PRESIDENTIAL ADDRESS

Science in Rural America

Address to the South Dakota Academy of Sciences
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I. Introduction

The South Dakota Academy of Sciences (SDAS) represents the broadest spectrum of scientists in the state, representing virtually every discipline, every level of education, and every school in South Dakota. Our state is one of the most rural in the country, with all of the benefits and problems that affords. Consequently, this audience may contain the world's most expert group on the topic of this talk, "Science in Rural America." Therefore, this is a most appropriate group to discuss the topic with and this is the group that is, perhaps unknowingly, charged with guiding this rural state into the future.

Our country's attitude toward and willingness to support science has changed frequently over recent years, and not always in a predictable direction. For example, just two years ago, the budgets of science-related federal agencies were under considerable attack, and now, due in large measure to an active collective voice of the science community, we are looking toward some of the healthiest increases we've seen in many of our careers. It is clear that we are working under different conditions than we have known in the past, and those conditions have especially profound implications to states that, like South Dakota, have historically held a restricted view as to the role of university-based science. Both nationally and at home, there are increasing expectations of our educational system, and that certainly applies to science. Students have an increasing array of choices for their education and the distinction between those choices is increasingly blurred. To be sure, the demands upon each of us as scientists and educators continue to increase as we try to fulfill the expectations of our peers, our supervisors, and ourselves.

This talk will be divided into three parts: 1) background information and data that show how the rural states compare with respect to a variety of parameters; 2) a discussion of expectations of scientific research and education that come from various national dialogues; and 3) some considerations as to how South Dakota might respond to national expectations and state needs.

II. Background

The National Science Foundation has prepared an extensive graphical database in which states are profiled. This database is available on the web and makes use of a geographic information system to show trends and contrasts. I've picked out some of the data from that "Almanac" to illustrate how the rural states, and South Dakota in particular, look with respect to some defining characteristics. The parameters cover a wide range, from simple population distribution to technology-related economic development trends.

First, let's look at a few demographic issues. State population is the primary criteria I want to use to define "rural" in the context of this discussion. Certainly, there are many areas of the country that use the term rural to describe parts of their states, particularly in the context of advertising a certain quality of life. However, total state population will be used here to define rural, because it seems to be a state's population base that, in large measure, determines the magnitude of its science and technology enterprise. The central plains and the mountain west constitute the major rural section of the country, with South Dakota right near the top of the "most rural" list. Furthermore, population changes over the past decade show that many of these areas are becoming more, not less, rural. Exceptions are a few of the mountain states, which have shown substantial growth in recent years. The distribution of gross state products (GSP) by state largely mirrors state populations, as does the distribution of appropriations to the state higher education systems. There are some notable exceptions to these distributions, however. For example, two rural states, Wyoming and Nevada, are among the highest in *per capita* GSP. Several of the plains states are among the highest in *per capita* state appropriations for higher education. In fact, all of the states surrounding South Dakota except Montana are in the top third with respect to *per capita* appropriations. South Dakota and Montana are in the lower third, with $163 and $144, respectively, compared to $251 and higher for the surrounding states.

The Southern Technology Council is an alliance that has been formed to improve economic conditions in the south through science and technology. They have worked aggressively to study and strengthen the interactions between southern universities and the private sector of the state. One of the parameters they have investigated has to do with student retention and migration into and out of the states. They looked at four trends: 1) retention of high school graduates; 2) retention of people with degrees in higher education; 3) migration of high school graduates; and 4) migration of people with degrees. The net migration index is a measure of how people with degrees move into and out of a state. An index of 1 indicates an overall balance between people leaving the state and entering the state after receiving their highest degree. A value below 1 indicates a net exporter of human resources; above 1 indicates a next importer. Many of the rural states are net exporters of the product of education, with South Dakota one

of the most obvious. With respect to the cumulative of all four parameters, the states with the overall highest index (greatest importers) tend to be along a coast. This trend is especially relevant to South Dakota. For example, Gateway 2000 has made the decision to move management of its operation to New York and California partly because it can't fill its employment demands from the local labor pool.

Let's look specifically at the distribution of some factors related to science and technology. For example, the number of scientists and engineers in each of the states has been examined by the National Science Foundation, and shows that the states with the lower populations, not suprisingly, have fewer scientists and engineers. However, even on a *per capita* basis, there are indications that the more rural the state, the lower the proportion of its population engaged in science and engineering. That observation correlates well with the number of high-technology establishments present in the rural states, which again, is often disproportionately low. Interestingly, the number of graduate students in science and engineering on a *per capita* basis doesn't clearly show the same trends as population, suggesting that we educate our respective "share" of science and technology people, then send them out of the state for employment.

Let's finish this descriptive section with some research trends, because there are some nice surprises there. As a country, we concentrate our research resources into a relatively small number of states. For example, approximately 50% of the nation's federal R&D resources go to only 6 states. There are a large number of states that make up the "tail" of the federal R&D picture, with 20 states receiving the bottom 5%. The picture with respect to the distribution of NSF dollars has changed significantly in recent years, however. Let's look specifically now at South Dakota. As a state, we have moved from being essentially at the bottom of all the states to being in the middle third of the country on a *per capita* basis of NSF awards and dollars. In fact, as of 1997, no other state in the country has shown a faster relative increase in the number of NSF awards than has South Dakota and the state is among the leaders in relative increase in NSF funding. That may say more about where we were than where we are, but is nonetheless a fact that has attracted the attention of NSF officials. Likewise, South Dakota has been on the move with respect to funding through the Small Business Research Innovation program, which provides funding for private sector enterprises to development new products and processes. Through the concerted efforts of Mel Ustad at DSU, South Dakota has dramatically increased its awards through the SBIR program.

The overall picture of South Dakota in this discussion of demographics and performance shows a state that is one of the least equipped to move into the technological economy, but that is nonetheless making impressive gains. How does that position us to respond to what the nation demands from its higher education community?

III. National Expectations of Higher Education in the Sciences

During the past several years, there have been a number of special task forces to examine the effectiveness of higher education and the ability of the country to move into our technological future. You are probably all aware of Congressman Vern Ehler's Congressional Committee on Science and Technology. Ehlers is a Ph.D. physicist and former faculty member at Calvin College in Michigan. He has assembled an impressive group of educators and private sector scientists, (with barely any representation from the rural states) to examine how our scientific infrastructure needs to change to keep the country competitive. They are in the early stages of their work.

The National Science Foundation conducted an intensive study recently to examine the status of undergraduate science education and to make recommendations as to how we, as a nation, can improve it. The study resulted in the report, "Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology. The committee was chaired by Melvin George, then of the University of Minnesota. The committee did not have any members from the low population states. The report has, however, been discussed widely, even in the rural states. For example, in May there is a conference at the University of Nebraska to conduct follow-up activity related to the report. The goal to be derived from the review is:

> "All students have access to supportive, excellent undergraduate education in science, mathematics, engineering, and technology, and all students learn these subjects by direct experience with methods and processes of inquiry."

While at first this sounds like apple pie, the report emphasizes that certain key words in the statement call for a change in the way we, as educators, approach our work. "All students" is calling for us to stop the perceived practice of concentrating on cloning ourselves; "supportive" suggests that we currently practice the weeding out approach to teaching; "inquiry" emphasizes the process and the wonder of investigation as opposed to mastering just factual material. The committee formulated a series of recommendations targeted at a variety of groups.

- Faculty should believe and affirm that every student can learn, should start the learning process with the student's experience, and have high expectations within a supportive climate, build inquiry, a sense of wonder, and the excitement of discovery.
- Departments should set goals and accept responsibility for undergraduate learning with measurable expectations for all students, should work collaboratively with departments of education and the K-12 sector, the business world, and provide pedagogical skill development for those graduate students intending on becoming teachers.

- Governing Boards and Administrators need to reexamine institutional missions in light of needs in undergraduate education, hold accountable and develop reward systems for departments and programs, provide for strong faculty development and reduce organizational rigidities.
- Accrediting agencies need to focus on student learning, not just organizational and process issues.

The report continues with recommendations to business and industry, the government, and the National Science Foundation itself, urging that the agency accept leadership for implementing all the recommendations.

At the same time, the National Research Council was conducting its own study of undergraduate education in science, mathematics, engineering, and technology, also with a select committee, and also without any representation from a rural state. The recommendations of this group sound quite similar:

- Students should have access to supportive, excellent programs, and all students should acquire literacy by direct experience with the methods and processes of inquiry.
- Departments and programs should define their missions and establish specific educational goals; they should be evaluated against those goals by fair assessments that are as rigorous as the ones applied for research.
- Institutions must promote a new balance and a new linkage between teaching and research so that teaching is enlivened by investigation and research is defined more broadly, so that faculty can be rewarded for educational scholarship as well as for other kinds of scholarship.
- Institutions and departments should promote educational innovation both through cultural change and through providing resources.

I have been involved in the same kind of self-examination of the subdiscipline of analytical chemistry that involved a small group of faculty, private sector scientists, and government laboratory scientists. This one was organized by Ted Kuwana from Kansas University, so it involved at least a handful of people from rural states.

The main point is that the nation, through the work of these committees and many others, is examining the effectiveness of the way we teach science and engineering and recommendations are being made and listened to that have important impact on our lives.

Research is under equally intense pressure, as educational institutions are looked to more and more to be the engines of economic development and to be relevant to the daily lives of taxpayers and policy-makers. For example, I just recently attended a workshop sponsored by NASULGC entitled, “The Research *Business* of the University,” which focuses on how individual faculty as well as whole institutions could move into the private sector through technology transfer, intel-

lectual property considerations, initiation of research parks, and industry-university partnerships. A NASULGC publication called, "For Every Dollar Invested…. The economic impact of public universities," describes how investments in research result in both direct and indirect returns to the economy.

Another recent publication entitled, "University Research, Touching the Lives of all Americans," describes a number of research activities around the nation under topics such as health, the information age, the environment, automobiles, and the energy supply. In fact, the National Science Foundation has recently changed its review criteria to increase emphasis on the broader impact of the proposed research.

IV. South Dakota's response

How does South Dakota's rural nature fit in with the increasing expectations from both the national and local public? I think we are well-suited to respond to some areas, and it will be a struggle responding to others. These are my thoughts on some of these areas.

The Research-Education Connection Within our system of higher education, we have the potential for integrating research and education to a greater degree than most states. The research expectations of faculty vary considerably from campus to campus in South Dakota, as they should. But nowhere are they so stringent as to preclude the involvement of undergraduates as is often the case at large, research-intensive universities. The relatively modest settings that our science programs are housed in and the instrumentation facilities we have usually demand the overlap of teaching and research, making it relatively easy to combine the two. In fact, one could argue that in order to carry out research, there had better be a strong overlap with teaching because of the relatively large amount of time we spend teaching. For the most part, South Dakota faculty don't enjoy the luxury of large blocks of time dedicated solely to research. Our class and program size, compared to most other states, is small, so that it is not a difficult task to learn who the capable and interested students are. Those are the students that we can encourage into our research laboratories. The intimacy of our environments should work to our advantage in integrating teaching and research.

Relevancy of Science to Lives of Citizens The rural nature of our state results in our population being quite aware of, if not directly involved in, the land and natural features around us. One could say that the Black Hills and the Badlands are a part of the everyday lives of the people of West River, the Missouri River is a unique feature that most people in the central and southeastern parts of our state have dealt with or enjoyed on some level, and the prairie pothole region of the northeast represents one of the most productive habitats in the region, if not the country. Why not make increasing use of these natural laboratories in our courses and seminars, not only in those courses that pertain in an obvious way to them, such as geology or ecology, but in physics, chemistry, and mathematics as

well? There are programs around the country that focus on marine science, the Desert Research Institute, the Great Lakes Center, and so on. These institutes all take an interdisciplinary approach to scientific research and education. Could we consider and promote teaching and research efforts that focus on our own natural wonders?

Public Awareness Despite the seemingly wide gulf between those of us in academics and those in public policy or those in the private sector, there exists the potential to bridge that gap more easily than in many other states. The lines of communication in South Dakota are not that difficult to overcome. It isn't in many states where I could say my local legislature was my hardware man, one of my U.S. Senators did the contract for deed when I bought my house, or I can get on the program of the local service club just about any time I want. An example of interest on the part of policy-makers is the student poster session in the Capitol in Pierre, which incidentally was cosponsored by the Academy of Science. Nearly half the legislature showed up!

V. Conclusion The SDAS is in an excellent position to become a strong voice for science education in South Dakota. It is made up of scientists from all of the schools in the state, public and private, it has ties to industry, and has strong connections to the K-12 sector. Its membership runs the spectrum from nationally prominent research scientists to excellent classroom teachers, and there aren't too many members that don't serve in both roles. Many of our members are well-connected to national societies and therefore keep abreast of innovations in the nation. The Academy, as a whole, has a broad view of the world of research and education, and has the stature to not only respond to the forces acting upon us, but to help define those forces and shape the local and national responses to them.