Human Capacity Development

The Road to Global Competitiveness and Leadership in Food, Agriculture, Natural Resources, and Related Sciences (FANRRS)

MAY 2009

ASSOCIATION OF PUBLIC AND LAND-GRANT UNIVERSITIES

This publication was prepared by the Academic Programs Section (APS), Board on Agriculture Assembly (BAA) of the Association of Public and Land-grant Universities (APLU). The mission of APS is to assure that the development of human capital in agriculture, food, natural resources, life sciences and related areas is a preeminent concern of the Land-Grant System and its federal partners.

APS is comprised of the principal officer(s) responsible for academic or instructional programs (undergraduate, graduate, and continuing education) offered by the faculty within colleges of agriculture and related disciplines. Its members represent 120 different institutions that include the 1862 land-grants, 1890 land-grants, 1994 land-grants, and the more than 40 institutions belonging to American Association of State Colleges of Agriculture and Renewable Resources (AASCARR). In total, APS represents more than 160 institutions having academic programs in agriculture, natural resources, life, and related sciences.

Association of Public and Land-grant Universities

1307 New York Avenue, NW, Suite 400
Washington, DC 20005-4722
202-478-6040

Additional copies of this publication are available by contacting:

Office of Public Affairs
Association of Public and Land-grant Universities
1307 New York Avenue, NW, Suite 400
Washington, DC 20005-4722
202-478-6040

Human Capacity Development

The Road to Global Competitiveness and Leadership
in Food, Agriculture, Natural Resources, and Related Sciences
(FANRRS)

Association of
Public and
Land-grant
Universities

The National Research Council issued an expert consensus report that clearly signals an urgent need for and a commitment to transforming education in agriculture. "Many of today's major challenges — including energy security, national security, human health, and climate change — are closely tied to the global food and agriculture enterprise. Academic institutions with programs in agriculture are in a perfect position to foster the next generation of leaders and professionals needed to address these challenges" (The National Academies, 2009). Leaders of academic programs in the nation's colleges of food, agriculture, natural resources and related sciences responded to that call by adopting this plan on March 6, 2009.

Success of this transformation will require robust partnerships between universities and USDA, industry, and public education systems and a significant increase in public investment. The consequences of failure are unacceptable: "Failure to respond to the changes affecting agriculture and education will place many aspects of the nation's universities, agriculture system, and society at risk... Failure could mean that the U.S. will fall behind other nations in agriculture-based science and stewardship. And failure could contribute to the loss or pollution of our land, water, and natural resources" (National Research Council, 2009).

THE PROBLEM:
SCIENCE CAPACITY IN THE FOOD, AGRICULTURE, NATURAL RESOURCES AND RELATED SCIENCES IS AT RISK AT A TIME OF CRITICAL NEED

In an employment projection sponsored by the USDA, Goecker et al. (2005) noted that about 55,000 scientists and professionals will be required annually to fill job vacancies in the food, agriculture, and natural resources system between 2005 and 2010 in the United States alone. At the same time, FANRRS colleges (including veterinary medicine) are graduating about 35,000 students at all levels (i.e., undergraduate, graduate and professional) per year. Although there has been almost 100 percent growth over the past 20 years (from approximately 18,000 degrees granted in 1987), the higher education system must refocus its efforts to train the next generation of scientists and technologists. The growth in demand is projected for graduates with advanced academic preparation closely tied to rapid advances in knowledge and technologies.

The widening gap between available capacity and need is partially due to many tenured faculty members reaching retirement age. For example, by 2012, 43 percent of the State University

System of Florida's tenured faculty members in Agricultural Sciences will reach the age of 65 (Florida Board of Governors, 2005), the second highest percentage of projected retirements of all disciplines reported. This rapid loss of highly trained personnel coincides with the increasing need for advanced education of the next generation of professionals.

This need is highly correlated with the lack of investment in science and math education. In 2007, the National Academy of Sciences (NAS) published *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* which hypothesized that the United States is allowing itself to slip from its global leadership role in science and technology. NAS built the case that a nation's workforce quality and its scientific and technical innovations directly affect its prosperity and security. Four recommendations were provided for preserving U.S. economic and strategic security: 1) Increase America's talent pool by vastly improving K–12 mathematics and science education; 2) Sustain and strengthen the nation's commitment to long-term basic research; 3) Develop, recruit, and retain top students, scientists, and engineers from both the United States and abroad; and 4) Ensure that the United States is the premier place in the world for innovation. These recommendations are relevant for FANRRS because the United States has long been a world leader in the production of food and must continue to develop a talented workforce to retain that leadership position. The "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (COMPETES)" was signed into law in 2007 in direct response to the warnings issued in the NAS report.

Thomas Friedman states in *The World is Flat* that globalization is driving significant changes "that challenge the economic and strategic leadership of the U.S." Clearly, globalization in the U.S. economy is dramatically affecting agriculture, as well. Interrelated global markets are driving the development of new technologies and more efficient procedures in agricultural production, heightening awareness of human impacts on ecosystems and global climate change, addressing the energy supply and alternative energy resources, impacting worldwide food prices/ food security in developing nations, and exacerbating challenges posed by the introduction of invasive species.

At the global scale, the issues of population pressure and hunger will continue to heighten the demand for innovative complex solutions requiring advanced education. In *World Agriculture: Towards 2015/2030, An FAO Perspective,* Jelle Bruinsma writes,

> The spread of science-based agriculture emanating from the significant past investments in agricultural research underpinned much of the growth of agriculture in the historical period. The need for further increases in production in the future while conserving the resource base of agriculture and minimizing adverse effects on the wider environment calls for ever greater contributions from agricultural research. The research agenda for the future will be more comprehensive and complex than in the past because the resource base of agriculture and the wider environment are so much more stretched today compared with the past. Research must increasingly integrate current advances

> in the molecular sciences, in biotechnology and in plant and pest ecology with a more fundamental understanding of plant and animal production in the context of optimizing soil, water and nutrient use efficiencies and synergies. Effective exploitation of advances in information and communication technology will be necessary not only to facilitate interactions across this broad spectrum of scientific disciplines but also to document and integrate traditional wisdom and knowledge in the planning of the research agenda and to disseminate the research results more widely.

If America is to maintain its competitive advantage, it must invest in ***human capacity development***.

THE CHALLENGE: **ACT NOW TO MAINTAIN GLOBAL LEADERSHIP**

In a letter to all USDA employees dated February 12, 2009, Secretary Tom Vilsack outlined five specific goals that he has for the agency. One of these, "Building a modern workplace with a modern workforce" reflects the need for human capacity development. Maintaining the future leadership position of the United States in the food, agriculture, natural resources and related sciences (FANRRS) sectors will require greater emphasis on the development of human capacity to translate discoveries to impact. Accordingly, the gap between investment in research and human capacity development in FANRRS colleges must be closed. We recommend that 15 percent of all AFRI funding be committed to human capacity development efforts. In 2008, approximately 3.5 percent of USDA's REE budget was committed to higher education programs (USDA, 2008). Comparatively, the Education and Human Resources Division of the National Science Foundation comprised more than 12 percent of the FY 2008 budget while the strategic goal of "Learning" broadly comprised almost 15 percent (NSF, 2008). A similar meaningful funding commitment by USDA to human capacity development in its life sciences and social sciences programs has been lacking. Strategic objectives for human capacity development should be explicitly addressed by all major elements of the USDA Roadmap much like the "Broader Impacts Criterion" of the National Science Foundation.

The evolving challenges that drive the FANRRS research agenda reveal that deeper expertise is called for in some areas, while advancements will only be achieved through interdisciplinary efforts in other areas. To meet these challenges, students must have increased capacity in breadth and depth. Research, education, and outreach enterprises must become more tightly integrated to prepare 21st century scientists to rapidly translate discoveries to impact. Congress has called for this increased integration through creation of the National Institute for Food and Agriculture (NIFA) and the Agriculture and Food Research Initiative (AFRI) within the 2008 Farm Bill.

Additionally, America needs to increase its training of students at the K–12 and collegiate levels in the STEM (science, technology, engineering and mathematics) disciplines to enhance the talent pool in science and technology. This need has been recognized by the National Science Foundation (NSF), which has sponsored programs to increase exposure of students to careers in these fields. The National Institutes of Health (NIH) and NSF provide strategic funding for programs that target undergraduate students, students from underrepresented backgrounds, as well as honors students' research experiences with STEM scientists at institutes of higher education. Key STEM disciplines are also within the purview of USDA which has an important role to play through the sciences it funds. FANRRS institutions need to aggressively pursue opportunities to expose students from non-agricultural backgrounds to applied science. With a workforce trained in the STEM disciplines, the United States will remain a world leader of innovation. Greater involvement of the higher education enterprise is needed and can be achieved by purposeful integration of teaching with the research and extension missions of the land-grant system and their interaction with USDA and related federal agencies (e.g., FDA, EPA). Partnerships will also need to extend to industry, foundations, NGOs and non-traditional audiences. In total, there is no partnership better positioned to integrate learning, research and outreach in a way that builds diverse, prepared scientists and educators for the future.

Significant Gaps Exist

In the past, higher education's primary goal was to prepare students to be knowledgeable in their discipline and graduate as "subject experts." This is no longer sufficient if the U.S. wishes to remain competitive in the global economy. Boteler (2006) reported that food and agri-business employers ranked interpersonal skills and critical thinking twice as highly as production agriculture experience as components necessary for career success. In addition, graduates need to be knowledgeable about issues of globalization, the value of a diverse workplace, information literacy, and how their products/processes affect environmental sustainability. Teachers of these future leaders also need to be aware of these competencies, of the modern approaches to curricular development, of efficient information delivery, and of self-directed learning. Curricular change is needed on a national scale; it must recognize the complex set of life and social sciences skills that must be integrated in the learning process.

The scale and complexity of emerging issues and opportunities described by our colleagues in the Experiment Stations and Extension System demand all of the diversity of our human capacity to be competitive. Yet in the United States, some groups remain significantly underrepresented among scientists, faculty, and the workforce in FANRRS. The gap between the representation in the population and engagement in higher education is widening (Gilmore, 2006). The development of robust approaches to resolving complex societal issues requires that every sector contribute to the solution. Students from under-represented backgrounds reflect a relatively untapped student resource for the science-based disciplines embraced by the broad field of FANRRS. Students from under-represented backgrounds enrolled in U.S. public schools have increased from 22 to 39 percent of the student population over the past 30 years. Hispanic students have demonstrated the largest increase from 6 percent to 18 percent. In addition to higher education, students in K–12 must be exposed within both formal and informal settings to the complex issues and solutions identified within the research and extension missions.

In "Rethinking Undergraduate Science Education: Concepts and Practicalities — A Traditional Curriculum in a Changed World," Robert Yuan (2006) posits that a "fundamental change… would enable students to learn how to acquire and use an ever expanding body of knowledge where change is occurring at breakneck speed." He suggests that to practice science in a global environment often involves the interface between science, economics and culture, and requires students to be given authentic experiences in how scientists work and think within diverse teams, at the interfaces of disciplines, and in cultural/ethical contexts. The institutions of higher education in FANRRS are prepared to catalyze this change. They have a solid record of collaboration with USDA that has contributed to the development of human capacity to fill identified strategic areas with well-prepared scientists and technologists. However, the collaboration needs to be more engaged and deliberate. A significantly greater percentage of the REE budget should be committed to higher education programs.

Broad Conclusions

The United States has enjoyed immense scientific and technological success in the past. However, warning signs have emerged that indicate a greater need for development of human capacity if our country's leadership role is to be maintained. The following conclusions are relevant:

- Globalization is impacting the future workforce in food, agriculture, natural resources and related areas. Students will need to develop a portfolio of skills in collaborative and interdisciplinary approaches, and be able to comprehend increasingly complex systems models across scales with global effects. To keep its competitive edge, the United States must increase investments in human capacity development.

- U.S. leadership in science, mathematics, engineering and technology is slipping. Engagement of institutions of higher education, agribusiness, and public-funded agencies is needed to define and create initiatives in problem-based learning.

- The rate of investment in human capacity development in FANRRS has lagged behind investment in the creation of new knowledge, resulting in an increasing gap between discovery and implementation.

- Educational programs are seeking to be more relevant than ever, but the increasing separation between discovery and the classroom has left curricular development behind where it needs to be.

- Demographically, there is a disproportionately low participation by certain groups in FANRRS at all levels, including workforce, management, professional, and executive levels—especially scientists, extension staff, and educators. This has resulted in programs that are not as robust and relevant as they must be to have broad implementation and impact.
- Fewer students are pursuing agriculturally related sciences in higher education than required to meet future needs—especially to provide worldwide leadership.

OPPORTUNITIES FOR THE NIFA: HIGHER EDUCATION PARTNERSHIP

The National Institute for Food and Agriculture (NIFA), in partnership with the higher education system, can provide the structural framework for developing human capacity to meet evolving challenges by deliberate and engaged pursuit of the following strategic goals.

STRATEGIC GOAL 1

Increase supply of trained graduates in the Food and Agricultural Sciences: Inspire, Insure Access, and Enhance Academic Capacity of Students from all groups in the United States to excel in the Agricultural and Natural Resources Sciences (K–12, Community College, and Higher Education Systems).

Rationale

To maintain and/or increase its security and competitiveness in the food, agricultural, and natural resources and related sciences, the United States should aim to help Americans attain and fulfill their potential in these fields. Students must be trained in the STEM disciplines within a context that is critical for workforce development within FANRRS disciplines.

Employment opportunities for U.S. college graduates with expertise in the food, agricultural, and natural resources system are predicted to remain strong, yet the state and land-grant university system continues to fall short in meeting employment needs. Stakeholders also indicate that the skills and competencies of graduates need to change. Business and industry leaders are demanding accountability and are increasingly involved in helping determine the outcome of education. The National Research Council recently called for curricular transformation in agricultural education (NRC, 2009). Higher education is tradition-bound and slow to change. Colleges and schools at all levels struggle to keep their curricula on pace with the rapid advances in science and technology. Global opportunities will continue to evolve as well. The global implications of climate change, economic challenges, and demographic changes serve to impact the FANRRS perhaps more than any other industrial entity. Graduates of our programs must acquire an international perspective for their own career success as well as the success of the broad U.S. agriculture enterprise. State legislatures continue to advocate for greater access to public universities, and the historic boundaries between secondary and community college education, and between community college and baccalaureate education are softening. Yet, there needs to be much more collaboration and integration of the common goals among these.

The future of the industry rests in the hands of the next generation of youth who will become the growers, producers, leaders, researchers, and educators engaged in the broad fields represented by FANRRS. However, sub-populations continue to be underrepresented in FANRRS programs, intensifying the critical need to address the issue of underrepresented populations among scientists and faculty in the workforce. Fewer and fewer students from under-represented backgrounds are seeking agricultural and science related careers each year (Nelson, 2007); their enrollment in FANRRS colleges remains low and in many locales is decreasing. While agricultural and natural resource higher education programs have been working to attract a more diverse student population, only very small increases have been realized. Family misconceptions about agricultural and natural resources careers inhibit enrollment in these fields. Gilmore (2006) cited a study by J. A. Gonzalez that indicated 41 percent of students in high school have a misconception or image issue with agricultural sciences, 33 percent lack knowledge about employment opportunities and 22 percent are unaware of fields of study in FANRRS. The public perception of agriculture and agricultural careers as being solely production-based has discouraged many high school students that lack a direct connection to farming from pursuing a science-based degree in our colleges/schools. This has been exacerbated by the increasing disconnect between those individuals that influence high school students in their selection of college study (e.g., high school teachers in the STEM disciplines, high school counselors) and the broad disciplines embraced by FANRRS.

There is a significant need for youth development and training of students at the K–12 and collegiate levels in the STEM disciplines. It is universally accepted that the time to influence people is early in life. The Young Scholars Program of the University of Georgia, or similar programs at FANRRS institutions, serves as an open door to opportunities for those historically underserved and/or unaware of what colleges of food, agriculture, natural resources and related sciences offer and the career and professional opportunities that lie ahead. It exposes high school students to the college experience, to college faculty, and to research and extension careers. Expansion of such programs throughout our public university systems could greatly increase the exposure of underserved and/or unaware students to the FANRRS disciplines and potential career opportunities.

Conclusions

Workforce needs in the food, agricultural, natural resources and related sciences require a steady supply of qualified graduates trained in science and technology within the context of FANRRS disciplines. The demographic of these individuals must reflect that of the country as a whole so that we are developing our total human resource. Leadership development and an appreciation for the impacts and opportunities of globalization are critical components that must be embraced concomitantly with traditional curricular assessment and change implementation.

Recommendations

1. **Advance Changes in Curriculum and Teaching:** Implement the curricular recommendations of the National Academies' Academic Summit (NRC, 2009). Develop a system-wide curriculum model that addresses the changing needs of the food and fiber system and spans geographic regions and disciplines. Implement faculty development, informed by research, on cognition in the teaching/learning process.

2. **Create AG*STEM Programs:** Create and implement a program to enhance the teaching of agricultural, natural and related sciences within broad science, technology, engineering and mathematics (STEM) throughout the education system. Strengthen pre-collegiate preparation and encourage pre-collegiate high school students to pursue and complete a baccalaureate or higher degree in the food and agricultural sciences.

3. **Establish a National Young Scholars Program:** Establish a United States Young Scholars Program to interest pre-collegiate high school students in FANRRS disciplines, targeted at diverse ethnic, social and gender backgrounds, and particularly underserved, under-represented, socially disadvantaged and first generation students. This will require improved coordination with K–12 and community colleges.

4. **Develop Youth Leadership programs:** Create seamless leadership development programs from high school through higher education. Youth development is critical for ensuring that the next generation is sufficiently qualified to lead in the quest for continued prominence of the U.S. FANRRS industries internationally. We recommend involving undergraduate and graduate students in the higher-education youth development enterprise in order to increase program impact and the capacity of future professionals.

5. **Integrate Global Experiences:** Target an international or cross-cultural experience for at least 50 percent of students graduating from colleges of FANRRS, and provide international experiences for faculty members that strengthen the global dimensions of the curriculum.

6. **Provide for Internship Experiences:** Target an internship experience for at least 50 percent of all students in colleges of FANRRS.

STRATEGIC GOAL 2

Enhance Human Capacity Development: Integrate Research and Extension Engagement into the Undergraduate Experience.

Rationale

The tripartite mission of land-grant universities and the successful achievements that have emanated from it have become the envy of the world. While this may be true, the teaching mission must work to more significantly integrate its efforts with those of research and outreach in order to prepare a more holistic graduate.

The integration of undergraduate education with research and discovery are well established as priorities within NSF and NIH programs. A similar emphasis is needed to prepare the next generation of scientists in FANRRS. The USDA competitive grants programs, unlike their counterparts in NSF and NIH, fail to provide essentially any types of supplementary or stand-alone training funds for ensuring the training and development of the next generation of scientists in the FANRRS fields.

It has been well-established that a significant amount of learning at the undergraduate level occurs not only within the traditional classroom environs but beyond them. Service learning activities, internships, and cooperative education programming present effective vehicles to accomplish this. For example, service learning combines traditional instruction with community service to provide a more complete educational experience for students. It has evolved rapidly in recent years as a relevant pedagogical approach. The greatest challenge to implementing service learning approaches is identification of relevant community-based opportunities; the Extension system is ideally positioned to help identify these. A number of institutions have mandated a "hands-on" or experiential learning experience as a graduation requirement because these exposures to the "real world" provide learning opportunities conjoined with work experiences that enhance retention.

Conclusions

There has been a growing recognition that informal education and experiential learning play a critical complementary role to formal education opportunities that students traditionally encounter at land-grant colleges and universities. Transformation of the learning experience for future undergraduates must involve a broad range of complementary learning experiences that result from independent inquiry and community-based involvement. "Transformational" learning experiences help students develop the life skills and knowledge necessary to become "society ready" graduates. The human capacity that exists within undergraduate and graduate programs is significant and should be tapped to a greater extent than in the past for contributing to the extension and research missions. At the same time, extension and research have the capacity to contribute significantly to the intellectual and affective development of undergraduate and graduate students.

Recommendations

1. **Involve Undergraduates in Authentic Research:** Provide supplemental funds to competitive research grants for undergraduate students from both traditional and under-represented backgrounds to participate in cutting-edge discovery. Proposals for all integrated funds should be evaluated by panelists who represent primary commitments to education, extension and/or research and ideally who themselves are nationally accomplished in at least two of the three missions.

2. **Strengthen Service Learning through Integration with Extension:** Foster the integration of education and extension missions for purposes of service learning. Extension continues at the forefront of outreach education in communities. It has the potential to provide the educational mission of land-grant colleges/universities with diverse and relevant opportunities for service learning. These will enhance undergraduate education and further strengthen the community-based role that extension plays.

3. **Integrate Distance Learning and extension:** Address the common communications technology needs of higher education and extension missions to maximize efficiency for delivering non-credit coursework, certificate programs for adult learners, and distance courses for undergraduate and graduate students.

STRATEGIC GOAL 3

Renew the Academy: Address the Needs for Doctoral-level Professionals in the Food, Agriculture, Natural Resources, and Related Sciences.

Rationale

Serious deficiencies of doctoral graduates in science-related fields exist both within and outside the academy. In a review from the National Science Foundation's Directorate for Education and Human Resources (1996), it was noted that educational preparation in science, mathematics, engineering, and technology at this level needs great improvement. Significant employment demand is projected for graduates with advanced academic and leadership preparation closely tied to rapid advances in knowledge and technologies.

The Bureau of Labor Statistics' 2008–09 Occupational Outlook Handbook and Career Guide predicts a 9 percent increase in demand for agricultural and food scientists, noting specifically that those with a Ph.D. in agricultural and food sciences will experience the best opportunities. The report suggests that employment growth at this level will be driven by complex issues such as insect and disease adaptation to pesticides, the need to improve water quality, emerging biotechnologies, energy diversification and increasing demands for biofuels, the use of agricultural products in industrial processes, the need to balance increased food production with ecosystem preservation, the demand for safe food, heightened awareness of diet and health, and biosecurity.

The Ph.D. degree is a research degree and the processes for educating Ph.D. students have been narrowly focused on the development of high-level research skills and the research outcomes themselves. In recent years, there has been increased interest in the design of programs attempting to produce more holistic professionals from Ph.D. graduate programs. A number of reports — including those from professional societies, The National Academy of Science, the National Science Board, the Association of American Universities, and higher education leadership organizations — have represented views that the "overly specialized research training leaves future faculty ill-equipped to perform other faculty roles, especially teaching. Improving teaching is a pressing need in light of attention to improving the quality of undergraduate education. Business, industry, government, and the non-profit sectors need intelligent, skilled employees. Yet PhD holders often struggle to make the transition out of the academy and into the workforce" (Golde and Dore, 2001).

A new vision for the graduate-level preparation of scientists for academia and industry positions was developed for the sciences and mathematics in the late 1990s. This vision emerged as a result of a number of studies regarding the inadequacy of traditional science graduate educational programs to meet future societal needs. In 1998, academic programs in the biological sciences, chemistry, mathematics, and physics initiated a formal collaboration to create and adopt a program titled "Preparing Future Faculty" or PFF. The new vision and guide for change via PFF is well presented in *Preparing Future Faculty in the Sciences and Mathematics: A Guide for Change* (Pruitt-Logan, Gaff and Jentof, 2002). The PFF initiative is a formalized program supported by the Council of Graduate Schools and the Association of American Colleges and Universities. It is also formally supported by a significant number of specialized grant programs administered by the National Science Foundation. There is a need to develop a related program for Ph.D. graduates of the FANRRS disciplines.

In the agricultural and associated life sciences the need to revolutionize the process for the preparation of future scientists for academic careers, and science positions in the private sector is well recognized. The preparation of scientists in FANRRS has, to this point, continued primarily along a very conservative and traditional path. While the research, teaching and extension missions are closely woven together through our Land-Grant System, graduate education remains clearly and narrowly focused on applied and basic research only. Concurrent with this reality is the observation that the number of graduate students is declining, the diversity of these graduates does not reflect our national demographic, graduates are not prepared for teamwork approaches in research projects that require an integrated approach, and new faculty are not well prepared to teach and advise a diverse student body. Additionally, while scientists often recognize the importance of their role in K–12 and undergraduate education, doctoral students are rarely provided with opportunities to work with undergraduates or to gain a formal understanding of the principles of teaching and learning. These principles are valuable to all workplace environments; industry, government and academia.

The opportunities to emphasize and directly support human capacity development, in particular the preparation of future faculty and scientists for the private sector as an integrated component of research, teaching and outreach initiatives of AFRI are tremendous. The need to do so is compelling. We do not have to develop a vision for the preparation of future scientists in FANRRS, rather we can embrace the vision provided by Pruitt-Logan, Gaff and Jentof (2002). However, we must provide the incentives and resources our educational institutions need.

The age profile of faculty members in land-grant and AASCARR institutions suggests that the demand for replacement of FANRRS professionals will increase significantly over the next decade. Likewise, the future need for Ph.D.-level scientists in government and industry will increase as a result of retirements. Higher order disciplinary expertise will be increasingly needed in all sectors to do so.

The diversity profile of faculty members in the 1862 land-grant institutions and AASCARR schools does not reflect that of the student body at the undergraduate and graduate levels, or of the population at large. Contributions to the collective diversity of students and faculty members in the agricultural and natural resources sciences occur within the 1890 and 1994 land-grant institutions, and Hispanic-serving institutions. Cultural competence of faculty members must be developed as the diversification and internationalization of the undergraduate and graduate student body continues to emerge as a priority of higher education institutions.

Conclusions

The need for Ph.D.-trained professionals will increase substantially in the future. In fact, the current economic downturn provides a situation for delayed retirements that will only exacerbate the "brain drain" when economic recovery occurs. It is generally recognized that these students must be educated in a manner that recognizes the skill set required of this highly educated workforce to meet the myriad challenges that are present in academia, industry and/or government. An excellent comprehensive model for preparing future faculty members entitled, Preparing Future Faculty in the Sciences and Mathematics has been published by the Council of Graduate Schools of the Association of American Colleges and Universities (Pruitt-Logan, Gaff and Jentoft, 2002). This model, among others, should guide our future strategic planning endeavors.

Recommendations

1. **Develop Initiatives to Renew the Academy:** Implement initiatives to develop the capacity of graduate and undergraduate students to enter and renew the academy. The National Science Foundation has developed several programs that seek to accomplish this goal including ADVANCE for Women in Science and Engineering, CAREER (Faculty Early Career Development) and Graduate Fellowship and Traineeship programs (e.g., GRF, IGERT, GK–12 and REU). These programs serve as models for implementation in the FANRRS.

2. **Design and Implement Programs to Prepare Future Faculty:** Expect all research initiatives to include funding and organized activities to provide for the complete (i.e., technical and leadership) preparation of doctoral candidates in the concepts of learning, engagement and discovery.

3. **Achieve Broader Impacts through Meaningful Promotion, Review and Implementation of Integrated Programs.** A paradigm shift is required in the attitudes of program leaders, academic investigators and panel reviewers if true integration of education, research and extension is to be achieved.

STRATEGIC GOAL 4

Expand Learning and Engagement: Leverage Information, Communications and Instructional Technology

Rationale

The world is becoming smaller as a consequence of technology that readily links countries, governments, universities and research programs with instantaneous communication. Technology allows immediate access to global events as they occur, and 24/7 access to wireless connectivity in all buildings on college campuses (and increasingly in K–12 environments) is becoming the norm. Our greatest challenge is managing the vast reams of information that are currently accessible. This access has facilitated the evolution of research funding away from traditional single investigator-led efforts toward collaborative efforts that typically involve one or more disciplines and that cross national and international boundaries. The development of human capacity via higher education programs must similarly embrace evolving technology and apply it in creative ways to better prepare future scientists in the agricultural and natural resources disciplines.

Students use electronic media and technology to communicate and collaborate with peers and for information discovery — thus facilitating the implementation of distance education. Current technology including podcasts, video casts, blogs and social networking allow students to communicate rapidly and effectively. Teachers in the higher education environment have been less adaptable to the new technology and are often challenged relative to its use with instructional strategies. Twenty-first century learners readily accept and expect technology to be a pedagogical tool. Both on-campus and distance education courses are enhanced by the integration of technology during classroom delivery and for supplemental learning outside the classroom. The use of hybrid course delivery is critical to experiential-based approaches.

Distance delivery of courses and programs offers many advantages to students, instructors and institutions including enhanced schedule flexibility, delivery of course material from and to anywhere in the world, greater engagement of working adults and place-bound learners, outreach opportunities to pre-K–12 and secondary education audiences, the sharing of instructors between institutions; relief for overstretched institutional budgets; and development of strategic partnerships. There is a need to develop distance technologies combining these with pedagogical approaches that are more efficient than those that currently exist.

Finally, technology needs extend also to effective pedagogical approaches that have evolved in sophistication in recent years. These include problem-based learning, place- and context- based courses and approaches that facilitate self-directed discovery. There is a need to modernize learning environments including field, laboratory and equipment investments that leverage and parallel research investments.

Conclusions

Distance education and the virtual classroom will continue to evolve as a critical pedagogical tool for providing diverse learning opportunities. To effectively accomplish this type of teaching, instructors need a working knowledge of technology that today/tomorrow's students take for granted and will expect. Current and future faculty members need regular professional development opportunities to remain abreast of evolving technologies and their potential for implementation in different educational settings. Students must be led in the proper use of technology to facilitate their role in becoming life-long learners and to communicate globally to assume positions of leadership worldwide.

Recommendations

1. **Develop New Technologies for Learning:** Foster the development and dissemination of applications of new technologies that enhance learning in FANRRS.

2. **Add Capacity to Distance Education Consortia:** Develop collaborative arrangements between institutions to share faculty expertise through distance delivery of courses and programs.

3. **Increase Funding for Acquisition of New Technology:** Provide infrastructure funding to acquire and replace technology and equipment appropriate to FANRRS disciplines.

A CONCLUDING COMMENT

Several years ago a senior APS colleague challenged the leaders of academic programs to critically think about a preferred future for ensuring that there is not only the capability, but also the willingness to recognize and reform and/or reframe higher education programs within FANRRS to meet the challenges of "preparing society ready graduates" and proactively act upon it (Newcomb, 2004). To this challenge has now been added the voice of the National Academy of Sciences with specific recommendations and a call for change that engages many stakeholders in the discourse.

This paper provides a roadmap with a clear and purposeful approach to a preferred future. It is now incumbent upon all for whom the transformation of higher education in FANRRS is critical to meaningfully engage in those processes.

BIBLIOGRAPHY

Boteler, F. E. 2006. *Response to Recommendations of the National Food and Agribusiness Management Commision*. Presentation at the American Agricultural Economics Association Meeting. Long Beach, CA.

Bruinsma, J. (ed.) 2003. *World Agriculture: Towards 2015/2030*. An FAO Perspective. Food and Agriculture Organization. Earthscan Publications Limited. London, UK.

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2008-09 Edition, Agricultural and Food Scientists,* on the Internet at http://www.bls.gov/oco/ocos046.htm (visited October 02, 2008).

Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2008-09 Edition,* Agriculture, Forestry, and Fishing, on the Internet at http://www.bls.gov/oco/cg/cgs001.htm (visited October 02, 2008).

Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2008-09 Edition,* Food Manufacturing, on the Internet at http://www.bls.gov/oco/cg/cgs011.htm (visited October 02, 2008).

Florida Board of Governers. 2005. *Impact of projected state university system faculty retirements. Information Brief 2005-#3*. Planning and Institutional Research Division of Colleges and Universities, Florida Department of Education. Tallahassee, Florida.

Friedman, T. 2005. *The World Is Flat: A Brief History Of The Twenty-first Century.* Farrar, Straus and Giroux Publ. NY.

Gilmore, J.L., Goecker, A.D., Smith, E., Smith, G.P., Boteler, F.E., Gonzalez, J.A., Mack, T.P. and Whittaker, A.D. 2006. Shifts in the Production and Employment of Baccalaureate Degree Graduates from U.S. Colleges of Agriculture and Natural Resoources, 1999-2005. Background paper for "A Leadership Summit to Effect Change in Teaching and Learning".
http://dels.nas.edu/banr/summit/GilmorePaper.pdf

Goecker, A.D., Gilmore, J.L., Smith, E. and Smith, P.G. March 2005. *Employment Opportunities for College Graduates in the U.S. Food, Agricultural, and Natural Resources System, 2005–2010.* Purdue University College of Agriculture, West Lafayette, Indiana.

Golde, C.M. & Dore, T.M. (2001). At Cross Purposes: What the experiences of doctoral students reveal about doctoral education (www.phd-survey.org). Philadelphia, PA: A report prepared for The Pew Charitable Trusts.

National Academy of Science Committee on Science, Engineering, and Public Policy. 2007. *Rising above the gathering storm: energizing and employing America for a brighter economic future.* Committee on Prospering in the Global Economy of the 21st Century : an agenda for American science and technology ; National Academies Press. Washington, D.C.

National Research Council. 2009. *Transforming Agricultural Education for a Changing World.* National Academies Press, Washington D.C.

The National Academies. 2009. *Transforming Agricultural Education for a Changing World: Report in Brief.* National Academies Press, Washington D.C.

Nelson, D.J., *A National Analysis of Minorities in Science and Engineering Faculties at Research Universities.* October 31, 2007, on the internet at http://cheminfo.chem.ou.edu/faculty/djn/diversity/Faculty_Tables_FY07/07Report.pdf

National Science Foundation. FY2008 Budget Request to Congress. February 5, 2007. http://www.nsf.gov/about/budget/fy2008/

Pruitt-Logan, A.S., Gaff, J.G. and Jentoft, J.E. 2002. Preparing future faculty in the sciences and methematics: A guide for change. Council of Graduate Schools and the Association of American Colleges and Universities. Washington D.C.

Newcomb, L.H., *Creating a Preferred Future for Instruction In Colleges of Agriculture and Related Sciences,* unpublished paper, The Ohio State University, March 2004

Vilsack, T.J. 2009. Letter to USDA Employees. February 12, 2009.

Yuan, R. T. 2006. Rethinking Undergraduate Science Education: Concepts and Practicalities — A Traditional Curriculum in a Changed World. Presented at A Leadership Summit to Effect Change in Teaching and Learning. Oct. 2006. Board on Agriculture and Natural Resources, Board on Life Sciences, National Academy of Sciences. Washington, D.C.

Association of Public and Land-grant Universities

Founded in 1887, the Association of Public and Land-grant Universities is an association of public research universities, land-grant institutions, and many state public university systems. Its 218 members enroll more than 4.7 million students and award nearly one-million degrees annually. With nearly $30 billion in research, A•P•L•U-member universities comprise 10 of the top 20 universities in total federal spending on research and development in science and engineering. As the nation's oldest higher education association, A•P•L•U is dedicated to excellence in learning, discovery and engagement. For more information visit www.aplu.org.

Association of
Public and
Land-grant
Universities

1307 New York Avenue, NW, Suite 400
Washington, DC 20005-4722
tel. 202-478-6040 • fax 202-478-6046
www.aplu.org