Farm Foundation

Issue Report

Agriculture Research and Productivity for the Future

Executive Summary

Populations and demand for food continue to increase worldwide, but growth in U.S. agricultural productivity is slowing. While public funding of research to enhance agricultural productivity has declined in the United States, developing nations such as Brazil, India and China are increasing their investments in agricultural research.

New studies examining investments in agricultural productivity–enhancing research have identified these trends:

- U.S. commodity yields are growing at a much lower rate—about half as much in the post-1990 period when compared to the 1950-1989 period. (Figure 1.)
- Research productivity from all sources is growing at a decreasing annual average growth rate.
- Reduced support for farm productivity-enhancing research is the major factor in the slowing of farm-level productivity growth. The farm productivity orientation of U.S. public research and development funding dropped to 57% in 2006/07 from 68% in 1985.
- The pool of research funds is being divided into more, but smaller parcels as more issues evolve that require research attention, such as food safety, nutrition and environmental concerns.
- Significant public expenditures are needed to maintain agricultural productivity, not just to grow it.

Evolving issues critical to agriculture and food production—including climate change, food safety and animal production practices—must be addressed through research if farm-level agricultural productivity growth is to be maintained or accelerated. The existence of a relatively safe and low-cost food supply for consumers presents a challenge for agricultural interests seeking to communicate the importance of adequate research funding. Participants at an April 28, 2009, workshop hosted by Farm Foundation and USDA's National Agriculture Research, Extension, Education and Economics Advisory Board, suggested these options:

- A unified, holistic approach is needed to pursue research funding. It must be driven by industry and agricultural leaders, assisted by Land Grant universities.
- Core funding is needed to address long-term and overarching issues. Competitively-funded projects can supplement or replace core funding as follow-up activity.
- Private-sector companies, producers and Land Grant universities must collaborate on a common agenda, using their combined political influence to generate funding for the basic research that is needed.
- Funding must be adequate to sustain and increase agricultural productivity-enhancing research, while at the same time addressing the diverse and important issues evolving in the agricultural and food system.

Growing demand for food in developing countries, expanded use of agricultural crops for biofuels, and increased feed demand challenge the world's agriculture to increase productivity at a time when increased pressures are being placed on natural resources.

Historically, the competitiveness of U.S. agriculture in global markets has been driven by a combination of public- and private-sector investments in research, education and technology transfer. In recent years, however, the growth in U.S. agricultural productivity appears to have slowed. Growth in funding for research with the potential to enhance agricultural productivity has declined.

On April 28, 2009, Farm Foundation and the U.S. Department of Agriculture's National Agriculture Research, Extension, Education and Economics Advisory Board hosted a workshop to examine the relationship between public- and private-sector research and trends in agricultural productivity growth, both in the United States and worldwide. Workshop participants identified specific challenges for agricultural research and explored research funding strategies.

Research, Adoption and Productivity

There is significant evidence concerning the impact of research on growth in agricultural productivity, both in the United States and worldwide. According to Ken Fuglie of USDA's Economic Research Service, numerous studies have shown that public investments in research and development contributed to about half of all agricultural growth since 1950. In terms of returns from public investment in agricultural research, the benefits reaped by the public through greater abundance and lower prices are about twice those seen by private interests.

Determining the exact rate of return on agricultural research is complicated by a number of factors. These include: the attribution of benefits to public vs. private investment; spillovers from research in other regions or disciplines; efficiency losses due to the economic costs of collecting taxes; and the indirect consequences of adopting a new technology, such as environmental and health costs. Fifty years of scholarly research, and an extensive database of government research and development investments, allow economists to provide the following profile of the U.S. agricultural research system:

- The United States spent $5.1 billion on public research in 2007, with 58% of the funds coming from the federal government. State agricultural research stations conducted 75% of the resulting research.
- In 2007, private entities invested $3 billion to $4 billion researching farm technologies, including machinery, chemicals, pharmaceuticals, biotechnology, and food science.
- These totals represent about 20% of the world's public investment in agricultural research and 33% of the world's private investment.
- Both public and private investments in agricultural research have social internal rates of return of about 45% per year, regardless of where the research is conducted. This annual stream of benefits from adoption of research outcomes includes both higher profits for farms and lower costs for consumers.
- Spillovers and social benefits are significant. Research benefits are widely distributed throughout the economy, with many captured by the public at large in the form of greater, more stable supplies and lower food and commodity prices.
- Agriculture, which represents only 1.8% of the nation's Gross Domestic Product (GDP), accounted for 12.1% of total productivity growth in the U.S. economy between 1970 and 2004.

A review of 35 studies of U.S. agricultural research investments indicated an average annual economic rate of return to the public of 53%. That means an investment of $100,000 returns an annual stream of benefits of $53,000 per year over a period of several decades. Four studies of private agriculture-related research investments indicated an average annual economic rate of return to the public of 45%.

Few investments produce this kind of return over the long term. Indeed, some argue that the high rate of return implies that society is probably under investing in agricultural research. Other regions of the world also experience very high rates of return on research investments, prompting some developing economies such as Brazil, China and India, to increase agricultural research investments.

Historical research investment trends must be viewed in perspective, including more recent changes in productivity. According to Philip Pardey of the University of Minnesota, U.S. commodity yields grew rapidly from 1950 to 1989, especially for corn and rice. Between 1950 and1989, U.S. agricultural productivity growth was driven by improvements in labor productivity of 4.01% per year, rather than land productivity which grew at 1.77% per year. (Figure 2.)But productivity growth has slowed by half since 1990—the growth in labor productivity has fallen 1.69% per year, while land productivity has grown slowly at 1.85% per year. Most labor productivity increases have occurred in developed nations, while most of the population growth is occurring in the developing world.

Some of the decline in productivity growth may be attributed to unfavorable weather, changes in the regulatory environment, or the degradation of the natural resource base of soil, water and air. But, contends Pardey, more ominous are changes in the funding and conduct of U.S. agricultural research.

- Between 1950 and 1969, public investment in agricultural research increased 3.8% per year. After 1970, the annual increase declined to 1.5% per year, and since 1990, has been only 1.1% per year. (Figure 3.)
- Private agricultural research investments appear to have leveled

off, as well, and are increasingly focused on a narrow range of proprietary products and technologies.

- Research done within USDA agencies, also known as intramural research, has also declined. By the late 1990s, it was barely 30% of the public agricultural research and development (R&D) investment, compared with almost 60% in the 1940s.
- Funding for Extension declined to less than 30% of public investment in 2007, from 55% in 1920. Private sector and fee-based income provide the balance of Extension funding today.
- There has been a gradual but continuing shift in the focus of agricultural research from farm productivity to important societal topics, such as climate change, renewable energy, nutrition and obesity. (Figure 4.)

With continued decline in growth of public research investments and a continued shift away from productivity research and Extension funding, the growth of agricultural productivity has also declined. As USDA and public funding of state-based research has declined, other federal, industry and non-agricultural sources have stepped in. But total funding from all sources shows a decreasing rate in average annual real growth. The Cooperative State Research, Extension and Education Service (CSREES) is no longer the primary information source of farmers and ranchers, and no longer the principal disseminator of new agricultural technology. Reduced funding contributed to this change.

At the same time, some emerging market competitors of the U.S. are increasing agricultural productivity enhancing research funding. For example, between 1981 and 2000, China increased its publicly-funded agricultural research to 9% from 4% of the world's total, while the U.S. share increased to 19% from 18%.

Figure 1: U.S. Commodity Yields, 1866-2008

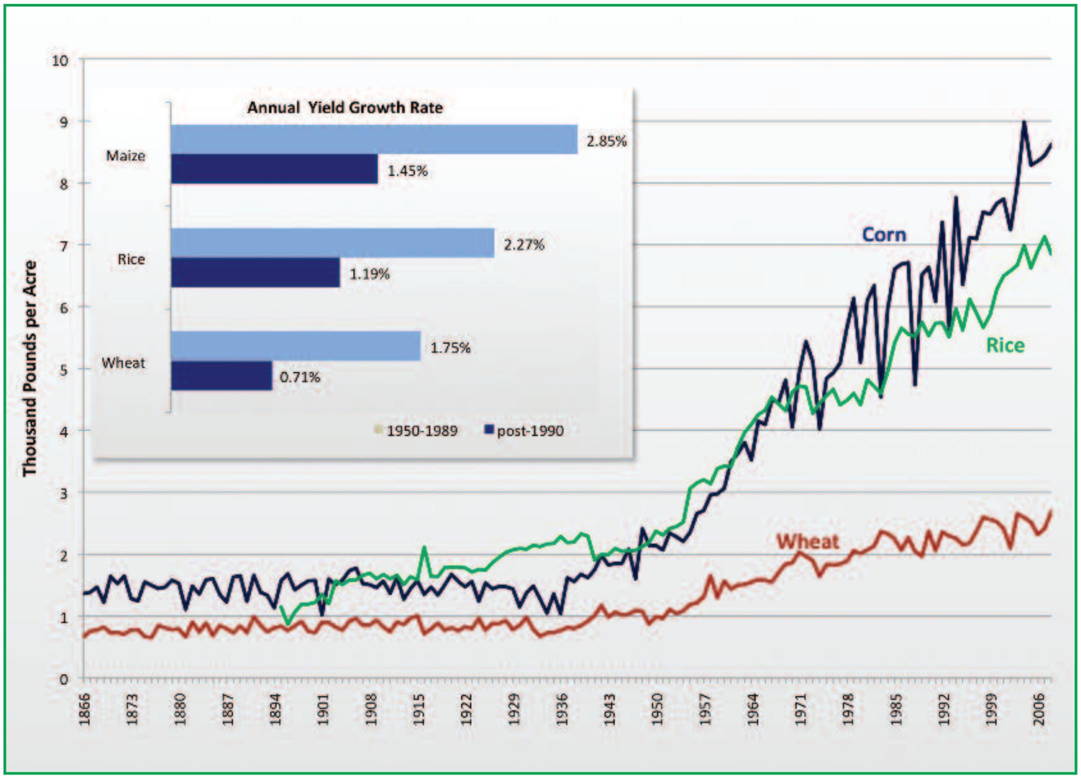
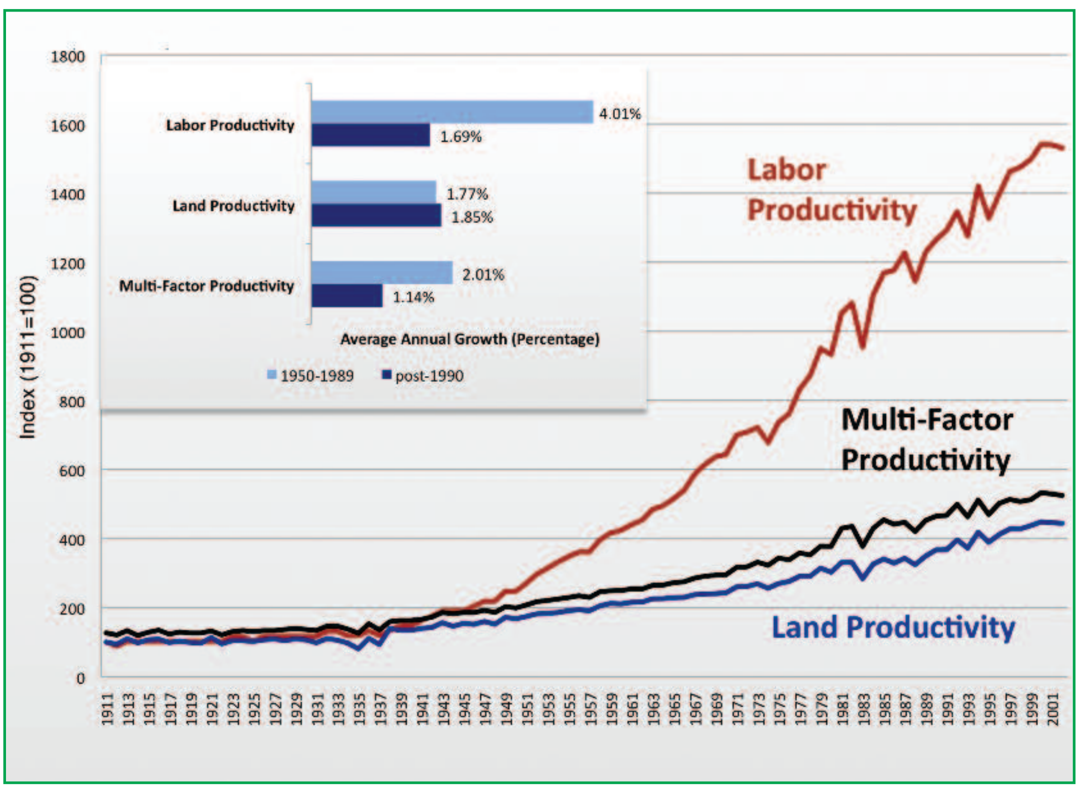


Figure 2: U.S. Labor, Land, and Multi-Factor Productivity, 1911-2002



Research Needs

Agriculture and the food system face significant challenges that require research to guide decision making in the public policy arena and the private sector. There are a number of challenges critical to the future of agriculture in the United States, including the overarching need to help feed the expanding world population while meeting the demand for better diets in emerging economies. The April 2009 workshop focused on only three challenge areas: climate change, food safety and livestock production issues.

Margaret Walsh of USDA's Global Change Program Office noted that global climate change is expected to alter temperature, precipitation and growing conditions, significantly affecting agriculture, forestry and land use in the United States. Potential changes include variances in plant lifecycles, increased risk of crop failure due to heat and drought, wider distribution of herbicide resistance in weeds, and increased disease pressure on crops and livestock due to higher temperatures. Research questions include: how to measure effects of climate change on farm productivity and on rural communities; strategies to cope with the physical and economic impacts of climate change; and how to communicate information to producers, processors and policymakers, who need to plan for climate change.

Agricultural and forestry systems are potentially significant players in the mitigation of greenhouse gases (GHG), which contribute to climate change. GHG include carbon dioxide, ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulates.

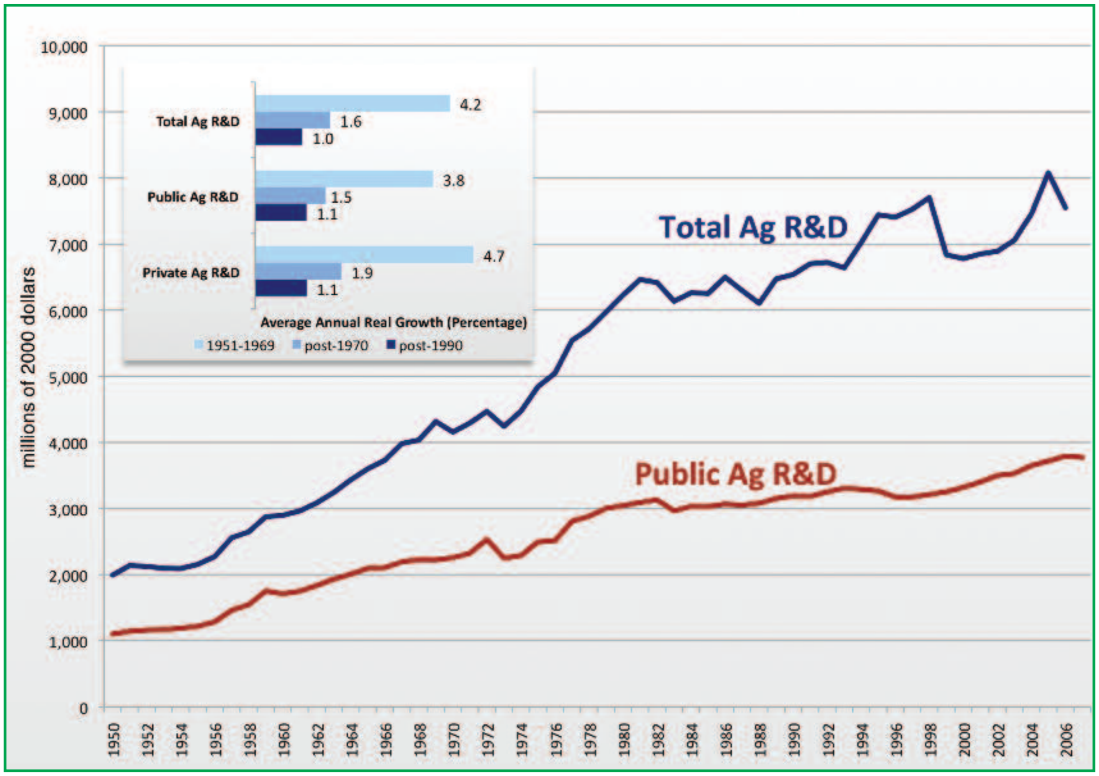
At present, agriculture is responsible for 7% of U.S. GHG emissions, with half of that amount from animal operations. Agriculture is also responsible for 11% of the GHG that are sequestered each year, primarily through forestry and wood products. Economic models suggest that under the current cap-and-trade proposals, agriculture and forestry could make an even greater contribution to GHG reductions—from 10% of total CO_2 emissions at $15 per ton, to 25% at $30 per ton. Most of the increase would come from planting new forests and producing cleaner-burning biofuels.

Continued research is needed on technologies and strategies for reducing emissions and increasing sequestration, as well as techniques for assessing the effectiveness and economics of GHG sequestration. Importantly, research investments that raise productivity serve to reduce GHG emissions from agriculture. Technologies that increase crop and animal yields improve fertilizer efficiency and reduce energy usage, resulting in fewer GHG emissions per unit of output. Reversing the slowdown in productivity growth should be an important element of a climate change policy.

Jennifer Greiner of the National Pork Producers Council, discussed continuing efforts to address food safety in a comprehensive, farm-to-fork approach that intervenes at key points throughout the food chain. Additional basic research is needed on pathogen ecology, and the costs and impacts of food safety practices. With zero risk impossible to achieve, public education is needed on the concept of acceptable risk. Better risk management models and more data are needed to produce a scientific basis for policy and regulation. Public funding of this and related research will be needed to build public trust and understanding.

Jeff Armstrong of Michigan State University identified challenges facing livestock production, including urbanization, the cost and quality of feed, global climate change and animal welfare. In some states, ballot initiatives related to animal welfare are outrunning the science. According to Armstrong, these challenges call for a more holistic view of sustainability. He also cited the disparity in funding for animal research—USDA spends two to four times as much for crop research as for animal research. The National Institutes

Figure 3: Total and Public Spending on Ag R&D, 1950-2007



of Health (NIH) spends $120 on competitive research for every dollar spent by USDA. Armstrong suggested a number of potential actions:

- Increase funding for the Agriculture and Food Research Initiative to $1.4 billion from the present $191 million. AFRI is the new USDA competitive grants program authorized in the 2008 Farm Bill to replace the National Research Initiative.
- Enhance research partnerships with NIH and the National Science Foundation.
- Collaborate with commodity groups, corporations and foundations to establish competitive, multi-year centers of agricultural research excellence.
- Link existing formula funds allocated to states based on politically specified factors to multi-institutional efforts.
- Enhance collaborations between Land Grant universities, veterinarians and USDA's Agricultural Research Service.
- Eliminate Congressional earmarks for specific research projects, topics or centers in favor of investing more resources in competitive funding.

Workshop participants also cited the need for industry and USDA to better communicate the work they are doing. More agriculture-specific research is needed on risk perception, consumer behavior, and the economics of best practices.

Research Partnerships

Robert Steele of Pennsylvania State University, reported that multi-state university collaborations have demonstrated that state and regional boundaries are artificial, and focusing on best available knowledge has strong merits. An example is the Johne's Disease Integrated Program (JDIP). Johne's Disease is a chronic disease that infects up to 70% of U.S. dairy herds. Initiated in 2004, JDIP began with 70 scientists from 24 U.S. universities. Today, the project involves 170 scientists from 30 academic institutions, government agencies and industries around the world. JDIP was originally funded by a $4.4 million competitive grant in 2004 and, because of the extent of the resulting progress, was renewed in 2008 at $4.8 million for four years. Similar consortia have been established to support research in colony collapse disorder, soybean rust, biosensors for corn earworm, and conversion of biomass to bioenergy.

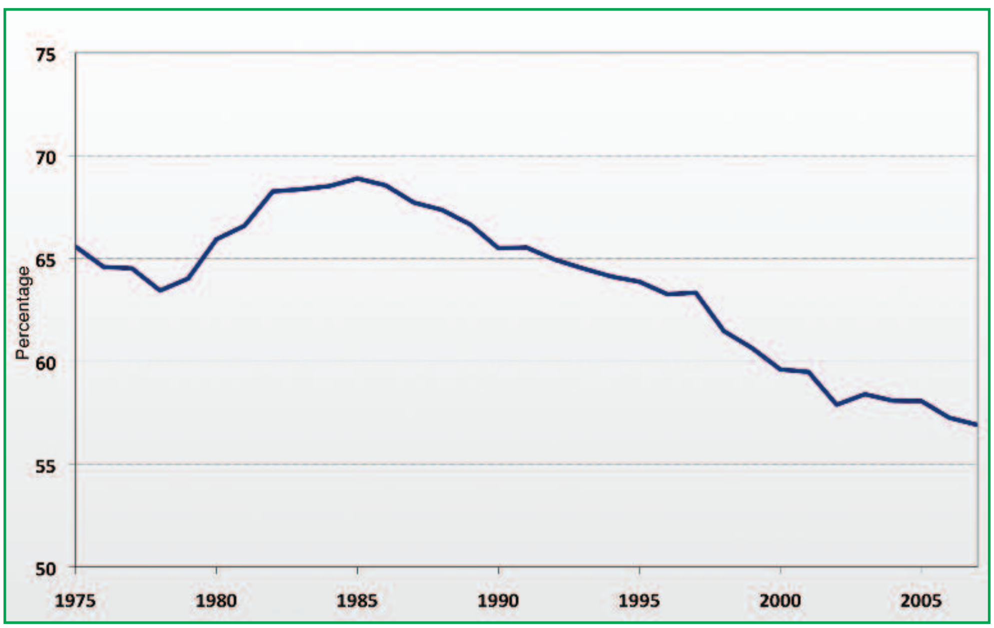
Steele identified several keys to the success of collaborative research projects:

- The issue must be the driver.
- Invest in base capacity.
- Identify the expertise, regardless of location.
- Design the program to be compelling to the experts, in both funding and time.
- Assure accountability, but do not interfere with researchers and project collaborators.

Through its Program on Public Private Partnerships, NIH partners with industry, academia and others to support and conduct medical research to improve human health. By law, no more than 11% of NIH-funded research can be intramural, creating a need for outreach and partnership. According to Barbara Mittleman of NIH, experience has demonstrated that partnerships allow NIH to move more quickly and efficiently on timely issues by joining forces with a research partner whose resources and expertise leverage those of NIH. Each partnership is formalized in a memorandum of understanding, usually with no prearrangements with regard to intellectual property. Based on common interest and a common goal, the agreements require trust, commitment and communication. These are formal partnerships, not technology-transfer arrangements or informal research collaborations.

The National Academy of Science (NAS) University-Industry Demonstration Partnership was created to enhance the value of collaborative partnerships between universities and industry in the United States. Anthony Boccanfuso of NAS reports that universities and companies experiment with new approaches to sponsored research, licensing arrangements and other alliances. The guiding principles of this effort are to support the mission of each partner, foster appropriate long-term relationships, and streamline negotiations—especially on intellectual property. New models that have emerged in recent years include research for hire; corporate

Figure 4: Farm Productivity Orientation of U.S. Public Agriculture R&D



requests for proposals; tenure and promotion credits for industry grants; open innovation; and prize mechanisms.

USDA's Agricultural Research Service (ARS) has created research partnerships with universities and industry. According to ARS Administrator Edward Knipling, partners have included commodity organizations, established corporations, startup companies, foundations, professional societies, and nongovernmental organizations. Collocation, research support agreements and cooperative agreements are used to implement these partnerships. A new mechanism authorized by the 2008 Farm Bill is the enhanced use lease, which allows outside entities to rent space and collocate researchers at the Beltsville Agricultural Research Center and National Agricultural Library. Intellectual property can be a thorny issue, as can the clash of cultures, but in many cases the sponsored research ARS gets is worth a lot more than the patents it doesn't get.

Future Strategies

To maintain a robust agriculture benefiting all taxpayers, the United States must support a strong agricultural research system. Agricultural researchers and producers are being asked to address a long list of new and evolving issues. Success will require generation and application of new knowledge. Workshop participants identified strategic tools needed to strengthen agricultural research:

- Communicate a stronger and more cohesive vision of the role and importance of agriculture to society. Communicate the value of agriculture research to every taxpayer/consumer, including Congress, based on the ability of agricultural research to solve pressing real-world problems. NIH succeeds in part because biomedical research focuses on a high-visibility issue—human health. A similarly compelling focus is needed for agricultural research.
- Create a stakeholder-driven strategic plan to communicate the need and value of research, the importance of adequate funding and the value of the potential returns to society as a whole. Strategic research plans within specific challenge areas might also be useful.
- Place greater emphasis on organizing research around issues rather than funding state-specific topics.
- Explore options to increase funding under existing authorities through the appropriations process. This would require a united vision by university and industry representatives.
- Invest in innovative university/private sector relationships.
- Explore options to increase research funding for high priority topics through the USDA National Institute for Food and Agriculture.
- Provide leadership through industry organizations—from grass-roots members to senior leadership—to generate long-term funding support for agricultural productivity-enhancing research.
- Provide leadership in cooperative research at the local, state and regional level, as well as at the national level. Changes in the research model have emerged since the 1960s, as industry has played a greater role. For example, a number of commodity groups generate research funding through check-off programs, a form of self-imposed "tax".
- Engage private-sector companies with producers and Land Grant universities to work on a common agenda, using their respective political influences to generate the needed funds for the underlying basic research.

Moving Forward

Public investment in agricultural research is extremely valuable, providing about half of the agricultural productivity growth. Agriculture makes outsized contributions to productivity growth in the U.S. economy compared to other sectors. Agricultural productivity is growing at a decreasing annual average growth rate, the result of slower growth in total agricultural R&D investment and reduced support for farm productivity-enhancing research. The farm productivity orientation of U.S. public R&D funding dropped to 57% in 2006/07 from 68% in 1985.

There is renewed interest in the role of science in the competitiveness of the United States. Significant public research expenditures are needed to maintain and grow agricultural productivity, while at the same time providing research to help guide sound public- and private-sector decisions on a multitude of evolving food system issues. These research investments are important tools for agriculture to maintain its role in contributing to the strength of the U.S. economy.

1301 West 22nd Street • Oak Brook, IL 60523 • Tel (630) 571-9393 • Fax (630) 571-9580 • *www.farmfoundation.org*