Trends in Soil Science Education and Employment

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ABSTRACT
During recent strategic planning exercises, the SSSA identified several trends related to the soil science profession: 1) declining academic programs and course offerings at land-grant universities, 2) decreased enrollments, and 3) improved employment opportunities for soil science graduates. To quantify these trends, the SSSA conducted surveys in 2008 of soil science students, academic departments in the U.S. and Canada offering soil science courses/degrees, and employers hiring people with soil science backgrounds. Survey results confirmed that employment opportunities in soil and related sciences are increasing, although employers generally thought it would be more difficult to find soil science trained employees in the future. Although most departments indicated that student enrollments have not changed greatly over the last decade, future increases in enrollments will likely come from students enrolled in environmental and other related sciences as opposed to traditional soil science degree programs. All survey groups provided positive comments regarding the future of soil science as a profession; however, all groups indicated areas of concern that should be addressed to enhance the soil science profession relative to other related sciences. Specific recommendations for action by the SSSA are identified.
INTRODUCTION

Since the early 1990’s, Soil Science Society of America (SSSA) members have expressed concerns over a decline in student enrollment, the number of university faculty, and the number of traditional soil and related science departments (Dalmasso, 1990; Hanson et al., 2007; McBratney, 2006; McCallister et al., 2005; Collins, 2008; Ferris et al., 2010). Recent survey data documented a 42% enrollment decline in M.S. and Ph.D. degree programs in North America between 1992 and 2004 (Baveye et al., 2006). Similar data are reported in other regions (Hartemink et al., 2008).

In contrast, recent assessments suggest a resurgence of interest in soil science. In addition to increased focus by international organizations on soils related issues important to world food security and human health, increased numbers of soils related publications and a substantial increase in impact factors of the major soil science journals suggest increased emphasis in and demand for soil science knowledge (Lal, 2007; Hartemink, 2008; Hartemink and McBratney, 2008). Hartemink et al. (2008) also provides evidence of increased enrollment in soil science related programs in selected countries. In addition, membership in SSSA has been increasing over the last five years (Fig. 1). The majority of this increase is in undergraduate and graduate students (a new membership category since 2005).

Figure 1. SSSA membership from 1989 to 2008.

SSSA recently engaged in a number of strategic planning efforts culminating in the development of its current strategic plan (SSSA, 2006). The document communicates initiatives needed to enhance the vitality of the organization, and it also addresses critical issues important to the soil science profession and general public understanding of the importance of soils to life. Although only anecdotal information were available, several trends related to soil science education were identified including 1) traditional course offerings and programs at land-grant universities in the
soil science profession are disappearing, 2) the number of soil scientists is substantially declining, and 3) students in soil science are finding great job opportunities at graduation.

Guided by the strategic plan, SSSA formed an Advocacy/Education Task Force (Task Force) to enhance visibility and recognition of the soil science profession. The Task Force met in 2007 and agreed that over the last several decades student enrollment, availability of core soil science courses and programs, and faculty positions at academic institutions has decreased. Although only based on anecdotal information, the Task Force also suggested that professional opportunities in soil and related sciences are increasing, especially over the last decade, and likely will continue to increase. The Task Force recognized that students taking soil science courses and faculty teaching soil science may be involved in broader applications related to ecosystem sciences, microbial ecology, environmental and natural resource sciences, and other related curricula, which may explain why soil science specific programs have declined. The Task Force concluded that quantitative survey information was needed to document trends in soil science and related academic programs, student enrollment, faculty in soil science, and job opportunities for graduates. The Task Force and SSSA Staff agreed that a survey should be facilitated by a social scientist to assist in design, analysis, and interpretation of survey data. The Task Force suggested survey topics included:

- Has recognition of soil science as a distinct discipline increased or decreased?
- How has the job market changed during the past decade, and will the majority of future job opportunities for soil scientists be related to agronomy, environmental science, ecology, earth science, or other areas?
- Has the soils curriculum moved away from production agriculture? What is the new emphasis?
- Have the number of students enrolled in soil science majors changed during the past decade?
- How have soils curricula (both undergraduate and graduate) changed during the last decade?
- Have soils programs been combined with other programs?

Therefore, the objective of the survey was to quantify trends in student enrollment, faculty positions, pertinent educational issues in soil and related sciences, and career/job opportunities and trends. It should be noted that the survey was undertaken in late 2008 when the economic recession worsened, especially in the last quarter of 2008, which may further impact academic departments, students and employers.

**Methodology**

The Social & Economic Sciences Research Center (SESRC) at Washington State University conducted a series of surveys for SSSA during June through November 2008. The project involved three separate surveys: (1) current students enrolled in soil science courses and recent graduates, (2) academic departments in the U.S. and Canada offering soil science courses/degrees, and (3) employers hiring people with soil science backgrounds. The SESRC collaborated with members of the SSSA Task Force and staff to draft the surveys. Further, the SSSA Board of Directors reviewed the survey for additional input to ensure clarity and complete coverage of the questions. Participants completed the survey in September and October 2008. SESRC implemented carefully designed and timed mailings to each survey group. Four email reminders were sent to survey recipients to ensure a high response rate.
**Student Survey**

The objective of the student survey was to quantify both anticipated career paths of current students and actual career paths for recent graduates, and their perceptions of career opportunities in soil science. The final web-based survey contained 35 questions of which 22 had an open-ended response component.

The population for this survey consisted of students either currently or recently enrolled in soil science courses or in a soil science degree program, based on SSSA student membership. The list of undergraduate and graduate students was selected from SSSA’s membership database, including all current student members and those who had not renewed in the previous two years. Among 2,915 survey recipients, 1,521 were current SSSA members and 1,394 were former members. Prospective participants were provided with an Internet address and a unique access number to the online questionnaire. Of the survey recipients, 947 (33%) completed or partially completed the web survey.

**Department Survey**

The objective of the academic department survey was to quantify trends in departments with soil science programs, including courses, faculty, and enrollment (both past, present and future). The final mixed mode (web and mail) survey contained 121 questions, of which 69 had an open-ended response component. The population for this survey consisted of academic departments in the U.S. and Canada in the soils, agronomic, crop/plant, and environmental sciences. A sample list of 245 department contacts (primarily department heads/chairs) was provided to SESRC by SSSA.

Survey recipients were provided with an Internet address and a unique access number to the online questionnaire. A print copy of the survey was also mailed to all prospective participants. For completed mail questionnaires, the data entry process consisted of three main stages: initial data entry, verification, and a final validation step to ensure all questionnaires were entered and verified. Of 245 survey recipients, 155 (63%) responses were completed.

**Employer Survey**

The objective of the employer survey was to quantify job opportunities and career trends for people with education in soil science. In addition, respondents provided input pertinent to academic preparation of soil scientists relative to expectations and needs of the job market.

The web-based survey contained 54 questions of which 16 had an open-ended response component. The employer population consisted of private and public industries, consulting firms, and government agencies in the U.S. who employs people with soil science backgrounds. The employers sample was generated by SSSA and sent to SESRC. Of 1,046 survey recipients, 864 were from soil science industries and consulting businesses and 182 were from government agencies (reviewed to ensure representation within government agencies such as USDA-NRCS, USDA-ARS, USEPA, USFS, etc.). Survey recipients were provided with an Internet address and a unique access number to the online questionnaire. Of 1,046 survey recipients, 438 (42%) completed or partially completed the web survey.
RESULTS AND DISCUSSION

Student Survey
Demographics and Degree Goals
The majority of students that responded to the survey were Caucasian (66%) and male (59%), currently living in the U.S. (70%), and between the ages of 26 and 30 (32%) (Fig. 2). The age distribution of the remaining respondents was divided into approximate thirds at ≤25 (31%) and ≥30 (37%) (data not shown). Most respondents were U.S. residents; only 13% lived outside the U.S. Together student respondents represented approximately 167 colleges and universities worldwide (40% outside the U.S.).

Figure 2. Gender and ethnicity demographics of student respondents.

More than half of student respondents were currently enrolled in a college or university (64%). The remainder of students had either graduated (34%) or was not currently enrolled and not yet graduated (2%). Of the enrolled students, the majority were graduate students (81%), followed by undergraduates (18%), and post docs (1%). Although the majority of students were pursuing a degree in soil science (47%), most others were in a degree program related to soil science (44%); only a small percentage (9%) of respondents were not pursuing a degree in, or related to, soil science (Fig. 3). Finally, these enrollment percentages aligned with the professional memberships of student respondents: SSSA (90%), ASA (78%), and CSSA (68%), followed by state level Soil Science societies (15%), GSA (12%), and NSCSS (1%). Taken together, these results demonstrate that the majority of students that participated in the survey were graduate students currently enrolled in soil science or majors related to soil science such as agronomy and environmental science.
Figure 3. Major distribution of student respondents. The “Other” (20.3%) category includes (in no particular order) majors in Economics, Biological Engineering, Waste Management, Hydrology and Water Resources, Molecular and Environmental Plant Sciences, Weed Science, Terrestrial Biogeochemistry, Oceanography and Coastal Sciences, Animal and Veterinary Science, Computers, Entomology, Ecology and Evolution, Wildlife and Fisheries, Pedology andGeomorphology, and Land Rehabilitation.

A positive relationship existed between current class rank and terminal degree goal of student respondents, such that a higher class rank corresponded with more individuals planning to pursue graduate studies. However, student attitudes toward soil science were different before and after attending college. Before going to college, most students (85%) were either very or somewhat interested in science. However, once in school, almost all students (98.5%) were very or somewhat interested in science. Accordingly, the top five cited reasons students became interested in a soil science major included: classes or projects in college (39%), previous work experience/agricultural experience (28%), a professor suggested it (8%), or a class or project in (5%) or before (3%) high school. Therefore, the primary method to increase the number of students enrolling in soil science would be to offer contemporary introductory soils courses that compliment other majors and attract students with undeclared majors (Collins 2008). Working with local K-12 schools to expose potential students (and their parents) to soil science would have less impact.

Student Employment and Salaries
Current student employment was also assessed in this survey. In 2008, a little over one-third of student respondents described their employment as full-time jobs, followed by 31% that cited assistantships. The remaining 33% of respondents were not employed full time, but were either seeking employment, were part-time, or were not seeking employment; only a small percentage (3%) had internships. Of the student respondents that were employed or had an internship, 79% were engaged in work directly related to soil science.
Because the highest percentage of student respondents were graduate students, we analyzed the percentage of students employed in each job type (e.g. graduate research position), but still enrolled in a college or university. The survey results showed that 15% of students enrolled in a college or university held a full-time job, while 17% said they held part-time positions. The majority of students still enrolled in a college or university were not employed. When internships were isolated, only 4% of enrolled students held an internship and even fewer (2%) that had graduated were currently in an internship. Relative to assistantships, 48% of students currently enrolled in a college or university reported holding an assistantship, while the remainder (53%) did not. Following graduation, employment numbers among student respondents sorted as expected. The majority of college graduates (75%) held full-time jobs and only 10% of graduates held part-time positions. The remainder was either continuing internships, unemployed, or not seeking employment.

There was no clear majority indicated for employer focus. Agronomy was the most cited at 31%, followed by an “other” category of 20+ different fields (18%), environmental science (17%), general soil science (14%), and single digit percentages including ecology, land management, and consulting. Because the majority of students who responded were graduate students, the primary employer of soils students was academia (69%), followed by government (20%), industry (9%), and non-profits (1%). This ranking also held for students employed in jobs related to soil science with the exception of family agricultural operations, which ranked above non-profits.

Current and expected annual salaries also varied among student respondents (Table 1). More than half of students enrolled in a college or university reported a full-time salary of $25,000 or less, while a majority (69%) of students that had graduated reported a salary between $25,000 and $49,999. This same salary range was reported by the greatest amount of students (64%) that were employed full-time regardless of enrollment. Of students employed part-time, 65% reported a salary of $25,000 or less. The salary among students with internships was roughly split between $25,000 or less and $25,000 to $49,000, 53% and 47%, respectively. The majority of students on assistantships (59%) reported salaries of $25,000 or less.

<table>
<thead>
<tr>
<th>Salary Range ($)</th>
<th>Full-Time</th>
<th>Part-Time</th>
<th>Internship</th>
<th>Assistantship</th>
<th>Enrolled in School</th>
<th>Graduated</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25,000</td>
<td>9.7</td>
<td>64.7</td>
<td>52.6</td>
<td>59.2</td>
<td>56.5</td>
<td>7.3</td>
</tr>
<tr>
<td>25,000 - 49,999</td>
<td>64.3</td>
<td>32.9</td>
<td>47.4</td>
<td>39.9</td>
<td>38.5</td>
<td>69.2</td>
</tr>
<tr>
<td>50,000 - 74,000</td>
<td>23.1</td>
<td>1.2</td>
<td>0</td>
<td>0.9</td>
<td>3.8</td>
<td>21.4</td>
</tr>
<tr>
<td>75,000 - 99,999</td>
<td>2.9</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
<td>1.2</td>
<td>2.1</td>
</tr>
</tbody>
</table>
When salary expectations were assessed relative to student degree goals, 71% of those planning to obtain a “Bachelors” as their highest degree expected starting salaries between $25,000 and $49,999, whereas slightly less (66%) of those obtaining a “Masters” expected the same annual salary range. For students who were planning to obtain a “Doctorate” as their highest degree, more than half expected an annual salary between $50,000 and $74,999 after graduation. Collectively, these results show that most students are currently employed in academic jobs directly or indirectly related to soil science and that salary expectations increase with degree status. These results are consistent with the majority of student respondents being enrolled in graduate programs.

**Career Interest and Perceptions**

It was clear that most students were very or somewhat interested in pursuing a career in soil science (82%); only 2% were not interested in pursuing a career in soil science. Moreover, 76% of student respondents recommended it as a good career choice for a young person. Students who were interested in a soil science career cited a variety of reasons for their interest (Fig. 4). For those that were not interested in a soil science career, the top three reasons included prior background or experience with the work (29%), other unrelated reasons (21%), or lack of job opportunities/salary/benefits (18%) (Fig. 5).

![Figure 4. Top seven reasons student respondents were interested in a career in soil science.](image)
Pursuing a career in soil science was influenced by whether or not a student had been employed or had past experience in a soil science field. When a student was employed in a job directly or indirectly related to soil science, they were more likely (86% and 66%, respectively) to seek future employment in the soil science profession. Moreover, when unemployed students were asked whether they would be looking for a job related to soil science, an overwhelming 86% responded affirmatively. The majority (44%) of these students were content with being employed by any type of organization, although some specifically identified academia (27%), industry or consulting (14%), government (13%), and non-profits (2%). Finally, when student respondents were asked about individual fields they would seek for employment; environmental science received the highest endorsement, followed by land management, agronomy, consulting, ecology and other earth science fields (Fig. 6). Thus, students are largely interested in a variety of careers directly related to soil science and the drive to secure soil-related positions appears to increase markedly when students are exposed to the profession while in college. We recognize that these results may be somewhat skewed by the demographics of the student respondents, as the majority of student respondents were continuing in a graduate program directly or indirectly related to soil science.

Figure 5. Top seven reasons student respondents were not interested in a soil science career.
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Figure 6. Fields of employment student respondents chose to pursue upon graduation from college. Note that more than one could be chosen by each respondent. Options within the “Other” category were not specified.

Student Attitudes toward the Soil Science Profession
Although students displayed a positive attitude toward the profession of soil science, clear and consistent areas for improvement were elucidated from analysis of the open-ended questions. Student respondents were offered the opportunity to add any additional comments relative to their experience as a soil science student or to the survey itself. We received 176 comments, which was approximately 19% of respondents. We used a simple qualitative method to analyze these results. Answers were first read and coded for repeating keywords and phrases. We then measured the frequency to identify areas of repetition. The majority of responses were characterized by a simple note of appreciation, a personal experience, or an offer for further involvement in the study. However, over 50% of the students (91) responded with suggestions or opinions on the soil science discipline of which 10 reoccurring themes were identified (Table 2).

Table 2. Ten repeating themes and keywords identified in the qualitative data. The top nine entries are footnoted with example comments below taken directly from the survey.

<table>
<thead>
<tr>
<th>Key Word or Phrase</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>difficult finding job opportunities / department out of touch with job opportunities¹</td>
<td>22</td>
</tr>
<tr>
<td>move away from agriculture / revamp curriculum / disconnect with real world²</td>
<td>19</td>
</tr>
<tr>
<td>soils is basis of all living systems / it is essential / connected to other disciplines³</td>
<td>8</td>
</tr>
<tr>
<td>soil judging essential⁴</td>
<td>8</td>
</tr>
<tr>
<td>get young minds / recruit more⁵</td>
<td>6</td>
</tr>
<tr>
<td>need for instructors and classes / more contemporary theme⁶</td>
<td>5</td>
</tr>
<tr>
<td>more funding⁷</td>
<td>4</td>
</tr>
<tr>
<td>employers hiring positions that soil scientist could fill⁸</td>
<td>4</td>
</tr>
<tr>
<td>excellent collaboration opportunities with others, but need more</td>
<td>3</td>
</tr>
<tr>
<td>hooked by engaging instructor</td>
<td>2</td>
</tr>
</tbody>
</table>
When I first became interested in soil science, I was encouraged by professors and other professionals who told us about how vast the job opportunities were going to be in the NRCS and other federal and state agencies as older soil scientists retired. However, I've found that those jobs don't seem to be as plentiful as we were led to expect.

To clarify my thoughts on the question that asked whether soil science is a "good" career for a young person to pursue... I think that soil science is a great field to study... However, I think that the profession of 'soil scientist' is under-appreciated in the job market and this can make finding an appropriate job difficult.

There is little interest in soils from people who are non-Agriculture minded and do not want to go into an agricultural field; they see soils as purely an agricultural job....I think the interest in soils could dramatically increase if more emphasis was put on the non-Agricultural aspects of soils when recruiting. I know I would have gone into it right away if I would have known it wasn't just for farmers.

Soil science should expand its tentacles to cover the environment more and not majorly directed towards Agriculture.

Work needs to continue on changing the image of soil science- it's much more than ag/agronomy and many young students still do not realize this.

After working in soils for 30 years, it is refreshing to be exposed to yet another application of soils to an outside discipline. For me, that is the greatest benefit (and attraction) of soils--its applicability to so many other disciplines.

My undergrad field of study was Geography and geog is an interdisciplinary study. I learn more about the importance of soil for the biotic life and the influence of problem soil on the biotic life. Soil is the base of all living things in the ecosystem even if the contribution of the other is not less. So, background environment and the influence of the past field of study forced me to join Soil Science.

There needs to be a huge push for soil judging. I know that most already realize this, but it is fun and really gets people hooked. Without soil judging, I sincerely doubt I would be in soils today.

We need to get to young minds (classroom gardens and primary education) to let people understand that soil science exists. Often students find out about soil science well into their undergrad studies. If people understood about soil as a science and potential career they might look to it as they enter higher education. “I believe we as soil scientist should be doing more to recruit new soil scientist from related disciplines.”

Classes offered under this discipline are diminishing so it is difficult to get a wide breadth in the discipline of soil science compared to what was offered during the training of current professors.

Professors of soil science courses need to make this field more entertaining and attractive for their students.

Soil science needs more funding and more acceptances in the fields other than Agriculture.

I'm concerned our discipline is under-appreciated and soil science programs are losing interest/funding, especially at the undergraduate level.

In my experience, jobs that would be best suited to soil scientists, are often being given to engineers, ecologists, or geologists. This could be because the people doing the hiring believe that these alternative fields have a broader and more 'useful' skill set, or these individuals have not have been exposed to soil scientists and perhaps do not recognize the field as one that matches their employment requirements.

I love soil science, but I think the best thing the society could do for graduates of soil science is make potential employers aware of what a soil scientist could do and how transferable many of our skills and knowledge is. In many cases we are competing against engineers and geologists and we are equally qualified, but employers don't recognize that just from our degrees.
From this analysis, the most frequent (top 5) comments focused on the difficulty in locating job opportunities, the need to revamp the image of soil science, an appreciation of soils in the natural world, the essential role of soil judging, and the need to engage young minds in this discipline. Increased support for graduates to find employment following college is not only critical to the role soil science will play in the environmental sciences and agriculture, but would provide a positive feedback on recruitment of future students, as available career opportunities are often cited in choosing a major (Collins 2008).

**Department Survey**

**Demographics**

Responding departments described their academic programs as primarily environmental science (18%), agronomy (11%), natural resources (10%), and soil science (6%) (Fig. 7). Many departments (38%) indicated multiple program emphases (38%), and 90% indicated that soil science is part of a larger department. Although 60% of soil science components have always been part of a larger department, 33% have merged with another department, and only 7% remain exclusively a soil science department.

Of all responding departments, only 27% offer degrees in soil science, nearly 80% offer courses but not degree programs in soil science, and 27% offering courses also offer a “concentration” in soil science. Of those offering degrees in soil science, none offer AA/AS degrees, 18% offer BA/BS degrees with soil science as a major, 15% offer BA/BS degrees with soil science as a minor, 21% offer an MA/MS in soil science, 18% offer a Ph.D. in soil science, and 3% offer “other” degrees in soil science.

![Figure 7. Primary focus of departments with programs in or related to soil science.](image)
Of the 130 departments responding, the average number of soil science faculty was 3.6 FTE/department; however, the median and mode were 1.0 FTE/department. Departments reported an average of 1.8 teaching FTE, 2.3 research FTE, and 0.9 extension FTE. On average, soil science faculty represented 19% of total faculty FTE/department. Eighty percent of soil science faculty are male and 86% are Caucasian.

In 53% of responding departments the number of soil science faculty FTE has not changed during the past 10 years; however, 31% indicated the number had decreased but only 16% reported increases (Fig. 8). Although most respondents (72%) do not anticipate a loss of soil science FTEs during the next 10 years, 17% anticipated a decrease and 11% anticipated an increase in soil science FTE during the next 10 years. Other data indicate that the ongoing economic recession and additional state budget cuts to higher education have further squeezed faculty salaries and sizes on many campuses (Chronicle Higher Ed., 2009).

Of those departments that offer an undergraduate degree or minor in soil science, 58% had ≤10 students enrolled as a major and 94% had ≤10 students enrolled as a minor (Fig. 9). Total undergraduate majors and minors reported were 349 and 254, respectively. Departments reported 282 M.S. and 245 Ph.D. students enrolled, and two-thirds of the departments reported ≤10 students enrolled in graduate degree programs. Similar to the distribution in gender and ethnic background of faculty, the majority of students in soil science degree programs and undergraduate minors are Caucasian males. However, 57% of soil science students are male and 43% are female, compared to the 80% male, 20% female composition of soil science faculty. Soil science students are 70% Caucasian, with African-American, Asian, and Hispanic students each composing <5% of the student population.
Enrollments
Students from many other degree programs take soil science courses. Although Fig. 10 shows the most common programs, a large percentage of students come from many “other” programs areas including ecology, biology, horticulture, forestry, wildlife, fisheries, range science and many other. Two-thirds of the departments reported that the majors of students enrolled in soil science courses are not changing.

Figure 10. Primary degree programs other than soil science of students enrolling in soil science courses. Respondents were instructed to indicate all that apply.
In 44% of departments, enrollment in soil science degree programs has not changed during the past 10 years; however, 41% indicated enrollment had decreased whereas only 15% reported increases during the past 10 years. Looking to the future, most respondents (70%) predicted enrollment in soil science degree programs would not likely change in the next 10 years, 28% predicted enrollments would increase and only 2% thought enrollment in soil science degrees would decrease in the next 10 years. In a related question, 44% of responding departments reported that enrollment in soil science undergraduate courses had not changed during the past 10 years (Fig. 11). More than 25% of departments reported increased course enrollment during this period, and about the same percentage reported decreased enrollments. Almost 60% of departments predicted no change in undergraduate enrollment in soils courses during the next 10 years, 30% predicted increased enrollment, and only 10% predicted decreased enrollment. More than 50% of departments reported no change in graduate course enrollments during the past 10 years, and 20% reported increased enrollment. Looking to the future, 60% of departments predicted no change in graduate soils course enrollments, 30% predicted increases, and about 10% predicted decreases. Thus, departments predicted similar trends in undergraduate and graduate course enrollments during the next 10 years. However, the economic recession is expected to exert further negative impact on students and their ability to afford tuition (Chronicle of Higher Ed, 2009).

![Figure 11](image)

**Figure 11.** Change in undergraduate (UG) and graduate (GR) student enrollment in soil science courses during the past 10 years and projected during the next 10 years.

**Curriculum**

Only 45% of departments have added new required soil science courses during the past ten years, 55% have added new elective courses. Most of these new courses included “environment” in the course title (e.g., environmental soil science, environmental soil chemistry), although other courses added were commonly related to wetlands, urban soils, ecology/biology, and sustainability. Most (70%) departments have not dropped soil science courses from their core
curriculum during the past ten years. Although 45% of responding departments never had an emphasis in production agriculture, nearly 22% of indicated that the emphasis on production agriculture has decreased during the past ten years, and only 4% indicated the emphasis increased. Of the remaining respondents, 30% indicated the emphasis on production agriculture has not changed.

Employment and Internships
Not surprisingly, most departments viewed soil science as very important (68%) or somewhat important (30%) as a discipline in the future. Overall, departments indicated a positive attitude about student employment opportunities in soil science. Departments reported that job opportunities for those completing both undergraduate and graduate degrees have greatly or somewhat increased (50%) during the past ten years, whereas 39% report that job opportunities have stayed the same, and 11% report that job opportunities have decreased. This positive outlook is reflected in attitudes about soil science as a career; 85% of respondents view soil science as a good career choice for young people. Only 2% thought soil science would not be a good career, and 13% were neutral. Respondents felt that the most promising job opportunities for graduates were to be found in environmental science, land management, soil science, and agronomy (Fig. 12).

![Figure 12. Fields that offer the most future job opportunities for students with a degree or background in soil science. Department respondents were asked to rank the top three areas. Data represent the sum of the rankings.](image)

To help students enter the workforce, 73% of departments indicated that they assist students to obtain internships with soil science employers or organizations. Departments reported that an annual average of five students per department had internships with soil science employers or organizations, although the median and mode were two students per department.
Respondents were asked to provide comments regarding selected questions. Relative to potential changes in undergraduate enrollment, the majority indicated increased enrollments over the next 10 years, primarily due to enhanced or expanded programmatic emphasis on the environment and related applications of soil science. Nearly two-thirds of the comments mentioned increased interest in varied aspects of the environment, with increasing requirements for soil science courses across disciplines. Although a few respondents indicated an increase in interest in agriculture and food production, several respondents also indicated decreasing interest and enrollment in agricultural related programs. Similar responses were provided for past and projected changes in graduate enrollment in soil science courses. A number of respondents indicated decreasing soil science faculty, primarily due to retirements, would reduce the department’s ability to offer graduate courses and train graduate students. Current constraints in state funding further limits replacement of soil science faculty.

**Employer Survey**

**Demographics**

Employers surveyed included government (25%), private industry (17%) professional consulting firms (53%), non-profit organizations (2%), and 4% who identified themselves as “other”. These employers further identified 63 different states or Canadian provinces in which they were located. The locations with the highest response rates for organizations were California (28 organizations, 8% of total responses), North Carolina (28, 8%), Illinois (25, 7%), District of Columbia (23, 7%), and Georgia (20, 6%). Of the Canadian provinces, Alberta had the highest number of responding organizations (5) with 2% of the total responses.

The majority (57%) of responding organizations had \( \leq 50 \) employees, and 38% had \( \leq 10 \) employees. Although the number of employees is not linked to the type of organization, government organizations tend to have large numbers of employees compared to typically smaller consulting or non-profit organizations; although there are several large consulting firms of over 500 employees located in the U.S.

The majority of respondents employ five or fewer soil scientists. A large majority of employers (96%) indicated they have a background in soil science and many are members of professional organizations such as SSSA (91%), their state’s soil science society (74%), American Society of Agronomy (72%), National Society of Consulting Soil Scientists (49%), Crop Science Society of America (27%), and Geological Society of America (10%). Respondents were also asked how often they hire soil scientists. More than half of employers don’t hire people with degrees or backgrounds in soil science every year. Of those organizations that do hire on an annual basis, 36% hire 1 to 2 undergraduates with degrees in soil science and 3% hire 3 to 5 every year. Responses showing estimated numbers of hires annually are shown in Table 3.
Table 3. Number of people hired annually with an undergraduate or graduate degree in soil science or an undergraduate degree in an area related to soil science.

<table>
<thead>
<tr>
<th>Annual New Hires</th>
<th>Level of Education in Soil Science</th>
<th># responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Undergraduate degree</td>
<td>Undergraduate degree in related area</td>
</tr>
<tr>
<td>None</td>
<td>246</td>
<td>205</td>
</tr>
<tr>
<td>1-2</td>
<td>146</td>
<td>162</td>
</tr>
<tr>
<td>3-5</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>6-10</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>11-20</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>409</td>
<td>405</td>
</tr>
</tbody>
</table>

The primary employer work emphasis was consulting, followed by environmental science and soil science (Fig. 13). Combining agronomy and crop science work areas would still be slightly less than soil science related work. Because consulting firms perform many types of work, there is likely overlap in these responses. The “other” category (15%) included horticulture, forestry, Superfund cleanup, and mining.

Figure 13. Areas of work emphasis of employers in soil science.

Over the next 10 years, employers thought environmental science, followed by consulting and wetland work were the best employment opportunities for people with an education and background in soil science (Fig. 14). Conversely, employers indicated that earth science and “other” jobs (not specifically included on the survey list) would be the least promising areas for employment opportunities.
Employers were asked to identify the most important soil science skill sets needed by their employees (Fig. 15). Respondents indicated that soil classification/survey, soil physical property/engineering assessment, and wetland soils were the three most important soil science skill sets. Ranked only slightly lower were soil test/interpretation (chemical properties, nutrients, etc.) and soil/landscape assessment. Turf/landscape application was the least chosen skill set.

Figure 14. Best job opportunities for people with an education or background in soil science. Employer participants were asked to rank the top three areas. Data represent the sum of the rankings.

Figure 15. Employer identified soil science skill sets required by the organization. Employer participants were asked to rank the top three areas. Data represent the sum of the rankings.
Relative to the ease or difficulty in finding and hiring qualified soil scientists, 48% of employers responded it was somewhat or very difficult, 30% were neutral, and 21% found it very easy or somewhat easy to recruit and hire people with backgrounds or degrees in soil science. Among government employers, more than half (55%) found it somewhat or very difficult to recruit and hire people with backgrounds or degrees in soil science; 28% were neutral and only 17% found it very or somewhat easy. Among “industry” employers, 50% found it somewhat or very difficult to recruit and hire people with backgrounds or degrees in soil science. Among non-profit organizations, no clear trend was observed as one-third of the responses each fell into the very or somewhat difficult, neutral, and or somewhat easy categories. Among professional consulting employers 45% found it very or somewhat difficult, 32% were neutral, and 22% found it very or somewhat easy to find qualified soil scientists. Of the “other” employers who didn’t identify themselves in the government, industry, non-profit, and private professional consulting areas, 62% found it very or somewhat difficult, 23% found it very or somewhat easy and only 15% were neutral. It should be noted that this survey does not break down the responses by region, which may have been helpful in looking at trends across the U.S. and in Canada.

Demand
Although nearly half (47%) of employers indicated that demand for soil scientists remained constant over the last 10 years, 37% thought demand increased, while only 16% of employers said demand had decreased. Therefore, the majority of employers (~84%) thought soil scientists are in demand.

Employers were also asked about the ease of finding employees with appropriate soil science skills during the past 10 years. Although 56% of employers thought there had been no change, 7% thought it was easier to find soil science trained employees; however, nearly 37% thought it was harder to find qualified soil scientists.

Availability of internships can help facilitate employment opportunities for people pursuing careers in soil science and can also encourage students to enter soil science careers. Only 30% of employers’ organizations offer internships for students in soil science on an annual basis. Of these employers, the majority (64%) offers only one internship annually; the survey did not ask employers to indicate whether these internships were paid or not.

Income Potential
Attracting students to a profession is partly dependent on income potential. Approximately 85% of employers reported a starting annual salary of $25,000 to $49,999 for a new full-time hire with an undergraduate degree in soil or related science (Table 4). Starting salaries were about $25,000 higher for graduate degrees in soil science or related areas, although one third of employers reported a $25,000-49,999 starting annual salary. The approximate starting annual salary for a full-time mid-level soil science hire was $50,000 to $75,000 (57% of employers).
Table 4. Starting salary levels for employees with degrees or backgrounds in soil science.

<table>
<thead>
<tr>
<th>Salary Range</th>
<th>Undergraduate degree in Soil science</th>
<th>Graduate degree in Soil science</th>
<th>Undergraduate degree in related area</th>
<th>Graduate degree in related area</th>
<th>Mid Career</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25,000</td>
<td>4.0</td>
<td>0.9</td>
<td>6.4</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>25,000 - 49,999</td>
<td>87.6</td>
<td>35.3</td>
<td>84.5</td>
<td>38.4</td>
<td>24.2</td>
</tr>
<tr>
<td>50,000 - 74,999</td>
<td>8.1</td>
<td>55.6</td>
<td>8.4</td>
<td>53.0</td>
<td>56.9</td>
</tr>
<tr>
<td>75,000 - 99,999</td>
<td>0.3</td>
<td>6.9</td>
<td>0.68</td>
<td>6.4</td>
<td>17.3</td>
</tr>
<tr>
<td>100,000 - 124,999</td>
<td>0</td>
<td>1.3</td>
<td>0.9</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

Training
Although availability of qualified employees is essential, application of learned skills is critical to an employer. Among employers of new hires over the past few years, the majority (79%) were either very satisfied or somewhat satisfied with their new hires’ education in soil science; the remaining employers were somewhat dissatisfied or very dissatisfied. In contrast, only 49% of employers either strongly or somewhat agree that colleges and universities are doing a good job of educating soil science students and preparing them for careers in soil and related sciences; the remainder were either neutral (25%) or disagreed (25%) with this statement. Respondents were asked to provide specific information regarding their concerns with the quality of university education in soil science, in an open-ended question. The primary issues inherent in their comments included:

- practical skills needed in the field are not being taught
  - seems like there has been a focus away from pedology
  - graduates lack basic field skills in current technology (i.e., GPS and GIS)
  - suggest instituting a soils field camp like geologist use to teach field skills
- rigor may be lost when combined with other programs such as environmental science; need to restore core sciences in programs of study
- writing, communication, and critical thinking skills are lacking and needed
- improved integration of subject matter as well as more instruction on regulations
- need for licensing/professional registrations to compete with Professional Engineers
- encourage students to join professional organizations while still in school

Career Choice
An important concluding survey question focused on the value of soil science as a career choice. Most employers (75%) either strongly agree or somewhat agree that soil science is a good career for a young person, while 16% were neutral and only 9% either somewhat or strongly disagreed. Specific comments were also solicited where the common themes were:

- lack of recognition for the importance of soil science in decision-making processes.
- not that many jobs available and salaries are lower than other disciplines
- integration of skills is needed to succeed
lack of respect for soil scientists by other disciplines
• demand should increase for soil scientists as regulations are changed to specify that soils work to be done by licensed or certified soil scientists. Any lag in the response to this demand will default workload to alternate disciplines (i.e., engineers, ecologists)

Employer Comments
At the conclusion of the survey, employers were asked to provide additional comments on experiences as an employer of people with soil science backgrounds. Numerous comments were submitted and the common issues included:
• need for more support of certification/licensing/registration programs
• there are conflict and respect issues between government agencies and consultants
• academia should work with industry more
• young people entering the profession have unrealistic salary expectations and need to improve work ethic and attitudes
• focus on new applications of soil science with the environment; Universities need to address current and changing needs of society and not cut or reduce soils departments
• haven’t done enough to sell soil science to the public or other professionals
• need to get away from the agronomy image

SUMMARY AND CONCLUSIONS
Survey responses provided interesting similarities and differences between the three survey groups. Differences in diversity between student and faculty populations were apparent, where the proportion of male and Caucasian faculty was higher than in the student population. Greater diversity in the student population will likely translate into improved diversity in future faculty.

The majority of departments indicated student enrollment in soil science degree programs has not changed over the past 10 years (44%), and would not likely change (70%) in the next 10 years. Over the past 10 years, 41% indicated enrollment had decreased, whereas only 15% indicated enrollment had increased. In contrast, 28% predicted enrollments would increase, but only 2.5% thought enrollments in soil science degrees would decrease in the next 10 years. Although these data suggest that most departments thought future enrollments in soil science would increase or stay the same relative to the previous 10 years, students seem to foresee a decline in enrollment due to the identity of soil science being associated with agriculture. A majority of students surveyed felt soil science as a discipline was suffering from an out-dated linkage to agriculture and cited the need to emphasize an environmental focus. These data are likewise consistent with the majority of future employment opportunities in environmental science as predicted by both students and employers. Although 17% of students reported being employed in environmental science, 88% said they plan to pursue careers in environmental science after graduation.

Departments are optimistic overall about the future of soil science. Many department responses indicate that student interest in the environment and sustainability is, in some cases, fueling increased student interest in soils. In relation to coursework, the majority of departments indicated undergraduate and graduate enrollments in soil science courses has not changed over the last 10 years. However, more departments thought enrollment in soil science courses would increase (69%) in the next 10 years compared to decreases (56%) in the last 10 years. Students...
cited taking an introductory course in soil science, being involved in a soils-related class project, or work experience in soils as being the most powerful mechanisms to generate interest in additional soil science courses and soil science as a discipline. Moreover, the more coursework taken in soils or the longer the student was in a soil science major, the more they wanted to continue their education (and eventual employment) in soil science. Thus, it appears that these gateway courses and soil science experiences are critical to attracting new majors, as once they are in the major, most continue pursuing the discipline.

Responding departments report that they have not, in general, been losing soil science faculty positions in recent years. Most responding departments include soil science as part of a larger department, with an average and median of only 3.6 and 1.0 soils faculty FTE per department, respectively. Only 27% of departments offer degrees in soil science, even though soils are often an important part of their curriculum. Thus, only a minority of departments are graduating degreed soil scientists. Fewer than 25% of soil science undergraduates participate in soil science internships. This should be of concern for departments and employers.

Nearly 50% of departments thought job opportunities for soil science graduates had increased over the last 10 years, while 40% indicated no change and 11% indicated job opportunities had decreased. In contrast, fewer employers (37%) thought job opportunities had increased over the last 10 years, whereas 47% indicated no change and 16% indicated job opportunities had decreased. Respondents were generally optimistic about future prospects for soil science employment opportunities.

Although slightly more departments thought student enrollments would increase than decrease over the next 10 years, nearly 37% of employers thought it would be more difficult to find trained soil scientists compared to only 7% who thought it would be easier to find qualified employees over the next 10 years. Currently, 50% of employers reported difficulty in finding qualified employees, where currently 21 and 29% found it less difficult or were neutral, respectively. The contrast between employer demand and department supply of trained soil scientists may indicate poor communication between departments and employers and warrants further study.

The suggested disconnect between departments and employers is supported by numerous comments by students who suggested: 1) difficulties in finding job opportunities and 2) departments are not fully aware of potential job opportunities. Once students were employed or completed an internship in an organization that actually engaged in soils work, they were more likely to seek employment in soil science. These results provide a tremendous opportunity for departments, students, and employers to grow the field of soil science, however improved communication between these groups is critical and consistently lacking as evidenced by the results of this study.

Departments and employers were in close agreement regarding fields that presented graduates with the best employment opportunities (Fig. 16). Based on Figs. 12 and 14, three of the top four fields were ranked similarly by both groups: environmental science, agronomy, and land management.
Figure 16. Similarity between employer and department ranking of best job opportunities. Cumulative rank represent the sum of the 3 priority ranks as reported in Fig. 12 (departments) and Fig. 14 (employers). Dashed line represents 1:1 line.

The majority of employers that responded to the survey were consulting firms (53%) and government agencies (25%). Although the survey did not provide information about the number of employees to organization type, it is likely that these two sectors account for the majority of soil science hires. Although most (79%) employers thought soil science education and training was adequate; there was some dissatisfaction with abilities of graduates. Employers consistently referred to the lack of field experience, in addition to poor communication (written and verbal), and critical thinking skills. Based on written comments, employers thought lack of problem solving skills reflected lack of rigor or integration of knowledge within the curriculum. Specifically, employers emphasized enhanced field experiences in soil science including pedology and soil survey, site assessment, GPS, and related areas.

Apparently, differences exist between academic departments and employers relative to soil science curriculum content. Several employers suggested that faculty and employers need to enhance communication relative to expected learning goals and outcomes, which is essential to academia providing quality employees to meet industry needs, and enhancing industry understanding and appreciation for the educational goals of an undergraduate or graduate education. One important opportunity to enhance student understanding of employer needs is to encourage and facilitate student membership in professional societies, and to specifically organize industry-faculty communication sessions through SSSA annual meetings and through web-based programming.

Although not specifically addressed in the survey, a number of employer respondents suggested that there is a lack of respect for soil science among related professionals. Commonly, soil scientists compete with other professionals (i.e., engineers, geologists) in soil science related applications. Unfortunately soil science may not be as recognized as engineering, geology, and
related fields because each view soil science work as part of their responsibilities. Although both professions require certification or licensing, these programs may be unknown or unused by soil scientists. In fact, several employers indicated there should be licensing or certification programs available to soil scientists. Therefore, it may be beneficial to enhance the marketing activities of current certification and licensing programs.

Additional employer comments that should be addressed include soil science separation from the traditional agronomy image and enhanced promotion of soil science. These barriers continue to concern employers as indicated in their comments. Although licensing and certification are essential, SSSA and individual soil scientists need to continually promote the value of soil science to a diverse audience.

GENERAL RECOMMENDATIONS
To address the concerns communicated by survey respondents, the SSSA should consider enhancing or initiating the following efforts:

1. The most important barrier to enhancing public understanding of the integrated science of soils is to comprehensively include soil properties, systems, and relationships to all other ecosystems in K-16 education curriculum, mostly early undergraduate courses. Since 2005, the SSSA has an established program to enhance soil science education; however, substantially more resources are needed to effect substantive changes in science curricula.

2. Similar to #1, the discipline of soil science needs to evaluate its image relative to agriculture and the environment. Although localized efforts are underway in this regard, the SSSA may need to assess its marketing at the national level relative to venues and groups unaware of the role of soil in the world. Because the perception of soils often varies even among soil science colleagues, marketing experts should be included in this effort.

3. To increase student enrollment in soil science, departments should evaluate the effectiveness of introductory courses to attract new majors (e.g., introductory courses in soils should be required by all environmental science majors), provide additional projects and internships to enhance student interest in soils, and market the major beyond agriculture at earlier stages in education (e.g., high school). The SSSA should encourage teaching faculty to develop and include a general soil and related science course available in the curriculum to any college student as part of their required general education science credits.

4. Provide specific and direct communication to colleges and universities regarding future demand for trained scientists with substantial background in soil science. Industry must collaborate with colleges and universities to substantially increase the number of internships and scholarships supporting student enrollment in soil related sciences.

5. Bolster communication between departments and students regarding job opportunities and internships. Students overwhelmingly cited a lack of communication relative to employment beyond college. This effort will require employers’ direct assistance to departments so that such opportunities can be made known.
6. The SSSA should consider including in its strategic planning process the importance of producing trained soil-related scientists and practitioners with functional skills valued and needed by employers. Enhancing the soil science curriculum to insure that students graduate with appropriate and functional field skills is urgently needed. Providing relevant departments with specific learning goals, objectives, and relevant curriculum materials, established in cooperation with industry partners is essential.

7. Departments, employers, and students agreed that soil science professionals do not enjoy the same professional recognition as professionals in environmental science and engineering. The SSSA has had a certification program for nearly two decades; however, its efforts have not been sufficiently successful to enhance professional status of Soil Scientists. It is imperative that SSSA reevaluate current certification programs to include a broader audience and to enhance SSSA assistance to states to enact licensing programs.

8. To encourage certification and state licensing as a natural step in the career process, the SSSA should help facilitate certification programs and state licensing by integrating the fundamentals exam into soil science curricula.

Clearly, students, departments, and employers agree that soil science is a viable career path for diverse applications in environmental, agricultural, land resource, and related sciences. Although differences exist between student career interests and employer opportunities, enhanced promotion of soil science education and employment opportunities will advance soil science as a fundamental science integral to many related sciences.

References


