Range Science Graduate Education/Research

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Analysis and assessment of undergraduate range science education has been reported by the academic community (e.g., Cook and Bonham 1974, Norton and Eastman 1981), but comparable emphasis on graduate education/research has been neglected by the range profession. The future of the profession is jeopardized by the perception that undergraduate education must be evaluated and altered to address change while graduate education can remain relatively unchanged. It is graduate education that produces future faculty and leaders of discovery.

In this article, we assess the current status and future of graduate programs in the United States, describe some characteristics of the rapidly changing environment in which graduate education and research operates, and suggest opportunities for directing the future of range graduate education/research. The assessment was supported in part by survey questionnaires mailed to department heads or graduate program coordinators of 39 institutions in mid-September, 1991. Only 2 institutions that have a graduate program failed to response to the survey. Of the 31 institutions that responded, 26 institutions currently offer a graduate program in range science.

Survey Results

Number of Degrees Granted and Size of Programs. Little change occurred in the past decade in the number of graduate degrees awarded in the U.S. An average of 117 graduate degrees (including non-thesis, M.S. and Ph.D.) were awarded annually in the decade of 1980–89 whereas 120 graduate degrees were awarded in the 1990–91 academic year. The number of M.S. degrees awarded decreased from an average of 77 in the decade of 1980–89 to 70 in the 1990–91 academic year, whereas 39 Ph.D. degrees were awarded in 1990–91 compared to 32 in the average year of the previous decade.

A few institutions have awarded a large portion of the degrees. For the period 1980–1989, 5 institutions (Colorado State University, University of Nebraska-Lincoln, New Mexico State University, Texas A&M University, and Utah State University) accounted for more than half of all graduate degrees awarded. This disparity continued in the 1990–91 academic year. Furthermore, 4 institutions did not award an M.S. degree and 18 institutions awarded less than 5 M.S. degrees in the 1990–91 academic year.

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Student Populations. In the previous decade, about half of the average program's graduate student population had an academic background in range. By the 1990–91 academic year, the population of students with a range background had declined considerably. This may have resulted from a shortage of qualified students with a range background, or institutions may be choosing to recruit students with academic backgrounds in other disciplines.

The range graduate student population at U.S. institutions is dominated by U.S. citizens and no major shifts in the student population appear to be occurring. However, 75% of non-U.S. students graduated from 4 graduate programs in the 1990–91 academic year.

Goals and Priorities. For 5 of the 26 institutions, graduate program maintenance was the primary goal. Only five reported their primary goal was to expand, develop, or implement their graduate programs. The most commonly reported student-oriented, institutional goal was to provide instruction in range science, mostly in the broadest sense (e.g., in range science, range ecology, range management). Only half of the respondents (13 of 26 institutions) reported a primary goal of developing independent and critical thinking.

Provenza (1991) identified 3 kinds of research. Research which:

1. Describes components of range ecosystems to provide information for management.
2. Develops understanding of the processes of nature that are important for management of range resources.
3. Develops new technologies and management by applying the understanding of processes of nature.

Respondents were asked to rank the relative importance of each kind of graduate research at their institution. No single graduate research category dominated, but research that develops an understanding of processes was the most common (11 of 24, 46%).

Only 13 of 24 (54%) graduate program leaders considered their institution's primary research category consistent with their perceived need. Although most program leaders (17 of 24, 71%) identified process-oriented research as the most important, it was not the most common kind of graduate research at their institutions.

Program Obstacles

Institutional Issues. Insufficient funding, especially for assistantships and/or research operational support, and limited numbers of research faculty, either because of excessive teaching loads or inadequate faculty full time equivalents (FTE's), are common obstacles to effective and viable graduate programs for many institutions. All

institutions would likely benefit from additional faculty and larger support budgets. However, institutions with larger graduate programs expressed less concern with these factors, perhaps because they have more diverse faculty or because the larger graduate student population fills a niche at minimum cost (e.g., teaching assistants). Regardless, larger programs may be in a more competitive position than smaller programs within their respective universities.

Program name recognition may limit graduate program strength. Conversely, broad-based degree programs offer small programs a haven from program cuts. Of the nonthesis degrees, only half have "range" or "rangeland" in the name of the major or option. Many of the M.S. and Ph.D. degrees in which "range" appears on the transcript or diploma are combined with other disciplines. Many graduate degrees in range science are not identified as such on the transcript or diploma. These degrees are a mixture of general (biology, agriculture, and natural resources) and specific disciplines (agronomy, crop science, animal science, forestry, and wildlife).

National Issues. Graduate program leaders also shared a similar perception of national obstacles to range graduate education. Declining financial support was the primary obstacle, but low professional credibility (e.g., lack of national recognition and negative image) also contributes. The 2 factors likely have a cause-and-effect relationship that together contribute to other obstacles, including limited employment opportunities.

Funding for graduate assistantships is another critical limiting factor at both the institutional and national level. Funded assistantships declined from 248 in the 1980–89 period to 235 in the 1990–91 academic year. The largest sources of graduate assistantships in both periods were competitive grants and agricultural experiment stations.

Expectations and Implications for the Future

Program leaders are anticipating changes in range science graduate education/research. Respondents were optimistic, however, expecting that range graduate degrees awarded nationwide will increase from 120 in 1990–91 to 145 in 2000–01. Program leaders (n = 19) expected the number of funded assistantships to remain stable in the future (235 in 1990–91, 237 in 2000–01).

Funding for assistantships may rely more on competitive grants in the future, but program leaders foresee no large changes in funding sources. The proportion of funding from competitive grants was predicted to increase from about 29% in 1990–91 to 35% in 2000–01. Other major sources of funding assistantships are expected to change little. Although expected to be candidates for significant cuts, assistantships funded by agricultural experiment stations were predicted to decline only by 3 percentage units from 1990–91 to 2000–01.

If projections are correct and the past decade's trend continues, fewer graduates will have an academic background in a traditional agricultural discipline and more will be recruited from the biological sciences by 2000–01. Program leaders expected numbers of graduate students with an academic background in range to remain constant. This seems unrealistic given the proportion dropped by 11 percentage units from the decade of 1980–89 to the 1990–91 academic year. A revealing corollary to this challenge is that a smaller proportion of students will pursue grazing management and range improvement research in favor of range ecology and wildlife. The latter may be more appealing to students lacking a background in range or agriculture.

Changes in funding could reduce the number of graduate institutions if small programs have inadequate student numbers to warrant continuation. Some believe the current system produces a concentration of graduates from a few institutions that can perpetuate unhealthy academic and scientific similarity in the profession (inbreeding). An alternative perspective is that some, if not most, smaller programs lack the breadth of faculty necessary to offer graduate degrees in range science, so that a winnowing of graduate institutions would be healthy for the profession.

The survey identifies several trends in the missions and strategies of graduate programs that are capable of changing the timbre of the profession. For example, an increase in the proportion of students with academic backgrounds in disciplines other than range and agriculture will result in an even more diverse population of graduate-educated range professionals. This will be encouraged further by the demands on faculty to compete for competitive grant funding, requiring scientific expertise in specialities of importance in addressing national research priorities.

These factors will lead to a diversified faculty with more biology and mathematics expertise but with less understanding of applied management considerations. These scientists will compete more effectively for funding supplied from national research programs, but fewer of them will have the background to appropriately educate undergraduate or graduate students for most traditional management and technical advisory positions. It may be argued that students educated by such a faculty will be prepared for a broader array of employment opportunities, but federal agencies with management priorities are expected to continue to serve as the principal employer.

Graduate range programs may have more difficulty recruiting students in the future if visibility and recognition of range science as a professional discipline are reduced on a national and institutional level. However, only 8 programs are currently identified as range programs by unit title. One range program is within a natural resources administrative unit and 2 others are in forestry units. Six programs are in agriculture administrative units. An alarming trend for the alignment of smaller range programs in the western U.S. states with other natural resources disciplines may continue. This will probably not occur in the Great Plains states because the majority of range programs are already integrated with agriculture rather than natural resources (e.g., animal science or agronomy in colleges of agriculture). The lack

of distinction and visibility that has apparently hampered growth of graduate programs in the Great Plains may occur in the graduate programs of western states if they merge into natural resources administrative units.

The Changing Environment of Graduate Education/Research

Range graduate education/research is evolving in a rapidly changing environment common to the academic community in general (The Government-University-Industry Research Roundtable 1989). Professions can only survive and grow by adapting to the changing environment that is the context of their existence (Kessler 1993). Elements in several arenas of change are particularly apt to influence the future of range graduate education/research.

Socioeconomic and Political

The decline in rural population, particularly evident on rangeland, reduces the proportion of people directly knowledgeable about or financially dependent on rangeland. Thus, the advocates for good range management must organize from the non-consumptive users, the general public and, most importantly, the profession.

The demand for products and uses of rangelands will increase, but the composition of the products and uses will change dramatically. There will be a decreasing demand for the forage resource, but the demand for non-grazing uses and products of rangelands will increase and environmental quality will be emphasized over production.

The magnitude of the global rangeland resource ensures that its sustainability is a fundamental issue of all nations. However, as the decision-making process for natural resources moves from the private arena to public debate, policy and regulations become as important as scientific principles and ecologically sound practices. From all indications, we are in a new era of land and resource management—one shaped as much by social forces as by science (National Research Council 1990).

Public and political recognition of the importance of the environment will focus society's agenda on the nation's natural resources. Protection and preservation will be the primary emphasis unless the range science profession can communicate the value of research-based utilization, maintenance and/or restoration. Already a highly charged political issue, the role of rangelands in providing critical wildlife habitat, refuge for threatened and endangered species, wildlife corridors, and high quality watersheds will become increasingly political.

Land-Grant System

The land-grant system with its ties to agricultural and natural resources research is an integral component of the range science profession. Many expect the land-grant system to undergo major change and restructuring in the near future. Congress is currently reviewing the USDA, particularly the Extension Service and agricultural research in general. Consolidation and reduction will have significant impact on the range science profession. However, the ramifications of the changes are not receiving the attention they deserve from program leaders, and they are not looking to make changes in programs. An uncertainty has resulted from an inability to abandon the once appropriate paradigm of production agriculture in favor of the new paradigm of natural resource stewardship and concern for the environment. Yesterday's priorities are not today's realities (Kessler, personal communications).

Image

The range science profession has historically been perceived as a component of production agriculture, primarily through the visibility of grazing management. The profession has not been able to significantly alter this perception. While other disciplines or professional organizations prospered under the auspices of the environmental or sustainable agriculture issues, the range science profession, which uniquely and legitimately encompasses both, claimed neither. The future of the profession depends on altering the perception of those outside the profession by developing alliances of academic and research disciplines with compatible, effective groups that have credibility with the national audience.

Scientific

Increasing demand for scientific expertise in landscape ecology, conservation biology, restoration ecology, etc., will focus the research agenda on a systems approach. The new "ecology" will integrate basic, developmental, adaptive and integrated systems across both the social and physical/biological sciences. The social and political environment will require range management decisions to be based on social values as well as on science. New technologies such as computerization, biotechnology, and systems science will provide an ever increasing opportunity for range scientists to understand and manage range ecosystems. However, if fundamental change in the profession is not achieved, new technologies will only result in enhanced irrelevancy (Kessler, personal communication).

Research Funding

Increases in competitive grants funding will stimulate agricultural and environmental research (National Research Council 1989). The trend from formula funding to competitive grants will become a critical issue in institutions where formula funds historically supported long-term, applied research including range science research. Unfortunately, states are unlikely to fund the difference by providing additional funds, and the ability of universities to generate significantly greater research funds through internal sources is also limited (The Government-University-Industry Research Roundtable 1989, National Research Council 1989). As research programs become more dependent on grant funds, the stability of long-term research priorities are jeopardized by the volatile nature of grantor priorities. This may constitute one of the most difficult challenges: maintaining long-term research agendas in an atmosphere of 1 and 2-year grant cycles.

Funding for research will continue to focus on a relatively small number of research issues that enjoy broad scientific and public support. Moreover, federal grant programs will fund research on basic biological and physical phenomena that relate to agriculture and the environment (National Research Council 1989). Unfortunately, the general scientific community often fails to identify range science as a relevant scientific profession, overlooking the contributions that it can make to such research priorities. Our reluctance to visibly embrace and claim these same issues as priorities and the lack of leadership may be perpetuating anonymity and limiting funding opportunities for range research.

Academic

Shrinking financial support for higher education and a relatively small faculty associated with many institutions will result in fewer institutions offering Ph.D. degrees in range science. Smaller institutions will be relegated to offering M.S. degrees and/or non-thesis degrees in range science while smaller faculties in multidisciplinary administrative units will offer the Ph.D. in affiliated areas.

Fewer generalists and more specialized scientists/academicians will compose the future faculties. A shortage of rigorous generalists compared to specialists currently exists among the faculty. The existing reward system and the competition of research appears to be a dominant reason for this (Meyer 1992). This will present a significant limitation to serving the increasing demand for alternative graduate programs that require a broad perspective and often lead to a non-research career.

Institutional inertia is a barrier to comprehensive curricular restructuring and to creating new organization structures to improve interdisciplinary and interinstitutional educational and research programs (Meyer 1992). Thus, adaptive change in higher education institutions is often frustratingly slow, even when faculty and administrators recognize the need for change. Moreover, leadership for change is deferred at every level throughout the profession's hierarchy. Unit administrators, for example, rarely serve as effective agents of change in the profession, largely because of the demands placed upon them from "top-down restructuring" and other threats to their units imposed at the local level.

Employment

Recent periods of saturation in the employment arena at all levels have resulted in degree inflation, yet employers lack clear guidelines for the degree needed for practitioners at various levels. The recent decline in permanent positions available in the employment market at the Ph.D. level has resulted in an increase in post-doctoral positions. Institutions are downsizing faculties to address budgetary problems, which will adversely affect the normal rate of faculty turnover that had supported the employment of a large number of Ph.D. graduates.

Opportunities for the Future

If we value the future of our profession, we are compelled to address means by which the community of range scientists can serve as catalysts of change and adaptation in a changing environment. The following are some of the opportunities we see for shaping the future of graduate education/research.

Opportunities for Educators

Graduate Education/Research. Graduate institutions should recognize their obligation to develop professionals with social, cultural, political, and economic awareness rather than narrowly trained scientists. Graduate programs should be redesigned to complement the science of the discipline with a broad, liberal education. As a first step, language requirements should be reinstated in Ph.D. programs, and a greater proportion of social sciences should be integrated into graduate programs of study. This will necessitate requiring fewer credits of research, especially toward the Ph.D. degree.

Now more than ever before students need balance in their graduate education/research program for developing their research, intellectual, and leadership skills. Courses and policies should encourage developing integrators who can work effectively with other disciplines inside and outside of natural resources rather than developing narrowly focused researchers. To this end, degree plans must allow flexibility and encourage breadth in courses and in the creative component. Although difficult to accomplish within the current environment, institutions should go beyond traditional classroom instruction and student research advising to preparing Ph.D. students to be effective interdisciplinary team builders, grantspersons, and leaders.

Students should be provided a broadly defined education that places a renewed emphasis on developing independent and critical thinking. Graduate education in this paradigm is viewed as providing education and experience in developing problem-solving skills. Greater emphasis must therefore be placed on integrating the social sciences into graduate education and research. A balance should be provided in a basic core of courses in biology, mathematics, and the social sciences. In addition, students should be required to take courses in science ethics, risk assessment, impact assessment, and regulatory policy to prepare them to encounter successfully the problems for which science and technology alone are inadequate to solve. Because they will operate in a global context, students must be given the encouragement to develop and demonstrate an ability to think and act globally.

Graduate institutions should seize the opportunity to address broad, national-global issues (e.g., biodiversity, climate change, multiple use, and biotechnology). Educating students in the ecology and management of alternative uses of rangelands is a mandate from the public on which graduate institutions must act. Above all, courses and resource in which production of commodities is central must contain obvious renewed emphasis on conservation of the range resource.

Preparing future researchers for a career in research rather than merely educating them in the application of

current technology for solving research problems is becoming an increasingly critical mission of graduate institutions. Thus, research must be more functionally integrated, and the relationships between basic, developmental, and adaptive research clearly understood. Furthermore, students should be given the background necessary to understand the social and economic dimensions of rangelands and of their research.

The major contribution of future professionals in range science and the fundamental role of the profession is educating the public about the issues relevant to resource management. Therefore, the profession is challenged to renew its commitment to preparing graduate students to be educators and to rewarding and properly recognizing those in public education. This demands additional attention focused on educating students to understand more fully the processes of thinking, learning, and teaching so they can be effective teachers regardless of their function in the profession.

The profession needs innovative graduate programs that address the needs of students, professionals and the profession. The profession should initiate practitioner degrees similar to the Ed.D. or J.D. and suitable for upper-level policy and regulatory positions. Providing range professionals with opportunities for continuing education should also be a major priority. Identifying the employment opportunities/market demand for the traditional as well as new degree programs should be a major initiative.

More than ever before, a single range science institution can not be all things to all people. One proposal applicable to range science colleges and universities calls for a national network of institutions in which each takes pride in its own distinctive mission and seeks to complement rather than imitate others, especially the more prestigious research institutions (Boyer 1990). Larger programs may offer the necessary diversity of curriculum, faculty, and graduate students to support Ph.D. programs. However, small programs may be very capable of providing excellent M.S. programs for the thesis option and relevant regional education for the non-thesis degree.

Individual institutions with inadequate resident faculty or research funding to support independent graduate research programs should develop consortia offering programs in integrated graduate research. Thesis or dissertation research can be conducted on site through the supervision of faculty at selected institutions while the academic training and degree can be offered through a Ph.D.-level institution.

The importance of the international student to our graduate programs and the profession's responsibility to the global community are critical considerations. A critical challenge will be to meet the needs of the international student while educating the domestic student who competes in a more techically advanced society. Graduate programs must increase the institutional flexibility to design graduate research for international students that is appropriate for the social, economic, and scientific environment of their country.

Undergraduate Curriculum Development. To promote critical thinking and problem solving while educating students on research, a senior thesis or equivalent should be required of students. Many innovations can increase flexibility of students entering a complex work world in which not every entry-level position requires an equal amount of education preparation. One innovation, a 5-year B.S./non-thesis M.S. program (e.g., Master of Range Science), should be considered as an alternative approach to a 4-year B.S. degree.

The potential correlation between accredited undergraduate curriculums and the perceived quality of graduate programs should not be overlooked. Although the accreditation process focuses on undergraduate programs, the respective graduate program is a beneficiary of an institution's accreditation. The diversity and persistence of the profession demands an undergraduate accreditation program that is professionally rigorous, sensitive to the linkage between undergraduate and graduate programs, and not exclusive by size.

Opportunities for Employers

As a start, employers should recognize the advantages of employing professionals with advanced degrees by providing them with more rapid career advancement, promotions, and pay increases. Employers should also support continuing education by communicating the need for it to the academic community and by developing programs that encourage employees to continue their education.

As importantly, employers should become an active participant in the research agenda and assume the role of advocates for range science education. Identifying and supporting research specialty areas of value to the employer allows students and advisors to tailor their education/research experience accordingly. Employer public relations and marketing programs must communicate to the general public the unique value of range science education.

Opportunities for the Society for Range Management

Change at the institutional level is so demanding, graduate program leaders have deferred change at the national level to others. Therefore, it is imperative that SRM provide the stimulus and vehicle for educational institutions to take the steps necessary for meeting the graduate education demands of the future. An appropriate beginning point for SRM involvement is in establishing guidelines for continuing education for professional certification. The SRM should identify the national and global needs for continuing environmental education for professionals at all levels. Also, the SRM should pursue ways to promote cooperative programs in graduate education, including consortia among universities at the national and international level.

Foremost, the SRM must provide political action to encourage support for graduate education/research. SRM must develop new coalitions and alliances with professional groups to promote range science as the underpin-

ning of appropriate and proper use of rangelands. Thus, the profession can become partners in important issues, but without forfeiting the uniqueness of the profession.

The profession must increase visibility at the policy-making level. To this end, the SRM should develop high visibility education-public relations programs. As a first step to this end, a Congressional Fellows program, which offers both an effective promotional vehicle of benefit to the education of the individual and to the public relations benefit of the profession, should be initiated by the Society.

Conclusions

Graduate education/research in the U.S. is viable and effective, and university department heads and graduate coordinators were generally confident of a bright future. However, revised institutional missions and strategies will change the graduate education/research infrastructure, perhaps transforming the range profession. Thus, the enthusiasm of department heads and graduate coordinators for the future seems overly optimistic.

In some respects, the range profession and range science graduate education programs have been hesitant to embrace new missions and strategies. The future success of range graduate education/research programs depends on how well educators adapt to change and how well others in the profession facilitate adaptive change. Small programs in particular have funding and faculty limitations that will stress their ability to exist in an increasingly competitive academic environment. Without substantive mechanisms to involve the small programs in graduate education/research, the profession as a whole may suffer from lack of diversity.

Range graduate education/research is at a crossroads. Exciting technological and scientific advances will provide range science the opportunity to progress with other biological/natural resource sciences into new realms of scientific understanding and application of science to current pressing problems. The range science profession might instead choose to languish in past tradition and issues and assume a secondary role to other disciplines in scientific inquiry and advancement of knowledge related to issues the public considers important. The vitality and effectiveness of graduate education/research programs will be a key factor in deciding which road the profession eventually takes.

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