Pursuing a Unifying Message

Elevating Food, Agricultural and Natural Resources Research as a National Priority

Raising the Profile of Federal Research

Charles Valentine Riley Memorial Foundation

SoAR FOUNDATION

IOWA STATE UNIVERSITY

AMERICAN SOCIETY OF PLANT BIOLOGISTS

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Supporters of Agricultural Research Foundation

Iowa State University

and

American Society of Plant Biologists

in a partnership with

Colorado State University, Mississippi State University,
Purdue University, Soil and Water Conservation Society,
Texas A&M University and Texas Tech University

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Charles Valentine Riley Memorial Foundation

The Charles Valentine Riley Memorial Foundation (RMF) is committed to promoting a broader and more complete understanding of agriculture and to building upon Charles Valentine Riley's legacy as a "whole picture" person with a vision for enhancing agriculture through scientific knowledge. RMF, founded in 1985, recognized that agriculture is the most basic human endeavor and that a vibrant, robust, food, agricultural, forestry and environmental-resource system is essential for human progress and world peace. The theme for RMF program activities is "to promote a broader and more complete understanding of agriculture as the most basic human endeavor and to enhance agriculture through increased scientific knowledge."

Supporters of Agricultural Research Foundation

The Supporters of Agricultural Research (SoAR) Foundation leads a nonpartisan coalition working to educate stakeholders about the importance of agricultural research and focus more of our best minds on feeding America and the world. SoAR advocates for full funding for USDA's Agriculture Food and Research Initiative (AFRI) to encourage top scientists from multiple disciplines to address agriculture-related challenges in order to improve public health, strengthen our national security and enhance our economic competitiveness.

Iowa State University

Iowa State University is one of the world's premier institutions of agriculture, with more than 150 years of leadership in agricultural science, education and extension and outreach. The College of Agriculture and Life Sciences educates future leaders, conducts mission-oriented research and shares new knowledge for the betterment of the state of Iowa and the world. The college offers more than two dozen undergraduate majors and 35 graduate programs. The college integrates international perspectives into many of its programs, and has led agricultural research, education and development efforts in many countries. The trademark of the college's agricultural research is responsiveness to emerging needs, providing leadership to solve critical challenges and partnering to achieve goals. Iowa State's 40,000 living agricultural alumni work daily to make a difference around the world.

American Society of Plant Biologists

The American Society of Plant Biologists (ASPB) was founded in 1924 to promote the growth and development of plant biology, to encourage and publish research in plant biology and to promote the interests and growth of plant scientists in general. Over the decades, ASPB has evolved and expanded to provide a forum for molecular and cellular biology, as well as to serve the basic interests of plant science. It publishes the highly cited and respected journals *Plant Physiology* and *The Plant Cell*. Membership spans six continents, and ASPB plays a key role in uniting the international plant science disciplines. Members work in such diverse areas as academia, government laboratories and industrial and commercial environments. ASPB also has a large student membership.

Editorial Committee
Tim Fink, Supporters of Agricultural Research Foundation
Richard L. Ridgway, Charles Valentine Riley Memorial Foundation
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The Charles Valentine Riley Memorial Foundation (RMF) thanks the American Association for the Advancement of Science (AAAS) for hosting the federal agency workshop on April 27, 2016, from which the content of this report originates. Special thanks to Rush Holt, CEO of AAAS and Executive Publisher of Science, who opened the roundtable with insightful remarks and engaged with participants. RMF is grateful for the assistance of the AAAS staff, particularly Joanne Carney, Edward Derrick, Juli Staiano, Anne Moraske, Bethany Spencer, Matthew Hourihan and David Parks, with the workshop and other RMF-related events. RMF values its relationship with AAAS in hosting unifying message events and in the continuing partnership in conducting the annual AAAS Charles Valentine Riley Memorial Lecture and Riley Lecture Leadership Breakfast.

RMF thanks the Supporters of Agricultural Research Foundation (SoAR), Iowa State University (ISU) and American Society of Plant Biologists (ASPB) who served as co-conveners of the workshop. RMF also thanks the 20 agency representatives who made time in their busy schedules to participate for this critically important event. RMF values how each contributed their ideas and perspectives to the discussions. Special thanks to Brian Meyer, ISU, and Stacy Loewentritt and Jean Rosenberg, ASPB, who provided support before and during the workshop; to Caren Wilcox, USDA (retired), for her assistance with the USDA program descriptions; and to Keith Fuglie, USDA Economic Research Service, who provided data on international investments in agricultural research and productivity. Ten people, mostly from federal agencies, attended the workshop as observers.

The program for the workshop was developed by an organizing committee composed of Tim Fink, SoAR; Richard Ridgway, RMF; Crispin Taylor, ASPB; Brian Meyer, ISU; Tom Grumbly, SoAR; and Robert Easter, RMF and SoAR. Workshop presentations and discussions were recorded for use by the editors to develop this report. Key presenters reviewed edited versions of their remarks for concurrence prior to publication. The editors summarized the agency presentations and, in some cases, augmented the information with additional public sources.

Glossary

AAAS	American Association for the Advancement of Science
AFRI	Agriculture and Food Research Initiative
ARS	Agricultural Research Service
ASPB	American Society of Plant Biologists
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
ERS	USDA Economic Research Service
FS	USDA Forest Service
ISU	Iowa State University
NASA	National Aeronautics and Space Administration
NASS	USDA National Agricultural Statistics Service
NIFA	National Institute of Food and Agriculture
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OSTP	White House Office of Science and Technology Policy
REE	USDA Research, Education and Economics
RMF	Riley Memorial Foundation
SoAR	Supporters of Agricultural Research Foundation
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USGS	United States Geological Survey

About this Report

In June 2013, informal discussions were held with representatives from the Charles Valentine Riley Memorial Foundation (RMF), U.S. Department of Agriculture (USDA) and American Society for the Advancement of Science (AAAS). Following these discussions, RMF distributed information on international investments in agricultural research that illustrated a concerning lack of investment by the United States. This was followed by the publication of an editorial in *Science* in August 2013 by Alan Leshner, then the CEO of AAAS, that included the following quote: *"Agriculture R&D provides a dramatic example of how neglect can undermine a scientific domain."* In November 2013, AAAS hosted a group of 17 leaders to discuss the need for a common message in support of food, agricultural and natural resources research.

In January 2014, RMF and Iowa State University formed a partnership to pursue this "unifying message." Others soon joined the partnership, including Mississippi State University, Colorado State University, Texas Tech University and the Soil and Water Conservation Society. The partnership released its first report in December 2014 entitled *"Pursuing a Unifying Message: Elevating Food, Agricultural and Natural Resources Research as a National Priority."*

In 2015, the partners convened two stakeholder roundtables, one on *A University Perspective* and one on *A Scientific Society Perspective.* Reports on these roundtables have been published and are available online. Also, in 2015, Purdue University and Texas A&M University joined the unifying message partnership and provided representatives on the RMF Unifying Message Task Force, which gives input into the overall unifying message effort. Subsequently, a stakeholder roundtable on food, nutrition and health research interests was held in May 2016, and a report is forthcoming.

As the process to pursue a unifying message in support of food, agricultural and natural resources research led by RMF and its partners has progressed, it became obvious that a better understanding of current federal research was needed. Therefore, RMF convened a federal agency workshop on April 27, 2016, jointly with the Supporters of Agricultural Research Foundation, Iowa State University and the American Society of Plant Biologists, and hosted by AAAS.

This report details the presentations and the information shared during the April 27, 2016, meeting. Opening presentations were made by representatives of AAAS, the White House Office of Science and Technology Policy, U.S. Department of Agriculture and RMF, which are included in this report with attribution. Participants then heard from representatives of five USDA agencies and seven other federal agencies. A closing presentation by a representative of SoAR is included, again with attribution. These presentations have been summarized by the editors with additional material included as appropriate. This report also includes agency budget information prepared by the editors from publicly available sources as well as information from the meeting transcript.

Setting the Stage

An Overview of the Need to Raise the Profile of Federal Agricultural Research

Our agricultural system is facing a number of serious challenges as it transitions into the 21st century. According to the United Nations, addressing the combination of an additional of 2.5 billion more people by 2050 and improved standards of living throughout the globe will require a near doubling of the world's agricultural production. Meeting this ambitious goal is complicated by the need to simultaneously reduce agriculture's environmental footprint to protect vital resources like soil and water. And all of this must be done beneath the backdrop of a changing climate that is altering growing conditions and enabling pests and pathogens to thrive in new regions. Successfully meeting each of these challenges requires a new generation of scientists and scientific discoveries within the numerous disciplines that contribute to agricultural research, including food, nutrition, natural resources, bioenergy, climate change and economics. It also requires investments across the entire agricultural innovation enterprise, from fundamental discovery to more focused development and deployment efforts.

Many nations throughout the world are rising to this challenge. For instance, China has doubled its investment in agricultural R&D since 2006 such that it now leads all nations in public agricultural research spending. A similar trend is seen in other countries such as India and appears to be bearing fruit as production in these nations continues to grow at a rapid rate.

The same, however, cannot be said of the United States where agricultural research investment has largely declined since the turn of the century and only modest production growth is occurring. Nonetheless, agriculture remains a vital part of our economy. One in 10 U.S. jobs is tied to the food and agriculture production and distribution system – 16 million jobs in all. Over recent decades, agricultural products have represented 6 to 10 percent of the annual value of U.S. exports, and agriculture is one of the few categories to consistently be on the positive side of the balance of payments. Expanded investment in research is essential for the United States to continue to be competitive in world markets.

The U.S. Department of Agriculture (USDA) is the single largest funder of agricultural research, with both intramural and extramural research programs that provide links to a many institutions and other research partners throughout the nation. USDA is not alone in supporting research related to food, agriculture and natural resources. Other agencies, such the National Science Foundation (NSF), National Institutes of Health (NIH), U.S. Geological Survey (USGS), Department of Energy (DOE), U.S. Agency for International Development (USAID), National Oceanic and Atmospheric Agency (NOAA) and Department of Defense (DOD) play a vital role in conducting agricultural research and providing key partnerships. The contributions of these agencies, as well those within USDA, can be found summarized in this report.

While a review of each of these agencies reveals that critical research is being done, present funding is not commensurate with the challenges facing agriculture at home and abroad. In fact, an examination shows the research budgets for many of these agencies have remained flat, if not declined. Additional investments into our nation's agricultural research system are essential to the success of our nation. At stake is not just our historic leadership role in agriculture, but the health of our citizens, the strength of our economy, the productivity of future generations and the stability of a rapidly changing world.

Chet Susslin/National Journal

Rush Holt, Ph.D

CEO, American Association for the Advancement of Science, and Executive Publisher of Science

A Perspective from AAAS

The American Association for the Advancement of Science was delighted to serve as host for this federal agency workshop convened by the Charles Valentine Riley Memorial Foundation (RMF), Supporters of Agricultural Research (SoAR) Foundation, Iowa State University (ISU) and the American Society of Plant Biologists (ASPB). This workshop is part of a continuing effort by AAAS and RMF that began more than half a decade ago when RMF established an endowment at AAAS to support the Charles Valentine Riley Memorial Lecture. One of the purposes of the lecture – and a number of other events that have been hosted by AAAS – is to shed light on the importance of agricultural research.

We are not content with what we see in federal support for agricultural research. It is far, far less than what is needed. I am particularly concerned about the insufficient research support for soil ecosystems, soil health and carbon sequestration. If farms and forests have the potential to mitigate 15 percent of greenhouse gas emissions, we should be paying a lot more attention to them. And that is just one example. The people who participated in this workshop represented a broad range of important fields contributing to agricultural research, including food and nutrition, bioenergy, forestry, economics and a number of other disciplines. This work is essential to the well-being of our nation and the world.

AAAS looks forward to working with the conveners of this workshop, other interested organizations and the agricultural research community in general in advancing the importance of public agricultural research.

Jo Handelsman, Ph.D

Associate Director for Science, Office of Science and Technology Policy, The White House

A Perspective from OSTP

Today is an important day for agricultural discussions and for considering the future of agricultural research. I am particularly pleased to have a chance to share some thoughts on this topic since there will likely be a new administration in place the next time a similar workshop is held.

Several areas in agriculture intersect with the Obama administration's most salient initiatives. One is economic growth and matching the workforce with employment opportunities. Another is science, technology, engineering and math (STEM) education, a high priority from the very beginning of the administration that has important intersections with agriculture. Finally, climate change has been a significant concern for the administration. I think the importance of agriculture and climate change has been under-addressed, but this is one of President Obama's areas of highest interest.

I would like to concentrate my own comments on three areas that relate to those intersections. The first is the agricultural workforce. The second is the issue of plant breeding and plant breeders and the workforce. The third is soil protection for both agriculture and climate change.

Recent studies show that we have an enormous challenge in agriculture to retain and build our workforce. Feeding the predicted over 9 billion people of 2050 is going to take innovation, a lot of hard work and a global effort requiring high levels of education and training in agriculture and science generally. I think this starts with our efforts here in the United States since we've always been important educators and trainers of the agricultural workforce for the world, not just for the U.S.

We have a number of issues that stand out. One is that only one percent of our population is actively engaged in agricultural production today. That means that just a small proportion of people know what agriculture is about and understand where our food comes from. Nonetheless, we still need a large cadre of people to support a successful agricultural enterprise, both in agriculture itself and in the many allied areas. So I think we are inadequately preparing our young people to meet the U.S. and global needs in agriculture.

Today, most careers in agriculture aren't about traditional farming. But kids don't know that and they don't know that their STEM interests – interests in computer science and everything from space satellites to chemistry – have a significant role to play in the agricultural sciences. We need get the message out that the modern skill-set is important in agriculture and we must modernize some of the traditional views of what agricultural science is about.

Another factor is that the average age of the U.S. farmer is 60 years old. I think we all know how the demographics are driving the workforce in agriculture. There's a flow out of the agricultural field because of age and demographic distribution, land costs and geographic distribution, and we have an inadequate flow in of personnel into farming and other elements of the farm-to-table employment chain. And that gap is increasing.

A recent National Institute for Food and Agriculture (NIFA) and Purdue University report showed that we're under-producing agriculture graduates by about 22,000 per year and, to meet that need, we would have to increase our agricultural sciences graduates by almost 65 percent. That's a very significant increase. I can attest to that. When we were looking at the President's goal of a million more STEM workers by 2022, considering even a 30 percent increase was a major challenge to our universities.

We have to think seriously about where those graduates are going to come from. There's a dual gap here. We

have a shortage of STEM workers in the private sector as well as in those with graduate and post-doctoral degrees going into the public sector in government research and universities. This creates a double bind because there's something of a vicious cycle here. A significant number of the most talented researchers are recruited into industry, which is suffering from a shortage of well-trained scientists, and that diminishes the availability of academic talent to train the next generation. And the problem continues to get worse.

Also, unlike in the past when many graduate students came to the United States for advanced training and stayed to fill positions in academia and industry in the U.S., these students now return to their own countries in great numbers. So we need to focus on filling the jobs gap, addressing industry's needs, as well as the skills that are required in modern agricultural sciences.

There have been strong efforts in the Obama administration to address the need for agricultural workers at every level, from K-12 programs onward. High school programs, in particular, have been developed that challenge youth to look at the issues of agriculture and health and human welfare. Community college programs have been a focus for the administration. Training students with marketable skills for agriculture in our community colleges is one of the most important areas, in my opinion, that we could invest in. The administration has also expanded teaching programs to train more teachers, but we could be doing a better job of training teachers to address agricultural sciences in our colleges and universities and creating curricula for K-12 programs.

One area that hasn't received enough attention is the use of research courses. This may sound like a very specific curriculum intervention, but it can have a global effect. The administration has been advocating for the use of research courses to keep students in STEM. There's a lot of research showing that when students get engaged in research, and when research courses are included in their first and second years of college, they are far more likely to finish college, stay in STEM careers and develop a better appreciation of STEM science. In addition, their grades generally improve – and not just in STEM.

This is an area that is ripe for agriculture because research shows that students are far more interested in STEM when they can see and experience applications of science. What better way to demonstrate applications than research that has the potential for feeding people and improving human welfare? I think agriculture can seize this opportunity to not only serve the general STEM purposes of training students and attracting them to STEM fields, but – even more so – to train the general population in the science of agriculture and to use the many, many fabulous model systems that work in the classroom to conduct research with undergraduates. After all, it's a lot harder to do experiments on mice or animal tissue culture in the freshman classroom than it is to perform plant and soil experiments. I think we have a lot of opportunities to build on the Obama administration's initiatives. These are ideas that have already been introduced and we can simply strengthen them in the agricultural field.

The second area of my comments concerns plant breeding. This is a specific workforce need in the general workforce deficit that we have in agriculture and I see it becoming a real challenge. All the reports and studies have shown that we are shrinking education and training in plant breeding. The calculations that my office did suggest that more than half of the plant breeders in this country at the Ph.D. level are trained in five programs across the country because we've lost so many plant breeding training programs. This is due to a number of different forces, the most important one probably being that funding for plant breeding has decreased.

Recently, there was a year when USDA gave out five grants in plant breeding. When funding is scarce, universities tend to be less enthusiastic about refilling plant breeding teaching and research positions. It's also not an area that we advertise enough in the general STEM curriculum. Plant breeding is a fascinating, important, modern field that involves computer science, all sorts of quantitative and computational sciences, as well as a breadth of biology, nutrition, chemistry and soil science. I think this is an area we must focus on. If we don't have plant breeders, we don't have agriculture. It's the fundamental basis for everything else in agriculture.

As we're facing the changing landscape and a changing climate, plant breeding will be even more important. We will need to figure out how to achieve the maximum potential of our crops. Plant breeders are the ones to do this. We know that today we're only increasing productivity by about 1 percent a year, compared with the time

of the Green Revolution when we were increasing productivity by about 2 percent a year. Much of that loss is because we're not achieving the full potential of the genetics of those plants. We need to better understand many aspects of the interaction of plant genes and the environment, and breed for the changing environment we're going to face in the future.

This means increasing interest at the K-12 level, the undergraduate level and the Ph.D. level. And it means, in my opinion, using creative strategies for funding because universities will never engage enthusiastically in expanding plant breeding programs if there isn't sustained funding – and that doesn't necessarily mean only from the federal government. I've talked to a number of agriculture school deans about ways that we might leverage some of the federal government's interest into private-sector investments that would meet this need.

As the private sector draws more and more plant breeders into their employ to meet an increase in their needs, that can also create a downward spiral in the number of plant breeders going into academic plant breeding. Any reduction in the size of the graduate programs reduces our ability to produce plant breeders for the future. So this, again, is a vicious cycle that we must interrupt quickly.

My third area is soil protection. I see this as a growing crisis. The world is losing its soil at an unsustainable rate. In the United States, we're losing soil at about 10 times the rate at which soil is produced. Soil evolves and is generated through a very slow geologic and biological process, and that rate is much slower than the rate at which the soil is washing, for example, into the Mississippi River and then into the Gulf of Mexico. We have to take this seriously and we have to act in an aggressive way.

If we wanted to, we could drastically reduce soil erosion in a year's time. We could essentially reduce it to close to zero percent if we put our minds to it. And that's a real tribute to agricultural research. This is an area in which agricultural research has filled the need and has addressed a problem. Over the last 30 years, I think we've found many practices that are necessary to prevent soil erosion. Now we have to figure out how to implement those practices more broadly.

We need to focus on many aspects of soil health, but the microbial component clearly is the crux of what makes carbon flow. Carbon sequestration is tightly associated with plant and microbial activity in soil, and there's a very happy cycle there. Microbes increase nutrient availability, improve soil structure and promote plant growth. As plants grow and photosynthesize, they release carbon into the soil. Because plants allocate a large portion of their carbon to their roots and then into the soil around the roots, they feed local microbes which further strengthens the soil. Soil architecture and soil texture are critical features for all organisms in the soil and are particularly important for plant productivity and a healthy microbial community. We are just beginning to understand the complexities of these communities and their interactions with plant roots and the mineral components of soil.

Carbon sequestration is one of the benefits that is lost with soil erosion. As erosion gets worse, there is less soil to retain carbon and support plant growth. As soil erodes, it is more prone to releasing carbon into the atmosphere. As much as half the carbon in eroded soil may end up as greenhouse gases. So there are two reasons to keep soil – for what it does when it's in place and to avoid what it does when it moves to the Gulf of Mexico or some other place and emits nitrogen, carbon and other pollutants.

We need to think about soil protection in terms of land stewardship, which I think is a less popular concept than it was a few decades ago. We need to go back to the lessons of Aldo Leopold and many of the earlier 20th century thinkers about conservation and land protection. We need to think about our crop production practices and how we can make better use of the fabulous research that has generated production practices that build soil rather than degrade it.

Finally, we need to look very carefully at one area that has not been fully addressed: How do we generate soil? This is something that interests scientists at both the USDA and NASA for, as you can imagine, very different reasons. It's a ripe and very rich area for research.

In summary, we see the core elements of the future of agriculture as:

- Maintaining food security.
- Protecting the environment and land stewardship and making sure the earth is truly a sustainable planet.
- Conducting robust research to meet the needs of future food production while addressing climate change and environmental protection.
- Training a skilled workforce that can accomplish all these things.

Our three biggest challenges that I'd like us to think about as we move forward is educating our next generation of agricultural scientists, increasing the population of plant breeders and protecting our soil.

Thank you to the Riley Memorial Foundation, the Supporters of Agricultural Research Foundation, Iowa State University, American Society for Plant Biologists and the American Association for Advancement of Science for providing this opportunity to offer comments.

Catherine Woteki, Ph.D

Under Secretary for Research, Education and Economics, and Chief Scientist, U.S. Department of Agriculture

A Perspective from USDA

USDA conducts and sponsors research in support of American agriculture. The intramural research program is administered by the Agricultural Research Service (ARS), the Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS). The extramural program is administered by the National Institute of Food and Agriculture (NIFA). These five agencies' research and statistical programs address current and emerging problems in the American food system to assure the security and safety of the food supply, promote lifelong health through good nutrition, build the bioeconomy, conserve natural resources and provide the evidence base for USDA programs, policies and regulatory decisions.

That's a big job. Farm to table, there's a lot to protect. One in 10 jobs in the United States is tied to the food and agriculture production and distribution system – 16 million jobs in all. Over recent decades, agricultural products have represented 6 to 10 percent of the annual value of U.S. exports, and agriculture is one of the few categories consistently on the positive side of the balance of payments.

Beyond its role in the economy, the food system is a critical component of our infrastructure – essential for life and health and on par with other critical infrastructure components like electricity, water and public health. Research that USDA conducts to understand, mitigate and prevent hazards to human health – from emerging zoonotic diseases and foodborne pathogens and toxins – places it in the front line of public health.

Dr. Handelsman has highlighted some high priority areas of research and, since comments from five USDA agencies will be summarized elsewhere in this report, my focus will be on USDA's human nutrition program.

USDA has conducted and sponsored research on human nutrition throughout its long history, and its current roles and responsibilities are defined in an action plan that the Research, Education and Economics (REE) mission area developed in response to a request from Congress. The Food, Conservation and Energy Act of 2008 required that the Under Secretary for REE develop a road map for agricultural science. Following the release of the road map in the spring of 2010, consultations with Congress and the broader stakeholder community led our team to develop the REE action plan that provides specific goals and strategies for the research and education activities conducted to fulfill the vision and priorities established in the road map.

The REE goal for its human nutrition program is to build the evidence base for food-based and physical activity strategies and to develop and evaluate effective education, extension and other translational activities to promote health and reduce malnutrition and obesity. The populations targeted are children, high-risk populations and the general public. Four strategies are laid out in the plan:

- Link food systems to beneficial human health outcomes in the U.S. and internationally.
- Conduct nutrition monitoring of the American population and evaluate policies influencing nutritional health.
- Build the scientific basis for dietary guidance for health promotion and disease prevention across the life cycle.
- Develop and extend approaches to prevent obesity and related diseases, including translational activities to promote behavior change related to healthy eating and physical activity.

The human nutrition research program contributes to national nutrition policy in two specific ways. First, research results that define the levels of nutrients and other substances in food necessary for good nutrition and health, as well as the statistics generated from the nutritional monitoring program, are the building blocks

for the Dietary Reference Intakes and for the Dietary Guidelines. Dietary Reference Intakes are periodically reviewed and revised by the National Academy of Medicine. The Dietary Guidelines are similarly periodically revised and updated by the Departments of Agriculture and Health and Human Services. These two documents provide policy guidance to many programs throughout USDA and the federal government, including the food labeling, purchasing and assistance programs administered by USDA, DHHS, DOD, the Veterans Administration and others. NIFA and ARS are the two REE agencies contributing research to these policy activities.

Second, the USDA ERS conducts economic and policy studies related to regulations, the food assistance and nutrition safety net programs, consumer choices and market and industry response to government programs and regulations. Some examples of recent ERS studies include work on food purchased or acquired away from home and the impact that food has had on the quality of American diets. This work contributed important background to Congress as it developed legislation to authorize menu labeling. More recently, ERS, in partnership with the Food and Nutrition Service, competitively funded a Center for Behavioral Economics and Healthy Food Choice Research at Duke University and the University of North Carolina. A substantial portion of the center's research will focus on enhancing the effectiveness and efficiency of two major USDA food assistance programs: Supplemental Nutrition Assistance Program (SNAP) and Women, Infants and Children (WIC). The research will include a mix of field-based studies and secondary data analysis. The center is also charged to develop capacity for behavioral economics research via a sub-award program and to disseminate its findings.

In planning and conducting its human nutrition research programs, the REE agencies rely on a variety of research partnerships. Some examples include:

- Interagency agreements to formalize a collaborative program of research.
- Regular workshops with regulatory agencies to identify their research needs and to update on progress of ongoing projects.
- Whole-of-government approaches to bring the collective assets of agencies to bear on cross-cutting problems. Feed the Future, the Obama administration's approach to global food security, is a good case in point.
- Jointly sponsored requests for applications to provide grant support to university-based scientists in areas that two or more agencies have identified as a priority.

The ways in which REE agencies conduct their research and statistical programs continue to evolve.

Before I conclude, I want to highlight two new opportunities to form public-private partnerships that are available to further food and agricultural research. In the 2014 law reauthorizing REE programs, Congress established a Foundation for Food and Agriculture Research. This new, private, nonprofit foundation is intended to foster research, innovation and public-private partnerships to complement the work that USDA conducts and sponsors. A second opportunity for partnering is the Agricultural Technology Innovation Partnership Program (ATIP). The ATIP Foundation serves as a catalyst for the adoption and commercialization of USDA research outcomes. It enables the formation of collaborative partnerships to integrate industry, academic and government research with venture capital to speed the commercialization of the products of USDA research.

I want to thank the Riley Memorial Foundation and its partners in organizing this effort to raise the profile of food, agricultural and natural resources research throughout the federal government and for providing the opportunity for USDA to be a part of the effort.

Robert Easter, Ph.D

President Emeritus, University of Illinois, and Board Member, Charles Valentine Riley Memorial Foundation and Supporters of Agricultural Research Foundation

A Perspective from RMF

I find myself when I am on a flight to Washington, DC, thinking that all around me are individuals coming to the nation's capital to express their needs and ask policymakers for more resources. Then I grapple over the reality that we in the food, agricultural and natural resources research system have not articulated those needs successfully. In my view, we have a very real need, and so I am going to remind you of some things that you may already know.

Our efforts are not about funding agricultural science just because we want to keep scientists busy. It's because we're doing research that is needed to feed the people of the world and to sustain our planet into the future. Today there are still roughly a billion people in the world who struggle with hunger and nutritional insufficiency. We must also be concerned about how to deal with the United Nations' predictions that global population is expected to rise from 7.3 billion in 2015 to 9.7 billion in 2050 and 11.2 billion in 2100 (**Table 1**).

Gains in food production must be made within the context of a changing climate, which is another reality that we are all beginning to sense is upon us – perhaps sooner and with greater force than we have realized. Its environmental impacts, such as the loss of productive soils and emerging diseases, are discussed elsewhere in this report.

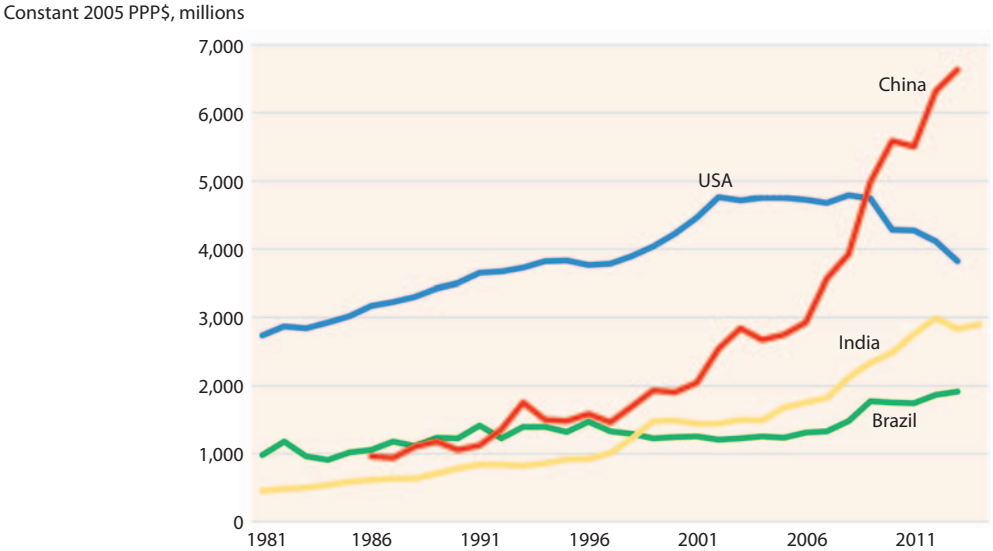
A strong agricultural research system is also critical to maintaining our country's status as a global leader. Our nation's public investment in agricultural research has not grown proportionately with other major nations, particularly China. We all must be concerned that China is now investing more in agricultural research than the U.S. and continues to increase that investment while public funding from our states and federal government declines. The numbers reported in the Riley Memorial Foundation's first unifying message report are now available for three additional years, and the gap in funding for agricultural research between China and the U.S. continues to widen (**Figure 1**).

TABLE 1. World Population Prospects

	Population (Millions)			
Major Area	**2015**	**2030**	**2050**	**2100**
World	7,349	8,501	9,725	11,213
Africa	1,186	1,679	2,478	4,387
Asia	4,393	4,923	5,267	4,889
Europe	738	734	707	646
Latin America and the Caribbean	634	721	784	721
Northern America	358	396	433	500
Oceania	39	47	57	71

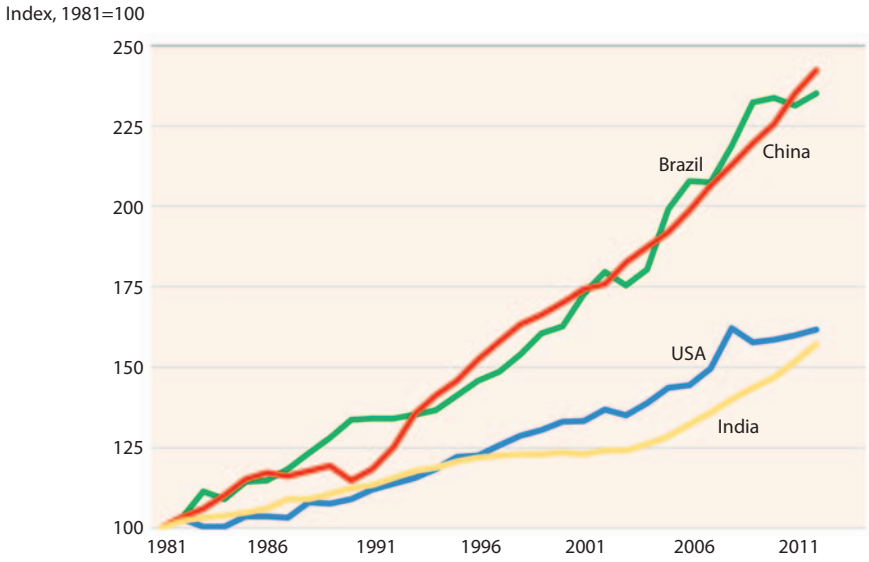
Source: United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision. New York: United Nations.

FIGURE 1. Global Public Agricultural R&D Spending, 1981–2014



Source: United States Department of Agriculture, Economic Research Service, and the International Food Policy Research Institute (IFPRI).

FIGURE 2. Agricultural Total Factor Productivity



Source: United States Department of Agriculture, Economic Research Service.

I have spent time visiting Chinese universities and other Chinese research enterprises. One has to be amazed with the extent of development there. Although the trends are less dramatic for other nations, the rate of increase in agricultural research, particularly in India, is also noteworthy. I sit on an advisory board for a university in India and am impressed with their agricultural research investment and their real interest in food and agriculture.

Agricultural production is a similar concern. U.S. agricultural productivity is much less than in countries such as Brazil, China and India – and the most recent data indicates that these trends are continuing (**Figure 2**).

Brazil has made enormous improvements, in part based upon technologies developed here in the United States, while China's increases are likely directly linked with its own agricultural research investments. During most of the last century, the U.S. food, agricultural and natural resources research system had been responsible for large increases in productivity. However, in more recent years, the U.S. has lagged behind China and Brazil in productivity growth, resulting in a negative impact on our competitiveness in world markets and, in time, this could adversely affect food security in the U.S.

When I think about conversations that I have been a part of as a university president, a vice chancellor for research, a dean of agriculture and a faculty member funded by competitive grants from USDA, I believe I have a real sense of what could be done with adequate resources. I am also a grain farmer in central Illinois, so I know the reality that individuals face in the fields as new challenges come along year by year. And as I sit around the table and listen to my colleagues express their concerns about emerging challenges – to say nothing of those who are farming in Africa and other parts of the world – I wonder where the resources needed are going to come from.

By resources, I do not mean just the financial resources, but the human resources needed to do the kind of work that needs to be done. I am glad Dr. Handelsman referred to the issue of training the next generation in her comments. As a university leader, I also struggled with this. I could clearly see areas where investments in hiring faculty and building laboratories was essential to progressing agriculture, yet adequate funding to support some of those areas was absent. It was almost an act of inhumanity to bring someone into a field where there was not adequate funding, knowing that in all likelihood they would not achieve tenure. Even if they were to get tenure, their opportunity for awards or recognition in the academic system would be limited. So it is important to recognize the breadth of need and to provide support for training the next generation.

Dr. Woteki is right when she says, "Agriculture and natural resources are at the crossroads of the world's most critical problems. The challenges are immense and need to be faced with the most robust research enterprise we can muster." And former American Association for the Advancement of Science CEO Alan Leshner's comment, "Agriculture R&D provides a dramatic example of how neglect can undermine a scientific domain," is an important addition to the conversation.

This brings us to another need: the need for a unifying message. The words "unifying message" represent the challenge that there have been a great many voices speaking to and articulating the needs in agriculture from their own perspectives. The unfortunate consequence of this has been a lack of coherent message to the public and policymakers. RMF has been developing a consensus to pursue such a unifying message. Its December 2014 report asked why there has been so little support, or growth in support, for agricultural research, concluding that supporters of agricultural research are fragmented in their interests, with different entities having different foci and priorities. This has made it difficult for the diverse field of food, agriculture and natural resources to come together as a whole. We need to grapple with these differences. Can we rally around a common ground going forward and recognize the global challenges? Can there be shared advocacy for the need? Or will we be forever stuck in a world where narrow interests and perspectives continue to frustrate our ability to make progress?

As we have looked at models for how we should proceed, one has to be impressed with what happened in the health community back in the late 1980s to late 1990s. During this time, the health community united around increasing public support for health research broadly, not just for fundamental research, but for translational research, education and the clinical application of sciences that impact human health. As a result, there was a highly successful focus on doubling the National Institutes of Health's funding. Though there's been challenges in sustaining that over the last several years, it changed a paradigm in terms of health funding.

RMF, with its partners, has done a number of things to pursue a unifying message in support of food, agriculture and natural resources. Reports have been produced, beginning with the release of the first unifying message report at a meeting at the National Press Club in December 2014. Additional meetings have been held involving various constituency groups, including universities, scientific societies and food, nutrition and health interests. There are other such reports and convening of meetings ahead as efforts continue to build consensus around

the need and how best to express the need to national decision-makers. The AAAS Charles Valentine Riley Memorial Lectures in 2015 and 2016 were presented by university presidents. Both lectures provided useful justifications for the importance of pursuing a unifying message to make agriculture a national priority.

A number of university leaders have joined with RMF's effort to express support for a unified message. This group must be joined by an even wider coalition of agricultural stakeholders, and the Supporters of Agricultural Research Foundation, RMF and others are working to do that. There must be a shared vision and a compelling statement of need for additional public funding that is articulated by a broad set of groups, including fundamental and applied as well as public and private research interests. This effort is not just about meeting nutritional needs in this country; it's about stability in the global population, our national security and sustaining the productivity of our environment. We look forward to working with all of you in developing this message and advancing this coalition.

Federal Agency Programs

The U.S. Department of Agriculture is generally recognized as the lead agency on federal food, agricultural and natural resources research. However, as documented in the proceedings of a roundtable conducted in 2011 by the Riley Memorial Foundation and four of its partners entitled "*Agriculture, Food, Nutrition and Natural Resources R&D Roundtable: Research Partnerships Yield Greater Societal Returns*," other federal agencies play important roles in advancing agricultural research. That roundtable highlighted eight exemplary cases of accomplishments that were chosen from a competitive process resulting in 61 nominations. The featured cases represented partnerships led by four USDA agencies and six other federal agencies. Policy officials from the Office of Science and Technology Policy and USDA also made presentations at the roundtable.

This earlier roundtable, as well as a 2015 unifying message roundtable and report on *A Scientific Society Perspective*, provided useful input into the selection of agencies for the federal agency workshop covered in this report. For this workshop, the organizing committee selected five USDA agencies and seven other federal agencies to participate. The USDA agencies were the Agricultural Research Service (ARS), National Institute for Food and Agriculture (NIFA), Economic Research Service (ERS), National Agricultural Statistics Service (NASS) and Forest Service (FS). The other agencies were the National Science Foundation (NSF), National Institutes of Health (NIH), U.S. Geological Survey (USGS), Department of Energy (DOE), U.S. Agency for International Development (USAID), National Oceanic and Atmospheric Agency (NOAA) and the Department of Defense (DOD). The USDA agencies included the Agricultural Research Service (ARS), National Institute for Food and Agriculture (NIFA), Economic Research Service (ERS), National Agricultural Statistics Service (NASS) and U.S. Forest Service (FS).

The agencies participating in this workshop were chosen before the Supporters of Agricultural Research Foundation released its June 2016 report entitled *Retaking the Field: The Case for a Surge in Agricultural Research*. It is worthy of note that of the 13 agricultural research success stories featured in SoAR's report, over half had received funding from agencies other than USDA, including NSF, NIH and DOD.

Other agencies such as the Food and Drug Administration, Environmental Protection Agency and the National Aeronautics and Space Administration collect information and conduct research that has application to agriculture. However, the 13 agencies selected for this workshop provided an adequate overview for the scope of work important in consideration of developing a unifying message in support of increased funding for food, agricultural and natural resources research.

Summary descriptions are provided for each participating agency. The summaries are offered as a glimpse – as opposed to a comprehensive examination – into the food and agricultural research performed by these agencies.

National Science Foundation

Mission

The National Science Foundation is an independent federal agency created by Congress in 1950 to promote the progress of science; advance the national health, prosperity and welfare; and secure our national defense. NSF funds approximately 24 percent of all federally supported basic research at America's colleges and universities. The agency is divided into the following seven directorates (research areas), which are further subdivided into divisions:

- Biological Sciences*
- Computer and Information Science and Engineering*
- Engineering*
- Geosciences
- Mathematical and Physical Sciences
- Social, Behavioral and Economic Sciences
- Education and Human Resources*

* *Research areas most relevant to agriculture*

NSF Research and Agriculture

NSF's **Biological Sciences (BIO)** mission area has the most direct relationship to agricultural research. BIO accounts for 68 percent of all federal supported basic research in the nonmedical biological sciences at academic institutions. BIO has made significant investments into a new program entitled **Innovations at the Nexus of Food, Energy and Water Systems (INFEWS)**. This program, a collaboration between NSF and USDA-NIFA, is catalyzing integrated interdisciplinary research efforts to transform our understanding of the food, water and energy nexus in order to improve the function and management of systems, increase resilience and ensure sustainability. BIO also is making investments in microbiome research to enrich our understanding of the role of microbes in soil, plant and animal function, productivity, health and resilience.

Examples of specific agricultural research supported by BIO include a project, conducted in partnership with the Bill & Melinda Gates Foundation, examining how genomic selection can accelerate the discovery of new traits, particularly those with potential to improve crop yields for developing nations. BIO is also supporting research projects aimed at improving biofortification, strengthening plant pest resistance and recovering lost plant traits to produce better crops without compromising yield or commercial value. Through its **Cyverse** project, BIO is providing life scientists with powerful computational infrastructure to handle huge datasets and complex analyses.

The **Computer and Information Science and Engineering** research area is contributing to food and agricultural research by exploring gene networks and genomic data to improve disease phenotyping, food security, bioinformatics research and computational techniques.

The **Education and Human Resources** research area has prioritized STEM education through programs that attract and retain a new generation of researchers, including scientists in agriculture, renewable energy and natural resources. The programs support curriculum development, professional development and funding for new researchers. For more information on NSF science, go to **www.nsf.gov.**

National Institutes of Health

Mission

The National Institutes of Health, a part of the U.S. Department of Health and Human Services, is the world's largest biomedical research agency. Its mission is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life and reduce illness and disability. The NIH is made up of 27 institutes and centers, each with a separately appropriated budget and specific research agenda, often focusing on particular diseases or body systems.

NIH Research and Agriculture

NIH has a broad portfolio of research relevant to agriculture, including genomic research, gene editing and other emerging technologies. Nutrition is an important part of the agency's work. Approximately 23 of NIH's 27 institutes and centers have interests or investments in nutrition. To coordinate these efforts, the **Office of Nutrition Research** has been established in the National Institute of Diabetes and Digestive and Kidney Diseases and the **Nutrition Coordinating Committee**, which includes representation from NIH institutes and centers as well as USDA and the Department of Defense, works to improve interorganizational communication and coordination in NIH. The **Interagency Committee on Human Nutrition Research (ICHNR)** increases the overall effectiveness and productivity of federally supported human nutrition research across multiple agencies. The committee, co-chaired by USDA Under Secretary for Research and Chief Scientist Dr. Catherine Woteki, produces a **National Nutrition Research Roadmap** that identifies research priorities for human nutrition and describes the role of the ICHNR departments and agencies in addressing the priorities over the next five to 10 years.

In addition to nutrition, much of the basic biological sciences research performed at NIH is applicable both to human health as well as agriculture. It should be noted that large agricultural mammals, such as swine, can sometimes function as a better analogue for humans in health research than mice. In recognition of this, the NIH is partnering with USDA on a number of projects. For instance, the **National Institute of Child Health and Human Development** is working with USDA-NIFA to invite submissions that use agricultural animals to improve human health. Through such projects, researchers hope to advance both human and veterinary biomedical research.

NIH has conducted research into the impacts of agricultural life on farmers and farm families. Research such as the **Agricultural Health Study (AHS)** has examined cancer and other health outcomes in licensed pesticide applicators and their spouses. The study is a collaborative effort involving investigators from the National Cancer Institute, National Institute of Environmental Health Sciences, Environmental Protection Agency and National Institute for Occupational Safety and Health. For more information on NIH science, go to **www.nih.gov**.

U.S. Geological Survey

Mission

Created by Congress in 1879, the U.S. Geological Survey is the sole science agency for the Department of the Interior. As the nation's largest water, earth and biological science and civilian mapping agency, USGS collects, monitors, analyzes and provides reliable and impartial science about natural resource conditions, issues and challenges. USGS, which has no regulatory authority, collects data and performs studies in cooperation with state, local and federal agencies and USGS national programs. Its work is divided into 7 mission areas:

- Climate and Land Use Change*
- Ecosystems*
- Environmental Health*
- Water*
- Natural Hazards
- Energy and Mineral Resources
- Core Science Systems

* *Mission areas most relevant to agriculture*

USGS Research and Agriculture

USGS conducts research in several areas related to agriculture. In its **Climate and Land Use** mission, USGS examines land use changes and the potential impacts of climate change on water, habitat and ecosystems. Through this mission, USGS manages LANDSAT data and developing remote sensing tools to gather information and develop early climate warning systems.

The **Ecosystems** mission area examines fish and wildlife conservation, land and water priority landscapes, invasive species and fish and wildlife diseases. Researchers are providing science to guide resource management and policy decisions supporting wildlife habitat and other environmental services compatible with USDA conservation goals. For example, USGS scientists are evaluating the benefits of species habitat and soil conservation associated with USDA's Conservation Reserve Program.

In the **Environmental Health** mission area, USGS scientists are studying the sources, transport and fate of contaminants, particularly as they relate to hydrology, land use and human and ecosystem health. This includes contaminants such as pesticides, fertilizers, zoonotic pathogens and veterinary medicines.

In the **Water** mission area, studies are conducted on groundwater and stream flow, providing forecasts, tools and real-time information to minimize loss from water-related hazards such as floods, droughts, hurricanes and spills. This mission area also explores availability and changes in the quality of the nation's freshwater resources and the human and natural factors influencing those trends. For example, USGS monitors the delivery of nutrients, sediment and other contaminants to inland and coastal waters by the nation's streams and rivers. USGS water quality models evaluate the sources of major contributors of nutrients and other contaminants in specific watersheds. These estimates are used by state and federal agencies to help guide effective implementation of management practices on the landscape. For more information on USGS science, go to **www.usgs.gov**.

Department of Energy

Mission

The mission of the U.S. Department of Energy is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions. The DOE Office of Science is the lead federal agency supporting fundamental scientific research for energy and the nation's largest supporter of basic research in the physical sciences. The Office of Science manages a research portfolio through six core program offices:

- Advanced Scientific Computing Research
- Basic Energy Sciences
- Biological and Environmental Research*
- Fusion Energy Sciences
- High Energy Physics
- Nuclear Physics

* *Mission area most relevant to agriculture*

DOE Research and Agriculture

The DOE **Office of Biological and Environmental Research** supports basic bioenergy research relevant to agriculture. It provides the foundational science to support the development of biofuels as a major and sustainable national energy resource; to understand the potential effects of greenhouse gas emissions on the Earth's climate and biosphere; and to create new tools to explore the interface of the biological and physical sciences.

The Office of Biological and Environmental Research's **Genomics Science Program** has an 11-year collaborative partnership with the USDA in basic plant biology to develop dedicated crops for bioenergy using the tools of genomics. This work is complemented by the office's three **Bioenergy Research Centers.** The centers' multidisciplinary scientific teams from universities, national laboratories, nonprofit organizations and private companies are working to develop next-generation bioenergy crops, discover and design enzymes and microbes with novel biomass-degrading capabilities and create microbe-mediated strategies for advanced biofuels production. The **Genomics Science Program** also supports sustainability research that, among other topics, examines the resilience of bioenergy crops to changing environmental conditions. DOE's **Joint Genome Institute** offers integrated high-throughput genome sequencing and analysis capabilities that enable systems-based understanding of bioenergy, carbon cycling and biogeochemical processes of relevance to the department's energy and environmental missions.

DOE also is engaged in computational bioscience, which includes the creation of open software and data platforms to aid researchers in accessing and analyzing large complex datasets via a unified system for integrating data; predicting and designing biological function; comparing functional genomic properties of microbes, microbial communities and plants; and collaborative opportunities for sharing methods and results.

The work of The Office of Biological and Environmental Research's **Climate and Environmental Sciences Division** has implications for agriculture. Its research seeks to increase understanding of climate to inform decision-making and improve predictive models. For more information, go to **www.science.energy.gov/ber**.

U.S. Agency for International Development

Mission

The U.S. Agency for International Development is charged with working to end extreme poverty and promote resilient, democratic societies while advancing U.S. security and prosperity. As part of this agency, **Feed the Future** was created in 2009 to serve as the U.S government's global hunger and food security initiative. In partnership with other governments, donor organizations, the private sector and civil society, Feed the Future seeks to use a whole-of-government approach to help farmers produce more, get more food to market, support R&D to improve smallholder agriculture, strengthen regional trade, create a better policy environment and improve access to nutritious food.

USAID Feed the Future Research and Agriculture

USAID's **Feed the Future Research Strategy** identified three priority areas for research: advancing the productivity frontier, transformation of production systems and improving food safety and nutrition. USAID implements the research strategy through seven program areas. Three program areas address long-term research objectives and constitute the largest research investments. The **Program for Climate Resistant Cereals** has tested 700 heat-tolerant hybrids, discovering 17 versions that outperform the best commercial varieties for South Asia. This program also is developing drought-resistant maize for introduction in Africa. The **Program for Productive Legumes** is breeding more heat- and drought-tolerant, soil-enhancing plants (e.g., soy, peanut, bean, cowpea, chickpea) that have the potential to deliver valuable proteins and nutrients, reduce poverty and return nitrogen to the soil. The **Program for Advanced Approaches on Pests and Diseases** is breeding, engineering and introducing pest- and disease-resistant crops, with successes that include the introduction of Bt eggplant in Bangladesh, which can reduce pesticide use by as much as 90 percent.

Feed the Future also has cross-cutting research programs. The **Program for Research on Nutritious and Safe Foods** is examining biofortified crops (e.g., vitamin A-rich sweet potatoes), animal source foods and postharvest storage to reduce loss. The **Program for Markets and Policies** works to improve the enabling environment in ways that foster trade and investment at all levels, as well as reducing risk. The **Program for Human and Institutional Capacity Development** is engaged in technical and professional skills training and institution building. The **Program for Sustainable Intensification** integrates technology and other research outputs in the context of smallholder natural resource management, human capital and market access.

As part of these broad efforts, 24 **Innovation Labs** have been established that draw on the expertise of top U.S. universities and research institutions in developing countries to advance Feed the Future's research priorities. Other direct research applications through Feed the Future include maize-legume intercropping and rotation, fertilizer decision support tools and agroforestry. For more information on Feed the Future's research, go to **www.feedthefuture.gov/research**.

National Oceanic and Atmospheric Administration

Mission

The National Oceanic and Atmospheric Administration is America's environmental intelligence agency with a mission to understand and predict changes in climate, weather, oceans and coasts; to share that knowledge and information with others; and conserve and manage coastal and marine ecosystems and resources. To fulfill this mission, NOAA engages in observations, monitoring, assessment, modeling and the development of forecasts and other products. NOAA's nine key focus areas are:

- Weather
- Climate
- Oceans and Coasts
- Fisheries
- Satellites
- Research
- Marine and Aviation
- Charting
- Sanctuaries

NOAA Research and Agriculture

NOAA's **National Centers for Environmental Information** maintains and provides comprehensive oceanic, atmospheric and geophysical data that are translated into tools for use by many stakeholders, including those in agriculture. The centers' data have produced crop model simulations and software such as Adapt-N, which helps corn growers potentially save money through more efficient use of nitrogen fertilizer. Other products used by agriculture include weather monitoring data, soil moisture and temperature information and data on snow cover, drought, frost and extreme precipitation.

The **National Integrated Drought Information System** was created to help move the nation to more proactive management of drought risks and impacts. The system coordinates national drought monitoring, forecasting, research and assessment. Its research supports improvements in understanding key physical processes behind the emergence and development of drought as well as interdisciplinary research dedicated to improving coping strategies. The system relies on partnerships among federal agencies, states and tribes for monitoring, assessment, outreach and preparedness and adaptation planning. USDA is a prominent partner for the system, working on projects that contribute to regional drought early warning systems. Examples include establishing a fallow land monitoring project as part of a regional drought early warning system in California to provide timely assessments of fallowed acreage and help decision makers anticipate changes in farm income, farm worker unemployment and conservation implications. Another partnership with USDA is working to more fully integrate soil moisture into monitoring and decision-making.

NOAA's **Regional Integrated Sciences and Assessments Program** supports research teams in expanding and building the nation's ability to prepare and adapt to climate change. The program has sponsored web-based platforms like AgroClimate, which provides interactive tools and climate information to improve crop management and reduce the production risks associated with climate change. Another important area where NOAA contributes to agriculture is the **Joint Agricultural Weather Facility** with USDA. This effort helps determine the cumulative impact of growing season weather conditions on prospects for crop and livestock production, and plays a leading role in providing the science to support the management and food safety associated with the nation's fisheries. Recently, NOAA launched its **Water Initiative.** The cornerstone of this the initiative is the NOAA Water Center, which will deliver a suite of products to help communities and industries make better-informed decisions about how to prepare for extreme water events. For more information on NOAA research, go to **www.research.noaa.gov**.

Department of Defense

Mission

The mission of the Department of Defense is to provide the military forces needed to deter war and to protect the security of the United States. While the majority of DOD's R&D funding is dedicated to the development of new defense technologies, a portion relates directly or indirectly to food and agriculture. Examples include research into advanced biofuels as well as improving the health and well-being of armed services members.

DOD Research and Agriculture

DOD has several programs to optimize the nutritional well-being of military members and their families. The **Go for Green** program uses color-coded labeling of food options (Green = Go, Yellow = Caution and Red = Stop) to generate awareness and promote the consumption of healthier foods and beverages while retaining choice. The **Military Nutrition Environment Assessment Tool** scores bases and other facilities using a variety of criteria as means of encouraging broader access to healthy options. The U.S. Army is using both programs to advance its "Performance Triad" of sleep, activity and nutrition.

The **Healthy Base Initiative** was a demonstration project for **Operation Live Well**, a broader campaign to improve the health, wellness and well-being of defense community members. The goal was to encourage active living, healthy eating and a tobacco-free environment. Lessons learned from the program included a need for greater emphasis on the whole supply chain and that additional focus should be given to nutritional education and partnering with other agencies like USDA.

The **Defense Commissary Agency's (DeCA) Nutrition Guide Program** is developing a guide for use in all commissaries worldwide. Through this program, DeCA will survey, assign and display nutritional information on its food items to align with Go for Green and other DOD criteria. Sales will be tracked to determine whether the Nutrition Guide Program is resulting in healthier purchases. Other DOD nutrition projects include teaching kitchens, calcium and Vitamin D supplementation and experimentation with Omega-3 enhanced diets.

The **U.S. Army Research, Development and Engineering Center** is engaged in a number of food-related research projects, including examining the threat of pathogens in low-moisture food; the dispersion and release properties of encapsulated natural insect repellents; finding new methods of detecting food contamination; and assessing the feasibility of containerized hydroponic systems to provide fresh produce to sailors.

In addition to food and nutrition programs, DOD has substantial biofuels initiatives that are helping to fund the development, testing and certification of alternative "drop-in" fuels from nonfood sources such as algae, biomass, switchgrass, camelina and vegetable oil. A portion of these efforts are conducted in partnership with the DOE and USDA.

U.S. Department of Agriculture

Each day, the work of USDA scientists and researchers touches the lives of all Americans – from the farm field to the kitchen table, the clothes we wear, the air we breathe and the energy that powers our homes and cars. Research funded by USDA – whether it be fostering continued economic growth, adapting to the effects of climate change and addressing food safety and security – helps maintain the United States' status as a global leader in agriculture.

Our nation's agricultural, natural resource and conservation challenges are immense and can only be met through a robust research enterprise and educational programs. USDA intramural and extramural science helps to protect, secure and improve our food, agricultural and natural resources systems. USDA accomplishes research primarily through its Research, Education and Economics (REE) mission area, which includes the:

- Agricultural Research Service (ARS)
- National Institute of Food and Agriculture (NIFA)
- Economic Research Service (ERS)
- National Agricultural Statistical Service (NASS)

Additional USDA research is conducted by the Forest Service in the Natural Resources and Environment mission area.

REE's Action Plan organizes its research efforts and works to ensure there is cooperation and coordination of research rather than duplication of effort among the four REE agencies and the Forest Service. The Action Plan (see Selected References) provides guidance for the Chief Scientist for USDA and the Under Secretary for Research, Education and Economics to facilitate linkages between USDA and other federal agencies that conduct research related to agriculture; between USDA and higher-education institutions of the Association of Public and Land-grant Universities, American Association of Universities and Non-land-grant Agriculture and Renewable Resources Universities; and between USDA and other public and private institutions. In addition, the individual USDA agencies have mechanisms for working with the private sector.

The new Foundation for Food and Agriculture Research was authorized in the 2014 Farm Bill (the Agricultural Act of 2014) with $200 million from the Commodity Credit Corporation. It was developed through USDA's leadership and charged with complementing and furthering the important work of the USDA. Although not a unit of USDA, the foundation, a 501 (c) (3) nonprofit organization, has the potential to become an important part of a future robust food, agricultural and natural resources research system and is charged with developing a grants program in which private funding for proposed research projects is matched with foundation funds. If awarded grants are successful in attracting nonfederal funds from institutions and enable progress towards critical issues, then additional federal funds for the foundation could be a priority in the next Farm Bill. For more information on USDA research, go to **www.usda.gov/.**

Agricultural Research Service

Mission

The Agricultural Research Service is the USDA's chief scientific, in-house intramural research agency. It provides the infrastructure to respond to immediate scientific and technical challenges to the nation's agricultural system. It also provides important resources and data developed over many years in geographically and climatologically diverse regions throughout the United States. ARS provides access to scientific information within the U.S. and globally. ARS also is responsible for technology transfer of scientific solutions via cooperative agreements, patents and communications. The agency's mission is to: Ensure high-quality, safe food and other agricultural products; maintain historic and current seed and other genomic collections as assets of the U.S. and for global use; assess the nutritional needs of all Americans; sustain a competitive agricultural economy; enhance the natural resource base and the environment; provide economic opportunities for rural citizens, communities and society as a whole; and provide the infrastructure necessary to create and maintain a diversified workplace.

Food, Agricultural and Natural Resources Research

ARS has over 6,500 employees who carry out approximately 700 research projects at 90 laboratories throughout the nation and in several other countries. Of the 90 ARS locations, the vast majority are located on the campuses of land-grant universities and related centers. Several are located on campuses of non-land-grant institutions. This arrangement facilitates synergistic interactions among scientists from the universities and ARS and provides an opportunity to share facilities and equipment. It also facilitates the sharing of genetic and other research collections and data resources that have been assembled by ARS scientists over many decades. ARS includes the National Arboretum and the National Agricultural Library, the nation's major information resource on food, agricultural and natural resource sciences and one of four national libraries of the U.S. government.

ARS research is managed through 17 national programs and priorities, including:

- *Crop production and protection,* with emphasis on genomics and genetic improvement and identifying diseases and challenges from pests
- *Animal production and protection,* with emphasis on food production, combating diseases and promoting animal and human health
- *Natural resources and sustainable agricultural systems,* with emphasis on water resources and watershed management, climate change impacts and the technological development of biorefined and other industrial products
- *Nutrition, food safety and quality*, with emphasis on the impacts of nutrition on healthy and health-challenged people and food safety relative to plants and animals

Recent ARS research has made significant contributions to agricultural science. With its work on zoonotic diseases, ARS is regarded as among the few sources of expertise on avian influenza, which devastated the U.S. poultry industry in 2015. Through the **National Plant Germplasm System and its Germplasm Resources Information Network** ARS collects and conserves living plant material and helps to safeguard plant genetic diversity for future plant breeding needs. ARS also is the science agency involved in the **One Health Initiative** to provide knowledge, strategies and new scientific developments to reduce the use of antibiotics while protecting animals in agriculture from disease. In partnership with the National Science Foundation, 18 ARS sites are part of the **Long Term Agro-ecosystem Research Network** that is examining long-term conditions, trends, data and sustainable agriculture systems. ARS scientists also are working on national biodefense issues to help protect the nation. For more information on ARS impacts see the link in Selected References. For more information on ARS, go to **www.ars.usda.gov.**

National Institute of Food and Agriculture

Mission

As the successor to the Cooperative State Research, Education and Extension Service, the National Institute of Food and Agriculture was established as part of the 2008 Farm Bill to serve as USDA's primary extramural research, education and extension funding agency. NIFA provides programmatic and financial linkages between the federal and state components of a broad-based, national agricultural research, extension and higher education system. NIFA has identified six national challenge areas that inform its research priorities: Food Security, Sustainable Bioenergy, Climate Variability and Change, Childhood Obesity Prevention, Water and Food Safety.

Food, Agriculture and Natural Resources Research

NIFA distributes federal funding using two primary mechanisms: capacity funding grants and competitive grants. Capacity funds support the capacity of the land-grant university system, made up of state agricultural experiment stations, the state cooperative extension system and educational components of colleges of agriculture and related sciences. The amount of capacity funding is determined by formulas in legislative statutes that include variables such as the rural population, farm population and poverty rates. Local or regional university leaders, informed with input from agricultural stakeholders, determine how agricultural research will be supported with capacity funds. Recent examples of accomplishments supported by capacity grants include:

- Biosecurity research in Kansas, including the heating of animal feeds, will help prevent the spread of porcine epidemic diarrhea virus, a new disease impacting U.S. swine herds.
- Florida researchers are working to repel a devastating bacterial disease threatening the U.S. citrus industry. Scientists have pinpointed the bacterial cause of citrus greening, worked to introduce resistance into insects spreading the bacteria and are developing resistant rootstock.
- Scientists from 10 land-grant universities are helping Midwestern corn farmers adapt to a more unpredictable future climate, through development of best management practices on field drainage, cover crops, tillage, fertilizers and crop rotations.
- Maryland research for detecting foodborne pathogens in blue crab meat and crab processing plants is allowing the seafood industry and regulatory agencies to refine methods for rapid detection of bacteria.
- Wyoming researchers developed an innovative flow-through filter that removes arsenic from groundwater and maintains federal standards for drinking water.

The **Agriculture and Food Research Initiative** is a peer-reviewed competitive grants program that supports fundamental and applied agricultural research. AFRI programming is informed by Farm Bill priority areas of: plant health and production; animal health and production; agricultural systems and technology; bioenergy, natural resources and environment; food safety and nutrition; and agricultural economics and rural communities. Recent examples of accomplishments supported by AFRI grants include:

- Combating plant pest and disease problems in strawberries and specifically in citrus greening in Florida and California
- Improving the disease resistance, nutritional value, yield and drought tolerance of wheat and barley varieties
- Enhancing identification of biofuel feedstocks that reduce greenhouse gas emissions as part of the life cycle

Other NIFA competitive programs tend to address more specific topics (e.g., specialty crop research) and the institutions eligible to receive this funding vary by program.

Additional information on recipients of NIFA funding and examples of program accomplishments can be found in this report's budget section as well as NIFA's 2015 Impact Report and 2015 Annual Report, listed in the Selected References at the end of this report. For more information on NIFA, go to **nifa.usda.gov.**

Economic Research Service

Mission

The mission of USDA's Economic Research Service is to anticipate trends and emerging issues in agriculture, food, the environment and rural America and to conduct high-quality, objective economic and social science research to inform and enhance public and private decision-making. ERS analyzes and provides access to data and information for use by other economists, legislative bodies and the general public. Much of ERS' work is covered by the Office of Management and Budget's statistical rules to ensure independence and continuous reliable data and analysis. ERS occasionally provides leadership in international bodies and organizations on the fundamentals of economic research and analysis so that global information on agriculture, food and fiber production, bioenergy and rural development can be collected and published. ERS works in four broad areas: Agricultural Production and Trade, Rural Prosperity, Natural Resources and Safe and Nutritious Food.

Economic and Social Science Research

ERS conducts research, analyzes food and commodity markets, produces policy studies and develops economic and statistical indicators to meet the information needs of USDA, other policy officials and the research community. ERS provides statistical indicators for the health of the farm sector, such as farm income estimates and projections, current and expected performance of agricultural industry and trade and food security in the United States and abroad. ERS research and analysis cover a broad range of economic and policy topics, including:

- *Agricultural Economy* – Farm sector performance and farm households' well-being; farm size and concentration; market analysis, data and projections on commodity supply, demand and prices; and federal farm policies
- *Food and Nutrition* – Food security, food and nutrition assistance programs, food choices and health outcomes, food access and store proximity, food retailing and marketing and food prices
- *Food Safety* – Societal benefits associated with reducing food safety risks, global trade implications and economic impacts of food hazards and potential results of regulation versus industry decisions
- *Global Markets and Trade* – Domestic and international markets, trade and the U.S. food and agriculture sector's performance in increasingly globalized markets
- *Resources and Environment* – Economic impacts of alternative conservation programs, efficacy of policies designed to protect the environment, challenges of climate change and water scarcity and enhancing agricultural competitiveness through technology
- *Rural Economy* – Investments in rural communities and the capacity of rural economies to prosper in a changing global marketplace, demographic change and its impact on rural communities and drivers of rural economic performance

ERS publishes its research and analysis online in economic research reports, articles in its award-winning *Amber Waves* magazine and data products throughout the year. Through its **Commodity Outlook Program,** ERS delivers timely, independent and objective information about agricultural markets and provides projections of U.S. and world agricultural commodity production, consumption and trade. ERS economists share their findings and conclusions through published articles in professional journals, presentations to academic colleagues at conferences and meetings and the **ERS InsightsWebinar Series,** which provides a forum for ERS experts to interact with the public and provide in-depth information on a research topic. ERS economists provide oral briefings, written staff analyses and congressionally mandated studies delivered directly to executive and legislative branch policymakers and program administrators. For more information on ERS work go to **www.ers.usda.gov.**

National Agricultural Statistics Service

Mission

The National Agricultural Statistics Service is committed to providing timely, accurate and useful statistics in service to U.S. agriculture. It conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture, including production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use and changes in the demographics of U.S. producers. NASS is one of the official statistical agencies of the United States government and, in keeping with that designation, its work is secured and conducted under conditions similar to the U.S. Census Bureau.

To fulfill its mission, NASS:

- Reports facts on American agriculture needed by people working in and depending upon U.S. agriculture
- Provides objective, unbiased statistics on a preannounced schedule that is fair and impartial to all market participants
- Conducts the Census of Agriculture every five years, providing the only source of consistent, comparable and detailed agricultural data for every county in America
- Safeguards the privacy of farmers, ranchers and other data providers, with a guarantee that confidentiality and data security continue to be its top priorities
- Serves the needs of its data users and customers at the local level through its network of state field offices and its cooperative relationship with universities and state departments of agriculture.

Agricultural Statistics

Every five years, NASS conducts the **Census of Agriculture** which provides a detailed picture of U.S. farms and ranches and the people who operate them. As a product that tracks innumerable factors over time, the data inform the decision-making of USDA and other parts of the U.S. government, as well as private agricultural and commercial interests.

Besides the census, NASS conducts 450 surveys on 200 different commodities on a continuing basis. The data illustrate the changing nature and needs of agriculture and provide accurate, up-to-date information necessary for decision-making by producers, agribusinesses, farm organizations, commodity groups and public officials. NASS data also keep agricultural markets stable, efficient and fair by ensuring accessible, objective data are available to both commodity market buyers and sellers in the U.S. and globally. Some recent NASS results include: forecasts of record high production of corn and soybeans in 2016; development and implementation of a program to quantify effects of agricultural production; and reports on declines or increases in cost of production for U.S. agriculture.

NASS has enhanced its programs and operations to deliver improved results, including opening a **National Operations Center** that centralizes data collection and service. For more information on NASS, go to **www.nass.usda.gov.**

Forest Service

Mission

The Forest Service maintains the world's largest forest research program. While its broad mission is to develop the knowledge and technology needed to enhance the economic and environmental values of all the nation's forests, the program also supports specific research needs that arise from managing 193 million acres of the National Forest System. Emerging FS research areas are:

- *Biomass and Bioenergy* – Alternative energy sources, new products and new markets that contribute to U.S. energy security, environmental quality and economic opportunity
- *Climate Change* – Improve the adaptation and resiliency of forests, rangelands and aquatic areas and to mitigate the adverse impacts of climate change on trees, forests and forest ecosystems
- *Nanotechnology* – Cutting-edge innovations in development of wood products
- *Urban Natural Resources Stewardship* – Management, protection and care of urban natural resources to improve people's lives, including air quality and climate of urban areas
- *Watershed Management and Restoration* – Improve watershed-scale understanding of where water shortages will occur, identify how future climate will affect rainfall and snowfall and reduce water pollution and protect water sources

Forest and Rangeland Research

The **Forest Inventory and Analysis Program** provides the information needed to assess America's forests. It strengthens the collection, coordination and assessment of field inventory data, creating a robust landscape-scale inventory and analysis based on information gathered from 50 states and the U.S. territories. In 2017, FS will continue working to stimulate the creation of 70 natural resources and environment commercial and industrial markets for underutilized or merchandisable forest resources resulting from restoration and fuel treatment operations. This work –coupled with the permanent authorization in the 2014 Farm Bill for **Stewardship End Result Contracting**, which helps achieve land management goals while meeting local and rural community needs –will produce value for landowners while creating sustainable natural resource jobs throughout the nation.

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FS basic and applied research is organized into seven primary areas:

- *Invasive Species* – Reduces or eliminates the introduction and establishment of invasive species
- *Inventory, Monitoring and Analysis* – Identifies current status and trends of forests, management options and effects and threats to the nation's forests and grasslands species
- *Outdoor Recreation* – Manages environments and experiences that connect people with the natural world
- *Resource Management and Use* – Explores forest and range resources and products, including agroforestry**,** forest products**,** landscape science**,** management and operations **and** urban research
- *Water, Air and Soil* – Enables clean air and safe drinking water, protection of lives and property from wildfire and smoke and adapting to climate variability and change
- *Wildland Fire and Fuel* – Focuses on reducing fire's negative impacts and enhancing its beneficial effects
- *Wildlife and Fish* – Investigates complex interactions among species, ecosystem dynamics and processes, land use and management and emerging threats

Recent FS research has included forecasting the influence of climate change on invasive weeds and weed biological control; examining the annual water supply of the United States; and the reintroduction or conservation of native plants more suited to growth in regions of the U.S. in response to climate change and water conservation needs. For more information on FS research, go to **www.fs.fed.us/research/**.

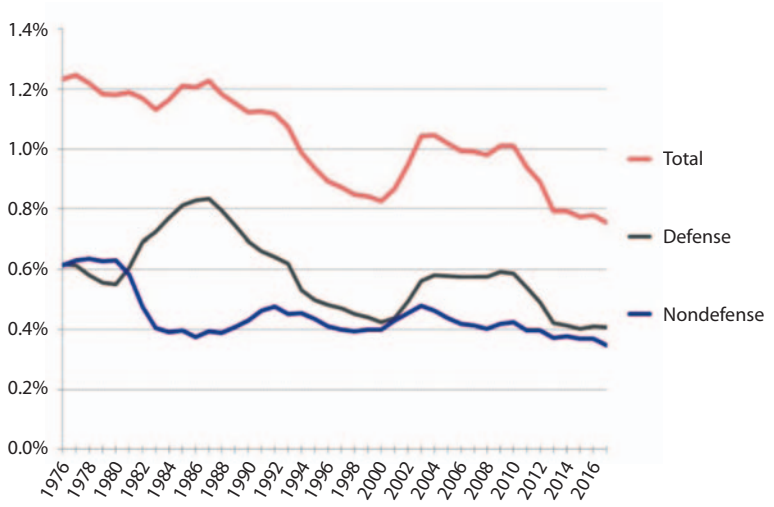
Federal Research Budgets

A Perspective

Overview. The decline in publicly funded agricultural research in the U.S. as other countries increase their investments has been mentioned earlier in this report (**Figure 1,** page 10). This trend, as well as the reduction in science investment in general, should be of broad concern since it is having an adverse effect on U.S. competitiveness and the well-being of its citizens. Reductions in federal R&D support over the past four decades are reflected in the decline in the percent of gross domestic product (GDP) spent on total R&D, from slightly over 1.2 percent in 1976 to 0.8 percent today. Since 1988 the percentage of GDP spent on nondefense R&D declined from slightly over 0.8 percent to under 0.4 percent today (**Figure 3**). Declines in public research investment are also reflected at the agency level. **Figure 4**, from the American Association for the Advancement of Science (AAAS), shows reductions in R&D spending since FY 2010 for every major research agency, including the National Science Foundation, Department of Energy, National Institutes of Health, National Aeronautics and Space Administration, U.S. Department of Agriculture and Department of Defense.

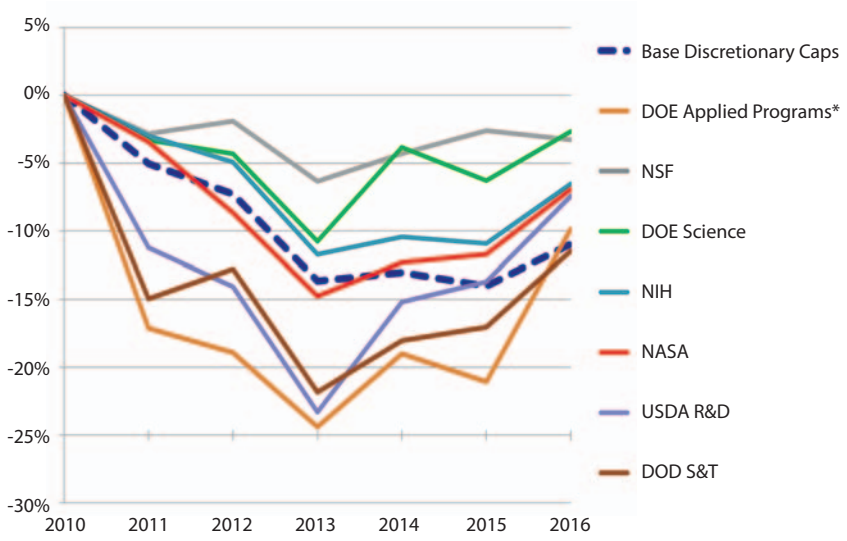
Selected agencies. The 13 agencies that participated in the federal agency workshop fund research of benefit to agriculture when broadly defined to include food, nutrition, agriculture, natural resources, bioenergy, climate change and related economics. However, the budgets for the non-USDA agencies are not organized in such a way as to readily determine the exact amount of their agriculture-related research. Still, the federal budgets assembled by AAAS provide a perspective on how research by some of these agencies affect agriculture. Related budget lines have been selected for the National Science Foundation, U.S. Geological Survey, Department of Energy and National Oceanic and Atmospheric Administration (**Table 2**). Sources for estimates for the National Institutes of Health and the U.S. Agency for International Development are provided in table footnotes. In addition, the Department of Defense conducts considerable research related to agriculture, but it is performed by a wide range of units and readily available budgets do not provide sufficient detail to reflect where the research is conducted.

FIGURE 3. Trends in Federal R&D Spending as a Percentage of GDP, 1978–2016



Source: AAAS analyses of historical budget and agency data and the FY 2017 request.
GOP figures from OMB. R&D includes conduct and facilities. ©AAAS.

FIGURE 4. Trends in Federal R&D Spending as a Percentage of GDP, 1978–2016



*Includes EERE, OE, Fossil, Nuclear; excludes ARPA-E (regular appropriations began in FY 2011).
Based on AAAS analyses of historical OMB, agency, and appropriations data and the President's FY2017. ©2016 AAAS.

TABLE 2. Budget Authority for Selected Agencies

	Millions of Dollars		
Activity	**2014**	**2015**	**2016**
NSF			
Biological Sciences	721	731	744
NIH			
Nutrition	1,555	1,574	1,600[a]
USGS			
Ecosystems	153	157	158
Energy, Minerals, Enviro Health	96	100	102
Natural Hazards	106	111	111
Water Resources	118	122	123
DOE			
Bioenergy Technologies	182	225	242
Biology, Enviro Research	594	592	609
USAID	—	—	140[b]
NOAA			
Climate Research	—	158	158
Weather and Air	—	91	103
National Weather Service	—	17	26
DOD	—	—	[c]

Primary Source: AAAS.
a. NIH. 2016. Estimates of Funding for Various Research, Condition, and Disease Categories (RCDC).
b. Estimate (provided by Robert Bertram, USAID), which is about 15% of the budget authority for the Feed the Future initiative.
c. Although DOD has a number of research efforts related to food, agriculture and natural resources, existing public databases apparently are not available to provide an indication of the magnitude of that research.

USDA. Budgets for the five USDA agencies are provided in **Table 3,** and more detailed budgets are shown for ARS and NIFA, USDA's two largest research agencies in **Tables 4** and **5**. The distribution of funds awarded by NIFA for research, education and extension by type of institution for FY 2015 is provided in **Table 6**. Although the differences are relatively small, there are some variances in the budgets assembled by AAAS for which the primary source is the Office of Management and Budget and budgets released by USDA.

Perhaps the most important message from the budgets for agencies with three years of data is that most funding levels have remained essentially flat. This means that they are effectively decreasing in funding when 1.8 percent inflation is taken into account. The bioenergy budget for DOE is an exception, with its increase from $182 million in FY 2014 to $242 million in FY 2016.

A review of the budgets, combined with inputs from previous unifying message roundtables and related discussions, indicate that, after USDA, NIH and NSF are perhaps the greatest contributors to food, agricultural and natural resources research. These agencies are followed closely by USGS because of its natural resources research and DOE because of its bioenergy research. Also, a review of the budget lines shows significant linkages between USDA and other agencies, as reflected in the summary descriptions of the agencies.

If one assumes that the approximate $2.5 billion for research programs in USDA is matched by $2.5 billion from the other selected agencies, then $5 billion could be a reasonable number for a current estimate of federally funded agricultural research, broadly defined.

Although at the time of this writing none of the appropriation bills for FY 2017 have been passed by Congress, there has been enough action by committees to provide an indication of what might happen. AAAS reported in August 2016 that there is likely to be little change in the overall science budget and USDA for FY 2017. Even factoring in a $25 million increase for NIFA's Agriculture and Food Research Initiative, the agricultural research budget for FY 2017 is less than in FY 2016 by $29 million in the House of Representatives and by $24 million in the Senate.

TABLE 3. Budget Authority for USDA Agencies

	Millions of Dollars		
Activity	**2014**	**2015**	**2016**
ARS			
Research Programs	1,122	1,133	1,144
Other	26	75	332
ERS	75	85	85
FS			
Forest and Rangeland Research	293	302	291
NASS	161	172	168
NIFA			
Biomass	3	3	3
Other	797	803	832
(AFRI Only)	(316)	(325)	(350)

Source: AAAS.

TABLE 4. Budget Authority for Agricultural Research Service (ARS) Research Programs

	Thousands of Dollars
Activity	**2016**
New Products/Product Quality/Value Added	101
Livestock Production	87
Crop Production	218
Food Safety	112
Livestock Protection	93
Crop Protection	195
Human Nutrition	87
Environmental Stewardship	203
Total:	**1,095[a]**

Source: USDA.
a. This amount is reported in USDA's FY 2017 Budget Summary and AAAS reports $1,144 million. AAAS uses the Office of Management and Budget as its primary source.

TABLE 5. Budget Authority for USDA National Institute of Food and Agriculture Research Programs, with Minor Exceptions

	Thousands of Dollars
Activity	**2016**
Selected Formula Discretionary Funds:	
Hatch Act of 1887 (Experiment Stations)	244
1890 Research and Extension	100
McIntire-Stennis Cooperative Forestry	34
Other Selected Discretionary Programs:	
Agriculture and Food Research Initiative	350
Sustainable Agriculture (Research, Education and Extension)	25
Crop Protection/Pest Management	17
Selected Mandatory Programs:	
Specialty Crop Initiative	51
Emergency Citrus Program (Research and Extension)	23
Organic Agriculture Initiative (Research and Extension)	19
Total:	**863**[a]

Source: USDA.
a. This amount is reported in USDA's FY 2017 Budget Summary and includes some education and extension. AAAS, which uses the Office of Management and Budget as its primary source, reports $813 million. USDA reports the total budget for NIFA for FY 2016 to be $1.502 billion.

TABLE 6. NIFA Awards by Category

States Award Statistics for Fiscal Year 2015 Non-Formula Awards

Performing Organization	Total Funding (Thousands of Dollars)
1862 Land-Grant University	461,213
1890 Land-Grant University	42,115
1994 Land-Grant University	10,664
Non Land-Grant Public University or College	26,803
Other	3,728
Private For-Profit	22,690
Private Nonprofit	56,450
Private University/College	19,806
State, Local or Tribal Government	11,688
USDA Agency	14,198
Total:	**669,353**

States Award Statistics for Fiscal Year 2015 Formula Awards

Performing Organization	Total Funding (Thousands of Dollars)
1862 Land-Grant University	614,138
1890 Land-Grant University	92,310
1994 Land-Grant University	0
Non Land-Grant Public University or College	4,902
Other	1,369
Other Federal Agency	0
Private For-Profit	0
Private Nonprofit	0
Private University/College	3,844
Public Secondary School	0
State, Local or Tribal Government	1,298
USDA Agency	0
Total:	**717,861**

Source: National Institute of Food and Agriculture 2015 Annual Report.

Tom Grumbly
President, Supporters of Agricultural Research Foundation

The Challenge

A Perspective from SoAR

Throughout this workshop and in this report, we have heard about some of the challenges and the opportunities being addressed by federal agencies. Part of our mission at the Supporters of Agricultural Research (SoAR) Foundation is to help the public and policymakers recognize the great agricultural research that is already being done and how it impacts the lives of ordinary citizens.

Along those lines, in June 2016 SoAR released a report titled *Retaking the Field: The Case for a Surge in Agricultural Research.* This effort is the product of a partnership of 13 universities that includes major public universities like Iowa State University and the University of Illinois as well as private institutions like Stanford and MIT. *Retaking the Field* summarizes the status of agricultural research, some of the challenges that we are facing and highlights examples of cutting-edge, groundbreaking research being done at each of these participating institutions. Though SoAR's primary focus is supporting USDA's Agriculture and Food Research Initiative (AFRI), *Retaking the Field* features research funded by a wide range of federal programs since we recognize that for AFRI to be successful, the entire research establishment needs to be more successful, more examined and more celebrated than it has been in the past. The goal of *Retaking the Field* is simple: to provide a compelling appeal to policymakers for additional research funding. We are trying to make the case that what the agricultural research community is doing is not just important; it's sexy and fascinating.

But discussing *where we are* as a community is only half the battle. The other half is telling people *where we're going*. I don't believe that our message will be sufficiently effective until we can offer the public and policymakers a compelling vision of what we will do with additional funding. If we want to take this research community from three or four billion dollars a year to six or seven billion dollars a year over the next 15 years, we have to tell the people who appropriate the money why they should support us in specific enough terms that they can understand. As a field, despite our diversity, I believe we must work together to articulate a vision for agricultural research that identifies the greatest scientific opportunities and provides clear pathways for achieving those goals. I see this as a prerequisite to our success in achieving desperately needed budget increases.

Frankly, I was heartened by the administration's FY 2017 proposal to provide seven hundred million for the AFRI program, a portion of which came from mandatory funding. Maybe we did not prepare the Congress well enough for using mandatory funds on agricultural research, but this idea is now on the table and it needs to continue to be on the table and be followed up with what are the specific kinds of research that need to be done between now and 2030 that would lead to lasting progress. Many of the federal agency representatives participating in this workshop have discussed how major planning processes have helped lead their way to additional funding. We need something like that in agriculture that brings together federal agencies, public and private university scientists and others into a structured process that will produce a clear vision of where agricultural research needs to go.

Finally, I think it's important that this workshop not be a one-off. Rather, we hope it is a springboard to even greater things. I think bringing senior career federal employees together along with new policy appointees would be a great exercise in 2017. This could be an opportunity to familiarize new leadership with the status of agricultural research in a way that could inform the first budget of the next president.

The SoAR Foundation was pleased to participate in this process. We look forward to continuing this discussion and working together with all of you in advancing agricultural research.

Observers and Support

Observers

Carol Bronick – Department of State
Jake Caldwell – USDA Research, Education and Economics
Joanne Carney – American Association for the Advancement of Science
Richard Derksen – USDA Research, Education and Economics
Ephraim Leibtag – USDA Economic Research Service
Jeanette Thurston – USDA National Institute for Agriculture
Anne Moraske – American Association for the Advancement of Science
Anne Sylvester – National Science Foundation
Ann Marie Thro – USDA Research, Education and Economics
Caren Wilcox – USDA Research, Education and Economics (retired)

Support

Stacy Loewentritt – American Society of Plant Biologists
Brian Meyer – Iowa State University
Jean Rosenberg – American Society of Plant Biologists

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