

National Evaluation of Capacity Programs



Quantitative and Qualitative Review of NIFA Capacity Funding

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Elements of the evaluation performed herein required the administration of a survey to university leadership, research and experiment station directors, and Cooperative Extension Directors at U.S. land-grant universities and colleges. The process of distributing these surveys was kindly facilitated by the Association of Public and Land-grant Universities (APLU) and the American Indian Higher Education Consortium. The TEconomy Partners' research team thanks these organizations for their assistance.



Evaluation of NIFA Capacity Programs: Study Highlights

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

Operating in all U.S. states and territories, and most individual counties, this agriculture value-chain **constitutes a nationwide economic system** that supplies products to all Americans and provides the fundamental economic driver for rural and small town America. Increasing productivity and output by more than 2.5 times since the 1940's, while utilizing less total acres, U.S. agriculture is the envy of the world and a true American success story. This track-record of success has not, however, occurred by chance. Rather, **it has resulted from the intense and deliberate application of scientific R&D and technological development** – with the involvement of the federal government and state and local (county) governments.

The federal government, through the USDA, both performs research and funds research through the National Institute of Food and Agriculture (NIFA) undertaken by other institutions, primarily academic institutions, across the United States. **A key component of this federal funding has been Capacity Funding 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, LLC was retained by NIFA to conduct a formal evaluation to assess current and future “fitness to purpose” of the Capacity Funding model.

The evaluation included detailed quantitative analysis of research productivity and other factors relevant to evaluating Capacity Funding.

The core finding is that Capacity Funding carries substantial and significant ongoing advantages as an R&D and extension funding model.

It not only continues to be a highly relevant model for NIFA funding, but also may be considered a model for consideration by other federal R&D funding agencies.

A key advantage of Capacity Funding is the financial leverage it receives through matching state funds, and additional local level (typically county level) funding. TEconomy finds Capacity Funding to generate an additional \$1.86 in non-federal funding for every \$1 in federal funds received. This leverage finding alone is compelling, but so too are multiple other advantages identified for the Capacity Funding model:

- Providing a relatively predictable base of funds, Capacity Funding allows universities to sustain the specialized personnel and scientific facilities and instruments, research station infrastructure and extension operations needed for complex agricultural and associated research programs.
- Capacity Funding is particularly well suited to supporting the practical, applied research needs of agriculture, forestry, associated industries, and the communities and populations that sustain them. Capacity Funding allows research and extension activity to be directed towards the spatially specific needs of individual states, regions, communities, and populations. The ability to focus on applied research has direct relevance to producers and specialized local or niche crop needs that would be unlikely to receive national-scale attention.
- Across all areas of research examined by TEconomy (except forestry), Capacity funded research generates significantly higher volumes of publications per million dollars of federal funding compared with Competitive Funding.
- Capacity Funding provides the flexibility to fund rapid research and extension work in response to emergencies or emerging issues.

Research is the fundamental engine that drives U.S. innovation, economic progress and competitiveness. Research funding is the fuel for that engine.

Because of U.S. R&D, the nation's agricultural sector has become expert in doing more with less. Deploying research-based solutions and technologies has empowered producers to increase output from finite U.S. land assets.

These sectors of the national and state economies comprise multiple small to midsize farms and enterprises that cannot sustain significant R&D budgets of their own.

Capacity Funding generates an additional \$1.86 in non-federal funding for every \$1 in federal funds received – considerably expanding the utility of federal funding dollars.

- Capacity Funding can fund the sustained, long-term work required to improve crops and livestock and advance them forward to commercial use.
- Funds can be allocated to support the research programs of junior-faculty, and thereby boost the career and research productivity of early-career faculty and researchers.
- Capacity Funds provide the 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, engage in research and successfully compete for Competitive grants.

A goal of federal funding for research is not only to expand the universe of knowledge (via academic publishing) but also to **ensure knowledge is deployed in furtherance of positive outcomes for the U.S. economy and society**. By supporting an integrated land-grant system of research and Cooperative Extension, Capacity Funding helps assure that important research discoveries, innovations, and technologies are brought to the attention of those needing to implement them whether they be in production sectors or among communities, families, or individuals.

Work supported by Capacity Funding is found to be responsive not only to needs identified at the local and regional level, but also responsive to the 2014 Farm Bill Priorities for NIFA. TEconomy’s cluster analysis of NIFA project data shows that the overwhelming majority of Capacity funded projects (almost 9 out of 10) are in 2014 Farm Bill priority areas. In addition, it is found that the impact of land-grant innovation on patenting in agriculture and associated technologies is also important, influencing up to one in every six agriscience patents (as identified through analysis of patent citations). This patenting is particularly focused around cutting-edge applications of biotechnology and associated life sciences and physical sciences.

The universe of research inquiry supported by NIFA Capacity Funding is extremely diverse, but 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. 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. **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.**

There continues to be 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. **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, continuity of Capacity Funding programs is recommended.** TEconomy notes, however, that compared with other major federal R&D funding agencies (including NIH, NSF, NASA and DoE) the USDA and NIFA R&D efforts receive the least amount of funding, by a quite considerable margin. Over the past 20-years the R&D budget for USDA represented only 4.3 percent of the R&D funds distributed across these five federal agencies. Indeed, in just the two most recent years, the NIH research budget alone has exceeded the entire 20-year budget for USDA research.

Based on the research herein, TEconomy concludes that Capacity Funding carries substantial and significant ongoing advantages as an R&D and extension funding model. 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 predominantly via Capacity Funding increase mechanisms. 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.

By supporting Cooperative Extension, and its spatially distributed delivery and communications system, large-scale elements of work at the land-grants is grounded in the “voice of the market” – responsive to direct input from individual counties and the expressed needs of local producers, value-added industries and communities.

Approximately 9 out of 10 Capacity funded projects are in 2014 Farm Bill priority areas.

Capacity Funding carries substantial and significant ongoing advantages as an R&D and extension funding model.

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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.

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,

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.

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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 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

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.

¹ In this report, for the sake of simplicity, the terms "agriculture," "agricultural sciences," and "agricultural industries" are considered to also embrace forestry,

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 Funding²) 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

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.

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.

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

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.

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

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.

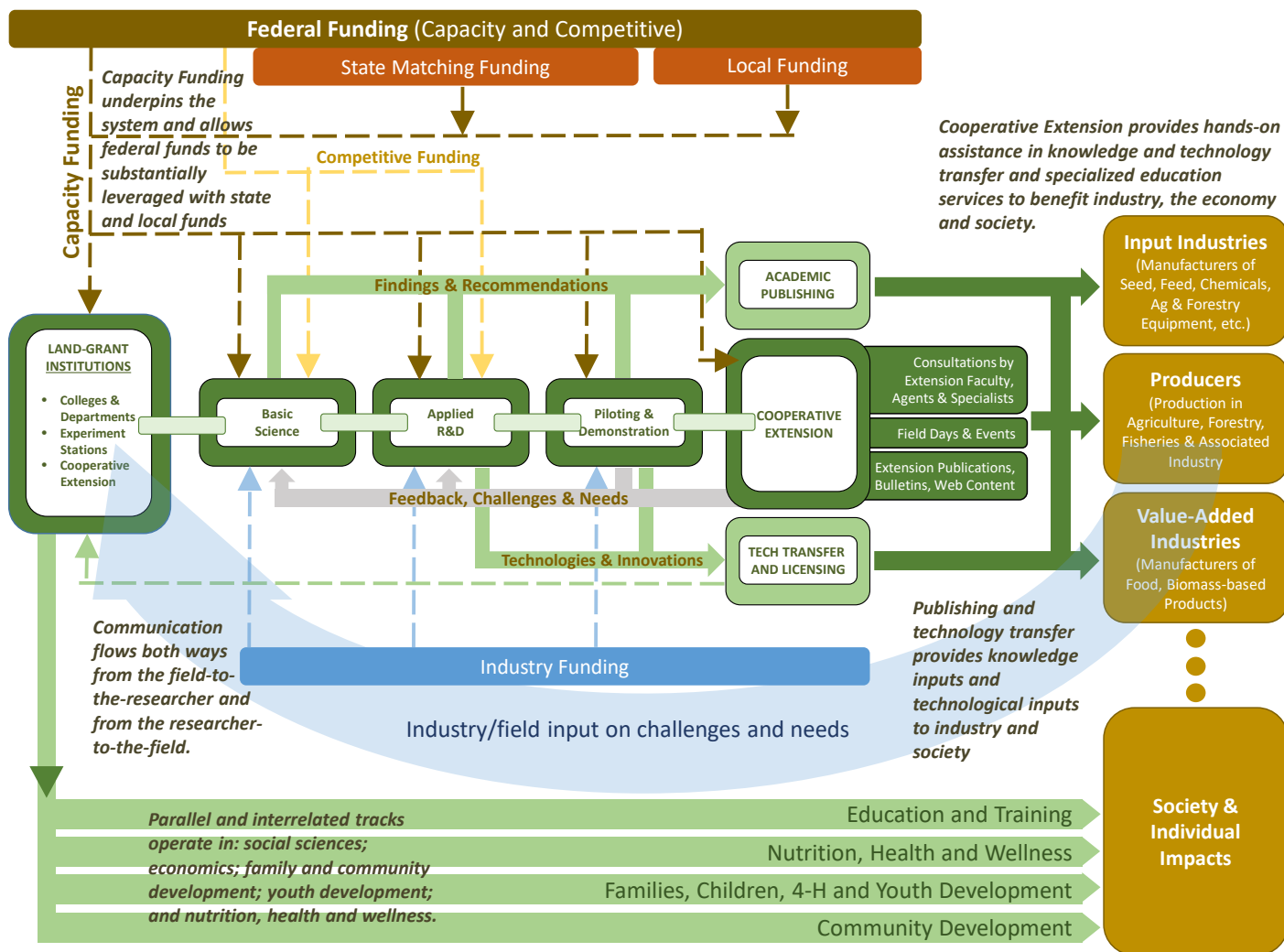
Fundamental to the ongoing success of this ecosystem is the legislatively mandated support provided to NIFA through the Farm Bill, that provides ongoing formula based funding (Capacity Funds) to land-grant colleges and universities. **The Capacity Funding system, requiring matching funds from the states, 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



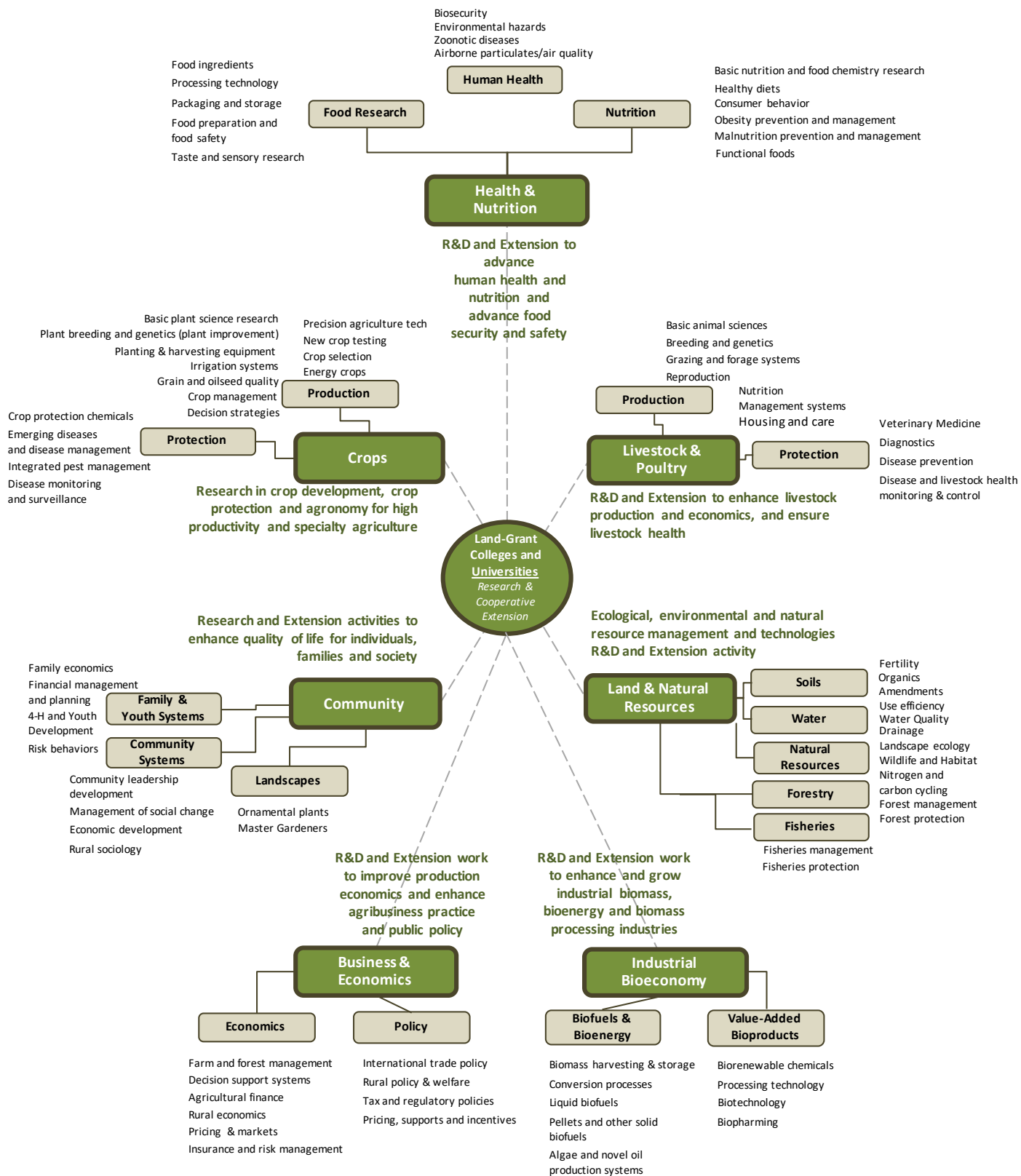
NIFA Funding Supports a Broad Base of R&D Enquiry to Enhance the U.S. Economy and Society

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:

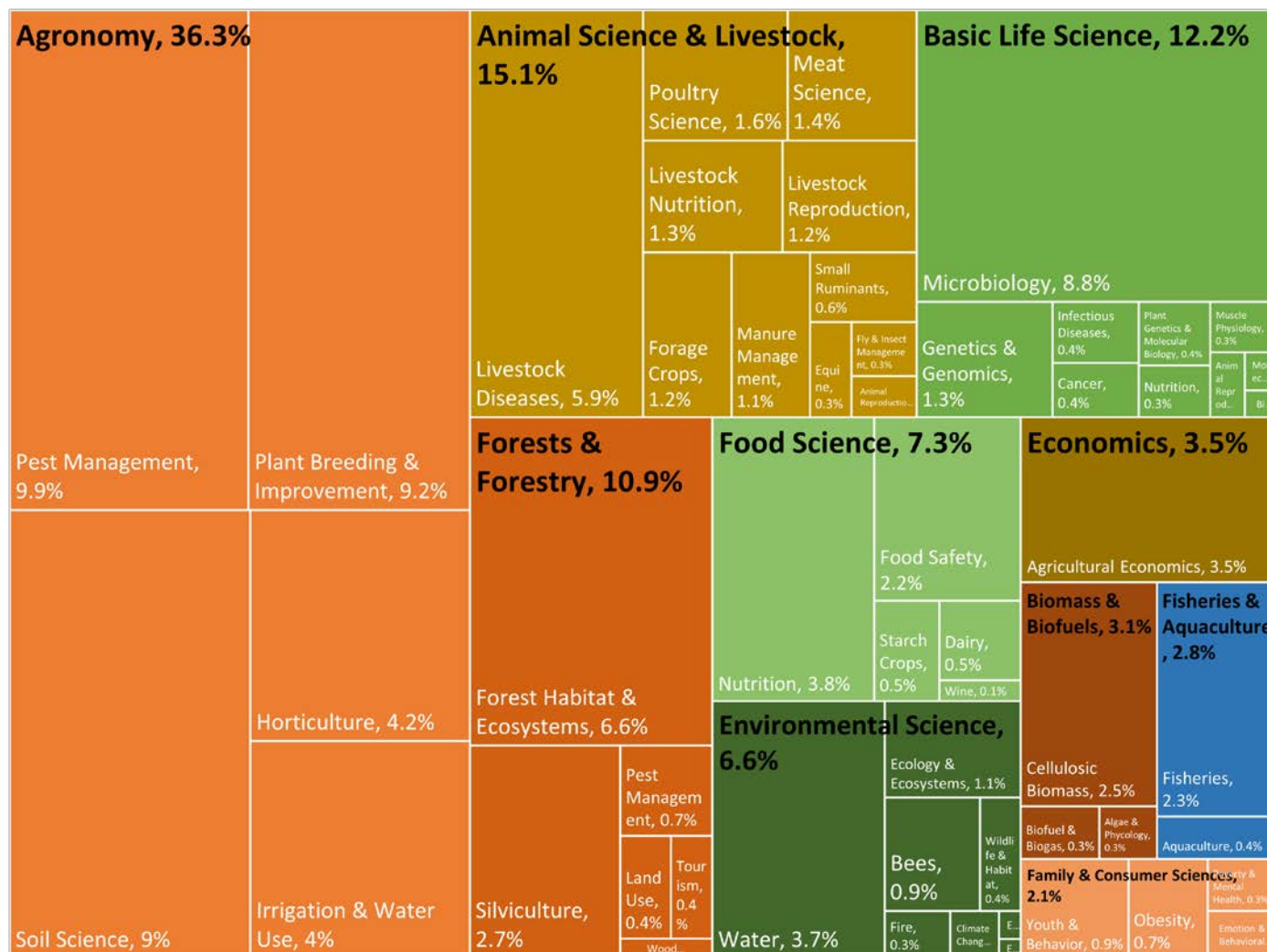
- **Publications Output:** Evaluating publication volume by key areas of research as identified in the Clarivate Analytics *Web of Science*[™] database.
- **Research and Extension Project Summaries:** using advanced real-text cluster analysis of NIFA Capacity and Competitive funded projects in the REEport 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 more **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 (REReport 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 REReport 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 REReport 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.

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.

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.**

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.

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

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.

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 (REReport 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 behaviors**, 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.**

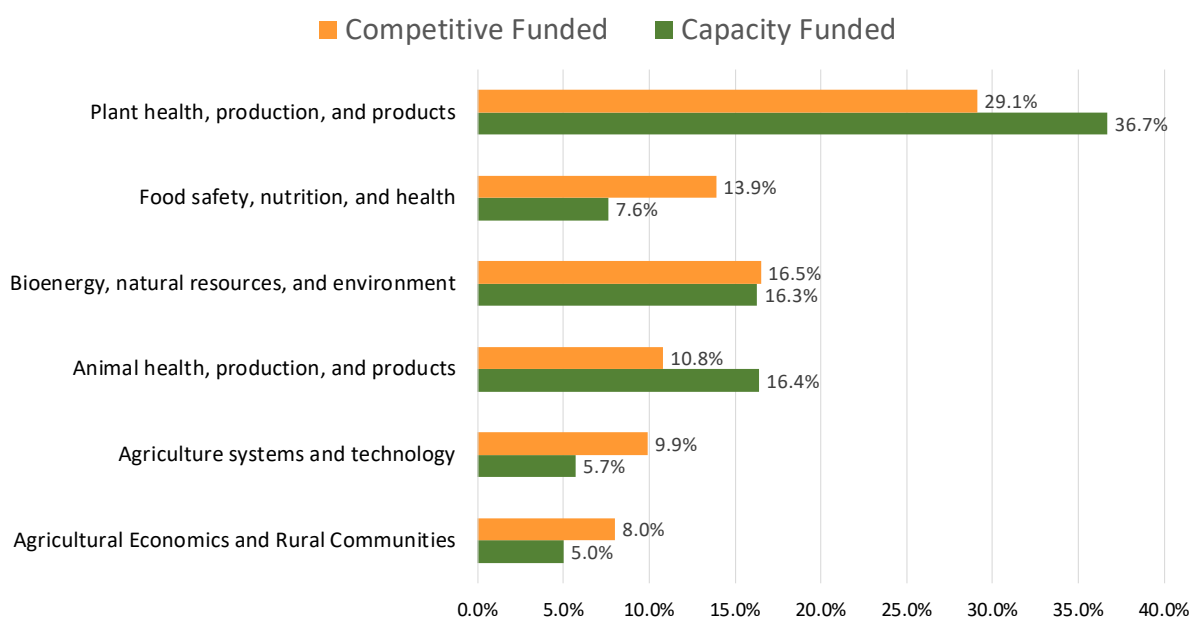
The cluster analysis of NIFA Capacity funded and Competitive funded project data maintained in the REReport system shows that the overwhelming majority in terms of both NIFA Capacity funded (87.7 percent) and NIFA Competitive grant funded (88.2 percent) portfolios of work are in areas relevant to the 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 REReport 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 website³, “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.

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.

- 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.**

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.

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

- Building career effectiveness in junior faculty members.

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?

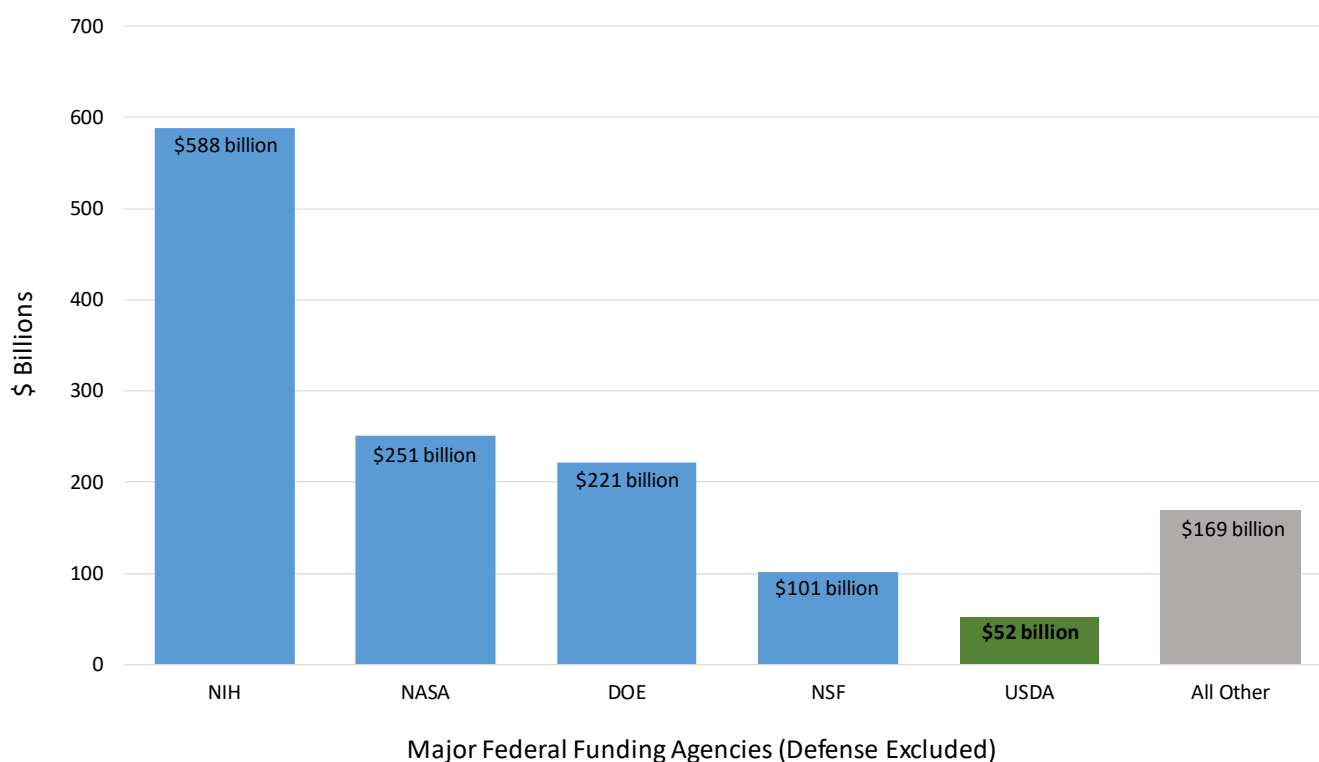
In terms of NIFA and Farm Bill priorities, it is clear that the majority of work programs pursued with Capacity and/or Competitive Funding are in alignment with federal government objectives. There is, however, significant potential for the United States in leveraging its world-class agricultural and 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 billion⁵), U.S. Department of Energy (“Science and Energy” only, at \$12.6 billion⁶), NASA (R&D programs only, at \$10 billion⁷), and the National Science Foundation (\$8 billion⁸). 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 industry¹⁰.

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 not 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.

**SECTION II:
INTRODUCTION
AND
QUANTITATIVE ANALYSIS OF NIFA FUNDING
OUTPUT**

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.¹²

I. Introduction

This is a report about a component of American life and commerce that is too often taken for granted. The U.S. agricultural and forestry system, together with the social and economic structures that sustain it, is fundamental to national and individual well-being; but, an increasingly urban U.S. population has become distanced from the system that feeds them and that contributes to sustainably clothing, sheltering, and fueling their way of life. This cognitive distancing is not benign because, if “knowledge is power,” the lack of understanding is the metaphorical off switch. Without understanding the systems that sustain their economy and society, Americans and their leaders are ill-equipped to make policy, program, and resource allocation decisions that are rational and strategic.

The United States’ vast land area of 2,261 million acres sustains 917 million acres of farmland (41 percent of national land area) on 2.1 million farms, and 737 million acres of forest (33 percent of land area). The productivity on this land is the envy of much of the world; and increasingly, U.S. agricultural and forest resources are enabling a path to economic growth for the nation that is built upon new applications of domestic renewable biomass resources as feedstocks for fuels, chemicals, plastics, fibers, and industrial materials. The system that sustains this productivity is wide ranging, geographically dispersed, and complex. Operating in all U.S. states and territories, and the majority of individual counties, the agriculture and forest industries’ value-chain constitutes an economic ecosystem that supplies products to all Americans and provides the fundamental economic driver for rural and small town America. Figure 1 illustrates key components of this ecosystem and multiple examples of the positive impacts associated with it.

Like a biological ecosystem, this economic and social ecosystem consists of interrelated actors and activities that serve specific functions and make possible the outcomes of the system extant. In modern developed economies, including the United States, the performance of many individual components of this system is particularly driven by research and development (R&D) and resulting advancements in knowledge, applied processes, and technological innovations.

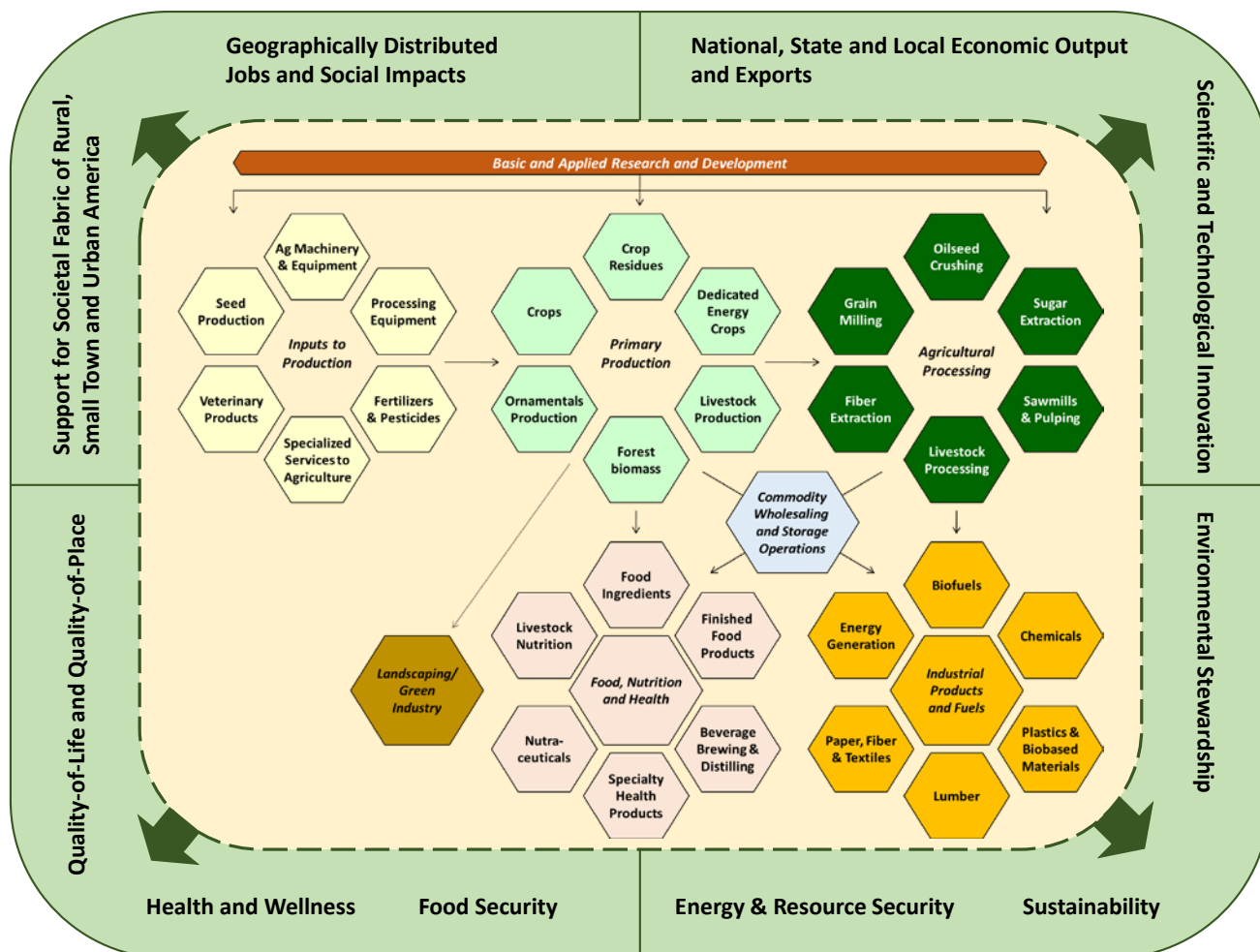
A. 21st Century American Agriculture

When considering “high-technology” industries in the United States, it is usual to think of such sectors as the information technology industry, aerospace industry, advanced materials, and medical products industries, to name just some. Fewer people, however, may consider agriculture or forestry as being high-tech industries; yet, the amount of technology deployed in modern, high-productivity American agriculture¹³ is substantial. Scientific research and associated technological innovation are very much a part of the history of U.S. agricultural progress, and, indeed, are the primary reasons why farm output has increased substantially and continuously since the 1940s, even though total land area in agricultural use has declined, together with the amount of labor required to produce the output. In effect, because of U.S. scientific research, and scientific knowledge translated into practice, the nation’s agricultural sector has become expert in doing more with less – working to deploy technologies and research-based solutions to produce increasing output from each acre of U.S. agricultural land.

¹² Tripp, Simon, and Deborah Cummings. 2011. *Power and Promise: Agbioscience in the North Central United States*. Battelle Memorial Institute Technology Partnership Practice, page 3.

¹³ 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.

Figure 6: The Agriculture and Forestry Economic Ecosystem and Associated Impact Domains



The increasing productivity of U.S. agriculture, and the growth of the large-scale value-added industry chain that benefits from it (Figure 6), has not occurred by serendipity. 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. Research-driven advancements in animal science, veterinary medicine, genetic marker-assisted livestock breeding, and advanced nutrition formulations, for example, have led to widespread gains in the output of the livestock and poultry sectors. Likewise, in crop agriculture, innovations in agronomic techniques, soil science, plant biology and breeding, molecular genetics, pest and disease management technology, and agricultural equipment engineering have led to similarly far-reaching increases in on-farm production. Today, revolutionary new technologies in biotechnology, genomics, precision equipment guidance, robotics, computerized decision support systems, and other technological fields are finding direct application in expanding agricultural production and efficiency. At the same time, rural sociologists, family and consumer science researchers, education and communications specialists, agricultural economists, and other allied academics and professionals have worked, and are working, to understand and sustain the economic and social fabric of rural, small town, and urban America that supports much of the progress in national farm, forest, and natural resource industries. In other words, research drives increasing productivity in agriculture and associated industries and works to sustain the societal, family, workforce, public policy, and other necessary pillars that support a sustainable agricultural economic ecosystem.

The need to assure ongoing advancement and productivity growth in agricultural industries is not just a matter of the obvious economic imperative, it is also driven by two interlocking global grand challenges:

1. An expanding global population and rising global middle-class incomes that are significantly increasing the demand for food and natural resources, and
2. The reality that the vast majority of land suitable for agricultural production has already been pressed into use, and thus, more has to be produced on this finite land.

Without agriculture increasing its productivity levels to meet rising demands, the world will not only see an increase in debilitating hunger and starvation, but will also suffer severe and accelerated environmental degradation as fragile ecosystems are destroyed to force marginal, fragile lands into agricultural production (leading to global deforestation, increasing desertification, and widespread loss of biosphere diversity and ecosystem services). The simple reality is that, to have any hope of a sustainable world under rising population- and income-level pressures, there is an absolute mandate to increase levels of food production from existing agronomic land and to sustain the economic and social fabric that supports it. This must be accomplished with the mindset that Americans are only the present custodians and beneficiaries of land that must be passed-on to feed future generations. The challenge is extremely significant, complex, and multidimensional – and R&D is the key component in America’s ability to rise to the challenge.

“With global populations rising rapidly, U.S. agriculture faces the challenge of producing enough food, feed, and fiber to meet increasing demand in conditions of changing climate and scarce natural resources. Innovative policies and new farming approaches based on a strong scientific foundation are needed to tackle the challenge of increasing production while also meeting environmental, economic, and social goals.”

U.S. National Research Council of the National Academies. *Toward Sustainable Agricultural Systems in the 21st Century.*

B. A Unique Industry

Achieving the necessary gains in agriculture is no easy task. Unlike almost every other industry, the agricultural industry operates within a production environment that has great year-to-year and season-to-season variability. It is (largely) an outdoors industry dependent on weather and open to the pressures of naturally occurring diseases and pests. Factors both abiotic (rainfall, sunlight, frost, etc.) and biotic (plant and livestock diseases, crop-damaging pests, etc.) are variables that substantially affect production but cannot be assured in advance. New diseases are emerging, and existing diseases and pests are expanding in their geographic range, spurred in part by human activities and the reactions of the biosphere and climate to them. The dynamic production environment, and the challenges associated with it, represent a unique signature of the agricultural industry.

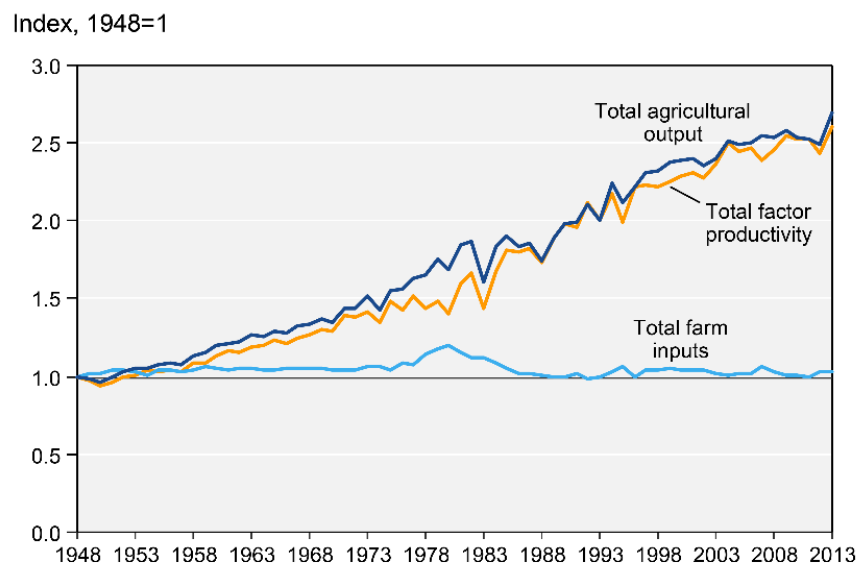
It is also the case, unlike most other manufacturing or technology industry sectors, that agriculture is almost entirely composed of small and midsize business enterprises in terms of primary production. Whereas the global automobile industry, for example, comprises circa two dozen or so major manufacturers, agricultural output in the United States alone stems from the work of 2.1 million individual farms. The national U.S. agricultural industry’s output is the net result of literally hundreds of millions of individual decisions made by farmers across their growing seasons, with those decisions having to take into account an exceptional number of variables (weather, soil fertility, pathogens, pests, commodity prices, global competition, etc.) and the potential deployment of multiple technologies and solutions (such as specific crop varieties and cultivars to use, livestock health products to employ, type of tillage to deploy, and capital investments in new farming equipment, to name just some).

The fact that American farmers and the R&D system that supports these farmers have together achieved the productivity increases shown on Figure 7 in the face of the variable production environment and multivariate decision-making environment in which farmers operate is a splendid American success story, but one that goes underrecognized and underappreciated. The success of U.S. agriculture is a testament to the dogged and sustained work of thousands of American scientists, technologists, and engineers developing and innovating solutions and to the millions of U.S. farmers who deploy the solutions these researchers provide. Importantly, 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. 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.

Figure 7.

U.S. agricultural output, inputs, and total factor productivity



Source: USDA, Economic Research Service, Agricultural Productivity in the U.S. data product. Data as of December 2015.

Clearly, not just maintaining, but expanding the productivity, capacity, and competitiveness of American agriculture and its associated value-chain is of fundamental economic and social importance. It is required to meet the grand challenge of rising global populations and to support the economy and social fabric of counties and communities across the entire United States.

C. Research as a Driver of Innovation and Knowledge to Enhance Agricultural Production. Key Actors and the Role of Land-Grant Universities and Colleges

As noted above, modern American agriculture may be characterized as an industry operated by **millions** (farmers, ranchers, foresters) and sustained by the innovations of **thousands** (in the R&D sector), but it also 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. 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 produces 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.

The federal government through the USDA both **performs** research, through its in-house ARS¹⁴, and **funds** research performed by other institutions, primarily academic institutions, across the United States. Unlike most other fields of scientific research, the broad institutional base of the academic agricultural research community was established by deliberate, coordinated, and far-sighted acts of the federal government that recognized the

¹⁴ The USDA Agricultural Research Service (ARS) has more than 2,200 permanent scientists working on approximately 1,100 research projects at more than 100 locations across the United States.

crucial importance of agriculture to national economic growth, sustainability, and security. A key component of the early federal commitment to the scientific advancement of agriculture and associated fields was the Morrill Land-Grant Act of 1862, which provided grants of land to the states that could then be sold to finance and support institutions to teach agriculture, mechanics and military tactics, without forgoing classical studies. These institutions particularly focused on providing a practical education suited to the demands of the expanding American economy and the workforce needs of the industrial revolution. The original Morrill Act gave rise to, and supported, a series of colleges and universities that have grown to become many of this nation's most prestigious and research-intensive institutions. Universities such as The Ohio State University, Iowa State University, Texas A&M, Kansas State University, University of California, and University of Florida, to name just a few, have their roots in the Act, while already existing institutions such as Michigan State, Penn State, and the University of Georgia were integrated into the land-grant fold as well and expanded because of it. The subsequent Hatch Act of 1887 further built upon the Morrill Act's foundation by authorizing federal grant funds to each state for the establishment of an agricultural experiment station connected to each state's land-grant institution. These experiment stations were then funded by ongoing federal funds leveraged with state matching dollars.

Momentum and capacity were further built through the second Morrill Act of 1890, which supported expansion of land-grant colleges in former Confederate and border states, and helped support growth and development at many of the nation's historically black colleges and universities. This recognition of the importance and ongoing relevance of skills imparted by a land-grant education was also expressed in the more recent 1994 Elementary and Secondary Education Reauthorization Act under which 29 tribal colleges and universities became land-grant institutions, and today includes 34 institutions.¹⁵

Another key landmark in the development of American agricultural progress and education was the Smith-Lever Act of 1914, which created a Cooperative Extension Service associated with each land-grant institution. The "Cooperative" part of the Extension Service name references the unique partnership between the federal (USDA), state (land-grant colleges), and local (county) entities that enables the pragmatic and crucially important work of translating and disseminating the latest know-how, information, and innovations that result from the research of the land-grant colleges and their experiment stations.

It is a testament to Representative Justin Smith Morrill of Vermont (for whom the Morrill Act is named), and each successive administration and congress, that this integrated system of **land-grant universities, Experiment Station Systems, and Cooperative Extension Services**, providing R&D-based solutions and pragmatic knowledge transfer, has grown and thrived for more than 150 years.

D. The Modern Relevance of the NIFA-Supported Land-Grant, Experiment Station, and Cooperative Extension Service Systems

In today's fast-moving, dynamic, and technologically complex world, it is rational to ask "*Can the Land-Grant University, Extension Service, and Experiment Station system, originally established in the 1800s and early 1900s, still be relevant?*" This question was asked in a 2013 analysis of Southern Region land-grant universities, and their experiment station and extension systems, in a study by the Battelle Memorial Institute.¹⁶ The Battelle analysis examined the operations and status of this interlocking system at the time, specifically asking the "contemporary relevance" question, and concluded:

America's land-grant universities uniquely engage across the full-spectrum of agbioscience—from the most basic scientific inquiry through to the practical services in support of producers, manufacturers and society provided via extension services. The integrated land-grant/experiment station/extension system is an American invention that has formed the platform for U.S. leadership in global agriculture and associated industries. It is an intensely relevant system, central to addressing key economic opportunities and global challenges.

Tripp, Simon, and Deborah Cummings. 2011. *Power and Promise: Agbiosciences in the North Central United States*. Battelle Memorial Institute Technology Partnership Practice.

¹⁵ Complete lists of current U.S. land-grant institutions are provided in Appendices A (1862), B (1890), and C (1994).

¹⁶ 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.

*The surprising answer is that agricultural research institutions and agricultural extension may well be more necessary and relevant than ever before. **Much of what is required for 21st century success (innovation, technology transfer, human capital enhancement, productivity improvement, networking, and quality of environment and place) is directly addressed through the mission and operations of the Land-grant Extension Service and Experiment Station System.** Being able to compete in the world agricultural economy requires constant innovation, practice improvement, new technology introduction, skills enhancement, and global intelligence—exactly the competitive factors that the Land-grant Extension Service and Experiment Station System were created to enhance, develop, and support.¹⁷*

Currently, this federally supported land-grant university system is deployed in addressing a large-scale contemporary suite of complex and dynamic challenges and needs. The system is, for example, researching, and extending into practice, solutions across a range of domains, including (but not limited to) the following:

- Deploying traditional and state-of-the-art modern scientific tools and techniques to protect and improve both the yield and quality of agricultural crops and livestock.
- Integrating advanced sensing, precision guidance, and metering technologies to maximize the efficient use of inputs to agriculture (such as water, fertilizers, and pesticides) and limit negative externalities associated with inputs use.
- Developing advanced predictive modeling technologies, big data, and decision support systems to enhance the accuracy of agricultural decision-making.
- Exploring and developing new and enhanced sustainable biomass-based industries in the production of energy, fuels, materials, chemicals, and fibers.
- Leveraging innovations and research findings to achieve rural development and enhanced economic and social opportunities for small towns, rural America, and metro areas engaged in value-added manufacturing using agricultural and natural resources.
- Increasing the education, skills, and technical capabilities of the workforce to meet current and projected needs of the high-tech, high-productivity agricultural sector and value-chain industries.

It should be recognized that advancements in these and other applied areas are built upon a platform of progress in fundamental, basic-science knowledge that is the result of research undertaken predominantly at academic research institutions, including the land-grant universities. While basic sciences, including biological sciences, have experienced an explosion in discovery and knowledge in recent decades, there is still no shortage of fundamental research questions to be explored. Just in plant biology, for example, the American Society of Plant Biologists¹⁸ notes the importance of advancing research in such fundamental areas as predicting plant traits from plant genomes in diverse environments; finding ways to assemble plant traits in different ways to solve specific challenges; discovering, cataloging, and utilizing plant-derived chemicals; and moving plant biology to a predictive science platform based on big data analytics. Basic science and applied science go hand-in-hand in terms of meeting grand challenges and opportunities in agriculture and associated areas of inquiry.

E. NIFA Support for the American Agricultural Research System

The Government of the United States is a key supporter of agricultural sciences and related research through three primary NIFA funding pathways:

1. **Legislatively mandated “Formula” or “Capacity”¹⁹ funding**, which is funding available exclusively to land-grant university research programs, and their associated extension services designed to support and sustain the specialized personnel, large-scale R&D and testing infrastructure, and geographic coverage afforded by the land-grant universities.

¹⁷ Ibid.

¹⁸ American Society of Plant Biologists. *Unleashing a Decade of Innovation in Plant Sciences: A Vision for 2015-2025*.

¹⁹ “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.

2. **Competitively awarded research funding** administered through NIFA's flagship Competitive grants program, the Agriculture and Food Research Initiative (AFRI), along with other competitive grants programs such as the Specialty Crops Research Initiative, Organic Research and Extension Initiative, and the Biomass Research and Development Initiative, which were established by Congress in the 2008 Farm Bill, as peer-reviewed competitive grants programs for fundamental and applied agricultural sciences.
3. **Internally conducted USDA research** performed within the USDA Agricultural Research Service (ARS) system and the Forest Service.

The federal government also supports agricultural and associated life science, physical science, engineering, and other research relevant to advancing the life sciences and agricultural sector through funding provided by other federal agencies such as the National Science Foundation, the Department of Energy, Environmental Protection Agency, National Institutes of Health, and others.

Table 2 provides a source/performer matrix that summarizes the environment of funding for, and performance of, agricultural research. It shows a research environment in which over \$17 billion was spent on research. As shown on Table 2, federal funding is an important component of the total agricultural research enterprise. As is the case in all research fields where there is a commercial market for innovations, industry is the largest performer and funder of research – comprising \$11.8 billion of the total research funds (69 percent). The commercial imperative to innovate, introduce new products, improve existing products, and sustain productivity increases drives industrial, private-sector research – and the United States is home to a rich tapestry of innovative companies in the development of agricultural production inputs (chemicals, seed, equipment, etc.) and the post-farm-gate processing of agricultural and natural resource output into value-added food, fiber, and industrial products. 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 agricultural research focused on specialty crops, livestock, and agricultural commodities specific to local geographies and production environments. As noted above, federal research also funds work in soils, water, environmental impacts, workforce development, rural development, and other elements critical to the sustainability of the agricultural production ecosystem that would not attract commercial research funding. Government research

Why Federally Funded Agricultural Sciences Research Matters

It is sometimes expressed, typically by those unfamiliar with the true interconnected structure of the American research ecosystem, that government should not be engaged in funding or performing research and that it should be the sole domain of private industry. This is a flawed rationale in general, but especially as it applies to agricultural research for the following reasons:

- Industry does not typically invest in basic science research. Industry cannot afford to undertake high-risk fundamental inquiries that may have a long-term or unknown payback and limited immediate commercial application.
- The agricultural production sector is highly diverse and produces many small and niche crops that are of insufficient scale to support sophisticated R&D programs within industry. Plus, the high degree of variability in geographic production environments means a “one-size-fits-all” commercial product often will not work; and localized customization must occur in terms of varieties, cultivars, soil management, pest management, and other factors.
- Agricultural science is so complex and multidisciplinary that it is a challenge for even the largest commercial agbioscience companies to sustain a scientific workforce capable of transdisciplinary research and the specialized infrastructure required to power in-depth inquiries.
- Multiple important areas of research need are not associated with commercial opportunities to an extent that industry will engage in finding solutions. Areas such as rural community and family sustainability, environmental preservation, soil conservation, trade policy studies, etc., do not naturally lend themselves to commercial research but are nonetheless vital to the ongoing viability and performance of the agricultural value-chain.
- The agricultural value-chain is of such fundamental importance to human health, widespread rural and small community sustainability, and the overall economic and strategic security of the United States that it cannot be solely the domain of private research. There are multiple public issues at stake.

For these, and other reasons, the federal government, through the USDA, has a critically important role to play in performing research and funding research programs at land-grant and other research universities that can address basic and applied science advancement and understanding of specialized local needs.

funding is thus a centrally important component of the U.S. agricultural research system and, as shown on Table 2, federal and state government funding for research approached \$5.3 billion, comprising 31 percent of research funds.

Table 2: Source/Performer Matrix for U.S. Agricultural and Agbioscience Research

FY 2013 Agricultural Research, Development, and Extension		Performer				
		USDA Intramural	LGU-SAES and Cooperating Institutions ^[1]	LGU Extension	Industry	Total
Source	USDA Federal	1,411	824	314	21	2,570
	Other Federal	86	470	--	--	556
	States	--	1,061	406	--	1,467
	Industry and All Other Sources	4	682		11,760	12,446
	TOTAL	1,501	3,037	720	11,781	17,039

Apparent from the discussion above is that agriculture and associated activities are of crucial importance to the well-being of the United States, and that ongoing work is absolutely required to sustain the agricultural sector in the face of multiple challenges and global demand increases. Equally clear is that R&D is crucial to finding solutions to these challenges and that federally funded research is a major component of the agricultural R&D and knowledge transfer system that is deployed in meeting these challenges. Within the federally funded agricultural R&D sphere, it is the USDA that provides most federal resources.

In the federal 2017 budget, the USDA has budgeted “a total of \$2.9 billion for agricultural research and related activities, including: \$1.1 billion that will support approximately 700 research projects in over 90 laboratories of the Agricultural Research Service; \$1.4 billion for extramural research, education, and extension programs of the National Institute of Food and Agriculture; \$177 million for the National Agricultural Statistics Service, and \$91 million for the Economic Research Service. The Budget provides \$700 million for Agriculture and Food Research Initiative (AFRI) Competitive research grants, including \$375 million in discretionary funding and \$325 million in mandatory funding to address key research needs.”²⁰ Additionally, the budget provides approximately \$135 million in Farm Bill mandatory funding, including such programs as the Specialty Crop Research Initiative (SCRI) and the Emergency Citrus Research and Education Program.

The \$0.85 billion in **Capacity Funds** for research and extension currently comprises a major component of the R&D funding programs of the USDA through NIFA. In addition to funding research projects, Capacity Funding is the highly important funding mechanism used in sustaining the specialized academic research infrastructure, geographically diverse experiment stations, specialized intellectual capacity, and the implementation and knowledge-diffusion capabilities of extension contained within the land-grant university system. Capacity Funding supports a pragmatic, proven, and long-standing system that identifies needs, performs research to innovate potential solutions, proves efficacy of solutions in the field, and diffuses them into widespread practice. It does this

^[1] Land-grant universities (LGU) and state agricultural experiment station (SAES) systems.

²⁰ Source: USDA FY2017 Budget Summary. Accessed online at: <http://www.obpa.usda.gov/budsum/fy17budsum.pdf>. Data for Figure 3, entitled The USDA Research Budget in Perspective, are derived from the following sources: NIH = HHS FY 2017 Budget in Brief – NIH (Accessed online at: <https://www.hhs.gov/about/budget/fy2017/budget-in-brief/nih/index.html>); DoE = FY 2017 Department of Energy Budget Request Fact Sheet (Accessed online at: <https://energy.gov/fy-2017-department-energy-budget-request-fact-sheet>); NASA = FY 2017 President’s Budget Request Summary (Accessed online at: https://www.nasa.gov/sites/default/files/atoms/files/fy_2017_budget_estimates.pdf); NSF = FY 2017 Budget Request for the National Science Foundation (NSF) (Accessed online at: <https://www.nsf.gov/about/budget/fy2017/>).

at a level of funding that is quite modest when reviewed against the R&D budgets of other major federal science funding agencies (Figure 8).

F. Conducting an Evaluation of the Capacity Funding Model

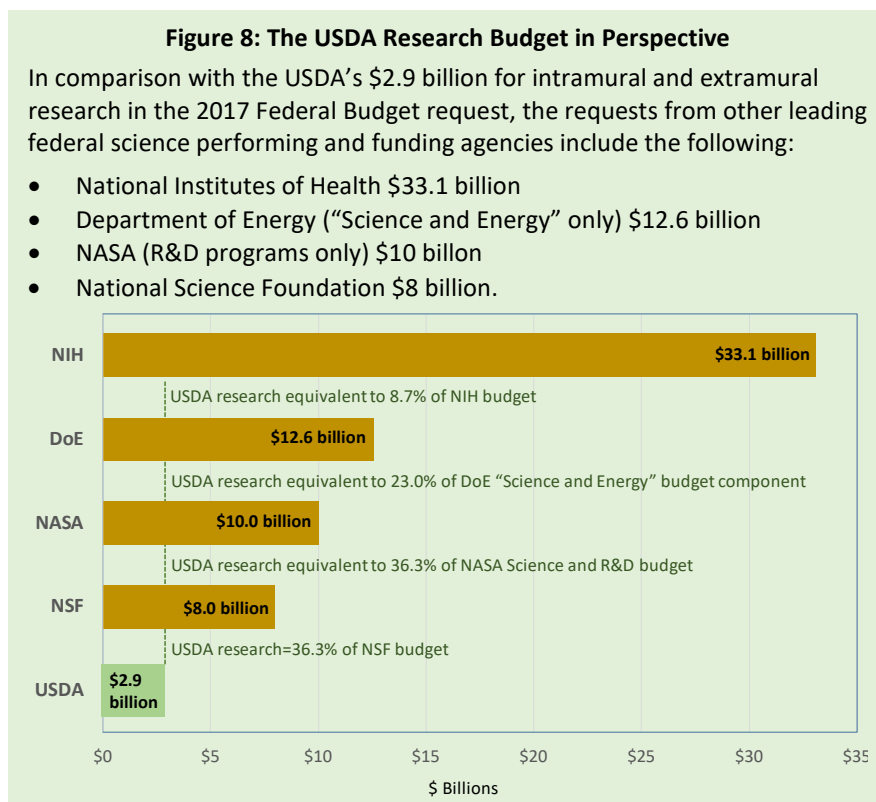
Given the scope of federal funds involved, and the importance of the ongoing challenges needing to be addressed in agriculture and associated areas, it is logical to examine the federal funding mechanisms presently being used by NIFA as to their “fitness to purpose.” It may be that the unique nature of agricultural research lends itself to the predictable, structured, and long-term funding model at the heart of Capacity 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, for example, under the AFRI model. Because Capacity Funding is such a long-standing model, first established in 1862, it is certainly worth considering whether the system is appropriate and relevant to today’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 to undertake an evaluation of Capacity Funding programs and to provide an analysis and overview of impacts being achieved under this funding model.

NIFA’s purpose for commissioning the evaluation is to provide a summative review of Capacity Programs, with the intent that results from the evaluation may be used to:

- Demonstrate the value of the programs to stakeholders and to strengthen NIFA’s focus on evidence-based decision-making.
- Identify research gaps and areas of improvement.
- Leverage the visibility and accountability of Capacity Programs by independent review.

Through the evaluation, NIFA sought to address questions across three categories: 1) Impact, Attribution, and Outcomes; 2) Function and Structure, and 3) Roles. Key questions considered for inclusion in the analysis included:

1. Impact, Attribution, and Outcomes	<p>a. Can sufficient evidence be found and measured for Capacity Programs’ main impacts? Are there examples where specific interventions led to successful outcomes and attribution of cause and effect can be adequately supported with evidence?</p> <p>b. Have Capacity Programs contributed to the broad field of agriculture and increase the performance of agricultural systems? If so, how? What fundamental capacities were built across the land-grant institutions due to Capacity Programs?</p> <p>c. Is the return on investment through Capacity Programs commensurate with the level of funding?</p> <p>d. To what extent have participating institutions been able to seize opportunities, foster innovation, and take risks on promising initiatives funded through Capacity grants?</p>
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	<p>e. Is there evidence that the Capacity Funds are a primary tool used by institutions to remain agile and adaptable to changing priorities and external factors?</p> <p>f. Is there evidence that, in the absence of Capacity Funds, agricultural sciences and production would be detrimentally affected?</p> <p>g. What are the challenges that these programs face in moving forward? What barriers prevent these programs from addressing the challenges?</p>
2. Function and Structure	<p>a. Are Capacity Funds, as currently designed, still the best way to support capacity building in the field of agriculture?</p> <p>b. Is there variability across institutions in the structure and process by which individual projects are supported with Capacity Funds? If so, do some structures and/or processes lead to higher returns on investment than others?</p> <p>c. To what extent have Capacity Funds allowed recipient institutions to compete successfully for Competitive funds and leveraged additional funding, from NIFA and from other federal agencies such as NSF, NIH, DOE, etc.?</p> <p>d. Are there opportunities to enhance the integration of research and extension and eliminate barriers at the regional and national level?</p>
3. Roles	<p>a. What role has the partnership between NIFA staff and LGUs played in the overall programs achieving their strategic goals?</p> <p>b. Are there recommendations for improving this partnership?</p>

TEconomy Partners (TEconomy) brings to the project an established reputation in the analysis of U.S. science and agricultural sciences, their importance and relevance to major grand challenges and opportunities, and the R&D enterprises and institutes engaged in performance of research and extension activities. Formerly comprising principals in the Battelle Technology Partnership Practice, TEconomy Partners became an independent research firm in 2015, continuing more than a decade of work in evaluating and reporting the economic and functional impacts of science, including agricultural science. The research team at TEconomy has authored multiple studies for states and regions in the United States focused on R&D core competencies and opportunities for agricultural and agbioscience-based development, and have been engaged in evaluating the impact of agricultural research and extension activities at multiple universities and for multistate associations representing research universities, experiment stations, and extension services. TEconomy's knowledge and perspectives regarding agricultural sciences R&D and development opportunities have also been deployed in service to private industry and in the profiling of opportunities for focused research park and new transdisciplinary agbioscience R&D building developments.²¹

G. Research Questions, Project Methodology, and Report Structure

Given the substantial volume of Capacity Funds provided to the agricultural research enterprise in the United States, and the very long-term commitment shown to this funding model by the Federal government, it does behoove the nation to examine what it is receiving in today's modern research environment under this funding system and whether the system could be amended, refined, or revisited to provide enhanced research impacts for the nation. As the Director of NIFA, Dr. Sonny Ramaswamy noted in discussions upon initiation of this project: *"We want to get a better sense of what the taxpayer gets for the approximately \$850 million a year"* in Capacity Funds.

The research methodology developed by TEconomy for the evaluation and impact assessment of Capacity Funding was structured to provide coverage of the following:

- An overview of NIFA's Capacity Funding programs and the general categorization of research topics addressed.
- The core challenges being addressed through research supported by Capacity Funding, and the suitability of this funding mechanism to the support of said research.

²¹ TEconomy principals leading the USDA Capacity Funding evaluation study (Simon Tripp and Martin Grueber) were also authors of the highly-cited research report, *The Economic Impact of the Human Genome Project*, which evaluated impacts associated with another major federally funded research initiative.

- Future issues and grand challenges needing to be addressed in agricultural sciences and the suitability of the Capacity Funding model for supporting that research.
- The financial leverage and expansion of research capacity achieved for the agricultural research enterprise through state funds matching.
- Quantitative and comparative metrics pertaining to research outputs as measured by publications, citations, intellectual property development, and associated patent citations, etc. Comparisons with AFRI Competitive Funding outputs are made where possible.
- The value associated with special characteristics of Capacity Funds, such as ability to address local and individual state needs, support for long-term research programs, ability to attract local matching funds, extension diffusion of innovations, and other factors as identified over the course of the analysis.

While Competitive Funding, under AFRI and other programs, is available to support worthy proposals introduced by any researcher within any university or research setting, it has been hypothesized that the unique characteristics of Capacity Funding may well have advantages of their own associated with the following:

- Sustained long-term support of the specialized infrastructure required for performing agbioscience research;
- The ability of land-grant programs to direct research toward specialized and niche needs in their localities that otherwise might not be regarded as nationally significant under an external national review model; and
- The ability of an integrated research and extension system to effectively diffuse new knowledge and innovations into practice.²²

A previous report for the President's Council of Advisors on Science and Technology (PCAST)²³ recommended that the United States should increase its investment in agricultural research by a total of \$700 million per year in recognition of the scope of challenges addressed by agricultural research and its substantial economic and strategic importance to the United States. There is strong agreement that more research funding is needed, and certainly considerable room to move USDA-funded research toward levels of other major federal research funding agencies (Figure 3). Controversy has occurred, however, regarding the additional conclusions of the PCAST report that: *"the focus of USDA research funding shift toward competitive grants, gradually rebalancing the research portfolio for intramural funding and funding for land grant institutions to incorporate incentives for innovation consistent with other research agencies across the Federal Government."* This conclusion is of concern to many in the land-grant university system and its myriad stakeholders who contend that a major shift to Competitive Funding models, away from Capacity Funding, would undermine the ability of universities to sustain the special infrastructure required for agricultural research, specialized research focused on state and local needs, and the practical focus on translating research innovations into improved agricultural practice via extension. Without the assurance of funds provided by Capacity Funding, there is concern that the specialized and unique system that has been developed for agricultural research and extension activities will be unsustainable and unravel. The TEconomy analysis of Capacity Funding program impacts herein considers this risk and examines the characteristics of the current funding system considering modern needs, challenges, and risks.

The research design developed by TEconomy (Figure 9) uses analysis of existing data from multiple sources to provide a detailed overview of the NIFA Capacity Funding programs and the 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 these funding models. Using quantitative data, TEconomy reports 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, TEconomy has deployed real-text statistical clustering software (Omniviz™) on research impact statements contained in the NIFA Research, Extension, and Education Project Online Reporting Tool (REEPort) system and Cooperative Extension impact statements contained

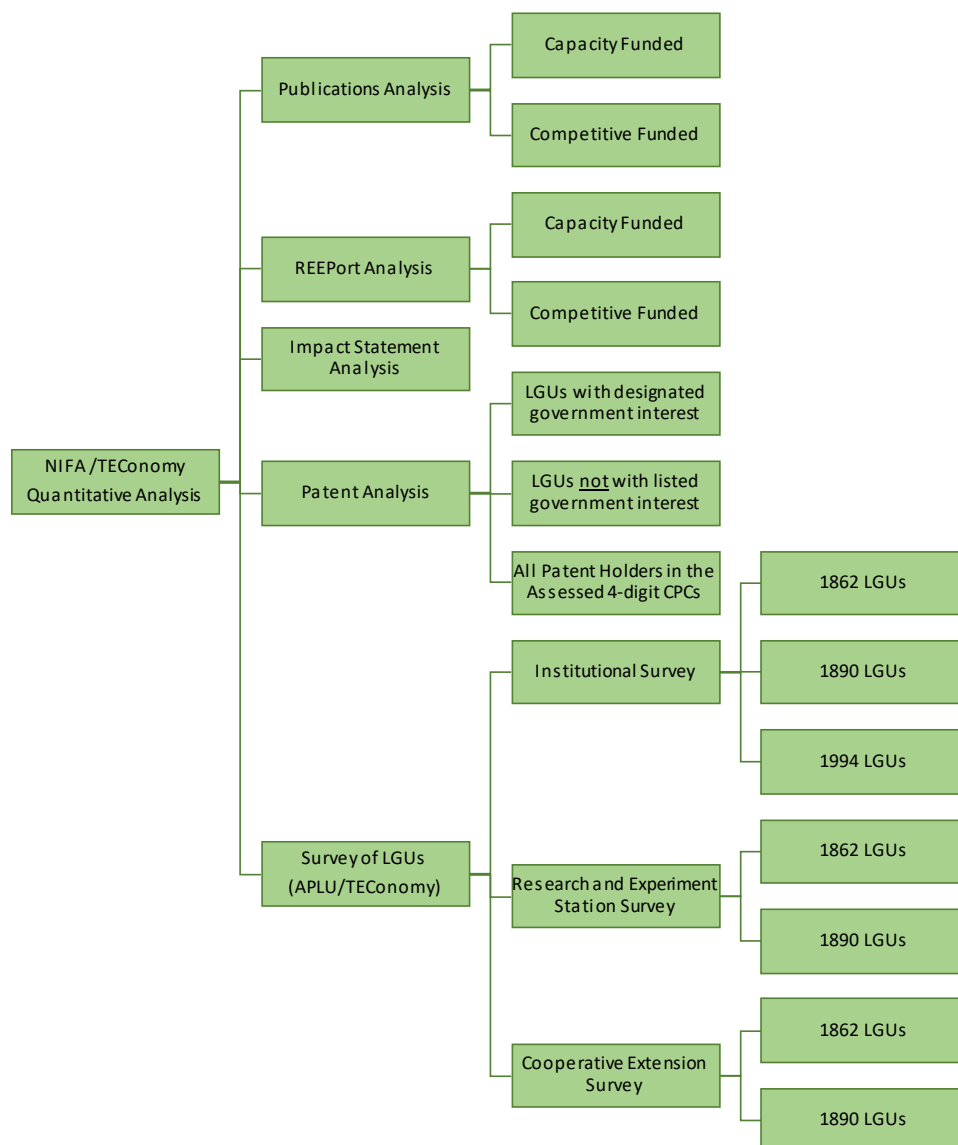
²² Discussion of these factors, and others, can be found in Huffman, Wallace E., George Norton, Greg Traxler, George Frisvold, and Jeremy Foltz. 2006. *Winners and Losers: Formula versus Competitive Funding of Agricultural Research*. Choices, 21(4).

²³ The President's Council of Advisors on Science and Technology. 2012. *Report to the President on Agricultural Preparedness and the Agriculture Research Enterprise*.

in the Land-Grant Impacts Database maintained at Texas A&M University AgriLife Extension Service to enable identification and classification of key areas of functional and applied impacts.

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 Capacity Funding and their thoughts on the comparative strengths and weaknesses of Capacity and Competitive Funding models. APLU generously provided resources and assistance in the deployment of the Land-Grant University surveys, which were distributed to all 1862, 1890, and 1994 institutions. The distribution of the survey instrument to the 1994 institutions was further facilitated through assistance provided by the American Indian Higher Education Consortium.

Figure 9: Capacity Funding Evaluation Program Overview



The large-scale datasets collected through the surveys of institutions receiving Capacity Funds, in combination with the quantitative analysis of NIFA and other existing database resources, have allowed wide-ranging analysis to be performed of the characteristics of Capacity Funding and its uses by the land-grant universities versus Competitive grant funding. The APLU support of the surveying allowed the surveys to also cover additional questions of interest to the APLU and NIFA beyond the core questions focused on the key research goals. Additional survey questions

were pursued in relation to administrative requirements pertaining to Capacity Funds and suggestions for improving processes, mechanisms used by the universities for allocating Capacity Funds received, the scale of faculty and staff supported through Capacity Funds and trends in these numbers, perceptions of factors influencing the ongoing availability of funds for research and extension, anticipated impact on matching state and local funds were Capacity Funding reduced, and examples of highly impactful research and extension programs that have been generated through Capacity Funding.

Because of the size and scope of data – particularly data collected through the multiple surveys administered– TEconomy has produced a separate Technical Appendix Report as a supplement to the overall summary report herein. The Technical Appendix Report contains the full findings and analysis from the surveys and should be of considerable interest and utility to NIFA, APLU, individual universities, research and extension funders, and the research community.

The report is divided into three principal sections:

- **Section I:** Contains the Executive Summary of overall project findings.
- **Section II:** Containing Chapter I includes the introduction and background to the report and Chapter II presenting quantitative and qualitative findings from TEconomy’s review of datasets covering outcomes and outputs generated via NIFA Capacity and Competitive research funding.
- **Section III:** Provides results from the surveys administered to key leadership at the 1862 and 1890 land-grant universities in Chapters III through VI. Chapter VII presents findings from the survey of 1994 Tribal Land-Grant Colleges and Universities.

II. Outcomes and Outputs

With \$0.85 billion currently going to Capacity Funding and \$0.7 billion budgeted for NIFA-funded Competitive research²⁴, it is important to examine, objectively, what outputs are occurring for the nation via USDA extramural funding of research and associated activities. To address this question, TEconomy accessed the data resources noted in Table 3 and Figure 10 to examine quantitative metrics of research output and extension activity.

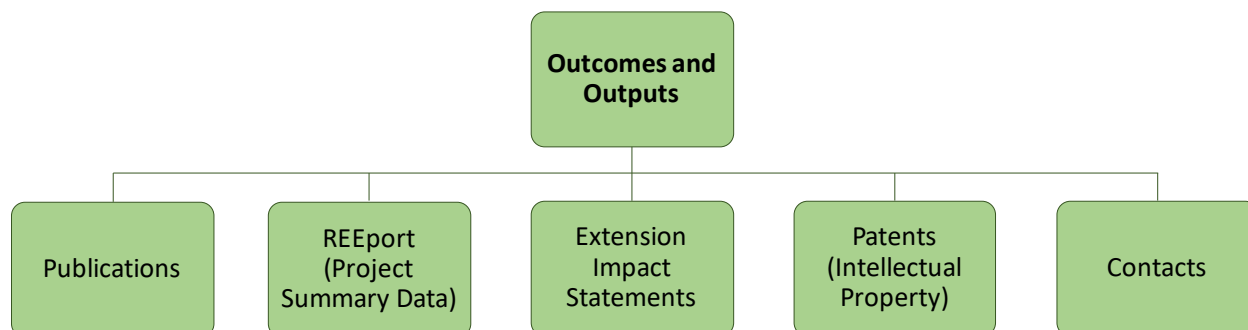
Table 3: Analysis of Outputs for Research and Extension at Land-Grant Universities

Output	Data Source and Description	Analysis
Publications	Publications analysis is performed using Clarivate Analytics' (formerly Thomson Reuters) Web of Science™ database. The data used in this analysis include peer-reviewed journal articles, reviews, and conference proceedings papers. The dataset includes documents from 2010 through 2016. This analysis includes all disciplines associated with agriculture, forestry, fisheries, and natural resources and is not limited to publications from research funded by NIFA. As such, it provides a baseline for comparison of the segmentation of subject matter in all agricultural research areas with which subsequent analysis of NIFA-funded projects may be compared.	OmniViz™ real-text cluster analysis of publication titles and abstracts to identify metaclusters, themes, and subthemes (see Figure 13) in the literature extant. A total of 123,790 records are included in the analysis.
Research and Extension Project Summaries	For the analysis of NIFA Capacity and Competitive funded projects, TEconomy was provided with annual data sets from the Research, Extension, and Education Project Online Reporting Tool (REEport), NIFA's grant reporting system, for the years 2010–2015. This consolidated dataset includes detailed descriptive information regarding the objectives, performance, and ongoing impacts of both Capacity and Competitive funded projects, including financial information regarding both NIFA funding and related state, local and industry funding.	OmniViz™ real-text cluster analysis of NIFA-funded projects in the REEport System. Separate analyses run for Capacity (n=19,791) and Competitive funded projects (n=2,299).
Extension Impact Statements	To further explore the impacts of NIFA-funded cooperative extension activities, TEconomy analyzed the extension-related impact profiles maintained in the Land-Grant Impacts portal, a cooperative system of capturing project impacts, maintained by Texas A&M AgriLife Extension. This voluntary database allows Cooperative Extension offices to document the breadth, impact, and importance of extension-related services delivered throughout the United States. ²⁵	OmniViz™ real-text cluster analysis of 1,418 impact statements from extension service projects nationwide.
Patents	Patent analysis is performed using the Clarivate Analytics "Thomson Innovation" patent database. The data used in this analysis include all issued U.S. patents from 2010–2016 within a set of key patent classes considered by TEconomy to be relevant to the USDA mission (using the Cooperative Patent Classification (CPC) system now used by the U.S. Patent and Trademark Office). Appendix J provides the patent class list. Analysis is performed of patents and forward citation of patents (to assess linkages to subsequent downstream innovation that may be rooted in original LGU-performed research).	Analysis of 23,512 total U.S. patents granted in relevant classes, including 950 patents where LGUs are one of the original assignees. Analysis also of forward citation data for these patents.
Contacts	Cooperative Extension through the Land-Grant Universities transfers knowledge and provides education to key groups and individuals by both direct and indirect contacts. LGUs report both direct and indirect contacts to NIFA in an annual "Plan of Work." Data regarding contacts are summarized for 2010 through 2015.	Summary of NIFA Plan of Work data for Cooperative Extension contacts.

²⁴ Competitive Funding includes AFRI, plus Mandatory Programs including the Specialty Crops Research Initiative (SCRI), Organic Agriculture Research and Extension Initiative (OREI), Beginning Farmers and Ranchers Development Initiative, and Biomass Research and Development Initiative (BRDI), and smaller Competitive Programs.

²⁵ This dataset recently began including agricultural research impacts, in addition to extension impacts. However, at the time of TEconomy's analysis, it was concluded that the number of research impact profiles was too few to allow for detailed analysis. This will, however, form a valuable resource for research evaluations in the future as the number of research impact statements grows.

Figure 10: Categorization of Outcomes and Outputs Examined

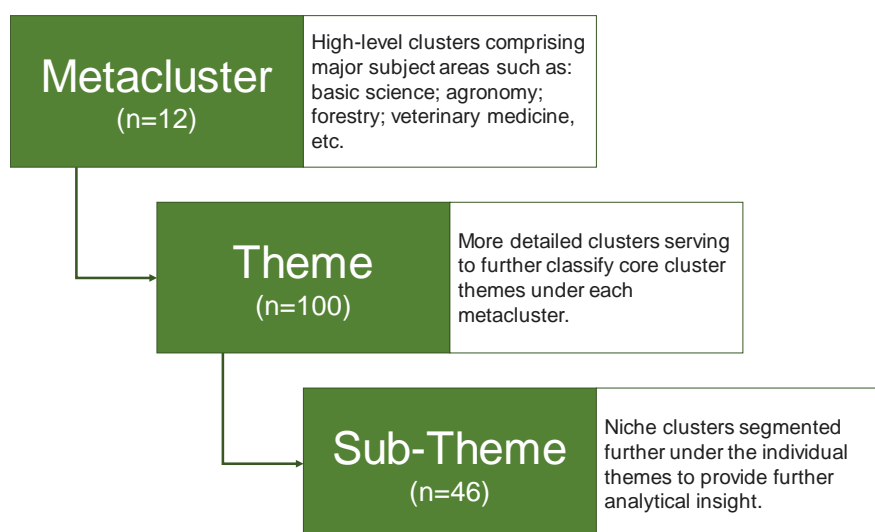


A. Publications Analysis

To establish a baseline for the segmentation of agriculture, forestry, fisheries, and natural resources research, TEconomy performed a cluster analysis of the Clarivate Analytics *Web of Science*[™] database for journal publications, articles, and conference proceedings publications in relevant disciplines. A total of 123,790 publications were included in the analysis (for 2010 through 2015). These data include all listed publications and do not provide details on the source of funds used for the research. As such, the analysis just establishes a baseline for the structure of the agriculture and related-disciplines' academic literature overall and is not limited to publications from research funded by NIFA.

A real-text cluster analysis was performed on the full dataset using the OmniViz[™] analysis system. The cluster analysis produced 100 total clusters comprising 108,180 total publications (with 15,610 publications clustering into an "artifact" cluster not incorporated in the final analysis). The 100 clusters were reviewed and provided with descriptive names for their content in a three-level hierarchy as summarized on Figure 11. In addition, Clarivate Analytics assigns a research area classification to each publication, and the percent segmentation for the highest order of this classification system is included herein also.

Figure 11: Three-Level Hierarchy of Publications Cluster Analysis (108,180 Publications Analyzed)



The use of OmniViz[™] cluster analysis allows the text of titles and abstracts of publications to be analyzed objectively, with no *a priori* categorization used. OmniViz[™] uses real-text pattern-recognition algorithms to analyze the titles and abstracts of research publications, allowing for free association based on the usage of words and

phrases rather than forcing clustering based on preselected key words. Thus, there is no *a priori* bias to the clusters identified. This analysis also has an advantage of being well suited to identifying multidisciplinary research areas that are often difficult to identify in traditional academic disciplinary classifications.

Figure 12 shows the clustering results for the *Web of Science*™ 2010–2015 data segmented into metaclusters (total color blocks) and associated themes (interior segments within each color block). For readers preferring to access data in tabular form, TEconomy has included data tables for each chart in the appendices and notes the relevant appendix in the title of each figure.

Figure 12: Percentage Segmentation of Publications across Key Disciplines (OmniViz™ Cluster Analysis of 108,180 Publications) **Metaclusters and Associated Themes** (Data Table in Appendix E)

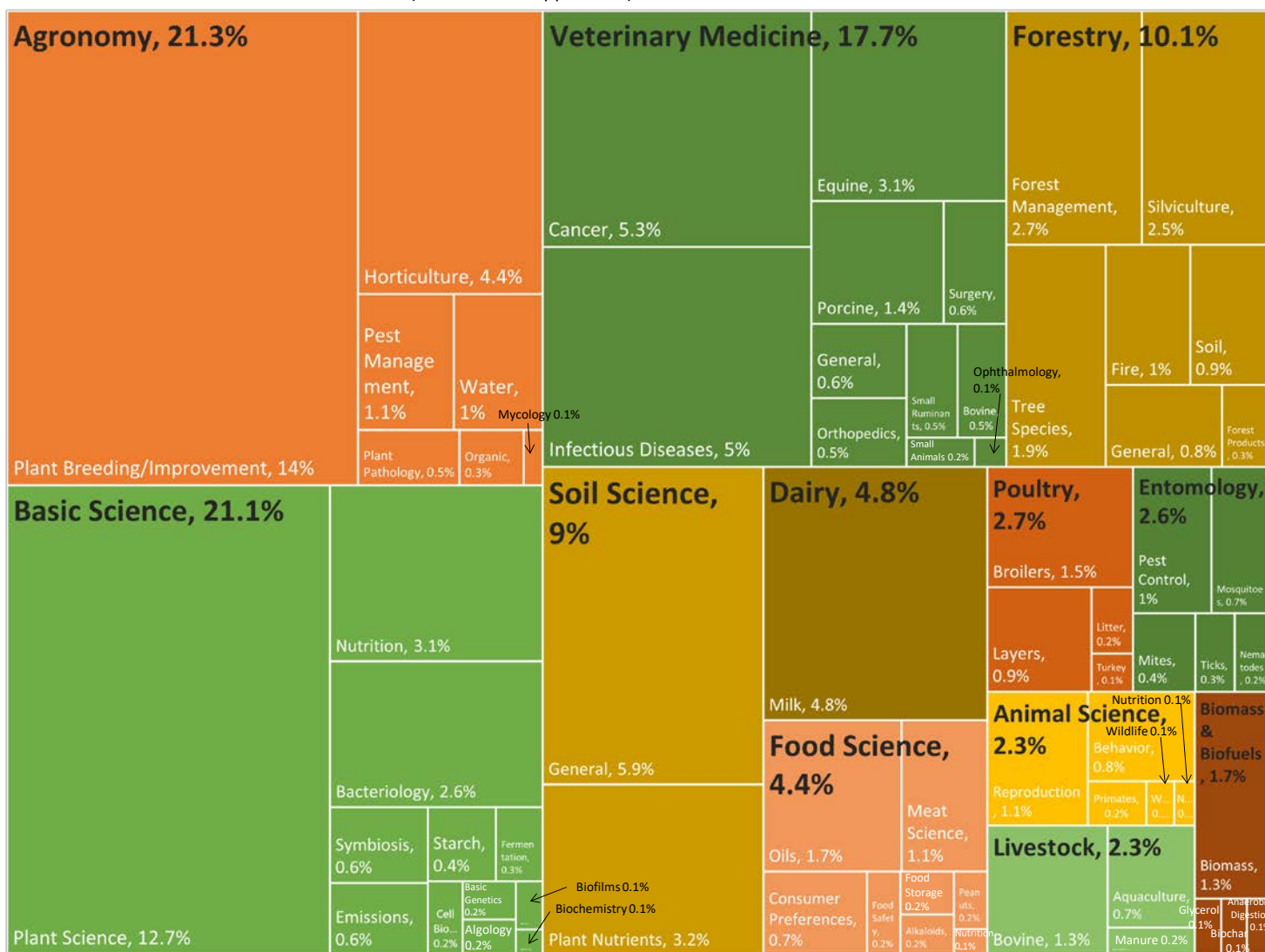


Figure 13 adds a further degree of depth to the analysis, showing subthemes (outer slices) as a level beyond the metaclusters (inner circle) and themes (middle circle).

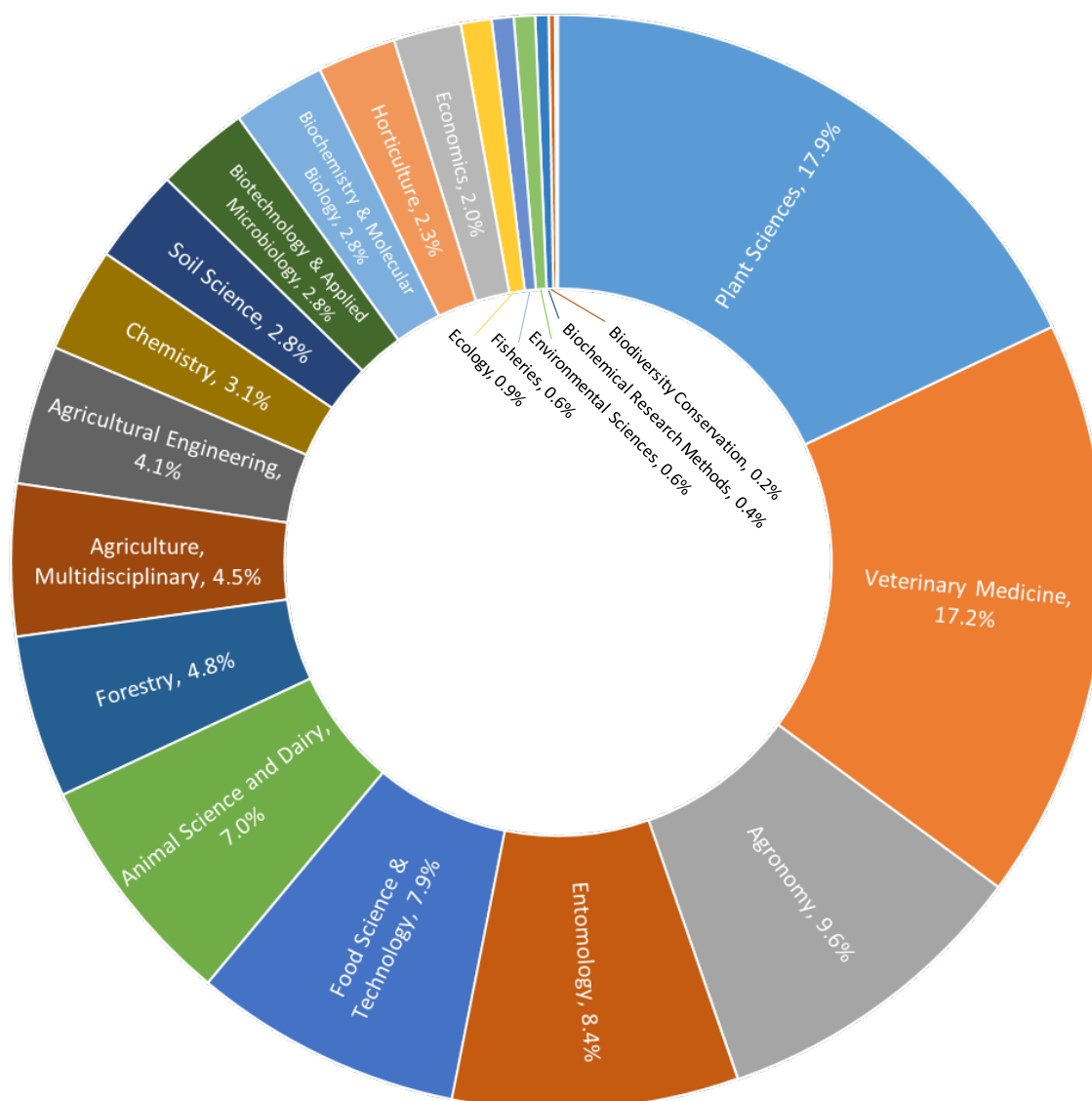
Figure 13: Percentage Segmentation of Publications across Key Disciplines (OmniViz™ Cluster Analysis of 108,180 Publications) Metaclusters, Associated Themes, and Subthemes (Data Table in Appendix F)



Again, the OmniViz™ analysis is “pure” in that it works by “reading” the publication titles and abstracts and is not rooted in prior classification schemata. The same cluster analysis technique is used in the analysis of REEreport data for both Capacity and Competitive funded projects, and the Extension Impacts dataset – thereby facilitating comparison in regards to apparent emphasis areas.

Clarivate Analytics also assigns a research area classification to each publication, and the clustering of classifications at the highest order of their classification system is shown in Figure 14. This classification scheme is more rooted in traditional academic discipline names.

Figure 14: Percentage Segmentation Using *Web of Science*™ Classifications



B. REEport Data Analysis (NIFA-Funded Project Data)

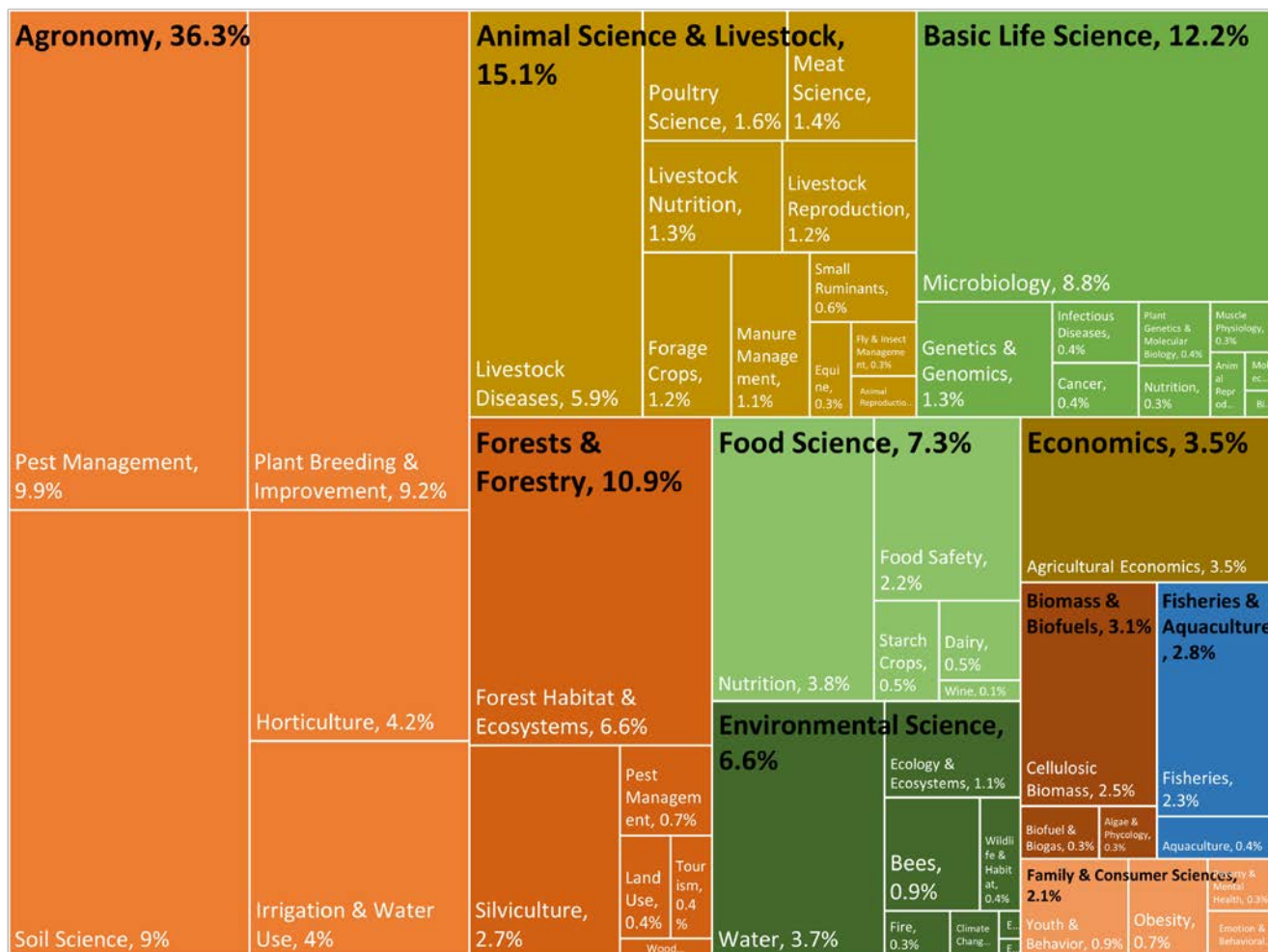
The Research, Extension, and Education Project Online Reporting Tool (REEport) data system at NIFA provides details for individual projects funded via Capacity and Competitive Funding processes. The coding contained within the dataset allows for identification of which projects are Capacity funded and which are supported by Competitive AFRI (or National Robotics Initiative [NRI]) funding.

TEconomy imported the REEport data, for the years 2010–2015, into the OmniViz™ real-text cluster analysis software to allow projects to be clustered by theme. The analysis, performed separately for Capacity and Competitively Funded projects, allows for comparison of the output, illustrating where there are differences in the type of projects pursued under Capacity and Competitive Funding models.

1. Capacity funded Projects in the REEport System

Figure 15 summarizes the clustering results for Capacity funded projects into metaclusters (total color blocks) and associated themes (interior segments within each color block). In total, the analysis covers 19,791 distinct Capacity funded projects.

Figure 15: Percentage Segmentation of 19,791 Capacity Funded Projects (REeport Data for 2010–2015) across Metaclusters and Associated Themes (Data Table in Appendix G)



It is evident that, in comparison to the *Web of Science*[™] total agbioscience dataset, **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*[™] dataset, 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 more 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. Similarly, Fisheries and Aquaculture has a Capacity funded cluster (2.8 percent of records), indicating an importance within Capacity funded activities above that observable in the overall literature.

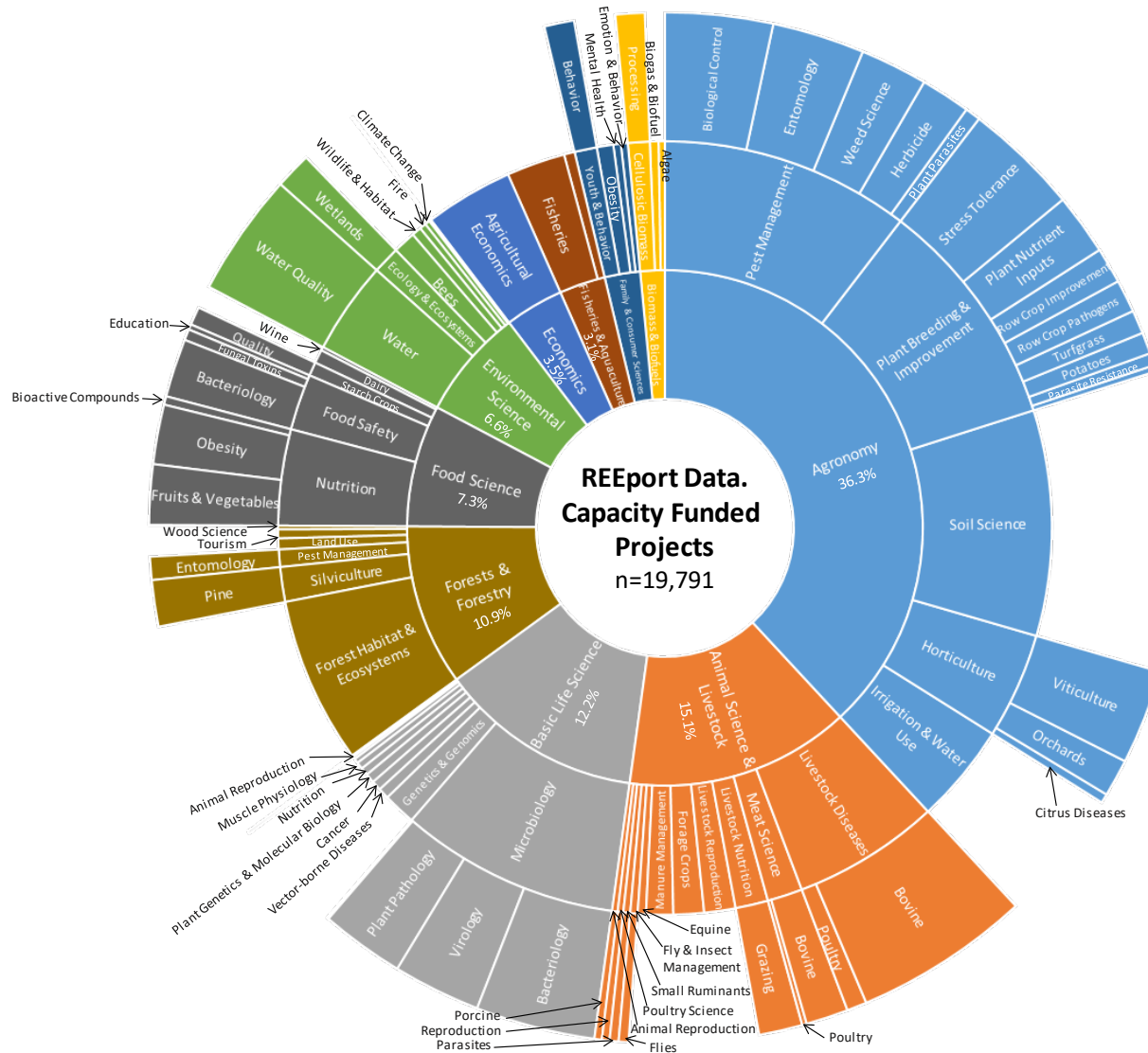
It is also notable that Agricultural Engineering does not produce a distinct cluster in either of the cluster analyses, although Figure 14 shows this discipline makes up 4.1 percent of the relevant *Web of Science*™ records. It is likely the case that this discipline’s research is divided out within the cluster analysis into multiple themes (e.g., Irrigation, Pest Management, Soil Science, Food Science, etc.).

Overall, the comparison between the Capacity funded and *Web of Science*™ datasets illustrates a generally focused inquiry through Capacity Projects on **applied research** – research focused toward current and emerging issues facing agriculture and natural resource sectors and communities.

CONCLUSION: Capacity funded research, in comparison with all research conducted in agriculture and associated disciplines, demonstrates a cluster structure that is more oriented toward applied research and downstream value-added activities in food and biomass industries.

Figure 16 provides further depth of analysis, allowing a further level of subthemes to be shown below the metaclusters and themes.

Figure 16: Percentage Segmentation of Capacity Funded Projects (REeport Data for 2010–2015) across Metaclusters, Associated Themes, and Subthemes (Data Table in Appendix G)



CONCLUSION: Over the 15-year period 2000–2015, almost 20,000 individual capacity-funded projects have been performed, with these clustering around 10 metacluster themes. While projects are diverse, approximately two-thirds (65.4 percent) have been focused in “production”-oriented areas, including Agronomy, Animal Science and Livestock, Fisheries and Aquaculture, and Forests and Forestry.

CONCLUSION: While 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 funded projects for 2000–2015, fundamental science (Basic Science) inquiry makes up 12.2 percent (2,414 projects). These are heavily focused in basic *life* sciences, with Microbiology and Genetics and Genomics comprising the largest subclusters therein.

2. Competitive (AFRI/NRI) Funded Projects in the REEport System

Figure 17 summarizes the clustering results for Competitive AFRI/NRI funded projects into metaclusters (total color blocks) and associated themes (interior segments within each color block). In total, the analysis covers 2,299 distinct Competitive funded projects.

Figure 17: Percentage Segmentation of 2,299 Competitive Funded Projects (REEport Data for AFRI/NRI Grants 2010–2015) across Metaclusters and Associated Themes (Data Table in Appendix H)

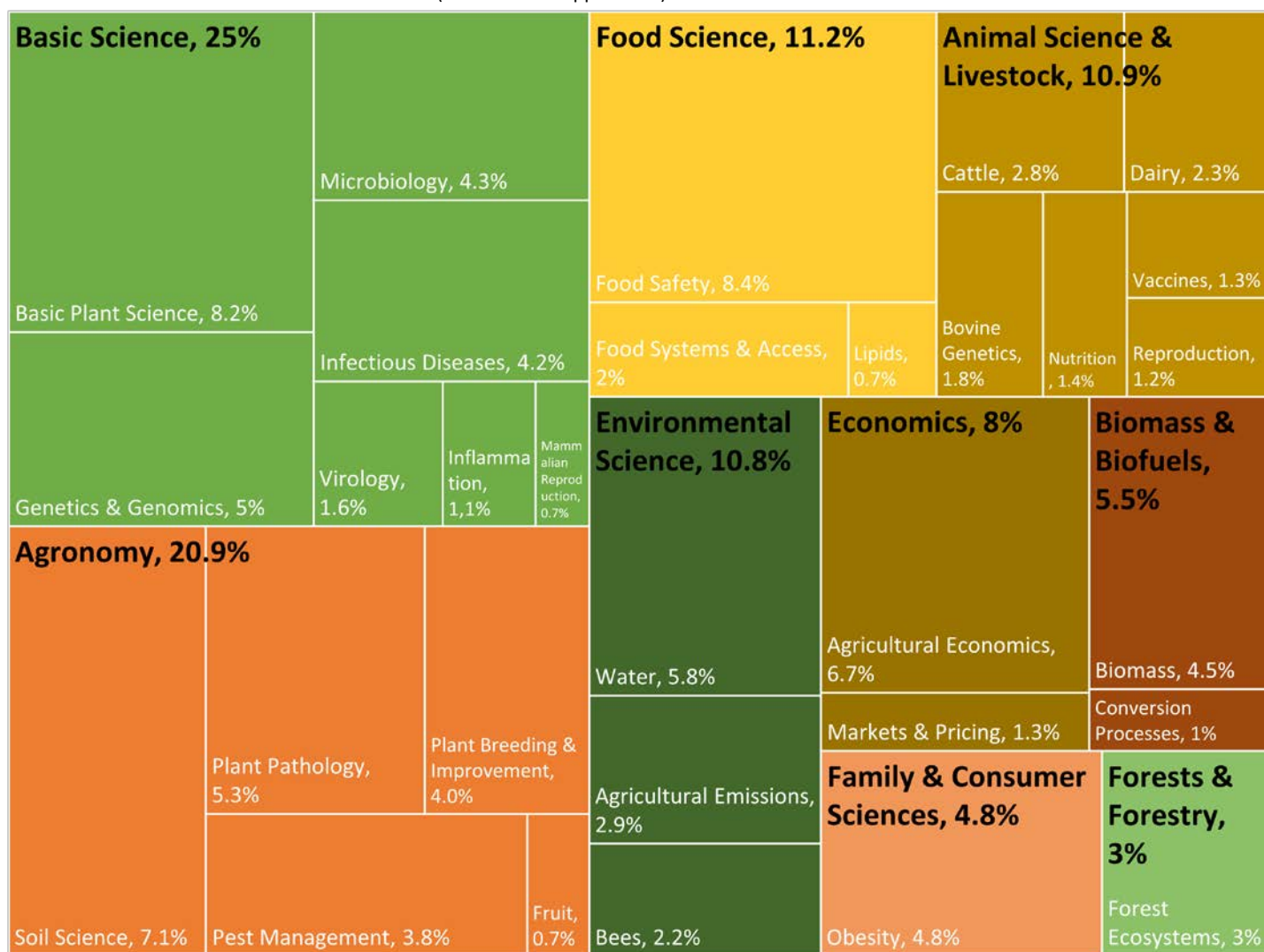
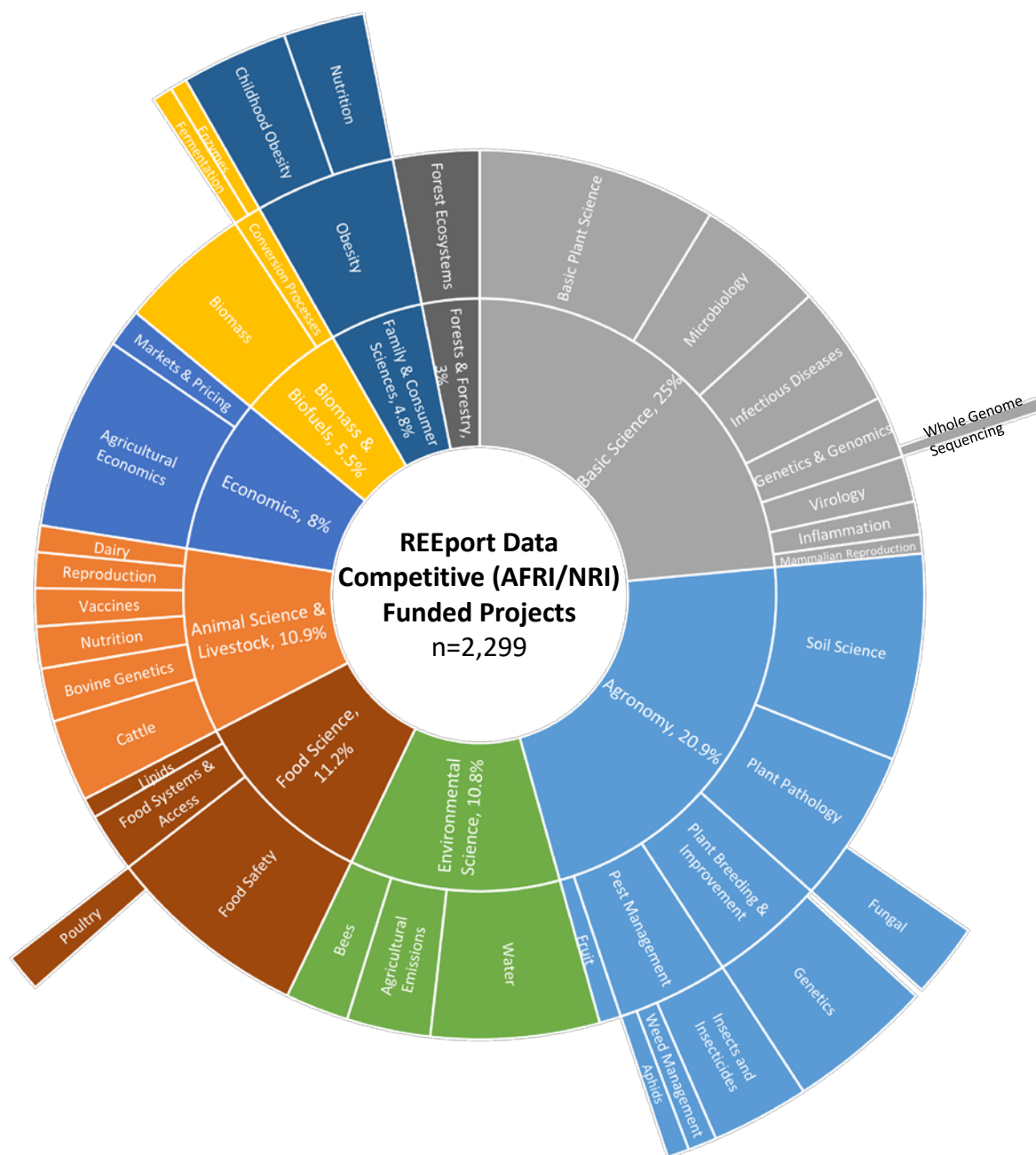


Figure 18 provides further depth of analysis of NIFA Competitively funded projects, allowing a further level of subthemes to be shown below the metaclusters and themes.

Figure 18: Percentage Segmentation of Competitive Funded Projects (REeport Data for 2010–2015) across Metaclusters, Associated Themes, and Subthemes (Data Table in Appendix H)

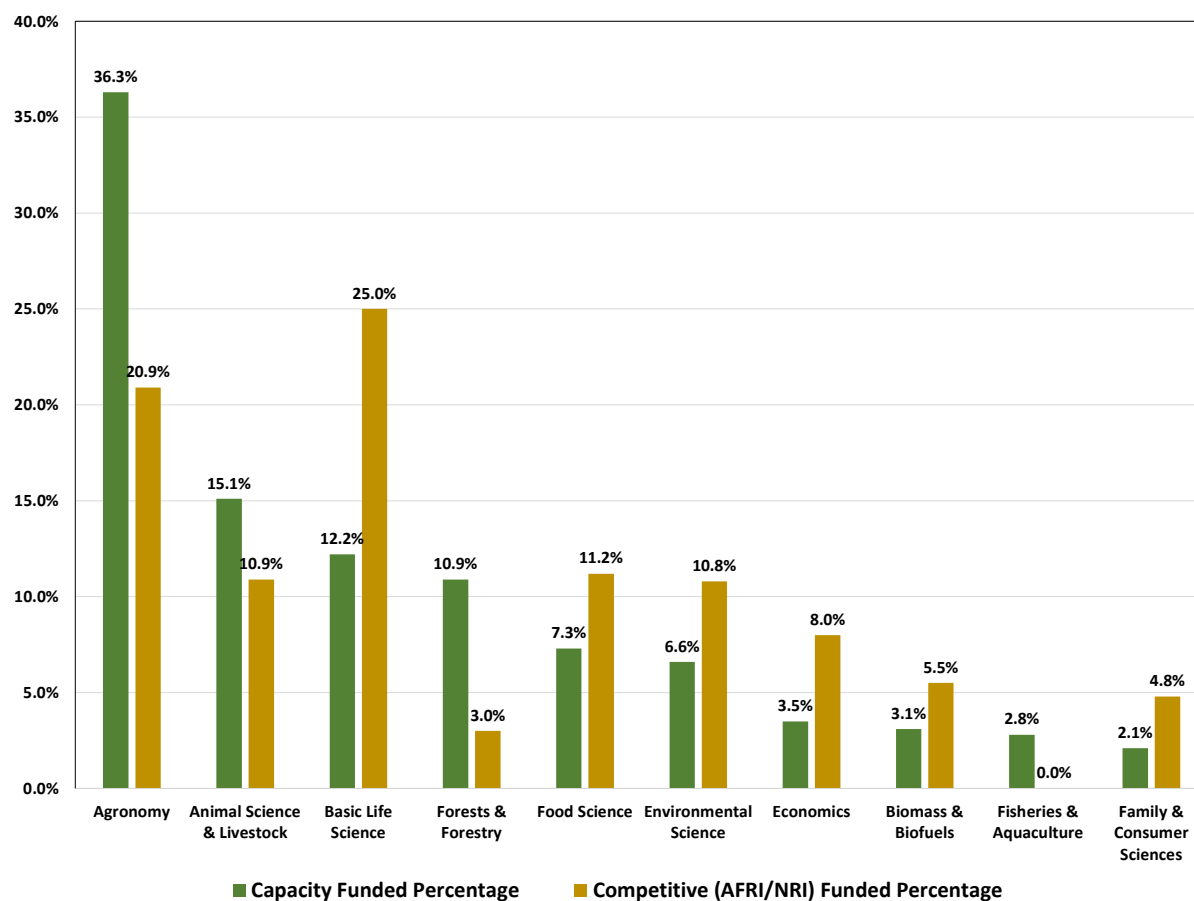


3. Comparing Capacity and Competitive (AFRI/NRI) Funded Project Metaclusters

Table 32 compares the results of the Capacity and Competitive funded projects clustering analysis. As would be expected, given the substantially larger numbers of records in REeport for Capacity funded projects (19,791) versus Competitive (2,299), the Capacity cluster analysis produces more themes and subthemes under each metacluster. The metaclusters for each of the funding sources are similar (except for the absence of a Fisheries and Aquaculture cluster in the Competitive analysis), but they differ considerably in terms of the percent of the total records that

each metacluster makes up for the respective funding types. Figure 19 illustrates these differences in the research output/emphasis of the two respective funding models. The biggest differences can be observed in double the percentage emphasis on Basic Life Science in the Competitively funded project universe when compared with Capacity funded projects – and in significantly more Capacity funded projects focused in Agronomy (comprising Plant Breeding and Improvement, Pest Management, Soil Science, Horticulture, and Irrigation and Water Use Management). Animal Science and Livestock also has a more significant emphasis in the Capacity funded portfolio than in the Competitive funded portfolio (15.1 percent and 10.9 percent, respectively). Forests and Forestry as a percentage of the Competitive portfolio is more than three-times smaller than under Capacity Funding, whereas several other metaclusters show a higher emphasis in terms of Competitive Funding (including Food Science, Environmental Science, Economics, Biomass and Biofuels, and Family and Consumer Sciences).

Figure 19: Comparative Percentage Segmentation of Capacity and Competitive Funded Projects (REeport Data for 2010–2015)



CONCLUSION: NIFA capacity and Competitive Funding demonstrate substantially different degrees of emphasis in terms of projects undertaken. **Capacity Funding is more likely to focus on production agriculture-oriented research projects** (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, challenges, and opportunities at a state, regional, or local level. **Competitive Funding skews more to an emphasis on Basic Life Sciences** (having double the emphasis here as seen in Capacity funded projects) and demonstrates marginally more 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 of REeport data and the expressed opinions of the 1862 Land-Grant survey respondents regarding which source of funding (Capacity or Competitive) is better suited to which topic area in agriculture and associated disciplines.

4. Comparing Capacity and Competitive (AFRI/NRI) Funded Project Metaclusters and Themes on the Six NIFA National Challenge Areas

In reviewing the cluster analysis of the respective portfolios of projects classified as either Capacity funded or Competitive funded, a comparison can be made of the alignment between these project portfolios and the six NIFA National Challenge Areas. Table 4 lists both the Capacity funded and Competitive funded project metaclusters and themes and their relationship, in terms of likely subject matter, to each of the six NIFA National Challenge Areas.

Table 4: Comparing Capacity and Competitive (AFRI/NRI) Funded Project Metaclusters and Themes as Identified in Analysis of REEport System Data on the Six NIFA National Challenge Areas

NIFA National Challenge	CAPACITY FUNDED Metaclusters (Percent of Total)	CAPACITY FUNDED Themes (Percent of Total)	COMPETITIVE FUNDED Metaclusters (Percent of Total)	COMPETITIVE FUNDED Themes (Percent of Total)
1. Food Security	<ul style="list-style-type: none"> • Agronomy (36.3%) • Animal Science and Livestock (15.1%) • Fisheries and Aquaculture (2.8%) 	<ul style="list-style-type: none"> • Pest Management (9.9%) • Plant Breeding and Improvement (9.2%) • Soil Science (9%) • Horticulture (4.2%) • Irrigation and Water Use (4%) • Livestock Diseases (5.9%) • Meat Science (1.4%) • Livestock Nutrition (1.3%) • Livestock Reproduction (1.3%) • Forage Crops (1.2%) • Manure Management (1.1%) 	<ul style="list-style-type: none"> • Agronomy (20.9%) • Animal Science and Livestock (10.9%) 	<ul style="list-style-type: none"> • Pest Management (3.8%) • Plant Breeding and Improvement (4%) • Soil Science (7.1%) • Vaccines (1.3%) • Animal Nutrition (1.4%) • Reproduction (1.2%) • Dairy (2.3%) • Cattle (2.8%) • Bovine Genetics (1.8%) • Fruit (0.7%) • Plant Pathology (5.3%)
2. Climate Variability and Change	<ul style="list-style-type: none"> • Environmental Science (6.6%) 	<ul style="list-style-type: none"> • Climate Change (0.2%) 	<ul style="list-style-type: none"> • Environmental Science (10.8%) 	<ul style="list-style-type: none"> • Agricultural Emissions (2.9%)
3. Water	<ul style="list-style-type: none"> • Environmental Science (6.6%) • Agronomy (36.3%) 	<ul style="list-style-type: none"> • Water Resources and Water Quality (3.7%) • Irrigation and Water Use in Agriculture (4%) 	<ul style="list-style-type: none"> • Environmental Science (10.8%) 	<ul style="list-style-type: none"> • Water (5.8%)
4. Bioenergy	<ul style="list-style-type: none"> • Biomass and Biofuels (3.1%) 	<ul style="list-style-type: none"> • Cellulosic Biomass (2.5%) • Biofuels and Biogas (0.3%) • Algae and Phycology (0.3%) 	<ul style="list-style-type: none"> • Biomass and Biofuels (5.5%) 	<ul style="list-style-type: none"> • Biomass (4.5%) • Conversion Processes (1%)
5. Childhood Obesity	<ul style="list-style-type: none"> • Food Science (7.3%) • Family and Consumer Sciences (2.1%) 	<ul style="list-style-type: none"> • Nutrition and Obesity (1.8%) • Obesity (0.7%) 	<ul style="list-style-type: none"> • Family and Consumer Sciences (4.8%) 	<ul style="list-style-type: none"> • Obesity (4.8%)
6. Food Safety	<ul style="list-style-type: none"> • Food Science (7.3%) 	<ul style="list-style-type: none"> • Food Safety (2.2%) 	<ul style="list-style-type: none"> • Food Science (11.2%) 	<ul style="list-style-type: none"> • Food Safety (8.4%)

	↓	↓
	Capacity funded (Percent of Identified Cluster Themes Focused on this Area)	Competitive funded (Percent of Identified Cluster Themes Focused on this Area)
Food Security	48.5%	31.7%
Climate Variability and Change	0.2%	2.9% ²⁶
Water	7.7%	5.8%
Bioenergy	3.1%	5.5%
Childhood Obesity	2.5%	4.8%
Food Safety	2.2%	8.4%
TOTAL	64.2%	59.1%

As Table 4 illustrates, 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 directed toward two of the challenges: Food Security (where it makes up 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 absolute project number terms, 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.

CONCLUSION: Capacity funded projects are providing robust coverage of the six NIFA National Challenge Areas, with almost two-thirds of projects so focused. Emphasis, as expected, is not equal across the six, with major focus placed on Food Security (with 48.5 percent of projects focused in production agriculture). Water sees the second-highest degree of emphasis in the Capacity funded project portfolio.

NIFA-AFRI/NRI competitive funds also see the majority of projects (59.1 percent) being classified in themes relevant to the six NIFA National Challenge Areas. In the case of competitive funds, the allocation of projects across the six National Challenge Areas shows less percentage variation in competitive project allocations.

5. Comparing Capacity and Competitive (AFRI/NRI) Funded Project Metaclusters and Themes on the Six Priority Areas in the 2014 Farm Bill

The 2014 Farm Bill provides authority to NIFA to pursue programs in support of six congressionally identified priority areas. The Farm Bill priorities are summarized by NIFA as follows (Table 5):²⁷

Table 5: 2014 Farm Bill Priorities for NIFA

2014 Farm Bill Priority Area	NIFA Description
Agricultural Economics and Rural Communities	<i>Prosperity and economic security for individuals and families, farmers and ranchers, business owners, and consumers are vital to a strong economy. The Farm Bill authorizes NIFA to continue to support programs that strengthen rural economies. NIFA's research, education, and extension programs help people make sound financial management decisions, discover new economic opportunities, develop successful agricultural and nonagricultural enterprises, take advantage of new and consumer-driven markets, and understand the implications of public policy on these activities.</i>
Agriculture Systems and Technology	<i>The Farm Bill supports the development of advanced technologies to meet the complex agricultural challenges faced by the United States and countries throughout the world. Agricultural systems—both crop and animal—involve issues such as labor, marketing, finances, natural resources, genetic stock, and equipment. NIFA-supported projects address</i>

²⁶ It should be noted that only some of the agricultural emissions work would relate to climate change. Some of the projects under this category also examine odor mitigation or other emission factors (not all of which are gases).

²⁷ <https://nifa.usda.gov/farm-bill-priorities>

	<i>these issues as a system, rather than on an individual basis, because a holistic approach offers greater management flexibility, safer working conditions, and a sounder economy and environment.</i>
Animal Health, Production, and Products	<i>Animals are one of the most important aspects of agriculture in America. NIFA’s investments in animal science have found new and better ways to advance animal production technology, enable the industry to respond to consumer demand, and advance human health and nutrition through better animal health and breeding. NIFA’s animal-related programs—which include beef, dairy cattle, poultry, swine, sheep, goats, and aquaculture—encourage a multidisciplinary approach to research, education, and extension activities.</i>
Bioenergy, Natural Resources, and Environment	<i>NIFA integrates research, education, and extension expertise to address environmental and natural resource priorities. The agency’s programs seek to develop the next generation of biofuels that will not only power machines, but the American economy as a whole. Furthermore, these programs improve air, soil, and water quality; fish and wildlife management; sustainable use and management of forests, rangeland, and watersheds; and lead to a better understanding of how the changing climate affects agriculture.</i>
Food Safety, Nutrition, and Health	<i>Poor dietary choices, unhealthy lifestyles, foodborne illnesses, and the potential for terrorism and other attacks on the U.S. food supply are national concerns. NIFA-funded programs help strengthen the nation’s ability to address and reduce the negative effects of these concerns as well as issues related to food security and food science and technology.</i>
Plant Health, Production, and Products.	<i>NIFA-funded plant and plant product programs provide better understanding of plants: how they grow, how to improve productivity, and how to use them in new ways. These programs reflect the diversity of plants and their uses around the world. NIFA also supports education programs, such as Master Gardeners and the eXtension program, which bring science-based information about growing plants to the public.</i>

These six Farm Bill priorities for NIFA can be compared to the results of the Capacity and Competitive NIFA funding REEport cluster analyses in order to produce an estimate of the projects undertaken by the land-grant universities relevant to these priorities. Table 6 lists both the Capacity funded and Competitive funded project metaclusters and themes and their relationship, in terms of likely subject matter, to each of the six 2014 Farm Bill priorities for NIFA.

Table 6: Comparing Capacity and Competitive (AFRI/NRI) Funded Project Metaclusters and Themes as Identified in Analysis of REEport System Data on the Six Priority Areas for NIFA in the 2014 Farm Bill

NIFA 2014 Farm Bill Priority	CAPACITY FUNDED Metaclusters (Percent of Total)	CAPACITY FUNDED Themes (Percent of Total)	COMPETITIVE FUNDED Metaclusters (Percent of Total)	COMPETITIVE FUNDED Themes (Percent of Total)
1. Agricultural Economics and Rural Communities	<ul style="list-style-type: none"> • Economics (3.5%) • Family & Consumer Sciences (2.1%) 	<ul style="list-style-type: none"> • Agricultural Economics (3.5%) • Youth & behavior (0.9%) • Emotion & behavioral Management (0.3%) • Poverty & Mental Health (0.3%) 	<ul style="list-style-type: none"> • Economics (8.0%) 	<ul style="list-style-type: none"> • Agricultural Economics (6.7%) • Markets & Pricing (1.3%)
2. Agriculture Systems and Technology	Not a specific metacluster, but elements contained within multiple other metaclusters and themes	<ul style="list-style-type: none"> • Irrigation and Water Use (4%) • Genetics & Genomics (1.3%) • Land Use (0.4%) 	Not a specific metacluster, but elements contained within multiple other metaclusters and themes	<ul style="list-style-type: none"> • Agricultural Emissions (2.9%) • Genetics & Genomics (5.0%) • Food Systems & Access (2.0%)
3. Animal Health, Production, and Products	<ul style="list-style-type: none"> • Animal Science and Livestock (15.1%) • Fisheries and Aquaculture (2.8%) 	<ul style="list-style-type: none"> • Livestock Diseases (5.9%) • Poultry Science (1.6%) • Meat Science (1.4%) • Livestock Nutrition (1.3%) • Livestock Reproduction (1.3%) 	<ul style="list-style-type: none"> • Animal Science & Livestock (10.9%) 	<ul style="list-style-type: none"> • Cattle (2.8%) • Dairy (2.3%) • Bovine Genetics (1.8%) • Nutrition (1.4%) • Vaccines (1.3%) • Reproduction (1.2%)

		<ul style="list-style-type: none"> • Manure Management (1.1%) • Small ruminants (0.6%) • Fly/Insect Management (0.3%) • Equine (0.3%) • Animal Reproduction (0.2%) • Fisheries (2.3%) • Aquaculture (0.4%) 		
4. Bioenergy, Natural Resources, and Environment	<ul style="list-style-type: none"> • Biomass and Biofuels (3.1%) • Environmental Science (6.6%) 	<ul style="list-style-type: none"> • Cellulosic Biomass (2.5%) • Biofuels and Biogas (0.3%) • Algae and Phycology (0.3%) • Ecology & Ecosystems (1.1%) • Climate Change (0.2%) • Water Resources and Water Quality (3.7%) • Fire Management 0.3% • Bees (0.9%) • Wildlife & Habitat (0.4%) • Forest Habitat & Ecosystems (6.6%) 	<ul style="list-style-type: none"> • Biomass and Biofuels (5.5%) • Environmental Science (10.8%) 	<ul style="list-style-type: none"> • Biomass (4.5%) • Conversion Processes (1.0%) • Water (5.8%) • Bees (2.2%) • Forest Ecosystems (3.0%)
5. Food Safety, Nutrition, and Health	<ul style="list-style-type: none"> • Food Science (7.3%) 	<ul style="list-style-type: none"> • Nutrition (3.8%) • Food Safety (2.2%) • Obesity (0.7%) • Dairy (0.5%) • Wine (0.1%) • Basic Nutrition (0.3%) 	<ul style="list-style-type: none"> • Food Science (11.2%) 	<ul style="list-style-type: none"> • Food Safety (8.4%) • Obesity (4.8%) • Lipids (0.7%)
6. Plant Health, Production, and Products.	<ul style="list-style-type: none"> • Agronomy (36.3%) • Forests & Forestry (10.9%) 	<ul style="list-style-type: none"> • Pest Management (9.9%) • Plant Breeding and Improvement (9.2%) • Soil Science (9.0%) • Horticulture (4.2%) • Silviculture (2.7%) • Forage Crops (1.2%) • Wood Science (0.2%) • Basic Plant Genetics & Molecular Biology (0.3%) 	<ul style="list-style-type: none"> • Agronomy (20.9%) 	<ul style="list-style-type: none"> • Basic Plant Sciences (8.2%) • Soil Science (7.1%) • Plant Pathology (5.3%) • Plant Breeding & Improvement (4.0%) • Pest Management (3.8%) • Fruit (0.7%)

	Capacity funded (Percent of Identified Cluster Themes Focused on this Area)	Competitive funded (Percent of Identified Cluster Themes Focused on this Area)
Agricultural Economics and Rural Communities	5.0%	8.0%
Agriculture systems and technology²⁸	5.7%	9.9%
Animal health, production, and products	16.4%	10.8%
Bioenergy, natural resources, and environment	16.3%	16.5%
Food safety, nutrition, and health	7.6%	13.9%
Plant health, production, and products.	36.7%	29.1%
TOTAL	87.7%	88.2%

²⁸ Not a specific metacluster.

As Table 6 illustrates, **both Capacity funded (87.7 percent) and Competitive grant funded (88.2 percent) portfolios of work see the majority of projects being relevant to the six priority areas in the 2014 Farm Bill.** 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). The Competitive portfolio shows a higher proportion of projects focused on the post farm gate area of “Food Safety, Nutrition, and Health” (13.9 percent of Competitive Projects versus 7.6 percent of Capacity Projects).

CONCLUSION: Both NIFA Capacity funded and NIFA Competitively funded portfolios see the vast majority of projects (almost 9 out of every 10) being focused in areas specific to the 2014 Farm Bill priorities.

6. Capacity Funding Leverage Identified in REEport Data

In Chapter II, it was noted that an advantage of the regional and local relevance of federal Capacity funded research is that state and local funders observe this local relevance and may then choose to provide additional matching financial support for the research and extension mission serving their state, county, or community. It could also be the case that the applied focus of much of the Capacity funded research portfolio holds appeal to commodity groups, agriscience companies, and other stakeholders to coinvest in land-grant R&D projects. The REEport data allow an evaluation of whether the opinions expressed by land-grant university leaders that “the characteristics of work funded with federal Capacity Funding allows significant further leveraged funding to be raised” hold true.

REEport data indicate that a substantial amount of leveraged funding is indeed occurring – and that these funds come from both public (state and local) and private (industry, foundations, commodity groups) funding sources. Table 7 summarizes funding data for the years 2010 through 2015 in aggregate, for each of the metacluster areas, identified through the cluster analysis of Capacity funded projects.

Table 7: Capacity Funded Projects. NIFA Funding and Additional Funds Raised (2010–2015)

Capacity-Funded Metacluster	\$ in Millions									
	A. Total NIFA Funding	B. Other USDA Funding	C. State Appropriations	D. Self-Generated Funds	E. Industry Funding	F. Other Non-Federal Funding	G. Other Non-USDA Federal Funding	H. Total, Non-Federal Funding (C+D+E+F)	I. Total, Federal Funding (A+B+G)	J. Total Funding (H+I)
Agronomy	\$621.4	\$328.9	\$2,228.2	\$318.3	\$647.2	\$453.5	\$635.1	\$3,647.2	\$1,585.4	\$5,232.6
Animal Science & Livestock	\$280.7	\$87.4	\$917.8	\$379.3	\$179.1	\$169.0	\$443.1	\$1,645.2	\$811.1	\$2,456.3
Basic Life Science	\$176.8	\$72.5	\$700.8	\$100.6	\$207.6	\$96.1	\$590.8	\$1,105.1	\$840.1	\$1,945.3
Biomass & Biofuels	\$57.3	\$28.4	\$180.0	\$15.7	\$50.1	\$31.7	\$96.2	\$277.5	\$181.9	\$459.4
Economics	\$47.3	\$13.0	\$138.9	\$6.5	\$15.5	\$21.5	\$33.0	\$182.4	\$93.2	\$275.7
Environmental Science	\$90.0	\$46.0	\$336.8	\$31.1	\$62.7	\$96.8	\$177.7	\$527.4	\$313.7	\$841.1
Family & Consumer Sciences	\$18.3	\$1.4	\$60.4	\$2.1	\$8.5	\$11.8	\$27.4	\$82.7	\$47.1	\$129.8
Fisheries & Aquaculture	\$49.4	\$17.3	\$139.3	\$13.5	\$27.1	\$50.7	\$86.3	\$230.7	\$152.9	\$383.6
Food Science	\$117.7	\$40.6	\$361.3	\$41.6	\$140.1	\$74.6	\$168.6	\$617.6	\$326.9	\$944.4
Forests & Forestry	\$184.8	\$109.4	\$448.2	\$42.9	\$80.0	\$133.4	\$196.2	\$704.5	\$490.3	\$1,194.9
Total	\$1,643.6	\$744.8	\$5,511.5	\$951.7	\$1,418.1	\$1,139.1	\$2,454.3	\$9,020.4	\$4,842.7	\$13,863.1

These data indicate that, across the 10 Capacity funded metaclusters, NIFA Capacity Funding totaled over \$1.64 billion with an additional federal funding support of \$3.2 billion over the six-year period. The projects supported by this combined federal investment received a further \$9 billion in funding from non-federal sources, for a combined funding of activity in the 10 metaclusters of almost \$13.9 billion.

Clearly, this represents a significant overall leverage of federal funding for work in these metaclusters equivalent to \$1.86 additional dollars in funding being raised for every \$1.00 in federal funding (Table 8). The metacluster achieving the highest leverage is Agronomy with a ratio of \$1 in federal funds leveraging an additional \$2.30 in non-federal funding. The lowest leverage is in Basic Life Science (still a robust 1 to 1.32), which is to be expected given the fundamental nature of research here having a less clear or assured path to applied relevance for key

external funders like state agencies, industry, or commodity groups. It is important to note that even the non-industry-oriented metaclusters of Family and Consumer Sciences achieves a robust level of leveraged external funding, with \$1 in federal funding generating an additional \$1.76 in external funds.

Table 8: Capacity Funded Projects. External Funds Leveraged by Federal Funding (2010–2015)

Capacity funded Metacluster	Total NIFA Funding	Total, Non-Federal Funding	Total, Federal Funding	Effective NIFA Leverage	Effective Federal Leverage
Agronomy	\$621.4	\$3,647.2	\$1,585.4	1 to 7.42	1 to 2.30
Animal Science and Livestock	\$280.7	\$1,645.2	\$811.1	1 to 7.75	1 to 2.03
Basic Life Science	\$176.8	\$1,105.1	\$840.1	1 to 10.00	1 to 1.32
Biomass and Biofuels	\$57.3	\$277.5	\$181.9	1 to 7.02	1 to 1.53
Economics	\$47.3	\$182.4	\$93.2	1 to 4.83	1 to 1.96
Environmental Science	\$90.0	\$527.4	\$313.7	1 to 8.35	1 to 1.68
Family and Consumer Sciences	\$18.3	\$82.7	\$47.1	1 to 6.09	1 to 1.76
Fisheries and Aquaculture	\$49.4	\$230.7	\$152.9	1 to 6.77	1 to 1.51
Food Science	\$117.7	\$617.6	\$326.9	1 to 7.03	1 to 1.89
Forests and Forestry	\$184.8	\$704.5	\$490.3	1 to 5.47	1 to 1.44
Total	\$1,643.6	\$9,020.4	\$4,842.7	1 to 7.43	1 to 1.86

CONCLUSION: *The importance and pragmatic nature of federally funded work at the land-grant universities in agricultural sciences and associated disciplines are reflected in the universities being able to leverage these federal funds to generate significant additional funding. The 10 Capacity Funded metaclusters, combined, generate an additional \$1.86 in non-federal funding for every \$1 in federal funds received.*

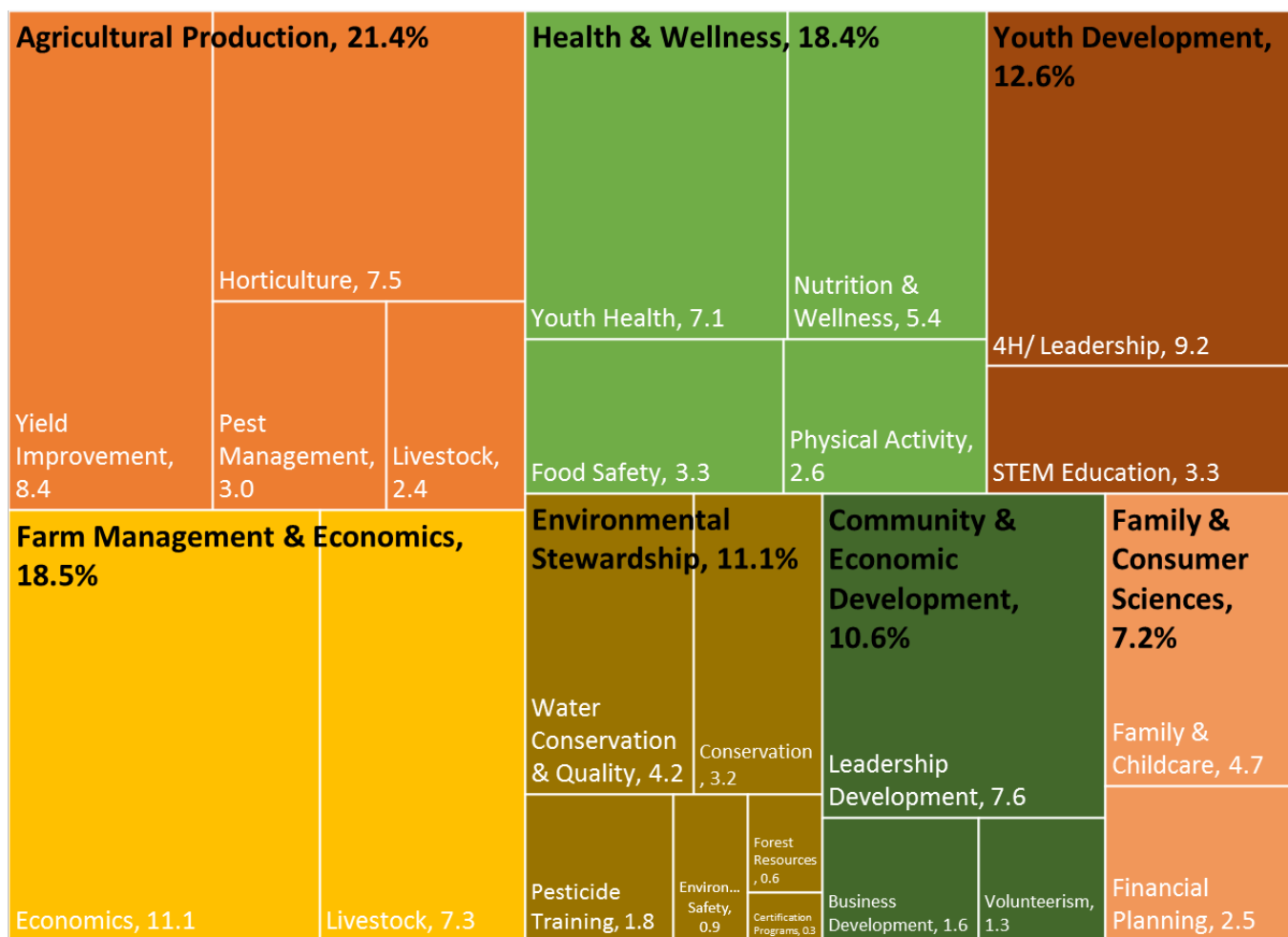
C. Extension Impact Statements (Land-Grant Impacts Portal Data)

Launched in March of 2015, the Land-Grant Impacts Portal is a joint development of land-grant university research and experiment station and extension service leadership designed to serve as a repository of project and program impact statements. Maintained at Texas A&M AgriLife Extension, the Land-Grant Impacts Portal (LGIP), to which TEconomy received access for the purposes of the NIFA evaluation project, contained 1,418 impact statements from extension service projects located throughout the nation (when analyzed by TEconomy in December 2016).²⁹

The records contained within the LGIP incorporate a detailed narrative statement on the nature of individual extension projects and the types and categories of impacts being achieved. TEconomy deployed real-text cluster analysis (using OmniViz™ software) to cluster the impact statements by themes contained in their narratives. Figure 20 provides a summary of the high-level metaclusters (total color blocks) and associated subthemes (interior segments within each color block) contained across the 1,418 impact statements analyzed.

²⁹ The system also contains impact statements for research and experiment station projects, but this is an area in development and TEconomy did not consider the data currently sufficient to provide an overview of thematic areas covered by USDA-NIFA-funded research.

Figure 20: Percentage Segmentation of the Current Universe of Cooperative Extension Impact Statements
(Data Table in Appendix I)



These programmatic themes are supported by Capacity Funding, and supplemented by considerable matching funding dollars at the state and county level in respective states.

As would be expected, two major theme areas pertain to production agriculture, with the Agricultural Production theme making up 21.4 percent of the impact statements and Farm Management and Economics making up 18.5 percent (for a combined total of 39.9 percent of the impact statements thus categorized). Particularly strong subthemes are evident in Yield Improvement, Horticulture, Livestock, and Economics – with a smaller niche area also represented in Pest Management.

To many people, Cooperative Extension is recognized for its work assisting agricultural producers with farm operations, agronomy, and management. The far-ranging extension programs that are focused on families and youth are perhaps less well recognized. In this regard, extension operates a broad variety of programs that cluster into three primary themes:

- **Health and Wellness** (18.4 percent of records)
- **Youth Development** (12.6 percent of records)
- **Family and Consumer Sciences** (7.2 percent of records).

Under **Health and Wellness**, subthemes are evident in Youth Health, Nutrition and Wellness, Food Safety, and Physical Activity.³⁰

Under **Youth Development**, a subtheme in Cooperative Extension's long-standing 4-H/Leadership programs is evident, together with support for Science, Technology, Engineering, and Mathematics (STEM) Education. Under **Family and Consumer Sciences**, subthemes are found in Financial Planning and in Family and Child Care.³¹

Two other major themes are evident from the cluster analysis:

- **Environmental Stewardship** (11.1 percent of records)
- **Community and Economic Development** (10.6 percent of records).

Several subthemes are evident in the work of extension in Environmental Stewardship, including Water Conservation and Quality, Conservation, Pesticide Training, Environmental Safety, Forest Resources, and Certification Programs. The largest subtheme under Community and Economic Development is in Leadership Development, with two smaller subthemes evident in Business Development and Volunteerism.

CONCLUSION: *Cooperative Extension, at the land-grant universities, is generating a broad range of impacts, not only in the areas of agricultural production and farm management, but also across important health and welfare, family and youth, community development, and environmental domains.*

Four of the six NIFA National Challenge Areas are particularly evident in the work of extension as identified in the TEconomy cluster analysis (Table 9). It should be noted, however, that the data contained within the LGIP is by voluntary submission and does not represent a universal listing of all extension programs and projects.

Table 9: Extension Impact Statement Clusters and Their Relation to NIFA National Challenge Areas.

NIFA National Challenge Area	Major Cluster Themes	Subthemes
Food Security	<ul style="list-style-type: none"> • Agricultural Production • Farm Management and Economics 	<ul style="list-style-type: none"> • Yield Improvement • Horticulture • Pest Management • Livestock • Agricultural Economics
Climate Variability and Change	<ul style="list-style-type: none"> • <i>Specific cluster not identified</i> 	
Water	<ul style="list-style-type: none"> • Environmental Stewardship 	<ul style="list-style-type: none"> • Water Conservation and Quality
Bioenergy	<ul style="list-style-type: none"> • <i>Specific cluster not identified</i> 	
Childhood Obesity	<ul style="list-style-type: none"> • Health and Wellness 	<ul style="list-style-type: none"> • Youth Health • Nutrition and Wellness • Physical Activity
Food Safety	<ul style="list-style-type: none"> • Health and Wellness 	<ul style="list-style-type: none"> • Food Safety

³⁰ The Supplemental Nutrition Assistance Program Education (SNAP-Ed) program administered through land-grant universities on behalf of the USDA is a key component of Health and Wellness activity undertaken by the land-grant universities. For the most recent report on the program and its impacts, see Tripp, Simon, Ryan Helwig, and Joe Simkins. 2016. *SNAP-Ed FY2015: Supplemental Nutrition Assistance Program Education through the Land-Grant University System. A Retrospective Review of Land-Grant University SNAP-Ed Programs and Impacts*. September. TEconomy Partners, LLC. The report may be accessed online at: <https://nifa.usda.gov/resource/supplemental-nutrition-assistance-program-education-snap-ed-report>.

³¹ Detailed analysis of the disciplinary content of Family and Consumer Sciences and the work performed by extension in this domain is reported by Anne Kemerer and Simon Tripp in a Battelle Technology Partnership Practice report entitled *Analysis of the Value of Family and Consumer Sciences (FCS) Extension in the North Central Region*. November 2015. The report provides an overview of the primary disciplinary content within Family and Consumer Sciences, and describes the impact this content has through the delivery of educational programming via the work of Cooperative Extension in the North Central Region. It also discusses those aspects of Family and Consumer Sciences Extension that make it particularly effective, and that differentiate it from other organizations working to improve the nation's health and well-being. Key findings, challenges, and opportunities are presented. The report may be accessed online at: <http://www.nceea.org/multistate-activities/fcs-battelle-report-2015/>.

CONCLUSION: LGIP data for Cooperative Extension at the land-grant universities show extension work concentrated in four of six NIFA National Challenge Areas: Food Security; Food Safety; Water; and Childhood Obesity.

D. Patents Analysis

Intellectual property (IP) generation represents another potential output of federal Capacity and Competitive funded projects, and thus examining patenting activity is useful for assessing part of the innovation impact of federally funded research. R&D at universities may result in novel innovations that may be protected for the university via patenting. The generation of a patent is similar to a peer-reviewed publication in that it is testament to unique and impactful research findings. NIFA's mission areas related to agriculture, food supply, public health, nutrition, natural resources, etc., may be served not only by generating new knowledge and recommendations rooted in research, but also by the generation of new innovations that have value when implemented as commercial technologies. Patents represent one measure of such commercial technology generation, but it should be noted that they are an imperfect measure in that the land-grant service ethos can result in multiple innovations being released to the field without patenting occurring. Patent data should be seen, therefore, as undercounting the total universe of technological innovation occurring.

Researchers examining the underpinnings of innovation have demonstrated the use of patents as an intermediary metric that identifies novel innovations with links to federal R&D investment, and thus patents may be used as proxies for "translatable innovation."^{32,33} Evaluating innovation impact via patents also allows for the usage of forward citations as a proxy measure for the downstream "forward innovation" that results from new patented innovations generating follow-on advances in related technological areas that effectively build upon the knowledge or technology contained within the referenced patents.

Using patent data published by the U.S. Patent and Trademark Office (USPTO), it is possible to profile the innovation areas that have indirect linkages to NIFA Capacity Funding programs.³⁴ The indirect impact of Capacity Programs on innovation can be profiled through examining the portfolio of IP being generated at institutions that are the primary recipients of Capacity Funding, land-grant universities. Patents tied to land-grant institutions can be identified by the assignees which are holders of the IP documented in patents, which can include multiple institutions and combinations of private and public entities. Although not all land-grant institution patents will originate from resources provided through NIFA or other USDA funding, the overall portfolio of innovation activity produced at these institutions can serve as an approximation for the types of innovation being funded by Capacity Programs given their role as major sources of research support at these institutions for agriculture and associated disciplinary work. Additionally, many patents cite the prior art established in existing patents in documenting new discoveries. Important IP that fundamentally advances the state of technology or science in an area will likely be cited by many other patents which use the initial discovery as the basis for downstream innovation. In examining the scope of land-grant university appearances in cited references for U.S. patents in agbioscience areas, the indirect impact of Capacity Program support for past research at these institutions can be highlighted for its foundational role in follow-on industry and academic innovation. These two ways of profiling the innovation impact of patents are outlined in Table 10.

³² Kalutkiewicz, Michael J., and Richard L. Ehman. 2014. *Patents as proxies: NIH hubs of innovation*. Nature Biotechnology, June 2014.

³³ Grueber, Martin, and Simon Tripp. 2015. *Patents as Proxies Revisited: NIH Innovation 2000 to 2013*. Battelle Technology Partnership Practice. March 2015.

³⁴ Direct attribution to NIFA Capacity Funding cannot be systematically identified since one of the few ways to capture direct linkages through documentation is use of the government interest field included on patents that provides any recognition or attribution to government funding support used in creating the IP described in the patent. Patents where the government interest field includes references to funding support from the NIFA and other USDA programs demonstrate a direct attribution back to these funding sources, but feedback from land-grant universities indicates that this form of documentation is not used consistently enough for analysis.

Table 10: Capturing Indirect Innovation Impacts from Patents

Approach	Indirect Linkage to Capacity Funding	Indirect Linkage to LGU-Supported Innovation
Identification of Patents	Land-grant institution listed as assignee of patent	Past land-grant institution patent listed in cited prior art references for newly issued patent
Relationship to Innovation Impact of Capacity Programs	IP and downstream innovation of LGU-assigned patents are representative of the innovation focus areas supported by Capacity Programs	Shows scope of downstream innovation support generated from institutions that rely heavily on Capacity Funding support to carry out innovative research

To capture the innovation activity related specifically to NIFA mission objective areas, detailed patent classes were used to identify relevant technologies and products with applications in agricultural sciences and associated fields. The USPTO assigns each patent with a specific numeric major patent “class” as well as supplemental secondary patent classes which detail the primary technology areas being documented by the patented IP. These classes are assigned to patents by dedicated classification staff who examine the documented IP’s key focus and end uses. By combining relevant patent classes across the wide array of bioscience-related activity, these class designations allow for an aggregation scheme that identifies broad technology themes specific to the technology areas that are part of NIFA’s key mission. TEconomy has grouped these relevant U.S.-invented patents into broader agbioscience patent class groups to allow an analysis of innovation trends.

Appendix J provides a listing of the patent classes and class groups that were used in this analysis as “agriculture and related sectors,” and how they are grouped into major technology themes.

1. Dynamics of Land-Grant University Patenting Activity

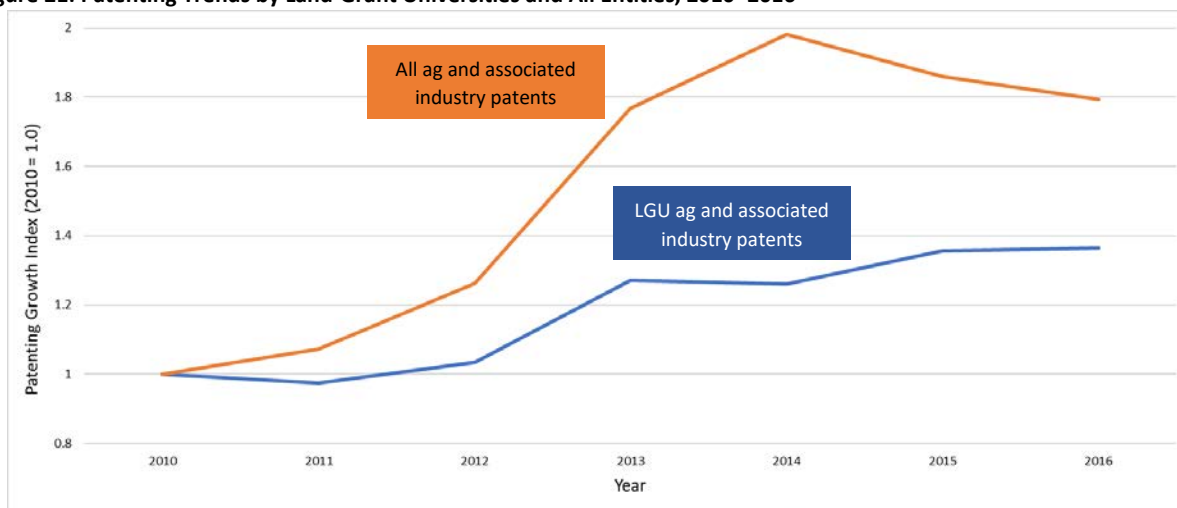
There were 23,512 total U.S. patents granted in the agriscience class areas shown in Appendix J from 2010 through 2016, 950 of which listed land-grant institutions as one of the original assignees. Note that plant breeders at land-grant universities have opted to use the Plant Variety Protection (PVP) Act³⁵, rather than patent plant varieties; this analysis did not include PVPs.

The patents constitute approximately 4 percent of the national share of agbioscience patents, and represents a significant component of national innovation activity given the highly-concentrated nature of institutions generating innovation in this space – the top five patenting entities in agbiosciences are corporations, and they account for almost 26 percent of all patents generated during this period. In this context, the cumulative patenting impact of land-grant university innovation supported by Capacity Funding can be thought of as roughly equivalent to a major agbioscience company in the United States. Of the total patents produced by land-grant universities, almost 88 percent originated from 1862 institutions.

Overall U.S. patenting in agbioscience classes rose significantly over this period, increasing by 77 percent. Land-grant university patenting, however, increased at a slower rate (growing by 37 percent over the same period). However, land-grant patenting activity did increase sharply after 2012 and has exhibited consistent annual growth since (despite declines in the overall patenting volume). This highlights the benefit of ongoing Capacity Funding support to maintain a consistent base of innovation despite year-to-year fluctuations in broader trends. Figure 21 shows growth trends for both land-grant (blue line) and all entities (orange line) assigned patents.

³⁵ See https://en.wikipedia.org/wiki/Plant_Variety_Protection_Act_of_1970

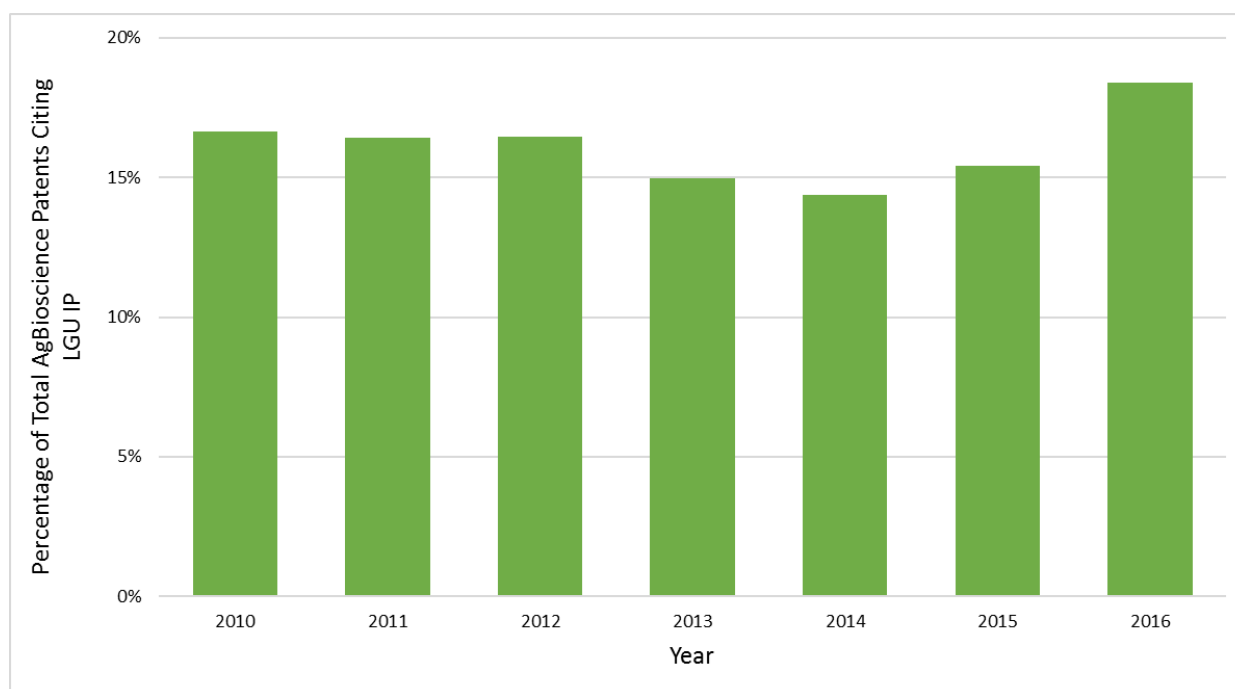
Figure 21: Patenting Trends by Land-Grant Universities and All Entities, 2010–2016



Viewing patent totals solely in terms of their final assignee does not capture the numerous patents where land-grant researchers contributed to technologies that were ultimately assigned to private industry and other institutions besides the land grant universities. It is challenging to trace all inventors listed on patents back to work produced during times at land-grant or non-land-grant institutions, but it is possible to examine the citation impacts of patents that have been assigned to land-grant institutions as an indication that innovative IP produced there was used as the basis for other downstream technologies.

Patents supported by Capacity Funding programs appear to play a significant role in generating downstream innovation by private industry and other institutions. From 2010–2016, land-grant university assigned patents in agriculture and related-industry areas were cited by 16 percent of all U.S. patents generated, with a peak of approximately one in every six patents citing prior land-grant work in 2016. Figure 22 shows the proportion of total agbioscience patents that cite land-grant assigned patents in their documentation of new IP from 2010 to 2016.

Figure 22: Percentage of Total U.S. Agriculture and Associated Sector Patents Citing Land-Grant University Assigned Patents, 2010–2016



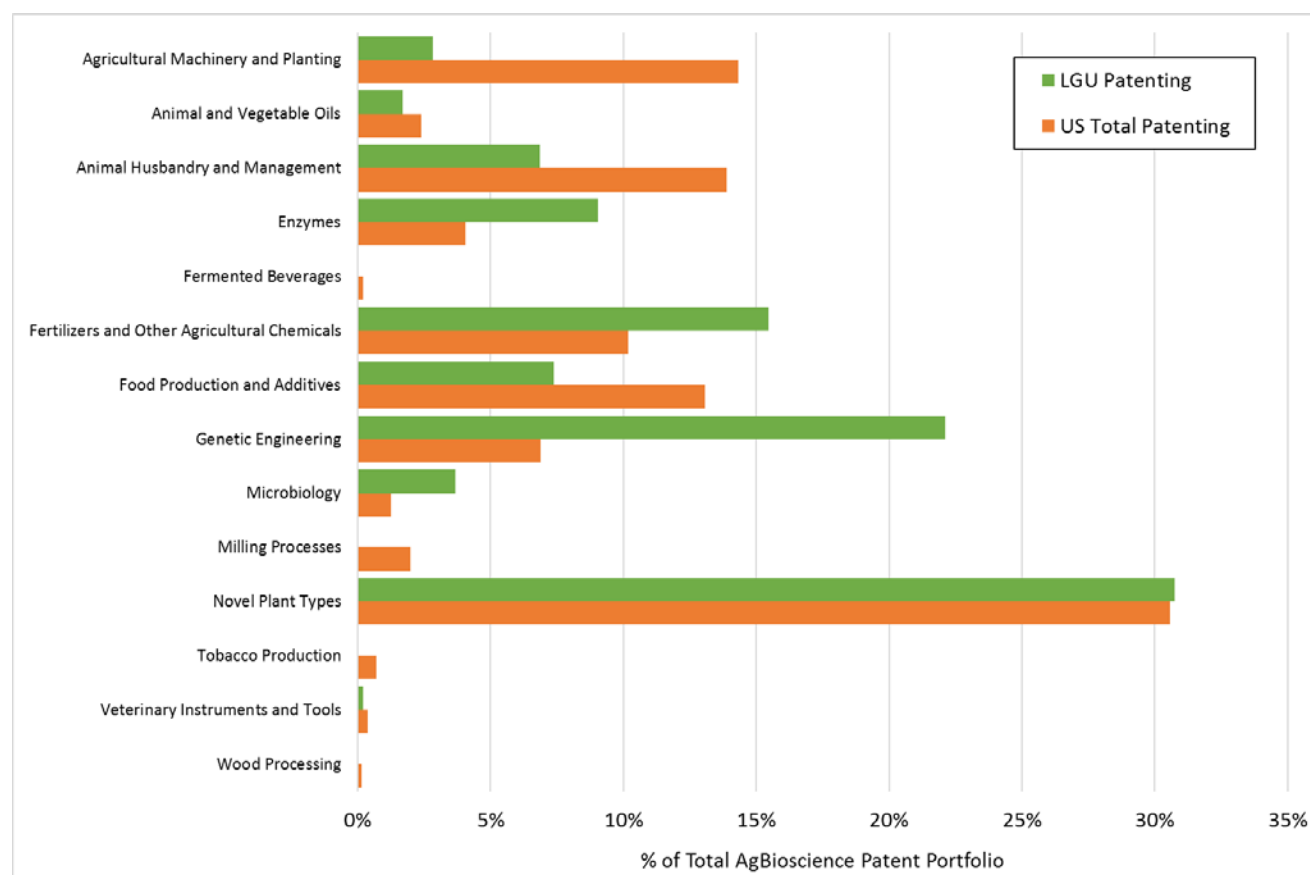
Capacity Funding programs serve as key supporting mechanisms for innovation activity at land-grant universities, and recent patenting demonstrates a significant impact on the country's stock of associated innovation. Many additional patents, especially those generated as a result of collaborative university and extension interactions with agriculture industry firms, are not able to be definitively captured through examination of historical patent data; and the innovative footprint of land-grant institutions in the patenting landscape is likely much larger (in other words, data presented herein are likely quite conservative).

CONCLUSION: Land-grant university patents in agriculture and associated technology categories (as defined by TEconomy) totaled 4 percent of total patenting in these fields in the seven-year period (2010–2016). However, the impact of land-grant innovation is more wide-ranging, influencing up to one in every six patents (as defined through patent citations) in agbiosciences in the United States.

2. Key Areas of Impact

The patents generated by the land-grants display several major innovation focus areas. These serve to highlight the innovation themes across land-grant institutions in terms of driving cutting-edge agricultural science and the importance of continued federal funding support for research. Figure 23 shows the percentages of the land-grant patenting portfolio across broad agriculture and associated-sector areas as compared with total U.S. percentages.

Figure 23: Agriculture and Associated Sector Patent Portfolio Composition of Land-Grant Institutions and Total United States, 2010–2016



Relative to total U.S. trends, land-grant university patenting is more concentrated in Fertilizers and Other Agricultural Chemicals, Genetic Engineering, Microbiology, and Novel Plant Types. New plant varieties and cultivars make up a large proportion of both the land-grant and national patenting portfolios, which is unsurprising given the end product of much agbioscience innovation is directed toward creating new crops that have improved disease resistance and favorable growth and yield traits. However, technologies that are perceived as more

traditionally agriculture-centric like Agricultural Machinery and Planting Processes and Animal Husbandry and Management are more highly concentrated in private industry at the national level, indicating that NIFA funding programs are supporting more cutting-edge science and applications in next-generation agricultural biotech as opposed to basic agricultural infrastructure. Land-grant institution patenting appears to be more specialized around the processes and techniques that help form the foundation of key agbioscience technology fields such as genetically engineered organisms, biologically derived agricultural compounds, and chemicals for use in precision agriculture. Several detailed technology applications of these fields represented in land-grant patenting portfolios are listed below in Table 11.

Table 11. Examples of Detailed Technology Areas Represented in Specialized Agriculture and Associated Sector Patenting Areas for Land-Grant Institutions

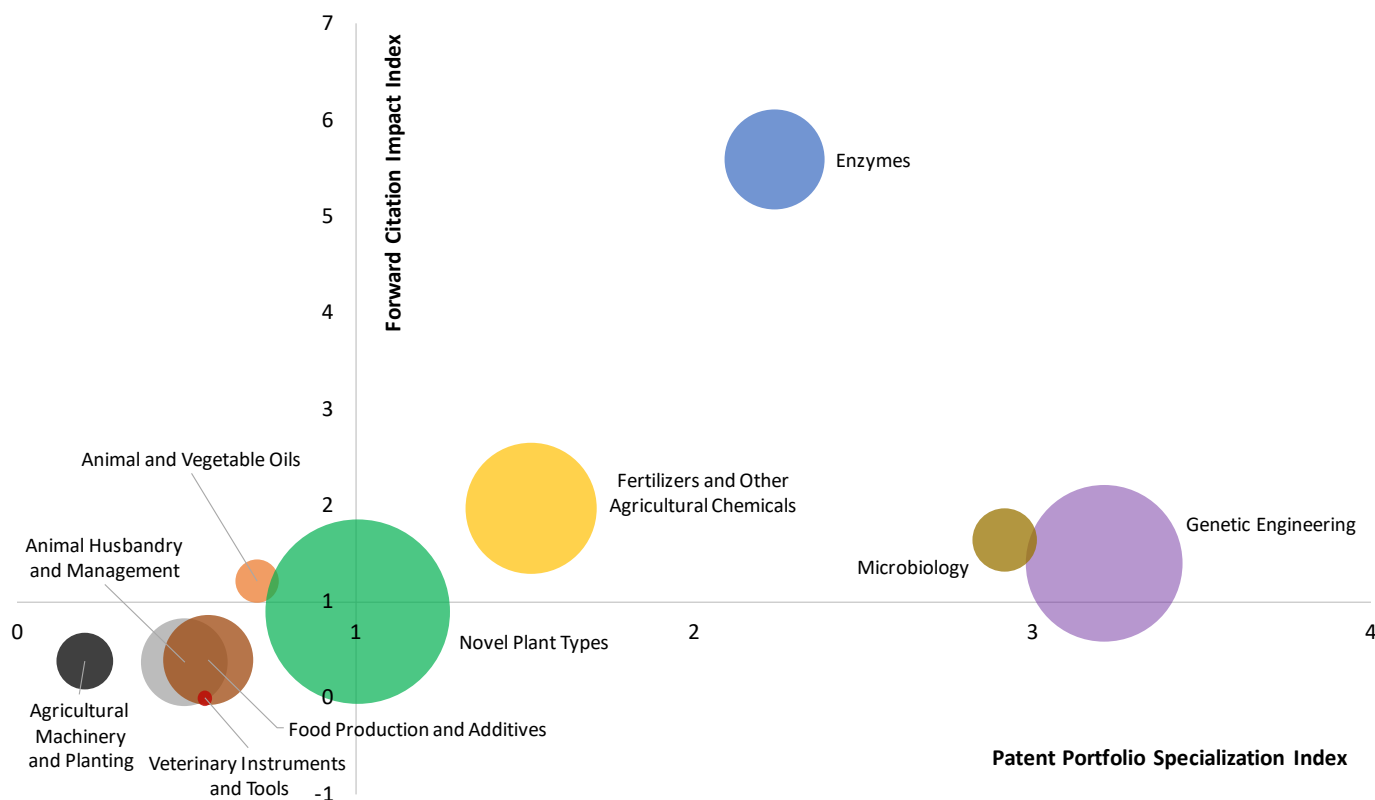
Broad Area	Examples of Detailed Technology Applications Present in Land-Grant Patenting Activity
Fertilizers and Other Agricultural Chemicals	<ul style="list-style-type: none"> • Biorepellents and environmentally compatible pesticides • Improved fungicide compounds • Biofilm and bacterial growth inhibitors • Improved delivery of biocides (via technologies like coated nanoparticles) and antimicrobial coatings and surfaces • Toxicity-minimizing fertilizers and growth enhancers • Pest insect attractants
Enzymes	<ul style="list-style-type: none"> • More efficient and cost-effective biofuels production • Synthesis of bioproducts and organic compounds via enzymes and other hosts • Delivery vectors for disease resistance in plants or animals
Genetic Engineering	<ul style="list-style-type: none"> • Transgenic plants and animals • Engineered disease/pest resistance and environmental tolerance • Precision breeding and improved yields for improved food production • Genetically modified organisms for biofuels production and bioreactors
Microbiology	<ul style="list-style-type: none"> • Genetically modified animal disease strains and growth media • Livestock stem cell lines and applications in improving animal health • Transgenic algae and other beneficial microorganisms

CONCLUSION: *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.*

Another way of viewing areas of specialized high performance in land-grant patenting is through their forward innovation impact. As noted above, forward citations from later patents that cite the IP documented in land-grants' agriculture and associated areas indicate the impact that the documented technologies have on furthering the pace of innovation. Often, distinct "bursts" in innovation as measured by forward citations can be traced back to critical IP documented in a select few patents that initially documented groundbreaking new research,³⁶ making forward citation impact a good indicator of the value of a patent's IP. Figure 24 shows both the specialization and forward citation impact of land-grant institution assigned patents relative to national patenting trends across broad agricultural and associated science and technology categories.

³⁶ Huang, Yi-Hung, Ming-Tat Ko, Chun-Nan Hsu. 2014. "Identifying Transformative Research in Biomedical Sciences," *Technologies and Applications of Artificial Intelligence*, Volume 8916 of the series *Lecture Notes in Computer Science*, November.

Figure 24: Specialization and Forward Citation Impact Indices of Land-Grant Institution Assigned Patents in Agriculture and Associated Areas, 2010–2016, Relative to National Trends



As seen in Figure 24, land-grant university agriscience patenting in Genetic Engineering, Microbiology, and Enzyme applications is both highly specialized and has high forward citation impact relative to national trends. In particular, patents documenting **Enzyme applications** in agriculture and associated areas had a citation impact almost six times higher than that of the United States, indicating that the IP developed by land-grant institutions in this area has generated significant downstream innovation activity. **Fertilizers and Other Agricultural Chemicals** also had above-average specialization and forward citation impacts relative to national trends. More traditional agricultural innovation in Food Production and Additives, Animal Husbandry and Management, and Veterinary Instruments and Tools were all below average for land-grants relative to total U.S. patenting, with Novel Plant Types being about the same as the wider United States in terms of its role in the land-grant patent portfolio. These areas of specialized and highly innovative impact partially speak to the changing nature of modern agricultural science where advanced biotechnology serves as much of the basis for new technologies, but, more importantly, highlights the advanced nature of land-grant universities' innovation activity supported by federal funding programs. The innovations being generated by land-grant institutions are clearly focused around next-generation applications for agriculture, and the role of Capacity Funds in driving the research activities that produce those outcomes is thus an important piece of the ongoing evolution of the wider U.S. agricultural sciences field.

The innovations being generated by land-grant institutions are clearly focused around next-generation applications for agriculture, and the role of Capacity Funds in driving the research activities that produce those outcomes is thus an important piece of the ongoing evolution of the wider U.S. agricultural sciences field.

E. Contacts

Cooperative Extension, at the land-grant universities, is a pragmatic enterprise that is designed to translate and disseminate research-based knowledge, know-how, and technologies out of the universities and into the field. As described by NIFA:

Extension provides non-formal education and learning activities to people throughout the country – to farmers and other residents of rural communities as well as to people living in urban areas. It emphasizes taking knowledge gained through research and education and bringing it directly to the people to create positive changes. All universities engage in research and teaching, but the nation's more than 100 land-grant colleges and universities have a third, critical mission – extension. Through extension, land-grant colleges and universities bring vital, practical information to agricultural producers, small business owners, consumers, families, and young people.³⁷

Translating and transferring knowledge and know-how is primarily undertaken via two pathways:

- **Direct Contact:** Whereby extension professionals meet with clients (such as farmers, ranchers, land-owners, community leaders, families, youth, etc.), either one-on-one or in group settings, to provide extension education.
- **Indirect Contact:** Whereby extension provides information that is generally available through online or published educational materials. Also, certified crop advisors and private consultants often obtain information from Extension and use it for the benefit of their clientele.

Extension works to

- Translate science for practical application
- Identify emerging research questions, find answers and encourage application of science and technology to improve agricultural, economic, and social conditions
- Prepare people to break the cycle of poverty, encourage healthful lifestyles, and prepare youth for responsible adulthood
- Provide rapid response regarding disasters and emergencies
- Connect people to information and assistance available online through eXtension.org.

Source: NIFA at <https://nifa.usda.gov/extension>.

Measuring the “output” of extension, therefore, requires quantification of the amount of contacts made by extension at the land-grant universities through these direct and indirect methods. NIFA data, provided in annual reporting of Plans of Work³⁸ for each land-grant university, captures both direct and indirect contact information that is self-reported by each institution. These data were provided by NIFA to TEconomy on a state-by-state basis, and aggregated for this national-level review. Data were reviewed for the most recent six-year period with complete data, 2010 through 2015, and are reported on Table 12.

Table 12: USDA Plan of Work Data for Cooperative Extension: Land-Grant University Extension Contacts, 2010–2015

Type of Contact	2010–2015 Six-Year Total	Annual Average
Direct Contacts	350,714,860	58,452,477
Indirect Contacts	2,251,568,631	421,928,105
Total Contacts	2,602,283,491	480,380,582

Cooperative Extension clearly constitutes a very large-scale knowledge dissemination and non-formal education provider with presence and impact in all states and U.S. territories. In the six-year period 2010–2015, **direct**

³⁷ <https://nifa.usda.gov/extension>.

³⁸ The Plan of Work data collection, including the Annual Report of Accomplishments, is the vehicle for Land-Grant Universities to report planned Agriculture Research and Extension programs and annual program results. The Plan of Work is mandated by the Agricultural Research, Extension, and Education Reform Act of 1998. The Plan of Work must be completed by eligible institutions receiving federal agricultural research and extension formula funds under the Hatch Act of 1887, as amended (7 U.S.C. 361a et seq.); sections 3(b)(1) and (c) of the Smith-Lever Act of 1914, as amended (7 U.S.C. 343 (b)(1) and (c)); and sections 1444 and 1445 of the National Agricultural Research, Extension, and Teaching Policy Act of 1977, as amended (7 U.S.C. 3221 and 3222).

contacts totaled almost 351 million contacts, with an average annual direct contact volume of 58.5 million contacts.³⁹ The indirect contact totals are extremely large, given all the opportunities that various populations and stakeholders have, to access and interact with extension data and information online or through other published resources. **Indirect contacts totaled over 2.2 billion** contacts made between 2010 and 2015, with an average annual total of indirect contacts of almost 422 million contacts.

CONCLUSION: *Cooperative Extension is a high-volume provider of knowledge, know-how, training, and informal education. NIFA Plan of Work data indicate that extension advice and educational content are in high demand. In recent years, extension has recorded an average of **58.5 million direct contacts** per year with the “clients” extension serves. Extension websites, published materials, etc., are accessed almost **422 million times** over the course of a typical year.*

³⁹ It should be noted that the contact figures shown do not equate to unique individuals since it is possible, for example, for the same person to have multiple direct or indirect contacts with extension over the course of the year. An individual farmer, for example, could engage with extension many times over the course of the year, with multiple direct contacts or visits by extension personnel and many indirect contacts via, for example, accessing extension information on individual land-grant or eXtension.org websites. Figures shown in Table 39 are for total contacts, not total individuals.

SECTION III:
THE VOICE OF THE LAND-GRANTS.
RESULTS OF SURVEYS DISTRIBUTED TO 1862,
1890 AND 1994 LAND-GRANT COLLEGES AND
UNIVERSITIES.

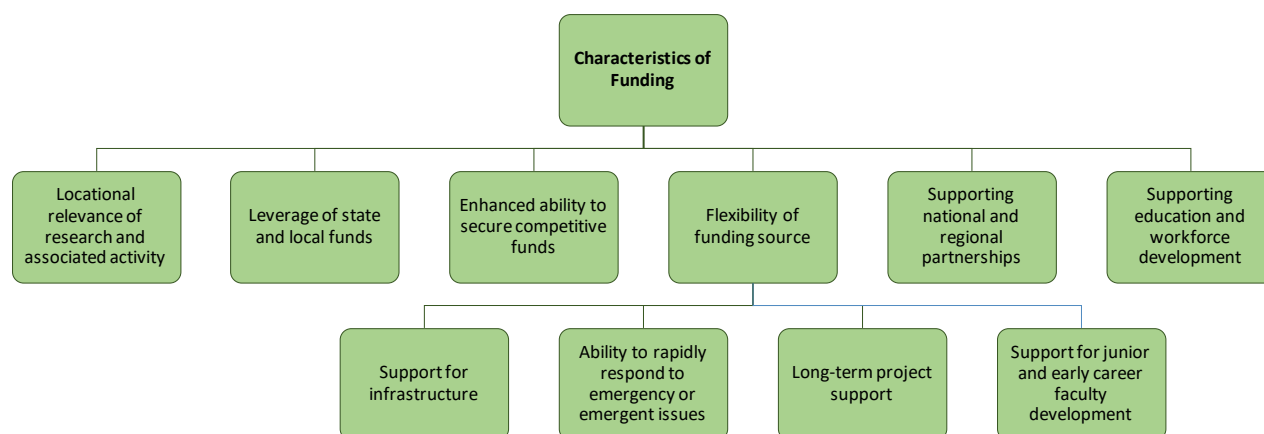
III. NIFA Funding and Structural Characteristics

Capacity Funding and Competitive Funding models differ in certain characteristics of their use. Competitive federal funds, including NIFA AFRI Competitive Funds, typically comprise grants awarded to applicants based on a process of peer review of submitted proposals. Competitive Funding is a common model that has multiple associated benefits, such as funds being awarded based on merit, funds able to be directed based on national or other agreed priorities, and an in-built peer feedback process that serves to improve proposals. Competitive Funding is the typical means by which major federal funding agencies distribute funding to academic institutions for research and associated activities.

Capacity Funding uses a very different model, allocating funds to recipient organizations based on predetermined formulas, and is not dependent on a reviewed grant application process. There are advantages and disadvantages to both funding models, and differing characteristics in their use, that are examined specifically herein in relation to NIFA funding.

Figure 25 provides an overview of the functional characteristics of funding reviewed in this report chapter. Each of these functional characteristics are reviewed and assessed to examine whether Capacity Funding has advantages or disadvantages versus Competitive Funding on each.

Figure 25: Evaluation of NIFA Funding and Associated Characteristics



A. The Spatial and Temporal Relevance of Funded Activity

As noted in Chapter I, local and temporal variation are key characteristics of the agricultural production environment and of the communities and social systems that support the value-added agricultural and natural resource ecosystem. Agriculture and associated communities do not represent a uniform national geographic system, rather they are highly specific to their localities and responsive to the unique characteristics of their environment in relation to climate, soils, biotic and abiotic stressors, market characteristics, and societal structures and needs. While basic research into fundamental model plant or animal biology, for example, might be relevant across the entire United States and internationally, most of the basic and, especially, applied science performed to enhance agriculture and associated regional economic and cultural support systems needs to be specific to the environment of relevance – which will usually be regional or even local in nature. **Capacity Funding was originally established in recognition of this fact, providing funds to all states in order that the location-specific needs of agricultural production, and its associated value-added ecosystem, could be understood and met.** Furthermore, Capacity Funding enabled the development of Cooperative Extension to assure that innovations and practice recommendations derived from the regional and local research system could be transferred to farmers and other producers, and economic and social solutions diffused into on-the-ground practice. While the findings of Competitively funded, peer-reviewed academic research (which may be performed by any research institution) may be recorded in the published academic research literature, only the uniquely integrated system of research,

experiment stations, and Cooperative Extension at the land-grant universities is purposely designed to assure new knowledge is diffused into practice – carried into the field by the focused actions of extension.

A TEconomy/APLU survey deployed to the Directors of State Research and Experiment Station Systems⁴⁰ gathered feedback regarding the comparative suitability of Capacity versus Competitive Funding models for achieving state and local impacts for farmers, ranchers, other producers, or consumers. The results of this survey question (Table 13) show that Research Directors find Capacity Funding sources to be substantially better suited to use in meeting state and local needs. This is a critically important study finding given the importance of locality-specific relevance to meaningful translation of research into results.

Table 13: Rating of Funding Source for Ease by Which They can be Adapted to Meet the Needs of Local and State Farmers, Ranchers, Other Producers, or Consumers. Results of Research Directors/Experiment Station Directors Survey.

	Inst. Type	Very Difficult	Difficult	Moderate	Easy	Very Easy	N/A
NIFA Capacity Funds for Agricultural Research	1862	0%	0%	9%	32%	60%	0%
	1890	0%	0%	0%	13%	88%	0%
	Non-LGU ⁴¹	0%	50%	0%	0%	0%	50%
	All Institutions	0%	2%	6%	26%	65%	2%
NIFA Capacity Funds for Animal Health and Disease/ Veterinary Research	1862	0%	4%	21%	32%	32%	11%
	1890	0%	0%	6%	6%	6%	81%
	Non-LGU	50%	0%	0%	0%	0%	50%
	All Institutions	2%	3%	17%	25%	25%	29%
NIFA Capacity Funds for Forestry Research	1862	0%	2%	15%	30%	43%	11%
	1890	0%	0%	6%	19%	38%	38%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	0%	2%	14%	28%	40%	17%
NIFA Competitive Funds for Research (AFRI)	1862	6%	26%	38%	19%	4%	6%
	1890	6%	25%	6%	25%	25%	13%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	6%	26%	31%	20%	9%	8%
All Other Federal Competitive Funds for Research	1862	9%	30%	46%	11%	2%	2%
	1890	13%	19%	25%	31%	13%	0%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	9%	30%	39%	16%	5%	2%
State/Local Funds for Research	1862	0%	0%	13%	30%	51%	6%
	1890	0%	6%	19%	38%	31%	6%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Institutions	0%	3%	14%	32%	45%	6%

⁴⁰ Multiple survey instruments were distributed, with the 1862 and 1890 Land-Grant Universities receiving separate instruments for completion at the “Institutional Level” (typically completed by the Dean of a college of agriculture or equivalent), together with surveys completed by the Directors of the Research/Experiment Station System and the Directors of Cooperative Extension. Multiple questions were repeated across the three different respondent types. Complete survey results from each of the surveys are available in the separate Technical Appendix Report.

⁴¹ Non-LGU in the context of this table, and all other tables in the report, refers to a select few universities in the United States that are designated to receive Capacity Funding, even though they are not land-grant universities. A listing of the four universities thus classified is provided in Appendix D.

Similar results are found for a related survey question that sought Research Directors' ratings of different funding sources in terms of supporting research leading to new approaches or processes to be deployed into the field. Given the importance of local deployment of novel technologies, techniques, or processes to meeting geographically diverse agricultural and associated challenges, it is important to note that the Directors see Capacity Funding again as being much better suited for generating applied and pragmatically deployable approaches and processes (Table 14).⁴² Findings are similar on Table 15, which looks specifically at new applied technologies developed. Capacity Funding is viewed as the more effective funding vehicle for achieving research results that result in new technologies for agriculture and associated uses (such as novel crops, new agricultural equipment, etc.).

Table 14: Rating of Funding Source for Generating Research Findings that Translate to New Approaches or Processes Deployed in the Field. Results of Research Directors/Experiment Station Directors Survey.

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	57%	28%	11%	4%	0%	0%
	1890	94%	6%	0%	0%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	65%	23%	8%	3%	0%	2%
NIFA Competitive Funds for Research (AFRI)	1862	26%	38%	21%	9%	0%	6%
	1890	44%	44%	0%	0%	0%	13%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Institutions	31%	38%	17%	6%	0%	8%
All Other Federal Competitive Funds for Research	1862	19%	40%	28%	9%	2%	2%
	1890	38%	31%	25%	6%	0%	0%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	23%	38%	28%	8%	2%	2%
State/Local Funds for Research	1862	47%	28%	15%	0%	0%	11%
	1890	38%	31%	13%	13%	0%	6%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	43%	31%	14%	3%	0%	9%

⁴² In many ways, this is akin to the National Institutes of Health (NIH) goal, in recent years, of seeking to boost the translation of NIH research findings into generating tangible medical products, therapies, and clinical practices. The NIH recognized that the traditional competitively funded, peer-reviewed model of biomedical research was producing a somewhat disappointing volume of applied technologies and innovations moving into clinical practice. The NIH has now directed considerable funds to building an enhanced translational sciences system, something that the USDA has had in place for more than a century through its Capacity Funding model incorporating research and extension.

Table 15: Rating of Funding Source for Research Leading to New Applied Technologies. (Question: Rate the following funding sources on the amount of new applied technologies (e.g., novel crops, new equipment, new approaches) developed with their funding.) **Results of Research Directors/Experiment Station Directors Survey.**

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	45%	30%	23%	2%	0%	0%
	1890	94%	0%	0%	0%	0%	6%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	55%	23%	17%	2%	0%	3%
NIFA Competitive Funds for Research (AFRI)	1862	23%	34%	28%	9%	0%	6%
	1890	38%	31%	6%	6%	0%	19%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Institutions	28%	32%	23%	8%	0%	9%
All Other Federal Competitive Funds for Research	1862	21%	38%	28%	9%	2%	2%
	1890	25%	31%	31%	13%	0%	0%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	22%	37%	29%	9%	2%	2%
State/Local Funds for Research	1862	30%	21%	30%	9%	0%	11%
	1890	38%	38%	13%	0%	6%	6%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	31%	28%	25%	6%	2%	9%

Under a pragmatic goal of moving new research-generated knowledge, practice recommendations, and innovative technologies into use in the field, the traditional academic pathway of diffusion via publishing of results in academic journals is not necessarily the best pathway. Extension and Experiment Station systems have found that non-formal (i.e., not academic journal) education materials (such as web-based information, tip/guide sheets, brochures, etc.) are a practical resource to deploy in translating scientific findings and recommendations into the field and raising awareness of new solutions and technologies. As Table 16 shows, the Deans and Senior Leadership survey results indicate that Competitive Funding models, whether through NIFA or other federal Competitive Funding sources (e.g., NSF, DoE, NIH, etc.), are found to be less well suited to such flexible knowledge-diffusion techniques than are Capacity Funding models.

Table 16: Rating of Funding Source for Research Leading to Non-Formal Educational Materials for the General Public. Results of Deans/Senior Leadership Survey.

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	53%	30%	13%	4%	0%	0%
	1890	81%	13%	0%	0%	6%	0%
	Non-LGU	50%	0%	0%	0%	0%	50%
	All Institutions	60%	25%	9%	3%	2%	2%
NIFA Capacity Funds for Animal Health and Disease/Veterinary Research	1862	21%	30%	26%	15%	2%	6%
	1890	19%	0%	0%	6%	0%	75%
	Non-LGU	0%	0%	0%	0%	0%	100%
	All Institutions	20%	22%	18%	12%	2%	26%

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Forestry Research	1862	38%	26%	15%	13%	0%	9%
	1890	38%	13%	13%	0%	0%	38%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Institutions	38%	22%	15%	9%	0%	15%
NIFA Competitive Funds for Research (AFRI)	1862	19%	32%	30%	6%	11%	2%
	1890	56%	6%	25%	13%	0%	0%
	Non-LGU	50%	0%	0%	0%	50%	0%
	All Institutions	29%	25%	28%	8%	9%	2%
All Other Federal Competitive Funds for Research	1862	17%	21%	40%	15%	4%	2%
	1890	44%	13%	38%	6%	0%	0%
	Non-LGU	50%	0%	0%	50%	0%	0%
	All Institutions	25%	18%	38%	14%	3%	2%
State/Local Funds for Research	1862	45%	36%	11%	0%	0%	9%
	1890	50%	25%	6%	13%	0%	6%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	46%	34%	9%	3%	0%	8%

CONCLUSION: Land-grant university leaders find 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 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.

B. Leveraging Additional Funding Beyond the Federal Contribution

An advantage of the regional and local relevance of federal Capacity funded research is that state and local funders observe this local relevance and may then choose to provide additional matching financial support for the research and extension mission serving their state, county, or community. In effect, the **localized relevance of Capacity funded activities creates a leveraging effect in attracting significant state and local funds to supplement federal funding and enhance positive impacts.** This is found to be the case in examining the results from the TEconomy/APLU survey findings, where the respondent institutions were asked to rate Capacity versus Competitive Funding for achieving leveraged funding from various sources: state; local/county; commodity groups; non-profit foundations; and corporate funding. In the case of each of these leveraged funding sources, the recipient institutions rate Capacity Funding as being either “much better” or “moderately better” than a Competitive Funding model (Table 17).

Table 17: Rating of Capacity versus Competitive Funding for Leveraging Additional Funding (by Source). Results of Deans/Senior Leadership Survey.

Leveraging	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
Leveraging matching state funding	1862	76%	3%	21%	0%	0%	0%
	1890	94%	6%	0%	0%	0%	0%
	Non-LGU	100%	0%	0%	0%	0%	0%
	All Institutions	84%	4%	12%	0%	0%	0%
Leveraging matching local and/or county funding	1862	64%	11%	18%	0%	0%	7%
	1890	88%	6%	6%	0%	0%	0%
	Non-LGU	67%	0%	33%	0%	0%	0%
	All Institutions	73%	8%	15%	0%	0%	4%
Leveraging matching commodity group funding	1862	48%	7%	21%	7%	7%	10%
	1890	53%	12%	18%	0%	6%	12%
	Non-LGU	67%	33%	0%	0%	0%	0%
	All Institutions	51%	10%	18%	4%	6%	10%
Leveraging matching foundation/ non-profit funding	1862	45%	10%	24%	7%	7%	7%
	1890	47%	6%	18%	0%	6%	24%
	Non-LGU	67%	33%	0%	0%	0%	0%
	All Institutions	47%	10%	20%	4%	6%	12%
Leveraging or generating industry (company) funding	1862	48%	7%	24%	10%	7%	3%
	1890	65%	6%	12%	0%	6%	12%
	Non-LGU	67%	0%	33%	0%	0%	0%
	All Institutions	55%	6%	20%	6%	6%	6%

CONCLUSION: Capacity Funding is found to be better than Competitive Funding for generating leverage for federal funding dollars from other non-federal sources, whether that be state, local/county, non-profit, or corporate leveraged research funding. Capacity Funding is viewed by respondents as providing state-level and county-level relevance that serves to attract matching dollars, significantly enhancing the level of research and knowledge-extension activity that can be performed. Chapter II of this report shows quantitative evidence of this.

C. Enhancing Ability to Secure Competitive Funds

A key characteristic of Capacity Funding is that it provides a flexible funding resource that allows land-grant universities to support the development of faculty and staff research capabilities and to invest in the instrumentation, field stations, and specialized agricultural and associated-research tools needed to advance basic and applied research. As its name implies, it is funding that builds capacity at institutions to meet the land-grant mission. TEconomy hypothesized that the building of capacity should logically provide an advantage for land-grant universities that would also support their pursuit of Competitive Funding opportunities. Table 18 illustrates that this is indeed found to be the case for the large majority of institutions.

Table 18: Has Success with Capacity Funds Impacted Success in Receiving Competitive Funds? (Question: For competitively funded research projects, has success with Capacity funded projects influenced or impacted success receiving competitive grant awards?) **Results of Deans/Senior Leadership Survey.**

Institution Type	Yes	No	Don't Know
1862	93%	7%	0%
1890	100%	0%	0%
Non-LGU	67%	0%	33%
All Institutions	94%	4%	2%

A similar question was asked in the survey directed to the Directors of Research and Agricultural Experiment Station systems (Table 19). The results indicate that 91 percent of Research Directors at the 1862 Land-Grants and 76 percent of the Research Directors at 1890 Land-Grants stated Capacity Funding has a “very significant” or “significant” influence on Competitive Funding success.

Table 19: Influence of Capacity Funding on Achieving Success in Competitive Awards. (Question: For Competitively funded research projects, has success with Capacity funded projects influenced or impacted success receiving Competitive grant awards?) **Results of Research Directors/Experiment Station Directors Survey.**

Inst. Type	Capacity Funding success has had a <u>very significant impact</u> on Competitive Funding success	Capacity Funding success has had a <u>significant impact</u> on Competitive Funding success	Capacity Funding success has had <u>limited impact</u> on Competitive Funding success	Don't Know	Have not received any competitive-based research funding
1862	68%	23%	2%	4%	2%
1890	63%	13%	13%	6%	6%
Non-LGU	0%	50%	50%	0%	0%
All Institutions	65%	22%	6%	5%	3%

Table 20: Rating of Funding Source by Suitability for Helping Faculty Increase Their Success in Receiving Competitive Funding. (Question: Rate the following funding sources in their ability to increase the success of faculty in terms of receiving follow-up Competitive Funding. In other words, to what degree does proven success from one of these funding sources increase the likelihood of future success in gaining additional Competitive Funding?) **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	47%	30%	23%	0%	0%	0%
	1890	94%	6%	0%	0%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	57%	25%	17%	0%	0%	2%
NIFA Capacity Funds for Animal Health and Disease/Veterinary Research	1862	38%	26%	30%	0%	0%	6%
	1890	13%	6%	0%	0%	0%	81%
	Non-LGU	0%	0%	0%	0%	0%	100%
	All Institutions	31%	20%	22%	0%	0%	28%
NIFA Capacity Funds for Forestry Research	1862	40%	21%	28%	2%	0%	9%
	1890	50%	13%	0%	0%	0%	38%
	Non-LGU	50%	0%	0%	50%	0%	0%
	All Institutions	43%	18%	20%	3%	0%	15%

		V. High	High	Medium	Low	V. Low	N/A
NIFA Competitive Funds for Research (AFRI)	1862	45%	36%	11%	2%	0%	6%
	1890	63%	25%	0%	0%	0%	13%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	48%	32%	9%	3%	0%	8%
All Other Federal Competitive Funds for Research	1862	51%	34%	9%	4%	0%	2%
	1890	44%	38%	6%	6%	0%	6%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	48%	34%	9%	6%	0%	3%
State/Local Funds for Research	1862	21%	15%	43%	15%	0%	6%
	1890	56%	19%	13%	0%	6%	6%
	Non-LGU	0%	0%	100%	0%	0%	0%
	All Institutions	29%	15%	37%	11%	2%	6%
Commodity Group, Industry, or Company Funds for Research	1862	11%	23%	43%	13%	2%	9%
	1890	19%	13%	44%	0%	13%	13%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	12%	20%	43%	11%	5%	9%

It should be further noted that Directors of Research and Experiment Stations at the land-grant universities see the Capacity Funded Cooperative Extension as being similarly beneficial in terms of improving the ability to successfully compete for federal Competitive Funding (Table 21).

Table 21: Influence of Cooperative Extension on Success in Achieving Competitive Funding. Results of Deans/Senior Leadership Survey.

Inst. Type	Yes	No	Don't Know/Not Applicable
1862	91%	6%	2%
1890	88%	0%	13%
Non-LGU	0%	0%	100%
All Institutions	88%	5%	8%

CONCLUSION: Capacity Funding, as anticipated in its name, improves the infrastructure and capabilities of land-grant institutions and this, in turn, helps these institutions to also successfully compete for competitive grants.

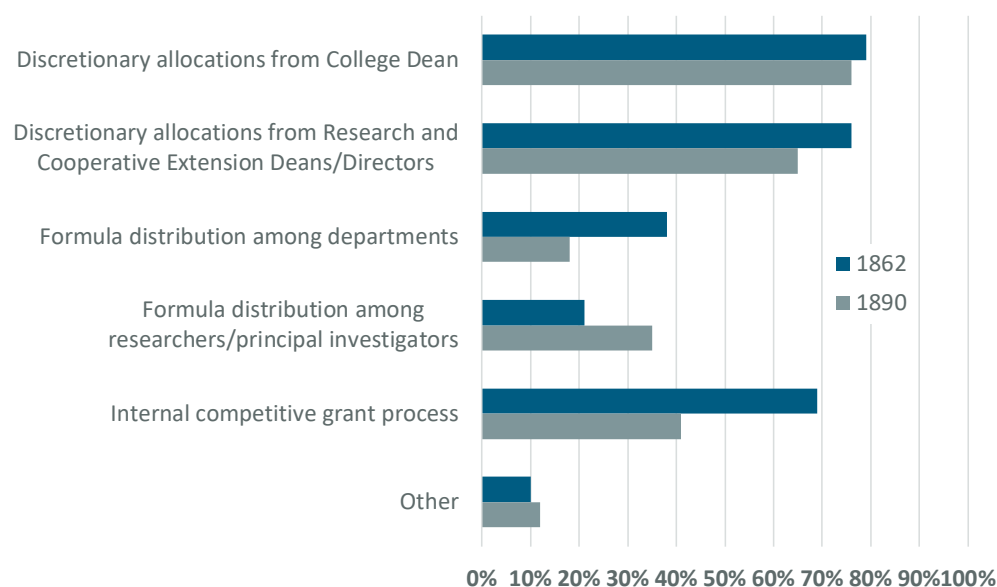
D. Funding Source Flexibility of Use

Capacity Funding, by virtue of being a formula-based allocation of funds to a land-grant institution, provides recipient universities and colleges with considerable leeway in terms of how they choose to allocate and use these funds. In comparison, a typical Competitive grant may have been initially steered in proposal content by the stated priorities of the funding agency, and then defined by the scope of the accepted proposal. There is comparatively limited flexibility to step outside of the predetermined and accepted scope of work when receiving Competitive Funding. There are advantages to the funding agency in terms of this latter, Competitive, model: the funding agency has an advance understanding of what will be performed under a Competitive grant, and the usual peer-review process on grant applications provides a measure of quality assurance for work performed. Competitive Funding is the *de facto* standard for most academic research performed using federal funds.

Capacity Funding is a more unusual model, but a long-established one in the land-grant university and agricultural research realm. The distribution of Capacity Funding allocated by NIFA to land-grant universities must be aligned with approved Plans of Work, and is shaped by the funding allocation decisions of Deans, Experiment Station

System Directors, and Cooperative Extension Directors to fit the priorities of the institution and the identified needs of the agriculture, forestry, and natural resource sectors and supporting communities specific to each state (although still reviewed at a federal level in terms of submitted annual Plans of Work). Flexibility of use in Capacity Funding has the benefit of pushing the setting of research and extension priorities, and associated allocation of funding support, down to the state level such that research and extension can meet specifically identified state and local needs. The survey of Deans and other Senior Administrators deployed by TEconomy/APLU shows the degree of variation in the allocation of funds by the land-grant universities, reflective of their flexibility of use (Figure 26).

Figure 26: Process by Which Land-Grant Institutions Allocate Federal Capacity Funds Received



When asked to rate Capacity versus Competitive funds, and other funding sources, on flexibility of use, the senior leadership at the land-grant institutions report Capacity Funding being considerably more flexible than competitive grants (Table 22). Fully 79 percent of the 1862 Land-Grant leadership respondents cited Capacity Funds as “very flexible” or “somewhat flexible,” versus AFRI Competitive grants at 35 percent and other competitive federal grants also at 35 percent.

Table 22: Rating of Funding Types by Flexibility of Use. Results of Deans/Senior Leadership Survey.

	Inst. Type	Very Flexible	Somewhat Flexible	Neutral	Somewhat Inflexible	Very Inflexible	N/A
NIFA Capacity Funds for Agricultural Research	1862	31%	48%	10%	10%	0%	0%
	1890	35%	35%	6%	12%	12%	0%
	Non-LGU	0%	0%	0%	0%	0%	100%
	All Institutions	31%	41%	8%	10%	4%	6%
NIFA Competitive Funds for Research (AFRI)	1862	7%	28%	21%	41%	3%	0%
	1890	0%	18%	18%	41%	0%	24%
	Non-LGU	0%	67%	0%	33%	0%	0%
	All Institutions	4%	27%	18%	41%	2%	8%
All Other Federal Competitive Funds for Research	1862	7%	28%	28%	31%	7%	0%
	1890	12%	24%	24%	24%	12%	6%
	Non-LGU	0%	33%	33%	0%	0%	33%
	All Institutions	8%	27%	27%	27%	8%	4%

Similar results are evident in the separate survey of Agricultural Research/Experiment Station System Directors (Table 23). A total of 81 percent of the 1862 Land-Grant research director respondents cited Capacity Funds as “very flexible” or “somewhat flexible,” versus AFRI Competitive grants at 26 percent and other competitive federal grants at 28 percent.

Table 23: Rating of Funding Types by Flexibility of Use. Results of Research Directors/Experiment Station Directors Survey.

NIFA Capacity Funds for Agricultural Research	Inst. Type	Very Flexible	Somewhat Flexible	Neutral	Somewhat Inflexible	Very Inflexible	N/A
	1862	34%	47%	13%	4%	2%	0%
1890	53%	27%	7%	7%	7%	0%	
Non-LGU	0%	0%	50%	0%	0%	50%	
All Institutions	38%	41%	13%	5%	3%	2%	
NIFA Competitive Funds for Research (AFRI)	Inst. Type	Very Flexible	Somewhat Flexible	Neutral	Somewhat Inflexible	Very Inflexible	N/A
	1862	0%	26%	21%	36%	9%	9%
1890	0%	44%	19%	25%	0%	13%	
Non-LGU	0%	50%	50%	0%	0%	0%	
All Institutions	0%	31%	22%	32%	6%	9%	
All Other Federal Competitive Funds for Research	Inst. Type	Very Flexible	Somewhat Flexible	Neutral	Somewhat Inflexible	Very Inflexible	N/A
	1862	2%	26%	30%	28%	11%	4%
1890	0%	27%	33%	33%	7%	0%	
Non-LGU	0%	0%	100%	0%	0%	0%	
All Institutions	2%	25%	33%	28%	9%	3%	

The flexibility-of-use characteristic of Capacity Funding may also provide other inherent benefits in terms of the following:

- **Responsiveness to short-term emergency needs or emergent issues.** Not subject to the strictures of a time-consuming grant application and review process, Capacity Funding can be allocated or redirected on a timely as-needed basis by land-grant institutions when an emergency occurs or a new challenge arises. For example, Capacity Funds can be rapidly directed by a land-grant university to address research or extension activities in areas such as the sudden outbreak of a plant or livestock disease, the emergence of an invasive pest, unanticipated major shifts in global markets, severe weather events, or sudden societal events.
- **Supporting investment in, and the maintenance of, the specialized infrastructure, research stations, and associated resources needed to advance agricultural research.** While a large individual Competitive grant might support the purchase of a specific instrument, such grants cannot support the development of the full-scale research infrastructure, network of experiment stations, and associated extension assets that Capacity Funding can support. Coming in major annual tranches with relatively predictable long-term funding stability, Capacity Funding provides universities with the ability to invest strategically over the long term in building up the highly-specialized infrastructure required to advance major programs of research, field testing, and associated extension activity.
- **Support for long-term projects.** The improvement of crops or livestock lines, for example, is typically a long-term process requiring multiple years of testing and validation before results can be published or new varieties or technologies released for use in the field. Such research and development programs are difficult to support under traditional competitive grant structures.
- **Support for junior/early-career faculty.** Capacity Funding provides universities with the flexibility to allocate seed-funding to junior faculty that may be used to advance an initial program of research to the point where the application for Competitive Funding might then be successful. Junior faculty can be engaged in an effective program of research immediately, rather than subjected to the less-

assured process of applying for competitive grants (which often have relatively small success rates for submitted proposals).

The following survey results confirm each of the above bulleted flexibility-of-use benefits as being associated with Capacity Funding.

1. Responsiveness to Short-Term Emergency Needs

In terms of responsiveness to short-term emergency needs, 92 percent of 1862 Land-Grant University Research Directors rate NIFA Capacity Funding as having “very high” or “high” suitability for addressing emergency needs, while AFRI Competitive funds are viewed as having such levels of suitability by only 4 percent of these respondents (Table 24).

Table 24: Rating of Funding Source by Suitability for Addressing Short-Term Emergency Needs. (Question: Rate the suitability of the following funding types for addressing short-term emergency needs (e.g., sudden community concern, disease or pest outbreak, natural disaster). **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	64%	28%	9%	0%	0%	0%
	1890	50%	38%	6%	0%	6%	0%
	Non-LGU	0%	0%	50%	0%	0%	50%
	All Institutions	58%	29%	9%	0%	2%	2%
NIFA Competitive Funds for Research (AFRI)	1862	2%	2%	19%	38%	34%	4%
	1890	6%	13%	6%	44%	19%	13%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	3%	5%	17%	40%	29%	6%
All Other Federal Competitive Funds for Research	1862	2%	0%	15%	40%	40%	2%
	1890	13%	13%	6%	50%	19%	0%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	5%	3%	14%	43%	34%	2%

2. Supporting Investment in, and the Maintenance of, the Specialized Infrastructure, Research Stations, and Associated Resources Needed to Advance Agricultural Research

The survey of Deans and other Senior Leadership finds the majority or plurality of respondents rating Capacity Funds as better than Competitive funds in terms of acquiring equipment and infrastructure and the maintenance of equipment and infrastructure (Table 25).

Table 25: Rating of Funding Source by Suitability for Supporting Infrastructure Investments and Maintenance. (Question: For the following set of funding characteristics, indicate whether you think that Capacity or Competitive Funding sources are more suited to funding each). **Results of Deans/Senior Leadership Survey.**

Supporting purchases of instruments, tools, and equipment	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	24%	28%	24%	21%	3%	0%
	1890	82%	6%	6%	6%	0%	0%
	Non-LGU	0%	67%	33%	0%	0%	0%
	All Institutions	43%	22%	18%	14%	2%	0%

Supporting maintenance of instruments, tools, and equipment	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	28%	41%	17%	7%	3%	3%
	1890	6%	82%	12%	0%	0%	0%
	Non-LGU	0%	33%	67%	0%	0%	0%
	All Institutions	18%	55%	18%	4%	2%	2%
Supporting maintenance of agricultural research fields/farms and related infrastructure	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	69%	21%	3%	3%	0%	3%
	1890	100%	0%	0%	0%	0%	0%
	Non-LGU	33%	0%	67%	0%	0%	0%
	All Institutions	78%	12%	6%	2%	0%	2%

3. Support for Long-Term Projects

Many respondents indicated that Capacity Funds are more dependable for long-term projects. The volatility and inflexibility of Competitive Funds prohibit their use for infrastructure and salary support that are actually necessary for the completion of Competitively funded projects. Capacity Funds also provide a base level of funding that allows for sufficient certainty in long-term planning. Finally, Capacity Funds help to sustain the impacts of Competitively funded projects after that funding has expired and provide support for ongoing applied and mission-oriented research that Competitive Funds may or may not support.

4. Support for Junior/Early-Career Faculty

One of the criticisms of Competitive grant funding is that it can be challenging for early-career faculty and researchers to compete for the limited pool of funds that each funding agency releases. Capacity Funding provides universities with a flexible funding stream that can support the research of early-career faculty, helping to build their experience base and a portfolio of research that will help them better compete for scarce competitive research grants. Senior leadership at the land-grant universities certainly see this as being the case, and rate Capacity Funding as superior to Competitive Funding by a wide margin (Table 26).

“The [Competitive Funding] system tends to make research much more project oriented rather than program oriented. We find that when the funding ends the projects seems to die-off and we don’t get the buildup and gains we see with a well-funded, long-term research program.”

1862 – Deputy Director of Agricultural Experiment Station

“Competitive Funding does not fit long-term funding of programs. Every 3–5 years there would be risk that a complete turnover of programmatic effort would occur. Thus, it is difficult to sustain a research enterprise with only Competitive Funding.”

1862 – Director of Agricultural Experiment Station

Table 26: Rating of Funding Source by Suitability for Supporting Junior Faculty. (Question: For the following set of funding characteristics, indicate whether you think that Capacity or Competitive Funding sources are more suited to funding each.)
Results of Deans/Senior Leadership Survey.

Supporting junior faculty	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	52%	28%	7%	7%	3%	3%
	1890	65%	18%	18%	0%	0%	0%
	Non-LGU	67%	0%	33%	0%	0%	0%
	All Institutions	57%	22%	12%	4%	2%	2%

CONCLUSION: Capacity Funding provides flexibility in the use of funds, and this flexibility 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 to land-grant universities in terms of their ability to deal with short-term emergencies and emerging challenges, supporting the large-scale infrastructure required for complex agricultural and associated research, sustaining long-term programs of work in crop and livestock improvement or other longitudinal studies, and building career effectiveness in junior faculty members.

E. Supporting National and Regional Partnerships and Multi-Institution Collaborations

The complexity of research and extension activity, in combination with the increasing complexity of science and technology in general, means that there are benefits to research funding that can support national or regional partnerships assuring knowledge transfer. Through collaborations at a national or multistate scale, complex research questions and challenges may be addressed through assembling consortia of institutions based on the core competencies of participants. It is becoming increasingly rare for one university alone to have all the expert faculty or specialized resources required to optimally address multidimensional, high-complexity challenges. There is an advantage for the nation, therefore, in having research and extension funding models that encourage national-level and multistate/multi-institution collaborations.

In the survey of Deans and other Senior University and College Leadership, the question was directly asked regarding whether Capacity Funding or Competitive Funding is better suited to encouraging development of a **national research system** and a **national cooperative extension system**. The results (Table 27) indicate that Capacity Funding is seen by the land-grant university community to be better suited than Competitive grant funding to engendering the development of such national systems.

Table 27: Rating of Funding Source by Suitability for Creating National Research and Cooperative Extension Systems.

(Question: For the following set of funding characteristics, indicate whether you think that Capacity or Competitive Funding sources are more suited to funding each.) **Results of Deans/Senior Leadership Survey.**

Creating a national research system	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	45%	14%	28%	3%	10%	0%
1890	76%	0%	24%	0%	0%	0%	
Non-LGU	0%	67%	33%	0%	0%	0%	
All Institutions	53%	12%	27%	2%	6%	0%	
Creating a national cooperative extension system	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	66%	17%	14%	0%	0%	3%
1890	88%	0%	6%	0%	6%	0%	
Non-LGU	0%	0%	33%	0%	0%	67%	
All Institutions	69%	10%	12%	0%	2%	6%	

In terms of specifically facilitating the development of **multistate or multi-institution collaborations**, Capacity Funding is again regarded by the land-grants as superior to Competitive Funding for achieving such collaborations (Table 28). Fully 89 percent of the 1862 and 94 percent of the 1890 Land-Grant University research leadership respondents rate NIFA Capacity Funding as between “easy and very easy to facilitate collaboration,” whereas for NIFA Competitive (AFRI) funding, these percentages are 55 percent and 75 percent, respectively.

Table 28: Rating of Funding Source by Suitability for Facilitating Multistate or Multi-Institution Collaboration. (Question: Rate the following funding sources on their ability to facilitate multistate or multi-institution collaboration.) **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very Difficult to Facilitate Collaboration	Difficult to Facilitate Collaboration	Somewhat Easy to Facilitate Collaboration	Easy to Facilitate Collaboration	Very Easy to Facilitate Collaboration	N/A
NIFA Capacity Funds for Agricultural Research	1862	0%	4%	6%	34%	55%	0%
	1890	0%	6%	0%	19%	75%	0%
	Non-LGU	0%	0%	50%	0%	0%	50%
	All Inst.	0%	5%	6%	29%	58%	2%
NIFA Competitive Funds for Research (AFRI)	1862	0%	13%	28%	36%	19%	4%
	1890	0%	6%	6%	19%	56%	13%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Inst.	0%	12%	22%	32%	28%	6%
All Other Federal Competitive Funds for Research	1862	4%	13%	32%	34%	15%	2%
	1890	0%	13%	6%	50%	25%	6%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Inst.	3%	14%	26%	37%	17%	3%

CONCLUSION: Per land-grant university leaders, Capacity Funding is the 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.

F. Supporting Education and Workforce Development

Research and extension activities are important components of the mission of land-grant universities and colleges, but (like other higher education institutions) education is a central mission also. In a science-, technology-, and knowledge-driven economy, education is a central differentiating factor in a region, state, or nation’s ability to compete. Education drives advanced human capital capabilities. In surveying Deans and other Senior Leaders at land-grant universities, the respondents were asked to identify whether they consider Capacity Funding or Competitive Funding to be better than the other, or both equally suited, for supporting “undergraduate engagement,” “graduate students/PhD candidates,” and “international students.” Table 29 provides the response data, indicating that “both equally suited” was the modal value; but, on average, “undergraduate engagement” and “graduate student” support are viewed as benefiting more under a Capacity model than a Competitive one, with the inverse holding true for “supporting international students” where Competitive Funding is favored.

Table 29: Rating of Funding Source by Suitability for Supporting Students. Results of Deans/Senior Leadership Survey.

Supporting under-graduate engagement	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	31%	10%	48%	3%	0%	7%
	1890	59%	0%	35%	6%	0%	0%
	Non-LGU	0%	33%	67%	0%	0%	0%
	All Institutions	39%	8%	45%	4%	0%	4%
Supporting graduate students/ PhD candidates	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	7%	21%	41%	17%	10%	3%
	1890	35%	0%	41%	12%	0%	12%
	Non-LGU	33%	33%	33%	0%	0%	0%
	All Institutions	18%	14%	41%	14%	6%	6%
Supporting international students	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	Do Not Currently Receive
	1862	0%	11%	50%	11%	21%	7%
	1890	24%	6%	35%	24%	12%	0%
	Non-LGU	0%	0%	100%	0%	0%	0%
	All Institutions	8%	8%	48%	15%	17%	4%

CONCLUSION: 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 somewhat more supportive of this student type.

G. Other Factors

1. Scalability

It was noted in Chapter I that NIFA funding to support research is considerably smaller than other major federal research funding agencies. This leads to the question of whether the leading institutions in performance of agricultural research (the land-grant universities) would have current capabilities to perform enhanced levels of research and extension activity were more federal funds to be allocated to NIFA.

The results of the survey of Deans and Senior Leadership at the land-grant universities indicates that **there is considerable capacity and scalability in the current system if more funding were secured for NIFA** (Table 30). In terms of research capacity, **the 1862 Land-Grants indicated an average of 76 percent more research funding could be absorbed before having to add more research staff.** At the 1890 institutions, the scalability factor was less, but still significant at 33 percent.

Table 30: Estimated Capacity at Institution to Absorb Increased Capacity Funding for Research. (Question: If your institution were to receive significantly more Capacity or formula-based research funding, what percent increase in funding could be used without increasing your current FTE researcher count? In other words, how much more research funding could be effectively absorbed by your existing research staff?) **Results of Deans/Senior Leadership Survey.**

	1862	1890	Non-LGU	All Institutions
Average Percent Increase	76%	33%	133%	65%

Similar results are observed for scalability of Cooperative Extension, where the 1962 Land-Grant University respondents felt they could, on average, absorb **an additional 63 percent** in funding with current staff levels, while the 1890s recorded 30 percent (Table 31).

Table 31: Estimated Capacity at Institution to Absorb Increased Capacity Funding for Cooperative Extension. (Question: If your institution were to receive significantly more capacity or formula-based cooperative extension funding, what percent increase in funding could be used without increasing your current FTE employment count? In other words, how much more cooperative extension funding could be effectively absorbed by your existing Cooperative Extension staff?) **Results of Deans/Senior Leadership Survey.**

	1862	1890	Non-LGU	All Institutions
Average Percent Increase	63%	30%	--	51%

CONCLUSION: *Research funding for the NIFA is considerably smaller than for many other federal research funding agencies (Figure 3). There exists considerable capacity in the current land-grant university systems of research and extension to accommodate significantly higher levels of research funding even without raising the number of personnel engaged. It is likely that were the NIFA research budget to be expanded by two-thirds, the current land-grant system could potentially absorb that funding without increasing faculty or staff. In Cooperative Extension, funding scalability is similar.*

2. Time-on-Task

With Capacity Funding representing a relatively stable source of funding, it has the advantage of providing research and extension faculty and staff with a predictable funding resource to sustain their research and extension activities. The TEconomy/APLU surveys of land-grants illustrate that the most frequently used mechanisms for distributing federal Capacity Funds to research and extension projects at the land-grants is via “discretionary allocations by the senior administration” (Deans, Experiment Station System Directors, Extension Directors, etc.). This method of allocation helps reduce the time-consuming process of preparing proposals for Competitive grant applications – a process that reduces “time on actual research” and is often unsuccessful, given the relatively low percentage of proposals that are typically accepted for funding by federal agencies. It can take 120 to 150 hours of work to prepare a modest-sized proposal for a federal grant⁴³ (with the NSF estimating 120 hours as typical) – that equates to the equivalent of a month or more (assuming a 40-hour workweek) spent to develop a proposal that may have only a 10 to 17 percent chance of success. The Capacity Funding model, in contrast, gives land-grant universities more discretion and freedom to allocate their funding to what they conclude will be valuable research and extension programs. This is not without federal oversight, however, since the institutions are required to submit a Plan of work, which is reviewed and approved by NIFA; institutions are also required to submit annual accomplishment reports, along with project impact statements.

CONCLUSION: *The relatively assured nature of Capacity Funding allows land-grant universities to allocate funds to faculty without the need for time-consuming individual proposal development and the loss of time-on-task associated with the writing of proposals that are ultimately unsuccessful in winning a competitive award.*

⁴³ See, for example, estimates by UC Santa Cruz at: https://grants.soe.ucsc.edu/proposal_time_commitment.

3. Geographic Distribution of the Research and Extension Enterprise

The Capacity Funding model assures that agricultural and associated research and extension programs are pursued in all 50 states, and in U.S. territories. Given the geographically distributed nature of agricultural production, and the need for locally researched and extended solutions (as discussed in Chapter I), the Capacity Funding model provides an equitable, beneficial, and logical mechanism for assuring necessary R&D and extension activity occurs in all U.S. regions. While Competitive Funding, allocated via peer-review processes, has the benefit of supporting potentially high-impact projects and research questions, by its nature it will tend to aggregate to those institutions best equipped to submit major proposals and will tend to support projects with basic or national-scope impacts rather than those of niche and locally applied relevance. The Capacity Model helps to assure that the research and extension needs of farmers and communities across the United States, in smaller states and regions, are not overlooked.

CONCLUSION: Capacity Funding allows a spatially distributed program of research and extension to occur, providing benefits in terms of relevance to local needs and issues.

4. Acceptance of Research Risk

Academic research, whether basic or applied, is not without risk. Research pursues answers to the unknown – seeking to confirm or refute hypotheses. Research that posits a research question outside of the bounds of an academic discipline’s typical paradigms, or research that transcends disciplinary boundaries, may be seen by reviewers for Competitive grants as outside of their comfort zone and as being “too high risk” to support. Capacity Funding removes this external review constraint, giving universities the leeway to take a risk on an atypical idea or concept.

The hypothesis that Capacity Funding may be more accepting of programmatic risk is supported by the findings of the survey of Research Directors, where 79 percent of the 1862 and 56 percent of the 1890 Land-Grant Universities rated Capacity Funding as having “very high” or “high” risk acceptance, versus AFRI Competitive Funding at just 19 percent and 24 percent, respectively, and all other competitive federal funding at 32 percent and 12 percent, respectively (Table 32).

Table 32: Rating of Funding Source by Amount of Risk Tolerance in Research. (Question: Please indicate, by funding source, the amount of risk accepted in proposed research. In other words, do different funding sources allow for more, or less, risky research?) **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	34%	45%	15%	6%	0%	0%
	1890	25%	31%	25%	6%	13%	0%
	Non-LGU	50%	0%	0%	0%	0%	50%
	All Institutions	32%	40%	17%	6%	3%	2%
NIFA Competitive Funds for Research (AFRI)	1862	4%	15%	47%	17%	11%	6%
	1890	19%	6%	25%	38%	0%	13%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Institutions	8%	14%	40%	23%	8%	8%
All Other Federal Competitive Funds for Research	1862	11%	21%	32%	23%	9%	4%
	1890	6%	6%	50%	31%	6%	0%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Institutions	9%	18%	35%	26%	8%	3%

CONCLUSION: *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 report Capacity Funding as being superior to Competitive Funding in terms of risk tolerance.*

5. Support for Basic Research

Basic research, or fundamental scientific inquiry, comprises curiosity-driven research aimed at improving scientific theories or enhancing understanding or prediction of natural processes or other phenomena. In agriculture, forestry, and natural resource sectors, basic research may seek answers to fundamental questions across a range of disciplines and themes in areas such as biology, biochemistry, biophysics, physical systems, rural sociology, or economics. Such basic inquiry will tend to be more “universal,” applying to the scientific area overall rather than focused on a research question specific to an individual state or locality.

It was established earlier in this report that Capacity Funding is viewed by the majority of land-grant university survey respondents as being the superior vehicle for work that is directed toward the needs of regional, state, and local research questions and needs. This suggests that perhaps Competitive Funding, directed typically from a national funding agency level and steered by peer review by a geographically distributed review group, is likely better suited to the more universal nature of basic science inquiry. The survey results find this to hold true, with respondent Research and Experiment Station System Directors at the land-grant universities rating Competitive Funding as having a higher level of overall suitability to basic science questions than Capacity Funding (Table 33). However, the margin of difference in the respondents’ rating of Competitive versus Capacity Funding in this regard is relatively narrow, and Capacity Funding is still seen by a large majority of respondents to be suited to basic research inquiry.

Table 33: Rating of Funding Source by Suitability for Basic Research. (Question: Rate the suitability of the following funding sources for projects in basic research). **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	23%	45%	26%	4%	2%	0%
	1890	25%	19%	38%	19%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	23%	38%	28%	8%	2%	2%
NIFA Competitive Funds for Research (AFRI)	1862	51%	36%	6%	2%	0%	4%
	1890	13%	31%	38%	6%	0%	13%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	40%	35%	15%	3%	0%	6%
All Other Federal Competitive Funds for Research	1862	64%	30%	2%	2%	0%	2%
	1890	19%	44%	25%	13%	0%	0%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	51%	35%	8%	5%	0%	2%

6. Support for Applied Research

Applied research may be defined as scientific study and research seeking to solve practical problems. It will typically draw upon part of the research communities' existing base of accumulated theories, knowledge, methods, and techniques to derive solutions to identified needs and challenges. Applied research is, of course, crucially important in agriculture, forestry, and associated sectors where abiotic and biotic challenges regularly present themselves and fundamental science knowledge is leveraged in applied R&D projects to develop tangible technologies and solutions such as crops resistant to droughts or pests, biopharmaceuticals to combat livestock diseases, technologies to assure food safety, processes by which biomass may be converted into useful fuels or

chemicals, and precision agricultural technologies to assure optimal use of agronomic inputs (to name just some). Similarly, in the social sciences, applied research may use established theories and practice to investigate ways to encourage increasing education participation among at-risk youth, means by which the U.S. population may be encouraged to pursue healthier diets or lifestyles, and ways to develop programs for helping families and communities deal with crises (again, to name just a few examples).

It should be expected that the land-grant university system (given its original founding mission to develop institutions dedicated to practical agriculture, science, military science, and engineering) should be well suited to using Capacity Funding in support of practical applied research. This is found to be the case, as reported by respondents to the Research Directors survey, in which 96 percent of the Directors at 1862 institutions rated Capacity Funds as having “very high” or “high” suitability for supporting applied research, and 100 percent of 1890 Research Directors responded similarly (Table 34). This stands in contrast to the rating for Competitive Funding in support of applied research, where only 19 percent of the 1862 Research Director respondents rated Competitive Funds as suitable for applied research projects.

Table 34: Rating of Funding Source by Suitability for Applied Research. (Question: Rate the suitability of the following funding sources for projects in applied research). **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Applied Agricultural Research	1862	68%	28%	4%	0%	0%	0%
	1890	88%	12%	0%	0%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	71%	25%	3%	0%	0%	2%
NIFA Competitive Funds for Applied Research (AFRI)	1862	6%	13%	55%	21%	0%	4%
	1890	38%	31%	6%	13%	0%	13%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	14%	18%	43%	18%	0%	6%
All Other Federal Competitive Funds for Applied Research	1862	4%	2%	34%	49%	9%	2%
	1890	19%	38%	31%	13%	0%	0%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Institutions	8%	12%	32%	40%	6%	2%
State/Local Funds for Applied Research	1862	51%	28%	15%	0%	0%	6%
	1890	44%	38%	6%	6%	0%	6%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	49%	31%	12%	2%	0%	6%

CONCLUSION: Capacity Funding is particularly well suited to supporting the practical, applied research needs of agriculture, forestry, associated industries and the communities and populations that sustain them. As noted in Chapter I, 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.

Chapter IV. Core Challenges and Opportunities Addressed Through NIFA Funding

Chapter III described findings pertaining to the structure and characteristics of Capacity versus Competitive Funding. In Chapter IV consideration is given to whether there are differences in the types of challenges and opportunities addressed by these respective USDA-NIFA funding sources and to whether these respective funding sources are more, or less, suited to various challenge types and domains.

A. Funding Models and NIFA Challenge Areas

A core priority of NIFA funding is to assure that several key challenge areas are addressed via research and extension activity across U.S. institutions. As noted on the NIFA website⁴⁴, “NIFA supports research, education, and extension in six national challenge areas. These challenge areas, as noted in Chapter II, 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.

Given the importance of these six areas as NIFA priorities, opinions on Capacity versus Competitive Funding models were solicited across three primary TEconomy/APLU surveys, comprising Deans and other Senior College Leadership, Research and Experiment Station Directors, and Cooperative Extension System Directors. The findings from respondents to each of these three surveys on the six NIFA challenge areas are shown on Tables 35 through 38. The results are particularly interesting in that no single funding mechanism is seen as best suited to supporting research across all six challenge areas. For several, Capacity is viewed as the best-suited mechanism; for several others, Competitive Funds are considered to be the better mechanism.

Table 35: Summary of Respondent Rating of Capacity versus Competitive Funds for Work Focused on the Six NIFA Priority Challenge Areas

	Capacity Funds Best Suited	Competitive Funds Best Suited
Food Security	X X X	
Climate Variability and Change	X	X X
Water	X X	X
Bioenergy		X X X
Childhood Obesity	X X	X
Food Safety	X X	X

X = Deans/Senior Leadership X = Research/Experiment Station Directors X = Cooperative Extension Directors

It is evident that Deans and Cooperative Extension Directors generally favor the Capacity model as best suited to the challenge areas, except in the case of “Bioenergy” and Deans’ favoring Competitive Funding for “Climate

⁴⁴ <https://nifa.usda.gov/challenge-areas>.

Variability and Change.” An interesting contrast is evident, however, in that Research and Experiment Station Directors rate Competitive Funding (including both AFRI and other federal sources of Competitive Funds) as moderately better suited to supporting research in five of the challenge areas (Bioenergy, Childhood Obesity, Climate Variability and Change, Food Safety research and Water) and Capacity the better funding model for Food Security research.

Table 36: Funding Sources Best Suited for Research to Meet NIFA Priority Challenge Areas. (Question: For each of the six NIFA challenge areas, please indicate which funding source is best suited to meet funding requirements for research and cooperative extension projects/programs). **Results of Deans/Senior Leadership Survey.**

	Institution Type	NIFA Capacity Funds	NIFA Competitive Funds (AFRI)	All Other Competitive Funds	Not a Priority Area for Institution
Food Security	1862	66%	31%	3%	0%
	1890	76%	12%	6%	6%
	Non-LGU	33%	0%	33%	33%
	All Institutions	67%	22%	6%	4%
Climate Variability and Change	1862	21%	43%	36%	0%
	1890	65%	18%	12%	6%
	Non-LGU	67%	0%	33%	0%
	All Institutions	40%	31%	27%	2%
Water	1862	50%	29%	21%	0%
	1890	65%	6%	12%	18%
	Non-LGU	67%	33%	0%	0%
	All Institutions	56%	21%	17%	6%
Bioenergy	1862	18%	39%	25%	18%
	1890	76%	0%	6%	18%
	Non-LGU	67%	33%	0%	0%
	All Institutions	42%	25%	17%	17%
Childhood Obesity	1862	63%	15%	19%	4%
	1890	88%	6%	6%	0%
	Non-LGU	0%	0%	33%	67%
	All Institutions	68%	11%	15%	6%
Food Safety	1862	66%	34%	0%	0%
	1890	76%	12%	6%	6%
	Non-LGU	0%	0%	33%	67%
	All Institutions	65%	24%	4%	6%

Table 37: Funding Sources Best Suited for Research to Meet NIFA Priority Challenge Areas. Results of Research Directors/Experiment Station Directors Survey.

	Institution Type	NIFA Capacity Funds for Research	NIFA Competitive Funds for Research (AFRI)	All Other Federal Competitive Funds	All Other Non-Federal Competitive Funds	Not Currently a Priority Area for Our Research Activities
Food Security	1862	66%	30%	4%	0%	0%
	1890	88%	0%	6%	0%	6%
	Non-LGU	0%	0%	100%	0%	0%
	All Institutions	69%	22%	8%	0%	2%
Climate Variability and Change	1862	21%	43%	34%	0%	2%
	1890	75%	13%	6%	6%	0%
	Non-LGU	50%	0%	50%	0%	0%
	All Institutions	35%	34%	28%	2%	2%
Water	1862	43%	38%	15%	2%	2%
	1890	75%	0%	6%	0%	19%
	Non-LGU	50%	0%	50%	0%	0%
	All Institutions	51%	28%	14%	2%	6%
Bioenergy	1862	19%	36%	28%	0%	17%
	1890	81%	0%	0%	6%	13%
	Non-LGU	50%	50%	0%	0%	0%
	All Institutions	35%	28%	20%	2%	15%
Childhood Obesity	1862	36%	26%	28%	0%	11%
	1890	69%	6%	6%	0%	19%
	Non-LGU	0%	0%	100%	0%	0%
	All Institutions	43%	20%	25%	0%	12%
Food Safety	1862	47%	47%	4%	0%	2%
	1890	63%	13%	13%	0%	13%
	Non-LGU	50%	0%	50%	0%	0%
	All Institutions	51%	37%	8%	0%	5%

Table 38: Funding Sources Best Suited for Research to Meet NIFA Priority Challenge Areas. Results of Cooperative Extension Directors Survey.

	Institution Type	NIFA Capacity Funds for Extension	NIFA Competitive Funds for Extension	All Other Federal Funds	All Other Non-Federal Funds	Not a Priority Area for Extension
Food Security	1862	88%	8%	4%	0%	0%
	1890	81%	19%	0%	0%	0%
	All Institutions	87%	10%	3%	0%	0%
Climate Variability and Change	1862	54%	35%	10%	2%	0%
	1890	56%	19%	19%	0%	6%
	All Institutions	54%	31%	12%	1%	1%
Water	1862	79%	15%	4%	0%	2%
	1890	53%	24%	0%	0%	24%
	All Institutions	72%	17%	3%	0%	7%
Bioenergy	1862	13%	42%	15%	2%	27%
	1890	38%	19%	6%	0%	38%
	All Institutions	19%	37%	13%	1%	29%
Childhood Obesity	1862	75%	13%	10%	2%	0%
	1890	88%	6%	6%	0%	0%
	All Institutions	78%	12%	9%	1%	0%
Food Safety	1862	87%	6%	6%	2%	0%
	1890	88%	6%	6%	0%	0%
	All Institutions	87%	6%	6%	1%	0%

CONCLUSION: While Chapter III showed Capacity Funding to be favored over Competitive Funding in regards to most characteristics by senior land-grant personnel, this pivots when examining the application of Capacity Funding or Competitive Funding mechanisms to the six NIFA challenge areas. Capacity Funding remains the preferred funding mechanism for extension activities addressing these challenges (except for Bioenergy), whereas Research and Experiment Station Directors see an edge for Competitive Funding sources for many of the challenges. College Dean respondents lean more toward the extension characterization than the Research Directors' rating of these respective funding types.

B. Funding Models and Results Leading to Publications

In funding research at land-grant universities and other institutions, NIFA has interest in seeing the findings of research disseminated to other researchers, academics, and practitioners through the publishing of findings. Research for the “public good” is a clear goal for government-funded research, and publication of findings builds humankind’s collective knowledge-base, providing the following:

- Accumulated knowledge that may favorably impact practice and behavior;
- Understanding around which innovations and technological development may occur;
- Next-generation questions for further investigation, and
- A means by which other researchers can avoid duplication of research that has already been performed.

Responses to the survey administered to Research Directors indicate that both Capacity Funding and Competitive Funding are viewed as effective in terms of generating research findings that translate into publications (Table 39).

In general, Competitive Funds tend to receive a “very high” rating as a funding source for generating publications more so than do Capacity Funds. This is perhaps to be expected given the prior review process that research proposals will have typically gone through to receive Competitive Funding. The funding review process for Competitive Funds, often conducted via peer review, would tend to favor research for which reviewers could see a pathway to the publication of findings. Capacity Funding is well suited to working in both basic and, especially, applied R&D activities, often taking existing findings and doing the important work of testing application to a location-specific, crop-specific, or livestock-specific question. Academic journals are also available for the publishing of applied research, and thus Capacity Funding is also rated “very high” or “high” for work leading to publishable findings.

Table 39 Rating of Funding Source for Research Leading to Publishable Research Findings. (Question: Rate the following funding sources on the ability of your institution to translate the research into publishable research findings). **Results of Research Directors/Experiment Station Directors Survey.**

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	55%	34%	6%	4%	0%	0%
	1890	94%	6%	0%	0%	0%	0%
	Non-LGU	50%	0%	0%	0%	0%	50%
	All Institutions	65%	26%	5%	3%	0%	2%
NIFA Competitive Funds for Research (AFRI)	1862	74%	17%	2%	0%	0%	6%
	1890	56%	19%	13%	0%	0%	13%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	69%	18%	5%	0%	0%	8%
All Other Federal Competitive Funds for Research	1862	70%	21%	4%	0%	0%	4%
	1890	44%	13%	38%	6%	0%	0%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	63%	20%	12%	2%	0%	3%
State/Local Funds for Research	1862	23%	26%	30%	13%	0%	9%
	1890	38%	25%	25%	6%	0%	6%
	Non-LGU	100%	0%	0%	0%	0%	0%
	All Institutions	29%	25%	28%	11%	0%	8%

C. Funding Models: Specific Areas of Research and Emerging Themes in Research

The practice of science, engineering, social science, and other areas of research is not static. During the past decade, the long-standing model of a lone principal investigator driving forward his or her own research has begun to be challenged by a movement toward team science, transdisciplinary and interdisciplinary research. “Big Science” has become a term reflective of the degree of complexity surrounding many scientific and societal challenges, whereby no single researcher, or even single discipline, can have the knowledge and resources required to understand the complex interplay between mechanisms, phenomena, and outcomes. As the practice of research evolves, and the knowledge base expands, it is not unreasonable to question whether a funding scheme established in the late 1800s is still relevant or able to evolve to remain relevant.

In a similar vein, American society and the U.S. economy have evolved. Urban populations have grown while rural and small town populations have declined. U.S. population is more diverse, and family structures have altered. The number of farms in the United States has reduced, while average farm size has increased significantly. Global trade and competition are increasingly intense. Again, these changes raise the question of whether Capacity Funding is still a relevant mechanism for funding research and extension activities across these varied domains and challenges.

To examine this question, the TEconomy/APLU surveys of the land-grant institutions asked respondents to rate Capacity and Competitive Funding across a broad range of research characteristics, topical issues, and areas of scientific inquiry. Tables 40 and 41 summarize key findings for these from the Research Directors survey.

In Table 40, across all variables, except for “providing prestige to the university,” the 1890 Land-Grant respondents view Capacity Funding as the better mechanism for research and associated activities. The 1862 Land-Grant Universities demonstrate more variation in opinion. Among the 1862s, for “supporting team science,” the modal value is “both equally suited,” as is the case for “supporting transdisciplinary science” – so it may be concluded that both Capacity and Competitive models are suited to funding the team science needed to tackle large-scale complex challenges.

Table 40: Rating of Capacity versus Competitive Funding for Supporting Various Types of Research and Functional Activities. Results of Research Directors/Experiment Station Directors Survey.

Supporting team science	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	N/A
	1862	13%	11%	53%	21%	2%	0%
	1890	31%	25%	31%	13%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	17%	15%	46%	18%	2%	2%
Supporting transdisciplinary research							
	1862	4%	13%	51%	28%	4%	0%
	1890	25%	25%	44%	6%	0%	0%
	Non-LGU	0%	0%	0%	0%	50%	50%
	All Institutions	9%	15%	48%	22%	5%	2%
Supporting integrated research and cooperative extension activities							
	1862	30%	38%	28%	4%	0%	0%
	1890	81%	13%	6%	0%	0%	0%
	Non-LGU	0%	0%	0%	0%	50%	50%
	All Institutions	42%	31%	22%	3%	2%	2%
Supporting university research institutes or centers							
	1862	15%	19%	26%	26%	13%	2%
	1890	56%	6%	31%	6%	0%	0%
	Non-LGU	50%	0%	0%	0%	50%	0%
	All Institutions	26%	15%	26%	20%	11%	2%
Supporting international research initiatives							
	1862	4%	6%	26%	32%	28%	4%
	1890	25%	13%	19%	19%	19%	6%
	Non-LGU	0%	0%	0%	100%	0%	0%
	All Institutions	9%	8%	23%	31%	25%	5%
Supporting knowledge transfer/diffusion activities							
	1862	33%	30%	33%	4%	0%	0%
	1890	53%	20%	13%	13%	0%	0%
	Non-LGU	50%	0%	0%	50%	0%	0%
	All Institutions	38%	27%	27%	8%	0%	0%
Supporting family-owned farming operations							
	1862	57%	17%	19%	0%	0%	6%
	1890	69%	19%	0%	13%	0%	0%
	Non-LGU	0%	0%	0%	0%	50%	50%
	All Institutions	58%	17%	14%	3%	2%	6%

	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	N/A
Supporting corporate farming operations	1862	23%	23%	32%	11%	2%	9%
	1890	38%	13%	6%	19%	13%	13%
	Non-LGU	0%	0%	0%	0%	0%	100%
	All Institutions	26%	20%	25%	12%	5%	12%
Providing prestige to the university	1862	4%	2%	21%	21%	51%	0%
	1890	6%	13%	31%	38%	13%	0%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Institutions	6%	5%	25%	25%	40%	0%

The 1862 respondents view several of the listed activities as favoring a Capacity Funding model, most notably in “supporting integrated research and cooperative extension activities,” “supporting knowledge transfer/diffusion activities,” “supporting family-owned farming operations,” and “supporting corporate farming operations.” Capacity Funding is thus viewed favorably for those activities that are quite applied in nature – pragmatically working to transfer knowledge into use across agricultural and other application domains. Competitive Funding tends to be viewed by the 1862 respondents favorably for “supporting university research institutes or centers” and “supporting international research initiatives” and especially favorably for “providing prestige to the university.” This latter factor can be an issue for colleges of agriculture and other university colleges and departments that receive substantial Capacity Funding. As major research universities, the 1862 Land-Grants have evolved substantial research enterprises beyond those funded by NIFA, and university leadership will typically place great stock in reputational rankings. Capacity Funding, as a relatively assured annual inflow of funds, is taken for granted and discounted versus the “win” of bringing in Competitive grant funds– despite the fact that, as has been seen, the two forms of funding are both appropriate for supporting advanced research.

CONCLUSION: *The complexity and transdisciplinarity of major scientific challenges are placing a premium on the ability of funding to support team science and transdisciplinary scientific inquiry. Both Capacity Funding and Competitive Funding models are seen 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. Competitive Funding has an edge in supporting international work and in achieving recognition for the institution resulting in increased prestige.*

Table 41 explores certain emerging and fast-growing thematic areas in relation to research, agriculture, and associated sectors. Again, the respondents at the land-grants were asked to rate whether they see Capacity or Competitive Funding better suited to this thematic area or see them both equally suited.

Generally, with the 1862 universities, the more “local environment”-oriented research themes are seen as lending themselves more toward Capacity Funding, as seen in their responses to “supporting local and statewide interests in organic foods and farming,” “supporting local and statewide food security efforts,” “supporting local food demand-supply (locavore efforts),” and any research that is quite “locality specific.” It is also notable that two large-scale research areas for NIFA funding – supporting “new variety and cultivar research” and “supporting urgent research needs (such as emerging pathogens, invasive species, etc.)” also skew toward the Capacity Funding side – again, likely reflective of cultivars being needed that are suited to the characteristics of specific locations, and urgent/emergency needs likewise tending toward emergence in tightly focused geographies.

Research into “frontier areas of agriscience” sees a modal value of “both equally suited,” although the overall results of the question skew slightly in favor of Capacity Funding – and this is also the case with “precision agriculture R&D.” Areas oriented to more fundamental science skew toward a more favorable rating for Competitive Funding by the 1862s, including “data analytics and big data processing research,” “genetic modification,” “plant-microbial symbiosis research,” and R&D in relation to “bioenergy and industrial biomass.” Questions on “global grand challenges” are likewise seen favoring Competitive Funding models.

Open-ended responses in the surveys submitted by the 1890 institutions emphasize the significant challenges of these institutions in achieving Competitive Funding. Thus, evident in Table 41 is an almost universal rating of Capacity Funding as most suited to the thematic elements presented at the 1890s.

Table 41: Rating of Capacity versus Competitive Funding for Supporting Various Topical Areas. (Question: For the following set of topical characteristics, indicate whether you think that Capacity or Competitive Funding sources are more suited to funding each.) **Results of Research Directors/Experiment Station Directors Survey.**

	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	N/A
Supporting local and statewide interest in organic foods and farming	1862	26%	26%	40%	4%	4%	0%
	1890	81%	13%	6%	0%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	38%	23%	31%	3%	3%	2%
Supporting local and statewide food security efforts	1862	36%	23%	36%	4%	0%	0%
	1890	81%	6%	13%	0%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	46%	20%	29%	3%	0%	2%
Supporting "local food" demand-supply (also known as locavore) efforts	1862	38%	30%	23%	4%	0%	4%
	1890	75%	13%	6%	6%	0%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	46%	26%	18%	5%	0%	5%
Supporting locality-specific research issues (i.e., findings are geographically limited in their application)	1862	57%	37%	7%	0%	0%	0%
	1890	94%	0%	6%	0%	0%	0%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	66%	28%	6%	0%	0%	0%
Supporting urgent research needs (e.g., emerging pathogens, invasive species, natural disaster issues)	1862	57%	23%	15%	4%	0%	0%
	1890	56%	25%	13%	6%	0%	0%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	55%	25%	15%	5%	0%	0%
Supporting emerging and frontier areas of agriscience	1862	11%	4%	49%	28%	9%	0%
	1890	31%	19%	38%	13%	0%	0%
	Non-LGU	0%	0%	50%	50%	0%	0%
	All Institutions	15%	8%	46%	25%	6%	0%
Supporting new variety or cultivar development and research	1862	43%	36%	19%	2%	0%	0%
	1890	69%	19%	6%	6%	0%	0%
	Non-LGU	0%	50%	0%	0%	50%	0%
	All Institutions	48%	32%	15%	3%	2%	0%
Supporting precision agriculture research and development, including software, sensors, robotics, and drones	1862	9%	15%	51%	19%	6%	0%
	1890	38%	25%	13%	19%	6%	0%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Institutions	15%	18%	40%	20%	6%	0%

	Inst. Type	Capacity Much Better	Capacity Moderately Better	Both Equally Suited	Competitive Moderately Better	Competitive Much Better	N/A
Supporting data analytics and big data processing research	1862	4%	4%	45%	28%	19%	0%
	1890	33%	13%	20%	20%	13%	0%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	11%	9%	38%	25%	17%	0%
Supporting research incorporating genetic modification	1862	2%	11%	43%	28%	17%	0%
	1890	38%	19%	13%	25%	6%	0%
	Non-LGU	0%	50%	0%	0%	0%	50%
	All Institutions	11%	14%	34%	26%	14%	2%
Supporting plant-microbial symbiosis research	1862	4%	6%	53%	26%	11%	0%
	1890	31%	19%	13%	38%	0%	0%
	Non-LGU	0%	50%	0%	0%	50%	0%
	All Institutions	11%	11%	42%	28%	9%	0%
Supporting research for bioenergy or industrial biomass applications	1862	2%	9%	51%	28%	9%	2%
	1890	50%	31%	13%	6%	0%	0%
	Non-LGU	0%	50%	0%	50%	0%	0%
	All Institutions	14%	15%	40%	23%	6%	2%
Addressing questions pertaining to global grand challenges	1862	4%	2%	36%	36%	19%	2%
	1890	19%	25%	25%	31%	0%	0%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	8%	9%	34%	34%	14%	2%

CONCLUSION: Modern research themes relevant to the land-grants range in spatial scale from local and state-specific needs to wide-ranging 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 oriented more toward basic science or global challenges, the more Competitive Funding is favored. Since, as discussed in Chapter I, 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 and crucially important funding tool for the foreseeable future.

D. Research Output

In addition to the quantitative data discussed in Chapter II, several questions deployed in the surveys administered by TEconomy/APLU are relevant to the discussion of outputs occurring via NIFA research and extension funding.

Research/Experiment Station Directors were asked to give a comparative rating between Capacity and Competitive Funding sources in terms of “**volume of research outcomes achieved (number of publications, patents, etc.)**”

Table 42 shows the data from respondents. Among the 1862 Land-Grant Universities, Competitive Funding sources (whether from AFRI or other federal Competitive Funding sources) are rated more highly in terms of generating research output resulting in publications and/or patents.

Table 42: Rating of Funding Source for Volume of Research Outcomes Achieved. (Question: Rate the following funding sources on the volume of research outcomes (e.g., numbers of publications, patents, etc.) achieved with their funding). **Results of Research Directors/Experiment Station Directors Survey.**

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	36%	32%	28%	4%	0%	0%
	1890	69%	25%	0%	0%	0%	6%
	Non-LGU	0%	0%	50%	0%	0%	50%
	All Institutions	43%	29%	22%	3%	0%	3%
NIFA Competitive Funds for Research (AFRI)	1862	47%	40%	6%	0%	0%	6%
	1890	44%	25%	13%	6%	0%	13%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	45%	38%	8%	2%	0%	8%
All Other Federal Competitive Funds for Research	1862	43%	47%	6%	2%	0%	2%
	1890	44%	19%	31%	6%	0%	0%
	Non-LGU	0%	100%	0%	0%	0%	0%
	All Institutions	42%	42%	12%	3%	0%	2%
State/Local Funds for Research	1862	17%	28%	36%	9%	2%	9%
	1890	31%	13%	50%	0%	0%	6%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Institutions	22%	23%	40%	6%	2%	8%

Publications as a measure of research output were examined more specifically in a question asking respondents to “rate the suitability of funding sources for generating peer-reviewed research papers and other academic publications.” Table 43 lists results from this survey question. The 1862 Land-Grants generally rated Competitive Funding sources as having a “very high” degree of suitability for generating journal publications, whereas Capacity Funds were generally rated one category lower at a “high” degree of suitability.

Table 43: Rating of Funding Source by Suitability for Research Leading to Peer-Reviewed Papers and Other Academic Publications. Results of Research Directors/Experiment Station Directors Survey.

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	36%	49%	15%	0%	0%	0%
	1890	88%	13%	0%	0%	0%	0%
	Non-LGU	50%	0%	0%	0%	0%	50%
	All Institutions	49%	38%	11%	0%	0%	2%
NIFA Competitive Funds for Research (AFRI)	1862	74%	19%	0%	0%	0%	6%
	1890	63%	25%	0%	0%	0%	13%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	71%	22%	0%	0%	0%	8%
All Other Federal Competitive Funds for Research	1862	79%	19%	0%	0%	0%	2%
	1890	38%	44%	13%	6%	0%	0%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	68%	26%	3%	2%	0%	2%
State/Local Funds for Research	1862	17%	34%	28%	9%	6%	6%
	1890	38%	13%	25%	13%	6%	6%
	Non-LGU	50%	50%	0%	0%	0%	0%
	All Institutions	23%	29%	26%	9%	6%	6%

CONCLUSION: *The traditional academic metric of peer-reviewed papers can be supported by both capacity and Competitive Funding models, but Competitive Funding is viewed by land-grant respondents as more highly suited to generating academic publications in journals.*

Research leading to tangible innovations will often result in the generation of invention disclosures, and some of these will advance to patenting. Survey recipients at the land-grant universities were asked to rate funding sources in terms of their suitability for generating such intellectual property (IP). Both Capacity Funding and Competitive Funding are generally viewed as suitable to funding research that may lead to IP generation, with the 1862s giving a somewhat higher rating to Competitive Funds, and the 1890s more highly rating Capacity Funding (Table 44).

Table 44: Rating of Funding Source by Suitability for Generating Intellectual Property. (Question: Rate the suitability of the following funding sources for generating disclosures, patents, and other intellectual property.) **Results of Research Directors/Experiment Station Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	34%	28%	30%	9%	0%	0%
	1890	69%	19%	13%	0%	0%	0%
	Non-LGU	0%	0%	50%	0%	0%	50%
	All Institutions	42%	25%	26%	6%	0%	2%
NIFA Competitive Funds for Research (AFRI)	1862	32%	47%	11%	6%	0%	4%
	1890	63%	25%	6%	0%	0%	6%
	Non-LGU	0%	0%	100%	0%	0%	0%
	All Institutions	38%	40%	12%	5%	0%	5%
All Other Federal Competitive Funds for Research	1862	34%	45%	13%	6%	0%	2%
	1890	33%	47%	13%	7%	0%	0%
	Non-LGU	0%	0%	100%	0%	0%	0%
	All Institutions	33%	44%	16%	6%	0%	2%
State/Local Funds for Research	1862	17%	15%	30%	28%	4%	6%
	1890	25%	19%	38%	13%	0%	6%
	Non-LGU	0%	50%	50%	0%	0%	0%
	All Institutions	18%	17%	32%	23%	3%	6%

CONCLUSION: *Intellectual property (IP) may derive from Capacity funded or Competitively funded research. 1862 institutions give a somewhat higher rating to Competitive Funds in this regard, whereas 1890s find Capacity Funding more conducive to IP generation.*

Cooperative Extension embodies the pragmatic mission of land-grant universities and NIFA in seeking to assure that new knowledge, practice innovations, and technological advancements derived from research are efficiently adopted in agriculture, forestry, and natural resource industries and in key populations and communities. Academic journal publications are outstanding resources for communicating results to fellow scientists and academicians, but tend not to be ideal communication vehicles for reaching key audiences in the daily practice of agriculture or other special populations that would benefit from implementing or adopting recommended approaches, practices, or technologies based on research findings and associated innovations. With literally thousands of scientific journals in current publication, agriculture and associated industry practitioners, community development professionals, etc., cannot be expected to keep up with such publications. Practitioners and the non-academic public rather are served by Cooperative Extension whose professionals capture, summarize, and translate key findings of applied relevance stemming from research and the work of the land-grant agricultural experiment station systems and individual university academic departments, centers, and institutes. Extension, in

effect, serves as an educational organization providing external parties with access to current information rooted in research and the research literature.

Survey respondents were asked to rate funding sources for “**developing and supporting knowledge-diffusion activities,**” with knowledge diffusion defined to include “any method to document and share knowledge, practice recommendations, fact sheets, policy reports, education and training outreach activities, webinars, presentations, and field days, among others.” Tables 45 and 46 report the findings for this question from the Research/Experiment Station System Directors and the Directors of Cooperative Extension, respectively. The results of the surveys clearly show respondents rating Capacity Funding at a significantly higher level than Competitive Funding for achieving the pragmatic goal of diffusing knowledge into practice.

Table 45: Rating of Funding Source by Suitability for Knowledge-Diffusion Activities. Results of Research Directors/Experiment Station Directors Survey.

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Agricultural Research	1862	57%	26%	15%	2%	0%	0%
	1890	75%	19%	6%	0%	0%	0%
	Non-LGU	50%	0%	0%	0%	0%	50%
	All Inst.	62%	23%	12%	2%	0%	2%
NIFA Competitive Funds for Research (AFRI)	1862	23%	13%	45%	13%	0%	6%
	1890	38%	31%	13%	6%	0%	13%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Inst.	28%	17%	37%	11%	0%	8%
All Other Federal Competitive Funds for Research	1862	21%	11%	40%	21%	4%	2%
	1890	31%	31%	25%	13%	0%	0%
	Non-LGU	50%	0%	50%	0%	0%	0%
	All Inst.	25%	15%	37%	18%	3%	2%
State/Local Funds for Research	1862	45%	32%	17%	0%	0%	6%
	1890	31%	38%	19%	0%	6%	6%
	Non-LGU	100%	0%	0%	0%	0%	0%
	All Inst.	43%	32%	17%	0%	2%	6%

Table 46: Rating of Funding Source by Suitability for Knowledge-Diffusion Activities. Results of Cooperative Extension Directors Survey.

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Cooperative Extension	1862	82%	16%	2%	0%	0%	0%
	1890	88%	6%	6%	0%	0%	0%
	All Inst.	84%	13%	3%	0%	0%	0%
NIFA Capacity Funds for Forestry Extension	1862	49%	27%	4%	0%	0%	20%
	1890	50%	6%	19%	0%	0%	25%
	All Inst.	49%	22%	7%	0%	0%	21%
NIFA Capacity Funds for Expanded Food and Nutrition Education Program (EFNEP)	1862	57%	22%	10%	12%	0%	0%
	1890	53%	27%	13%	0%	7%	0%
	All Inst.	56%	23%	11%	9%	2%	0%

	Inst. Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Competitive Funds for Cooperative Extension	1862	12%	37%	22%	18%	10%	2%
	1890	31%	13%	38%	6%	0%	13%
	All Inst.	16%	31%	25%	15%	7%	4%
All Other Federal Competitive Funds for Cooperative Extension	1862	16%	24%	31%	18%	10%	2%
	1890	31%	0%	56%	6%	0%	6%
	All Inst.	19%	18%	37%	15%	7%	3%
State/Local Funds for Cooperative Extension	1862	57%	20%	16%	4%	2%	2%
	1890	38%	25%	25%	0%	6%	6%
	All Inst.	52%	21%	18%	3%	3%	3%

CONCLUSION: Respondent land-grant institutions rate Capacity Funding at a significantly higher level than Competitive Funding for achieving the pragmatic goal of diffusing knowledge into practice.

The survey of Cooperative Extension Directors asked a series of additional questions pertaining to funding sources and their suitability for supporting extension outputs. Tables 47 through 49 summarize key findings and clearly show Capacity Funding to be considerably better suited to funding these key extension activities versus Competitive Funding.

Table 47: Rating of Funding Source by Suitability to Address Extension Work in Generating Publications Leading to Behavioral Change. (Question: Rate the suitability of the following funding sources for generating extension-specific publications, web information/modules, web-based decision tools, and other programs leading to behavioral change.) **Results of Cooperative Extension Directors Survey.**

	Institution Type	Very High	High	Medium	Low	Very Low	N/A
NIFA Capacity Funds for Cooperative Extension	1862	71%	22%	6%	0%	2%	0%
	1890	94%	0%	6%	0%	0%	0%
	All Inst.	76%	16%	6%	0%	1%	0%
NIFA Capacity Funds for Forestry Extension	1862	51%	25%	2%	0%	0%	22%
	1890	38%	19%	13%	0%	0%	31%
	All Inst.	48%	24%	4%	0%	0%	24%
NIFA Capacity Funds for EFNEP	1862	45%	22%	27%	4%	2%	0%
	1890	50%	25%	19%	0%	6%	0%
	All Inst.	46%	22%	25%	3%	3%	0%
NIFA Competitive Funds for Cooperative Extension	1862	24%	33%	29%	10%	2%	2%
	1890	13%	38%	31%	6%	0%	13%
	All Inst.	21%	34%	30%	9%	1%	4%
All Other Federal Competitive Funds for Cooperative Extension	1862	22%	27%	24%	20%	2%	6%
	1890	19%	19%	50%	6%	0%	6%
	All Inst.	21%	25%	30%	16%	1%	6%
State/Local Funds for Cooperative Extension	1862	47%	25%	18%	8%	0%	2%
	1890	31%	38%	19%	0%	6%	6%
	All Inst.	43%	28%	18%	6%	1%	3%

Table 48: Rating of Funding Source by Suitability to Apply the Results of Research to the Needs of Farmers, Ranchers, Businesses, Consumers, Families, or Communities. Results of Cooperative Extension Directors Survey.

Funding Source	Institution Type	Very High	High	Medium	Low	Very Low	N/A
	NIFA Capacity Funds for Cooperative Extension	1862	81%	15%	2%	2%	0%
	1890	81%	6%	13%	0%	0%	0%
	All Inst.	81%	13%	4%	1%	0%	0%
NIFA Capacity Funds for Forestry Extension	1862	46%	21%	10%	2%	0%	21%
	1890	44%	6%	19%	0%	0%	31%
	All Inst.	46%	18%	12%	1%	0%	24%
NIFA Capacity Funds for EFNEP	1862	54%	23%	13%	6%	0%	4%
	1890	69%	13%	19%	0%	0%	0%
	All Inst.	57%	21%	15%	4%	0%	3%
NIFA Competitive Funds for Cooperative Extension	1862	21%	31%	31%	10%	6%	2%
	1890	31%	13%	38%	6%	0%	13%
	All Inst.	24%	26%	32%	9%	4%	4%
All Other Federal Competitive Funds for Cooperative Extension	1862	17%	31%	33%	10%	6%	4%
	1890	31%	13%	44%	6%	0%	6%
	All Inst.	21%	26%	35%	9%	4%	4%
State/Local Funds for Cooperative Extension	1862	56%	17%	15%	8%	2%	2%
	1890	56%	19%	19%	0%	0%	6%
	All Inst.	56%	18%	16%	6%	1%	3%

Table 49: Rating of Funding Source for Funding Work Leading to Behavioral Change Outcomes for Farmers, Ranchers, or Other Producers. Results of Cooperative Extension Directors Survey.

Funding Source	Institution Type	Very High	High	Medium	Low	Very Low	N/A
	NIFA Capacity Funds for Cooperative Extension	1862	69%	19%	10%	2%	0%
	1890	63%	31%	6%	0%	0%	0%
	All Inst.	68%	22%	9%	1%	0%	0%
NIFA Capacity Funds for Forestry Extension	1862	37%	25%	15%	0%	2%	21%
	1890	31%	25%	0%	13%	0%	31%
	All Inst.	35%	25%	12%	3%	1%	24%
NIFA Capacity Funds for EFNEP	1862	42%	19%	13%	8%	4%	13%
	1890	38%	31%	0%	0%	0%	31%
	All Inst.	41%	22%	10%	6%	3%	18%
NIFA Competitive Funds for Cooperative Extension	1862	13%	15%	44%	19%	4%	4%
	1890	19%	19%	44%	0%	6%	13%
	All Inst.	15%	16%	44%	15%	4%	6%

		Very High	High	Medium	Low	Very Low	N/A
All Other Federal Competitive Funds for Cooperative Extension	1862	12%	17%	44%	19%	3.85%	4%
	1890	19%	25%	38%	6%	6.25%	6%
	All Inst.	13%	19%	43%	16%	4.41%	4%
State/Local Funds for Cooperative Extension							
	1862	50%	21%	19%	6%	0%	4%
	1890	31%	44%	13%	6%	0%	6%
	All Inst.	46%	26%	18%	6%	0%	4%

CONCLUSION: Capacity Funding is especially important to supporting Cooperative Extension activities that lead to actual change in behaviors, both in terms of production sectors and among communities, families, or individuals.

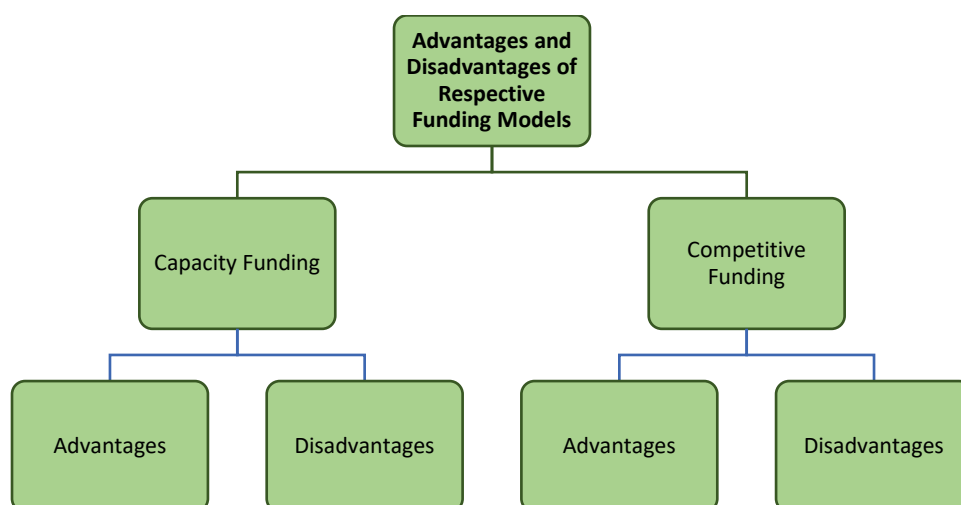
Cooperative Extension's mission and the populations it seeks to serve extend beyond agriculture and forestry activities, and into the communities, family structures, and individuals (including adults, youth, and children) that make up American rural, small town, and urban life. The survey of Extension Directors examined Capacity Funding and Competitive Funding models in terms of their ability to support this type of extension activity, and again found that Capacity Funding is viewed as much better suited to the support of this work than Competitive grants. This held true for questions pertaining to the following:

- The amount of behavioral change outcomes in **nutrition, health, and physical activity** achieved with their funding.
- The amount of behavioral change outcomes for **children and youth** achieved with their funding.
- The amount of behavioral change outcomes in **parent and family skills development** achieved with their funding.
- The amount of behavioral change outcomes in **leadership and civic/community engagement** achieved with their funding.

V. Advantages and Disadvantages of Capacity Funding

Capacity Funding and Competitive Funding differ in certain characteristics of their acquisition and use. These characteristics have meaningful consequences for the ways in which funding is utilized by researchers, staff, and administrators across the land-grant universities. Therefore, the TEconomy/APLU questionnaires to the Deans and Senior Leaders, Research and Experiment Station Directors, and Cooperative Extension Directors contained questions regarding the relative advantages and disadvantages of the Capacity and Competitive Funding systems. Overall, respondents provided strikingly similar answers to these questions, suggesting that many of their observations are shared widely across the research and extension landscape. Importantly, many responses reflect commonly held beliefs regarding the funding processes. Consistency in these responses strengthens the understanding of the benefits and challenges implicit in Capacity and Competitive Funding. Consequently, the results from these questions, across the three surveys, have been synthesized in this chapter to demonstrate the ubiquity of the responses.

Figure 27: Advantages and Disadvantages of Funding Models – Analysis Performed



A. Advantages of Capacity Funding

The most recurrent theme throughout all open response questions is the notion that Capacity Funding provides both the infrastructure and the stable, ongoing source of funding that are necessary for research and extension activities. Capacity Funding, in effect, is viewed as the “glue” that holds the system together, allowing for a sense of continuity that makes long-term planning possible. Capacity Funding provides a baseline of support for faculty and staff salaries, graduate student stipends, and equipment purchases and maintenance that then facilitate the great majority of research and extension work.

In addition to being a stable resource, Capacity Funds are valued as a source of large-scale leverage for institutions seeking competitive grants and matching funding from state governments. Respondents expressed a deep concern that decreases in Capacity Funds may result in the loss of other sources of funding that are vital to research and extension efforts. For many researchers, Capacity Funds also allow for the possibility of pilot studies and the collection of preliminary data that makes their projects more compelling for review in Competitive grant proposals. Capacity Funding is also vital to junior faculty, who may not have experience in grant writing, in establishing new research programs.

Respondents emphasized two other strengths of Capacity Funds that allow research and extension activities to bring maximum benefit to stakeholders. The first is flexibility. Capacity Funds are more flexible in use than Competitive grants and can be allocated differently by each institution. This allows funding to be directed or redirected to new and emerging issues as they occur. For example, respondents commonly listed natural disasters as one key area where flexibility impacts outcomes. These events cannot be planned for, and thus, reliable funding can be reallocated when the situation arises.

The second strength of Capacity Funding that respondents believe most actively benefits stakeholders is its superiority for handling issues of local, regional, and statewide importance. Researchers can conduct applied research that has significant impacts for the stakeholders in their area, while these issues may otherwise be excluded from the set of more nationally-oriented priorities that determine the success of Competitive grant proposals. Likewise, extension outreach efforts can target the specific needs of underserved and disadvantaged

“Capacity Funding is vital for partial funding of salaries for faculty, professionals and field laborers that also work in Competitively funded projects. It is also important for the acquisition of major pieces of equipment needed for work in both Capacity and Competitive projects. And it is very significant in the maintenance of labs and infrastructure at the different research centers and substations. Competitive funds, which in our case are limited, largely depend on the infrastructure and resources maintained by Capacity Funds and their local match contribution.”

potentially “crippling” and “devastating.”

B. Disadvantages of Capacity Funding

Despite their overwhelming support for, and appreciation of, Capacity Funding, respondents exhibited some common concerns regarding the Capacity Funding system. In addition to frustration with the available volume of funds that is common across academia, the pool of Capacity Funds has not grown to keep pace with inflation and the cost of doing research. The lack of growth means that an erosion of buying power further limits the effectiveness of programming and prevents institutions from making the infrastructural improvements they need to remain competitive.

A survey respondent noted: “Some of the greatest strengths of NIFA Capacity Funding are the stability, flexibility, and ease of use of the funding. Capacity Funding allows each state the ability to respond to the local, county, regional, and statewide issues immediately, thus allowing Land-Grant Institutions with a mechanism to directly fulfill the land-grant mission. Due to the process of Competitive Funding, the mechanism could not accomplish this.”

members of their communities. Respondents from tropical areas and other unique environments, for example, emphasized the significance of this attribute, as they believe the issues that are unique to tropical areas are not frequently included as national priorities in Competitive requests for proposals.

Finally, respondents were asked to describe how a hypothetical absence of Capacity Funding would impact research and cooperative extension activities at their institutions. Given the consistency of responses above, it is not surprising that a substantial number of respondents indicated that there would be a reduction or a complete cessation of their programs without Capacity Funding, which was described separately as

“Capacity Funds have not received a significant increase in allocation over the past decade. As a result, level funding allocations over time mean we lose ground in the ability to keep pace with programming demands, emerging issues and societal grand challenges at the state, regional and national level. This means we hire fewer faculty and staff or consolidate expertise in order to be financially accountable while struggling to meet the real demand of constituent needs.”

Two additional concerns relate to the role of Congress in appropriating and approving Capacity Funding. First is dissatisfaction with delays in receiving funding. Several respondents note that funding earmarked for a fiscal year often arrives so late in that year that planning around such funds is difficult. This was of particular concern to the 1890 institutions because of differences in the carryover rule. Respondents from the 1890 institutions, where only 20 percent of Capacity Funds can carry over from year to year, faced the loss of funding due to receiving it so late. The 1862 institutions, with 100 percent carryover, do not express the same level of concern. Another common argument suggested that the institutions receiving Capacity Funding have not done enough to ensure that Congress and the American people understand the importance of all varieties of agricultural research as well as the economic and social impacts of research and extension programs. These comments argued that a lack of communication of the successes of Capacity funded activities has resulted in a misunderstanding of their value.

C. Advantages of Competitive Funding

Despite harboring some concerns over the Competitive proposal and review process discussed below, the most commonly cited advantage of Competitive Funding among respondents was the peer-review process. Many respondents argued that peer review produces the best science and rewards the most capable researchers through its open and meritocratic nature. While some considered it a disadvantage, the prioritization of national issues in Competitive Funding Requests for Application (RFA) is a benefit to institutions conducting basic research with broad impacts. Respondents noted that cutting-edge research tends to receive funding, fostering innovation. Furthermore, success in peer review also confers a level of prestige to the university that some respondents valued.

Additionally, responses indicate that Competitive Funding may allow for more in-depth and targeted research of specific issues. This is due, in part, to the generally higher levels of funding awarded to specific projects from Competitive Funding as well as the lack of flexibility that mandates those funds be used on the specific project and not diverted to another use. There is also a general agreement that Competitive Funding encourages a level of collaboration between departments, institutions, and states that might not exist otherwise.

D. Disadvantages of Competitive Funding

Compared with Capacity Funding, respondents expressed challenges with more facets of Competitive Funding. Interestingly, these disadvantages are largely a consequence of the strengths noted above.

“Budgeting challenges are among the greatest weaknesses given that funding often is not allocated timely to [this university] and must be returned at end of year. Funds are too restrictive. For example, 25% multi-state requirement is too high considering a high percentage of the funding needs to be used for matching local salaries and projects that local partners often do not want benefiting other counties, much less states. The perceived weaknesses are often misperceptions regarding Capacity Funding. Assuming that the Capacity Funds are equitably distributed based on need, performance, and priorities, it's difficult to identify real weaknesses. A perceived weakness may include a lower level of productivity or drive to achieve goals and develop real impact. This is simply not the case in today's climate of increasingly high expectations for faculty and staff who must produce at high levels for merit pay, to maintain use of office, lab, greenhouse, and field resources and or promotion and tenure. Another perceived weakness is that the funding agency gets less return on their funding dollar. This view is often short-sighted, again looking at a conglomeration of the "smallest unit" outputs of many short projects/programs that may never result in real outcomes or impacts. Capacity Funds allow for longer, more meaningful programs and projects to develop that really change behaviors and improve the lives of citizens.”

“Since it's merit based, it strives for research effectiveness by giving funding to the most productive institutions. It helps in addressing national research priorities as set by the RFA. Integrated projects will strengthen the links between all three missions of the land-grant goals: academic, research and extension. The peer-review process and objectivity of the competition process. It provides valuable feedback to non-funded proposals to help them improve quality over time.”

While Capacity Funding is designed to provide funding that is proportionate to need, some respondents noted that there are inequities in the system that should be addressed. Though these concerns may be valid, they were overshadowed by a widespread sense that the Capacity Funding system largely works as it was intended to and brings benefits to all who participate. The same level of consensus is not present in comments regarding Competitive Funding. Respondents from small institutions, particularly those from non-R1 and 1890 universities, perceive themselves to be at a significant disadvantage in the Competitive system. They see the larger, R1 universities as having more resources to compete for grants, more faculty with experience in grant writing and Competitive grant success, and smaller teaching loads. Smaller institutions see the Competitive grant process as daunting, and they predict significant barriers of entry to compete for these limited resources.

“One of the greatest weaknesses of the Competitive Funding system is that it is difficult for non-R01 schools to compete, even if the research proposed is of high quality. Panels often look askance at a faculty member’s request to buy out time from teaching (something that R1 faculty rarely, if ever, ask to do, but that is essential for our faculty). The panels also compare the facilities available at our campus to those at R1 schools, and in many cases, our facilities, while adequate to the research proposed, are inferior to those at the R1s.”

The relatively low success rate of Competitive proposals is also a challenge to larger institutions, whose faculty may be discouraged from submitting proposals in a Competitive process with such low chances of reward. Researchers may choose to seek funding from other agencies, which may then impact the direction of their research agendas. The transaction costs of Competitive Funding are viewed as high, while the perceived benefits are low, which makes it challenging for junior faculty to acquire the funding they need to establish their research agendas.

Finally, several other concerns were discussed with some frequency. While narrow and nationally focused RFAs can be a benefit to institutions with relevant research programs, it is difficult to acquire Competitive Funding for projects that are smaller and more local or regional in scope. It was also noted that Competitive Funds are inherently time-limited and inflexible, based on strict timelines and narrow proposals. These characteristics inhibit the development of applied research and outreach programs to meet the needs of communities that respondents believe would be better met with Capacity Funding.

“Insufficient funding is probably the greatest problem. The lack of dollars makes it harder to attract young people into agricultural research. To get promoted, many of our most promising scholars move to NSF and NIH funding. That is well and good, but we lose the focus on our food system and rural environments.”

VI. The Future for NIFA Funding Models

Though Capacity Funding has stood the test of time for over 150 years, because it is an atypical model for federal government extramural research funding, it has been the subject of critique. The alternative model, that of Competitive Funding, certainly has positive attributes (as recorded herein), but Capacity Funding goes significantly further than Competitive grant funding in terms of supporting the highly specialized infrastructure and broad faculty and staff capabilities needed to manage agricultural and associated research missions – and it supports the crucial work of Cooperative Extension in assuring research findings are disseminated and put to use in the field with key stakeholder populations.

Competitive grants certainly carry some advantages of their own, most notably the ability to fund research at a much wider pool of institutions that are not land-grant institutions and therefore not eligible for Capacity Funding. The capabilities of the full population of U.S. universities in life sciences, engineering, data sciences, social sciences, etc., are extraordinarily broad and deep and certainly have, or could have, application to agricultural science questions or questions pertaining to social structures and the communities supporting the agriculture value-chain. More Competitive Funding for agriculture and associated research would likely allow more of these non-land-grant capabilities in relevant disciplinary areas to compete to be engaged in agricultural and associated research inquiry. This does not represent any threat to the current status of the land-grant universities, since their base faculty and infrastructure capabilities lead them to be highly effective in applications for Competitive funds (with upwards of 70 percent of AFRI Competitive grants won by Land-grants in recent years).

Broadening the pool of U.S. faculty and researchers engaged in agbioscience questions by raising Competitive Funding amounts available would undoubtedly carry some benefits, but it also behooves asking the question of whether those benefits could or would be exceeded were increased funds directed instead through increases to the Capacity Funding available to land-grant institutions.

Arguments for increasing Capacity Funding are evident in multiple findings and items of discussion in this TEconomy report, including the following:

- Because of the unique nature of the agricultural sector, the clear majority of farms are too small to engage in research programs of their own and thus need the combination of research plus extension to enable two-way flows of information regarding both research needs and research solutions.
- The specialized nature of agricultural research requires the operation of large-scale infrastructure, including research farms and experiment stations across specific geographies. The need for field stations is not confined to only applied research and testing activities, it is also increasingly necessary in field phenotyping to gather data informing fundamental agricultural science questions. Individual research grants cannot provide the funding required to support the necessary large-scale, geographically specific infrastructure, nor the long-term guarantee of funding required to finance and maintain it.
- Competitive Funding is a relatively “low yield” activity in terms of requiring substantial faculty time to be dedicated to writing grant applications (requiring upward of 120 to 150 hours of faculty time per proposal) in an environment where only 10-17 percent of proposed projects may be funded. Capacity Funding, on the other hand, provides institutions with the ability to support any faculty and their research based on local and institutional priorities and needs.
- Capacity Funding can be used to address locality-specific research needs, specialized niche crops, and other tightly focused projects and programs that would be unlikely to achieve Competitive grant funding (where reviewers will tend to support research questions that are more universally applicable or fundamental in scope).
- Competitive Funding is not well suited to supporting the long-term programs needed to achieve crop and livestock improvements, test them, and move through the certification process prior to release.
- Competitive Funding (requiring proposal preparation and external review processes) is poorly suited to meeting needs for fast-tracked research addressing emergencies. Capacity Funds can be rapidly redirected by institutions to address emergencies such as livestock or crop disease outbreaks, emerging or invasive pests, or the results of natural or man-made disasters.

- The traditional academic journal publishing pathway of competitively funded research requires lengthy paper review processes and contains often significant delay as papers are queued for publication in future journal issues. This is a less-efficient pathway to putting research findings into action than the research and extension model that can be deployed by the land-grants to carry research findings directly to users and implementers.
- Research by Huffman and Evenson⁴⁵ concluded that the social rate of return to public agricultural research is high, at a real rate of return of approximately 50 percent. They concluded that shifting federal formula (Capacity) to Competitive grant programs would lower the impact and rate of return. In a more recent paper, Pardey and Beddow⁴⁶ note that “all evidence indicates that the economic returns to US producers and consumers from publicly funded agricultural R&D are exceptionally large: on the order of 20 dollars of social benefit for every dollar spent.” Pardey and Beddow cite the research of Alston et al⁴⁷ in support of this statement.
- And, one of the most important factors, **Capacity Funding achieves large-scale leverage of matching state and local funds**, funding that would be unlikely to be as forthcoming under Competitive grant funding models. Data for 2015 for four of the USDA Capacity Programs (Hatch, Smith-Lever 3(b) and 3(c), 1890 Extension, and Evans-Allen) show \$548.2 million in federal funding leveraging an additional matching dollar amount of \$920.8 million. In other words, every \$1 dollar of federal investment received an average leverage of an additional \$1.68 in matching funds.

In the TEconomy/APLU survey, a hypothetical situation was presented to survey recipients to gauge their opinions of what would happen under an end to Capacity Funding, or a shift to “an all Competitive Funding” model. One of the questions posed was “which of the following best describe your outlook regarding state/local funding under this ‘all Competitive-based funding’ scenario?” Table 50 presents the results for this question, confirming the conclusion that matching state and local funds would be unlikely to be as forthcoming under a Competitive grant funding model. Both 1862 and 1890 Land-Grant Universities would foresee a decline in leverage, and therefore a decline in impacts that could be achieved through the federal funding.

Table 50: Outlook for State Funding under an All Competitive-Based Funding Scenario. Results of Deans/Senior Leadership Survey. (Note: Question allowed respondents to check all that apply).

State/Local Funding under an All Competitive Federal Funding Model	1862	1890	Non-LGU	All Inst.
It will be difficult to generate the same total level of state/local funding	69%	47%	100%	63%
State/local funds for staffing/operations would be limited	59%	59%	0%	55%
State/local funds for infrastructure would be limited	55%	53%	33%	53%
State/local funding might be significantly reduced or eliminated if it did not automatically leverage federal funding	52%	88%	67%	65%
State/local funding match might be available for some current programmatic activities, but not all	45%	6%	0%	29%
State/local funding would be impacted some, but not significantly	21%	0%	0%	12%
We would likely have to seek state/local match funding on a proposal-by-proposal basis	14%	18%	33%	16%
State/local funding would be very minimally affected, if at all	10%	0%	0%	6%
State/local funding would increase, if we generated federal "competitive" funding in excess of our current federal "capacity" funding	0%	0%	0%	0%

⁴⁵ Huffman, W.E., and R.E. Evenson. 2006. “Do formula or competitive grant funds have greater impact on state agricultural productivity?” *American Journal of Agricultural Economics* 88, 783–798.

⁴⁶ Pardey, Philip G. and Jason M. Beddow. “Revitalizing Agricultural research and Development to Sustain US Competitiveness.” Farm Journal Foundation.

⁴⁷ Alston, J.M., M.A. Andersen, J.S. James, and P.G. Pardey. 2010. “Persistence Pays: US Agricultural Productivity Growth and the benefits from Public R&D Spending.” New York: Springer.

CONCLUSION: Respondent land-grants predict that a move toward Competitive Funding over Capacity Funding would most likely result in declining levels of state and local funding match – and therefore a net decline in the volume of research that could be performed for a given level of federal funding.

It should be noted that Capacity Funding, is a relatively assured and predictable year-to-year funding mechanism, whereas Competitive Funding can demonstrate peaks and valleys depending on staff proposal writing success and the timing of the start and end of individual grants. Such fluctuations in funding, under a Competitive model, make it more challenging to maintain the infrastructure and operational supports required to sustain a major agricultural research capability. To investigate this, a question was asked of survey recipients as follows: “For each of the following areas, would your institution struggle to maintain current levels of operations and performance in between Competitive grant funding award periods if Capacity Funds were not available?” Table 51 lists results for this question from the survey of Deans and other Senior Leadership. The results indicate that the majority of both 1862 and 1890 institution leadership respondents confirm that, in an absence of Capacity Funds, and in a Competitive Funding model, they would definitely struggle to sustain physical infrastructure, research stations, research personnel, extension personnel, and support personnel.

Table 51: Would Institution Struggle to Maintain Operations and Performance between Competitive Funding Awards in the Absence of Capacity Funding? Results of Deans/Senior Leadership Survey.

Laboratory/Building Infrastructure	Inst. Type	Definitely YES	Probably YES	Probably NOT	Definitely NOT
	1862	55%	10%	28%	7%
	1890	82%	12%	0%	6%
	Non-LGU	67%	33%	0%	0%
	All Institutions	65%	12%	16%	6%
Research/Test Fields (Farms) Infrastructure	Inst. Type	Definitely YES	Probably YES	Probably NOT	Definitely NOT
	1862	69%	14%	14%	3%
	1890	88%	0%	0%	12%
	Non-LGU	67%	33%	0%	0%
	All Institutions	76%	10%	8%	6%
Research Personnel	Inst. Type	Definitely YES	Probably YES	Probably NOT	Definitely NOT
	1862	55%	31%	14%	0%
	1890	88%	0%	0%	12%
	Non-LGU	33%	33%	33%	0%
	All Institutions	65%	20%	10%	4%
Extension Personnel	Inst. Type	Definitely YES	Probably YES	Probably NOT	Definitely NOT
	1862	64%	29%	4%	4%
	1890	88%	0%	0%	12%
	Non-LGU	0%	0%	0%	100%
	All Institutions	70%	17%	2%	11%
Support Personnel	Inst. Type	Definitely YES	Probably YES	Probably NOT	Definitely NOT
	1862	55%	41%	0%	3%
	1890	88%	0%	0%	12%
	Non-LGU	0%	33%	33%	33%
	All Institutions	63%	27%	2%	8%

CONCLUSION: Capacity Funding gives land-grants a baseload “carrying capacity” for infrastructure and personnel that would be difficult to duplicate under a Competitive Funding model.

The TEconomy/APLU surveys also suggest that there are perceived to be multiple challenges and concerns among the land-grant universities that many see as having a potential impact on the continued availability of, and commitment to, Capacity Funds (Table 52). Concerns regarding federal budgets and the potential for “decreases in federal funding” are the most expressed, closely followed by a concern that there is “pressure to shift federal

resources from Capacity Funding to Competitive Funding.” The lack of public knowledge regarding the role and importance of extension, agricultural research, and science in general is also viewed as a contributory threat.

Table 52: Rating of Challenges in Terms of Their Importance and Seriousness regarding the Continued Availability of Capacity Funds. Results of Deans/Senior Leadership Survey.

	Inst. Type	Very High	High	Moderate	Low	Very Low
Decreases in federal funding	1862	62%	34%	3%	0%	0%
	1890	88%	0%	12%	0%	0%
	Non-LGU	67%	33%	0%	0%	0%
	All Institutions	71%	22%	6%	0%	0%
	Inst. Type	Very High	High	Moderate	Low	Very Low
Pressure to shift federal resources from Capacity Funding to Competitive Funding	1862	57%	21%	14%	7%	0%
	1890	88%	6%	6%	0%	0%
	Non-LGU	67%	0%	33%	0%	0%
	All Institutions	69%	15%	13%	4%	0%
	Inst. Type	Very High	High	Moderate	Low	Very Low
State funding budget challenges limiting availability of matching funds	1862	38%	28%	17%	14%	3%
	1890	88%	0%	12%	0%	0%
	Non-LGU	33%	0%	67%	0%	0%
	All Institutions	55%	16%	18%	8%	2%
	Inst. Type	Very High	High	Moderate	Low	Very Low
Public knowledge and understanding about the importance of cooperative extension	1862	45%	31%	24%	0%	0%
	1890	76%	24%	0%	0%	0%
	Non-LGU	33%	0%	0%	33%	33%
	All Institutions	55%	27%	14%	2%	2%
	Inst. Type	Very High	High	Moderate	Low	Very Low
Public knowledge and understanding about the importance of agricultural research	1862	41%	34%	24%	0%	0%
	1890	88%	12%	0%	0%	0%
	Non-LGU	33%	0%	33%	33%	0%
	All Institutions	57%	24%	16%	2%	0%
	Inst. Type	Very High	High	Moderate	Low	Very Low
Public knowledge and understanding about science	1862	31%	52%	17%	0%	0%
	1890	71%	18%	12%	0%	0%
	Non-LGU	0%	33%	67%	0%	0%
	All Institutions	43%	39%	18%	0%	0%
	Inst. Type	Very High	High	Moderate	Low	Very Low
Continued shift of political representation toward urban areas	1862	17%	52%	17%	14%	0%
	1890	47%	29%	24%	0%	0%
	Non-LGU	33%	33%	33%	0%	0%
	All Institutions	29%	43%	20%	8%	0%
	Inst. Type	Very High	High	Moderate	Low	Very Low
Other critical challenge	1862	82%	9%	9%	0%	0%
	1890	100%	0%	0%	0%	0%
	Non-LGU	0%	0%	0%	0%	0%
	All Institutions	88%	6%	6%	0%	0%
	Inst. Type	Very High	High	Moderate	Low	Very Low

A concern over the trajectory for Capacity Funding amounts is perhaps legitimate, based on survey responses from Deans and other Senior Land-Grant University Leadership. Table 53 summarizes responses received to the question: “For each of the following sources, indicate whether the total funding your institution received to support of agricultural research and cooperative extension has increased, decreased, or remained stable over the past three years from this source.” These data show that, while the majority of respondents indicate that Capacity

Funds were stable over the past three years, Competitive Funding sources have been more likely to receive an increase. This, of course, is not bad news (as an increase is an increase), but it does reflect an effective decline in the percent of funds coming to land-grants from the assured Capacity structure. Overall, however, a positive sign is that the funds from most sources trend toward stable or increasing rather than decreasing.

Table 53: Funding Change over Past Three Years by Funding Source/Type

NIFA Capacity Funding for Agricultural Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	28%	72%	0%	0%
	1890	41%	59%	0%	0%
	Non-LGU	0%	0%	0%	100%
	All Institutions	31%	63%	0%	6%
NIFA Capacity Funds for Animal Health and Disease/Veterinary Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	25%	43%	18%	14%
	1890	0%	19%	0%	81%
	Non-LGU	0%	0%	0%	100%
	All Institutions	15%	32%	11%	43%
NIFA Capacity Funds for Forestry Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	18%	64%	7%	11%
	1890	29%	35%	6%	29%
	Non-LGU	0%	67%	33%	0%
	All Institutions	21%	54%	8%	17%
NIFA Competitive Funding/Grants for Research (AFRI)	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	41%	41%	10%	7%
	1890	31%	25%	13%	31%
	Non-LGU	0%	33%	33%	33%
	All Institutions	35%	35%	13%	17%
Other Federal Funding/Grants for Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	66%	24%	10%	0%
	1890	31%	56%	13%	0%
	Non-LGU	33%	33%	0%	33%
	All Institutions	52%	35%	10%	2%
NIFA Capacity Funding for Cooperative Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	14%	71%	14%	0%
	1890	41%	59%	0%	0%
	Non-LGU	0%	0%	0%	100%
	All Institutions	23%	63%	8%	6%
NIFA Capacity Funding for Forestry Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	7%	57%	7%	29%
	1890	29%	29%	0%	41%
	Non-LGU	0%	0%	0%	100%
	All Institutions	15%	44%	4%	38%
NIFA Capacity Funds for EFNEP	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	4%	82%	11%	4%
	1890	35%	53%	6%	6%
	Non-LGU	0%	0%	0%	100%
	All Institutions	15%	67%	8%	10%
NIFA Competitive Funding for Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	25%	50%	14%	11%
	1890	35%	41%	12%	12%
	Non-LGU	0%	0%	0%	100%
	All Institutions	27%	44%	13%	17%

Other Federal Funding/Grants for Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	36%	54%	7%	4%
	1890	19%	50%	13%	19%
	Non-LGU	0%	0%	0%	100%
	All Institutions	28%	49%	9%	15%
State Funding/Grants for Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	21%	39%	32%	7%
	1890	35%	29%	24%	12%
	Non-LGU	0%	0%	0%	100%
	All Institutions	25%	33%	27%	15%
State Funding/Grants for Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	29%	36%	32%	4%
	1890	35%	29%	29%	6%
	Non-LGU	33%	33%	0%	33%
	All Institutions	31%	33%	29%	6%
Local/County Funding/Grants for Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	25%	32%	21%	21%
	1890	25%	31%	13%	31%
	Non-LGU	0%	0%	0%	100%
	All Institutions	23%	30%	17%	30%
Local/County Funding/Grants for Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	14%	39%	0%	46%
	1890	6%	13%	6%	75%
	Non-LGU	0%	33%	0%	67%
	All Institutions	11%	30%	2%	57%
Industry (Company) Funding/Grants for Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	45%	45%	3%	7%
	1890	25%	13%	6%	56%
	Non-LGU	33%	67%	0%	0%
	All Institutions	38%	35%	4%	23%
Commodity Group/Association Funding/Grants for Extension	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	18%	43%	7%	32%
	1890	6%	13%	6%	75%
	Non-LGU	0%	0%	0%	100%
	All Institutions	13%	30%	6%	51%
Commodity Group/Association Funding/Grants for Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	28%	48%	3%	21%
	1890	19%	19%	6%	56%
	Non-LGU	0%	67%	0%	33%
	All Institutions	23%	40%	4%	33%
Other Funding/Grants for Either Extension or Research	Inst. Type	Increased	Stable	Decreased	Do Not Receive
	1862	36%	50%	11%	4%
	1890	13%	50%	6%	31%
	Non-LGU	67%	0%	0%	33%
	All Institutions	30%	47%	9%	15%

An extreme “straw man” was put forward in the surveys to evaluate the comparative impact of Capacity versus Competitive Funds, and the difference in dependence on these funds by land-grant university type. The question sought an answer to a hypothetical situation of all Capacity Funds being ended, and how much of their research

program do the institutions think they could sustain. Table 54 shows the response summary for Deans/Senior Leadership, indicating that the 1890 Land-Grant Universities would predict the greatest negative impact, being able to support “almost none” or “none” of their research under such a model. Of the 1862s, 21 percent put forth a similar response, with most (55 percent) believing they could continue to sustain “some of it.”

Table 54: Amount of Research that Institution Could Continue without Capacity Funds. (Question: How much of your Research program would you say your institution could continue if Capacity Funds were entirely cut?) **Results of Deans/Senior Leadership Survey.**

Institution Type	Most of it	Some of it	Almost none of it	None of it
1862	24%	55%	14%	7%
1890	0%	0%	59%	41%
Non-LGU	0%	67%	33%	0%
All Institutions	14%	37%	31%	18%

A similar question was posed to the Cooperative Extension Directors, asking “How much of your Cooperative Extension program would you say your institution could continue if Capacity Funds were entirely cut?” Findings (Table 55) again showed highly negative predictions for extension at the 1890 institutions (the majority saying “none of it”), and the modal response from 1862s being “some of it.”

Table 55: Amount of Cooperative Extension Program that Institution Could Continue without Capacity Funds. Results of Deans/Senior Leadership Survey.

Institution Type	Most of it	Some of it	Almost none of it	None of it
1862	10%	55%	21%	14%
1890	0%	0%	41%	59%
Non-LGU	0%	33%	0%	67%
All Institutions	6%	35%	27%	33%

CONCLUSION: *Competitive Funding and Capacity Funding have several fundamental differences between them that mean that one is not 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. A move away from Capacity Funding would likely cause significant negative ramifications for research and extension operations at all land-grant universities, and would be especially detrimental to these programs at the 1890 Land-Grants (and, as seen in Chapter VII, the 1994 Tribal Land-Grant Colleges and Universities also).*

VII. NIFA Funding Review for the 1994 Tribal Land-Grant Colleges and Universities.

A. Introduction

The 1994 Tribal Land-Grant Colleges and Universities provide important resources to American Indian populations by emphasizing individual and community development. **Education and outreach programs at these institutions are tailored to help address the unique set of issues faced by this historically underserved and disadvantaged population.**

Tribal Lands comprise 72 million acres in the U.S., with 80 percent being forested or agricultural lands. The education and extension programs of the 1994 land-grants are working, with quite limited federal funding resources, to assure each tribe can better manage their land, and associated resources, to provide long-term sustainable assets for the good of the tribe and the nation. As noted by the American Indian Higher Education Consortium (AIHEC)⁴⁸ the 1994 land-grants seek to fulfill a vision and mission “of self-sufficient place-based peoples through an Indigenous Land-Grant model that incorporates holistic planning, traditional knowledge, and the integration of education, research, and extension activities.” AIHEC reports that:

*The small federal investments in the 1990s has already paid great dividends in terms of increased employment, access to higher education, more effective land and water use, increased crop production, better health and nutrition, and economic development. Continuation of and growth in this investment makes sound moral and fiscal sense.*⁴⁹

Several examples of 1994 Tribal Land-Grant College and University programs in action serve to illustrate some of the range and diversity of impacts across programs developed and implemented by these institutions:

Program Example: United Tribes Technical College (UTTC) – Combatting Tribal Diabetes.

According to the Department of Health and Human Services’ Indian Health Service, American Indians are 2.2 times more likely to have diabetes compared to non-Hispanic whites. The United Tribes Technical College (UTTC), in Bismarck, North Dakota, is doing its part to lower that number by mentoring nearly 450 people at five diabetes-related events. UTTC also produces three publications that were delivered to more than 11,000 local households. In 2017, UTTC plans to host three 6-week training sessions for 10-15 people each, covering topics such as understanding and monitoring the human body, nutrition, and physical activity.

1994 institutions differ in significant ways from the 1862 and 1890 land-grant institutions, particularly regarding educational objectives and funding sources. Because of these key differences, a specific survey was developed to understand the perspectives of leaders within the 1994 institutions.

The Tribal Land-Grant Colleges and Universities survey instrument was designed to address the advantages and disadvantages of the funding sources that are exclusive to the 1994 institutions. It consisted of quantitative and qualitative questions developed to assess the strengths and weaknesses of each funding model as well as the role each funding source plays in sustaining education, research, and outreach programs within each institution.

The survey was distributed through SurveyMonkey with the assistance of the American Indian Higher Education Consortium and the Association of Public and Land-grant Universities.

⁴⁸ Statement of the American Indian Higher Education Consortium to the United States Senate. April 3, 2014. Committee on Appropriations Subcommittee on Agriculture, Rural Development, Food and Drug Administration, and Related Agencies.

⁴⁹ Ibid.

Program Example: Salish Kootenai College – Training Programs

SKC used NIFA funding to create a program that more than tripled the number of Native Americans working on tribal forests and attending advanced degree programs in forestry. The faculty created this program by going to graduate schools and federal agencies to find out what kind of training would get students hired and selected for graduate programming. The college has also begun a similar initiative in hydrology. Last year, NIFA funding supported 116 students by allowing the college to provide nine additional courses in environmental science and upgrading the curriculums of five environmental science courses. These advances allowed the college to offer students a four-year degree in wildlife and fisheries for the first time. The faculty hope this will increase the number of Native Americans in fish and wildlife protection on Native lands.

Program Example: Fort Peck Community College – Extension

NIFA funding provided the ability to install an IT/digital switch that facilitated the development of Wi-Fi capabilities that enable the provision of online resources to 270 students throughout the college campus. This has been a critical step in ensuring that the digital divide faced by remote reservation communities may be breached.

Program Example: Bay Mills Community College – Endowment

NIFA funding supports a Student Success Center. This center has provided 3,410 students with tutoring services, allowing several to continue in STEM studies. In addition, the funding supports services to help students who may have an undiagnosed learning disability obtain the services they need. Eight students received testing and were provided with 16 referral services to help them succeed in their post-secondary education.

Program Example: Northwest Indian College – Endowment and Tribal College Research

The Northwest Indian College (NWIC) Salish Sea Research Center researchers, Andres Quesada and Dr. Marco Hatch, have teamed up with Dr. Andrew Thurber from Oregon State University to study what is causing the clam population to decline. Sulphur Cycling Hydrogen sulfide is a compound that is toxic even in low concentrations to most animals. NWIC's research is exploring the role of sulfide in limiting the clam populations to devise effective management schemes by identifying the ecological mechanism that is limiting their productivity. The performance of the research is also facilitating the training of an elite cadre of students with talent in science to conduct laboratory work as interns for this research.

NWIC students are using biomarkers, including stable isotope and fatty acids, that identifies what the clams are eating and how that varies throughout the year. The students will also learn how to collect and prepare samples for analysis on a variety of instruments, including gas chromatograph-mass spectrometers and isotope ratio mass spectrometers, interpret data, and then apply cutting-edge trophic models. In addition, the project has engaged 20 college students through classroom work and more than 40 Native middle and high school students have learned about the project through outreach events.

Program Example: Chief Dull Knife College – Extension

A Volunteer Income Tax Association tax site served 501 reservation citizens resulting in \$1,343,216 brought back to community. This program also provided entrepreneur classes serving 40 community members with six applications resulting for a state competitive business grant and four of the six receiving \$7,000 each for their business ventures. The Project Director provided 30 adults financial education classes (budgeting, credit building, asset development) and all participants were referred to local non-profit organization for additional services.

Program Example: Dine' College

In response to a 2014 report from the Arizona Department of Education that said American Indian Children had the lowest math achievement scores in the state's National Subject Area testing, the college launched an all-out effort to train its education majors and current math teachers so that students can achieve a 20 percent improvement in their scores. The project also has an outreach to reservation youth. In 2015, 80 teachers participated in workshops and 443 participated in annual STEM Circles Festival for teachers and their students to showcase best practices in STEM teaching and learning.

The Tribal Land-Grant Colleges and Universities survey instrument, deployed by TEconomy, was designed to examine how federal Capacity Funding is supporting the work of the 1994s, and gather input from the institutions regarding characteristics of funding sources and their use in achieving institutional goals and objectives.

B. Survey Respondent Profile

The survey was sent to 35 Tribal Land-grant colleges and universities, with 12 completed surveys returned, for a response rate of 34 percent.

C. Federal Funding Types Received

Question. *Which of the following federal funding sources are received by your institution (college or university)? Check all that apply.*

Table 56: NIFA Types of Federal Funding Received by Institution

Type of Funding	Percent Receiving
NIFA Education Equity	100%
NIFA Endowment Funds	91%
NIFA Tribal Research	64%
NIFA Extension Capacity	91%
NIFA Extension Special Emphasis	55%
NIFA Agriculture and Food Research Initiative (AFRI) Grants	9%
Competitive/Contract Funds from the USDA Agricultural Research Service (ARS)	0%
National Science Foundation (NSF)	64%
National Institutes of Health (NIH)	27%
Other Federal Agency Competitive Funds	73%

D. How Federal Funds Received are Allocated

Question. Describe the process in which NIFA equity and endowment funds are distributed to support activities, programs, and projects at your institution. Within your institution is this process different for different colleges, schools, departments, or different funding mechanisms?

Write-in responses

- *Project proposals and plans are developed through a collaborative process involving administration and land grant faculty. Designated project directors are then responsible for implementing plans and managing project funds. Project activities are reported to supervisors and the college president in monthly reports. A similar process is followed throughout the institution.*
- *Funds are distributed directly by the financial office by Purchase Order requests for activities, programs, and projects. Purchase Orders are first approved by the Land Grant Director before they are sent to the financial office, where they must be approved by the financial office and the college president before funds are released.*
- *Marketing, recruitment, and program development.*
- *Equity- Once funding notification is received, accounts are established for the grant. As purchases are made and invoices are received in the Business Office, the Grant Coordinator tracks all expenditures. Draw-downs are requested periodically, and reimbursements are deposited to [institution's] bank accounts. Endowment- This is the first year for [this institution] to receive endowment funds, and future endowment funding will be utilized to support educational programs as necessary. When funding notification is received, funds are drawn-down into the [institution's] endowment account. The process for distributing funds throughout [the institution] is standard since we are a small institution. We do not have multiple colleges, so all grants are handled through the Business Office in accordance with established policies and procedures.*
- *NIFA Equity currently supports the [teacher education program] in promoting STEM for local schools (K-12) and K-12 teachers. Endowment is used to secure the Land Grant Office staff and support operations of programs not supported by grant funds. Yes, they are different by providing different course of engaging the community. Equity if focus on STEM initiative and Endowment focuses on agricultural activities and initiative.*
- *NIFA equity funds are overseen by the college's Agriculture Department to support activities, programs and projects identified within the funded applications, with all spending occurring through the institution's Business Office per their policies and procedures. This funds distribution process is uniform across all entities under the umbrella of the college.*
- *Currently, NIFA funds are received and distributed directly to support project and program activities, as administered by the Project Director. 2016 is the first year that [this institution] has received NIFA endowment funds, which will be directly distributed to support the land-grant programs.*
- *The land grant endowment is used to fund a college recruiter within our student services department as well as other projects as determined by the president. The equity grant is used to supplement our math and sciences department, curriculum development, internships and other items as determined by the PD and Dean of Academics.*
- *The process is that the awards are announced. The business office is notified. The program director of the Equity Programs at [this institution] is the Academic Dean. The program director for the Endowment programs is the President. The endowment funds are utilized as additional things completed. The equity grant is almost entirely faculty salaries.*
- *These programs run independently from other college programs. And all programs that are offered support the college mission and the grant objectives.*
- *All NIFA Equity funds are used to support the Environmental Science degree program at our Institution and a [criminal justice] program. Endowment funds are held in reserve for any major project or initiatives that fit into the guidelines of that program. The last project I am aware of was the building of the [extension office].*

E. Scale of the Supported Enterprise

Question. *What is the total number of teaching faculty within your College, School, or Division?*

Average = 21

Question. *In the last three years, has the overall number of teaching faculty at your institution increased, decreased, or remained stable?*

Table 57: Change in Faculty Numbers in Past Three Years

Increased	27%
Remained Stable	45%
Decreased	27%

Question. *In your opinion, what is the primary reason for this?*

Write-in responses

- *Our college is extremely remote and we have trouble finding and hiring qualified faculty. Last year, we had several full-time faculty positions that were vacant the entire year. Fortunately, we were able to fill several of these positions, so our faculty numbers have increased a bit.*
- *Although student enrollment has dropped during the past three years, no major changes have been implemented to the degree programs in place to increase or decline the faculty number.*
- *Decreasing student enrollment.*
- *Increased enrollment and the need to offer a larger number of courses and sections.*
- *The increase is a result from opening three four-year programs.*
- *Enrollment has decreased at a slight pace the last few years, but the educational offerings have remained level.*
- *Development and creation of additional academic programs.*
- *We had people leave and have been finding difficulty in finding qualified people to accept full time positions with the low levels of pay.*
- *lack of funding to hire additional full time faculty.*
- *Lack of funding.*

Question. *What is the total number of **NIFA supported** teaching faculty within your College, School, or Division?*

Average = 2

Question. *In the last three years, has the overall number of NIFA supported teaching faculty at your institution increased, decreased, or remained stable?*

Table 58: Change in NIFA Funding-supported Faculty Numbers in Past Three Years

Increased	27%
Remained Stable	45%
Decreased	27%

In your opinion, what is the primary reason for this?

Write-in responses

- *The amount of our NIFA funding has remained static, while salaries for instructors have increased. Because of this, NIFA funding is supporting a smaller portion of individuals' total salaries.*
- *Small class size does not suggest additional faculty to be hired at this time.*
- *Class load required faculty to move to a separate funding line.*
- *This instructor was hired as a direct response to receiving the NIFA grant promoting healthy lifestyles through gardening and fitness initiatives.*
- *The increase is related to serving our students in an interest in the Natural Resources certificate programs (GIS, Natural Resources, and Irrigation Technology).*
- *The college's funding applications have remained steady, with the teaching positions in the NSF grant.*
- *The curriculum development position was left open since the fall of 2015.*
- *Stable funding sources.*
- *Objectives within the grant.*
- *Lack of funding.*

Question. What is the total number of administrative and supporting staff (including administrative, financial, marketing, communications, etc.) within your institution?

Average = 33

Question. In the last three years, has the overall number of administrative and supporting staff at your institution increased, decreased, or remained stable?

Table 59: Change in Administrative and Support Staff Numbers in Past Three Years

Increased	27%
Remained Stable	55%
Decreased	18%

Question. In your opinion, what is the primary reason for this?

Write-in responses

- *Shrinking enrollment has led to shrinking budgets.*
- *Overall growth in the college. We have more students enrolling and therefore have needed to expand services in order to support these students.*
- *Gain by one position under the Vice President of Finance. The gain is Assistant Vice President of Finance and Administration who oversees technology department.*
- *Decreased enrollment has resulted in decrease funding from the primary source of formula funding received by the institution in the form of TCCA funds coming through the Bureau of Indian Education. The college has had to be innovative in filling faculty and staff positions, combining duties amongst positions and not filling vacancies that may have occurred.*
- *Increased funding for the establishment of additional programs.*
- *Stable funding sources.*
- *Lack of funding to hire more staff.*
- *Partially it is lack of funding, but we are reasonably well staffed in the support positions.*

Question. *What is the total number of NIFA supported administrative and supporting staff (including administrative, financial, marketing, communications, etc.) within your institution?*

Average = 3

Question. *In the last three years, has the overall number of NIFA supported administrative and supporting staff at your institution increased, decreased, or remained stable?*

Table 60: Change in NIFA Funding-supported Administrative and Support Staff Numbers in Past Three Years

Increased	18%
Remained Stable	73%
Decreased	9%

Question. *In your opinion, what is the primary reason for this?*

Write-in responses

- *Information technology (IT) staff formerly supported by NIFA funds were shifted to another funding program.*
- *Received more grant project approval.*
- *USDA NIFA Tribal College funding programs remains the least amount of 1862, 1890 institution.*
- *Stable funding from NIFA grant programs.*
- *Stable funding.*
- *Lack of funding.*
- *Lack of funding.*

F. Use of NIFA Equity and Endowment Funds

Question. *How are equity funds used at your institution? Check all that apply.*

Table 61: Uses of NIFA Equity Funds at Institution

	Percent
Salaries	91%
Human Resources	0%
Faculty Development	64%
Student Recruitment and Retention	36%
Classroom/Lab Renovation	18%
Education Equipment	64%
Curriculum Development	55%
Internships	45%
Outdoor Learning Labs	45%
Other (please specify)	9%

Write-in response for "Other"

- *Assessment of new program potential.*

Question. *How are endowment funds used at your institution? Check all that apply.*

Table 62: Uses of NIFA Endowment Funds at Institution

	Percent
Salaries	55%
Human Resources	0%
Faculty Development	27%
Student Recruitment and Retention	27%
Classroom/Lab Renovation	9%
Education Equipment	36%
Curriculum Development	27%
New Construction	9%
Land Procurement	0%
Non-Educational Facilities	9%
Internal Operating Costs	27%
Saving for Future Use	27%
Other	18%

Question. *What recent (within the last three years) fundamental capacities have been built within your institution using NIFA equity and endowment funding?*

Write-in responses

- *Curriculum revisions supported with Equity funds have become institutionalized. Relationships with partner agencies supporting student internships have been strengthened. Endowment funds have been used to develop IT capabilities (infrastructure, hardware and software) and provide the training and support faculty need to use technology effectively in the classroom.*
- *A garage space was converted into a laboratory classroom. Monies were used to purchase equipment for the classroom.*
- *The outdoor learning lab has created a new program infrastructure to utilized within and across the community and increase local stakeholder involvement. Robust internship program focused on sustainability. The program has opened new doors and engaged more stakeholders. Established ability for the institution to improve and increase its capacity to get marketing materials distributed across the service community.*
- *The equity grant funds have enabled [this institution] to develop a program and curriculum to support healthy living and sovereign food sources in order to bridge culture and education. The instructor hired with NIFA funding has students working in an outdoor classroom to cultivate traditional plants and knowledge of healthy lifestyles. This is [this institution's] first opportunity to receiving endowment funding. We will be developing an outdoor learning lab with these funds.*
- *Increase [land-grant] staff by two. Improving the Demonstration Farms. Assist with curriculum development in Natural Resources, Irrigation Technology and GIS Programs.*
- *Over the last year, NIFA equity funding has enabled us to build both personnel and program capacities, both fundamental to successful land-grant programs.*
- *NIFA provided some funding for our library construction.*
- *The ability to offer consistent extension programs, faculty instruction, and transportation.*
- *Classroom equipment and educational supplies for teaching science courses.*

- *Equity has funded curriculum development and faculty development in the areas of geospatial technologies and law enforcement/search and rescue tracking. It has also supported the purchase of educational materials. Endowment funds have been saved in the last three years.*

G. Administrative and Use Characteristics of Key Funding Sources

Question. Rate the following funding sources on the level of administrative difficulty (e.g., time, effort, paperwork) involved for your institution in the development and preparation of proposals associated with these funds.

Table 63: Rating of Administrative Difficulty (Burden) for Preparing Proposals by Funding Type

Funding Source	Very High	High	Medium	Low	Very Low	N/A
Endowment	0%	10%	20%	0%	70%	0%
Equity	10%	10%	50%	30%	0%	0%
Extension	10%	10%	40%	30%	0%	10%
Research	0%	30%	40%	10%	0%	20%

Question. Rate the following funding sources on the level of administrative difficulty (e.g., time, effort, paperwork) involved for your institution in the use, administration, and reporting requirements associated with these funds.

Table 64: Rating of Administrative Difficulty (Burden) for Funds Administration and Reporting by Funding Type

Funding Source	Very High	High	Medium	Low	Very Low	N/A
Endowment	0%	10%	20%	0%	50%	20%
Equity	10%	0%	60%	30%	0%	0%
Extension	10%	0%	50%	30%	0%	10%
Research	0%	0%	50%	30%	0%	20%

Question. Please rate the following funding sources in terms of how flexible they are regarding the types of expenditures they can be used for (e.g., labor, equipment, student wages and stipends, etc.).

Table 65: Rating of Funding Categories in Terms of their Flexibility-of-use

Funding Source	Very Flexible	Somewhat Flexible	Neutral	Somewhat Inflexible	Very Inflexible	N/A
Endowment	70%	0%	0%	0%	20%	10%
Equity	30%	30%	20%	10%	10%	
Extension	30%	10%	20%	20%	10%	10%
Research	20%	10%	30%	10%	0%	30%

Question. Provide up to three recent (last three years) examples or experiences from your institution of the different ways in which the NIFA funding sources listed in the previous question are more or less flexible. For each example, identify the specific funding type(s) used (endowment, equity, extension, or research) and provide a brief (2-3 sentence) description or narrative.

Write-in responses

- *Endowment funds are very flexible. We were able to quickly change our focus from computer technology instruction, technical assistance and faculty training to environmental science in response to shifts in funding availability from other externally funded programs. Research funds were also quite flexible.*

Changes in key project personnel required us to make some significant changes to the project plan, but we were able to keep the award and make the necessary adjustments to our scope of work. The extension program's limitation on using funds to support classroom instruction continues to limit our use of these funds. At a small institution like ours the lines between teaching and extension often blur. More flexibility here would lead to greater integration of our extension projects with teaching and learning that take place through our equity and research grants.

- *Improved continuation process for equity to be less burdensome. Improved continuation process for extension to be less burdensome. Research grant required modification. Working with project officer to modify project deliverables was a straightforward process. Tribal project officer is very responsive and easy to work with.*
- *Endowment- These funds have not been spent; however, after reviewing documentation, NIFA seems very flexible in the expenditure of funds. NIFA Equity- Construction is not allowed as part of this grant, which causes funds to be somewhat less flexible; however, funds have been allocated easily in order to meet the objectives of the grant. The funds are less flexible because of the required documentation for equipment and hiring guest speakers (research), contractors, etc.*
- *The USDA NIFA programs acknowledge our cultural ways and allow for the ability to develop new approaches of education. The USDA NIFA Tribal funding Program Leader is very accessible to answer questions and concerns. One important aspect is allowing to conduct research applicable to tribal communities.*
- *Changing personnel in the equity grant is easy as we included it in our new budget with prior email permission. Changes that stay within the grants scope are also easy. The equity grant allowed us to add a STEM tutor which increased our number of hours of tutoring which directly affects retention in our classes.*
- *The endowment funds are used as a contingency fund at the college to fund unanticipated expenses and travel costs. A variety of different educational events take place all time with extension funds.*
- *Extension funds could not be used for the removal of a wall to create a community education classroom to run NIFA programs and EQUITY student group to meet. Prior to the renovation permission was given and then once the renovation was complete that permission was withdrawn so the college needed to find resources to cover the cost. While the Equity staff lead the student group they cannot use any of their funds for the programs they offer. Such as, equipment for [student event] or pay for facility rental for the student groups to practice for competitions (Archery, Volley Ball, Basket Ball). Funds to purchase software and hardware for the science lab and classroom.*
- *The best thing about the flexibility of Endowment is that it can be used for building and remodeling. This is an important benefit that we and a number of other TCU's have benefitted from. Equity, Extension, and Research all allow changes in our budgets of up to 10 percent without approval from the National Program Office. This is a major benefit to TCU's where the unexpected is the norm and changes are often necessary in order to best achieve the grant goals in changing circumstances. No-cost extensions are also easy and straightforward to request for these programs. I especially appreciate this, because it allows us to use funds more strategically rather than spending down for the sake of closing out the grant. This has particularly benefitted my research projects by allowing us to collect data over complete growing seasons rather than having to close out the projects by August 31.*

H. Funding Source Rating by Area of Output

Question. Rate the following funding sources in terms of amount of **community, family, and youth outcomes** (e.g., education programs, farmer or consumer assistance, youth development, rural entrepreneurship, assistance publications, etc.) achieved with their funding.

Table 66: Rating of Funding Types by Amount of Community, Family and Youth Outcomes

Funding Source	Very High	High	Medium	Low	Very Low	N/A
Endowment	20%	10%	20%	30%	10%	10%
Equity	30%	20%	30%	20%	0%	0%
Extension	60%	10%	10%	10%	0%	10%
Research	0%	22%	33%	33%	0%	11%

I. Examples of High Impact Outcomes from Federally Funded Projects

Question. Provide up to three recent (last three years) examples from your institution of particularly strong or meaningful outcomes from NIFA funding. For each example, please identify the funding type(s) used (endowment, equity, extension, or research) and provide a brief (2-3 sentence) description or narrative. Feel free to provide links as well as citations to additional information.

Write-in responses

- One positive outcome of research awards has been the number of students making presentations at national research conferences and successfully transferring to 4-year institutions.
- A strong outcome was the review of the curriculum and the implementation of changes to the curriculum to increase student transferability and success in transferring to a 4-year institution or obtaining a position with the 2-year degree.
- Extension funding provided hands on knowledge building for usually a thousand participants per year. Skills and knowledge included job building skills, financial literacy, cultural sharing, farmers market, and food sovereignty.
- Endowment- These funds have not yet been expended; however, they will be utilized for the outdoor classroom. NIFA Equity- Students have expressed a high level of interest in gardening activities through classroom exposure and independently. Additionally, students have learned the importance of personal health through classroom instruction. Since health and fitness initiatives coincide with personal health objectives, students have easily made the connection between what they learned in the classroom and knowledge they take with them. NIFA Research- Students have participated in all stages of research procedures by testing water samples. Students chosen from [this institution] will be submitting proposals for presentations at the FALCON conference.
- The Equity fund will sponsor a junior high STEM festival where 250 students will experience STEM activities. The Extension fund is used to provide outreach to approximately over 800 farmers, ranchers and youth. The Endowment program allows [this institution] to sustain programs that were considered successes. The Research funds allow students and staff to participate in applied research.
- Equity- Built new science lab that has allowed [this institution] to conduct better STEM labs and conduct more research with the students. Team members [from one such program] have gone on to 4 year colleges in computer science. Extension- We have had a great response from the public for our outreach programs and community garden.
- Extension, bridge between community and college, the community workshops offered. Equity, student group and STEM Recruiter Endowment, use for a portion of salary for Math and Science Instructors when needed.

- *Our strongest community impact comes from our Extension work which is heavily focused on youth development. We have an extensive list of partners and collaborative events that greatly expands the impact of these funds. Our research funds have supported projects that come directly out of the needs and goals of our community. Our current water research activities were designed entirely based on community priorities.*

J. Funding Sources and Their Suitability for Addressing Short-term Emergency Needs

Question. *Please rate the suitability of the following funding types for addressing short-term emergency needs (e.g., sudden community concern, disease or pest outbreak, natural disaster).*

Table 67: Rating of Funding Types by Suitability for Use in Addressing Short-term Emergency Needs

Funding Source	Very High	High	Medium	Low	Very Low	N/A
Endowment	20%	30%	20%	0%	10%	20%
Equity	0%	0%	10%	30%	40%	20%
Extension	0%	20%	10%	20%	20.00%	30%
Research	0%	0%	0%	30%	40%	30%

Question. *Provide up to three recent (last three years) examples from your institution of times when NIFA funds were able to be redirected by your institution to respond to a short-term emergency need. For each example, identify the funding type(s) used (endowment, equity, extension, or research) and provide a brief (2-3 sentence) description or narrative. Feel free to provide links as well as citations to additional information.*

Write-in responses

- *The [Name] Nation faced a detrimental environment impact from the [Name] Mine spill that contaminated the major source of water irrigation from the river that supported the [Name] Nation farmers. In addition, the climate is changing and the [Name] Nation faces water shortage in the future because the lack of rain in the summer and warmer winters which will bring less amount of snow fall in the mountains.*
- *Endowment was used for a portion of the instructor salary when there was a shortage in other funding sources. Extension and Equity have not been used for short term emergency needs.*

K. Greatest Strengths and Advantages of the NIFA Equity and Endowment Funding Programs

Question. List what you believe are the greatest strengths/advantages of the NIFA equity and endowment funding.

Figure 28: Word Cloud of greatest strengths/advantages of the NIFA equity and endowment funding programs



Write-in responses

- *The greatest strength of equity funding is that it can be used to directly support teaching and learning in the classroom. The greatest strength of endowment funding is that it provides maximum flexibility for colleges to use these funds where they are most needed.*
- *The greatest strength/advantage is the resources it allows us to tie into for the associate program that we have in the Natural Resources Department. Without the funding, we would not be able to keep the program running.*
- *Overall the greatest strength of both equity and endowment is the level of flexibility allowing TCU's to best meet their identified needs. Additionally, it is equally distributed and reliable. Finally, the new reporting process does not create undue burden.*
- *Strengths include the ability to provide programs that fit within our mission, and expose students to the importance of food and agriculture both historically, and in today's society. The greatest strength is in NIFA's support of land-grant institutions to provide relevant programs and research opportunities for students.*
- *Strengths: 1) Endowment is flexible to develop or change programs that will support the immediate needs of the community. 2) Equity is flexible to develop innovative programs that involve faculty and promotes education for the public. 3) Both Equity and Endowment can be utilized to support both institutional and community needs.*
- *The greatest strengths and/or advantages of the NIFA funding is the flexibility and relatively low-administrative burden.*
- *Equity - The grant is very flexible and allows [Name] to move funds within the grant as long as we maintain the same scope outlined in the initial proposal. [Name] has readjusted the grant budget with ease to address our changing needs. The grant is diverse and allows [Name] to use it in many ways to address the needs of the college. [Name] has used the grant to pay partial salaries, buy lab materials, pay for professional development, and purchase teaching materials. The grant is a major component in helping [Name] STEM maintain the level of teaching that we have now developed. Getting questions answered in a timely fashion. For instance, when we call there is a 24-hour turnaround on NIFA's End. We have called multiple times and are impressed with the response time and handling of questions on NIFA's end.*
- *The Endowment funding allowed the college to renovate a science classroom and lab. This has been the biggest benefit. The STEM Recruiter position has assisted with engaging students in AIHEC Science Bowl Competition and promoting student leadership. The Extension program has created a greater awareness*

of the college in the local community. The community education workshops, while educating the participants, provides an overarching message, higher education is attainable.

- The greatest strength of the Equity has been the opportunity to support our Environmental Science (ES) Instructor position on a continuing basis. This has taken a lot of pressure off our general fund and allowed us to offer classes that both meet general education requirements and make the ES degree program possible. It would not have been possible for our institution to build facilities for our Extension activities at the new campus site without Endowment funds. The disconnect of having the Extension Office in its original location nearly a mile from campus would have seriously reduced our effectiveness and efficiency. Finally, the flexibility of the Equity Program and the National level staff has allowed me to be very innovative in creating indigenized science curricula. These innovations have proven highly successful in spite of the fact that they may not always have appeared intuitive initially.

L. Greatest Weaknesses or Disadvantages of NIFA Equity and Endowment Funding Programs

Question. List what you believe are the greatest weaknesses/disadvantages of the NIFA equity and endowment funding.

Figure 29: Word Cloud of Greatest Strengths/Advantages of NIFA Equity and Endowment Funding Programs



Write-in responses

- The greatest weakness of the equity funding is that the amount of funding has not increased. Each year, level funding means a reduction in the support these funds actually provide to our educational programs as the costs for operating these programs continue to increase. For example, an equity project that used to support a full-time instructor now supports three-quarters of a full-time faculty position.
- The greatest weaknesses/disadvantages is the amount of funding that we can apply for during the funding cycle (equity). If this funding was more or we had the ability to apply for more funding, the department could grow and there would be a stability that is currently not there.
- Level of funding does not actually meet the needs of TCU's. Research funding does not build the research capacity of TCU's in a meaningful way. The sheer disproportionate funding levels between land grant schools gives TCU's very little opportunity.
- None, NIFA equity and endowment has provided relevant programming that is important to our students.
- Weaknesses: 1) Equity is not to flexible once the objectives and the scope of work are developed. 2) Endowment is too flexible that its oversight and usage can easily be changed. 3) The USDA NIFA programs lack support of advertising their initiatives to institutions and communities.
- The greatest disadvantages of the NIFA funding are the funding amounts.
- Equity - not having more money in the equity grant, as it is diverse and with more funding LLTC could expand the capacity of the STEM program and increase student research. The grant has provided a lot to LLTC over the years and with an increase in funding would do even more.
- While the funding seems adequate for programing it is not enough to hire additional staff and have programing. The Endowment has been used to cover shortfall of instructor salaries, it would be beneficial to use the funds to hire an IT person who would be able to move the college forward in the technology arena.

- *Equity funding, in particular, has not grown at anything near the rate of real inflation. Cost of Living increases in pay for the staff these funds support makes it increasingly difficult to continue to grow our impacts and activities.*

M. Recommendations on Changes to Improve NIFA Equity and Endowment Funding Programs

Question. *Describe what changes you think would be beneficial to improve the impacts of NIFA equity and endowment funding.*

Figure 30: Word Cloud of Recommended Changes for NIFA Equity and Endowment Funding Programs



Write-in responses

- *Except for increasing funding levels, I can't think of any major changes needed.*
- *An increase in funding of equity would be greatly beneficial to the capacity of the land grant programs. With an increase in funds available, the competition for the grants could be reduced even if the grants themselves could not be increased. This would allow for more stability in the Land Grant programs.*
- *Increase award levels. Invest in building research, institutional, and technology capacity in a meaningful way. Fund more rural activities and projects that extend beyond ag. Provide same opportunities provided to the 1862's and 1890's that will level the playing field.*
- *The allowance of construction of new facilities and/or lab space would be very beneficial to expanding programs.*
- *1) Establish more site visits to institution to bring a clear cohesive communication with other administrators who do not use USDA NIFA funding as their daily operations. In addition, to help support the staff and administrators to begin establishing new communication methods.*
- *Increased/new NIFA Capacity Funding to build additional capacity at [Name] would enable greater impacts from the NIFA equity and endowment funding. Current faculty and staff serve multiple roles*
- *Increase funding levels that would be adequate to develop programs and hire additional staff.*
- *Increased funding, of course.*

N. Recommendations for Streamlining NIFA Equity and Endowment Funding Processes

Question. *Provide any recommendations you may have to streamline processes, reporting requirements, or flexibility of use associated with NIFA equity and endowment funding.*

Figure 31: Word Cloud of Recommendations for Streamlining NIFA Processes



Write-in responses

- NIFA has done a great job streamlining the application process for equity and endowment in recent years. They are now true multi-year awards. That's a great step forward.
- The new process for reporting and applying for the equity have helped drastically, but there is always room for improvement. This could be done by furthering improving the computer reporting process.
- Process is adequate.
- The reporting requirements were appropriate.
- 1) Establish a few new webinar training such as utilization of the REEPort systems. 2) Create a timeline for Institutions as to due dates of financial reports, annual reports, log in to ASAP, draw downs, and survey reporting.
- REEPORT used to be easier to navigate; however, now - with recent changes - it has become a little clumsy. We found it hard to find the grant this reporting period and to follow filling out forms. We would like to see the process cleaned up because it used to be better.
- The system for reporting is confusing and I am not sure how that can be fixed.
- The National Program staff have made tremendous strides in doing this already. In particular, the renewal process for Equity is incomparably easier than it was initially. They continue to make improvements on a yearly basis and I can't commend them enough for their efforts and for the effectiveness of those efforts.

Question. In the space below, please provide any recommendations you may have to improve the ability of your institution to cooperate with other NIFA-funded land grant institutions on issue of concern to your community?

Figure 32: Word Cloud of Recommendations to Improve Cooperation with Other LGUs



Write-in responses

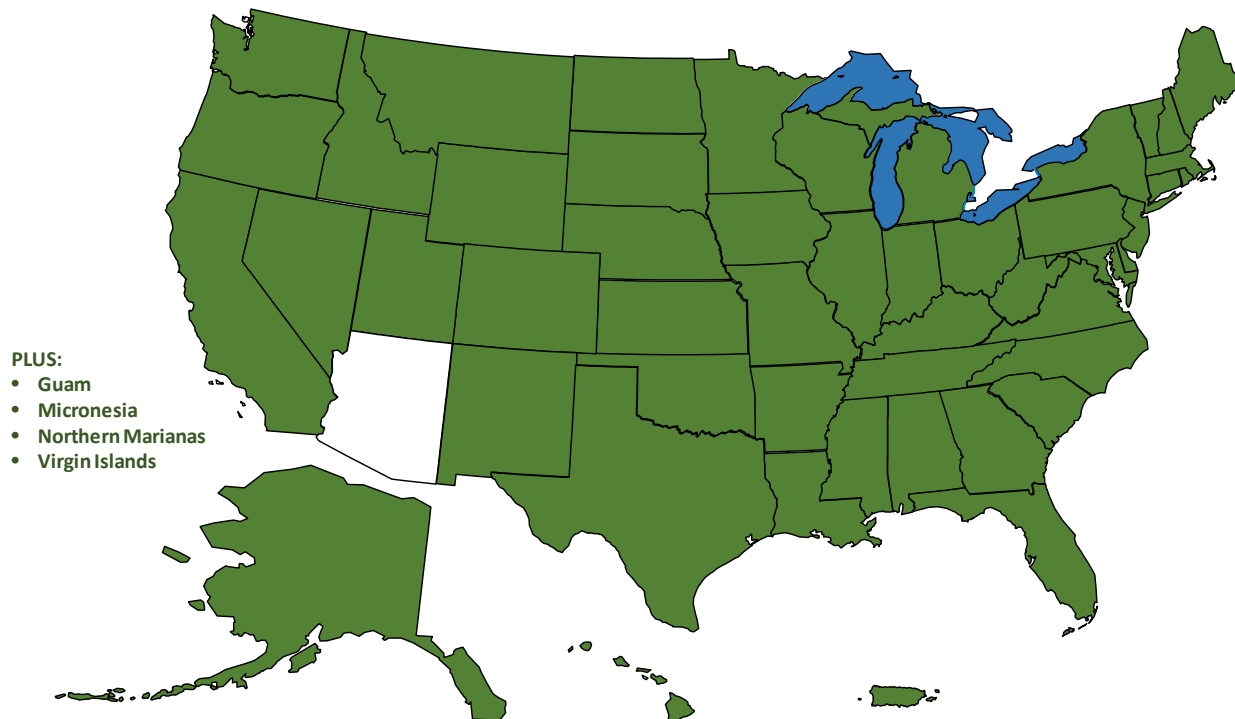
- One recommendation would be to eliminate the REQUIREMENT for 1994s to partner with an 1862 on research projects. This fosters distorted relations of dependency and actually hinders genuine partnership. Encouraging this kind of collaboration is a good thing; requiring it is not so good.
- Cooperation begins with better communication. This issue is being worked on, but again, there is always room for improvement.
- Require 62's and 90's to partner with 94's in the same way 94's are required to partner with them.
- More training and conferences to support networking and an exchange of ideas among the NIFA funded land grant institutions.
- 1) If a Tribal College exist in tribal communities all other higher educational institutions should collaborate to share resources, such as FRTEP, development of MOU's, Cooperative Agreements, and funding.
- The ability of [Name] to cooperate with other land grant institutions would be greatly improved through a liaison or staff to facilitate relationship-building and collaboration with institutions. Time available for these cooperative activities by current staff is limited and oftentimes, collaborations and cooperation depends upon personal relationships and connections between staff at institutions.
- The distance of the two other tribal colleges is problematic. [Nearby 1862 LGU] has always had a limited working relationship with the tribal college.
- The Research Grant Program requires us to collaborate with 1862 institutions. It would be beneficial for the 1862's to be required to partner with TCU's in order to receive some of their funding. This would insure

that the mainstream institutions are addressing the needs of their often-neglected Native constituents and allow for stronger partnerships between the 1862's and TCU's.

Appendices

Appendix A: 1862 Land-Grant University Survey Respondents

1862 LGU Respondent States and Territories



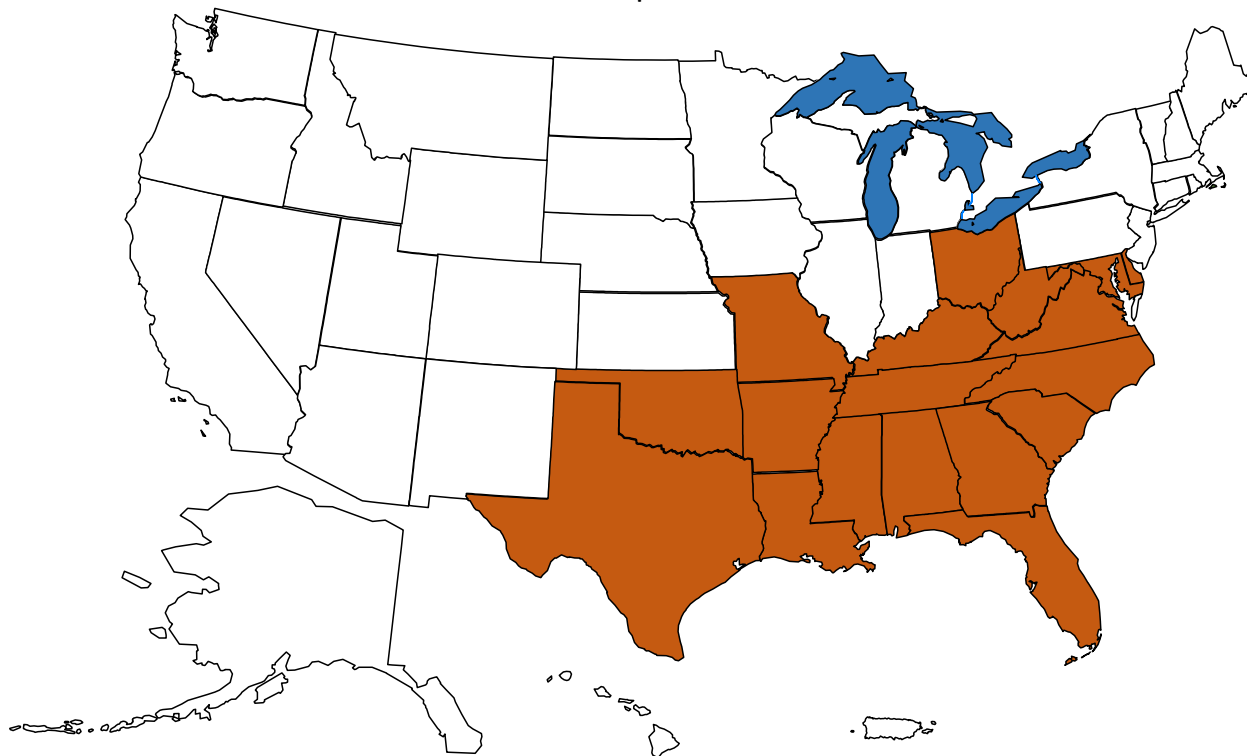
State or Territory	1862 Land-Grant Institution	Institution Survey Returned	Cooperative Extension Survey Returned	Research Survey Returned
Alabama	Auburn University		X	X
Alaska	University of Alaska Fairbanks	X	X	X
Arkansas	University of Arkansas (Fayetteville)	X	X	X
California	University of California, Berkeley	X	X	
California	University of California - Davis, School of Veterinary Medicine	X		
Colorado	Colorado State University		X	
Connecticut	University of Connecticut	X	X	X
Delaware	University of Delaware	X	X	X
Florida	University of Florida		X	X
Georgia	University of Georgia	X	X	X
Guam	University of Guam		X	X
Hawaii	University of Hawaii	X	X	X
Idaho	University of Idaho		X	X

State or Territory	1862 Land-Grant Institution	Institution Survey Returned	Cooperative Extension Survey Returned	Research Survey Returned
Illinois	University of Illinois at Urbana-Champaign		X	X
Indiana	Purdue University		X	X
Iowa	Iowa State University	X	X	X
Kansas	Kansas State University	X	X	X
Kentucky	University of Kentucky	X	X	X
Louisiana	Louisiana State University		X	X
Maine	University of Maine		X	X
Maryland	University of Maryland, College Park			X
Massachusetts	University of Massachusetts Amherst	X	X	X
Michigan	Michigan State University		X	X
Micronesia	College of Micronesia		X	X
Minnesota	University of Minnesota	X	X	X
Mississippi	Mississippi State University	X	X	X
Missouri	University of Missouri			X
Montana	Montana State University (Bozeman)	X	X	
Nebraska	University of Nebraska-Lincoln		X	X
Nevada	University of Nevada, Reno	X	X	X
New Hampshire	University of New Hampshire		X	
New Jersey	Rutgers, The State University of New Jersey		X	X
New Mexico	New Mexico State University		X	X
New York	Cornell University	X	X	X
North Carolina	North Carolina State University	X	X	X
North Dakota	North Dakota State University		X	X
Northern Marianas	Northern Marianas College	X	X	X
Ohio	The Ohio State University		X	X
Oklahoma	Oklahoma State University	X	X	X
Oregon	Oregon State University	X	X	X
Pennsylvania	The Pennsylvania State University		X	X
Puerto Rico	University of Puerto Rico at Mayagüez	X	X	X
Rhode Island	University of Rhode Island	X	X	
South Carolina	Clemson University	X	X	
South Dakota	South Dakota State University		X	X
Tennessee	University of Tennessee	X	X	X
Texas	Texas A&M University	X	X	

State or Territory	1862 Land-Grant Institution	Institution Survey Returned	Cooperative Extension Survey Returned	Research Survey Returned
Utah	Utah State University	X	X	X
Vermont	University of Vermont		X	
Virgin Islands	University of the Virgin Islands		X	X
Virginia	Virginia Polytechnic Institute and State University	X	X	X
Washington	Washington State University		X	
West Virginia	West Virginia University		X	X
Wisconsin	University of Wisconsin–Madison	X	X	X
Wyoming	University of Wyoming	X	X	X

Appendix B: 1890 Land-Grant University Survey Respondents

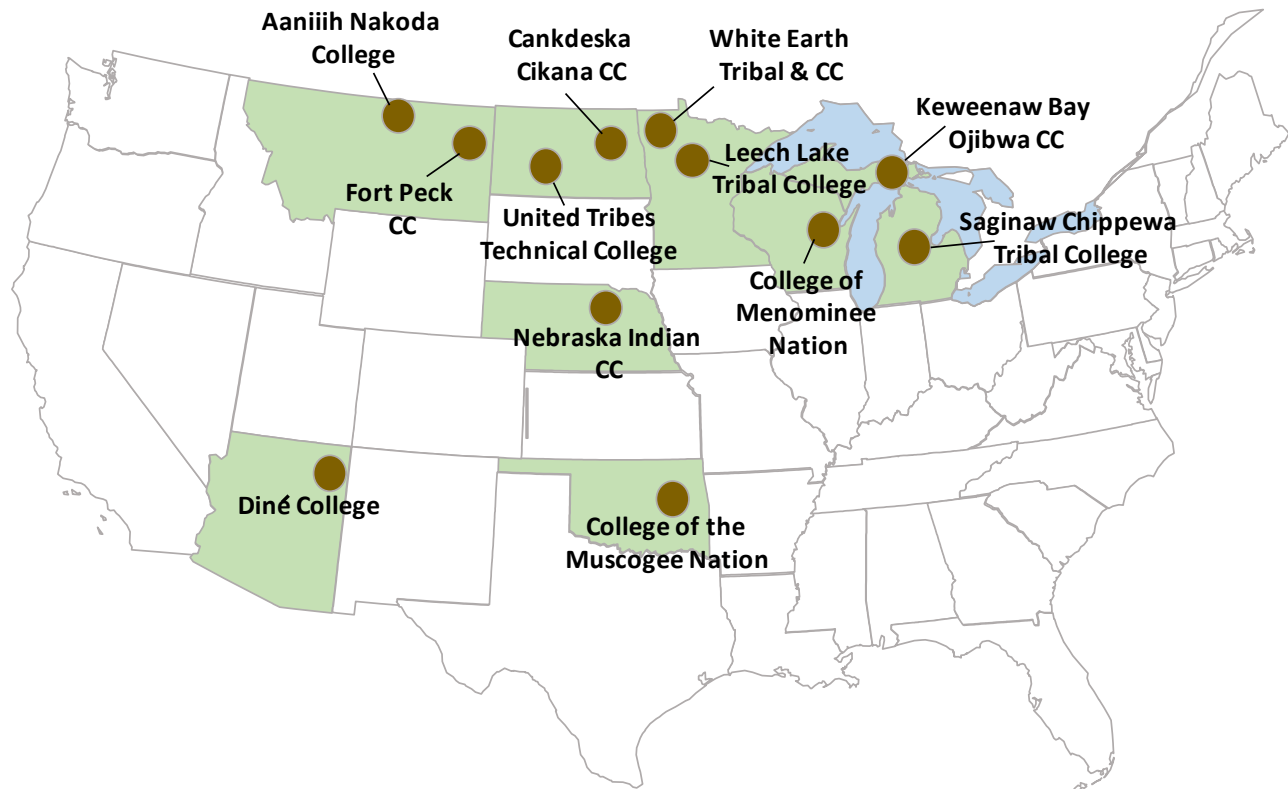
1890 LGU Respondent States



State	1890 Land-Grant Institution	Institution Survey Returned	Cooperative Extension Survey Returned	Research Survey Returned
Alabama	Alabama A&M University		X	
Alabama	Tuskegee University	X	X	X
Arkansas	University of Arkansas at Pine Bluff			
Delaware	Delaware State University	X	X	X
Florida	Florida A&M University	X	X	X
Georgia	Fort Valley State University	X	X	X
Kentucky	Kentucky State University	X	X	X
Louisiana	Southern University and A&M College	X		
Maryland	University of Maryland, Eastern Shore	X	X	X
Mississippi	Alcorn State University	X	X	X
Missouri	Lincoln University	X	X	X
North Carolina	North Carolina A&T State University	X	X	X
Ohio	Central State University	X	X	X
Oklahoma	Langston University	X	X	X
South Carolina	South Carolina State University	X	X	X

State	1890 Land-Grant Institution	Institution Survey Returned	Cooperative Extension Survey Returned	Research Survey Returned
Tennessee	Tennessee State University	X	X	X
Texas	Prairie View A&M University	X	X	X
Virginia	Virginia State University	X	X	X
West Virginia	West Virginia State University	X	X	X

Appendix C: 1994 Tribal Land-Grant Colleges and Universities – Survey Respondents



State	Institution
Arizona	Diné College (DC)
Michigan	Keweenaw Bay Ojibwa Community College (KBOCC)
Michigan	Saginaw Chippewa Tribal College(SCTC)
Minnesota	White Earth Tribal and Community College (WETCC)
Minnesota	Leech Lake Tribal College (LLTC)
Montana	Aaniiih Nakoda College (ANC)
Montana	Fort Peck Community College (FPCC)
Nebraska	Nebraska Indian Community College(NICC)
North Dakota	Cankdeska Cikana Community College (CCCC)
North Dakota	United Tribes Technical College(UTTC)
Oklahoma	College of the Muscogee Nation(CtMN)
Wisconsin	College of Menominee Nation (CMN)

Appendix D: Non-LGU Recipients of Formula/Capacity Funding: Survey Respondents

State	Institution	Institution Survey Returned	Cooperative Extension Survey Returned	Research Survey Returned
Arizona	Northern Arizona University	X		
California	California Polytechnic State University–San Luis Obispo	X		X
California	Humboldt State University	X		X
Connecticut	Connecticut Agricultural Experiment Station	X		

Appendix E: Figure 12 Data

Data for Figure 12: Percentage Segmentation of Publications across Key Disciplines (OmniViz™ Cluster Analysis of 108,180 Publications) **Metaclusters and Associated Themes**

Metacluster	Theme	Number of Cluster Records
Agronomy, 21.3%	Horticulture, 4.4%	4,740
Agronomy, 21.3%	Mycology, 0.1%	95
Agronomy, 21.3%	Organic, 0.3%	324
Agronomy, 21.3%	Pest Management, 1.1%	1,176
Agronomy, 21.3%	Plant Pathology, 0.5%	510
Agronomy, 21.3%	Plant Breeding/Improvement, 14%	15,107
Agronomy, 21.3%	Water, 1%	1,095
Animal Science, 2.3%	Behavior, 0.8%	867
Animal Science, 2.3%	Nutrition, 0.1%	82
Animal Science, 2.3%	Primates, 0.2%	235
Animal Science, 2.3%	Reproduction, 1.1%	1,219
Animal Science, 2.3%	Wildlife, 0.1%	111
Basic Science, 21.1%	Algology, 0.2%	171
Basic Science, 21.1%	Bacteriology, 2.6%	2,810
Basic Science, 21.1%	Biochemistry, 0.1%	63
Basic Science, 21.1%	Biofilms, 0.1%	118
Basic Science, 21.1%	Cell Biology, 0.2%	233
Basic Science, 21.1%	Emissions, 0.6%	641
Basic Science, 21.1%	Fermentation, 0.3%	314
Basic Science, 21.1%	Basic Genetics, 0.2%	184
Basic Science, 21.1%	Nutrition, 3.1%	3,394
Basic Science, 21.1%	Plant Science, 12.7%	13,745
Basic Science, 21.1%	Starch, 0.4%	458
Basic Science, 21.1%	Symbiosis, 0.6%	672
Biomass & Biofuels, 1.7%	Anaerobic Digestion, 0.1%	125
Biomass & Biofuels, 1.7%	Biochar, 0.1%	131
Biomass & Biofuels, 1.7%	Biomass, 1.3%	1,438
Biomass & Biofuels, 1.7%	Glycerol, 0.1%	135
Dairy, 4.8%	Milk, 4.8%	5,141
Entomology, 2.6%	Mites, 0.4%	444
Entomology, 2.6%	Mosquitoes, 0.7%	794
Entomology, 2.6%	Nematodes, 0.2%	260
Entomology, 2.6%	Pest Control, 1%	1,040
Entomology, 2.6%	Ticks, 0.3%	279
Food Science, 4.4%	Alkaloids, 0.2%	197
Food Science, 4.4%	Consumer Preferences, 0.7%	787

Food Science, 4.4%	Food Safety, 0.2%	254
Food Science, 4.4%	Food Storage, 0.2%	207
Food Science, 4.4%	Meat Science, 1.1%	1,174
Food Science, 4.4%	Nutrition, 0.1%	79
Food Science, 4.4%	Oils, 1.7%	1,891
Food Science, 4.4%	Peanuts, 0.2%	176
Forestry, 10.1%	Fire, 1%	1,072
Forestry, 10.1%	Forest Management, 2.7%	2,877
Forestry, 10.1%	Forest Products, 0.3%	368
Forestry, 10.1%	General, 0.8%	863
Forestry, 10.1%	Silviculture, 2.5%	2,747
Forestry, 10.1%	Soil, 0.9%	1,027
Forestry, 10.1%	Tree Species, 1.9%	2,003
Livestock, 2.3%	Aquaculture, 0.7%	806
Livestock, 2.3%	Bovine, 1.3%	1,416
Livestock, 2.3%	Manure Management, 0.2%	217
Poultry, 2.7%	Broilers, 1.5%	1,588
Poultry, 2.7%	Layers, 0.9%	984
Poultry, 2.7%	Litter, 0.2%	249
Poultry, 2.7%	Turkey, 0.1%	143
Soil Science, 9%	General, 5.9%	6,347
Soil Science, 9%	Plant Nutrients, 3.2%	3,408
Veterinary Medicine, 17.7%	Bovine, 0.5%	501
Veterinary Medicine, 17.7%	Cancer, 5.3%	5,751
Veterinary Medicine, 17.7%	Equine, 3.1%	3,355
Veterinary Medicine, 17.7%	General, 0.6%	641
Veterinary Medicine, 17.7%	Infectious Diseases, 5%	5,355
Veterinary Medicine, 17.7%	Ophthalmology, 0.1%	84
Veterinary Medicine, 17.7%	Orthopedics, 0.5%	592
Veterinary Medicine, 17.7%	Porcine, 1.4%	1,468
Veterinary Medicine, 17.7%	Small Animals, 0.2%	181
Veterinary Medicine, 17.7%	Small Ruminants, 0.5%	527
Veterinary Medicine, 17.7%	Surgery, 0.6%	694
	TOTAL	108,180

Appendix F: Figure 13 Data

Data for Figure 13: Percentage Segmentation of Publications across Key Disciplines (OmniViz™ Cluster Analysis of 108,180 Publications) Metaclusters, Associated Themes, and Subthemes

Metacluster	Theme	Subtheme	Number of Cluster Records
Agronomy, 21.3%	Horticulture	Apples	308
Agronomy, 21.3%	Horticulture	Fruit	3,800
Agronomy, 21.3%	Horticulture	Strawberries	83
Agronomy, 21.3%	Horticulture	Tomatoes	474
Agronomy, 21.3%	Horticulture		75
Agronomy, 21.3%	Mycology	Mushrooms	95
Agronomy, 21.3%	Organic		324
Agronomy, 21.3%	Pest Management	Weeds	1,176
Agronomy, 21.3%	Plant Pathology	Citrus	510
Agronomy, 21.3%	Plant Science	Beans	209
Agronomy, 21.3%	Plant Science	Corn	2,958
Agronomy, 21.3%	Plant Science	Cotton	700
Agronomy, 21.3%	Plant Science	General	4,810
Agronomy, 21.3%	Plant Science	Grasses	734
Agronomy, 21.3%	Plant Science	Potato	1,005
Agronomy, 21.3%	Plant Science	Rice	1,101
Agronomy, 21.3%	Plant Science	Soybean	1,215
Agronomy, 21.3%	Plant Science	Wheat	2,375
Agronomy, 21.3%	Water	Irrigation	406
Agronomy, 21.3%	Water	Nutrient Runoff	340
Agronomy, 21.3%	Water	Sedimentation	349
Animal Science, 2.3%	Behavior		867
Animal Science, 2.3%	Nutrition	Probiotics	82
Animal Science, 2.3%	Primates		235
Animal Science, 2.3%	Reproduction		1,219
Animal Science, 2.3%	Wildlife		111
Basic Science, 21.1%	Algology		171
Basic Science, 21.1%	Bacteriology	e-coli	2,810
Basic Science, 21.1%	Biochemistry		63
Basic Science, 21.1%	Biofilms		118
Basic Science, 21.1%	Cell Biology		233
Basic Science, 21.1%	Emissions		641
Basic Science, 21.1%	Fermentation		314
Basic Science, 21.1%	Genetics	Micro RNA	184
Basic Science, 21.1%	Nutrition		3,394

Basic Science, 21.1%	Plant Science	Fungicide Resistance	177
Basic Science, 21.1%	Plant Science	Genetics	1,437
Basic Science, 21.1%	Plant Science	Mutation	235
Basic Science, 21.1%	Plant Science	Physiology & Morphology	2,862
Basic Science, 21.1%	Plant Science	Pollination	1,220
Basic Science, 21.1%	Plant Science	Roots	1,899
Basic Science, 21.1%	Plant Science	Salt Tolerance	231
Basic Science, 21.1%	Plant Science	Seeds	2,747
Basic Science, 21.1%	Plant Science	Stress Resistance	2,937
Basic Science, 21.1%	Starch		458
Basic Science, 21.1%	Symbiosis		672
Biomass & Biofuels, 1.7%	Anaerobic Digestion		125
Biomass & Biofuels, 1.7%	Biochar		131
Biomass & Biofuels, 1.7%	Biomass	Crop Residues	379
Biomass & Biofuels, 1.7%	Biomass	Switchgrass	1,059
Biomass & Biofuels, 1.7%	Glycerol		135
Dairy, 4.8%	Milk		5,141
Entomology, 2.6%	Mites		444
Entomology, 2.6%	Mosquitoes		794
Entomology, 2.6%	Nematodes		260
Entomology, 2.6%	Pest Control		1,040
Entomology, 2.6%	Ticks		279
Food Science, 4.4%	Alkaloids		197
Food Science, 4.4%	Consumer Preferences		787
Food Science, 4.4%	Food Safety	Listeria	254
Food Science, 4.4%	Food Storage		207
Food Science, 4.4%	Meat Science	Beef	1,174
Food Science, 4.4%	Nutrition		79
Food Science, 4.4%	Oils		1,891
Food Science, 4.4%	Peanuts	Allergens	176
Forestry, 10.1%	Fire		1,072
Forestry, 10.1%	Forest Management		2,877
Forestry, 10.1%	Forest Products	Biofuel	66
Forestry, 10.1%	Forest Products	Lumber	302
Forestry, 10.1%	General		863
Forestry, 10.1%	Silviculture	Aspen	129
Forestry, 10.1%	Silviculture	Pine	2,049
Forestry, 10.1%	Silviculture		569
Forestry, 10.1%	Soil		1,027
Forestry, 10.1%	Tree Species		2,003
Livestock, 2.3%	Aquaculture	Catfish	806

Livestock, 2.3%	Bovine	Beef Cattle	994
Livestock, 2.3%	Bovine	Forage	260
Livestock, 2.3%	Bovine	Grazing	162
Livestock, 2.3%	Manure Management		217
Poultry, 2.7%	Broilers		1,588
Poultry, 2.7%	Layers		984
Poultry, 2.7%	Litter		249
Poultry, 2.7%	Turkey		143
Soil Science, 9%	General		6,347
Soil Science, 9%	Plant Nutrients		3,408
Veterinary Medicine, 17.7%	Bovine		501
Veterinary Medicine, 17.7%	Cancer		201
Veterinary Medicine, 17.7%	Canine		5,550
Veterinary Medicine, 17.7%	Equine		3,355
Veterinary Medicine, 17.7%	General		641
Veterinary Medicine, 17.7%	Infectious Diseases	Vaccines	404
Veterinary Medicine, 17.7%	Infectious Diseases	Virology	2,039
Veterinary Medicine, 17.7%	Infectious Diseases		2,912
Veterinary Medicine, 17.7%	Ophthalmology		84
Veterinary Medicine, 17.7%	Orthopedics		592
Veterinary Medicine, 17.7%	Porcine		1,468
Veterinary Medicine, 17.7%	Small Animals		181
Veterinary Medicine, 17.7%	Small Ruminants		527
Veterinary Medicine, 17.7%	Surgery		694
		TOTAL	108,180

Appendix G: Figures 15 and 16 Data. REEport Capacity funded Projects

Data for Figures 15 and 16:

Metacluster Name	Focus Area	Subfocus	# of Distinct Capacity Projects
Agronomy	Horticulture	Citrus Diseases	54
Agronomy	Horticulture	Orchards	222
Agronomy	Horticulture	Viticulture	560
Agronomy	Irrigation & Water Use		786
Agronomy	Pest Management	Biological Control	636
Agronomy	Pest Management	Entomology	546
Agronomy	Pest Management	Herbicide	294
Agronomy	Pest Management	Plant Parasites	91
Agronomy	Pest Management	Weed Science	399
Agronomy	Plant Breeding & Improvement	Grains	37
Agronomy	Plant Breeding & Improvement	Parasite Resistance	73
Agronomy	Plant Breeding & Improvement	Plant Nutrient Inputs	363
Agronomy	Plant Breeding & Improvement	Potatoes	127
Agronomy	Plant Breeding & Improvement	Row Crop Improvement	212
Agronomy	Plant Breeding & Improvement	Row Crop Pathogens	194
Agronomy	Plant Breeding & Improvement	Stress Tolerance	679
Agronomy	Plant Breeding & Improvement	Turfgrass	139
Agronomy	Soil Science		1,778
Animal Science & Livestock	Animal Reproduction	Porcine	44
Animal Science & Livestock	Equine		65
Animal Science & Livestock	Forage Crops		240
Animal Science & Livestock	Livestock Diseases	Bovine	1,042
Animal Science & Livestock	Livestock Diseases	Poultry	118
Animal Science & Livestock	Livestock Nutrition	Grazing	257
Animal Science & Livestock	Livestock Reproduction		247
Animal Science & Livestock	Manure Management		213
Animal Science & Livestock	Meat Science	Bovine	250
Animal Science & Livestock	Meat Science	Poultry	27
Animal Science & Livestock	Fly & Insect Management	Flies	58
Animal Science & Livestock	Poultry Science	Reproduction	45
Animal Science & Livestock	Poultry Science		266
Animal Science & Livestock	Small Ruminants	Parasites	53
Animal Science & Livestock	Small Ruminants		69
Basic Life Science	Animal Reproduction		37
Basic Life Science	Biosensors	Nanotechnology	14

Basic Life Science	Cancer		77
Basic Life Science	Genetics & Genomics		258
Basic Life Science	Vector-borne Diseases		87
Basic Life Science	Microbiology	Bacteriology	707
Basic Life Science	Microbiology	Phages	10
Basic Life Science	Microbiology	Plant Pathology	496
Basic Life Science	Microbiology	Virology	519
Basic Life Science	Molecular Biology		20
Basic Life Science	Muscle Physiology		55
Basic Life Science	Nutrition		61
Basic Life Science	Plant Genetics & Molecular Biology		75
Biomass & Biofuels	Algae & Phycology		50
Biomass & Biofuels	Biofuel & Biogas		68
Biomass & Biofuels	Cellulosic Biomass	Processing	172
Biomass & Biofuels	Cellulosic Biomass		330
Economics	Agricultural Economics		696
Environmental Science	Bees		178
Environmental Science	Climate Change		38
Environmental Science	Ecology & Ecosystems	Wetlands	216
Environmental Science	Emissions		10
Environmental Science	Environmental Contaminants	Mercury & Metals	7
Environmental Science	Fire		51
Environmental Science	Water	Water Quality	730
Environmental Science	Wildlife & Habitat		76
Family & Consumer Sciences	Emotion & Behavioral Management		54
Family & Consumer Sciences	Obesity		130
Family & Consumer Sciences	Poverty & Mental Health		59
Family & Consumer Sciences	Youth & Behavior	Behavior	176
Fisheries & Aquaculture	Aquaculture		84
Fisheries & Aquaculture	Fisheries		462
Food Science	Dairy		107
Food Science	Food Safety	Bacteriology	346
Food Science	Food Safety	Education	32
Food Science	Food Safety	Fungal Toxins	65
Food Science	Nutrition	Bioactive Compounds	50
Food Science	Nutrition	Fruits & Vegetables	355
Food Science	Nutrition	Obesity	352
Food Science	Starch Crops	Quality	108
Food Science	Wine		28
Forests & Forestry	Forest Habitat & Ecosystems		1,311
Forests & Forestry	Land Use		86

Forests & Forestry	Pest Management	Entomology	137
Forests & Forestry	Silviculture	Pine	274
Forests & Forestry	Silviculture		253
Forests & Forestry	Tourism		70
Forests & Forestry	Wood Science		30
		TOTAL	19,791

Appendix H: Figures 17 and 18 Data. REEport Competitive AFRI/NRI Funded Projects

Data for Figures 17 and 18:

Metacluster Name	Theme	Subtheme	# of Distinct AFRI/NRI Projects
Agronomy, 20.9%	Pest Management	Aphids	13
Agronomy, 20.9%	Pest Management	Insects and Insecticides	58
Agronomy, 20.9%	Pest Management	Weed Management	17
Agronomy, 20.9%	Plant Pathology		77
Agronomy, 20.9%	Plant Pathology	Fungal	44
Agronomy, 20.9%	Fruit		17
Agronomy, 20.9%	Plant Breeding & Improvement		5
Agronomy, 20.9%	Plant Breeding & Improvement	Genetics	86
Agronomy, 20.9%	Soil Science		163
Animal Science & Livestock, 10.9%	Vaccines		30
Animal Science & Livestock, 10.9%	Reproduction		28
Animal Science & Livestock, 10.9%	Nutrition		33
Animal Science & Livestock, 10.9%	Cattle		65
Animal Science & Livestock, 10.9%	Dairy		21
Animal Science & Livestock, 10.9%	Dairy		31
Animal Science & Livestock, 10.9%	Bovine Genetics		42
Basic Science, 25%	Genetics & Genomics		41
Basic Science, 25%	Genetics & Genomics		61
Basic Science, 25%	Genetics & Genomics		4
Basic Science, 25%	Genetics & Genomics	Whole Genome Sequencing	8
Basic Science, 25%	Mammalian Reproduction		15
Basic Science, 25%	Basic Plant Science		188
Basic Science, 25%	Inflammation		26
Basic Science, 25%	Virology		36
Basic Science, 25%	Infectious Diseases		96
Basic Science, 25%	Microbiology		100
Biomass & Biofuels, 5.5%	Biomass		104
Biomass & Biofuels, 5.5%	Conversion Processes	Enzymes	10
Biomass & Biofuels, 5.5%	Conversion Processes	Fermentation	12
Economics, 8%	Agricultural Economics		153
Economics, 8%	Markets & Pricing		30
Environmental Science, 10.8%	Water		133
Environmental Science, 10.8%	Agricultural Emissions		66
Environmental Science, 10.8%	Bees		50
Family & Consumer Sciences, 4.8%	Obesity	Childhood Obesity	63
Family & Consumer Sciences, 4.8%	Obesity	Nutrition	48

Food Science, 11.2%	Food Safety		138
Food Science, 11.2%	Food Safety		14
Food Science, 11.2%	Food Safety	Poultry	22
Food Science, 11.2%	Food Safety		20
Food Science, 11.2%	Food Systems & Access		47
Food Science, 11.2%	Lipids		16
Forests & Forestry, 3%	Forest Ecosystems		68
		TOTAL	2,299

Appendix I: Figure 20 Data.

Data for Figure 20:

Metacluster Name	Theme	Percent in Cluster
Agricultural Production, 21.4%	Yield Improvement	8.4
Agricultural Production, 21.4%	Pest Management	3
Agricultural Production, 21.4%	Horticulture	7.5
Agricultural Production, 21.4%	Livestock	2.4
Farm Management & Economics, 18.5%	Economics	11.1
Farm Management & Economics, 18.5%	Livestock	7.3
Health & Wellness, 18.4%	Youth Health	7.1
Health & Wellness, 18.4%	Nutrition & Wellness	5.4
Health & Wellness, 18.4%	Physical Activity	2.6
Health & Wellness, 18.4%	Food Safety	3.3
Youth Development, 12.6%	4-H/ Leadership	9.2
Youth Development, 12.6%	STEM Education	3.3
Environmental Stewardship, 11.1%	Conservation	3.2
Environmental Stewardship, 11.1%	Environmental Safety	0.9
Environmental Stewardship, 11.1%	Pesticide Training	1.8
Environmental Stewardship, 11.1%	Water Conservation & Quality	4.2
Environmental Stewardship, 11.1%	Forest Resources	0.6
Environmental Stewardship, 11.1%	Certification Programs	0.3
Community & Economic Development, 10.6%	Leadership Development	7.6
Community & Economic Development, 10.6%	Business Development	1.6
Community & Economic Development, 10.6%	Volunteerism	1.3
Family & Consumer Sciences, 7.2%	Family & Child Care	4.7
Family & Consumer Sciences, 7.2%	Financial Planning	2.5

Appendix J: CPC Patent Classes Used in Patent Analysis

Mapping of CPC Classes to Broad AgBioscience Areas

Broad AgBioscience Area	CPC Class Number	Description
Agricultural Machinery and Planting Processes	A01B	Soil working and agricultural machinery
	A01C	Planting, sowing, and fertilizing processes
	A01D	Harvesting and mowing
	A01F	Threshing, baling, cutting, and produce storage
	A01G	Horticulture, forestry, and watering
Animal Husbandry and Management	A01K	Animal husbandry and breeding
	A01L	Animal shoeing
	A01M	Catching and trapping animals
Veterinary Instruments and Tools	A61D	Veterinary instruments, tools, or methods
Food Production and Additives	A01J	Manufacture of dairy products
	A21B	Baking equipment
	A21C	Dough processing
	A21D	Baking additives, products, and preservation
	A22B	Animal slaughtering
	A22C	Meat, poultry, and fish processing
	A23B	Food preservation
	A23C	Downstream dairy products
	A23D	Edible oils and fats
	A23F	Coffee and tea
	A23G	Cocoa products and other candy
	A23J	Protein compositions for foodstuffs
	A23K	Animal feedstocks
	A23L	Foods or foodstuffs not covered by other classes
	A23N	Machines for treating harvested plants
A23P	Shaping or working of foodstuffs	
Fertilizers and Other Agricultural Chemicals	A01N	Preservation, biocides, pest repellants/attractants, growth regulators
	C05B	Phosphatic fertilizers
	C05C	Nitrogenous fertilizers
	C05D	Other inorganic fertilizers
	C05F	Other organic fertilizers
	C05G	Fertilizer mixtures and additives
Animal and Vegetable Oils	C11B	Producing and refining animal and vegetable oils
	C11C	Secondary fats, oils, or fatty acids obtained from processing
Milling Processes	B02B	Preparing grain and fruit for milling
	B02C	Specific milling processes
Novel Plant Types	A01H	New plants and processes for obtaining them
Tobacco Production	A24B	Manufacture or preparation of tobacco
Wood Processing	B27L	Removing bark and splitting wood; manufacture of wood stock, veneer, shavings, fibers, or powder
Fermented Beverages	C12C	Beer brewing
	C12G	Preparation of wine and other alcoholic beverages
	C12H	Pasteurization, sterilization, purification, clarification, and aging of alcoholic beverages

Enzymes ⁵⁰	C12N (part.)	Preparation and compositions of enzymes, proenzymes, or carrier-bound or immobilized cells
Genetic Engineering ⁵⁰	C12N (part.)	Mutation or genetic engineering substances (DNA or RNA), vectors, and host organisms
Microbiology ⁵⁰	C12N (part.)	Micro-organisms, spores, undifferentiated animal or plant cells, tissues, and culture media, viruses, and bacteria

⁵⁰Patent classes that document areas related to micro-organisms, plant and animal cell lines, and genetic engineering techniques often do not distinguish between human biomedical and agricultural applications for the end use of the IP listed and many times have multidisciplinary innovation impacts across human and agricultural biotech areas, making attribution of new technologies directly to agricultural biotechnology difficult. For these classes, expert review of all U.S. patents generated for the analysis period was conducted to determine those that had agricultural biotechnology contexts for inclusion.