National Evaluation of Capacity Programs




Quantitative and Qualitative Review of NIFA Capacity Funding

Prepared by:
TEConomy Partners, LLC.
Authors: Simon Tripp, Martin Grueber, Dylan Yetter
Joseph Simkins & Alyssa Yetter

Prepared for:
National Institute of Food and Agriculture

Published:
March 2017

SECTION I:
EXECUTIVE SUMMARY

Executive Summary

A. Introduction

The U.S. agriculture, forestry, fisheries, and natural resource industries, together with the social and economic structures that sustain them, are fundamental to national and individual well-being and economic performance.[1] Akin to a biological ecosystem, agricultural and associated industries are part of an economic and social ecosystem that consists of a complex web of actors and activities that serve specific functions and make possible the positive outcomes of the system as a whole. Because it is a knowledge-driven and technology-intensive life-sciences sector, the agricultural system is very much dependent on knowledge-advancements, innovations, and the transfer of knowledge from a highly active research and development (R&D) sector.

The U.S. agriculture, forestry, fisheries, and natural resource industries, together with the social and economic structures that sustain them, are fundamental to national and individual well-being and economic performance.

This sector of the U.S. economy is a high-performer in terms of sustained growth in economic output and productivity. The increasing productivity of U.S. agriculture, and the growth of the large-scale value-added industry chain that benefits from it, has not occurred by chance. Rather, it has resulted from the intense and deliberate application of scientific research and technological development across a broad-range of disciplines and research challenges.

The ongoing success of U.S. agriculture is a testament to the sustained work of thousands of American scientists, technologists, and engineers researching and innovating solutions – and to the millions of U.S. farmers, foresters, and natural resource professionals who deploy the solutions these researchers provide. In relation to this, it is important to understand that, unlike many other industries, the primary production sector in agriculture, being made up of millions of small and midsize enterprises, has only a limited internal R&D capacity of its own. Instead, innovations and productivity increases predominantly depend on R&D and knowledge transfer from agricultural inputs suppliers, the United States Department of Agriculture (USDA) Agricultural Research Service (ARS), and America's unique system of land-grant universities and Cooperative Extension Services.

The ongoing success of U.S. agriculture is a testament to the sustained work of thousands of American scientists, technologists, and engineers researching and innovating solutions – and to the millions of U.S. farmers, foresters, and natural resource professionals who deploy the solutions these researchers provide.

The common thread that runs through scientific, technological, and practice advancements, including in agriculture, is research. Basic and applied research in biological sciences, physical sciences, social sciences, engineering, and a broad suite of associated disciplines produce the knowledge and advancements upon which progress is made. Research is the fundamental engine that drives U.S. economic progress and competitiveness, and research funding is the fuel for that engine. While American agriculture is an industry operated by millions (farmers, ranchers, foresters), and sustained by the innovations of thousands (in the R&D sector), it is critically important to note that it is financially supported in its foundational advancement by the funding of a **select few**. This select few comprises private-sector industrial companies that develop applied technologies and solutions in terms of farm inputs and agricultural and processing equipment, the U.S. Federal Government (most notably through the USDA and its National Institute of Food and Agriculture [NIFA]), state governments, commodity organizations, and non-profit foundations.

Recognizing the need for scientific progress and R&D-based solutions for agricultural and associated sector advancement, the United States has operated a long-standing program of dedicated funding to land-grant universities. Established through the Morrill Act of 1862 and subsequently expanded, America's system of land-grant

[1] In this report, for the sake of simplicity, the terms "agriculture," "agricultural sciences," and "agricultural industries" are considered to also embrace forestry, fisheries, and other natural resource-based industries that are of relevance to the work of the USDA, NIFA, and the nation's Land-Grant Universities.

universities has a more than 150-year history of contributing to national economic growth, sustainability, and security. NIFA supports this land-grant system through a series of legislatively mandated Formula Funds (also known as Capacity Funding[2]) that financially support an integrated system of land-grant universities, experiment stations, and Cooperative Extension Services. This integrated system works to research and disseminate solutions to identified sector challenges, and the challenges of communities that support these sectors, at national, state, and local levels.

Besides the private sector, the federal government is the next-highest funder of agricultural and related research by a wide margin – and is **the primary funder of early-stage, exploratory research and applied agricultural research focused on specialty crops, livestock, and agricultural commodities specific to local geographies and production environments.** Importantly, federally funded research also supports work in soils, water, ecological systems, workforce development, rural development, and other elements critical to the sustainability of the agricultural production ecosystem that do not attract significant commercial research funding.

There is no doubt that federally funded research plays a critically important role in supporting America's high-performance agriculture sector and its associated industries. There is, however, potential for debate as to whether the Capacity Funding model, with roots in legislation passed in 1862, remains a suitable model for supporting academic institution-based research and extension in the 21st century. Given the scope of federal funds involved, and the importance of the ongoing challenges needing to be addressed in agriculture and associated areas, it is logical to examine the federal funding mechanisms presently being deployed by NIFA as to their "fitness to purpose." It may be that the unique nature of agricultural research lends itself to the predictable, structured, and long-term funding model at the heart of capacity/formula funding. But, it might also be the case that major elements of agricultural sciences research may be equally well, or better, supported by an alternative, competitive peer-reviewed funding model as deployed under the NIFA Agriculture and Food Research Initiative (AFRI) model. Because Capacity Funding is such a long-standing model, it is certainly logical to ask whether it is appropriate and relevant to today's and tomorrow's R&D and extension needs. Recognizing this need for a third-party review of this "fitness to purpose" question, NIFA commissioned TEConomy Partners LLC (TEConomy) to undertake an evaluation of Capacity Funding programs and to provide an analysis and overview of impacts being achieved under this funding model.

There is no doubt that federally funded research plays a critically important role in supporting America's high-performance agriculture sector and its associated industries.

B. Methodology

The research design developed by TEConomy uses analysis of existing data from multiple sources to provide a detailed overview of the NIFA Capacity Funding programs and the outputs and impacts being achieved. The analysis assesses the types of basic and applied research programs funded under the Capacity Funding programs, the types of impacts being generated, the relevance of research to current and future national and state needs, and the strengths and weaknesses of the funding model.

Using quantitative data, the study evaluated a series of metrics pertaining to research output (as measured by publications and citations) and the generation of intellectual property (as measured by patents and patent citations). Furthermore, the research team deployed real-text statistical clustering software on research impact statements contained in the NIFA Research, Extension, and Education Project Online Reporting Tool (REEPort) system and Cooperative Extension impact statements contained in the Land-Grant Impacts Database maintained at Texas A&M University AgriLife Extension Service to enable identification and classification of key areas of

[2] "Capacity Funding" refers to federal funding, authorized in the Farm Bill, which is distributed via formula primarily to land-grant universities to support agricultural and forestry research and extension programs. The use of the term "capacity" recognizes that the performance of research in agriculture and associated disciplines requires investment in large-scale research infrastructure and investment in sustaining the skilled and specialized faculty and workforce needed to accomplish research and cooperative extension missions. In effect, America invests in having the capacity (resources) necessary to advance agricultural land-associated research and translate that research into the production/implementation environment.

functional and applied impact being achieved through NIFA funding.

Supplementing the analysis of existing datasets, the Association of Public and Land-grant Universities (APLU) supported a series of concurrent TEConomy-administered surveys deployed at land-grant universities and colleges to gather insight and input from the institutions regarding their specific use of NIFA Capacity Funding and NIFA-AFRI Competitive Funding, and their experience regarding the comparative strengths and weaknesses of these funding models. APLU generously provided resources and assistance in the deployment of the Land-Grant University surveys that were distributed to all 1862, 1890, and 1994 Land-Grant institutions. The distribution of the survey instrument to the 1994 institutions was further facilitated through assistance provided by the American Indian Higher Education Consortium.

C. Research Findings and Conclusions

NIFA Funding Supports a Holistic Research and Extension Ecosystem

NIFA Capacity Funding and, to a lesser extent, Competitive Funding supports a holistic land-grant-based R&D and extension ecosystem. This ecosystem, depicted in Figure 1, comprises a complete continuum of R&D activity from basic inquiry, through applied and translational research, and piloting and field demonstration. The innovations and practical knowledge derived from R&D are disseminated through Cooperative Extension and land-grant technology transfer activities to those in production agriculture, industry, and society who can put this knowledge and innovation to work for the betterment of the U.S. economy and society.

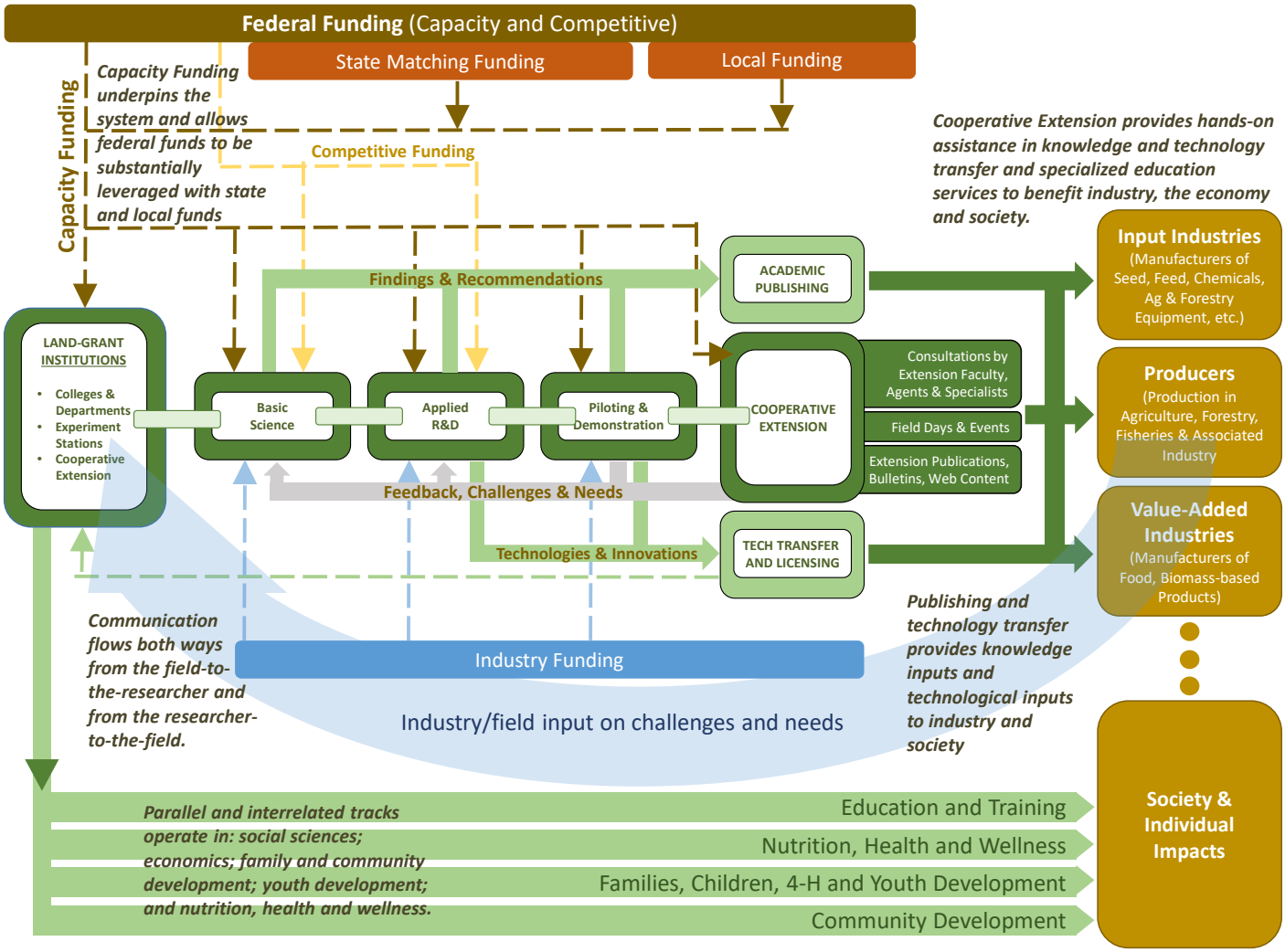
Of particular note is that this system is bidirectional. Communication of needs, challenges, opportunities and innovations moves from the field-to-the-researcher and from the researcher-to-the-field. This NIFA supported ecosystem (Figure 1), rooted in the original vision for land-grant universities and Cooperative Extension, was envisioned, and subsequently evolved and refined, to provide a pragmatic feedback loop – assuring R&D activity is responsive to tangible needs, and that novel innovations and findings are not only reported in academic journals, but are proactively disseminated by Cooperative Extension activities for use in farms, industries, communities and beyond.

Fundamental to the ongoing success of this ecosystem is the legislatively mandated support provided to NIFA through the Farm Bill, that provides ongoing formula based funding (Capacity Funds) to land-grant colleges and universities. **The Capacity Funding system, requiring matching funds from the states, and further supported by local (typically county) funding, is highly leveraged to assure maximum utility of scarce federal funding dollars**. By providing a relatively reliable base of funds for the land-grants, Capacity Funding enables the universities to sustain the specialized infrastructure, research capabilities and extension operations at the heart of this ecosystem. By supporting extension, and its spatially distributed delivery and communications system, large-scale elements of the program-of-work at the land-grants is grounded in the "voice of the market" reflecting direct input from individual counties and the expressed needs of local producers, value-added industries and communities.

R&D activity within the ecosystem is further supported by NIFA AFRI and other federal competitive grant programs, which are awarded to land-grant institutions and other research institutions based on competitive review of the merit of submitted proposals. Via both forms of funding NIFA is able to take into account national priorities and needs, and provide input to both Competitive and Capacity Programs-of-work to assure that large-scale, nationally and internationally significant needs are addressed, in addition to local needs. Industry funding is also brought into the system through commodity groups, trade associations and individual companies funding research at the land-grant universities. In effect, the "voice of the market" is very much engaged in the land-grant research and extension enterprise, with the system designed to listen and respond to the input of government, industry, community leaders and other key stakeholders.

Fundamental to the ongoing success of this ecosystem is the legislatively mandated support provided to NIFA through the Farm Bill, that provides ongoing formula based funding (Capacity Funds) to land-grant colleges and universities.

Figure 1: Federal Funding and the Land-Grant University Research and Cooperative Extension Ecosystem

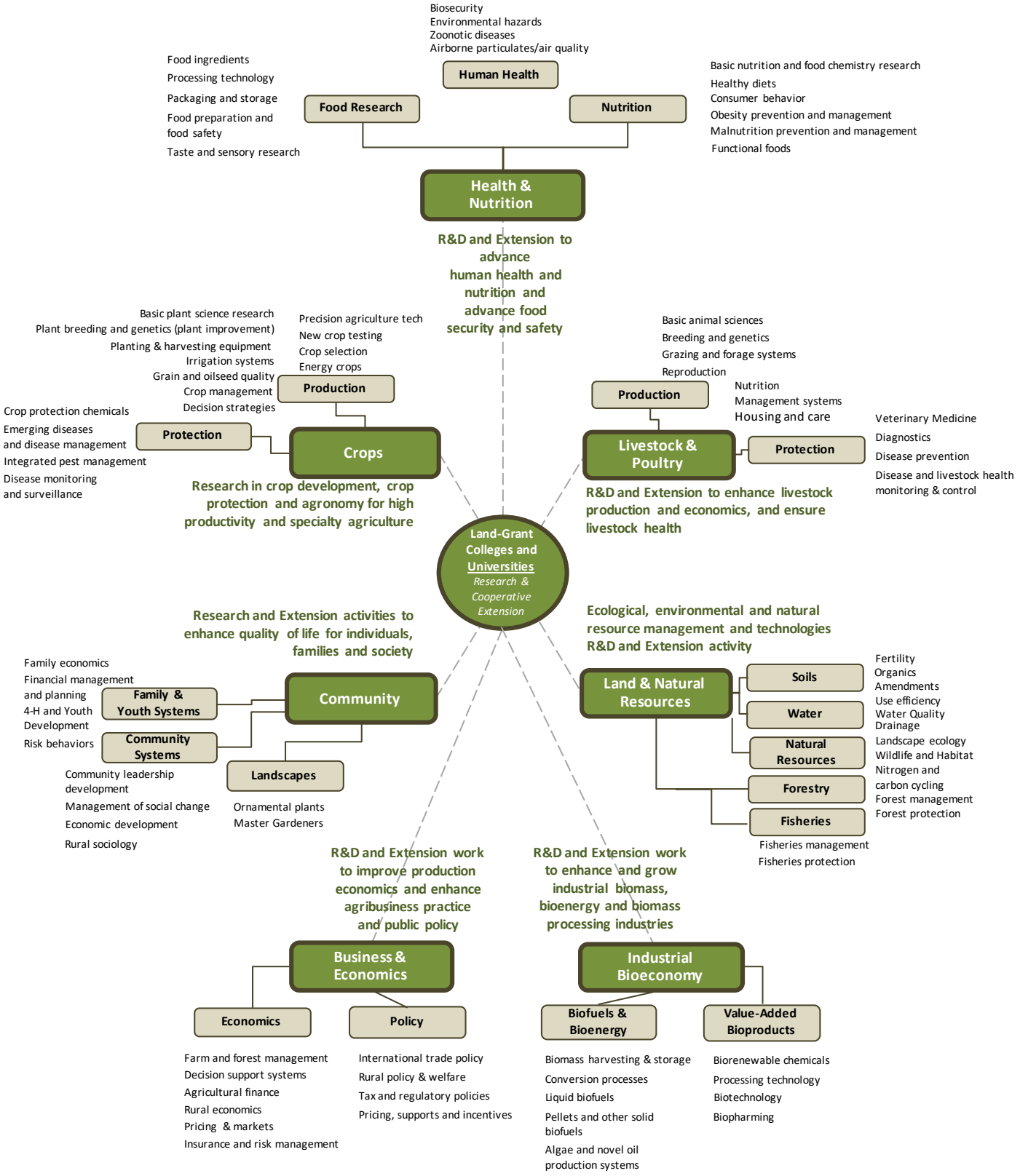


NIFA Funding Supports a Broad Base of R&D Enquiry to Enhance the U.S. Economy and Society

The universe of potential research inquiry supported by NIFA is extremely diverse. Not surprisingly there is a robust emphasis on work in support of enhancing and sustaining American production agriculture, forestry and natural resource industries but the activities undertaken extend far beyond core areas of agronomy, plant science and livestock-related animal sciences. NIFA funding supports fundamental basic science inquiry in life sciences of relevance to better understanding life processes and mechanisms of action. Further, NIFA supports applied work in the value-added industries that work beyond the farm gate, across the supply chain, to provide U.S. residents and global consumers with access to nutritious foods, health products, lumber and wood products, fibers, renewable biobased fuels, chemical products and materials. Because of the nationwide nature of agriculture and its associated value-chain the benefits these sectors extend are present in all states and U.S. territories, and NIFA also supports research and extension activity that is focused on sustaining the rural families and the small-town fabric that is crucial to the resiliency of this industry sector.

Figure 2 depicts core areas of land-grant research activity identified by TEConomy in performance of this project and in previous engagements analyzing land-grant university and extension services impacts. The broad diversity of research activity, noted above, is graphically illustrated in this figure.

Figure 2: An Illustration of the Varied Scope of Subject Matter Relevant to Research and Cooperative Extension at Land-Grant Colleges and Universities.



Throughout TEConomy's full project report, data analysis and associated analytical narrative are provided that lead to multiple key findings and conclusions. The user of this report is highly encouraged to review the full report to gain complete context regarding the rationale for each conclusion. A separate Technical Appendix Report has also been developed which summarizes all of the input received through the multiple administered surveys. Below are highlighted key topline findings and conclusions.

1. What are the primary focus areas in which Capacity Funding is generating impacts?

With $0.85 billion currently going annually to Capacity Funding and $0.7 billion budgeted annually for NIFA-funded Competitive research, including AFRI and other Competitive Programs, it is important to examine, objectively, what outputs are occurring for the nation via NIFA extramural funding of research and associated activities. TEConomy evaluated a series of data across multiple datasets, to answer this question – accessing data for:

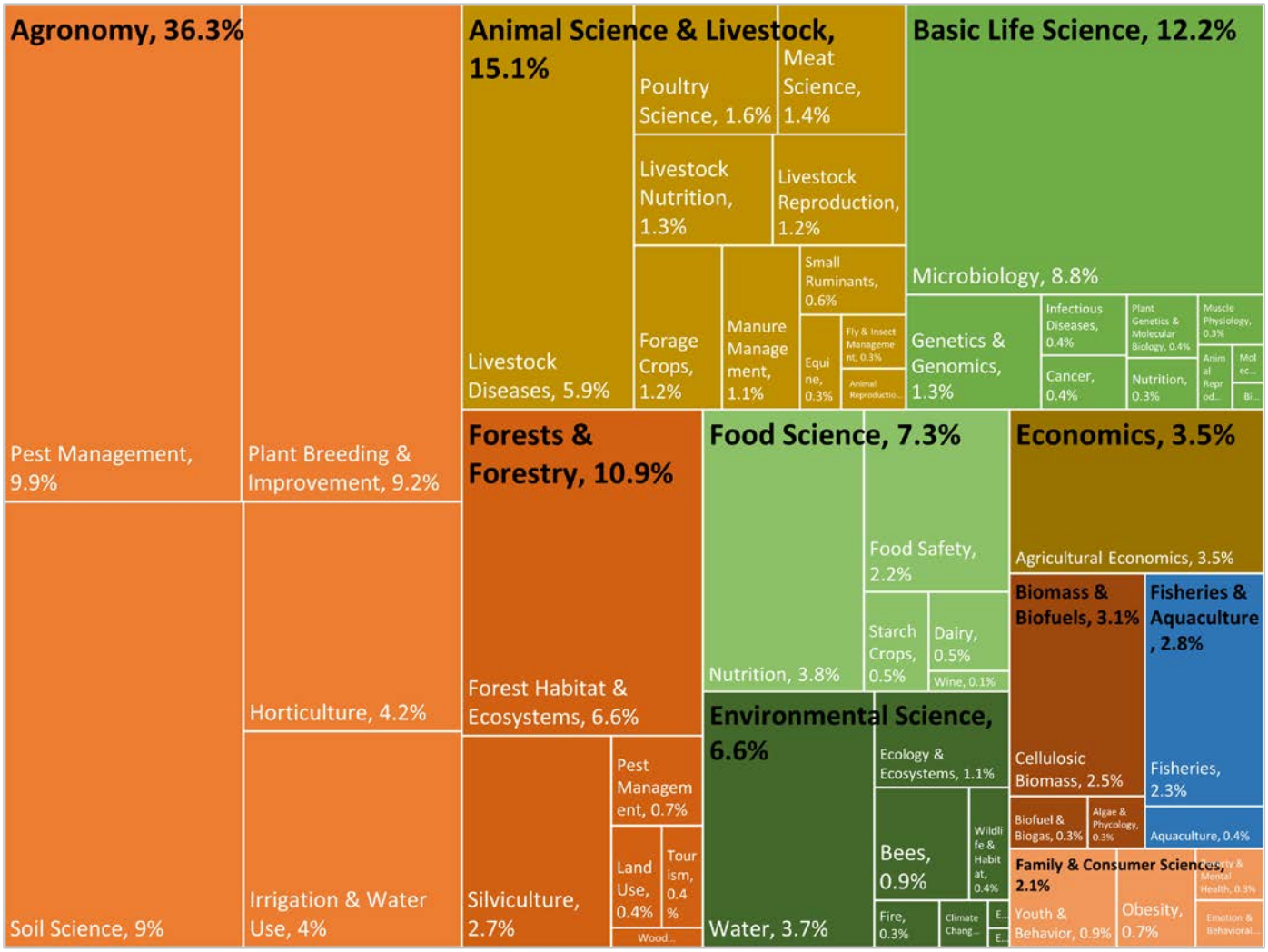
- **Publications Output**: Evaluating publication volume by key areas of research as identified in the Clarivate Analytics *Web of Science*™ database.
- **Research and Extension Project Summaries**: using advanced real-text cluster analysis of NIFA Capacity and Competitive funded projects in the REEport System. 19,791 individual Capacity funded projects were analyzed for 2010-2015, together with 2,299 Competitively funded projects.
- **Extension Impact Statements**: using textual cluster analysis of extension impact statements maintained in the Land Grants Impact Portal. 1,418 impact statements were incorporated in this analysis.
- **Patents**: using cluster analysis to identify core focus areas in patenting at the land-grants in agricultural sciences and associated disciplines. 23,512 total patents in relevant fields were analyzed to identify those comprising land-grant innovations and/or government interests.
- **Contacts**: data captured by NIFA in the annual Plan of Work submitted by Cooperative Extension reporting statistics on direct and indirect contacts with the audiences served by Extension.

These cluster analyses of REEport data indicate that Capacity funded research is particularly clustered across the core themes shown in Figure 3.

TEConomy compared these Capacity-funded clusters to a separate cluster analysis of 108,180 records contained in the Clarivate Analytics Web of Science™ total agbioscience dataset. This comparative analysis shows that Capacity Funding projects have several "signatures" in terms of focus:

- **Less emphasis on Basic Science projects**. Basic Science projects are 21.1 percent of all publications in the Web of Science™ cluster analysis, whereas Capacity funded projects see 12.2 percent of projects clustered as Basic Science.
- Animal Science and Livestock research is more focused in the Capacity funded projects on **animals used in production agriculture**, and a separate Veterinary Medicine cluster is not evident (as it is in the full Web of Science™ dataset).
- A considerably **larger emphasis on Pest Management as a theme**, with 9.9 percent of total records in the Capacity funded analysis, versus just 1.1 percent in the Web of Science™ data.
- There is more emphasis in the Capacity funded projects on **Water as a research theme** (7.7 percent of records across two clusters), as opposed to a 1 percent cluster in the Web of Science™ data.
- There is mo**re emphasis in the Capacity funded projects on Food Science** (7.3 percent of records), as opposed to 4.4 percent in the Web of Science™ data.
- **A greater emphasis on Biomass and Biofuels in the Capacity records** (3.1 percent) when compared with the Web of Science™ clustering (1.7 percent).
- **A Family and Consumer Sciences cluster** (with 2.1 percent of records) and an **Economics cluster** (3.5 percent of records) present under the Capacity Funding analysis that are not distinct clusters in the Web of Science™ analysis. These areas are important components of the full integrated Capacity Funding portfolio of research and extension. Similarly, Fisheries and Aquaculture has a Capacity funded cluster with 2.8 percent of records, indicating an importance within Capacity funded activities above that observable in the overall literature.

Figure 3: Percentage Segmentation of 19,791 Capacity Funded Projects (REEport Data for 2010–2015) across Metaclusters and Associated Themes (Data Table in Appendix G)



Over the 6-year period of 2010–2015, data on almost 20,000 individual Capacity funded projects were recorded in the REEport system. The cluster analysis shows these to be focused in 10 large metacluster themes (comprising 100 specific clusters). **While projects are diverse, approximately two-thirds of Capacity funded projects (65.4 percent) demonstrate focus in "production" oriented areas of R&D, including Agronomy, Animal Science and Livestock, Fisheries and Aquaculture, and Forests and Forestry. Other areas addressed include important health and welfare, family and youth, community development, and environmental domains.**

Through comparing cluster analyses of Capacity and Competitive funded projects in the REEPort system, TEConomy also finds that **NIFA Capacity and Competitive Funding demonstrate substantially different degrees of emphasis in terms of projects undertaken.** The analysis illustrates that **Capacity Funding is more likely to focus on research projects oriented to production agriculture** (in Agronomy, Animal Science and Livestock, Fisheries and Aquaculture, and Forests and Forestry). This is a logical finding, given the ability of Capacity Funding to be focused on the particular needs of agricultural and natural resource industry needs, and challenges and opportunities at a state, regional, or local level. **Competitive Funding demonstrates more of an emphasis in Basic Life Science** (having double the emphasis here as seen in Capacity funded projects) and demonstrates marginally more percentage emphasis on Food Science, Environmental Science,

Biomass and Biofuels, Economics, and Family and Consumer Sciences. There is general congruence in these quantitative cluster analysis findings from REEport data and the expressed opinions of the 1862 Land-Grant survey respondents regarding which source of funding (Capacity or Competitive) are better suited to which topic area in agriculture and associated disciplines.

Capacity Funding is shown by analysis to be particularly well suited to supporting the practical, applied research needs of agriculture, forestry, associated industries, and the communities and populations that sustain them.

These sectors of the national and state economies comprise multiple small to midsize enterprises that cannot sustain R&D budgets of their own; rather, they are dependent on the work of the USDA-ARS and NIFA-supported land-grant universities to research solutions to tangible problems and everyday challenges, and to disseminate knowledge and practical advice regarding solutions and recommendations through Cooperative Extension.

2. Is the return on investment, or research productivity, through Capacity Programs commensurate with the level of funding?

Answering return on investment questions for academic research is never simple. There is a significant difference in how "return" might be defined, for example, between a basic science project that elucidates a biological process but produces no commercial technology, versus say a soybean improvement project that produces a 5 percent yield increase in certain environmental conditions. Both are important, but they differ in their type of impacts. What both basic and applied research share in common is that research results produced by faculty at universities are likely to be published. Publishing activity may thus provide a baseline surrogate metric for productivity suitable for a high-level evaluation of academic research.

Although Capacity Funding is highly suited to the support of applied and translational research and extension projects, it is not to the exclusion of basic science inquiry. Among the 19,791 Capacity funded projects for 2000–2015, 12.2 percent (2,414 projects) categorize through the cluster analysis as fundamental science (basic science) inquiry. These are heavily focused in basic life sciences, with Microbiology and Genetics and Genomics comprising the largest subclusters.

NIFA REEport data contain information on the source and amount of funding for each project. TEConomy's cluster analysis of REEport data for Capacity and Competitive funded projects thus allows for a comparison to be made for the highest level metaclusters that are present for both types of funded research. **The results of the analysis (Table 1) show that across all areas of research, except forestry, Capacity funded research generates significantly higher volumes of publications per million dollars of federal funding when compared to Competitive Funding**. **Because of the leverage of Capacity Funds, achieved through state and local sources, the federal government, for its share of the funding, receives a high return in terms of knowledge generated and disseminated through land-grant research**.

It should be noted, however, that while the majority of all academic disciplines target research towards the generation of peer-reviewed academic publications, the work of the land-grants recorded in Table 1 contains publications that are also geared towards agricultural producers, foresters, consumers, etc. that require information in a more concise form than the typical academic paper. For comparison purposes, therefore, care must be taken in comparing the Capacity and Competitive funded research coming via NIFA federally funded research as opposed to some other federal funding agencies, such as for example the National Institutes of Health, where TEConomy's analysis of NIH RePORT data finds circa 3.5 peer-reviewed publications generated per $1 million in NIH funding (using the same publication years).

Table 1: Publications per $1 million in Funding for Capacity and Competitive Funded Projects (REEport Data for 2010–2015) across Metaclusters[1]

	Publications per $1M Total Capacity & Leveraged Funds	Publications per $1M in Competitive NIFA AFRI (and previously NRI) Funds	Difference between Capacity and Competitive Funded Publications per $1M
Agronomy	12.78	4.90	**+7.88**
Animal Science & Livestock	9.96	7.60	**+2.35**
Basic Science	9.14	5.27	**+3.87**
Biomass & Biofuels	11.69	7.42	**+4.27**
Economics	16.95	4.78	**+12.17**
Environmental Science	12.54	11.03	**+1.51**
Family & Consumer Sciences	16.23	3.44	**+12.79**
Food Science	11.45	8.09	**+3.35**
Forests & Forestry	13.08	13.71	**-0.63**

The land-grant survey respondents report that the traditional academic metric of peer-reviewed papers can be supported by both Capacity and Competitive Funding models. However, Competitive Funding is viewed by respondents as more highly suited to generating academic publications in traditional academic journals. It should be noted, however, that the goal of federal funding for research is not only to expand the universe of knowledge (via academic publishing) but also to see knowledge put to work in furtherance of positive outcomes for the U.S. economy and society. Respondent land-grants rate Capacity Funding at a significantly higher level than Competitive Funding for achieving the pragmatic goal of **diffusing knowledge into practice**; Capacity Funding is rated as especially important for supporting Cooperative Extension's activities that lead to **actual change in behavior**s, both in terms of production sectors and among communities, families, or individuals.

Another avenue of output for science and technology oriented research and innovation is patenting. As in almost every other area of commercial activity, private industry dominates the patenting landscape in agricultural sciences and associated disciplines. Land-grant university patents in agriculture and associated technology categories (Appendix J) were found to total 4 percent of total patenting in these fields (across the seven-year period 2010–2016). However, it is found that **the impact of land-grant innovation on patenting is more wide-ranging, influencing up to one in every six patents (as identified through analysis of patent citations)**. The analysis shows that **patenting in agriculture and associated fields at the land-grant universities is particularly focused around cutting-edge applications of biotechnology and associated life sciences and physical sciences.** Areas that are particularly strong include Fertilizers and Other Agricultural Chemicals, Genetic Engineering, and Novel Plant Types, together with Enzymes and Microbiology.

3. How does Capacity Funding perform in terms of supporting work on the 2014 Farm Bill Priorities for NIFA and on the six NIFA National Challenge Areas?

The 2014 Farm Bill authorizes NIFA to pursue programs in support of six congressionally identified priority areas. The **2014 Farm Bill priorities** are:

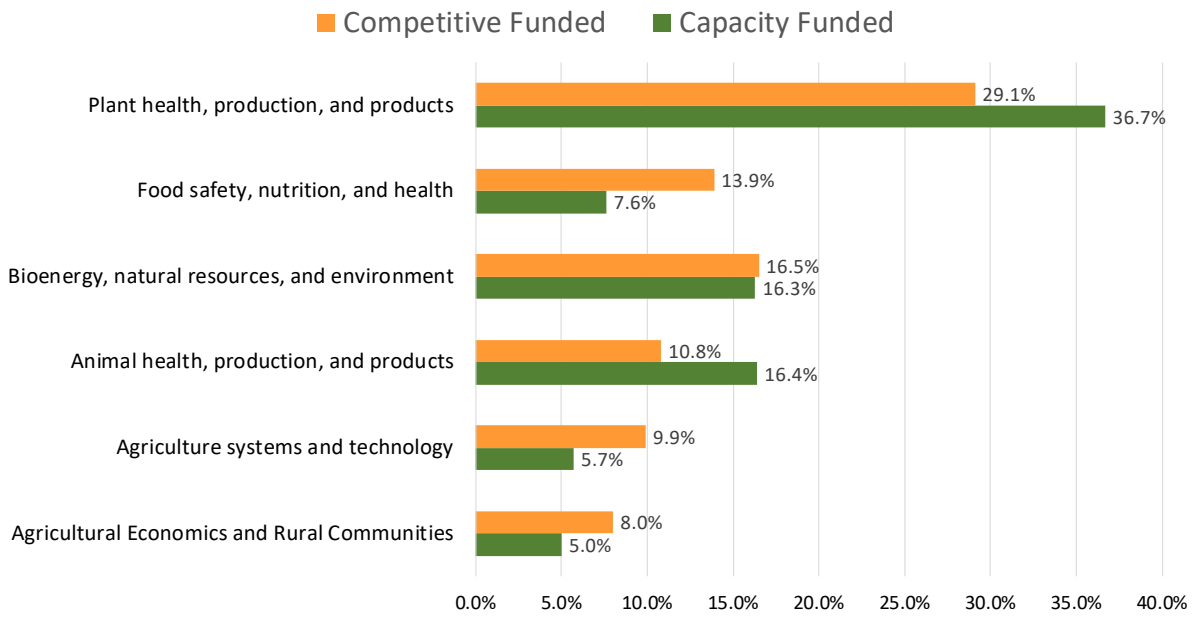
- **Agricultural economics and rural communities**
- **Agriculture systems and technology**
- **Animal health, production, and products**
- **Bioenergy, natural resources, and environment**
- **Food safety, nutrition, and health**
- **Plant health, production, and products.**

The cluster analysis of NIFA Capacity funded and Competitive funded project data maintained in the REEport system shows that the overwhelming majority in terms of both NIFA Capacity funded (87.7 percent) and NIFA Competitive grant funded (88.2 percent) portfolios of work are in areas relevant to the six priority areas in the 2014 Farm Bill. In other words, **almost 9 out of 10 projects in both NIFA funded portfolios of work are in Farm Bill priority**

[1] The same publication may show up multiple times across REEport years for multi-year projects. TEConomy manually removed these duplicates from the data to allow for accurate comparative analysis.

areas. Capacity Funding shows a higher proportion of projects directed toward the two challenges most directly focused on agricultural production: "Animal Health, Production, and Products" (16.4 percent of Capacity Projects versus 10.8 percent of Competitive Projects) and "Plant Health, Production, and Products" (36.7 percent of Capacity Projects versus 29.1 percent of Competitive Projects). Figure 4 summarizes these findings.

Figure 4: Percentage Segmentation of NIFA Capacity and Competitive Funded Projects in the REEport Data System Across the Six 2014 Farm Bill Priorities



In addition to the 2014 Farm Bill priorities, NIFA also seeks to assure that several key challenge areas are addressed via research and extension activity across U.S. institutions. As noted on the NIFA website[3], "NIFA supports research, education, and extension in **six national challenge areas**. These challenge areas include food security, climate variability and change, water, bioenergy, childhood obesity, and food safety." Specifically, they include the following:

- **Food Security.** Advance the nation's ability to achieve global food security and fight hunger.
- **Climate Variability and Change.** Advance the development and delivery of science for agricultural, forest, and range systems adapted to climate variability and to mitigate climate impacts.
- **Water.** Optimize the production of goods and services from working lands while protecting the nation's natural resource base and environment.
- **Bioenergy.** Contribute to U.S. energy independence and enhance other agricultural systems through the development of regional systems for the sustainable production of optimal biomass (forests and crops) for the production of bioenergy and value-added biobased industrial products.
- **Childhood Obesity.** Combat childhood obesity by ensuring the availability of affordable, nutritious food and providing individuals and families science-based nutritional guidance.
- **Food Safety.** Reduce the incidence of food-borne illness and provide a safer food supply.

In the quantitative analysis of Capacity versus Competitive funded projects in the REEport system, **the majority of projects in both the Capacity funded (64.2 percent) and Competitive funded (59.1 percent) portfolios of work are relevant to the six NIFA National Challenge Areas combined.** Capacity Funding shows a higher proportion of projects

[3] https://nifa.usda.gov/challenge-areas.

directed toward two of the challenges: Food Security (where it comprises almost half of the Capacity funded portfolio) and Water. Competitive Funding sees a proportionately higher focus on the themes of Climate Variability and Change, Bioenergy, Childhood Obesity, and Food Safety. It should be noted that, in terms of absolute project numbers rather than percent of projects, Capacity Funding has the higher total volume of work taking place across all of the National Challenge Areas except for Climate Variability and Change.

TEConomy also examined the Land Grant Impacts Portal for national data maintained for Cooperative Extension. This analysis shows that Cooperative Extension work is primarily concentrated in four out of six NIFA National Challenge Areas, these being Food Security, Food Safety, Water, and Childhood Obesity.

4. Does Capacity Funding have characteristics that sustain its relevance as an ongoing model for federal funding of research and extension activity?

Capacity Funding is found via the research reported herein to have multiple positive characteristics associated with it that secure ongoing relevance and positive scientific, economic, and social impacts. Chief among these benefits are the following:

- An ability to direct research and extension activity to the **spatially specific needs** of individual states, regions, communities, and populations.
- An ability to **focus on pragmatic, applied research** needs that have direct relevance to producers and specialized local or niche crop needs that would be unlikely to receive national-scale attention.
- An ability to **leverage substantial state, local, and private sector funding** to support research and extension activity because the land-grant institutions are seen to be focusing on relevant industry and societal needs.
- Flexibility to **fund rapid research and extension work in response to emergencies or emerging issues**.
- An ability to **fund sustained, long-term work required to improve crops and livestock** and advance them into commercial use.
- An ability to allocate funds to the **support of junior-faculty** research programs, and boost the career and research productivity of early-career faculty and researchers.
- **An assured base stream of funding** (typically matched with state and other local funding resources) that allow institutions to maintain the skilled personnel, specialized scientific facilities and instruments, and research station/farm infrastructure required to advance R&D.
- **Support for a dedicated Cooperative Extension System** working to assure that important research discoveries, innovations, and technologies are brought to the attention of those needing to implement them.
- **An ability to improve the infrastructure and capabilities of land-grant institutions in smaller states**, and **help non-R1 land-grant universities, such as the 1890 and 1994 institutions, to perform research and successfully compete for Competitive grants.**

The increasing complexity and transdisciplinarity of modern scientific challenges are placing a premium on funding that can support team science and transdisciplinary scientific inquiry. Both Capacity Funding and Competitive Funding models are viewed as being able to respond to this trend. Capacity Funding is generally seen as superior to Competitive Funding for highly applied research programs and those that can draw upon extension for integrating research with practice changes and knowledge transfer.

Modern research themes relevant to the land-grants vary considerably in spatial scale from local and state-specific needs to fundamental issues of global significance. **Generally, the more state, regional, or local the nature of solutions required, the more suited Capacity Funding is to supporting R&D and extension activity. When questions are more basic science-oriented, or global in application, the more Competitive Funding is favored (although Capacity Funding is still suited to, and used for, funding basic science inquiry). Because much of the need for R&D and knowledge diffusion is driven by local variation in production environments and communities, Capacity Funding remains a highly relevant, flexible, and crucially important funding tool for the foreseeable future.**

Land-grant university survey results indicate Capacity Funding to be better suited, in comparison with Competitive Funding, for the support of research activity focused on regional and local agricultural and associated sector requirements. It is found to be more effective in generating both tangible practice advancements and technological advancements for the agricultural sector and associated industries. The integration of research and Cooperative Extension activities, which provides an effective pathway for generating new applied knowledge and knowledge diffusion into practice in the field, is similarly reported to be best supported via a Capacity Funding model versus a Competitive Funding model.

Capacity Funding is shown in TEConomy's analysis to be better than Competitive Funding for leveraging federal funding dollars from other non-federal sources, whether that be state, local/county, non-profit, or corporate leveraged research funding. The land-grant universities confirm this to be their experience in the surveys. Capacity Funding is viewed by respondents as providing state-level and county-level relevance that serves to attract matching dollars, significantly increasing the volume of research and knowledge-extension activity that can be performed. This conclusion is supported by the quantitative analysis of NIFA REEport data, which shows Capacity funded projects generating an additional $1.86 in non-federal funding for every $1 in federal funds received.

The flexibility-of-use afforded by Capacity Funds also generates significant benefits for land-grant institutions, their faculty, and their research and extension programs. Capacity Funding is considerably more flexible than Competitive Funding in terms of the uses to which funds may be directed, and this brings tangible benefits in terms of recipient institutions having the ability to deal with the following:

- Short-term emergencies and emerging challenges.
- Supporting the purchase, operation, and maintenance of large-scale infrastructure required for complex agricultural and associated research.
- Sustaining a commitment to long-term programs of work necessary for crop and livestock improvement or other longitudinal studies.
- Building career effectiveness in junior faculty members.

Capacity funded projects generate an additional $1.86 in non-federal funding for every $1 in federal funds received.

Land-grant university leaders who responded to the TEConomy/APLU surveys note also that Capacity Funding is a superior vehicle (versus AFRI Competitive Funding or other Competitive Funding sources) for engendering multistate and multi-institutional collaborations and for forming national research and extension "systems." Collaborations are important in building robust research and extension teams with the capabilities required to address complex, multidimensional challenges. Similarly, such national networks help assure that peer-to-peer exchange of information and best-practices is accomplished via means beyond traditional academic journal publishing.

Per land-grant university leaders, Capacity Funding is the better vehicle (versus AFRI Competitive Funding) for supporting "undergraduate engagement" and "graduate students/PhD candidates." In the case of supporting international students, however, Competitive Grants are viewed as more supportive of this student type.

It is also important to note that research always carries risk; research findings may be unexpected, or anticipated results may be weaker than anticipated or not occur at all. Ideally, research funding needs to recognize the inherent risk of research and be tolerant of it. Research and Experiment Station Directors see Capacity Funding as being superior to Competitive Funding in terms of such risk tolerance.

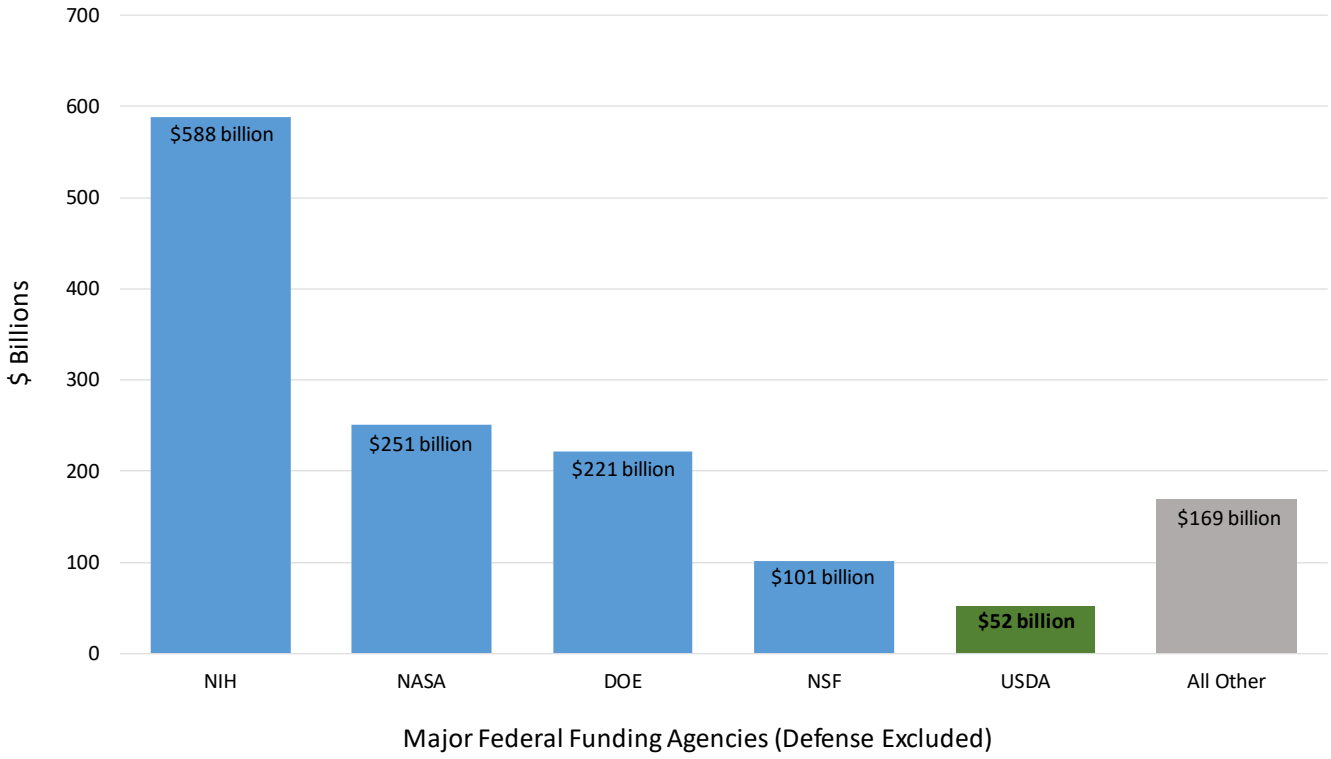
5. What can the federal government do to enhance the system and assure it meets national goals and objectives?

In terms of NIFA and Farm Bill priorities, it is clear that the majority of work programs pursued with Capacity and/or Competitive Funding are in alignment with federal government objectives. There is, however, significant potential for the United States in leveraging its world-class agricultural and associated science and engineering capabilities for further economic growth and societal resilience. In a 2011 report performed by the Battelle Technology Partnership Practice and BioDimensions, it is quoted that "There is no other arena of economic activity, or field of science and innovation, that so directly addresses human survival and quality of life, global economic

development, and prospects for an environmentally sustainable future as agriculture and agbioscience."[4] What was said in 2011, continues to hold true today and into the foreseeable future**. It is logical to conclude that given the importance of agriculture and associated industries, and the opportunities for further economic development and societal advancement contained within them, expanded federal funding for NIFA should be a national priority.**

When compared with funding for research at other major federal funding agencies, the USDA's $2.9 billion for research in the 2017 Federal Budget request is much reduced in comparison with the National Institutes of Health ($33.1 billion[5]), U.S. Department of Energy ("Science and Energy" only, at $12.6 billion[6]), NASA (R&D programs only, at $10 billon[7]), and the National Science Foundation ($8 billion[8]). Figure 5 provides additional analytical perspective on this issue, using NSF collected data, reported by the American Academy for the Advancement of Science, for the last 20 years to provide a sum for the total funding provided to major federal R&D funding agencies.[9]

Figure 5: Comparative Levels of Funding to Federal R&D Supporting/Performing Non-Defense Agencies from 1997 to 2016.



[4] Tripp, Simon, and Deborah Cummings. 2011. *Power and Promise: Agbioscience in the North Central United States*. Battelle Memorial Institute Technology Partnership Practice, page 3.
[5] HHS FY 2017 Budget in Brief – NIH (Accessed online at: https://www.hhs.gov/about/budget/fy2017/budget-in-brief/nih/index.html).
[6] FY 2017 Department of Energy Budget Request Fact Sheet (Accessed online at: https://energy.gov/fy-2017-department-energy-budget-request-fact-sheet).
[7] FY 2017 President's Budget Request Summary (Accessed online at: https://www.nasa.gov/sites/default/files/atoms/files/fy_2017_budget_estimates.pdf).
[8] FY 2017 Budget Request for the National Science Foundation (NSF) (Accessed online at: https://www.nsf.gov/about/budget/fy2017/).
[9] Federal R&D Funding by Agency (budget authority, millions of dollars). Accessed online at https://www.aaas.org/page/federal-rd-budget-dashboard. Analysis by TEConomy Partners. Data excludes American Recovery and Reinvestment Act (ARRA) and U.S. Department of Defense funding.

It is clear from these data, that **there has long been an inequity in federal allocation of research funds.** Over the past 20 years, these data graphically illustrate that USDA's funding for research (a cumulative $52 billion) has stood at approximately half that of the NSF, just a quarter of the funding spent for research at the DoE, only 20 percent of the amount spent on research at NASA, and less than 9 percent the amount of R&D funding provided to NIH by the federal government. Indeed, just the two most recent years of the NIH research budget exceeds the entire 20 years for USDA research. The $52 billion 20-year R&D budget for USDA represents only 4.3 percent of the R&D funds distributed across these five federal agencies.

Writing in the report "Impact and Innovation: Agbioscience in the Southern Region of the United States", Battelle noted:

> *The agbioscience industry in this nation is often overlooked or taken for granted. Much attention has been paid to medical advancements stemming from modern biological sciences, but the tools and technologies of the life scientist are no less powerful in advancing plant science, animal science, and agricultural sciences. Indeed, modern agbiosciences represent perhaps the most promising arena of applied science for addressing many of the most pressing challenges facing humanity—food security, human health, economic growth, and environmental sustainability.*
>
> *Agbiosciences provide a pathway to a sustainable global and domestic economic future. The sector produces products with assured demand, and those nations and regions that have the specialized skills, assets, knowledge and scientific infrastructure required to produce agbioscience innovations will be particularly well positioned to realize economic growth and development from the agbioscience industry*[10].

Because Capacity Funding is shown, herein, to generate an additional $1.86 in non-federal funding for every $1 in federal funds received – **it is logical to conclude that were a larger federal budget allocated to NIFA for the funding of research and extension activity, primary allocation should be made via Capacity Funding increase mechanisms.** The leverage argument alone is compelling, but so too are the other advantages noted for Capacity Funding herein, and these additional benefits should not be discounted. Indeed, the robust findings in favor of Capacity Funding suggest that this funding model should also be examined for relevance to other federal R&D funding agencies. A similar conclusion was reached by noted healthcare researcher Atul Gawande who examined the history of the Capacity funded agricultural research and extension enterprise in the U.S. and concluded that it should serve as an example for U.S. health research and healthcare reforms.[11] Gawande notes:

> *The government never took over agriculture, but the government didn't leave it alone, either. It shaped a feedback loop of experiment and learning and encouragement for farmers across the country. The results were beyond what anyone could have imagined. Productivity went way up, outpacing that of other Western countries. Prices fell by half. By 1930, food absorbed just twenty-four per cent of family spending and twenty per cent of the workforce. Today, food accounts for just eight per cent of household income and two per cent of the labor force. It is produced on no more land than was devoted to it a century ago, and with far greater variety and abundance than ever before in history.*

Increasing Capacity Funds for allocation by NIFA will enable the national and state benefits (from the multiple identified advantages) to expand via this funding model. It is also evident that Competitive Funding and Capacity Funding have several fundamental differences between them that mean that one is <u>not</u> a direct substitute for the other. Increasing levels of Competitive Funding would not mean that the benefits attributable to Capacity Funding would occur through this alternate funding source, and vice versa.

[10] Tripp, Simon, Deborah Cummings, and Peter Nelson. 2013. *Impact and Innovation: Agbioscience in the Southern United States. The Importance of the Southern Region's Land-grant Extension Service and Experiment Station System.* Battelle Memorial Institute Technology Partnership Practice and BioDimensions. February 2013.

[11] Gawande, Atul. 2009. *"Testing, Testing: The health-care bill has no master plan for curbing costs. Is that a bad thing?"* The New Yorker. December 2009.

The Capacity model of allocating funding by preset formulas to universities (in a manner not dependent upon national peer-review of individual proposals, but still subject to federal oversight in regards to plans of work) carries several advantages that may be of substantial relevance and importance to future U.S. economic growth and societal welfare. As such, it may be relevant as a model for consideration by other federal agencies. Increasingly, global economic competition is less nation-to-nation and more region-to-region: thus, a research funding model that facilitates regional decision making in regards to research priorities holds appeal. In addition, Capacity Funding is well-suited to facilitating work that:

- Steps outside of traditional disciplinary boundaries and provides the flexibility to form transdisciplinary teams to research solutions to complex challenges.
- Is directed, in part, by local stakeholders to advance R&D that addresses the needs of regional industry clusters by linking industry needs to university core competencies.
- Can be geared towards the significant regional differences that exist across the United States in terms of demographics, social challenges, opportunities and needs (rather than taking a one size fits all approach).
- Has the flexibility to facilitate industry-university partnerships, and provide for enhanced capture of economic returns to research by the United States and its industries through early access by American businesses to research results, findings and associated innovations.
- Provide for the geographic distribution of funds in a manner that is more equitable for the participation of all states, and disadvantaged populations, for engagement in the R&D sphere.
- Utilizes an extension service to assure two-way information flows and knowledge translation for practitioners. This assures a "voice of the market" and professional review of how best to translate research results into practice to achieve desirable results. It also discourages the compartmentalization of research results into tiny specialized niches where experts in narrow subject matter areas communicate only with other experts in their narrowly defined field.

The history of America's land-grant institutions is very much tied to the Capacity model. This exclusivity to land-grants is a special case, and works well. Were Capacity Funding to be used as part of the funding model at other federal funding agencies, TEConomy recommends that funding not be limited to public and land grant universities. TEConomy has found in its science and technology-based economic development practice that private universities can be as engaged as public universities in terms of translational science and support for local and regional economic development.

As a nation, the United States must recognize that in a 21st Century global economy driven increasingly by innovation as the principle determinant of competitiveness, the almost exclusively peer-reviewed model (used outside of the agricultural research sphere) for R&D support and performance may need to be revisited. Having at least some of the research funding portfolio for each federal R&D funding agency redirected via Capacity Funding to the states would be likely to provide many of the benefits that have been observed in NIFA Capacity Funding and, perhaps most notably, can be used to require matching funds leverage at the state and local level – thereby substantially increasing the total size of the pool of funding nationwide that is directed to R&D.

Based on the research herein, TEConomy concludes that Capacity Funding carries substantial and significant advantages as an R&D and extension funding model. This is not to say, however, that the current system is without flaws. In particular, 1890 and 1994 institutions do not share access to all the same programs as the 1862 universities, and the limitation on year-to-year funds carry-over imposed on the 1890 institutions creates planning and budgetary challenges (especially since a number of institutions note that funding that is earmarked for a fiscal year often arrives relatively late in the budget year). The Capacity model also inherently excludes many high-quality research universities from participating in this component of federal funding by virtue of them being excluded from the originating legislation. However, while non-land-grant universities cannot access Capacity Funds, they can compete for NIFA Competitive Funds (although even there they will likely be at a disadvantage since Capacity Funding supports the development and maintenance at the land-grants of the specialized infrastructure and talent required to advance specialized agbioscience research). There is certainly

a tension in the fact that so many world-class universities in the U.S. with leadership in life science disciplines are unable to access Capacity Funds. Rather than considering this tension to be an argument for reallocating funds from Capacity to Competitive modes of funding, TEConomy believes that instead the logical conclusion is that both Capacity and Competitive Funding pools need to increase. The former because it works, very effectively, (as evidenced in the findings of this report) and leverages large-scale state and local funding to enhance the total pool of funds, and the latter because the growing transdisciplinarity inherent in many frontier scientific areas (especially in life sciences research) merits having additional funds available to encourage other leading life-science universities to steer more of their research enterprise and expertise to the challenges and opportunities in agricultural sciences and associated areas.