STATEMENT FOR THE RECORD

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Food and Agriculture Research and Innovation Depends on the Land-Grant University System

The year 2012 marked the sesquicentennial celebration of the signing of the Morrill Act and the establishment of the land-grant university system. At the time that President Lincoln signed federal legislation, little could he or the authors of the bill have imagined the far-reaching implications of the enactment of that landmark legislation. The partnership that was developed between the states and the federal government with the Morrill Act, and subsequently the Hatch and Smith-Lever Acts, provided broader access to higher education and application of agricultural research findings on and off campus. One of the results was the development of an agricultural economy and a food system that is unmatched across the globe. Efficiencies achieved through knowledge generated by research and communicated to producers and industry through Extension programming have been a solid investment of public resources. The U.S. is fortunate to have abundant natural resources within its borders, and those resources have been critical in contributing to the food security enjoyed by her citizens. The public land-grant system has been critical in leveraging that investment into a safe and abundant supply of food.

Globally, much of the social and political unrest and riots that swept the planet in recent years have been connected to a single factor—the price of food. Studies, including data gathered by the United Nations, show strong correlations among the price of food against time, the so-called food price index of the Food and Agriculture Organization of the UN, and the dates of riots around the world, whatever their cause.. This seems to indicate that food price indices rising above a certain threshold results in trouble around the world[1]. Many recent events in the Middle East, North and Eastern

[1] M. Lagi, K.Z. Bertrand, Y. Bar-Yam (August 10, 2011). The Food Crises and Political Instability in North Africa and the Middle East. https://arefiles.ucdavis.edu/uploads/filer_public/2014/03/27/bellemarefoodpricesaugust2011.pdf and Lagi et al. 2011, http://necsi.edu/research/social/food_crises.pdf

Africa, Southeast Asia, Latin America and elsewhere around the world underscore the tragic consequences that can accompany regional food insecurity and food shortages, regardless of the root cause. In the words of the late Jamaican musician Bob Marley, "…a hungry mob is an angry mob." Food security is truly central to security and political stability, not just in the United States, but throughout the world. **Food security and political stability can be linked directly to agricultural and food-system innovation driven by investment in food and agricultural research.**

Agricultural Research Has an Impressive Impact and a Long-Lasting Value

The second piece of federal legislation that was important in transitioning and broadening the teaching mission of land-grant universities was the Hatch Act of 1887. That piece of federal legislation, celebrating its 130th anniversary this year, established the so-called Agricultural Experiment Stations that inaugurated the food and agriculture research function at land-grant universities. That legislation provided a framework for federal support of the research mission at land-grant institutions to be matched at least 1:1 (and in other cases 7 or 8:1) by state dollars through what are now referred to as federal capacity funds. This mix of federal and state funds is now further leveraged many-fold by federal competitive grants, grants from private industry, and other types of unrestricted gifts and awards to faculty conducting research at the nation's land-grant universities. That activity is further leveraged by integration with the research and economic arms of U.S. Department of Agriculture, the Agriculture Research Service and the Economic Research Service, to round out the nation's food and agriculture research enterprise. That enterprise has, for 13 decades, advanced scientific knowledge in all aspects of food production, and together with Cooperative Extension, has advanced production capacity, profitability, and safety of the nation's food system. Agricultural trade, in turn, engages the nation's food system with the larger global food system, extending the value of public and private investments in research and development worldwide.

What do experts say about the value of public investment in agricultural research? That question is central to the published, peer-reviewed research of agricultural economists at multiple land-grant institutions. These scientists essentially conduct research on the impact of agricultural research. The work of these economists, notably Dr. Wallace Huffman, Iowa State University; Dr. Phillip Pardey, University of Minnesota; and Dr. Julian Alston, University of California-Davis; all points to the value of public investment in research and further warns of the downstream consequences of public divestment from agriculture research. **In general, the published benefit-cost ratios vary by state but are always double digits, averaging 21:1 and corresponding to annual rates of return between 9-10%.** For example, in Kansas, the estimated benefit-cost ratio was **33.6:1** with an annual rate of return of about 10%[2]. An important nuance of these otherwise very impressive rates of return is that, especially considering research related to production agriculture, the payoff for investment is realized only after considerable lag time, in some cases multiple decades. **Thus, the reality is that failure to continue to invest in food and agriculture research would be expected to have negative consequences for decades to come, and that will take significant time to reverse.**

Even though the United States remains a world leader in agricultural science as measured by publications, citations, and patents, the U.S. lost its number one ranking in the world to China for

[2] Julian M. Alston, Matthew A. Andersen, Jennifer S. James, Philip G. Pardey; The Economic Returns to U.S. Public Agricultural Research. *Am J Agric Econ* 2011; 93 (5): 1257-1277. doi: 10.1093/ajae/aar044

public investment in food and agriculture research in 2009[3]. To fill the void, the private sector has become a key funder of research at land-grant universities. In general, this trend is in part a result of a very small funding base in USDA NIFA's flagship grant program AFRI. With the private sector funding food and agriculture research, essential "high risk-high consequence" questions to advance the science and solve fundamental problems relevant to agriculture and food (plants, animals, pests, diseases, safety, sustainability, etc.) are more likely to remain unexplored. Although progress is being made to incrementally increase appropriations to the AFRI program, it remains funded at considerably less than the $700 million authorized in the previous two Farm Bills. Although it is understood that budget management and fiscal accountability are shared responsibilities across federal agencies, the AFRI program simply does not have the level of base funding (as compared to NIH or NSF) to shoulder continued reductions. In fact, we support the goal of achieving appropriations in AFRI equal to that authorized in the last Farm Bill by 2020.

Food Science and Technology Research Adds Safety, Security, Quality, and Value to Agricultural Commodities and Our Food Supply

Studies of many ancient civilizations indicate that, throughout history, humans overcame hunger and disease not only by harvesting food from a cultivated land, but also by preserving and processing it. Today, our modern food system is complex, and our food supply is largely safe, nutritious, tasty, abundant, diverse, convenient, and less costly and more readily accessible than ever before. Contemporary food science and technology contributed greatly to the success of this modern food system by integrating science, engineering, and many other disciplines to solve difficult problems, such as enhancing food safety, improving availability, and resolving nutritional deficiencies, while adding tremendous value to raw agricultural commodities[4]. However, research funding for food science and technology within USDA has declined substantially over the years, with the possible exception of food safety research.

The impact of modern food preservation, processing, and manufacturing methods is evident in today's food supply. Food quality can be maintained or even improved, and food safety can be enhanced. Sensitive nutrients can be preserved, important vitamins and minerals can be added, toxins and anti-nutrients can be removed, and foods can be designed to optimize health and reduce the risk of disease. Similarly, processing and manufacturing can improve the overall efficiency of the food system, minimize waste or product loss, facilitate distribution of foods around the world to increase availability, and contribute significantly to increased trade and economic growth[5]. Research funding for food post-harvest handling, preservation, processing, packaging, and other manufacturing methods is now almost non-existent within USDA, with only some private investments in the broader area of food processing innovation.

Food manufacturing transforms raw agricultural materials into products for intermediate or final consumption by applying technology, labor, machinery, energy, and scientific knowledge. In 2011, food manufacturing accounted for 14.7% of the value of all shipments from U.S. manufacturing[6]. Also, according to USDA Economic Research Service, the farmer's share of the consumer's food

[3] USDA ERS Amber Waves at https://www.ers.usda.gov/amber-waves/2016/november/us-agricultural-rd-in-an-era-of-falling-public-funding/.
[4] Floros et al. 2010, Feeding the World Today and Tomorrow: The Importance of Food Science and Technology, Comprehensive Reviews in Food Science and Food Safety, Vol. 9, 2010, pp: 572-599.
[5] Floros et al. 2010, Comprehensive Reviews in Food Science and Food Safety, Vol. 9, 2010, pp: 572-599.
[6] USDA Economic Research Service, https://www.ers.usda.gov/topics/food-markets-prices/processing-marketing/manufacturing.aspx.

shopping dollar has decreased from 46% in 1913 to less than 20% in 2006[7]. Overall, today, only about $1 out of every $7 spent on food goes to primary agricultural production. The remaining value of approximately $6 is added by handling, processing, packaging, transportation, distribution, and other modern food manufacturing techniques. If we were to look at wheat, for example, an important agricultural commodity for Kansas, wheat represents less than 9% of the retail value of a typical loaf of bread. Milling, baking, and related manufacturing activities represent almost 65% of the final value, and the remaining 26% is due to transportation and retail mark-up[8]. However, drastically reduced research funding over several decades has considerably decreased innovation and competitiveness in the U.S. food manufacturing sector.

Many individual research studies and several comprehensive scientific reviews concluded that: (1) major advances in sustainable food production and availability can be achieved with the concerted application of current technologies; and (2) in order to enable the food system to cope with both known and unknown challenges in the coming decades, it is important to invest in research sooner rather than later[9].

International Research is a Key Component of America's Agriculture Research Portfolio
The United States Agency for International Development (USAID) is the lead federal agency working to end extreme poverty and enable success in resilient democratic societies[10]. The Feed the Future Innovation Labs, funded by USAID, draw upon faculty expertise of top U.S. universities and in-country research institutions that tackle the most difficult challenges in agriculture and food security[11]. As one inspects the list of U.S. universities leading these efforts, it is obvious that land-grant universities are generally best suited to provide key expertise and leadership fundamental to the success of each laboratory. At my home institution, Kansas State University, we went from not leading any labs in 2012 to now leading four Feed the Future laboratories. What has become obvious to us is that, although the target of the work is international in nature, the knowledge, relationships, and products of the work (e.g. sources of plant genetic diversity) become available to researchers as Kansas State University as a natural outcome of the labs, and, in turn, they help our farmers, ranchers, and industry to advance.

A Major Infrastructure Challenge
Since the last presidential election, major challenges associated with the current state of America's airports, roads, bridges, and ports have been in the news. It is apparent that our infrastructure, so important to the U.S. economy and national security, is aging and in need of upgrade and repair. Similarly, the country's land-grant universities, a network so vital to the nation's economy and national security, also have an aging infrastructure, and they are in desperate need for repair and rebuilding.

America's colleges of agriculture ***educate*** the next generation of leaders in this most important of industries; conduct the ***research*** that will allow us to provide food, feed, fiber, and fuel for a growing world population; and take ***science-based education*** to every county in the U.S. The physical infrastructure that supports these activities is the foundation of our national

[7] Value-Added Products and Enterprises, University of Maryland Extension, https://extension.umd.edu/agmarketing/value-added-products.
[8] Robert M. Kerr Food & Agricultural Products Center, Oklahoma State University, http://fapc.biz/valueadded.
[9] Godfray et al. 2010, The Future of the Global Food System, Phil. Trans. R. Soc. B, 365, 2769–2777.
[10] United States Agency for International Development. https://www.usaid.gov/who-we-are.
[11] Feed the Future Innovation Labs. https://feedthefuture.gov/lp/feed-future-innovation-labs.

competitiveness in food, agriculture, and natural resources. The infrastructure in most land-grant universities is aging, inadequate, and, in many cases, obsolete. A national study of capital facilities and deferred maintenance recently documented the magnitude of the infrastructure problem that threatens to further erode the United States' preeminent role in global food and agriculture. Building level data supplied by 91 colleges of agriculture (1862, 1890, and 1994 land-grant universities and colleges, and some non-land-grant universities) documented the existence of more than 15,000 facilities with 87 million gross square feet of space valued at over **$29 billion** in this largest and most comprehensive study in the U.S. Summary findings: 54% of facilities were constructed during 1951-1990, accounting for 68% of deferred maintenance needs; more than $5 billion of the deferred maintenance pertains to science research ($3.2 billion) and classroom/teaching ($2.0 billion), while the remaining $3.2 billion was marked as farm/animal, support, greenhouses and Extension buildings; only 20% of colleges of agriculture invest at levels that would at least stabilize, if not decrease, the backlog of deferred maintenance; 80% of the campuses are investing capital at such a low level that they will continue to add to the backlog of deferred maintenance every year. The conclusions from this *Sightlines LLC Study*[12] on the age of the buildings, the lack of capital investment over time, and the levels of deferred maintenance needs are sobering — **the total deferred maintenance cost is at least $8.4 billion**. **In order for the United States to remain the world leader in food and agricultural research, the aging infrastructure problem must be addressed.**

Pressure on NIFA Capacity Funding

The U.S. agriculture industry is the envy of the world and a true American success story. Since the 1940s, the U.S. food, agriculture, forestry, fishery, and natural resource industries' productivity and output have increased by more than 2.5 times, while using fewer total acres. However, this track-record of success has not occurred by chance. Rather, it is a result of the intense and deliberate application of scientific research and development and technological development—with the involvement of the federal government and state and local (county) governments. A key component of this federal funding has been Capacity Funding (Hatch, Smith-Lever, Evans-Allen, 1890 Extension) specifically dedicated to supporting research and Cooperative Extension programs at America's land-grant universities. With roots in legislation passed in 1862, NIFA has asked the question of "**whether Capacity Funding remains a productive model for supporting academic institution-based research and Extension in the 21st century**?" *TEConomy Partners* conducted a national survey and synthesized the results for NIFA.

The findings are strong and unequivocal in their impact: financial leveraging through matching state and local funds of at least $1.86 per $1 federal sustains the specialized personnel and scientific facilities and instruments, research station infrastructure, and Extension operations needed for complex agricultural and associated research programs; generates significantly higher volumes of publications; provides flexibility to fund rapid response to emergencies or emerging issues; allows long-term research, leading to improved crop and livestock management; and provides a base of support to successfully vie for competitive grants across all sizes of institutions and federal, state, and local agencies. Capacity funds align with 9 out of 10 2014 Farm Bill priority areas (as well as a majority of NIFA Challenge Areas); research programming thrust is evident across applied, translational, and basic sciences; patenting output is more wide-ranging and influences up to one in

[12] A National Study of Capital Infrastructure & Deferred Maintenance at Schools of Agriculture. Sightlines, LLC. http://www.aplu.org/projects-and-initiatives/agriculture-human-sciences-and-natural-resources/DeferredMaintenance_SchoolsofAg.pdf

every six patents; this funding model should be increased and maintained into the future. Comparative Levels of Funding to Federal R&D Supporting/Performing Non-Defense Agencies from 1997 to 2016[13] illustrates a very challenging narrative: NIH $588 B, NASA $251 B, DOE $221 B, NSF $101 B, USDA $52 B and all other $169 B.

The core finding is that Capacity Funding carries substantial and ongoing advantages as an agricultural research and Extension base funding model, and it should be considered by other federal funding agencies.

Training the Next Generation Food System Workforce

Recent revisions from the Population Division of the United Nations Department of Economic and Social Affairs of the United Nations Secretariat predict world population growth to 9.7 billion by 2050[14]. Awareness of the population growth, the need for action to prepare for the predicted growth, and the desire of that population for a higher standard of living was highlighted prominently in the publication[15], "A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution." This National Research Council publication became the roadmap for the organization of AFRI requests for applications. One of the grand societal challenges highlighted in those requests was global food security. Feeding a world of more than 9 billion people is a complex and multifaceted problem that will require significant advances in plant and animal genetics, soil fertility, water and nitrogen use efficiency, animal nutrition, tillage and irrigation practices, and other areas. These advances must occur in a world with a potentially more variable climate and must include major improvements in food distribution, breakthroughs in food processing and stored food preservation, and substantial progress toward reducing food waste and food loss. The grand challenge to feed the growing world population points to the need for AFRI to be re-authorized in the 2018 Farm Bill at no less than $700 M, and grown quickly to that level of appropriated funding.

Since its inception, the land-grant university system has played an important role in continually providing new knowledge that advances the science and application of new technology. These advances allowed production agriculture and agribusiness to meet and defeat agricultural production challenges, and have ensured food security for the United States. Undoubtedly, the land-grant university system played a major role in global food security, and until now, it has helped meet the ever-increasing population challenges. But who will continue the education, discovery, and outreach in the coming decades?

Replacing faculty positions vacated by retirements and lost to budget cuts at land-grant universities over the coming decade is going to be a major challenge, if not a crisis. However, awareness of this looming challenge is increasing. As an example, the Coalition for a Sustainable Agricultural Workforce formed a partnership aimed at increasing the workforce pipeline by generating greater numbers of bachelor to doctoral degree recipients in an array of disciplines within food and

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[13] National Evaluation of Capacity of Programs. Quantitative and Qualitative Review of NIFA Capacity Funding. *TEConomy Partners, LLC.* https://nifa.usda.gov/sites/default/files/resource/NIFA%20Capacity%20Funding%20Review%20-%20TEConomy%20Final%20Report.pdf

[14] World population projected to reach 9.7 billion by 2050. UN Department of Economic and Social Affairs, 2015. http://www.un.org/en/development/desa/news/population/2015-report.html.

[15] National Research Council. 2009. A New Biology for the 21st Century. Washington, DC: The National Academies Press. doi:https://doi.org/10.17226/12764.

agriculture[16]. The coalition, a collection of prominent, agriculturally related scientific societies, agribusinesses, and industry leaders, has proposed federal partnerships with leading agribusinesses to help fund this effort. This and other similar efforts are examples of initiatives needed to address a looming crisis. We support initiatives to enhance the number of students selecting agriculture and related disciplines for their university training. We encourage the Committee to explore avenues so that the next Farm Bill can raise national awareness of and authorization to begin to tackle this challenge of worldwide food security.

Related to the issue of the workforce pipeline, we additionally would encourage the committee to consider another problem. Like many STEM (Science, Technology, Engineering and Mathematics) disciplines, graduate programs in food and agriculture attract bright and very capable international applicants into their doctoral programs. If these doctoral recipients are not placed in faculty or research associate positions in land-grant universities in the United States, they return home. Home often means returning to the growing economies of India, China, Brazil, etc. It would seem prudent to consider ways to "reinvest" these doctoral recipients in the land-grant university system, and to nurture and diversify the system.

Finally, it must be pointed out that the agricultural research workforce dilemma has at the root of its solution the continued USDA investment in land-grant universities. Capacity funding via the Smith-Lever act provides base support for the 4-H program. This important youth development activity is the beginning of a pipeline directing both rural and urban youth to engage with greater probability in higher education with the potential for careers in the food and agriculture sectors. A percentage of those youth would be expected to choose graduate degrees that will credential them for careers in agricultural and food research, either at land-grant universities or in the private industry. **An important takeaway is that capacity funding through USDA supports ongoing programs through Extension that are interconnected to the workforce pipeline needs for the food system, including food and agricultural research.**

Conclusion

It is my hope that this testimony captures the enduring optimism that has been a common thread connecting more than 150 years of history of the land-grant university system. That thread is one of valued service to the farmers, ranchers, food and agricultural industries, and all the citizens of this great nation. Faculty and staff at land-grant universities across the nation recognize that their work takes place on behalf of a greater good, a broader goal, and a common vision that is much bigger than their individual achievements. Members of this United States Senate Committee on Agriculture, Nutrition, and Forestry can be confident that every dollar of federal investment authorized by the 2018 Farm Bill and expended at land-grant universities will be a wise investment. That investment is guaranteed to be leveraged further, and to spawn innovation and discovery that will be translated into solutions to improve the lives of U.S. citizens. I thank you for this opportunity to provide testimony.

[16] Coalition for a Sustainable Agricultural Workforce. http://www.apsnet.org/members/outreach/Pages/CSAW.aspx.