

Alumni and Employer Perceptions of Crop, Soil, and Environmental Sciences Curricula: Survey Results

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ABSTRACT

Periodic assessment of goals is critical to maintaining a vital academic program. The University of Arkansas' Department of Crop, Soil, and Environmental Sciences designed two surveys and distributed them to alumni and employers during summer 2002 to obtain information concerning current workforce requirements of college graduates. General objectives of both surveys were to assess curricula, increase recruitment, and enhance student advisement. Fewer alumni are self-employed or employed by the government than 15 yr ago. However, alumni become employed relatively quickly and appear to be earning competitive salaries. The profitability of an advanced degree was supported by survey data. Employers provided comparative salary information and stressed the importance of developing a strong foundation in the basic sciences for environmental science and crop management majors. General and organic chemistry and communications were stressed as important courses for both majors, with alumni and employers expressing differences in the value of other courses. Alumni rated microbiology, ecology, botany/plant science, and geology higher than business or social science courses for environmental science students. For crop management, business and science courses were intermixed among highest alumni ratings. In contrast, employers placed greater emphasis than alumni on courses such as ethics and law and policy. Employers and alumni valued oral communications and problem solving skills, while employers placed greater value on writing, cost-benefit analysis, and data synthesis. Alumni placed greater value on group projects than employers. Survey results reaffirmed the need to include both alumni and employer input in program assessment to support curriculum and advising decisions.

THE Department of Crop, Soil, and Environmental Sciences (CSES) at the University of Arkansas currently offers undergraduate Bachelor of Science (B.S.) majors in crop management (CPMG) and environmental, soil, and water science (ESWS). Since 1994, the ESWS major has been introduced, the traditional agronomy major has been revised and renamed crop management, and the department name has changed from Agronomy to Crop, Soil, and Environmental Sciences. These types of changes are not unique to this department, but are similar to a national trend in departments originally named Agronomy (Raun et al., 1998).

Post World War II agricultural education has expanded beyond a narrow production focus into areas such as environmental and bioremediation programs, biotechnology, home horticulture, urban forestry, and landscaping (Miller, 1995).

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Pierzynski and Thien (1997) have documented students' increased interest in environmental areas such as land application of waste materials, water quality, and soil remediation in place of more traditional courses such as soil fertility and soil chemistry. Grabau and Graveel (1995) discussed the public status of North American colleges of agriculture, the decline of agronomy-based programs, and the consideration of possibilities to better integrate agriculture and natural resources to increase public support and academic morale and remain relevant to society's needs.

The changes in CSES at the University of Arkansas initially attracted an expanded clientele of students, as indicated by increases in undergraduate enrollment from 40 students in 1989 to a peak of 106 in 1997. The ESWS major in particular may appeal to students from both rural and urban backgrounds. Between May 1994 and May 2000, 130 students have completed the requirements for a B.S. degree from CSES, 65% as ESWS majors, and 35% as Agronomy/CPMG majors (Bacon et al., 2000). However, undergraduate enrollment in CSES has steadily declined from the peak of 106 in 1997 to 62 in 2000 (Bacon et al., 2000). Based on exit interviews conducted by the department head and questionnaires completed for approximately 66% of graduating seniors, students have continually expressed concern about the agricultural focus of the ESWS major and the lack of water- and social-science-related courses (Bacon et al., 2000).

All academic programs need periodic reviews to evolve in response to advances in technology, changing societal needs, and overall increased states of knowledge. "Assessment is (especially) needed in higher education to provide accountability for funds, to ensure a well-trained workforce, and to improve the effectiveness of academic programs" (Miller et al., 1998). A comprehensive review including opinions from departmental graduates as well as their current and potential employers can provide guidance in judging overall program effectiveness. Other academic institutions have recognized the need to maintain an on-going dialogue with potential employers to gauge the quality of graduates' knowledge, skills, and thus the overall quality of the academic program (Andelt et al., 1997; Cole and Thompson, 2002). In recent years, academic faculty have stressed the importance of interacting with employers, and these interactions continue to be important as educating students for careers in agriculture and/or natural resources demand not only greater technical skills, but also a more holistic perspective on interactions with society (Grabau and Graveel, 1995; Andelt et al., 1997).

While employers can attest to the quality of graduates and, therefore, the quality of a program, alumni offer a unique perspective to judge the strengths and weaknesses of a program (Miller et al., 1998; Cole and Thompson, 2002). Alumni are

Abbreviations: B.A., Bachelor of Arts; B.S., Bachelor of Science; CPMG, crop management; CSES, Crop, Soil, and Environmental Sciences; ESWS, environmental, soil, and water science; GPA, grade point average; Ph.D., doctorate degree.

particularly important targets because the degree of satisfaction former students have with their education is an indication of the success of an academic program (Barkley, 1993). If students of agricultural programs do not receive what they perceive to be a worthwhile educational investment, then agricultural programs will inevitably lose students to other programs. Comprehensive reviews may indicate inadequately covered areas or skills graduates are lacking. Using the result of periodic reviews, academic departments can, in turn, establish a means to meet observed deficiencies. These reviews can also gauge departmental strengths, allowing for better communication and appeal to prospective students.

Previous efforts by CSES to evaluate academic programs have included alumni surveys and senior exit interviews. Although CSES continues to conduct exit interviews with graduating seniors, the last departmental alumni survey was distributed in 1988 (Davis et al., 1991), prior to the establishment of the ESWS degree and CPMG revisions. Therefore, as part of CSES's current curricula assessment, two surveys were designed and distributed to alumni and employers during the summer of 2002. Goals of the alumni survey included assessment of curricula effectiveness and relevance, evaluation of overall student satisfaction with CSES programs, and collection of information to assist in student recruitment and advising. The alumni survey was designed with the following specific objectives: (i) obtain demographic, education, and career information; (ii) obtain information regarding satisfaction with departmental courses; and (iii) assess overall curricula and degree satisfaction. The employer survey was designed with the following specific objectives: (i) evaluate the importance of selection criteria for employee hiring, (ii) obtain job descriptions and earning potentials, (iii) obtain professional opinions with regard to curriculum design, and (iv) recruit employers interested in interacting with CSES. Data obtained from the two surveys will be used to enhance CSES's assessment of its curricula with regard to undergraduate degree satisfaction and the workforce requirements of college graduates.

MATERIALS AND METHODS

Survey Construction

Both surveys were two pages, front and back, and consisted primarily of multiple choice, rank, rate, and categorical questions with six open-answer questions. Open-answer questions were kept to a minimum due to their ability to elicit repetitious and often irrelevant material (Sheatsley, 1983). The CSES Alumni Satisfaction Survey was comprised of five sections: Demographics, Educational Background, Employment, Course Satisfaction, and Curriculum Assessment. The CSES Employer Survey was comprised of four sections: Company Information, Student Advising, Curriculum Design, and an optional Employer Recruitment section.

Survey Disbursement

The CSES Alumni Satisfaction Survey was distributed in August 2002 to 792 alumni as an insert in the CSES annual newsletter. The CSES Alumni Satisfaction Survey was sent to all departmental alumni for whom current addresses were available, including graduates of the past Agronomy program as well as the current Crop, Soil, and Environmental Science programs.

The CSES Employer Survey was distributed to 281 environmental and crop science professionals in an effort to assess the needs of actual and potential employers. Recipients represented various sectors of the workforce including local and state governmental agencies, public and private businesses, and academic institutions. A contact list for the CSES Employer Survey was developed to resemble similar surveys administered by other agricultural colleges (Bekkum, 1997; Cole and Thompson, 2002). For example, former and current employers of department graduates, a national list of soybean board members, and the membership list for the Arkansas Environmental Federation were used to develop the initial potential-contact list. Fifty-three percent of employer survey recipients were located in Arkansas, with the remaining 47% generally located in adjacent states and midwestern states such as Iowa, Indiana, and Illinois. Repeated efforts were made to encourage alumni and employers to return completed surveys. In September 2002, online addresses were created for respondents to complete and submit surveys electronically.

Statistical Analysis

Frequencies, relative sample abundances, means, ranges, and standard deviations were calculated, depending on the question type. For some questions, respondents were asked to rate their agreement with statements on a scale from 1 to 5, with 5 being *strongly agree* and 1 being *strongly disagree*. In these situations, responses ≥ 3 were considered positive and < 3 were considered negative. In addition, past graduate opinions regarding curriculum effectiveness and relevance (i.e., data from the 1988 survey) were compared with those of more recent alumni (1992–2002) to qualitatively assess how opinions may have changed since the restructuring of the Agronomy Department into CSES.

RESULTS AND DISCUSSION

Survey Response Rate

Survey responses were received electronically and by mail through December 2002. A total of 103 alumni completed and returned surveys, resulting in a 13% response rate. Thirty-nine responses were received electronically and 64 by mail. Seventy-five percent of the alumni who submitted their survey electronically were post-1992 graduates. In addition, 31 of the original 281 employer surveys were received, resulting in an 11% response rate. The response rates for the two surveys are similar to response rates ranging from 5 to 20% that have been documented for surveys of similar length and content (Wolf and Schaffner, 2000). The relatively low response rates could be an indication that those who responded are more interested in educational quality than most, resulting in a possible response bias in the dataset (Wolf and Schaffner, 2000). More than 50% of the employer respondents completed the optional section volunteering to interact and/or collaborate with CSES, further supporting the idea that respondents had a heightened interest in the quality of higher education.

Demographics and Educational Background

Despite the fact that CSES has changed its name and degree programs during the past 15 yr, the demographics of survey respondents were similar to those of alumni survey re-

Table 1. Percentages of Department of Crop, Soil, and Environmental Sciences alumni employed in different areas following graduation (i.e., first job) and in current positions (current jobs).

| Area of employment | First job† | Current job |
|--------------------|------------|-------------|
| | % | |
| Government | 22 | 14 |
| Industry | 35 | 32 |
| Education | 36 | 38 |
| Self | 5 | 6 |
| Other | 1 | 1 |
| Retired | 0 | 9 |

† Numbers are rounded; therefore, percentages do not equal 100%.

spondents in 1988. Eighty-one percent of current survey respondents were male and 97% were U.S. citizens. In 1988, 85% of alumni respondents were male and 95% were U.S. citizens (Davis et al., 1991). Although CSES does not keep data on the gender of its graduates, estimates indicate that approximately 80% of CSES alumni are male. This statistic appears to be changing, however, because estimates indicate that approximately 40% of alumni graduating with a B.S. between 2000 and 2002 are female.

A lower percentage of alumni responding to the survey (75%) obtained advance degrees compared with those who completed the 1988 survey (85%). Of the 63 respondents who received B.S. degrees from the University of Arkansas, 71% obtained Master of Science (M.S.) degrees and most of these students stayed at the University of Arkansas. Thirty-two percent of the 63 respondents continued on for a doctorate degree (Ph.D.), but only 8% received their Ph.D. from the University of Arkansas. The high number of respondents holding advanced degrees is interesting to note, given that during exit interviews 67% of graduating seniors did not plan to attend graduate school, but rather expected to secure employment immediately upon graduation (Bacon et al., 2000). Apparently, many ESWS and CPMG B.S. graduates decide to continue their education by seeking more advanced degrees after working some time. Thirty-eight percent of alumni respondents graduated in the past 10 yr. Of this group, 44% obtained an M.S. and 10% obtained a Ph.D. Given the relatively small percentage of alumni who responded to the survey, the high percentage of advanced-degree-holding respondents may not be indicative of the total graduate population. Advanced-degree holders may be more likely to complete and return the survey, and could have introduced a bias in survey responses.

Employment

Prospective students frequently question the departmental recruiter about potential career opportunities and earnings. To gather data on this topic, alumni and employer respondents were asked about their employment and to disclose salary information. Following graduation, 35% of alumni began working in industry, 36% in educational positions (most of these were attending graduate school), and 22% obtained jobs with governmental organizations (Table 1, first job). Of alumni who entered industry positions, 4% were consultants, 13% were in sales, and the remainder held science-related positions, such as technicians, field scientists, and researchers. Few CSES alumni (5%) were self-employed, and most of them were farmers.

Table 2. Annual starting salaries for Department of Crop, Soil, and Environmental Sciences alumni graduating between 1992 and 2002.

| Salary information | Alumni with B.S. | Alumni with M.S. | Alumni with Ph.D. |
|--------------------|------------------|------------------|-------------------|
| Average | \$23 140 | \$31 290 | \$42 670 |
| Standard deviation | \$7 080 | \$9 320 | \$16 010 |
| Minimum | \$13 000 | \$14 500 | \$27 000 |
| Maximum | \$38 000 | \$46 000 | \$59 000 |
| Sample size | 18 | 17 | 3 |

Alumni were also asked to provide their current job titles. There was a similar distribution among areas of employment between first jobs and current jobs for alumni except for a notable decrease in governmental positions and the establishment of a new category for those who are retired (Table 1). Current positions differed from initial positions within higher education, as most current job titles were related to faculty or administrative positions rather than graduate degree-seeking positions. In industry, most job titles were associated with management and executive positions rather than with sales and technician-level positions.

Alumni career paths appeared to have changed since the 1988 survey (Davis et al., 1991). Results from the current survey showed fewer alumni were working in government or were self-employed and a higher number of respondents went into industry. Factors such as a burgeoning regional population, governmental downsizing, an influx of industry into the region, as well as the general consolidation of agriculture may have contributed to the evolving job market. A significant change in CSES's curricula and focus may have also been a factor influencing subsequent career decisions of alumni.

Starting annual salaries were tabulated only for those respondents having received their most advanced degree in the past 10 yr (i.e., between 1992 and 2002). Starting salaries for B.S. respondents averaged \$23 140, approximately \$8000 less than M.S. respondents (Table 2). As expected, Ph.D. respondents reported the highest average starting salary at \$42 670. Salaries from the 2002 survey were compared with salaries from the 1988 survey to determine if current graduates are financially "better off" than their peers of 15 yr before. Based on an average annual inflation rate of 3.1% (InflationData.com, 2003), starting salaries reported in 1988 were calculated to be equivalent to \$30 800, \$36 800, and \$50 300 for B.S., M.S., and Ph.D. degree holders, respectively. The average starting salary for alumni graduating since 1992 was \$28 330 ($n = 38$), after four individuals earning less than \$5000 were removed from the dataset. This amount is similar to the average starting salary of \$28 190 as reported in the 1988 survey (Davis et al., 1991). When adjusted for an average annual inflation rate of 3.1%, that salary in 1988 would be equivalent to \$44 560 today, indicating that average starting salaries for CSES alumni have not kept up with inflation. However, compared with the CSES Employer Survey, salaries appear to be within range of what can be expected. Employers indicated that starting salaries ranged from less than \$20 000 to nearly \$60 000, with 72% of employers indicating initial starting salaries in the \$20 000 to \$39 999 range. Twenty-one percent of employer respondents, primarily employers representing industry, indicated starting salaries were in the \$40 000 to 59 999 range.

Table 3. Percentages of Department of Crop, Soil, and Environmental Sciences alumni earning salaries within specified ranges ($n = 24$ for B.S., 35 for M.S., and 31 for Ph.D., respectively).

| Salary category | % Alumni with B.S. | % Alumni with M.S.† | % Alumni with Ph.D. |
|-------------------|--------------------|---------------------|---------------------|
| <\$30 000 | 25 | 28 | 10 |
| \$30 000–49 999 | 42 | 28 | 19 |
| \$50 000–79 999 | 29 | 26 | 42 |
| \$80 000–99 999 | 0 | 14 | 19 |
| \$100 000–129 999 | 4 | 3 | 10 |

† Numbers are rounded; therefore, percentages do not equal 100%.

Salaries were categorized with respect to the highest degree earned, in part to determine the profitability of investment in an advanced degree. Current salaries ranged from less than \$30 000 to \$129 999 for all CSES alumni (Table 3). Alumni were not questioned as to the number of years they have been employed in their current position; therefore, salary ranges simply indicate a composite of the total response group. The number of alumni reporting higher-end salaries increased to a greater extent among those with M.S. and Ph.D. degrees (Table 3). For example, only 4% of B.S. respondents—compared with 17% of M.S. and 29% of Ph.D. respondents—indicated annual earnings greater than \$80 000. Therefore, not only were starting salaries higher for advanced-degree holders, but those with M.S. and Ph.D. degrees had the greatest potential to advance their salaries. Current salaries disclosed in the employer survey also ranged from \$30 000 to \$100 000 (data not shown), again indicating that alumni salaries are within a representative range as that reported in employer surveys.

Alumni and employers were asked their opinions regarding whether a B.S. degree is sufficient for a successful career. While alumni felt that one could be successful with a B.S. in ESWS (average survey response value of 3.2), alumni were less inclined to agree that a B.S. was sufficient for students majoring in CPMG (average survey response value of 2.9). This supports the indication from salary data that one can obtain employment with an adequate salary, but potential for advancement is limited with only a B.S. degree. Employers were more likely than alumni to view a B.S. degree as sufficient for a successful career; this view is indicated by average survey response values of 3.4 for ESWS and 3.6 for CPMG majors.

Student Recruitment and Advising

Alumni were asked to indicate overall satisfaction with their University of Arkansas degrees. Responses were overwhelmingly positive, with 92% of alumni indicating that they were *satisfied* or *totally satisfied* with the degree received from CSES at the University of Arkansas. Small class sizes have always been considered a strength of the department. During exit interviews, seniors commented positively about the small class sizes and those opinions were reaffirmed by 95% of alumni in the survey. However, students had also indicated during exit interviews that CSES lacked required courses relating to the social science aspects of environmental science. Since there is room for only a limited number of degree requirements per program, employers were asked if, given a choice, would they prefer to hire a graduate with a Bachelor of Arts (B.A.) or a B.S. degree. Overwhelmingly,

Table 4. Employer ($n = 30$) and alumni ($n = 96$ –98) ratings and rankings concerning the importance of specific hiring criteria.

| Hiring criteria | Employer mean† (SD) | Employer rank | Alumni mean (SD) | Alumni rank |
|---------------------------------------|---------------------|---------------|------------------|-------------|
| Oral and written communication skills | 4.5 (0.7) | 1 | 4.6 (0.7) | 1 |
| Interpersonal skills | 4.4 (0.7) | 2 | 4.5 (0.7) | 2 |
| Research/hands-on work experience | 4.1 (1.0) | 3 | 4.4 (0.7) | 3 |
| Technical aptitude | 4.1 (0.5) | 3 | 4.2 (0.8) | 4 |
| Course relevance | 4.0 (0.8) | 5 | 4.2 (0.7) | 4 |
| Leadership/management skills | 3.8 (0.9) | 6 | 4.2 (0.7) | 4 |
| Grade point average | 3.3 (0.7) | 7 | 3.4 (0.7) | 8 |
| Business skills | 3.0 (0.9) | 8 | 3.1 (1.0) | 7 |
| Extra-curricular involvement | 2.9 (0.9) | 9 | 3.4 (1.0) | 8 |
| Foreign language | 1.9 (0.8) | 10 | 2.4 (1.0) | 10 |

† Respondents were asked to rate their agreement with statements on a scale from 1 to 5, with 5 being “strongly agree” and 1 being “strongly disagree.” Values ≥ 3 were considered positive.

employers stated that they preferred candidates with stronger science backgrounds. Only 10% of the employers indicated that they would choose a B.A. instead of a B.S. graduate.

Survey participants were asked to indicate their opinions with regard to future job prospects. Most alumni obtained their first job within a short period after graduation. Sixty-one percent of respondents indicated that they obtained their first job immediately after or even before completion of their last degree and only 6% reported needing more than a year to find a suitable position ($n = 89$, data not shown). Alumni agreed that jobs should be available in the future for ESWS graduates (average survey response value of 3.9), and were also optimistic about positions related to CPMG majors (average survey response value of 3.5). However, some participants commented that consolidation and downsizing in agronomic fields is a concern. Employers were also generally positive, but more likely to encourage a degree in ESWS (average survey response value 3.7) as compared with a CPMG degree (average survey response value 3.0). Despite the positive responses, 2002 respondents seemed to be slightly less optimistic than 15 years ago when approximately 82% of 1988 respondents indicated that a departmental graduate would be “able to find jobs in the next 4 to 6 years” (Davis et al., 1991). In conjunction with this trend, 71% of respondents in the employer survey indicated that hiring had not occurred at their place of business in over a year. Low employee turnover and low demand were the only explanations provided for the low hiring rate.

College graduates seeking employment are usually curious as to what areas they should highlight when constructing a resume. Seniors indicated during exit interviews that CSES does little to help students develop and refine job-seeking skills. Effort is made in this area through instruction in a colloquium course. However, this particular course is not required and many students opt not to take colloquium for various reasons. Approximately 60% of survey participants indicated that they were not adequately trained in job search skills as a CSES student. Thus, alumni and employers were asked to rate the importance of several general hiring criteria often included in resumes, such as grade point average (GPA) and previous work experience. Excellent oral and written communication skills as well as interpersonal skills were considered to be the most highly desired attributes in prospective employees by both employers and alumni; survey respondents rated these skills higher than GPA (Table 4). Similar results were obtained in 1988. Self-motivation was the most de-

Table 5. Alumni (graduating between 1992 and 2002) rankings of the top five most valuable courses, categorized by highest degree obtained.

| B.S. | Rank | M.S. | Rank | Ph.D. | Rank |
|---------------------------------|------|---|------|---------------------------------|------|
| Soil science | 1 | Scientific presentations | 1 | Soil chemistry | 1 |
| Weed science and identification | 2 | Soil science | 2 | Statistics/Experimental design | 2 |
| Environmental science | 3 | Weed science and identification | 3 | Soil physics | 2 |
| Soil fertility | 3 | Soil microbiology | 3 | Scientific presentations | 2 |
| Rice production | 5 | Biochemistry | 5 | Soil microbiology | 2 |
| Water science/Water quality | 5 | Soil classification and genesis | 5 | Biochemistry | 6 |
| Soil classification and genesis | 7 | Crop physiology | 5 | Soil science | 6 |
| Crop science | 7 | Soil chemistry | 8 | Crop physiology | 8 |
| | | Environmental soil science | 8 | Plant breeding | 8 |
| | | Geographic information systems/Remote sensing | 8 | Microbiology | 8 |
| | | | | Soil classification and genesis | 8 |

sired characteristic in 1988, along with oral and written communication skills and personality (Davis et al., 1991). The ability to speak a foreign language and extra-curricular involvement were given relatively low rankings. Interestingly though, in open comments, a few alumni cited their foreign language skills as inadequate after graduation. Soil and agronomic courses including soil profile descriptions; communication skills; practical, technical, and research experience; earning graduate degrees; and establishing close relationships with faculty were mentioned multiple times as beneficial to alumni in obtaining employment after graduation.

Curriculum and Course Content

The CSES department restructured its curricula between 1988 and 2002 by switching from a production-focused agronomy to the more diverse crop, soil, and environmental sciences curricula. In an effort to evaluate and improve CSES curricula effectiveness and relevance, alumni respondents were asked to indicate their five most and least valuable courses. Opinions as to the importance of certain courses appeared to change somewhat as students completed more advanced degrees (Table 5). Courses in soil science that were important to B.S. graduates included introduction to soil science, soil fertility, and soil classification and genesis. Also important were weed science and weed identification courses, environmental science, water quality, rice (*Oryza sativa* L.) production, and crop science. The importance of rice production to alumni most likely reflects the fact that Arkansas is the nation's leading producer of rice (NASS, 2002). While soil science courses continued to be important, courses not offered at the undergraduate level were indicated as being important to graduate students. Courses in statistics and scientific presentations reflect the fact that graduate students spend much of their time conducting and presenting research. Biochemistry, microbiology, and crop physiology courses were important to graduate-degree recipients, as were more specialized soils courses, such as soil physics, soil microbiology, and soil chemistry and the crop science course in plant breeding (Table 5). The value given to these types of courses reflects the notion that advanced understanding in environmental and agronomic sciences requires knowledge in the application of basic sciences.

Generally, alumni respondents with graduate degrees in the 1988 survey found the most value in basic science and communication courses, while those holding B.S. degrees found importance in the applied science courses (Davis et al., 1991). Despite the fact that curricula have been revised and a new major has been added since the 1988 survey, 1988 and 2002 survey results were similar overall with courses in applied sci-

ences receiving high rankings among undergraduates and greater emphasis placed on courses in communication, basic sciences, and the application of basic sciences among alumni holding graduate degrees. However, the high ranking of water quality and environmental science courses that are required to earn a B.S. in ESWS (Table 5) also show that the ESWS degree has influenced alumni perceptions of their most valuable courses. One of CSES's strengths is soil science. However, some alumni commented that more water science courses would be beneficial to the ESWS curriculum. In contrast, there were a wide variety of courses that received relatively few votes for courses considered least valuable (data not shown). Therefore, it was difficult to summarize data on courses that were not considered valuable.

In addition to naming their most and least valuable courses, alumni and employers were asked to indicate the overall importance of several independent courses within the CPMG and ESWS curricula. Out of several basic math and science courses, general and organic chemistry courses were rated high by both groups of survey participants (Table 6). Communications was also ranked high and was among the top five important courses. However, foreign language was given the lowest ranking for both majors and from employers. The two majors differed in that botany and business were given higher priority for CPMG, whereas ecology and microbiology were given higher priority for ESWS. Employers placed greater emphasis on ethics and law and policy than did alumni.

To further understand what educational courses employers value, survey participants were asked which five upper-division courses from a list of 12 they would incorporate into an ESWS degree program. Employers were provided a second list of 12 courses and asked which of those five upper-division courses they would incorporate into a CPMG degree program. For ESWS, employers' top choices included environmental law and policy, wastewater management, hazardous waste management, environmental health and safety, and air quality (Table 7). The top five choices for CPMG included pest management, nutrient management, crop production systems, agricultural law and policy, and sustainable agriculture.

Alumni also expressed their opinions of the importance of several more specific elements to consider in course design. Oral presentations were the most desired element to include in course design (Table 8). Problem solving, working independently and in teams, followed by written communication skills, critical thinking, computer skills, and leadership skills received the highest rankings. In open-ended comments, the most frequently mentioned areas that alumni felt inadequately prepared for included business skills, especially management,

Table 6. Alumni and employer ratings and rankings of the importance of several independent courses to Environmental, Soil, and Water Science (ESWS) and Crop Management (CPMG) curricula.

| Course | ESWS | | Course | CPMG | | Course | Employer | |
|----------------------|------------|------|----------------------|------------|------|----------------------|------------|------|
| | Mean† (SD) | Rank | | Mean† (SD) | Rank | | Mean† (SD) | Rank |
| Communication | 4.6 (0.8) | 1 | Botany/Plant science | 4.6 (0.9) | 1 | Communication | 4.4 (0.6) | 1 |
| General chemistry | 4.4 (0.9) | 2 | Communication | 4.6 (1.0) | 1 | General chemistry | 4.0 (1.1) | 2 |
| Organic chemistry | 4.4 (1.4) | 2 | General chemistry | 3.9 (1.0) | 3 | Organic chemistry | 3.9 (1.1) | 3 |
| Microbiology | 4.2 (1.0) | 4 | Organic chemistry | 3.9 (1.0) | 3 | Ethics | 3.8 (1.0) | 4 |
| Ecology | 4.2 (0.9) | 4 | Business | 3.7 (1.0) | 5 | Ecology | 3.6 (1.0) | 5 |
| Botany/Plant science | 4.1 (0.9) | 6 | Ecology | 3.7 (1.0) | 5 | Law and policy | 3.5 (1.1) | 6 |
| Geology | 4.1 (0.9) | 6 | Biochemistry | 3.6 (1.1) | 7 | Business management | 3.4 (0.8) | 7 |
| Biochemistry | 3.8 (1.1) | 7 | Economics | 3.6 (1.1) | 7 | Economics | 3.4 (0.9) | 7 |
| Physics | 3.6 (1.2) | 8 | Microbiology | 3.6 (1.0) | 7 | Physics | 3.4 (1.1) | 7 |
| Ethics | 3.5 (1.2) | 9 | Freshmen orientation | 3.6 (1.5) | 7 | Geology | 3.4 (1.2) | 7 |
| Freshmen orientation | 3.4 (1.5) | 10 | Ethics | 3.6 (1.3) | 7 | Biochemistry | 3.3 (1.0) | 11 |
| Law and policy | 3.4 (1.3) | 10 | Marketing | 3.4 (1.2) | 12 | Botany/Plant science | 3.2 (1.3) | 12 |
| Calculus | 3.3 (1.2) | 12 | Geology | 3.0 (1.0) | 13 | Microbiology | 3.1 (1.0) | 13 |
| Business | 3.2 (1.1) | 13 | Law and policy | 3.0 (1.1) | 13 | Marketing | 3.0 (1.0) | 14 |
| Economics | 3.1 (1.2) | 14 | International issues | 3.0 (1.2) | 13 | Calculus | 3.0 (1.3) | 14 |
| International issues | 3.0 (1.1) | 15 | Physics | 2.8 (1.1) | 16 | Genetics | 2.6 (1.4) | 16 |
| Marketing | 2.7 (1.2) | 16 | Calculus | 2.8 (1.1) | 16 | International issues | 2.3 (1.0) | 17 |
| Foreign language | 2.6 (1.2) | 17 | Foreign language | 2.6 (1.3) | 18 | Foreign language | 2.2 (0.8) | 18 |

† Respondents were asked to rate their agreement with statements on a scale from 1 to 5, with 5 being “strongly agree” and 1 being “strongly disagree.” Values ≥ 3 were considered positive.

public relations and financial aspects (data not shown). Biotechnology, genetics, statistics, and technical computer skills were also mentioned as inadequately covered areas. Areas of concern raised in the 1988 survey included public speaking, writing, computer skills, relevant experience, and knowledge of business and marketing (Davis et al., 1991). The emergence of biotechnology as an issue in the latest surveys probably reflects the prevalence of and advances in applied technologies. The CSES department has recently incorporated a required minor into the CPMG curriculum (either agricultural business or pest management) and has hired several new faculty with expertise in biotechnology.

Employers agreed that written and oral communication skills as well as problem solving should be included in course design. Employers also felt that data synthesis/interpretation and cost–benefit analysis were important. A few alumni commented in open-ended answers that they felt inadequately prepared for elements of project management (e.g., site assessment, project preparation and evaluation, sampling, cost–benefit analysis, etc.). Students reported during senior exit interviews and in questionnaires that the areas addressing regulatory issues are lacking in CSES curricula. Employers indicated that environmental compliance, regulatory action, and environmental permitting were important responsibilities of their jobs (data not shown).

Table 7. Employer selections of upper-division courses to incorporate into ESWS and CPMG curricula.

| ESWS course | Rank | CPMG course | Rank |
|-----------------------------------|------|-----------------------------|------|
| Environmental law and policy | 1 | Pest management | 1 |
| Wastewater management | 2 | Nutrient management | 2 |
| Hazardous waste management | 3 | Crop production systems | 3 |
| Environmental health and safety | 4 | Agricultural law and policy | 3 |
| Air quality | 5 | Sustainable agriculture | 5 |
| Conservation of natural resources | 6 | Business management | 6 |
| Environmental economics | 7 | Agricultural economics | 6 |
| Nutrient management | 8 | Organic production systems | 8 |
| Site remediation | 8 | Plant genetics | 8 |
| Wetland rehabilitation | 10 | Precision agriculture | 9 |

CONCLUSIONS

Despite the recent decline in enrollment in CSES, the majority of CSES graduates are employed quickly, earn adequate salaries in their respective careers, and seem to be generally satisfied with their degree and experience from CSES. Responses from both alumni and employers provided valuable insight for successful student advising and for the types of courses that are important for subsequent employment. Employers confirmed the importance of a strong science background in environmental science degrees. Both groups reaffirmed the importance of several courses currently being offered, such as the fundamental sciences, as well as soil, crop, and weed science courses. Incorporation of the ESWS degree into the CSES curriculum was also evident in that environmental science and water quality received high rankings among B.S. alumni as most valuable courses. Chemistry and

Table 8. Alumni and employer rankings of elements of course design ($n = 93$ to 97, depending on element).

| Element | Alumni | | Employer rank |
|---------------------------------|------------|------|---------------|
| | Mean† (SD) | Rank | |
| Oral presentations | 4.7 (0.6) | 1 | 2 |
| Problem solving | 4.6 (0.6) | 2 | 4 |
| Work independently | 4.5 (0.6) | 3 | ND‡ |
| Team skills/Group projects | 4.5 (0.7) | 3 | 10 |
| Writing | 4.4 (0.6) | 5 | 1 |
| Critical thinking | 4.4 (0.7) | 5 | 6 |
| Computer skills | 4.4 (0.7) | 5 | ND |
| Technical writing | 4.4 (0.7) | 5 | ND |
| Leadership | 4.4 (0.7) | 5 | ND |
| Time management/Self discipline | 4.3 (0.8) | 10 | ND |
| Interpersonal skills | 4.3 (0.8) | 10 | ND |
| Data synthesis/Interpretation | 4.2 (0.8) | 12 | 3 |
| Creativity | 4.2 (0.7) | 12 | ND |
| Hands-on lab | 4.0 (1.0) | 14 | 8 |
| Risk assessment | 3.6 (1.1) | 17 | 7 |
| Cost–benefit analysis | 3.5 (1.0) | 19 | 5 |

† Respondents were asked to rate their agreement with statements on a scale from 1 to 5, with 5 being “strongly agree” and 1 being “strongly disagree.” Values ≥ 3 were considered positive.

‡ Employers were given a truncated list compared to that given to alumni. Therefore, elements not included in employer list have been designated with an ND (not determined).

communications were highly valued courses among employers and alumni. Alumni gave higher ratings of importance to ecology and microbiology for environmental science students and plant sciences and business for crop management students. However, employers also appeared to value courses emphasizing broader applications of environmental science that are not currently being offered in the department, such as environmental law and policy and courses stressing data synthesis/interpretation and cost-benefit analysis. Employer input is a vital part of curriculum assessment, especially as job markets evolve and higher proportions of graduates establish careers in private industries. The importance of interpersonal and communication skills continued to be stressed and the Scientific Presentations course has proven to be a highly valued component of the graduate program. Continuous curriculum revitalization and revision are imperative for graduating competent and satisfied individuals. Alumni and employer insight gained through these surveys is serving as an essential component in the revision of current curricula in the Department of Crop, Soil, and Environmental Sciences at the University of Arkansas.

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