (PBL) is an instructional method that challenges students to "learn to learn," working cooperatively in groups to seek solutions to real world problems. These problems are used to engage students' curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources (Duch 1996; James 1998; Duch, *et al.* 2001).

Introduction to Soil Science course is well suited for development and delivery employing PBL. PBL has shown promising results in achieving course objectives and positive outcomes in soil science courses overseas (Smiles *et al.* 2000; Amador and Görres 2004). Previously, Introduction to Soil Science course was delivered as a traditional teacher-centered, lecture based course. The developed course has been designed for delivery in a studio style that models the project-oriented, team-based approach used universally by soil science professionals (Smiles *et al.* 2000; Amador and Görres 2004; Kelley 2004). Delivering the course using PBL shifts the focus to student-centered learning by assigning student teams to work and report on a number of current soil science themes. Teams of students are responsible for problem investigation and definition, for identifying and obtaining the information and skills they will need for development of a satisfactory solution. Each of the problems undertaken by student teams concludes with student presentations and the preparation and submission of a professional quality work product. Teams work semi-competitively on the same problems so that students can learn from the experience of other students that are reflected in the oral reports.

Course Design
Introduction to Soil Science course was developed around four learning modules employing the Problem-Based Learning and active learning methodology, supported by Blackboard or Moodle and computer technologies. Each learning module is of four weeks' duration. Each module is structured as a short project

in which students work to understand, explore, and recommend contributions to soil science goals. Table 1 shows an example of the structure of Module 1.

The course learning modules are:
1. Module 1 – Soil Genesis
2. Module 2 – Soil physics
3. Module 3 – Soil Mineralogy, Chemistry and Fertility
4. Module 4 – Soil Survey and Classification

Table 1. The Structure of Module 1 - Soil Genesis.

Week-1	Week-2	Week-3	Week-4
Meeting 1	Meeting 2	Meeting 3	Meeting 4
Session-1 *Course Introduction* **1. Introductions** **2. Distribute outlines** **3. Mini-lecture:** Introducing Problem-Based Learning **4. Assign PBL readings**	**Session-1** *Problem Exploration 1* **Team work and consultations**	**Session-1** *Problem Solving 1* **1. Mini-Lecture:** Soil Development, Chapter 4 **2. Team work and Consultations**	**Session-1** *Outcomes & Solutions* **1. Team Meetings** **2. Student Presentations & Report submission**
Session-2 *Team formation and Problem Assignment* **1. Mini-Lecture:** Introduction, Ecological Functions, Rocks and Minerals, Chapter 1, 2 and hand out 2. **Team formation** **3. Problem Assignment** 4. **Team work session**	**Session-2** *Problem Exploration 2* **1. Mini-Lecture:** Soil Formation, Chapter 4 **2.Team work and Consultations**	**Session-2** *Problem Solving 2* **Team work and consultations**	**Session-2** *Module Test:* **Chapters 1, 2, 4**
Lab -1	**Lab -2**	**Lab -3**	**Lab -4**

Use of technology
Blackboard or Moodle and computer technology have been employed in all class session. Many additional linls to technologies, activities and resources links have been added to provide depth for student exploration and use following graduation. Additional technologies, activities and links include (1) educational videos, (2) internet sites & links and browse documents, (3) communication/interaction between faculty/students & student/student (using e-mail, new groups, white board and broadcast), (4) online quizzes. Students gain access to a large database of high quality questions and answers covering a broad range of topics. The answers and explanations will enable student to learn more about the topic as well as related material), (5) online laboratory skills virtual resources and hands-on experience during the laboratory time, (6) Net.OP (class management software) for monitor student activity in class, (7) PowerPoint for basis of course and student presentations, and (8) Chime Plug-In for 3-D silicates minerals visualization.

Restructuring lectures (learning activities - integrating lectures and hands-on)
The class time is 100 min. The lecture is divided into two sessions, 50 min. each. Based on the activities in each session, the distribution of session time (different from one class to another, see Table 1) is as follow: (1) 20 min. mini-lecture or team work, (2) 15 -20 min. consultation or watching educational videos or/and accessing web sites searching for specific information, (3) 5-10 min. taking online quizzes, (4) 5 min. homework/assignment, (5) interacting with instructors or classmate, e-mail, new groups and browse documents, anytime, and (6) doing Lab exercises (hands-on experience) during the laboratory time.

Delivery Method
Synchronous and asynchronous e-learning deliveries have been incorporated into Introduction to Soil Science course. The synchronous delivery method includes (1) mini lectures, (2) in-class discussion and

analysis, (3) face- to- face student teams meetings in class, (4) student oral report presentation, and (5) online laboratory skills virtual resources and hands-on experience during the laboratory time. The asynchronous delivery method includes (1) E-mail & digital drop box and (2) browsable documents on Blackboard or Moodle. Table 2 shows the mapping of Intended Learning Outcomes (ILO's) of Introduction to Soil Science course to Soil Science Program.

Table 2. Mapping of Course ILO's to Program ILO's.

Learning objective	Program ILO's	Code	Course ILO's
Knowledge and Understanding	A.1. Understand the theoretical basis of different soil properties	A.1.1	Identify the nature, origin and function of soils.
		A.1.2	Describe the soil texture, structure, porosity and color.
		A.1.3	Define the soil CEC and pH.
		A.1.4	Explain the concept of soil fertility.
	A.2. Explain the concepts, principles and theories of soil–water–plant relationship	A.2.1	Define soil water content, classification, potential and availability
	A.3. Outline basics of soil formation, survey and classification	A.3.1	Describe elementary aspects of soil formation
		A.3.2	Name different horizons in soil profile
		A3.3	Identify 12 soil orders in the USA Soil Classification System.
Intellectual Skills	B.1. Obtain and use information and ideas from both on- and off-line sources	B.1.1	Solve problem assignments of each course module using on and off-line collected information
		B.1.2	Calculate soil bulk density, porosity and water content.
	B.2. Transfer and integrate appropriate knowledge and methods from one topic within the subject to another.	B.2.1	Relate soil physical, chemical and biological properties with nutrient availability and different agricultural practices.
Professional and Practical Skills	C.1. Analyze soil, water and plant efficiently	C.1.1	Analyze soil for texture, color, water content, CEC and pH.
	C.2. Identify and assess of different types of soil problems (i.e. salinity, alkalinity, compaction, pollution, … etc.) in the field and suggesting solutions.	C.2.1	Demonstrate the ability to apply the knowledge learned in the course during lab and field internship.
		C2.2	Identify soil problems by soil analysis and field examination and suggesting solution.
General and Transferable Skills	D.1. Communicate scientific ideas in written and oral form.	D.1.1	Communicate and present soil and water idea, principles and theories through written, oral and visual means.
		D.1.2	Evaluate approaches to problem-solving related to soil and water.
	D.3. Work as part of a team	D.3.1	Develop skills in lab and communicating tasks within a group setting, take part in group discussions and co-operative learning.

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Soil awareness and education – developing a pan European approach

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Abstract
This paper describes the activities of the Working Group (WG) on Soil Awareness and Education established in 2008 under the banner of the European Soil Bureau Network (ESBN), sponsored by the Joint Research Centre (JRC) of the European Commission (EC). In their individual countries members of the group have been involved in a range of activities reaching out to the education sector and policy and public stakeholder groups. This group plans to build on these activities, share best practice and develop initiatives to take forward at the European level.

Key Words
Stakeholder engagement, environmental policy support, soil framework directive, society and environment.

Introduction and rationale
The need to raise awareness and understanding of the importance of soil, both in the urban and rural environments, has been highlighted at both national member state and European scales. In Europe, soil-based threats are slowly affecting the future functions that the soil resource can perform. The proposed EU Soil Framework Directive (European Commission 2006) recognizes seven threats to European soils that are of relevance; these include: soil compaction, erosion, loss of organic matter, landslides, contamination, desertification, salinisation and soil sealing. The scientific community as a whole is being asked increasingly to connect with wider society, in addition to the traditional focus on our peers. Research outputs are increasingly being judged on both their scientific integrity and their relevance and societal impact. In addition to the production of scientific papers and reports, we must find new ways of communicating the importance of soil science to diverse groups from national and international politicians to primary-age school students.

Soil scientists need to connect with wider society in portraying their science as relevant. This presents a serious challenge as soil is often not bestowed with the same importance in society as a whole as for example water or air quality might be. It is therefore essential that soil scientists deliver the important positive message that soils perform functions which are essential for life, such as water purification, providing nutrients to grow food and fibre, and providing the habitat for billions of soil organisms to name but a few. In the USA the increased education, provision of guidance and legislation in soil resources and sustainable management has led to a dramatic change in farming practices. This was implemented as a result of mismanagement of soils leading to massive agricultural and environmental problems in the first half of the 20th century, e.g. the dustbowl of the 1930s in the Midwest. Thanks to soil conservation measures such as strip contouring and, more recently, no-till farming, this region is now one of the most productive agricultural areas of the world. This is an excellent example of reversing and mitigation soil degradation (Zdruli *et al.* 2009).

A number of soil awareness and education initiatives already exist throughout Europe from primary school education to informing decision makers and working with stakeholder groups. However the majority of these initiatives are occurring at local scale and in some cases at national scale. To redress this, the European Commission is sponsoring a Working Group on Soil Awareness and Education under the umbrella of the European Soil Bureau Network (ESBN) whose remit is "*To establish an action plan for the development of measures / programmes / initiatives to raise awareness of the importance of soil across European society (i.e. policy makers, general public, universities, schools, industry, etc.)*".

If the pending European Soil Framework Directive is ratified, each of the 27 European member states will be obliged legally to develop soil awareness programmes. This short paper illustrates some successful examples of raising awareness in soils as well as outlining the plans of the Working Group for the future.

Target audiences

The ESBN Working Group has identified three broad groups with whom it is felt the soil society community needs to connect:

The Education sector - covering the ages from primary to tertiary level. By introducing soil science into the school curriculum from an early age it is possible to use 'hands-on' activities to explore and explain basic soil characteristics and functions such as: the different textures soil have - feel tests (Figure 1); what organisms live in soils - microscope work to study soil bugs and animals (Figure 2); soils in the garden - composting and growing plants.

Politicians, policy advisors and associated agencies - through promoting awareness of soils across a number of sectors e.g. Environment, Agriculture, Transport and Energy, Regional Policy, Development etc. There are a large number of EU and consequently national policies and strategies that involve soils across a number of policy sectors; agriculture, forestry, waste management and climate change to name but a few.

Public stakeholder groups - such as planners, the land based industries (primarily but not exclusively agriculture and forestry), gardeners, NGOs and then ultimately all of society. This will be conducted through the adoption of measures to work with these groups to develop appropriate awareness-raising practices for dealing with soils; the role of soils compared with air and water in sustaining our lives, and promoting a greater awareness of the value and diversity of soils and the need to protect them.

A selection of activities to date

The ESBN Working Group is already multi-national, with representatives from nine countries, and already has collectively a wide experience of trying and testing different approaches across the three broad groups outlined above; this experience will provide best practice guidelines for a range of approaches for raising awareness on soils with these groups.

In the education sector we have experience of both direct involvement in classroom teaching to more indirect methods such as development of web-based and other resources for teachers to use in the classroom (see the 'Soil-Net' weblink; Hallett 2007). While classroom teaching is rewarding for the individual it is quite demanding on teacher's time and therefore not appropriate for large scale awareness raising, Increasingly, it is thought that better and more efficient approaches will be needed to provide the teaching community with resources either through CDs, websites, downloads for white boards, books, posters etc. (Figure 3). Many soil scientists are already involved in teaching at the university sector but other methods such as e-learning and summer schools are also available both to undergraduates and young (and the not so young!) soil science professionals. Education does not have to be a formal process. A number of different and novel approaches have been tried including science open days, museums and mobile soil laboratories to other more novel methods such as Soil of the year (Germany, see weblink), Calendars (Pan European through JRC see weblink), soil characters (Scotland see weblink) and web based competitions "What do you know about soils" for younger and older pupils (Slovakia see weblink). All of these have attracted positive feedback and experience indicates the importance of finding creative, interesting, simple and fun mechanisms to capture the public's imagination before they are ready to receive more serious, connected messages about soils. A soil museum has been established in Germany (see weblink) and we have learned that Bulgaria and Poland are planning similar venues.

Connecting with the political process can be slow but ultimately politicians pay for much of the research we undertake, so it is essential that we engage at that level. Both parties can learn from each other through mechanisms such as job shadowing and secondments of researchers to policy units. However, it has been observed that formal documents such as briefing notes on specific topics can be very effective. Another mechanism is bilateral workshops and conferences that seek to join up policy and research and these can be useful in establishing mutual trust and the essential human contacts; that could not be achieved through e-mail and other remote forms of contact (Figure 4). Soil scientists can even assist in the compilation of policy documents, for example in Scotland (see weblink)!

Public stakeholder groups have more specific demands and interest in soils. We have found attendance at agricultural shows, or similar events, provides a useful mechanism for engaging with specific groups such as farmers and gardeners. It is essential to work with stakeholder groups to develop materials, which will be put into action and not ignored. A number of best practice guidance notes have been developed at local levels across Europe with the building industry, planners, farmers, gardeners etc. The media, including television, cinema, radio, the Internet, and not forgetting, the written word are also means of achieving coverage to a mass audience.

Plans

The ESBN Working Group seeks to promote and learn from the many excellent knowledge exchange activities already underway throughout Europe, indeed part the role of the group is to encourage and promote such activities. The key role of the group is to provide the facility to collate these many activities and thereby to share best practice and examples to the identified stakeholder groups. The current plans of the group include the following initiatives:

1. Identify and work with existing networks that can assist in raising awareness; we recognize that the group cannot work in isolation. Groups might include soil science and ecology societies, teachers associations, the World Association for Soil and Water Conservation and the European Society for Soil Conservation.
2. Identify key topical issues to facilitate engagement with both policy makers and the general public, such as climate change, food security, habitat loss, water quality and quantity and soil threats.
3. Create a categorised directory of EU and separate national resources, to be hosted on the ESBN web portal.
4. Share knowledge and experience of different mechanisms and best-practices for raising soil awareness.
5. Identify case studies across a number of policy areas where soils have been crucial. This links closely to item 2 above, in that key topical issue can be ‘mapped’ against EU DG policy areas. As part of our programme we will organise a workshop with appropriate advisors in different policy areas contributing to the ongoing process of raising soil awareness to that crucial audience.
6. Compile a strategy document, which will outline an analysis of the gaps identified. We will then identify key material required to fill these gaps and provide a commentary on across country issues such as language, culture and differences in educational curricula.

Concluding remarks

There remains a perception among some scientists that raising awareness of the importance of soils and soil education is either not important or is ‘done by someone else’. Many scientists are much more comfortable exchanging information and research results with fellow scientists than with the wider society. It could be argued that consequently, because of this rather conservative attitude, soils tend not to be placed as high on the environmental agenda as matters concerning air, water, climate and biodiversity. In reality, soils should be at the centre of the environmental debate; where does our food and fibre come from; where is most of terrestrial carbon stored; where is most of the planet’s biodiversity? Equally, the majority of the world’s drinking water has passed through or over soil.

Soil is a highly complex medium and it is often difficult to convey simple messages about them particularly to non-specialists. Soil scientists often tend to accentuate the difficulties associated with soil and focus on the more negative aspects such as threats to soil and soil degradation. Whilst these aspects are indeed very important and deserve continued research funding, there is an associated need to continually accentuate the positive aspects of soil in terms of the wide range of services that they provide. Indeed this provides the first route for engendering public awareness and support of these issues. A clear demonstration of what soils do, as well as the many services they perform in our lives. **Humankind lives because soils live**.

The authors of this paper have all taken part in exchanging our knowledge to wider society. We have found this to be very satisfying, although there is an associated need to develop a resistance to the fear factor of ‘getting it wrong’. If the language and message is passed across in the right way, it has been found that people are genuinely interested in this subject area. However that should not be the main reason for increased activity; many report our planet to be at an important point in its history and we also have a moral obligation to inform society and in particular the younger generations of our most important natural resource - our soils.

Figure 1. Young soil scientists of the future?

Figure 2. Soil animals always fascinate our youngsters.

Figure 3. Soil-net.com-classroom soil activities.

Figure 4. An aptly named policy-science conference.

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Soil science education in China: present and future

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Abstract
China has seen rapid development of soil science education in higher education institutions since 1978, especially in the 1990s. Presently a complete degree program in the field of soil science has come into shape, formed of colleges, universities and research institutions providing education in all related disciplines to undergraduates, MSc and Ph.D. students, including cultivation of talents of academic and applied type. The numbers of education institutions which have an undergraduate major, MSc program or PhD program in soil science are 53, 45 and 17 respectively with annual enrolments of approximately 4000, 1600, and 250 respectively. The system is adequate to satisfy the need of the country for soil scientists and professionals in national economic and social development. China's soil science education initiative should be able to supply the nation with well trained individuals to satisfy its need in maintaining the sustainable development of the agriculture and the rural areas.

Key Words
Soil science, education, undergraduates, post-graduates, status quo, prospects.

Introduction
Soil science education in higher educational institutions in China began in 1910 when a major in agro-chemistry was established at the former Imperial University of Peking (the present Peking University) (Beijing Agricultural University). The major has been renamed several times, from soil and fertilizer science in 1946, soil science and agricultural chemistry in 1952 and agricultural resources and environments in 1998. In 1935, the first master's student in soil science was enrolled at Sun Yat-Sen University. There have been three rapid development periods in soil science education for undergraduates: 1950s, 1980s (started in 1978) and 1999-the present. Before 1949, less than 200 college students in a soil science major graduated from Chinese universities and at present, the numbers of students exceeds 3,000. For postgraduate education, there were very few master students and no PhD students graduated before 1949. The progress in postgraduate education occurred in term of enrolments in the late 1980s. By then a complete higher learning system comprising of undergraduates and postgraduates was established.

College soil science education
In 1998, Chinese reformed the higher education system and publicized a new list of academic majors. In 1999, new students in soil science education began to be enrolled in the major agricultural resources and environment fields, keeping pace with international trends in higher education and identified world-wide environmental challenges. The major is supported by two disciplines, Soil Science and Plant Nutrition. In fact, the latter was part of the soil science in broad sense, and soil science is the basis for the major. However, in the practical sense, more job positions in the local communities are for plant nutrition. They are equally important in college education.Over the last 10 years, the number of educational institutions that have a major in agricultural resources and environments has been doubled from 25 universities to 53 universities/colleges. Apart from traditional agricultural universities, a few other universities also enrol students in the major. Enrolment of students in the major for each university is between 30 to 90 students, with the average about 60 for each year. In addition, the numbers of students in agriculture taking soil sciences courses has also increased with the increase in the total enrolment numbers.

Graduate school education
An academic degree awarding system was established in 1980 and graduate schools at universities began to organize in early 1990s. Although postgraduate students were enrolled at both universities and research academies, no academic degrees were awarded. Besides, doctorial education was also lacking. The first postgraduates with academic degrees graduated in 1984 in mainland China.

At present, soil science education in graduate schools comprises 1) the first-level discipline, Agricultural Resource Utilization, and 2) the second level disciplines, Soil Science and Plant Nutrition. Numbers of authorized institutions for master degrees are 36 and 37 for soil science and plant nutrition, and for PhD degree programs 16 and 12 respectively. Since 1999, enrolment of postgraduates has increased rapidly, with an annual growth rate of 30% and 24% for master students and PhD candidates respectively. Between the years 1999-2004, growth slowed to 12% and 2.5% respectively in the years 2005 and 2006 (The Yearbook of China's Education). Total numbers enrolled in agriculture were 2,289 for PhD candidates and 12,552 for master students in 2006. About one eighth of these students were enrolled in either soil science or plant nutrition. Apart from academic degrees, professional degrees in soil science have also been awarded since 2005. The total enrolment is about 300 each year.

Problems faced in soil science education

While China has cultivated enough students for current demand, there are some general problems: (1) changes in quality of enrolled students with rapid increases in college enrolment; (2) increases in unemployment; (3) practical skills. The dramatic increase in college enrolment in China since 1999 has resulted in decrease in student quality in agriculture, except for the few national key universities, since other sectors than agriculture are more attractive for young people. Consequently, unemployment increases with the dramatic changes in graduate numbers. In addition, the increase in student numbers has not been kept in pace with increase in the financial budget for most of agricultural universities. Therefore, those university cut some practical courses and less training in this aspect will be expected.

Perspectives in soil science education

More emphasis will focus on improving the quality of education for both undergraduates and postgraduates in order to meet the demands of society for qualified professionals. For undergraduates, more training in practical skill is highly desirable, while for the undergraduates, especially for PhD candidates, the research quality needs to be improved. Training individuals for agricultural production will be the major task for soil science education since food security is a high priority for China now and in the future. With limited land and water resources, the education and cultivation of professionals will focus on the best use of natural resource and the minimization of environmental risks. In the meantime, some attention to environmental problems has to be paid, especially for agricultural non-point pollution. While research-oriented education is still needed, the general consensus is that most educational institutions should concentrate in professional education. Thus, more intensive practical trainings is desirable.

Concrete fundamental knowledge, a broadened view and developed leadership ability by the student are necessary to solve the problems we are facing both in agricultural production and research. As a whole, agriculture in China is still a very import and basic sector in the country’s economy. To meet the growing food demands and minimize environmental risks brought about by agricultural production is a great challenge for the nation. Some of the measures are under discuss to attract more qualified youth to the sector, which include waiving the tuition fees for college students enrolled in agriculture and to create more job positions in the local agricultural extension sector and environment agency, both of which have been very weak. For the people working in agricultural higher education institutions, to cultivate qualified professional with applicable knowledge and skill, will be another important aspect to attract young people.

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Striking a match: How to ignite a passion for soils

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Abstract
Initiating and sustaining interest in soils in the general community has historically been a difficult task. In the Northern Rivers region of NSW Australia, the development, by a group of farmers, of a monitoring tool adapted from the United States Department of Agriculture (USDA) Soil Health Card model has created a soil literate and informed group of proactive farmers. The Northern Rivers Soil Health Card (NRSHC) has been around for over 8 years and still finds interested audiences amongst farmers all over Australia. This paper proposes that the process of creating the NRSHC and the continued presence of a dedicated soil extension officer for over 15 years have been powerful factors in igniting a passion for soils amongst a group of north coast farmers. It is argued that ongoing support and an extension presence has resulted in a farming population with high 'soil literacy'. The instigation of a formal single purpose, region wide soils group and its activities could be said to have been stimulated by previous soil extension activities particularly the development of the NRSHC.

Key Words
Soil health monitoring, farmer participation, co-learning, soilcare

Introduction
Soils extension has always been a challenging area in which to work. For too long soils have been considered boring and some would argue that society subconsciously sees soils as both renewable and stable (Trudgill, 2006). Despite most farmers agreeing that the soil is the mainstay of their operations few, in the past, have found any need or desire to delve into the profile in great detail. Soil science is complex and in the past was often presented in ways that were not relevant to farmer's day to day operations. The solution to a greater understanding and connection with the soil need not be difficult. For long term behaviour change, many extension practitioners would argue that participation and farmer led activities lead to greater understanding, capacity and activity than other, more traditional, forms of adult education. Participation by farmers has been employed in the past for philosophical and practical reasons with the assumption that refining within a farm context would be more successful, (Wander and Drinkwater, 2000) but form of participation often involves taking a draft prepared by technical experts to a 'lay' person for comment. Others have pointed out that farmers' knowledge and input should be "used as a first iteration" for soil quality evaluation (Liebig et al 1996) an approach used in the development of the Northern Rivers Soil Health Card (NRSHC) on the north coast of News South Wales. What makes this case study interesting and the point that this paper seeks to highlight is the fact that participation in the development of a Soil Health Card, (SHC) prompted an increase in the farming community's activity and capacity around soil health.

The spark: Development of a Northern Rivers Soil Health Card
The NRSHC was developed in 2001-2002 by a group of primary producers representing a range of north coast industries in horticulture, dairy and cropping. The participants came together because they wanted to know more about the state of their soils than just the results of their regular laboratory tests. They wanted to improve the health of their soils without huge increases in inputs, and wanted to investigate the usefulness of alternatives to synthetic fertilisers. The NRSHC (Figure 1) was developed through a two facilitated workshops based on a format developed by the USDA (Tugel *et al.* 2001), available through the website (USDA, 2005) and a customised TAFE (Technical and Further Education) course. The workshops were conducted before and after the TAFE soils course which provided information on the range of soil health indicators that could be monitored, and the different field tests that could be used. It was thought that in providing a structured learning activity such workshops those involved in the card development would be better able to select both the indicators and the field tests that would be useful and repeatable on farm. During this process the groups also had access to technical expertise when required. The steps followed were:

1. Workshop 1: To define soil health
2. TAFE Soils course: one half day per week for 9 weeks
3. Workshop 2: To select soil health indicators and design layout for the card
4. Use and refinement of SHC in field.

In a 2006 scoping survey on the Alstonville plateau farmers (Northern NSW, Australia) it was found that, of the 32 publicly funded soil focused projects carried out over the past 5 years, the NRSHC was considered the most useful by farmers with over 30% of respondents indicating it was the most useful activity (*pers comm*).

Northern Rivers Soil Health Card (Page 8)

TEST RESULTS

Date: _________ Location / management: ______________________________(draw a sketch map overleaf)

Soil Type: __________________ Productivity: ____________________ Days since 20mm Rain: ____ Soil Moisture: dry / moist / water logged

RESULT► TEST▼	POOR 1 --------------- 2 --------------- 3	FAIR 4 --------------- 5 --------------- 6	GOOD 7 --------------- 8 --------------- 9	SITE SCORES (1 - 9) 1	2	3	4	5	Av.
1. GROUND COVER	Less than 50% ground cover (ground plants or mulch)	50% to 75% ground cover (ground plants or mulch)	More than 75% ground cover (ground plants or mulch)						
2. PENETROMETER	Wire probe will not penetrate.	Wire probe penetrates with difficulty to less than 20 cm.	Wire probe easily penetrates to 20 cm.						
3. INFILTRATION	Water level drops less than 2 cm in one minute.	Water level drops by from 2 to 5 cm in one minute.	Water level drops more than 5 cm in one minute.						
4. DIVERSITY OF MACROLIFE	Fewer than two types of soil animals.	Two to five types of soil animals.	More than five types of soil animals.						
5. ROOT DEVELOPMENT	Few fine roots only found near the surface.	Some fine roots mostly near the surface.	Many fine roots throughout.						
6. SOIL STRUCTURE	Mostly in clods or with a surface crust, few crumbs.	Some clods but also many 10 mm crumbs.	Friable, readily breaks into 10 mm crumbs.						
7. SLAKING 5 cm depth → 20 cm depth →	Aggregate broke apart in less than one minute.	Aggregate remained intact after one minute.	Aggregate remained intact after swirling.						
8. EARTHWORMS	0 - 3	4 - 6	more than 6						
9. ACIDITY 5 cm depth → 20 cm depth →	pH 5 or lower	pH 5.5	pH 6 to pH 7						
10. LEAF COLOUR	Stunted plants, leaf discolouration.	Some variation in growth and colour.	Appropriate leaf colour and uniform plant growth.						

NB Numbers resulting from the different tests are not intended to be combined to give an overall value of soil health.

Figure 1. The Northern Rivers Soil Health Card.

Fuelling the fire: A Role for long term designated soils extension personnel

The continued presence of a designated soil extension officer for over 15 years and the creation of the NRSHC has ensured that soils have gained and maintained a high profile in regional agriculture. This has encouraged landholders to think about their soil foremost and provided a sound platform for them to launch their own actions and inquiries. It would appear that these factors have established an environment where co-learning and dialogue are fostered allowing all those involved to "share a discourse about soil health issues, and thus relieve the pressure upon soil science alone to solve all soil health problems" (Lobry de Bruyn and Abbey 2003).

The level of activity around soil health issues has skyrocketed in the Northern Rivers of NSW. On first taking up the post as soil advisory officer I was informed that it was always difficult to get farmers to attend soils workshops and most people were really not that interested. Now people are not only interested they are running their own projects and in some cases working to their own priorities.

Fanning the flames: SoilCare and its activities

Following the development of the NRSHC a core group of farmers decided to start their own landcare group specifically focussed on soil and land issues. SoilCare is a farmer directed group devoted to soil health issues in the Northern Rivers region of NSW. From an initial group of 17 the group now has a member base of 145 spread across the whole region. Membership is family based, every membership covering individuals. Members of the group come from the farming community as well as universities and state government departments.

Capturing wider support

In the four and half years since its inception, SoilCare has developed five industry specific Soil Health Cards and five accompanying draft soil health best management practices for major regional industries. They are also embarking on groundcover demonstrations in the macadamia and banana industries. They have secured funding for ongoing eduction in collaboration with NSW TAFE from the national government and are running courses and special interest focus groups where a greater level of technical information will be presented in a practical on farm setting. The funding and support for this work came through the regional natural resource management authority, the Northern Rivers Catchment Management Authority (NRCMA) after the success of the NRSHC with its ability to stimulate action and learning made an impact.

Large public events: The SoilCare Expo
SoilCare expo is a biennial soils field day/show that has run very successfully for the past 7 years with over 300 people attending the event organised entirely by SoilCare. The one day show allows farmers and other landholders can come to one place where they are able to speak with all the 'players' in one space. Both public and private 'providers' have the opportunity showcase their work with soils. SoilCare also includes a series of seminars and workshops by an invited speaker both national and international. Speakers who have presented include Dr Marten Stapper, Dr Lukas Van Zwieten, Bob Shaffer and Dr Lyn Abbott and Gary Zimmer. It is further evidence of the increased interest, activity and capacity of the local farming community.

Spot fires: Wider interest in the NRSHC
Since its inception there have been numerous enquiries about the NRSHC from outside the region and outside the state of NSW. A local farmer introduced it at a healthy soils meeting convened by Land and Water Australia aNational government research and development organisation, and it has been showcased regularly at regional rural producers meetings and regional agricultural shows. Articles about the card have appeared in local newspapers and state-wide agriculture publications. Members who are also involved in local farmers' markets have showcased it at these venues. One committed member has garnered support from CSIRO (Commonwealth Scientific and Industrial Research Organisation) researchers in evaluating and assessing the tests chosen. More recently (2010) it has been exhibited at an organic soil symposium in Hawaii .The NRSHC is now included in the teaching materials for courses designed for farmers from a range of training bodies such as the Industry and Investment NSW (formerly Dept. Primary Industries), and NSW TAFE.

Observations from the Northern Rivers experience
Despite the debate about minimum data sets (MDS) for soil quality or health assessment and the scientific community's questions about the validity of qualitative information collected there are substantial benefits to be realised in developing and encouraging the use of farmers devised soil health monitoring tools. The interest it raises and the capacity for assessing, observing and documenting any number of indictors builds the capacity of any land manager engaged in such an activity. In this case it has undoubtedly acted as a catalyst and inspired further in-depth investigation of soil health and management, motivating a group of farmers in the Northern Rivers region of NSW Australia to ongoing interest in advocacy, learning and continual improvement in the management of their soil. In an era of shrinking government services and increased public awareness of natural resource management issues this can only be a positive step for the often forgotten natural resource, soil. Lobry de Bruyn and Abbey (2003) and Wander and Drinkwater (2000) have both pointed out the necessity for just this situation where individual farmers take on some of the responsibility for managing the soil resource under their control.

The timeliness of the initial NRSHC development activity and subsequent formation of SoilCare cannot be discounted coinciding as it did with a national focus on Australia's soil resource. However this national promotion, has not translated to the level of ongoing interest and engagement seen in the Northern Rivers region of NSW. A combination of direct farmer involvement from the beginning, a history of state funded soil extension support and continued input and support for workable self directed projects has fostered a continued interest in soils, creating a group of farmers who have the competency, networks and interest to maintain a self directed soil group.

Developing a SHC is a tool for deeper interest and engagement by any group of people interested in soils, eg farmers, primary students working in school food gardens; secondary school students doing geography/ agriculture/ environment; tertiary students learning soils/agriculture. It is important to remember that it is not necessarily the scientific accuracy or rigour of the tool that is paramount but the process used to develop it. The SHC's strength lies in its ability to act as a vehicle for dialogue between disparate groups and as a catalyst for further activities which only increase the understanding of soils and how they function in the broader ecosystem. "even though many on-farm measures may fail to produce information that scientists would accept….the importance of on-farm or in-context resource assessment must be recognised" (Wander and Drinkwater 2000).

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The need for soil science amateurs

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Abstract
Attracting more people to soil science is a concern shared by many practicing soil scientists and education institutions. Many disciplines have amateur societies whose members engage with the discipline out of sheer passion and personal interest. These amateur enthusiasts are members of the general community that have perceived something of value and interest in the discipline to which they may contribute knowledge and advancement of the discipline in its own right. Some examples of amateur societies are: botany, paleology and astronomy. Soil science has no recognised amateur society. The professional training may mostly focus on knowledge at the expense of development or fostering amateur qualities to which members of the public could relate. Soil science and the general community have much to gain by fostering amateur qualities and the creation of a Society of Amateur Soil Scientists.

Key Words
Amateur qualities, soil education, amateur societies.

Introduction
This paper is concerned with public awareness of soil science, the role and qualifications of soil science professionals, the changing role of soil scientists, soil science education, and the possible contribution of soil science amateurs in creating greater public interest and growth of the discipline. People who have not been formally educated in a discipline yet have a strong interest and passion for it, and engage with it in a practical way, are called amateurs. There are many amateur scientists, and Mims (1999) notes: “The term amateur can have a pejorative ring. But in science it retains the meaning of its French root *amour*, love, for amateurs do science because it's what they love to do. Without remuneration or reward, enthusiastic amateurs survey birds, tag butterflies, measure sunlight, and study transient solar eclipse phenomena. Others count sunspots, discover comets, monitor variable stars, and invent instruments.” Mims (1999) reports that these amateurs invest huge amounts of time in their scientific endeavours and data collection which they provide for scientific organisations and publish in prestigious journals. Perhaps the most famous amateur scientist was Thomas Edison (1847–1931) who held more than 1,000 US patents in his name (Wikipedia 2009a) and who began the journal *Science* in 1880 (Mims 1999). The Society for Amateur Scientists (SAS 2009) has a weekly publication (The Citizen Scientist), youth education, and community programs. The SAS was founded in 1994 by Shawn Carlson, a physicist from the University of California (Wikipedia 2009b). Amateur astronomers are probably the best-known group of amateur scientists that engage in research and invention of instruments (e.g., clocks, telescopes) and have made many significant scientific discoveries such as comets (e.g., Hale-Bopp in 1995), variable stars, and supernovae (Wikipedia 2009c), and they have an amateur astronomy magazine for the community (AAM 2009).

The perception or image of soil science, as portrayed by soil scientists, needs to be examined. As practicing soil scientists we need to ask ourselves what impressions are we giving the general community and what are the reasons for lack of interest amongst people who have not been educated in soil science? The systematic study of soils started more or less in the first half of the nineteenth century. Important contributions were made by the German F.A. Fallou (1794-1877) who had studied jurisprudence at the University of Leipzig (Germany) and was interested in mineralogy. Fallou was never married and his love of nature turned his attention to soils - he studied soils as a hobby. He worked as a land tax assessor (Asio 2005) and published Pedologie oder allgemeine und besondere Bodenkunde (Fallou 1862). Just like Senft (Senft 1857) he attempted to treat the study of soils as an independent science, and soil as a separate formation – ideas that are mostly attributed to V.V. Dokuchaev. Fallou distinguished between soils formed in-situ and “washed-in” or alluvial soils. He discussed the effect of relief on soil depth, and introduced new terms like pedology and soil quality (both mean different things to different people).

We are not aware of soil science amateurs and hobbyism throughout much of the twentieth century but in 1988 the famous soil scientist, Francis D. Hole commented: " The 1980s would be a logical decade in which to organise a Society of Amateur Soil Observers." There does not appear to have been any substantial follow-up to his suggestion, begging the question, where are the amateur soil scientists and what are we doing that prevents there being an amateur soil science society? In contrast, in a closely related discipline, there are apparently many amateur geologists ("rockhounds") for whom there is a ready source of information and equipment (e.g., Amateur Geologist, 2009) including books and guides specifically for the amateur geologist, e.g., Cvancara (1995). It seems that general community interest in soil is limited to its utility (farmers, gardeners) rather than being appreciated for its own sake in a broader and deeper context as proposed by Hole.

Qualities of amateurs and professionals

Perry (1904) was concerned with identifying the amateur spirit in comparison to that of professionals and his distinctions are summarised in Table 1. Perry did not produce such a table of opposites; this pairing is an interpretation of his writing by the authors of this paper.

Table 1. Summary of amateur and professional qualities as described by Perry (1904).

Amateur	Professional
Broad approach to life	One-sided narrow view
Breadth of interest	Specialised training, skilful, expert
Imaginative and idealistic	Lack of imagination
Works for the sheer love of working	Works for personal gain
No self interest	Self-sacrificing for the profession
Chivalrous, winning is not the aim	Strong desire to win
Generous spirit	Lack of sympathy
Individual initiative	Clannish narrow loyalty to the group
Versatile, spontaneous and adventurous	Machine-like
Human curiosity and eagerness	Dominated by exact methods and approved knowledge
Personal enthusiasm and boundless zest	Uninteresting

While it is most unlikely that we would agree with the full distinctions Perry perceived, we can recognise qualities of the professional that apply to ourselves, as indeed we would claim to have some of the amateur qualities too. Perry himself noted (p 31): "Many of us are fortunate enough to recognise in some friend this combination of qualities, this union of strict professional training with the free outlook upon life, that human curiosity and eagerness, which are the best endowment of the amateur." A balance of these qualities is clearly desirable in the soil science professional today.

Preparation of balanced professional soil scientists

If we agree that a balance of the amateur and professional qualities given in Table 1 is desirable, we may find it surprising that the performance objectives of the Soil Science Society of America's Council of Soil Science Examiners (SSSA 2007) are almost entirely concerned with technical skills and knowledge (24 pages) and 5 lines concerned with ethics in relation to a client. This approach is selecting for and encouraging the development of the one-sided, cold and hard qualities of the professional as perceived by Perry over 100 years ago. This would not endear the profession to the public at large and encourage more engagement with soil science.

Universities generally have a broader approach to the development of a balanced professional and these days; Perry's list of amateur and professional qualities would be described in terms of discipline knowledge and generic skills or attributes. The discipline knowledge would include specialised training in methods and thinking like a soil scientist. The generic attributes include other qualities of graduates that are claimed by most universities, such as research and inquiry, information literacy, personal and intellectual autonomy, ethical, social and professional understanding, and communication (The University of Sydney, 2004). One would expect graduates in soil science to have an appropriate balance of discipline knowledge and generic attributes, analogous to a mixture of the amateur and professional qualities given by Perry, for their professional life that would include interactions with employers and the general community.

Employers require a range of skills from their graduate recruits. Singh *et al*. (2004) surveyed employers (51 firms) for a wide range of skills (40 in total), knowledge and attributes desired of recent agriculture graduates. They found that the top six requirements were: self motivation; the ability to write clear reports; having strong presentation skills and use of graphics; the ability to speak clearly and concisely; the ability to express technical concepts clearly and in a non-technical manner; and teamwork abilities. These results showed that employers placed less emphasis on discipline knowledge and more on the personal attributes that approximate more closely to the amateur qualities of Perry than the professional ones. Thus skills required by professionals are people skills with the ability to interact with colleagues, clients and the community. Members of the community are unlikely to be impressed with representatives of the profession, or indeed the profession, without those people skills. Advocating soil science to the community and attracting more interest requires qualities of the amateur more than these of the professional.

A role for the amateur soil scientist?

The role of the soil scientist in response to society's needs has changed over the years. As mentioned over 150 years ago there were non-professionals (amateurs in that sense) concerned with the rational use and management of the soil (Table 2, column 1). Gradually the discipline of soil science formed and was concerned with discovering the nature of soil, the development of methods of analysis, and soil behaviour whilst being associated with production and use of soil (Table 2, column 2). More recently, there has been recognition that soil science has a much broader holistic role to play in society's needs and that soil scientists need to be more involved with other discipline scientists, stakeholders, policy makers and other users of soil information (Warkentin 1994; Bouma, 2001; Wessolek 2006), as shown in Table 2, column 3. Soil science is now recognised as an important part of ecological processes and has an essential scientific and economic part in contributing to the solution of the world's problems, including those of food, fuel, water scarcity and climate change (Hartemink and McBratney 2008). It seems that other disciplines are also more interested in soil science, including the social sciences and liberal arts which are contributing to the broader holistic nature if soil science knowledge (Warkentin 1999). Wessolek (2006) and Hartemink (2009) suggest that the public awareness and image of soil may be changed through aesthetics and art.

This development from left to right in Table 2 may lead to the next step (column 4) where amateurs co-exist with today's professionals and become involved with soil science. This amateur engagement with the discipline would parallel that of other scientific amateurs (astronomy, geology) who study and practice in the discipline out of sheer love and interest and develop expertise without necessarily having an academic qualification. Is that the definition of a community of practice, do we need that in soil science? Perhaps the only component missing at this point in time is that of the network (society) which is the mechanism through which amateurs in various disciplines engage.

Table 2. The progression of soil science from left to right and the possible co-existence of soil science amateurs

Amateurs (non-professionals)	Early professionals	Recent professionals	Amateurs
The study of soil for utilitarian and survival purposes (over 150 years ago)	The study of soil in its own right; development of methods and analytical procedures; linked to agricultural production	Linking soil science with other disciplines and engaging with other scientists, politicians and stakeholders to provide information and solutions to complex environmental issues and problems	Members of the public who engage with soil science out of personal interest and enthusiasm for the discipline and its practices.

Perhaps these soil amateurs already exist and practice within organisations such as landcare groups which are made up of people with diverse backgrounds and expertise who are interested in contributing to the solution of local problems (Landcare 2007). As such members of landcare groups may be amateurs in the true sense of the word, as well as professionals in some discipline, and would straddle the boundary between columns 3 and 4 of Table 2.

Conclusions

Unlike astronomy, geology, and other sciences, soil science has no amateur society. The appreciation and study of a discipline for its own sake, as practiced by amateurs in the general community, is apparently lacking for soil science. Amateurs have many qualities that enrich a discipline by their presence and activities as well as making possibly substantial contributions to the knowledge of that discipline as has occurred in science and astronomy for example.

Soil scientists are changing in response to society's recognition of the essential role of soil science in the well-being of the planet, and are interacting with other disciplines and many stakeholders. The one-sided development of soil science professionals that lack people skills and the ability to interact with and enthuse the general pubic about the discipline would work against this trend as well as detract from encouraging amateur interest. An important change that we can make to improve the public perception of soil science, thereby possibly attracting more students, is to change soil science teaching and/or academia engaging with the general public through student community projects. In short – getting out there and demonstrating how soil science can enrich local communities and also revealing that there is more to soil than its mere utilisation. For such a task, the professional would need to display amateur qualities. The residual impact of these activities may spark interest and enthusiasm which could then be channelled into a Society of Amateur Soil Scientists that is yet to be created.

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Towards a dirtier Australia: Facing the future soil management challenges

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Abstract.
Land degradation is a complex technical, socio-economic and political issue without simple answers (Sumner and Wilding 2000) and this is also true of soil degradation and improved soil and landscape management. The management of soil has been overshadowed by issues perceived to be more important and urgent such as water resources and climate change (Campbell 2008). While this has shifted focus from soils as a societal issue, the importance of soil management and science is recognised within these other broader environmental problems. This has created an opportunity and Hartemink and McBratney (2008) have discussed the approaching soil science renaissance, where novel approaches are needed in multidisciplinary framework to address societal environmental problems associated with the ground that we walk on. However, the disconnection between policy, soil science, industry, and consultant sectors is the root cause for the failure of sustainable soil management. This paper will explore the pressing present and future environmental soil challenges and possible solutions to the conundrum of soil management and disconnection in the Australian context.

Introduction
In the past, soil degradation was recognised in Australia as a matter of national significance (Bradsen 2000). Things have changed. A review of the Australian Commonwealth Government's policy on soil management by Campbell (2008) was damning. Over the last decade state and federal policy lacked focus and tended to be overshadowed by other important environmental issues. These include global climate change, the long term drought in Australia's south-east and biodiversity conservation. Soil science experts and practitioners within state and federal agencies have become isolated and their important work lacks the recognition it thoroughly deserves. A focus of the 6 o'clock news and the morning television of recent dust storm in Australia's south-east (October 2009), a result of the long-term drought, was not the soil degradation that was occurring but how the urban population was going to cope with the clean-up. This goes to the heart of Campbell's thesis, that Australian society is largely disconnected from the sustainable use of soil resources. Obviously there are exceptions, such farmers, composters, permaculturalist and other regenerative farming movements and keen gardeners. It also appears that the linkage between the broader environmental issues, such as climate change, and soil management is not fully appreciated by the public and government. This societal attitude shift may be a result of the economic shift from the dominance of agriculture to mining and tertiary industries. This has lead to political inaction, an ad-hoc short term funding model, and a decline in commitment, knowledge and capacity (Campbell 2008). Campbell (2008) states that to reverse this there needs to be significant reinvestment in data infrastructure, information and professional capacity, a rebuilding of soils literacy and a renewed energy and rekindling of enthusiasm in soils. The challenge has been set and as soil and environmental scientists we should tackle it.

What are the future soil challenges?
Before one can attempt to answer Campbell's (2008) challenge, a first question needs to addressed, is there an actual need to reinvigorate Australia's soil management and soil science? There are many soil issues that the world will face in the near future. The world's growing population, which is predicted to be 9.1 billion in 2050, will need to be fed from a fixed land area. In 2000 there was an estimated 1.5 billion ha of cultivation land in the world and assuming that this area stays constant, then in 2050 there will be only 0.15 ha/person available for food production. This is 25% of the amount of land (0.44 ha/person) available in 1960. It is predicted that the demand for food will also double and diversify as incomes increases and consumers are able to spend more on high end foods (Core 2009). Human society will need produce food much more efficiently to meet the growing demand without placing strain on the existing soil resources and our ability to sustainably manage land. Compounding the issue of population growth and demand is the increased cost of fertilisers. The world fertilser index (US$) is closely linked to the oil price and with the approach of peak oil and the rising demend, fertiliser price should increase in the future. There are also indications that phosphate supplies will begin to be exhausted in the next 50-100 years (Cordell *et al.* 2009). Thus there are two

significant nutrient issues that face the world's farming systems and society. Two growing areas of research are soil microbiology and interconnections between the different disciplines for the improved soil nutrient management and productivity. It is also apparent that soil carbon will be an issue of rising importance as the world grapples with climate change, but in the face of a significant knowledge deficit.

In south-eastern Australian catchments yields have declined more than expected due to reduced rainfall (Timbal and Jones 2008). It has been hypothesised that this has been caused by a shifted in the seasonality of the rainfall, ground and surface water extraction and significant soil moisture deficits. In areas where climate change will increase rainfall variability and temperatures agriculture production systems will need to be modified, especially downstream irrigation areas in the Murray-Darling Basin. Some management practices include the installation of leaky weirs in incised gullies to slow run-off and increase soil moisture and practices that increase infiltration. The effects of such practices on soil nutrient cycling and catchment productivity still need to be investigated.

In Australia many other parts of the world fertile and productive soils are being converted from agricultural to urban land uses. Many landholders are cash poor, but capital rich and are planning to sell their land and use the profits to self-fund their superannuation. This issue is particularly acute in the expanding peri-urban zones around major cities. This is a policy question that needs to be resolved for the maintenance of food production. Finally, one of Australia's priority research areas is overcoming soil loss, salinity and acidity. "A multidisciplinary effort is required to develop sustainable land management practices that are appropriate for Australian conditions and mitigate major land degradation processes and increase biodiversity" (ARC 2009). This is by no means an exhaustive list but it is clear that to achieve sustainable soil management and Australia's soil research priority there is a need for reinvestment in soil science by the public and private sectors.

Facing the present and future soil challenges: the way forward

Policy and Research

The way forward is develop a research, teaching, development and policy model that will invigorate soil science and the blue print is the Government's response to surface and ground water management. There is a need to manage soils at a Commonwealth level, allowing a co-ordinated approach for the database construction and maintenance, policy development, and extension. A dedicated unit within the Department of Agriculture, Fisheries and Forests is long overdue and its funding should be long term and sustainable. As well as policy guidance and specific programs, such a unit would be positioned to advise research funding organisations on priorities. This policy unit would be part of a structure that involved a National Soil Research and Training Centre or program, CSIRO, Industry, Australian Soil Science Society Inc., relevant university groups and extension organisations charged with research and developing of sustainable soil management. This will reconnect the policy, soil science, industry, and consultant sectors, thus correcting the root cause for the present failure of sustainable soil management.

Interdisciplinary education and training

Soil science faculties and teaching units in many undergraduate universities in Australia and around the world have been amalgamated with other disciplines (eg Biology, Geology) to form environmental science mega-schools. Many have declined in size over time. We should not lament the decline of isolated soil science teaching but greet the teaching challenge proactively because to solve future soil science challenges will need graduates with a broader interdisciplinary outlook (Hansen *et al.* 2007). Indeed novel approaches are needed in multidisciplinary framework to address societal environmental problems associated with soil (Hartemink and McBratney 2008). Our graduates have these skills, but there is still room for improvement. The teaching of soil science should occur at the postgraduate level but many universities have lost capacity in this discipline. To overcome this problem we believe that the establishment of Australian Soil Research and Training Centre (ASRTC) or some other form of coordinated program is needed to co-ordinate multi-universities and industry develop and deliver postgraduate research and course. This model has been established and tested by National Centre for Ground Water Research and Training, and collaborative graduate programs across key universities have been established in other areas (eg. the National Forestry Masters Program). However it is proposed that, as well as universities, CSIRO play a central role in ASRTC development and operation in keeping with its key role in soils research. Within the proposed centre a range of continuing education options should be developed for soil and environment science professionals to keep up to date with the latest techniques, methods and theories, and to combine courses from more than one institution. The Australian ground water school and the other professional organisations successfully run such programs and it would be a great boost for soil and environment science professionals. It may also be possible to integrate with the International Union of Soil Sciences and develop connections to international teaching and research training.

The role of Australian Society of Soil Science Incorporated (ASSSI)

ASSSI core objectives are to promote the field of soil science , further expertise, provide a forum for discussion, increase government and community awareness, encourage research and extension and development the wise management of soil resources and as a the professional body it would a key player in reinvigorating the discipline. We believe however that the ASSSI executive should produce a policy document from its biennial conference, broaden the conference to include industry groups, alternative practitioners and natural resource managers and possibly host a "soils festival" with the conference. This will immediately help lift the profile of soils within Australia government and society. It must be remembered that most undergraduate students in soil science classes now graduate with an environmental science degree and thus the conference should be broadened to include the multidisciplinary nature of the graduates. Also most Australian's do not have a direct connection with soils, unless it is on their boots, and a soils festival, which includes produce, art and good fun, is a way of attracting and increasing the awareness of the general public.

Soils in the real world

To address the problem and to make the globe a dirt friendly place "we need people talking about soil in the real world" (McBratney 2009). This may seem difficult, but to raise the interest of soil science out side the profession, we need to remove the jargon and explain the issues clearly. There are some examples of this occurring,

1. The US Soil Science Society has established a policy office which is supported directly by soil scientists and official working groups to inform congress about soils, and
2. Gardening and composting television programs and literature.

Typically scientists are generally absent from the general media and other information services. This needs to be reversed and we, the soil and environmental science professionals, need to explain the issues to the media and general public. The most obvious recent example is soil carbon and it's role in carbon sequestration. Most people would not know about this issue in a general sense and this is at a time when their governments are debating whether soil carbon and sequestration should be included in trading scheme. So it is really up to us to report our research findings and expertise in a meaningful way to the scientific literature and to translate and publicise these findings into information that a lay person can understand and use in there day-to-day lives. If soil issues are in the mainstream media then three things will occur, more people will join the profession, soil management, research and development will improve and society will be able to face and manage the future challenges.

Conclusions

Campbell (2008) has thrown down the gauntlet and it is up to the soil and environmental science community to meet the challenge to make Australia dirtier. It is clear that there is a need to reinvigorate soil science research, teaching and policy for sustainable management. A federal driven framework is required, that includes ASSSI, CSIRO, Universities, industries, state agencies and well funded Government department or unit. The overarching aim would be to provide the information base, skills and policy settings to enable the sustainable management and use of soil resources for the long term. The integration of soil science into broader undergraduate environmental science is an advantage because the graduates will have multidisciplinary skills to solve society's complex environmental problems. We believe that soil science should be taught at the graduate level and research and training coordinated by an over arching research and training centre or program. To achieve some quick runs the ASSSI executive should develop a policy document from the biennial conference. This conference should also be broadened and not focused only on soil taxonomic discussion. In the end it is up to us the soil science professions to reconnect with the general public and explain the importance soil science issues and the relevance to society.

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