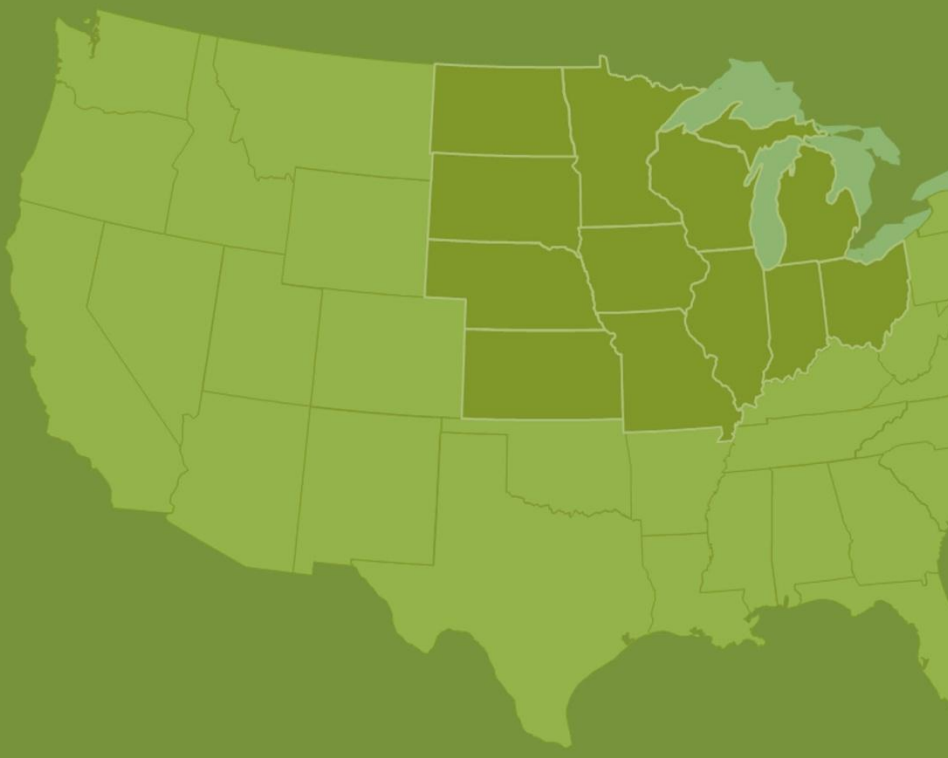
FINAL REPORT

POWER & PROMISE:

Agbioscience in the North Central United States

The Importance of North Central Experiment Stations, Extension Services and their Land-grant Universities in the Global Bioscience Economy



Performed For:
North Central Regional Association of State Agricultural Experiment Station Directors and the North Central Cooperative Extension Association

With Sponsorship By:
Iowa State University • Kansas State University • Michigan State University • North Dakota State University • The Ohio State University • Purdue University • South Dakota State University • University of Illinois • University of Minnesota • University of Missouri • University of Nebraska • University of Wisconsin

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Battelle
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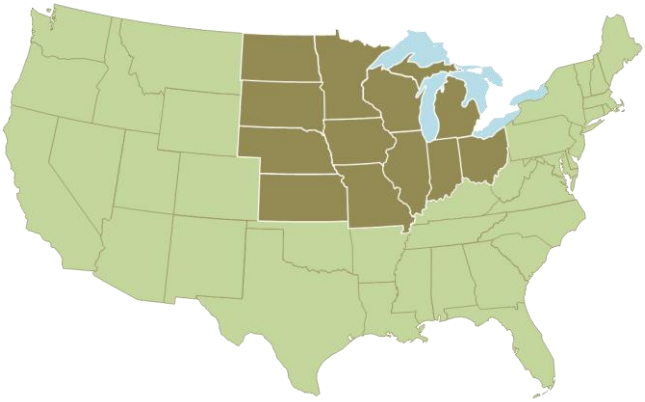
Sections:

Appendices



An independent Battelle report sponsored by the extension services and experiment stations of the twelve 1862 Land-grant Universities in the North Central region of the United States:

Iowa State University

Kansas State University

Michigan State University

North Dakota State University

The Ohio State University

Purdue University

South Dakota State University

University of Illinois

University of Minnesota

University of Missouri

University of Nebraska

University of Wisconsin

ABSTRACT

The North Central Region's Agricultural Extension Services and Experiment Stations are a foundation on which the $125 billion, 2.4 million job agriculture-driven industry in the region is built. This industry is already the most sophisticated and productive agriculture, forestry and value-added products system ever created, and it is poised to expand significantly with new markets such as novel health, specialty crops, biofuels and biobased products. Using just biobased products as an example, it is estimated that there is a potential to replace up to two-thirds of petro-based chemicals with agricultural-based materials, representing 50,000 different products—a $1 trillion global market.[1] There are similar opportunities with novel health, food safety, biofuels, and environmental technologies, each of which has potential to create thousands of new jobs and knowledge-based companies across the North Central region and the United States. Sustaining and protecting current agricultural value-chain production, while realizing the potential of exciting new economic opportunities, requires support for the fundamental scientific research and translational support mechanisms contained within land-grant agricultural experiment stations and extension services. The land-grant system has played a central role in the rise of American agriculture to global preeminence, but the scale of opportunities contained in a fast-expanding bio-based 21st century economy warrant considerably more attention be paid to these core institutions.

Sustained or expanded federal, state and local support will help this important land-grant, experiment station and extension service system to continue to perform its multi-faceted functions in cutting edge research for commercialization, education of knowledge workers for industry across the value chain, supply of unbiased information and support for farmers, and pursuit of opportunities for new collaborations and networks to grow the industry.

Through the 12 member institutions in the North Central Cooperative Extension Association (NCCEA), county extension agents are providing education to farmers serving as the primary unbiased link between the farm and new technologies and production practices. On the R&D front the 12 member institutions in the North Central Regional Association (NCRA) of State Agricultural Experiment Station Directors and the NCCEA are working to produce and disseminate agbioscience solutions to pressing economic and social needs. Collectively these thousands of knowledge-workers are driving a system that is providing for a safe, competitive, and healthy agbioscience based economy for the United States, while generating the knowledge and research support required to expand the sector in the future as a foundation for new and enhanced sustainable industries in food, feed, health, materials, chemicals and energy. Without ongoing public support for land-grant agbioscience research and extension activities national and regional agbioscience industries will not be able to realize their competitive potential. Indeed, at a national and state level, expanded support for agbioscience research and extension activities should ideally be pursued because the economic development opportunities are so large, the issues addressed strategic to the U.S., and funding support critical to maintaining and expanding U.S. leadership.

Agbioscience holds the key to a bright future for the U.S. and the North Central region in what has been termed the BioCentury. It is a base of economic power for the region and the nation, but moreover it holds great promise as a central driver of a successful economic and societal future.

[1] Jarrell, K.A., *"Synthetic Biology and Sustainable Chemistry Revolution."* Industrial Biotechnology. Winter 2009.

EXECUTIVE SUMMARY

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.

This report highlights the fact that agriculture and modern agbiosciences represent a scientific and economic sector of central importance to the future of the United States. Agriculture and agbioscience are directly relevant to finding solutions to key challenges facing the U.S. and the world—*economic growth*, *food security*, *human health*, and *environmental sustainability*. Within agbioscience the U.S. is a global R&D and production leader, working from a position of great strength. The U.S. is at the forefront in innovating and leveraging advanced technologies and bioscience knowledge advancements to enhance productivity and sustainability in food production and to create expanding economic opportunities in new advanced biobased products for fuels, chemicals, materials, healthcare products and a broad range of additional applications.

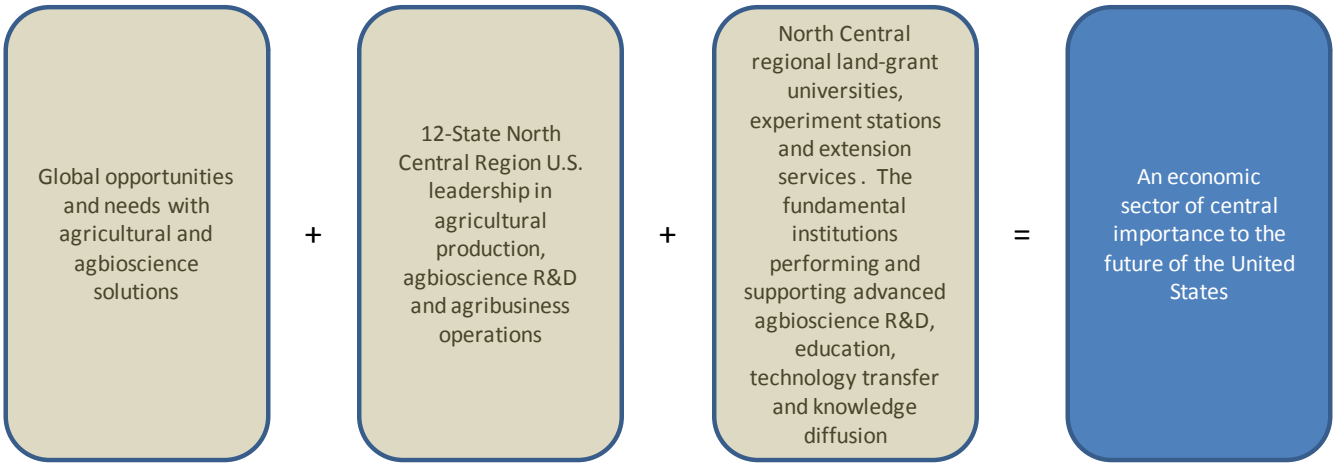
While agriculture is an economic sector present and important in every state, the twelve-state North Central region of the U.S. stands as a premiere location for agbioscience R&D, high-volume and high-efficiency agricultural production, and for agribusiness generating value-added products for domestic consumption and export.

Land-grant universities, through their experiment stations and extension services, are on the frontline of sustaining and securing America's leadership and competitiveness in what is and will be the key macroeconomic sector of our time.

Of central importance to progress in North Central regional agbiosciences are the presence and operations of land-grant universities, their experiment stations and extension services. These institutions undertake the fundamental and applied research leading to innovation in agbioscience. These institutions provide the testing, piloting and scale-up infrastructure and expertise to propel new innovations and technologies to market reality. These institutions provide support services in R&D, process improvement and the development of solutions to problems for industry. These institutions translate new knowledge, techniques and tools into the field through the translational activities of extension. And, these institutions educate the scientists, engineers and other skilled human capital required to sustain U.S. and North Central global leadership in agbiosciences.

In the "BioCentury" that is the 21st Century, land-grant universities, and their experiment stations and extension services, are on the frontline of sustaining and securing America's leadership and competitiveness in what is, and will be, the key macroeconomic sector of our time. As this report shows, sustaining these institutions, further investing in them, and addressing their challenges is of central importance to a sustainable economic future for the United States. The North Central region's agbioscience assets are part of an agricultural "equation for progress" (Figure ES-1):

Figure ES-1: Agriculture and Agbiosciences, an Equation for Sustainable U.S. Economic Progress



It is America's land-grant universities that uniquely engage across the full-spectrum of agbiosciences—from the most basic scientific enquiry through to practical services in support of producers, manufacturers and society provided via extension services.

By directly addressing key challenges and opportunities associated with agriculture and agbioscience the North Central regional land grant universities are playing a central role in U.S. progress across a range of fronts (Figure ES-2).

The importance and relevance of agriculture and agbiosciences to major challenges facing states, the nation and the globe are further documented in a recent report entitled "*A Science Roadmap for Food and Agriculture*" which highlights the direct impact of land-grant institutions on seven identified "grand challenges":[2]

- *Enhancing the sustainability, competitiveness, and profitability of U.S. food and agricultural systems*
- *Adapting to and mitigating the impacts of climate change on food, feed, fiber, and fuel systems in the United States*
- *Supporting the energy security and the development of the bioeconomy from renewable natural resources in the Unites States*
- *Playing a global leadership role to ensure a safe, secure, and abundant food supply for the United States and the world*
- *Improving human health, nutrition, and wellness of the U.S. population*
- *Heightening environmental stewardship through the development of sustainable management practices*
- *Strengthening individual, family, and community development and resilience.*

[2] Association of Public and Land-grant Universities, Experiment Station Committee on Organization and Policy – Science and Technology Committee, "A Science Roadmap for Food and Agriculture." November 2010.

Figure ES-2: Global Challenges with Agricultural and Agbioscience Solutions

Developments in agbioscience are also creating new markets for crops and crop residues as renewable, bio-based feedstocks for a number of key industries, including clean energy, chemicals, plastics and health products.

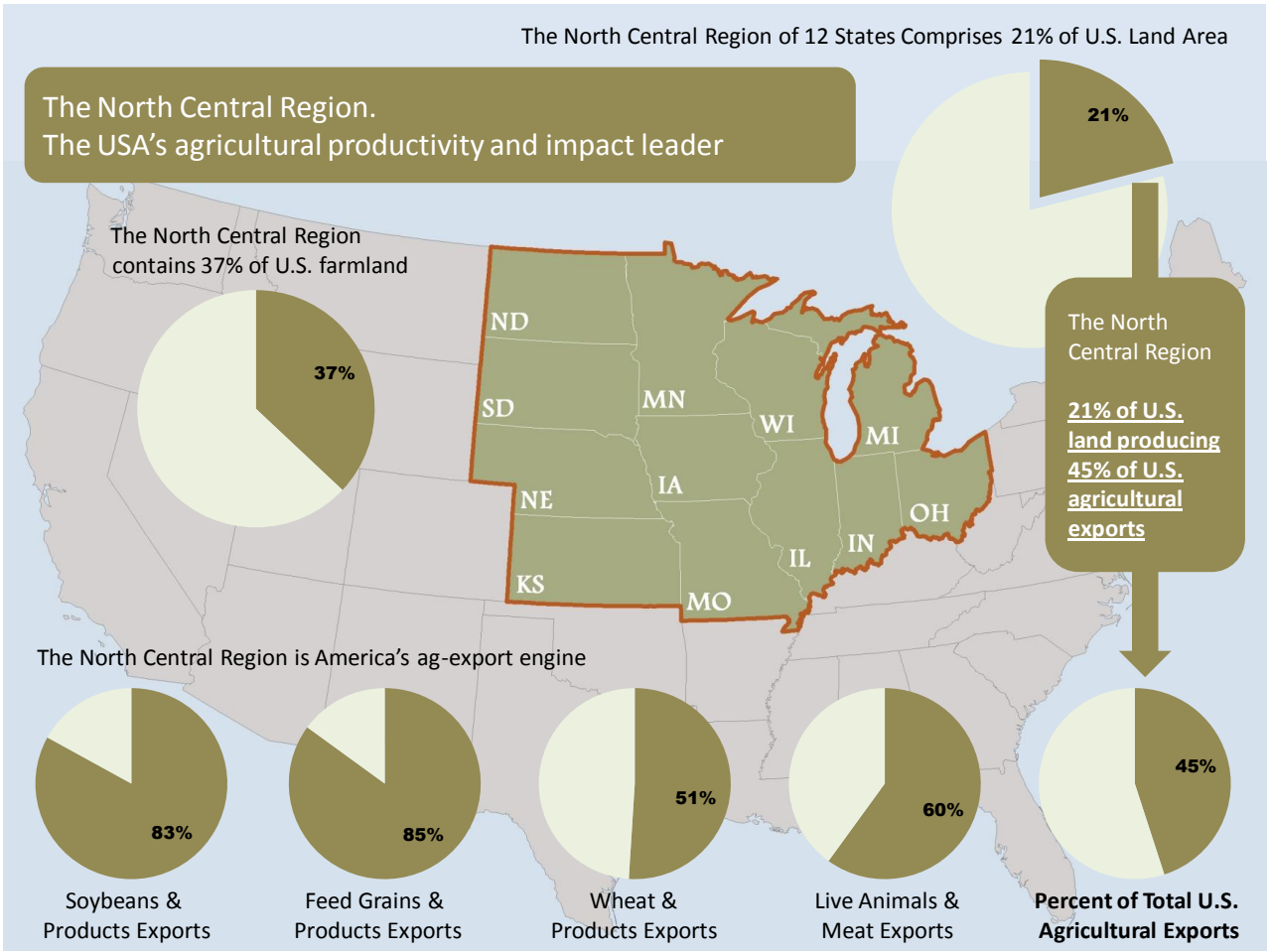
Battelle's work leads us to concur with the relevance of modern agriculture and agbiosciences to these grand challenges. Agbiosciences represent a unique field of science and applied R&D generating widespread innovations, technologies and solutions to tangible real-world needs.

Agbioscience practitioners, the research community sustaining America's leadership in agbioscience innovation, and the extension professionals translating advancements into the field, have a critical role to play in supporting a sustainable global future—economically, socially and environmentally.

The North Central Region

As noted above, the North Central region is a high performance center for agriculture, agbioscience R&D and educational activity. Its leading position in agricultural production is illustrated by Figure ES-3:

Figure ES-3: The North Central Region – The U.S. Leader in Agricultural Production



This agricultural and biomass-based economy is supported by an extensive network of land-grant assets. Underpinning the region's leadership in agriculture and agri-business, and its promise for the future, is an intensive

cluster of institutions, organizations and businesses engaged in agbiosciences research and associated R&D activities. Taken together, North Central regional assets in agricultural inputs development, agricultural production, ag-processing, ag-equipment development, and downstream value-added food, fiber and industrial products manufacturing comprise an "agbioscience innovation ecosystem"—an environment in which agbioscience business development is thriving.

North Central regional extension and experiment station assets focused on agricultural inputs development, agricultural production, ag-processing, ag-equipment development, and downstream value-added food, fiber and industrial products manufacturing comprise an "agbioscience innovation ecosystem" —an environment in which agbioscience business development is thriving.

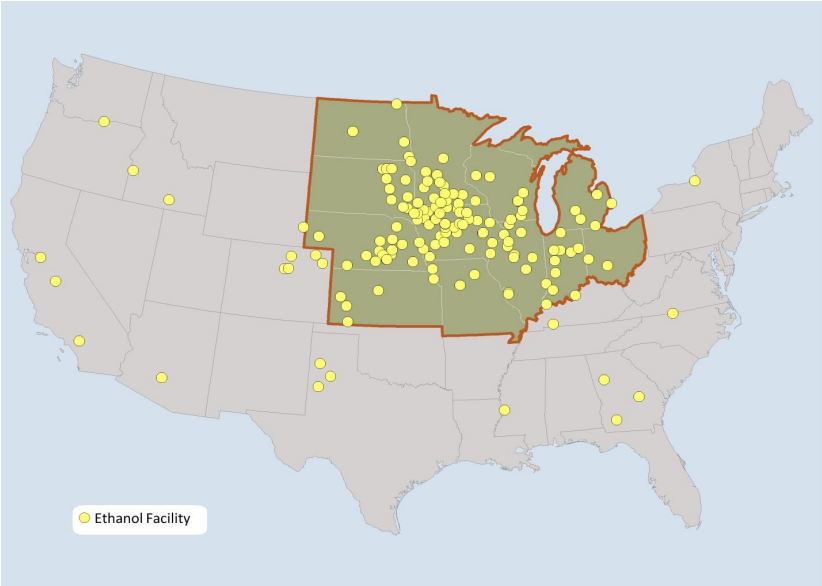
The North Central's academic agbioscience community is performing well. In 2009, colleges and universities in the North Central region attracted $3.6 billion in funding for academic R&D in agbiosciences and related disciplines. Likewise, the region is also a hub of major agbioscience-based industry multinationals that are active in R&D and technological innovation, for example:

- Ten of the top 25 U.S. food manufacturers have their HQ operations in the North Central Region (Kraft, Anheuser-Busch, General Mills, ConAgra, Kellogg, Sara Lee, Hormel, Cargill, SABMiller and Chiquita Brands).
- Two of the top five seed companies in the World are based in the North Central U.S. region (Monsanto and Land O'Lakes).
- Two of the world's preeminent agricultural equipment manufacturers are based in the region (John Deere in Illinios, the World's largest, and #2 ranked Case New Holland's North American HQ in Illinois).
- The North Central region is the hub for the U.S. animal health products industry, with operations of leading companies such as Fort Dodge Animal Health (Kansas), Abbott Animal Health (Illinois), Boehringer Ingelheim Vetmedica (Missouri), Novartis Animal Health (Iowa) and Pfizer Animal Genetics (Michigan).

Taken together this uniquely active system of agricultural production and advanced value-added manufacturing makes the North Central region the global leader in both traditional agricultural economic activity and the leading emerging areas of the modern bioeconomy. The degree of leadership shown by the region in the emerging bioeconomy is well documented and illustrated by the example of the distribution of first-generation renewable biofuels production plants (shown in Figure ES-4).

The renewable fuels sector, however, represents just one part of a multi-faceted emerging bioeconomy for the North Central region. The significant chemicals, polymers and materials industry in the region is proactively investigating the use of biobased feedstocks as substitutes for current environmentally unfriendly and price volatile fossil-resource based feedstocks (primarily petroleum). Similarly food and health product manufacturers in the region are on the frontier of developing and manufacturing advanced foods, functional foods, nutraceutical products and other health enhancing agriculture-based products.

Figure ES-4: Clustering of Renewable Biofuels Operations Evident in the North Central Region. Ethanol Manufacturing Facilities in the United States



Land Grants and their Experiment Stations and Extension Services: Of Central Importance to Agbioscience Power and Promise

The North Central region's leadership in agricultural production, agricultural processing and value-added manufacturing is advanced and supported by continuous innovation in agricultural and biological sciences, and within associated disciplines (such as engineering). Helping to drive scientific discovery, innovation and the deployment of new technologies and innovations to enhance industry productivity is a uniquely American system developed by visionaries in the late 1800's—the Land-grant University. "Land-grant University" is the term used to identify a public university in each state that was originally established as a land-grant college of agriculture pursuant to the Morrill Act of 1862. In most states (including all of the North Central states) the original agricultural colleges grew over time into full-fledged comprehensive public universities by adding other colleges (e.g., arts and sciences, medicine, law, etc.). Today these universities stand among the world's premier research institutions.

The twelve 1862 Land-grant universities in the North Central region include:

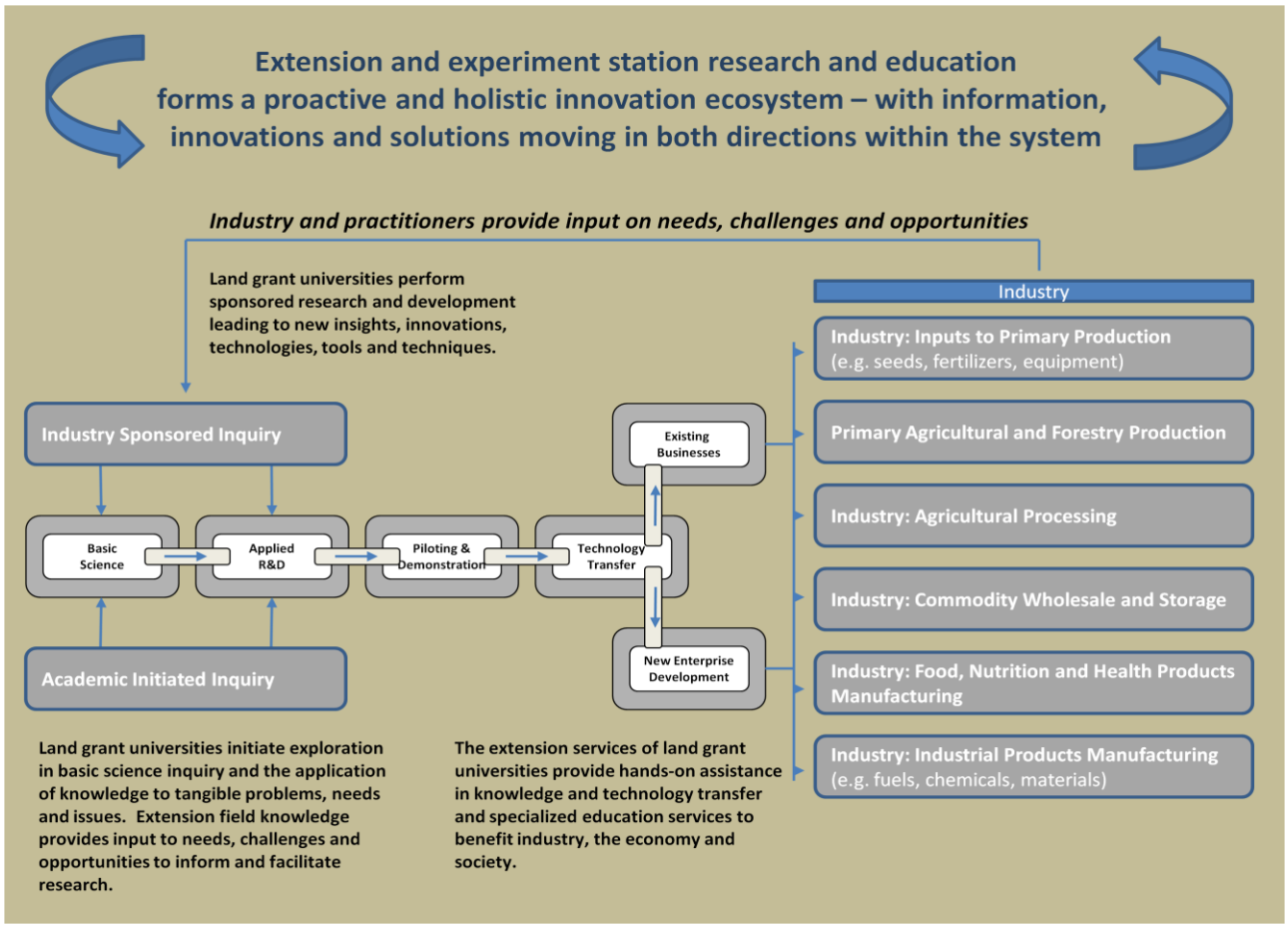
- **Iowa State University**
- **Kansas State University**
- **Michigan State University**
- **North Dakota State University**
- **The Ohio State University**
- **Purdue University**
- **South Dakota State University**
- **University of Illinois**
- **University of Minnesota**
- **University of Missouri**
- **University of Nebraska**
- **University of Wisconsin**

Providing a comprehensive and integrated system of education, research, and knowledge and advanced practice diffusion—the North Central region's land-grant universities provide the skilled human capital needed by the agbiosciences sector and they advance the basic and applied knowledge base that underpins agbioscience advancement. Unlike other academic-based disciplines, the agbiosciences at land-grant universities are deliberately leveraged for the good of agricultural producers, industry and society through the operations of a purpose-built extension system. This highly pragmatic system provides science and technology development and implementation services that keep U.S. agriculture, agribusiness and associated business sectors at the forefront of innovation, productivity and competitiveness.

Through a systematic pipeline of research and education (see Figure ES-5), comprising experiment station and extension service programs, these institutions are leading the way in agbioscience R&D, in new knowledge dissemination, and in technology transfer and commercialization of technologies for the agricultural production and processing sectors. Under this system, colleges of agriculture and their experiment stations conduct basic and

applied R&D in the agricultural and agbio industries through their laboratories, research farms and testing facilities. From basic science in molecular biology, biochemistry and genetics through to highly applied work in plant breeding, plant transgenics, agricultural engineering and biomaterials, this research work is helping to develop new crops, technologies, processes and value-added products for the American agricultural and agbio industries.

Figure ES-5: Land-grant Universities and their Experiment Stations and Extension Services – A Unique System for Agbioscience Research, Development, and Innovation Diffusion



As Figure ES-5 shows, in this land-grant innovation ecosystem research inquiries in basic and applied sciences (sponsored by federal grants, state support, foundation funding, industry sponsorship and other typically extramural sources) generate technologies, innovations and practice examples that are tested and piloted through the unique infrastructure contained in agricultural colleges, associated university departments and the experiment station system. Via licensing, new business formation, knowledge-diffusion and other technology transfer activities, the land-grants (often through the extension service) proactively move innovations, technologies and practice advancements into use within the agbioscience industry value-chain. As a result of this land-grant system new products, enhanced products, process

The proximity of the North Central Land-grant universities to distinctive clusters of plant bioscience and animal bioscience companies makes the North Central region a particularly vibrant center for realizing America's agbioscience industry opportunity.

improvements and other advancements in agbioscience knowledge and practice are transferred into commercial sectors—keeping them competitive and helping to drive U.S. economic growth.

Within the North Central region, thousands of projects are undertaken annually by the 12-university regional land-grant system and it would be impossible to illustrate the impacts of each and every one. However, the broad variety of positive impacts engendered by this system can be, in part, illustrated by referencing specific impact examples recorded by the North Central Regional Association of State Agricultural Experiment Station Directors. Figure ES-6, on the following page, classifies the many core categories of impacts generated by this unique system—illustrating the broad suite of impact categories addressed by the land-grant/experiment station/extension system.

Advances in agbioscience depend on the quality of the technology developed as well as the successful translation of that technology into commercial utilization by producers and processors. Extension Service Programs at each of the universities comprise a network of specialists (typically in each and every county) providing a wide variety of information, technical knowledge and education services for individuals and companies in the community. Extension service providers work closely with farmers, ranchers, foresters, business persons and other members of the local community to provide timely, and unbiased advice on issues like the introduction of new crop varieties and production requirements, agricultural marketing opportunities, disease and pest management tools, animal and livestock health products, agricultural equipment, irrigation technologies, and agricultural processing technologies.

The land-grant university, experiment station and extension service system is clearly a unique asset for the U.S. and represents a system of extreme relevance to the needs of a modern U.S. economy so dependent on innovation, knowledge and technological advancement to maintain its competitive edge.

Table ES-1 serves to illustrate a number of the key issues being addressed through the land-grant/experiment station/extension service system:

Figure ES-6: Examples of Impact Categories Within the North Central Region

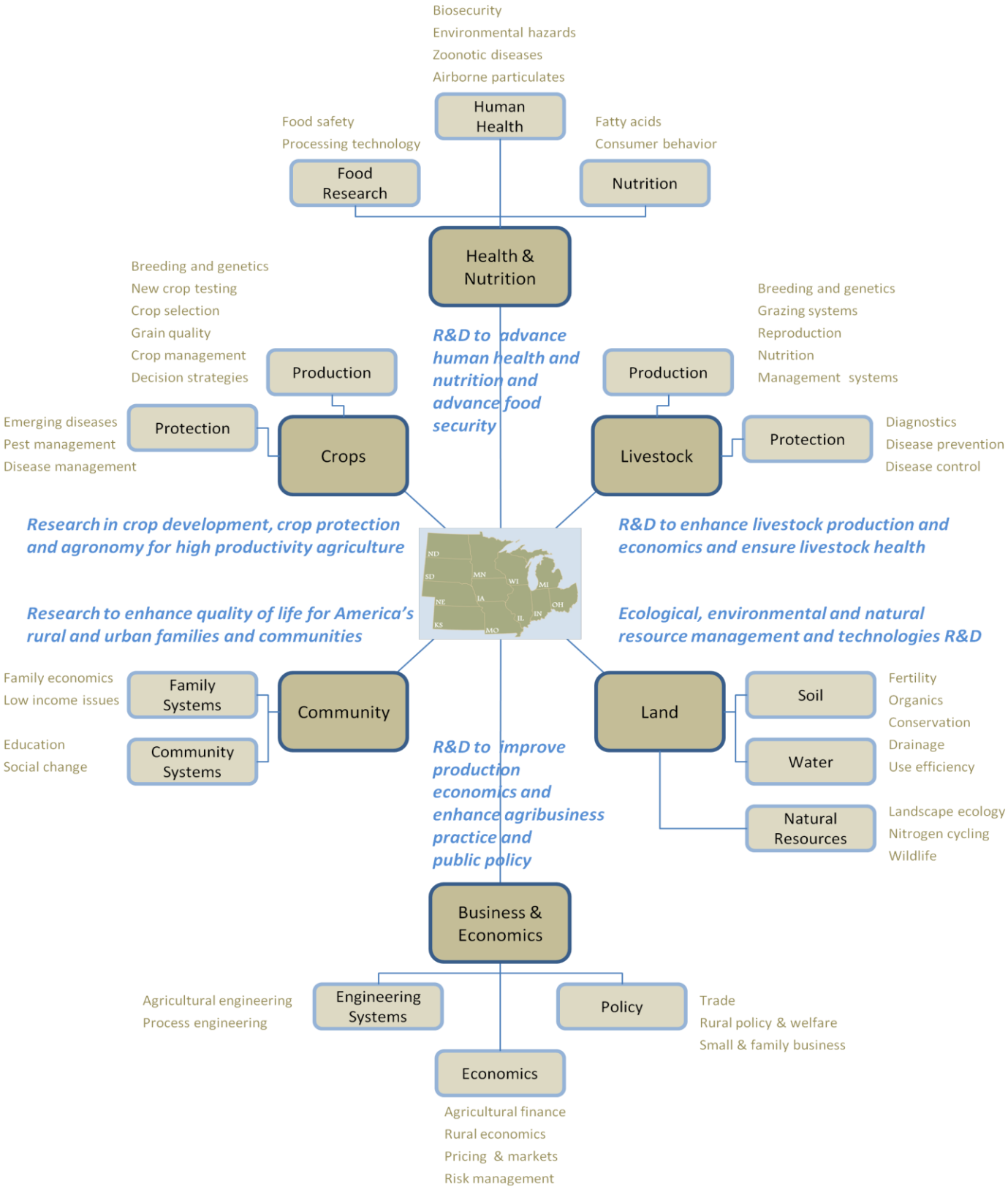


Table ES-1: Experiment Stations and Extension Services –Relevance to Major Issues and Challenges

Issues	Research Relevance	Extension Education Relevance
National economic competitiveness	Innovations to enhance agricultural and forest productivity. Innovations to enhance the productivity and competitiveness of value-adding industry. Field trials, testing and scale-up of new technologies. Facilitation of research in specific soils, climatic and agronomic zones. Specialized testing and R&D services for industry New products and technology innovations for commercialization. Business and new technology incubation services. Adding value to domestic, home-grown resources. Development of products for export.	Demonstration and field testing Education in new technologies and practices for producers. Education and technology transfer for industry. Direct consultation with producers on tools, techniques, products and markets to enhance competitiveness. Advisory services in new business development and commercialization.
Homeland security	Protecting the U.S. from plant, animal and zoonotic diseases. Specialized research infrastructure for specific crops, animals and associated threats. Reducing dependency on foreign imports and fossil fuel resources.	Widespread on the ground monitoring and observation network. Tangible, hands-on assistance and advice to producers and processors. Specific food safety and handling education.
Environmental sustainability	Innovations in production inputs use efficiency, and plant transformation to reduce agricultural inputs. Technologies for reducing waste streams and waste stream impacts, and for converting waste to value-added products e.g., energy. Production scale test sites for evaluation of environmental impacts and technologies. Demonstration facilities for environmentally sustainable practices, tools and technologies.	Widespread on the ground monitoring and observation network. Tangible, hands-on education and advice to producers and processors. Education of practitioners, community members and youth regarding environmental sustainability. Water, energy and resource conservation advisory services. Demonstration and field testing
Education, skilled human capital and workforce development	Direct education of undergraduate and graduate students. Continuing education courses. Development of new knowledge and know-how for diffusion into practice. Facilitation of regional access to expertise and development resources. Facilitation of field research in regional crops, specific agronomic zones, etc.	Knowledge and know-how diffusion. Continuing education for adult and youth audiences. K-12 programs and STEM (Science, technology, Engineering and Math) education support. 4-H educational and youth development programs. Development of web and distance learning systems and educational materials
Societal welfare	Economics research and policy analysis Policy analysis Community, urban and rural development research Education and extension operations research Research on the American family, youth development and other key social issues	4-H programs extending learning hours and reaching “at risk” youth. Tangible services in urban and rural economic development. Hands-on support and coaching for families, community groups and civic leaders. Promote public and individual health for adults, children and youth.

The North Central region's experiment stations and extension service programs provide an integrated system to research, develop, pilot, demonstrate, and disseminate new innovations to benefit practitioners and industry.

As highlighted above, the North Central region's experiment stations and extension service programs provide an integrated system to research, develop, pilot, demonstrate, and disseminate new innovations to benefit practitioners and industry. This system is providing innovative systems for improving the profitability of agricultural producers and processors, creating new businesses and new economic opportunity, protecting food sources from toxins and pathogens, and ensuring the sustainability of the environment for the next generation and beyond. Importantly, this is also a system that is well-structured to support U.S. economic development in the BioCentury—leveraging biobased resources to expand our economy and enhance economic, societal and environmental sustainability.

A System at Risk

While agriculture and agbioscience have great relevance to human health, economic and social progress, and environmental sustainability in the 21st Century, the core institutions that are supporting advancements in these fields—America's land-grant universities, colleges of agriculture, experiment stations and extension services—face considerable challenges.

Table ES-2 highlights some of the diverse challenges and issues facing experiment stations, extension services and land-grant universities, and it is evident that the challenges come from multiple quarters. Fundamentally, the importance of agbiosciences is expanding due to its relevance to global needs and challenges—BUT, this is occurring at a time of budget crises within federal, state and local funding agencies and within private industry. There is, therefore, a fundamental tension between meeting expanding needs and opportunities while attempting to operate within a budget crisis environment.

America's land-grant universities, their colleges of agriculture, experiment stations and extension services face considerable challenges.

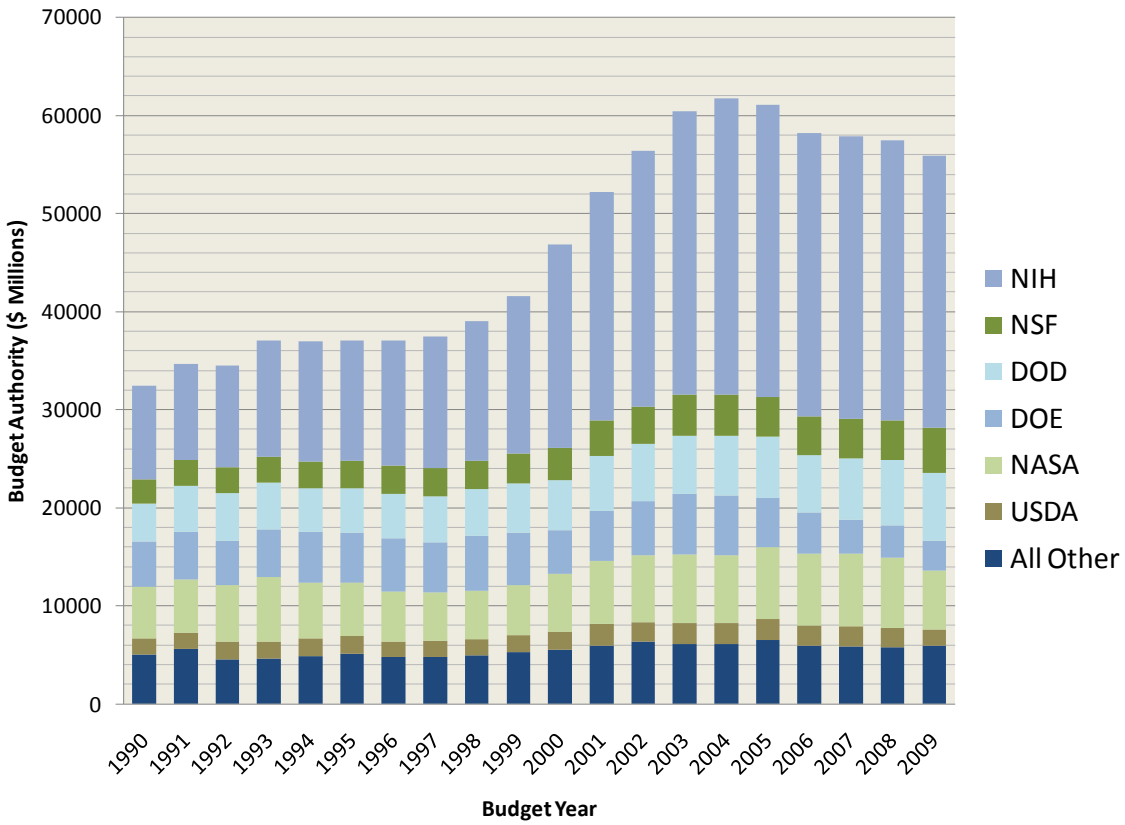
Table ES-2: Challenges to Agbioscience Institutions in the Current Environment

	Challenges and Issues
Federal	• Decline of federal formula funding. • A need to increase funding for agbioscience related R&D, via NIFA, if land-grants are to fully address the major issues and opportunities.
State	• Rising tide of state fiscal crises limiting support to state universities, experiment stations and extension. • Fiscal problems for U.S. counties limiting traditional local support for extension.
General Public	• Lack of communications regarding the growing importance of agriculture and agbioscience to global issues and development opportunities. • Need for those benefiting from programs to voice their impact and appreciation with key decision makers. • Need to communicate the "public value" of programs • Need to better connect the message of *agriculture = food = nutrition = health*

Perhaps chief among the challenges faced is an uncertain funding environment for agbioscience R&D and associated extension activities. While funding for the USDA and NIFA has been relatively steady, cuts are proposed in forthcoming budgets: cuts that will ripple through a system that leverages federal funding with state and local matching financial support.

As discussed in this report, agbiosciences are critically important to tackling many of the most pressing issues facing the nation and globe—yet, as a collective suite of disciplines, agbiosciences receive comparatively low levels of funding attention in the national R&D funding scheme. Figure ES-7 illustrates this funding situation, showing the level of funding provided via USDA versus other agencies. Ideally, recognition of the large-scale market opportunities in the agbioscience space should spur increased investment in NIFA because without such expanded investment it will be difficult to sustain U.S. R&D leadership in the sector, realize economic development gains from the development of R&D based agbioscience innovations to meet growing market needs, and reap the strategic benefits of a sustainable domestic biobased economy.

Figure ES-7: Federal Funding by Major Agency – 1990 through 2009 (in 2008 constant dollars)
(Source: American Association for the Advancement of Science - http://www.aaas.org/spp/rd/guihist.htm)



Not Just a Federal Issue

Constrained NIFA research funding represents an issue, but it is not the only financial challenge facing experiment stations and extension services. Extension is funded by the USDA at the federal level, with federal funding matched and highly leveraged by state and local (county) partners. Current budgetary challenges are impacting each of these three legs of the funding stool (noted by land-grant college of agriculture deans to be a "perfect storm")

There is a fundamental tension between meeting expanding needs and opportunities while attempting to operate within a budget crisis environment.

In addition, general budget crises in many states are leading state governors and legislatures to consider substantial cuts to funding of what they see as "discretionary programs" such as agricultural research and extension (even though these are actually core drivers of future economic growth potential).

The risk of not having agbioscience as a priority for the nation and states is potentially an erosion of financial support for land-grants, experiment stations and extension and, therefore, a reduction in our ability to compete effectively in global agriculture and agbioscience. The federal government and individual states are clearly in an era of budget crises and many programs appear to be at risk for funding cut-backs. Work performed by land-grant institutions in agbioscience though can provide a high return for funders -- giving back to

government more than is put-in. Independent research performed by Battelle in Nebraska and in Oklahoma found that the land-grant agbioscience complex in these states generated between a 15 to 1 and 25 to 1 return on investment for state resources[3].

Standing Still is Not an Option

The United States is not alone in the pursuit of frontier science as a driver of economic and societal development. Traditional competitors in Europe are being joined by fast developing economies such as India, China and Korea that see the benefits of investing in scientific research and applied development projects—including agbioscience projects.

At stake is leadership in the areas of science and technology development, and technical education, most relevant to key global challenges—and, therefore, most likely to generate high demand and economic opportunities.

The National Academies[4] has sounded warning bells regarding U.S. funding for science and the preparedness of our education system to sustain a leadership position. With funding challenges coming across multiple fronts we have a system at risk—a system in which the U.S. currently has a leading position and tremendous potential opportunities, but one that can be rapidly eroded by foreign competitors if the U.S. fails to support the system and its key institutions.

In Conclusion

Agbiosciences represent an opportunity for the United States—an opportunity to expand on U.S. leadership in a biobased, sustainable resource-driven economy with wide ranging innovation and technology-based development opportunities. Within the U.S. the North Central region is a clear leader in agbiosciences and production within the agricultural value-chain, a position that is supported by the R&D and education activities of agricultural experiment stations, extension systems and their twelve land-grant universities. These institutions should be considered priorities for further strategic investment and development given their importance in realizing the intrinsic growth potential of agbiosciences for the U.S. and regional economies.

[3] Battelle Technology Partnership Practice research reports:
"*The Oklahoma State University Division of Agricultural Sciences and Natural Resources Agbiosciences Activities Deliver Positive Economic Benefits for Oklahoma*". March 2007
"*The University of Nebraska Institute of Agriculture and Natural Resources: A Generator of Positive Economic Impacts for Nebraska*". February 2007.

[4] National Academies. July 2008. *"Rising Above the Gathering Storm, Revisited: Rapidly Approaching a Category Five."* National Academies Press.

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I. Agriculture and Agbiosciences – Of Central Importance in Meeting Expanding Global Needs

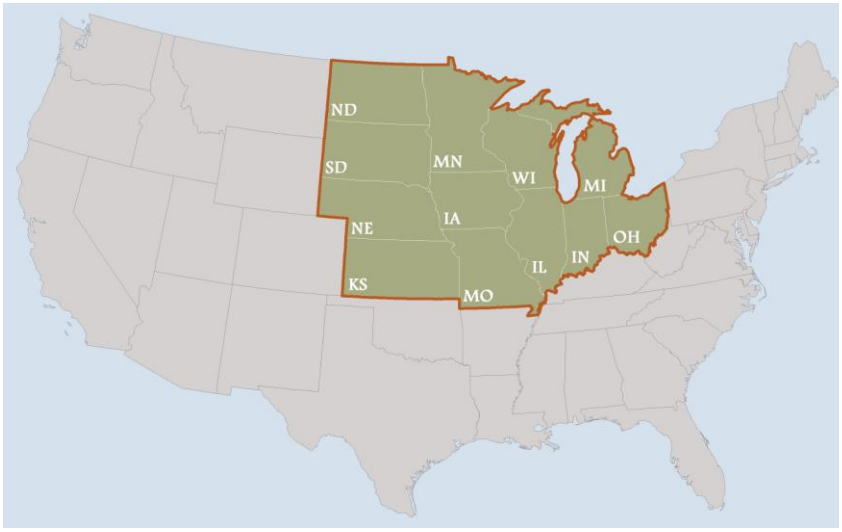
A. Introduction

This report addresses the importance of agriculture and agbioscience and their relevance to finding solutions to key challenges facing the U.S. and the world—*economic growth*, *food security*, *human health*, and *environmental sustainability*. Within agbioscience the U.S. is a global R&D and production leader. The U.S. is at the forefront in innovating and leveraging advanced technologies and bioscience knowledge advancements to enhance productivity and sustainability in food production and to create expanding economic opportunities in new advanced biobased products for fuels, chemicals, materials, healthcare products and a broad range of additional applications.

Within the United States, the twelve-state North Central region (Figure 1) is a leading agricultural powerhouse. Home to intensive agricultural productivity and many of the largest and most innovative companies in agbioscience and biobased development, the North Central region represents a concentrated and vertically integrated agricultural economic engine for the nation. In the North Central region new and advanced inputs to agriculture are developed, production technologies innovated and advanced, and new applications for agricultural and forest biomass developed for use as fuels, industrial feedstocks, health products and other key value added uses.

Home to intensive agricultural productivity and many of the largest and most innovative companies in agbioscience and biobased development, the North Central region represents a concentrated and vertically integrated agricultural economic engine for the nation.

Figure 1: The 12-State North Central Region



Of central importance to progress in North Central regional agbiosciences are the presence and operations of land-grant universities, their experiment stations and extension services. These

institutions undertake the fundamental and applied research leading to innovation in agbioscience. These institutions provide the testing, piloting and scale-up infrastructure and expertise to propel new innovations and technologies to market reality. These institutions provide support services in R&D, process improvement and the development of solutions to problems for industry. These institutions translate new knowledge, techniques and tools into the field through the translational activities of extension. And, these institutions educate the scientists, engineers, extension educators and other skilled human capital required to sustain U.S. and North Central global leadership in agbiosciences.

Land-grant universities, experiment stations and extension services are on the frontline of sustaining and securing America's leadership and competitiveness in what is and will be the key macroeconomic sector of our time.

In the "BioCentury" that is the 21st Century, land-grant universities, experiment stations and extension services are on the frontline of sustaining and securing America's leadership and competitiveness in what is and will be the key macroeconomic sector of our time. As this report shows, sustaining these institutions, further investing in them, and addressing their challenges is of central importance to a sustainable economic future for the United States.

B. At the Forefront of Meeting Key Global Challenges

Many of the greatest and most pressing challenges facing humankind have their solutions rooted in modern agriculture and agbioscience. 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.

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.

In the past, agriculture formed the foundation of human civilization. Providing the means to forgo a nomadic hunter gatherer existence, agriculture allowed our early ancestors to build stable communities, while improvements in agricultural productivity moved us from subsistence agriculture, to a position whereby farmers generated a surplus of food for sale in the market—freeing others to specialize in trades and forming the foundation for commercial economies. Agriculture thus made civilization possible and, as this document finds, once again agriculture has come to the fore as a central platform for human economic and social progress.

Today, most of us are distanced from the source of products used and consumed in our daily lives. We do not know, and often do not care, where our food comes from, where the lumber to build our homes originated, nor the source of the fibers in our clothes and furnishings. We don't know if the fuels we consume, the plastics we use, the paints we apply are petroleum or bio-based, nor the original source of their inputs.

Contemporary societies and economies are built on trade—a highly complex web of continuous activities, transactions and

interrelationships that we tend to take for granted. Agriculture has traditionally been a "basic" industry within this trading system, providing foodstuffs and natural resources that feed into a chain of further processing and value-added activity.

Today, however, the picture is more complex and vibrant. Modern agbioscience and associated biotechnologies are highly dynamic, providing new feedstocks and pathways to a host of novel and high-value materials, products and technologies. Biofuels, biobased chemicals and materials, plant and animal derived drugs and therapeutic products, advanced nutrition products and other emerging agbioscience product categories are opening up new horizons of opportunity and economic promise. Some have termed the 21st Century the "BioCentury," and against this background of bio-based opportunity, agriculture has emerged once again as a robust platform for economic growth and solutions to broad-ranging human needs.

To meet the rising demand for food (driven both by rising population and increasing income levels) it is anticipated that by 2030 we may actually need to double global food production, yet most cultivatable land is already in production.

On a global scale humankind's needs and challenges are daunting. Worldwide population is projected to increase from 7 billion in 2010 to 9.3 billion by 2030[5] (an increase of 2.3 billion, equivalent to doubling the entire current populations of China and India). To meet the rising demand for food (driven both by rising population and increasing income levels) it is anticipated that by 2030 we may actually need to double global food production,[6] yet most cultivatable land is already in production.[7] The inequity of global income levels and access to food across the planet already leads to debilitating levels of malnutrition, undernutrition and associated poor health for over 1 billion people.[8] Meeting the demands of a growing population, for more and better food, and the demand for the fiber, fuels and materials required as inputs for economic growth, is made all the more difficult by the pressing need to do so while reducing environmental impacts and global climate change associated with human economic activity.

Against this background of global need and challenges, of threats and opportunities, it becomes clear that the role of agriculture, and associated agbioscience advancements, has come once more to the fore as a critical driver of humankind's future (Figure 2).

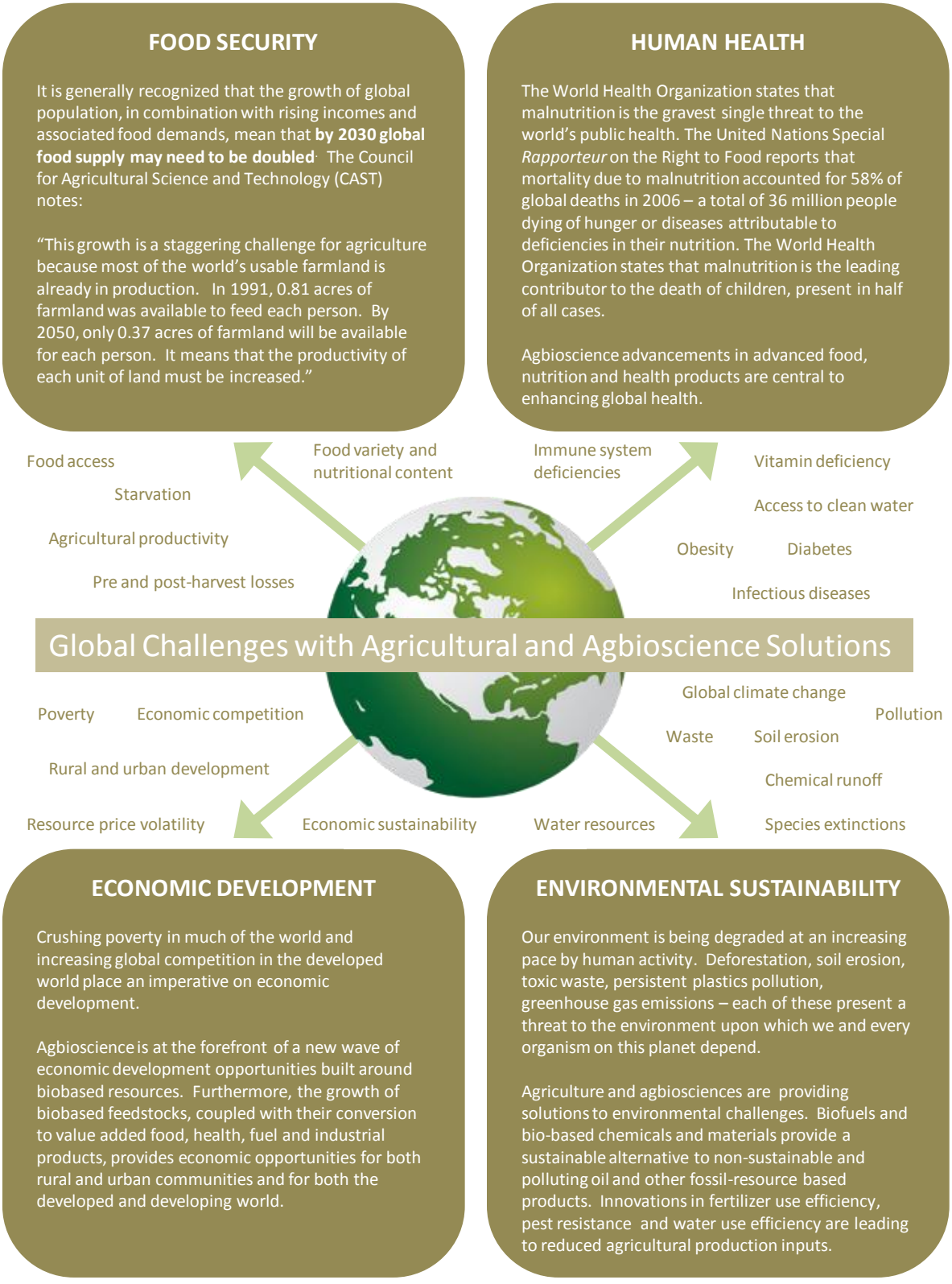
[5] University of North Carolina. Ibiblio.org services. Accessed online at *www.ibiblio.org/lunarbin/worldpop*

[6] Bruce M. Chassey, Wayne A. Parrott and Richard Roush. "Crop Biotechnology and the Future of Food: A Scientific Assessment." CAST Commentary, QTA 2005-2, October 2005.

[7] United Nations Food and Agriculture Organization (FAO). "World Agriculture Towards 2015/2030, Summary Report." Accessed online at *www.fao.org/documents/show_cdr?url_file/DOCREP*

[8] United Nations Food and Agriculture Organization (FAO). "The State of Food Insecurity in the World." Accessed online at *www.fao.org/publications/sofi/en/*

Figure 2: Global Challenges with Agricultural and Agbioscience Solutions



The importance and relevance of agriculture and agbiosciences to central challenges facing states, the nation and the globe are further documented in a recent report entitled "*A Science Roadmap for Food and Agriculture*" which highlights the direct impact of land-grant institutions on seven identified "grand challenges":[9]

- *Enhancing the sustainability, competitiveness, and profitability of U.S. food and agricultural systems*
- *Adapting to and mitigating the impacts of climate change on food, feed, fiber, and fuel systems in the United States*
- *Supporting the energy security and the development of the bioeconomy from renewable natural resources in the Unites States*
- *Playing a global leadership role to ensure a safe, secure, and abundant food supply for the United States and the world*
- *Improving human health, nutrition, and wellness of the U.S. population*
- *Heightening environmental stewardship through the development of sustainable management practices*
- *Strengthening individual, family, and community development and resilience.*

This is further reinforced in the six key strategic goals expressed extension nationally in the Cooperative State Research, Education, and Extension Service Strategic Plan for 2007-2012:[10]

- *Enhance International Competitiveness of American Agriculture*
- *Enhance the Competitiveness and Sustainability of Rural and Farm Economies*
- *Support Increased Economic Opportunities and Improved Quality of Life in Rural America*
- *Enhance Protection and Safety of the Nation's Agriculture and Food Supply*
- *Improve the Nation's Nutrition and Health*
- *Protect and Enhance the Nation's Natural Resource Base and Environment*

Battelle's work with multiple land-grant institutions and leading-edge work in strategic planning and economic analysis services focused on agbiosciences lead us to concur with the relevance of modern agriculture and agbiosciences to these grand challenges. Agbiosciences

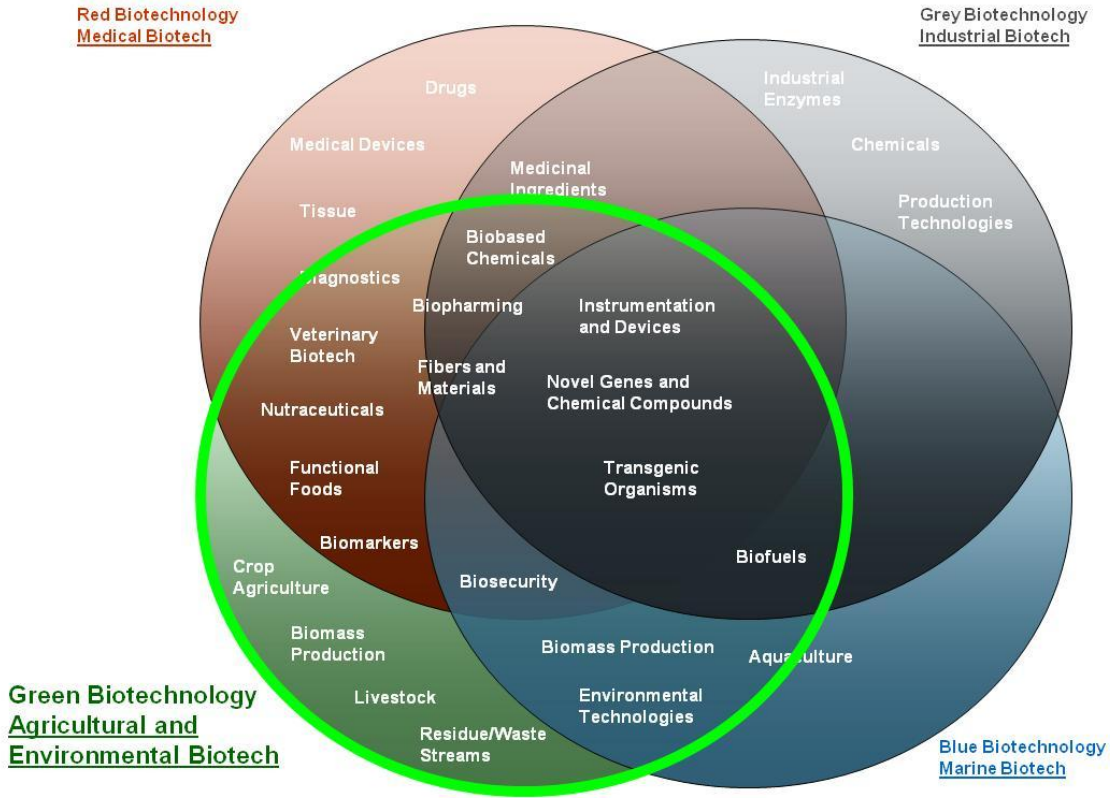
[9] Association of Public and Land-grant Universities, Experiment Station Committee on Organization and Policy – Science and Technology Committee, "A Science Roadmap for Food and Agriculture." November 2010.
[10] United States Department of Agriculture. "Cooperative State Research, Education, and Extension Service - Strategic Plan for 2007-2012." February 2007.

represent a unique field of science and applied R&D generating widespread innovations, technologies and solutions to needs.

Agbioscience practitioners, the research community sustaining America's leadership in agbioscience innovation, and the extension professionals translating advancements into the field, have a preeminent role to play in supporting a sustainable global future—economically, socially and environmentally.

It must be noted that agricultural and environmental biosciences do not stand separate from other fields of bioscience inquiry. Indeed, much of modern science is interdisciplinary and there is considerable overlap in the application of inquiry in one field (such as agbioscience) and another (such as human biomedical science). This is illustrated on Figure 3 which shows the intersections and general content areas of key bioscience/biotechnology arenas. Agbioscience stands as a key pillar and contributor to scientific and technological advancement in agricultural and environmental applications, but also contributes to advancements in biomedical, industrial and marine biotechnology:

Figure 3: Agbioscience and Key Biotechnology Intersections in the 21st Century Bioeconomy

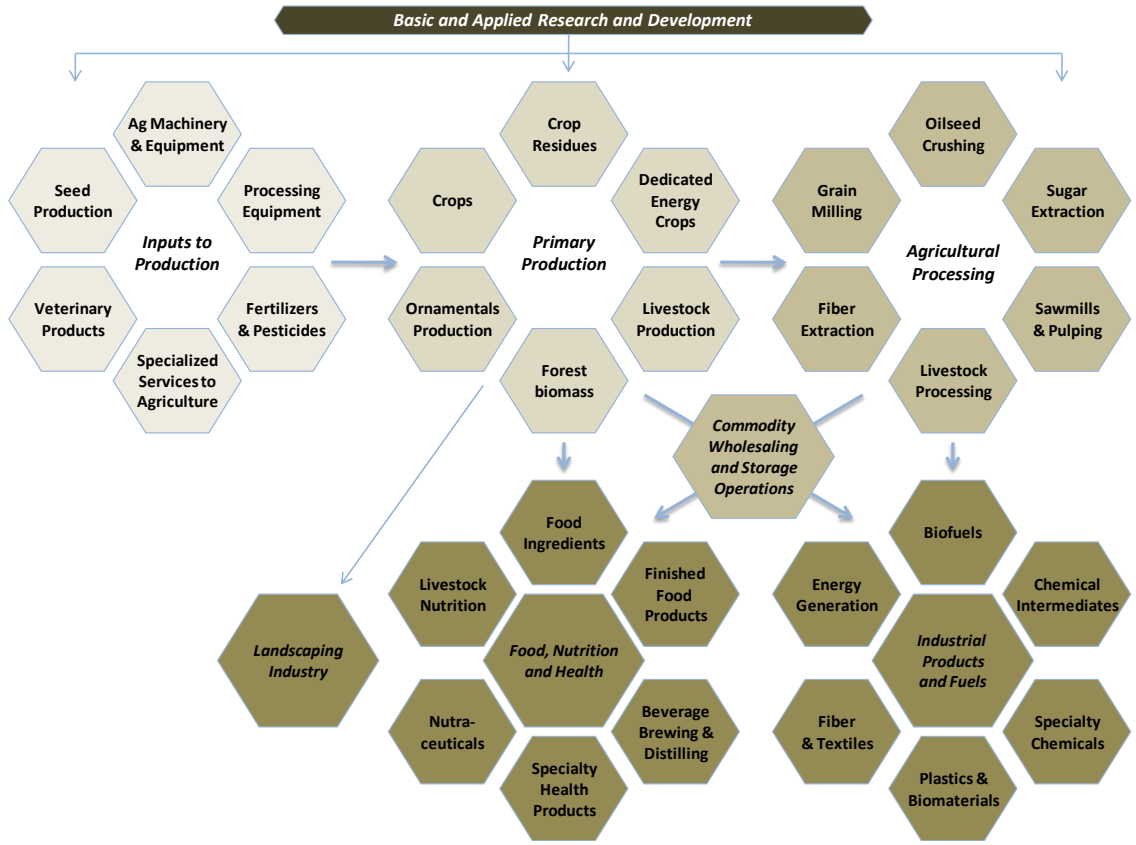


Agbiosciences embrace a broad continuum of activity in the development, production and use of plant and animal biological organisms for food, health, fuel and industrial applications.

C. Agbiosciences Defined

What is encompassed by the term "agbiosciences"? Well, agbiosciences can be viewed as embracing a broad continuum of activity in the development, production and use of plant and animal biological organisms for food, health, fuel and industrial applications. As used in this report, it is a holistic term encompassing a complex chain of activity from scientific inquiry and associated R&D through to the tangible production of inputs for agricultural production, primary agricultural and forestry production, and the downstream processing of agriculture and forest outputs into useful technologies and products. Figure 4 illustrates this holistic view of the integrated agbioscience system.

Figure 4: The Agbioscience Economy – From R&D through Inputs, Production, Processing and Applications



In the R&D sector agbiosciences embrace scientific, engineering and technological research in a range of fields from fundamental basic inquiry through applied science and commercializable technology development. The fields engaged in agbioscience are broad, including such fields of inquiry as: biology; biochemistry; genomics; plant sciences; animal sciences; plant pathology; entomology; veterinary sciences; horticulture and crop science; agronomy; forestry; agricultural

It is America's land-grant universities that uniquely engage across the full-spectrum of agbioscience—from the most basic scientific enquiry through to the practical services in support of producers, manufacturers and society provided via extension services.

and biological engineering; environmental sciences and natural resource management; food science; chemical engineering; materials science, and applied work in agricultural economics, community development , business management, finance and operations.

R&D in these fields occurs within the nation's universities (especially land-grant universities), and also within non-profit institutes, federal laboratories (such as USDA and DoE labs) and private industry. It is, however, America's land-grant universities that 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.

II. Agriculture and Agbioscience in the United States

Within global agbioscience and agriculture it is generally acknowledged that the U.S. is the worldwide leader.

Within global agbioscience and agriculture it is generally acknowledged that the U.S. is the worldwide leader. Statistics bear this out. Comprising just 6.1% of global land area, the United States in 2009/10 produced, for example, 18.7% of the world's grains, 22.4% of global oilseeds and 12% of worldwide cotton[11]. In livestock, the U.S. is the worldwide leader in beef and poultry production (with 20.8% and 23.2% of global production respectively, and produces 10.8% of the world's pork). [12]

As a result of this productivity, agriculture is a critically important part of the U.S. economy. In 2007 there were over 2.2 million farms in the United States using 922 million acres (about 40%) of the country's total land area for crops, forests and pastureland. These farms contributed over $325 billion to the American economy, including $96 billion in exports.[13]

Agriculture's contribution to the American economy, and society, does not end at the farm gate though. Continuous innovations in modern agbioscience have broadened opportunities for the production of agricultural commodities to help address some of the most important issues of our time: issues such as rapidly growing population, global poverty and malnutrition, climate change and environmental degradation.

Developments in agbioscience are also creating new markets for crops and crop residues as renewable, bio-based feedstocks for a number of key industries, including clean energy, chemicals, plastics and health products.

At the same time developments in agbioscience are also creating new markets for crops and crop residues as renewable, bio-based feedstocks for a number of key industries, including clean energy, chemicals, plastics and health products. New technologies, like those in biofuels, crop science and bio-processing, can prevent pollution, reduce costs, and conserve water and energy, while delivering valuable products to improve the quality of life not only for Americans but for people around the world. So, while the U.S. is currently the global leader in agbioscience and agricultural productivity, it is not resting on its laurels. Rather, U.S. institutions are taking a preeminent role in advancing scientific inquiry, developing new innovations, and commercializing new technologies to meet the challenges and opportunities of the

[11] USDA Office of Global Analysis. Foreign Agricultural Service. October 2010.
[12] U.S. Census Bureau. Online at http://www.census.gov/compendia/statab/2010/tables/10s1338.pdf
[13] U.S. Department of Agriculture – Economic Research Service. 'Farm Characteristics' & 'Farm Financial Indicators'. http://www.ers.usda.gov/statefacts/us.htm.

Note: The 'Other' category in *Top 5 – Agriculture Exports* includes wine, essential oils, sugar and tropical products, nursery & greenhouse products, beverages except juice, coffee, tea, cocoa, oilseeds (mostly rapeseed and safflower seed) meals and their oils, vegetable waxes, protein substances, chocolate, spices, rubber, fibers other than cotton, and horticultural products such as starches, soy sauce, condiments, soups, gelatins, yeast, baking powder, food preparations, vinegar and hops.

BioCentury. The U.S. is, for example, at the forefront of applying the tools and technologies of biotechnology and genomics in developing new and improved crops for global markets and is applying its technological expertise in the development of new processes for the utilization of biomass for energy and industrial applications. U.S. research and extension education is likewise pioneering the development and application of advanced food products with enhanced functional characteristics and nutraceutical applications. As the BioCentury continues to unfold, it is fair to expect that agbiosciences will represent a key national opportunity for economic expansion.

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Farmland (1000s of acres)	**United States**
Farmland	922,096
Cropland	406,425
Woodland	75,099
Pastureland	408,832
Total Land Area	**2,260,994**
Farms	
Number of Farms	**2,204,950**
Agriculture Output ($1,000s)	
Crops	151,107,498
Animals	138,592,007
Services and Forestry	37,063,790
Total Ag Output	**326,763,295**
Top 5 and Total Agriculture Commodities ($1000s)	
Cattle and Calves	43,776,568
Corn	42,035,337
Soybeans	30,056,466
Dairy products	24,342,440
Broilers	21,812,789
Total Ag Commodities	**283,406,168**
Top 5 Agriculture Exports ($ millions)	
Soybeans and products	17,708.8
Other (see source)	12,432.5
Feed grains and products	11,978.7
Live animals and meat	8,906.6
Wheat and products	8,598.2
Total Ag Exports	**96,632.0**
Source: 2007 data from USDA-ERS http://www.ers.usda.gov/statefacts/us.htm	

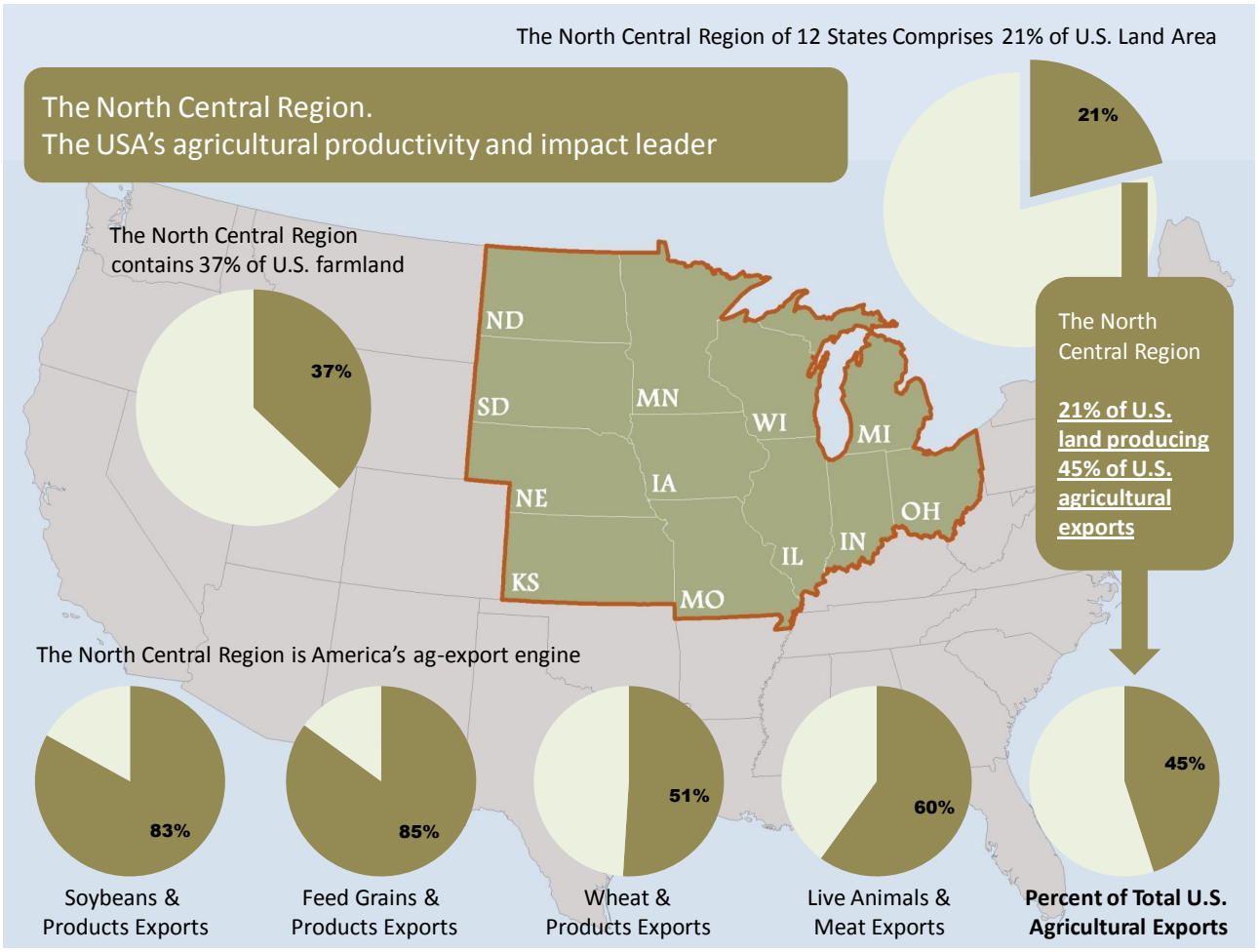
III. The Twelve-State North Central Region, a U.S. Agricultural and Agbioscience Powerhouse

A. The North Central Region: At the Forefront of U.S. Agbioscience and Agricultural Production

The North Central states comprise only 21% of U.S. land area, but together account for fully 44% of all US agricultural commodities and 45% of U.S. agricultural exports.

As noted above, the United States stands as the global leader in agricultural production, and within the U.S. the North Central region, comprising 12 Midwest states, is the leading agricultural and agbioscience region. The North Central states (as illustrated in Figure 5) comprise only 21% of U.S. land area, but together account for fully 44% of all US agricultural commodities and 45% of U.S. agricultural exports. In multiple major commodity categories, the region is highly important and productive—responsible for 83% of U.S. soybean exports, 85% of feed grain exports, 60% of live animal and meat exports and 51% of wheat exports.

Figure 5: The North Central Region – The U.S. Leader in Agricultural Production



Farmland (1000s of acres)	North Central Region	Percent of U.S.
Farmland	342,587	37%
Cropland	226,171	56%
Woodland	17,205	23%
Pastureland	86,166	21%
Total Land Area	**480,218**	**21%**
Farms		
Number of Farms	**806,300**	**37%**
Agriculture Output ($1,000s)		
Crops	67,732,260	45%
Animals	53,742,944	39%
Services and Forestry	13,154,651	35%
Total Ag Output	**134,629,855**	**41%**
Top and Total Agriculture Commodities ($1000s)		
Cattle and Calves	20,130,804	46%
Corn	36,661,158	87%
Soybeans	24,878,810	83%
Dairy products	6,706,927	28%
Total Ag Commodities	**125,968,737**	**44%**
Eggs (units thousands)	42,379	47%
Top 5 Agriculture Exports ($ millions)		
Soybeans and products	14,638	83%
Other (see source)	1,515	12%
Feed grains and products	10,191	85%
Live animals and meat	5,371	60%
Wheat and products	4,404	51%
Total Ag Exports	**43,111**	**45%**
Source: 2007 data from USDA-ERS http://www.ers.usda.gov/statefacts/us.htm		

The North Central region includes: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Together these states have 226 million acres in cropland, 86 million acres of pastureland, and 17 million acres of woodland. The approximately 800,000 farms in this region account for over 80% of the nation's corn and soybeans, as well as most of the country's wheat, sunflower, canola and sorghum production.[14] In fact, these twelve North Central states lead the nation in the production of the top three agricultural commodities, producing 46% of the nation's cattle and calves, 87% of corn, and 83% of soybeans.

The North Central region's exceptional level of agricultural output and productivity, together with the discovery and application of new technologies in agbioscience, has fueled the development of the agricultural processing and value-added products manufacturing industries in the region. Processing facilities add value to farm products before they leave each state; they also generate substantial local economic impact through direct expenditures and job creation. Additionally, facilities that are farmer-owned provide opportunities for producers to capture greater profits from processing and marketing their own value-added products.

Farms form part of a value-chain of agricultural production and agri-business. **In 2009, in addition to the 800,000+ farms in the region, the North Central states contained more than 88,000 companies participating in the value-added chain through the provision of products and services such as:**

- The manufacturing and supply of agricultural, inputs such as seed, fertilizer, insecticides, farm equipment, etc.
- Agriculture and forestry processing services such as grain milling, oilseed crushing, and lumber milling.

[14] 2007 Census of Agriculture.

- The value-added manufacturing of food, nutrition and health products.
- The production of industrial products from biomass including fuels, chemicals, materials, paper and textiles.

Taken together these farms and industries employed almost 2.4 million people (approximately 10% of private sector employment in the region). Demonstrating the intensity of the agbioscience economy across these twelve states, the concentration of agbioscience employment in the region is fully 25% greater than the national average (a location quotient of 1.25). **As a result of this concentration, and the often skilled nature of the occupations generated, these workers were paid, on average, $2,600 more annually than their counterparts in the overall private sector (a 6% wage premium)**.[15]

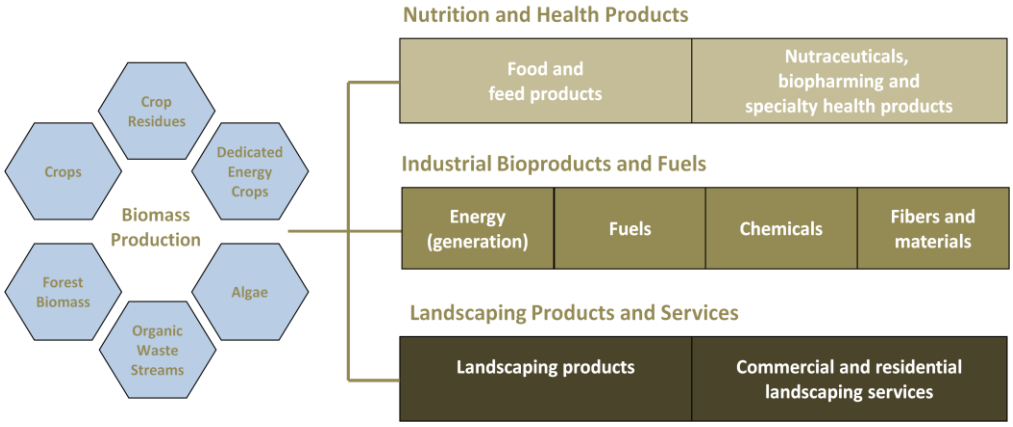
This is a cluster of current importance to the U.S. economy, but moreover represents a core strength for the nation to build upon as significant BioCentury opportunities continue to develop.

It is clear that the industries involved in the value-added agriculture and agribusiness chain, together with the thousands of agbioscience scientists and researchers (within regional higher education institutions, government labs and industry labs) and extension educators make up a specialized agbioscience industrial cluster in the North Central region. This is a cluster of current importance to the U.S. economy, but moreover represents a core strength for the nation to build upon as significant BioCentury opportunities continue to develop.

B. The North Central Region – Leading the Way in the New Biobased Economy

Agbioscience is driving innovation and economic development along multiple broad pathways of opportunity. As shown in Figure 6, biological (or "biomass") resources are the feedstocks for a broad range of value-added products and services in nutrition and health, industrial products and the cleantech industry.

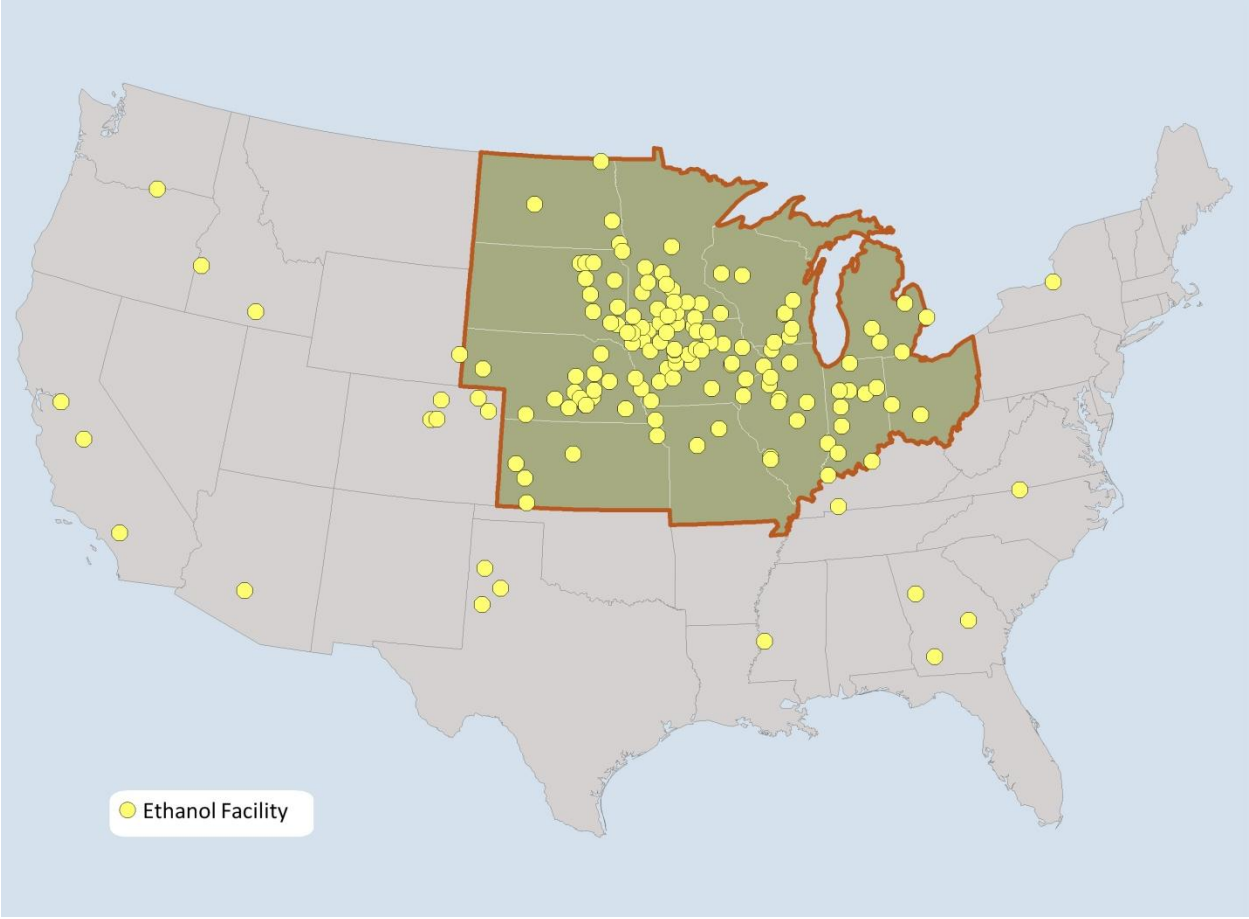
Figure 6: Principal Agbioscience-Based Development Categories



[15] Based on Battelle analysis of U.S. Bureau of Labor Statistics; QCEW data from IMPLAN; unincorporated farm employment from U.S. Bureau of Economic Analysis

As the new biobased economy emerges, the North Central region is proving to be the home of intensive innovation, an early adopter of new technologies, and the "go-to" location for economic activity in a new cleantech economy. A clear example of this leadership in the emerging biobased economy can be seen in the geographic clustering of biofuels enterprise within the North Central states. This is specifically illustrated in Figure 7 which plots the location of biofuel (in this case "ethanol") production facilities in the United States—clearly showing that the North Central region has emerged at the forefront of this renewable fuels industry.

Figure 7: Clustering of Renewable Biofuels Operations Evident in the North Central Region. Ethanol Manufacturing Facilities in the United States



At the time of this report writing, **within the United States there are 201 ethanol facilities in operation, producing 13.5 billion gallons of ethanol. The North Central region is home to 171 of these facilities, which are producing about 12 billion gallons of ethanol a year (fully**

89% of the U.S. total).[16] Importantly, based on regional agronomic conditions and infrastructure in the region, the North Central states have potential for expanding current production, not only of first generation corn ethanol, but also into second generation advanced biofuels including cellulosics.

According to the *EISA Renewable Fuels Standard* at least 16 billion gallons of the mandated advanced biofuels will come from cellulosic biofuels—i.e., biofuels produced from wood, grasses, and other non-edible parts of plants. Biomass feedstock supplies for cellulosic ethanol facilities will come from dedicated energy crops, like switchgrass and miscanthus, as well as the biomass of trees, and unneeded agricultural and forestry matter (commonly referred to as "residue"). A study by the National Renewable Energy Laboratory (NREL) analyzing feedstock availability found that the North Central states accounted for about 200 million tons (60 %) of the total biomass available in the U.S. If production capacity were developed proportionately to biomass availability, 60% of the 16 billion gallons of advanced cellulosic biofuels—or 9.6 billion gallons of capacity—could be generated in the North Central region. [17]

A multi-billion gallon cellulosic ethanol industry in the North Central states will offer new jobs to support rural communities and farm households and provide an economic stimulus for many agriculturally dependent areas. It is estimated that a 9.6 billion gallons per year industry would generate 192 production plants (at a typical 50 million gallons per year capacity per plant). The total initial investment for these plants would be almost $34 billion ($178 million per plant), and their annual direct expenditures benefiting local and regional economies would total nearly $10 billion. A production industry on this scale would directly employ nearly 15,000 workers (77 employees per plant), as well as support thousands of additional jobs in feedstock harvest and transportation. Additionally, feedstock payments could represent a substantial income supplement for agricultural producers (with feedstock estimated to account for nearly half of a plant's annual operating expenditures).[18]

[16] U.S. Department of Agriculture. 'USDA Biofuels Strategic Production Report – A USDA Roadmap to Meeting the Biofuels Goals of the Renewable Fuels Standard by 2022'. June 23, 2010.

[17] Milbrandt, A. 2005. A Geographic Perspective on the Current Biomass Resource Availability in the United States. Golden, CO: National Renewable Energy Laboratory, Technical Report TP-560-39181.

[18] Hodur, Nancy and Leistritz, Larry. Agricultural Marketing Resource Center. 'Renewable Energy Newsletter.' February 2009. http://www.agmrc.org/renewable_energy/biofuelsbiorefining_general/economic_impacts_of_biofuel_development.cfm.

The renewable fuels sector, however, represents just one part of a multi-faceted emerging bioeconomy for the North Central region. The significant chemicals, polymers and materials industry in the region is proactively investigating the use of biobased feedstocks as substitutes for current environmentally unfriendly and price volatile fossil-resource based feedstocks (primarily petroleum). Similarly food and health product manufacturers in the region are on the frontier of developing and manufacturing advanced foods, functional foods, nutraceutical products and other health enhancing agriculture-based products.

C. The North Central Region Agbioscience Innovation Ecosystem

Underpinning the region's leadership in agriculture and agri-business, and its promise for the future, is an intensive cluster of institutions, organizations and businesses engaged in agbiosciences research and associated R&D activities. These are further supported by a comprehensive extension education system. Taken together, North Central regional assets in agricultural inputs development, agricultural production, ag-processing, ag-equipment development, and downstream value-added food, fiber and industrial products manufacturing comprise an "agbioscience innovation ecosystem"—an environment in which agbioscience business development is thriving.

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The North Central's academic agbioscience community is performing well. In 2009, colleges and universities in the North Central region attracted $3.6 billion in funding for academic R&D in agbiosciences and related disciplines (about 22.5%of the national total). Likewise, the region is also a hub of major agbioscience-based industry multinationals that are active in R&D and technological innovation, for example:

- **Ten of the top 25 U.S. food manufacturers have their HQ operations in the North Central region** (Kraft, Anheuser-Busch, General Mills, ConAgra, Kellogg, Sara Lee, Hormel, Cargill, SABMiller and Chiquita Brands).
- **Two of the top five seed companies in the World are based in the North Central U.S. region** (Monsanto and Land O'Lakes).
- **Two of the world's preeminent agricultural equipment manufacturers are based in the region** (John Deere in Illinios, the World's largest, and #2 ranked Case New Holland's North American HQ in Illinois).
- **The North Central region is the hub for the U.S. animal health products industry**, with operations of leading companies such as Fort Dodge Animal Health (Kansas), Abbott Animal Health (Illinois),

Boehringer Ingelheim Vetmedica (Missouri), Novartis Animal Health (Iowa) and Pfizer Animal Genetics (Michigan).

Taken together this uniquely active system of agricultural production and advanced value-added manufacturing makes the North Central region the global leader in both traditional agricultural economic activity and in the leading emerging areas of the modern bioeconomy.

IV. A Powerful Support System – North Central Region Experiment Stations, Extension Services and their Land-grant Universities

The North Central region's leadership in agricultural production, agricultural processing and value-added manufacturing is advanced and supported by continuous innovation in agricultural and biological sciences, and within associated disciplines (such as engineering). **Helping to drive scientific discovery, innovation and the deployment of new technologies and innovations to enhance industry productivity is a uniquely American system developed by visionaries in the late 1800's—the Land-grant University.** "Land-grant University" is the term used to identify a public university in each state that was originally established as a land-grant college of agriculture pursuant to the Morrill Act of 1862. In most states (including all of the North Central states) the original agricultural colleges grew over time into full-fledged comprehensive public universities by adding other colleges (e.g., arts and sciences, medicine, law, etc.). Today these universities stand among the world's premier research and extension education institutions.

The twelve 1862 Land-grant universities in the North Central region include:

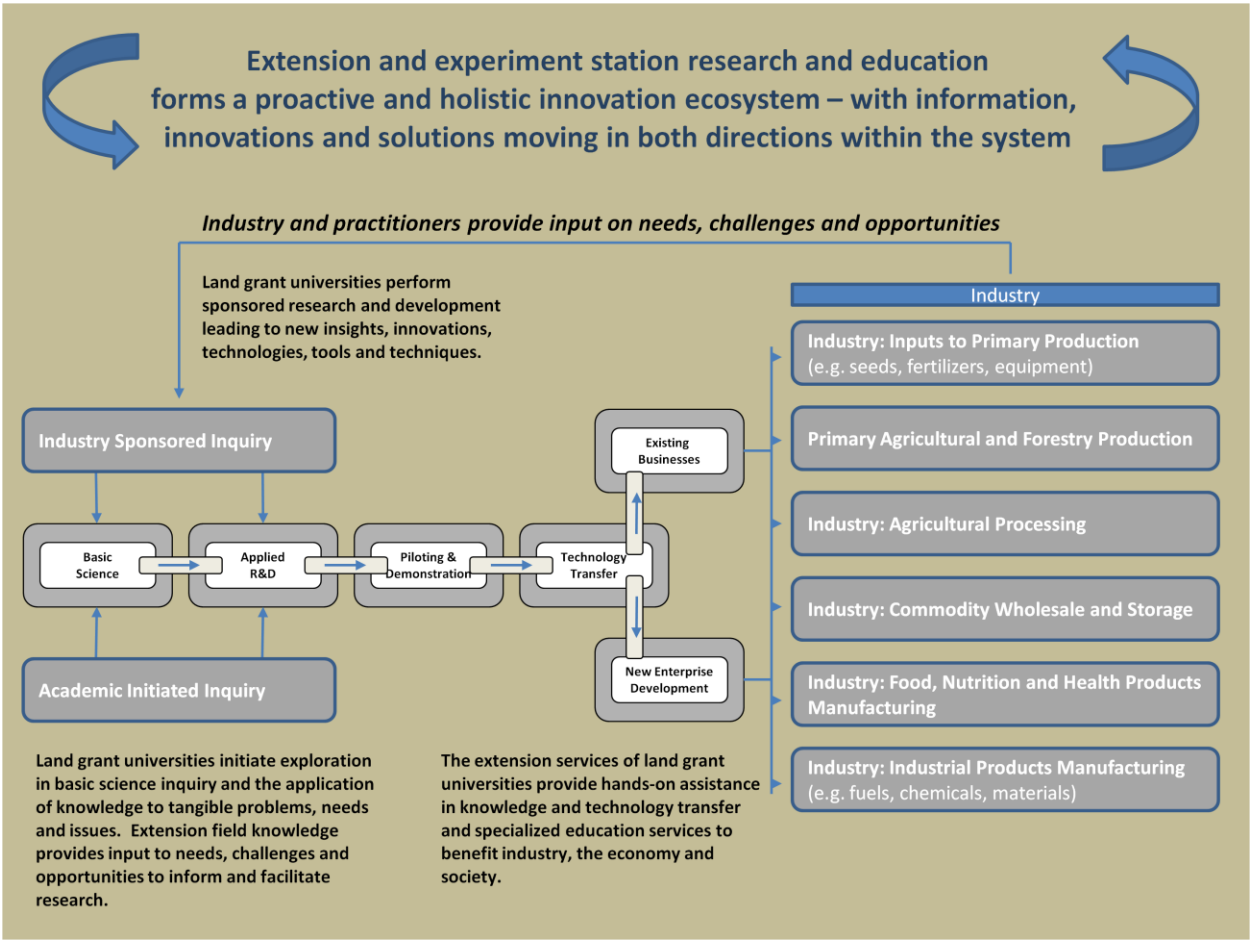
- **Iowa State University**
- **Kansas State University**
- **Michigan State University**
- **North Dakota State University**
- **The Ohio State University**
- **Purdue University**
- **South Dakota State University**
- **University of Illinois**
- **University of Minnesota**
- **University of Missouri**
- **University of Nebraska**
- **University of Wisconsin**

Providing a comprehensive and integrated system of education, research, and knowledge and advanced practice education—the North Central region's land-grant universities provide the skilled human capital needed by the agbiosciences sector, and advance the basic and applied knowledge base that underpins agbioscience advancement. **Unlike other academic-based disciplines, the agbiosciences at land-grant universities are deliberately leveraged for the good of industry, agricultural producers and society through the operations of a purpose-built extension system.** This highly pragmatic system provides science and technology development and implementation services that keep U.S. agriculture, agribusiness and associated business sectors at the forefront of innovation, productivity and competitiveness.

Through a systematic pipeline of research and extension (see Figure 8), comprising experiment station and extension service programs, these institutions are leading the way in agbioscience R&D, in new knowledge dissemination, and in technology transfer and commercialization of technologies for the agricultural production and processing sectors. Under this system, experiment stations and extension services conduct basic and applied R&D in the agricultural and agbioscience industries through their laboratories, research farms and testing facilities. From basic science in molecular biology, biochemistry and genetics through to highly applied work in plant breeding, plant transgenics, agricultural

engineering and biomaterials, this research and extension work is helping to develop new crops, technologies, processes and value-added products for agriculture and agbioscience industries and to integrate them into production, processing, distribution and marketing channels.

Figure 8: Land-grant Universities and their Experiment Stations and Extension Services – A Unique System for Agbioscience Research, Development and Education



As Figure 8 shows, in this land-grant innovation ecosystem research inquiries in basic and applied sciences (sponsored by federal grants, state support county/local support, foundation funding, industry sponsorship and other typically extramural sources) generate technologies, innovations and practice examples that are tested and piloted through the unique infrastructure contained in agricultural colleges, associated university departments and the experiment station system. Via licensing, new business formation, knowledge-diffusion and other technology transfer activities, the land-grants (often through the extension service) proactively move innovations, technologies and practice advancements into use within the vertically

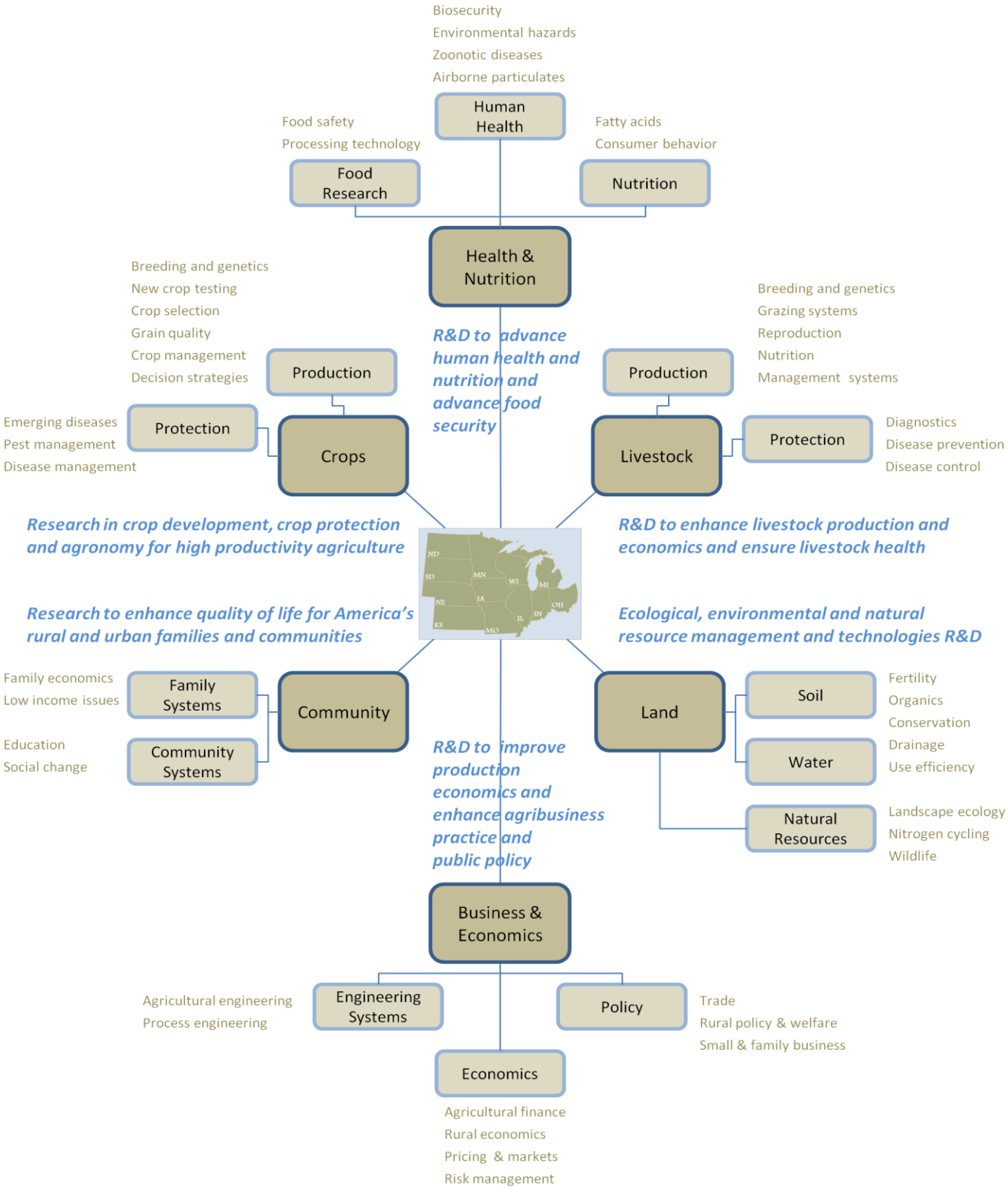
integrated agbioscience industry. As a result of this land-grant system new products, enhanced products, process improvements and other advancements in agbioscience knowledge and practice are transferred into commercial sectors—keeping them competitive and helping to drive U.S. economic growth.

Within the North Central region, thousands of projects are undertaken annually by the 12-university regional land-grant system and it would be impossible to illustrate the impacts of each and every one. However, the broad variety of positive impacts engendered by this system can be, in part, illustrated by referencing specific impact examples recorded by the North Central Regional Association of State Agricultural Experiment Station Directors. Figure9, on the following page, classifies the many core categories of impacts generated by this unique system—illustrating the broad suite of impact categories addressed by the land-grant/experiment station/extension system.

It is interesting to note that the National Institutes of Health (NIH) are working to encourage the development of systems to translate research discoveries into improvements in healthcare. Dubbed "bench-to-bedside" initiatives, these efforts to promote translational biomedical R&D are, in a way, mirroring what has been occurring in agbiosciences for more than a century through experiment stations and extension.

Advances in agbioscience depend on the quality of the technology developed as well as the successful translation of that technology into commercial utilization by producers and processors. Extension Service Programs at each of the universities comprise a network of specialists (typically in each and every county) providing a wide variety of information, technical knowledge and education services for individuals and companies in the community. Extension service providers work closely with farmers, ranchers, business persons and other members of the local community to provide timely, and unbiased advice on issues like the introduction of new crop varieties and production requirements, agricultural marketing opportunities, disease and pest management tools, animal and livestock health products, agricultural equipment, irrigation technologies, and agricultural processing technologies.

Figure 9: Examples of Impact Categories Within the North Central Region



The Land-grant university, experiment station and extension service system is clearly a unique asset for the U.S. and represents a system of extreme relevance to the needs of a modern U.S. economy so dependent on innovation, knowledge and technological advancement to maintain its competitive edge.

Table 1 serves to illustrate a number of the key issues being addressed through the land-grant/experiment station/extension service system:

Table 1: Experiment Stations and Extension Services –Relevance to Major Issues and Challenges

Issues	Research Relevance	Extension Education Relevance
National economic competitiveness	Innovations to enhance agricultural and forest productivity. Innovations to enhance the productivity and competitiveness of value-adding industry. Field trials, testing and scale-up of new technologies. Facilitation of research in specific soils, climatic and agronomic zones. Specialized testing and R&D services for industry New products and technology innovations for commercialization. Business and new technology incubation services. Adding value to domestic, home-grown resources. Development of products for export.	Demonstration and field testing Education in new technologies and practices for producers. Education and technology transfer for industry. Direct consultation with producers on tools, techniques, products and markets to enhance competitiveness. Advisory services in new business development and commercialization.
Homeland security	Protecting the U.S. from plant, animal and zoonotic diseases. Specialized research infrastructure for specific crops, animals and associated threats. Reducing dependency on foreign imports and fossil fuel resources.	Widespread on the ground monitoring and observation network. Tangible, hands-on assistance and advice to producers and processors. Specific food safety and handling education.
Environmental sustainability	Innovations in production inputs use efficiency, and plant transformation to reduce agricultural inputs. Technologies for reducing waste streams and waste stream impacts, and for converting waste to value-added products e.g., energy. Production scale test sites for evaluation of environmental impacts and technologies. Demonstration facilities for environmentally sustainable practices, tools and technologies.	Widespread on the ground monitoring and observation network. Tangible, hands-on education and advice to producers and processors. Education of practitioners, community members and youth regarding environmental sustainability. Water, energy and resource conservation advisory services. Demonstration and field testing
Education, skilled human capital and workforce development	Direct education of undergraduate and graduate students. Continuing education courses. Development of new knowledge and know-how for diffusion into practice. Facilitation of regional access to expertise and development resources.	Knowledge and know-how diffusion. Continuing education for adult and youth audiences. K-12 programs and STEM (Science, technology, Engineering and Math) education support. 4-H educational and youth development programs. Development of web and distance learning systems

	Facilitation of field research in regional crops, specific agronomic zones, etc.	and educational materials
Societal welfare	Economics research and policy analysis Policy analysis Community, urban and rural development research Education and extension operations research Research on the American family, youth development and other key social issues	4-H programs extending learning hours and reaching "at risk" youth. Tangible services in urban and rural economic development. Hands-on support and coaching for families, community groups and civic leaders. Promote public and individual health for adults, children and youth.

The North Central region's experiment stations and extension service programs provide an integrated system to research, develop, pilot, demonstrate, and disseminate new innovations to benefit practitioners and industry.

As highlighted above, the North Central region's experiment stations and extension service programs provide an integrated system to research, develop, pilot, demonstrate, and disseminate new innovations to benefit practitioners and industry. This system is providing innovative systems for improving the profitability of agricultural producers and processors, creating new businesses and new economic opportunity, protecting food sources from toxins and pathogens, and ensuring the sustainability of the environment for the next generation and beyond. With combined budgets totaling $0.96 billion for the experiment stations and $0.7 billion for the extension services, it would be an almost impossible task to illustrate all of the research programs and initiatives of the North Central experiment stations and extension services and their impacts on individual communities, home states, the region and the nation. Rather than attempt this, the Battelle/BioDimensions project team provides an assessment herein of:

- Some of the notable and unique assets of North Central institutions for agbioscience R&D and the acceleration of innovations into application
- Examples of some of the highly significant impacts being generated by North Central institutions.

V. The North Central Region and the Agbioscience Opportunity – Key Regional Assets for Agricultural and Agbioscience-Based Development

A. Size and Scope of the North Central 1862 Land-Grant Universities and Their Experiment Stations and Extension Operations

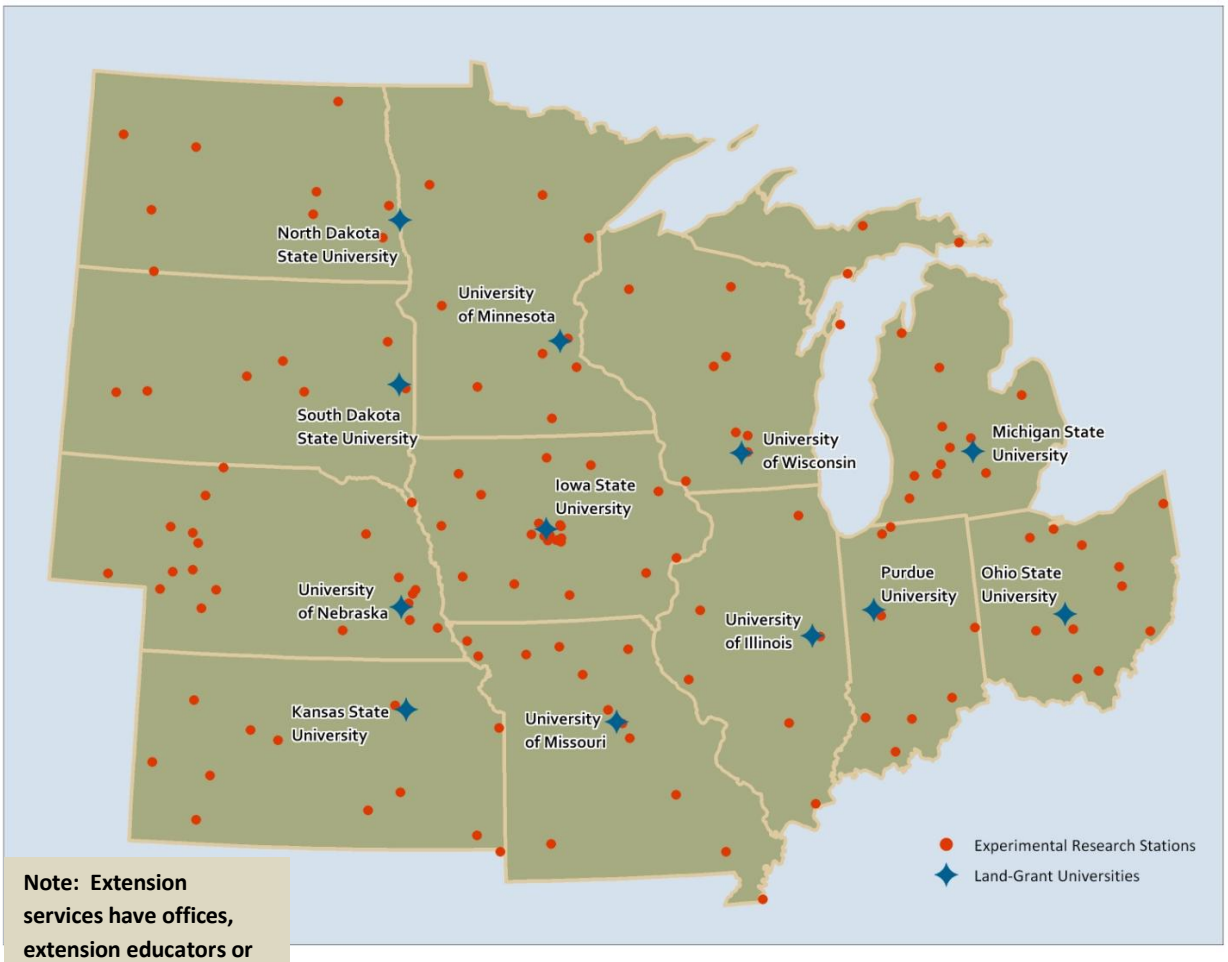
The twelve 1862 land-grant universities constitute large-scale assets for agbioscience R&D and research translation**. In terms of experiment station and extension service operations, the twelve combined institutions have 7,601 FTE extension personnel and 6,724 experiment station FTEs**. **Combined extension service budgets totaled almost $700 million (2010) while the experiment stations stood at a combined $956 million** (See Table 2).

Table 2: Personnel and Budgets of North Central Experiment Stations and Extension Services

Year	Experiment Stations FTEs	Experiment Stations Combined Budgets ($ millions)	Extension Services FTEs	Extension Services Combined Budgets ($ millions)
2006	6909	856.2	7921	644.6
2007	6836	864.0	8052	671.7
2008	6860	901.4	7991	697.1
2009	6730	939.0	7890	703.5
2010	**6724**	**955.7**	**7601**	**699.2**

The twelve states contain considerable variability from location to location in terms of agronomic characteristics (soil types, rainfall quantity, groundwater, etc.) and thus the land-grants have established multiple dedicated experiment station locations providing environments suited to testing and developing agricultural inputs, crop varieties, agricultural equipment and livestock operations. **Within the North Central region there are 149 experiment station locations covering a combined area of over 176,000 acres.** Figure 10 illustrates the significant geographic coverage provided by these experiment station assets. **To these experiment station assets must be added the specialized local knowledge provided by extension specialists who cover each county across the region—providing support and education for land-owners, agricultural producers and processors.**

Figure 10: Experiment Stations of the North Central Region



Note: Extension services have offices, extension educators or other presence providing coverage for every individual county within the region.

Profiling the full variety of key agbioscience R&D assets contained within North Central extension services, experiment stations and land-grant campuses would create a far too lengthy report (although appendices herein list many of these key assets across the institutions). Rather than provide a complete listing, Battelle reviewed major assets and has placed them into six categories:

1. Plant science, crops, agronomy and plant transformation assets
2. Animal science, animal health and livestock research assets
3. Food product R&D and advanced nutrition and health products development assets
4. Biosecurity and food safety assets
5. Industrial bioeconomy R&D assets (fuels, chemicals, materials)
6. Environmental sciences and sustainability assets.

Within each of these six categories an "asset map" is provided below, together with a general discussion of the asset category and its relevance to modern agbio-based opportunities and needs. It is apparent that the North Central region contains some of the most specialized and clustered assets for agbioscience R&D in the nation.

B. Plant Science, Crops, Agronomy and Plant Transformation Research and Extension Assets

As would be expected, each of the institutions across the 12 states has a significant focus on the development, improvement, protection and cultivation of agricultural crops suited to the growing conditions of their varied soil and climate characteristics and the needs and preferences of farmers. Experiment stations across the region perform R&D leading to crop improvements (such as increased yield, improved grain or oilseed quality, disease and pest resistance, etc.)—performing this work via traditional breeding and hybridization techniques and via the latest transgenic techniques.

A Crop Projects Example

Wheat Fusarium Head Blight (FHB) Management

FHB, or scab, caused by the fungus Fusarium graminearum, is the most economically threatening disease to wheat and barley, with yield losses of more than 45 percent in severe cases. In addition to lowering yield, the fungi also produce a toxin, commonly known as vomitoxin that is harmful to humans and livestock.

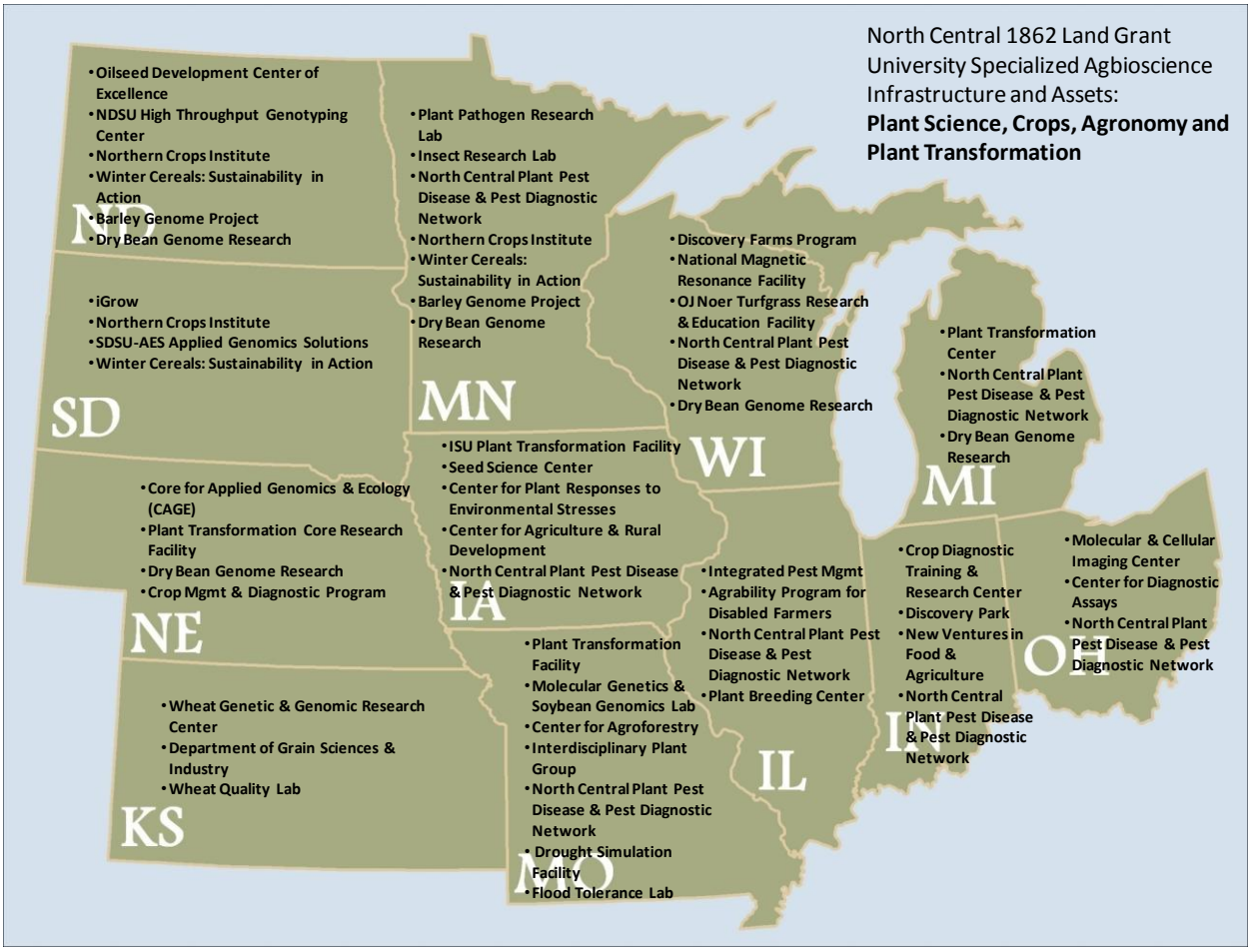
Scientists at North Dakota State University, Ohio State, Kansas State, South Dakota State and Penn State have been working together to develop a web-based model to predict the risk of FHB based on observed weather patterns in a given area. This web-based tool is currently used by growers, crop consultants, processors and others in 24 states to inform disease management and crop marketing decisions.

Applied research at experiment stations indicate that an integrated crop management strategy of disease resistant wheat varieties, fungicide application and crop rotation is the most effective way of protecting the crop against FHB. Extension personnel use the web-based tool as well as workshops, field days, news releases, letters and disease forecasts to demonstrate this integrated strategy.

Wheat breeding programs at the University of Missouri are developing new lines of wheat suitable to the region with a focus on FHB resistance and increased yields. Researchers at Ohio State have developed a non-synthetic biobased pesticide for FHB and collaborated with extension services to develop educational materials on bio-pesticide application and organic farming.

Figure 11 highlights some of the specialized programs and infrastructure located in the North central region. This is not, of course, an exhaustive list, but does serve to illustrate the intensity of specialized resources and assets dedicated to the development and improvement of advanced crops and cropping systems.

Figure 11: Examples of Major Assets for Plant Science, Crops, Agronomy and Plant Transformation within North Central Region 1862 Land-Grant Institutions



C. Animal Science, Animal Health and Livestock Research and Extension Assets

Livestock is a major component of the U.S. value-added agriculture system and the North Central region is well known for its intensive vertically-integrated livestock operations. North Central land-grants and their experiment stations and extension services have operations in: advanced nutrition for livestock; livestock health products; livestock breeding; animal husbandry technology; meat science; dairy science and associated food products development. The universities' work contributes to substantial economic impacts from the livestock industry. For example, a report by Battelle for the Ohio Soybean Council found that over 45,000 jobs are directly or indirectly generated within the state by livestock agriculture.[19] The value-added chain from the development of inputs to livestock agriculture through to the

[19] Battelle Memorial Institute, Technology Partnership Practice. April 2008. *"The Ohio Livestock Industry's Economic Impact on the State of Ohio."* Performed for the Ohio Soybean Council.

distribution of finished food and nutrition products generates widespread beneficial impacts as illustrated on Figure 12:

A Livestock Agriculture Example

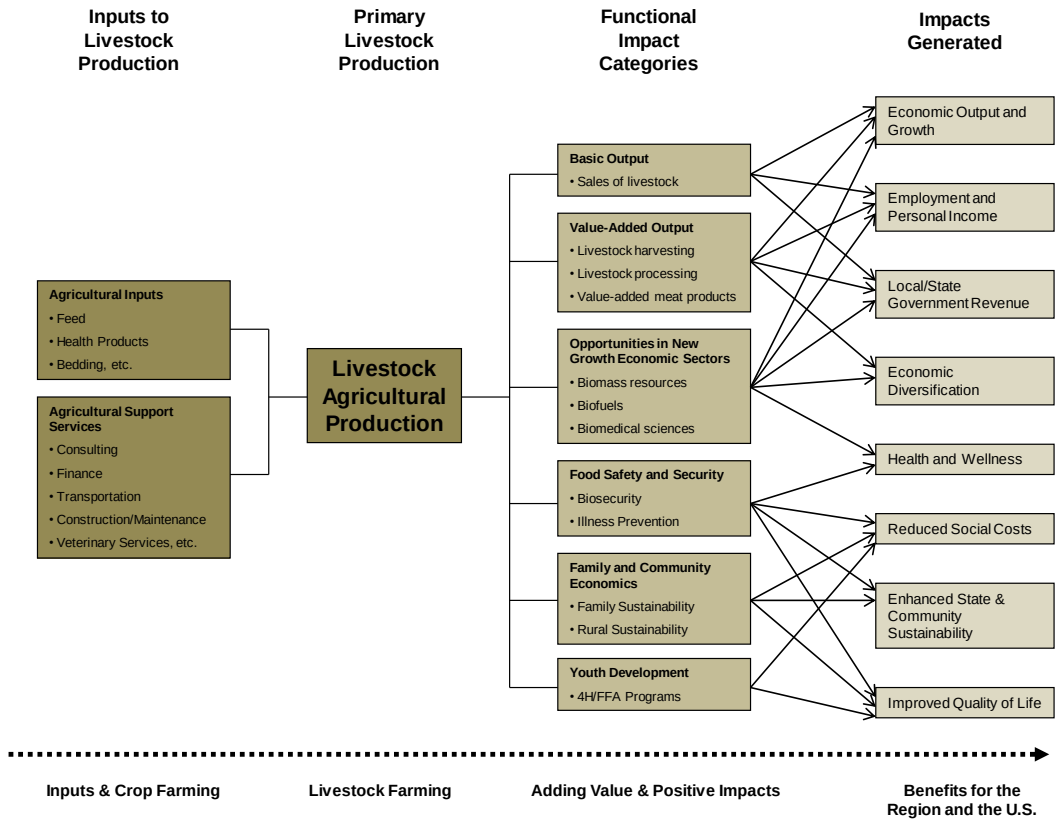
Wisconsin Dairy Programs

In 2007 Wisconsin generated $16.4 billion in dairy production and processing sales, along with contributing over 65,000 jobs. Dairy producers and processors in Wisconsin, the "Dairy State," are supported by the collaborative efforts of University of Wisconsin research and extension staff at the Emmons Blaine Cattle Research Center, the Wisconsin Center for Dairy Research and the Institute for Environmentally Integrated Dairy Management. Extension faculty work with researchers from these centers to develop educational resources, conduct outreach and otherwise share information and technologies with stakeholders in the dairy industry.

The Wisconsin Center for Dairy Research includes an operating dairy plant at the university, as well as over 30 scientists and staff researching dairy protein processing procedures, use of dairy ingredients in food, and technologies for dairy product safety and quality. The Center is partnered with the Center for Diary Profitability and the Wisconsin Milk Marketing Board to support economic, management and production practices for the state's multi-billion dollar dairy industry.

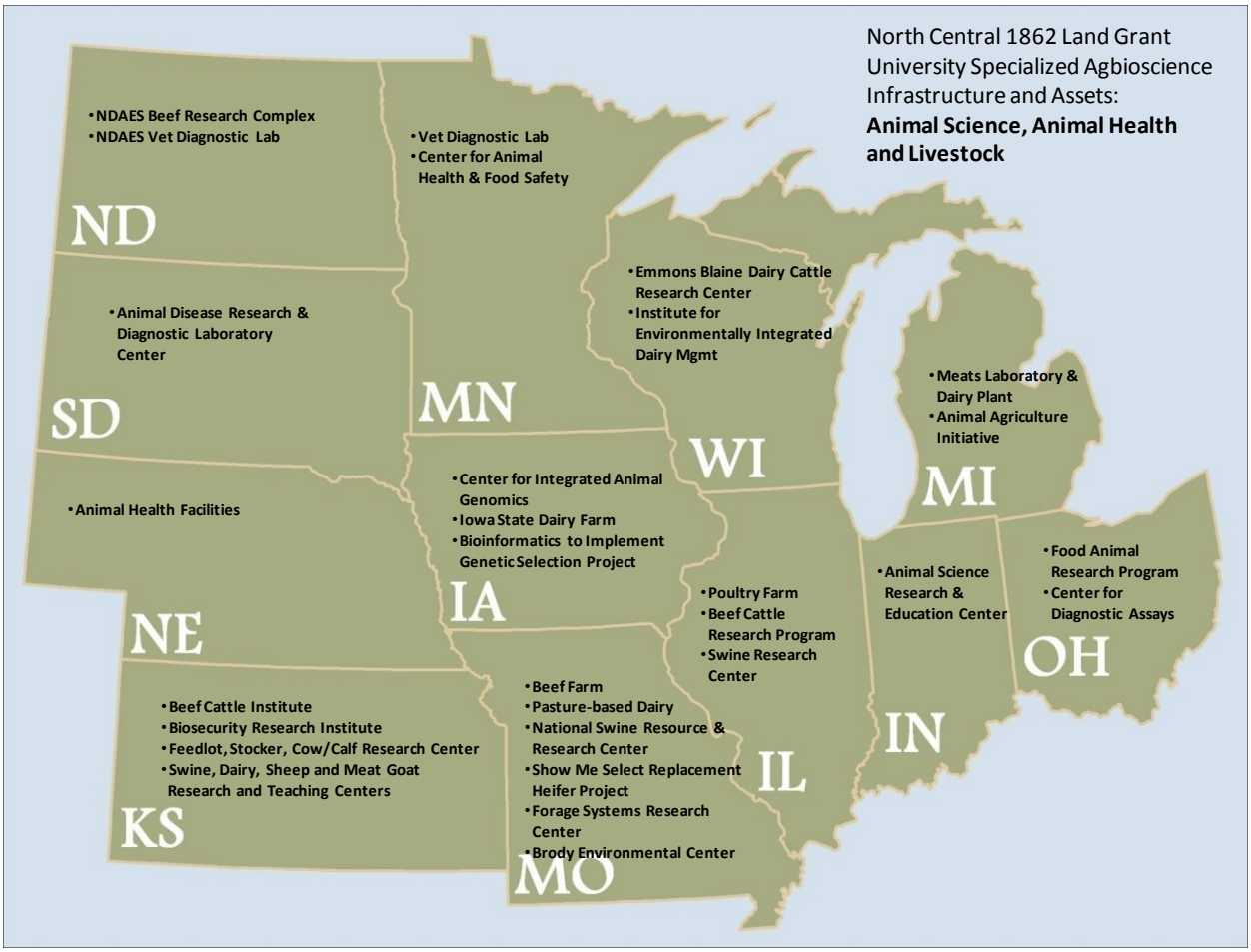
The Emmons Blaine Dairy Cattle Research Center is located at one of the university's 11 experiment stations. The Emmons Blaine Center is a state-of-the-art facility for research on pen-based nutrition work, mammary and reproductive physiology research, calf growth studies, and cow management practices.

Figure 12: Categories of Economic Impact Generated by the Livestock Agriculture Value Chain.



The scope of livestock agriculture in the North Central region is substantial. For example, the annual production value of cattle and calves totaled $20.1 billion in 2007 (46% of total U.S. production) and dairy product production value totaled $6.7 billion. The 12 Land-grant universities are supporting this industry with a broad range of specialized initiatives, R&D programs and investments in extension and research assets and infrastructure. Figure 13 illustrates some of the specialized assets for livestock agriculture contained within the regional experiment station and extension service system:

Figure 13: Examples of Major Assets for Animal Science, Animal Health and Livestock Systems within North Central Region 1862 Land-Grant Institutions

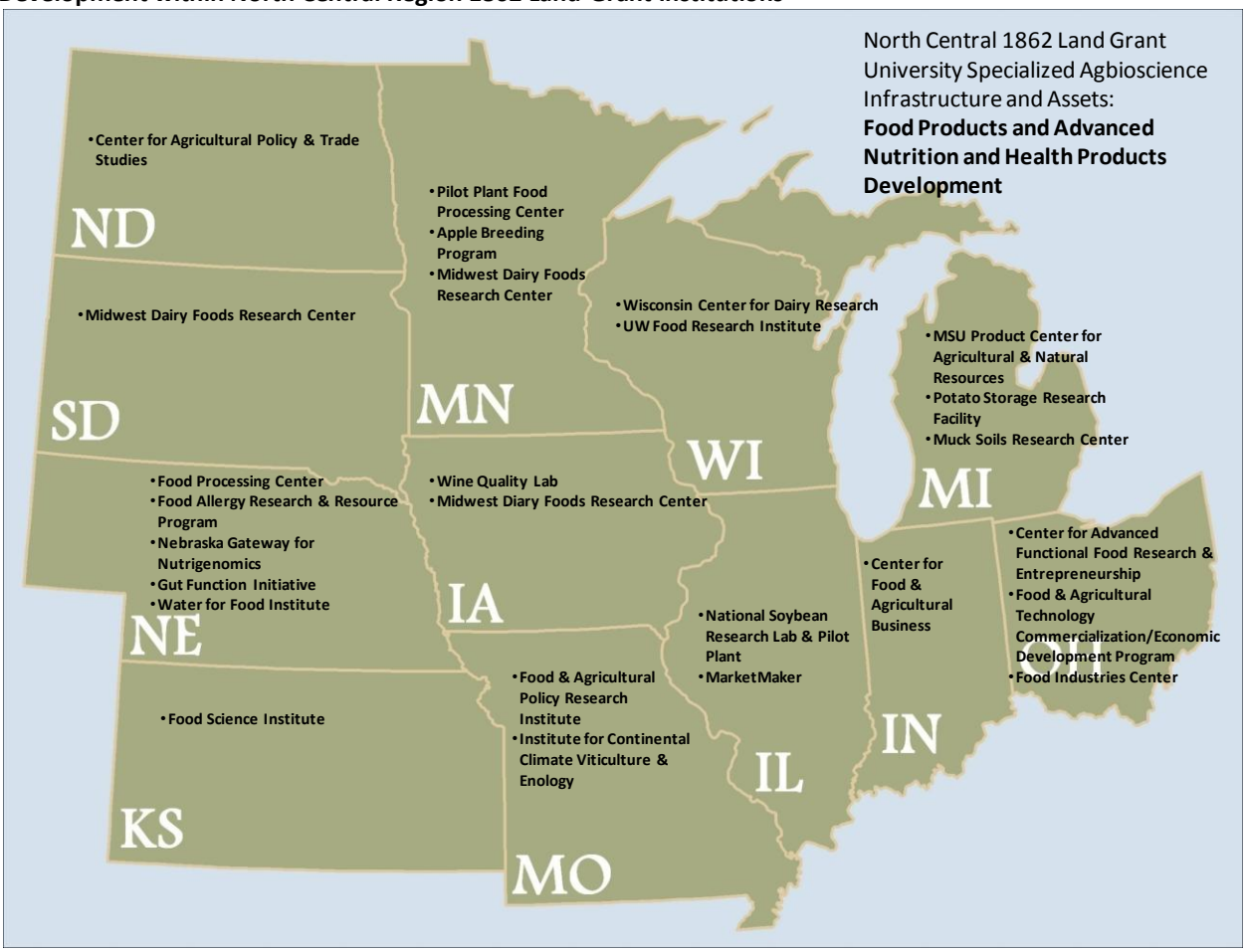


D. Food Product R&D and Advanced Nutrition and Health Products Development Assets

While most of the general public gives little thought to where the foods on their grocery store shelves come from, these foods (especially packaged/processed foods) derive from a complex chain of economic activity—ranging from agbioscience inputs to the growth of ingredients, through food science R&D, nutrition research, new product formulation, piloting and testing and onwards into the full-scale food products manufacturing industry. Regional land-grants and their experiment stations and extension services play an important role across this value-added process.

In basic sciences university researchers and extension educators in areas such nutritional sciences, proteomics, metabolomics and biochemistry perform R&D on the basic structure of food ingredients and the processes by which they are absorbed as nutrients and health promoting minerals and chemicals by humans (in the case of food) and livestock and companion animals (in the case of feed). Upstream of basic science inquiry, land-grant experts in translational science and engineering disciplines perform R&D in food formulation, food quality, processing technologies, packaging technologies and the range of disciplines required for the development of high quality packaged and processed food products. Multiple university centers and specialized institutes exist within the North Central region dedicated to the development of value-added food products. Some of these centers, for example the Center for Crops Utilization Research at Iowa State University, contain large-scale research and extension investments in pilot-scale production equipment, testing equipment and taste/sensory laboratories dedicated to working with industry and agricultural commodity groups to produce high-quality, high-value products. Likewise extension service specialists are frequently engaged with farmers and industry representatives in helping them generate value-added business opportunities and in work with more established food production companies in refining and optimizing food ingredients and processing technologies. Some of the specialized assets within North Central land-grant universities focused on the food, nutrition and health products category are listed on Figure 14.

Figure 14: Examples of Major Assets for Food Products and Advanced Nutrition and Health Products Development within North Central Region 1862 Land-Grant Institutions



Modern bioscience advancements are also allowing regional land-grant universities to build active programs specializing in high-value products in the expanding categories of advanced nutrition, functional food and healthcare products such as nutraceuticals and biopharmaceuticals. The emerging marketplace for advanced food and ag-based health products is opening up new pathways to the development and production of high value-added niche food and health products, including:

- **Functional Foods** – Characterized as food or food ingredients that may provide health benefits beyond the traditional nutrients they contain. Functional foods can be either plant- or animal-based.
- **Nutraceuticals** – A nutraceutical is "any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention or treatment of disease."

- **Phytochemicals** – Nutritionists use the term phytochemical when referring to naturally occurring components of plants that have physiological effects on humans. Such physiological effects might include, for example, enhanced immune system activity, chemoprevention, and reduced cholesterol.
- **Pharmaceuticals** – Modern transgenics capabilities for plant and animal transformation allow agbioscientists to develop specialized plants and animal organisms that express pharmaceutically active proteins or compounds. This field of development is also known as "biopharming".

BCC Research reports that in 2008 the global nutraceutical market was already valued at $123.9 billion and this leading market research organization forecasted nutraceuticals to reach $176.7 billion by 2013 (BCC Research, 2008). Just-foods.com research indicates that the global functional foods market will reach a market size of $90.5 billion in 2013.

A Human Health Science Example

Biomedical Research – University of Missouri National Swine Resource and Research Center (NSRRC)

The NSRRC was established in 2003 to develop the infrastructure to ensure that biomedical investigators across a variety of disciplines have access to critically needed swine models of human health and disease. The NSRRC also serves as a central resource for reagents, creation of new genetically modified swine, and information and training related to use of swine models in biomedical research. Swine are the optimal model species for the investigation of a large number of human diseases and have made valuable contributions to almost every field of human medicine. Swine share anatomic and physiologic characteristics with humans that make them ideal models for research. In addition, the anatomy and physiology make pig organs likely candidates for xenotransplantation (the transplantation of living cells, tissues or organs from one species to another).

Industry experts anticipate the U.S. market for functional foods to grow between 8.5% and 20% annually in the near term (Pricewaterhouse Coopers, 2009). Also, in 2008 the U.S. dietary supplement market was worth $25.2 billion with annual growth rates expected to run at 4–5% through 2013 (Pricewaterhouse Coopers, 2009).

It should be noted that much of the R&D capability applied to human food advancements is applicable to the needs for advanced animal nutrition products also.

E. Biosecurity and Food Safety Assets

With agricultural commodities primarily produced in open environments the opportunity exists for natural pathogens or contaminants to reside on harvested production. Likewise livestock, as natural organisms, face the threat of infectious diseases (limiting

production output or representing a zoonotic disease transmission risk for humans) while some microorganisms residing within livestock can engender food-borne illness in humans if ingested. Since the terrorist attacks of 9/11, awareness has also increased regarding threats to agriculture and food-stuffs through the deliberate introduction of pathogens or contaminants to our food supply.

Land-grant universities, experiment stations and extension services in the North Central region play multiple important roles in developing approaches and technologies to address food safety and biosecurity.

Cases in Food Safety

Confronting Salmonella

Michigan State University's Enteric Research Investigational Network is funded by the National Institutes of Health National Institute of Allergy and Infectious Diseases. It is led by researchers at MSU Agricultural Experiment Stations, along with investigators from the colleges of Veterinary Medicine, Human Medicine, Natural Science and Engineering. The research group is focused on illnesses caused by Salmonella, E. Coli, and other enteric microbium – microbes living in the human gut (there are 10 trillion of them). Researchers are studying the microbes that live in our intestines, and analyzing the role they play in food- and water-borne illnesses that kill millions of people worldwide each year. The goal is to understand what makes people more susceptible or resistant to food- and water-borne diseases, and develop new interventions and treatments for these enteric diseases.

A research and extension team at Ohio State University has developed a novel process for the pasteurization of raw shell eggs, one of the most common means of transmitting Salmonella. This process relies on ozone to decontaminate the eggs and is the only current technology to meet the US mandate for the production of pathogen-free shell eggs.

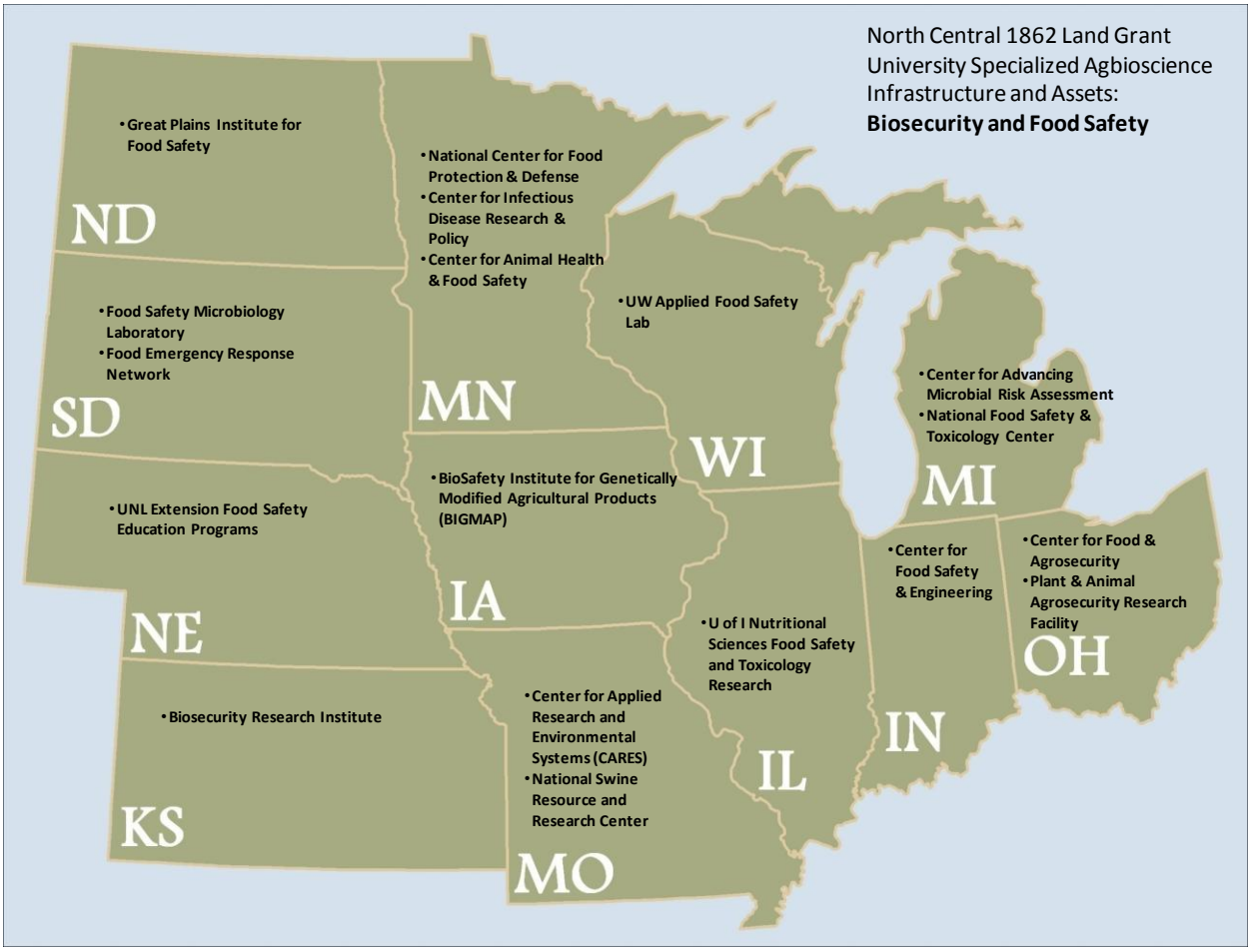
In an effort to improve animal health and food safety animal scientists at Iowa State University are developing blood tests to identify animals that shed the least amount of Salmonella into the environment. Their findings have identified a gene expression signature, or classifier, that can predict the level to which an animal will carry or transmit Salmonella. These results, introduced to producers via extension can help, for instance, to weed out pigs that are Salmonella "shedders" from swine herds through either traditional animal breeding methods or gene manipulation.

University faculty, research scientists and extension educators are at the forefront of work in fields such as microbiology, immunology, plant pathology and molecular biology working to investigate diseases and develop tools for preventing infection/contamination and, rapid diagnostics for contamination events. Applied scientists are developing new tools and technologies for food product decontamination, sterilization, packaging technologies to avoid contamination and advanced sensing equipment. The large-scale network of extension agents employed by the universities also provides a unique "in the field" monitoring and surveillance network able to identify and respond to

issues and provide education services for producers and processors on preventive measures and response protocols.

Given the large-scale importance of agriculture and the food industry across the North Central states it is not surprising to find a robust suite of biosecurity and food safety assets developed at the regional land-grant universities. Figure 15 highlights some of these key assets:

Figure 15: Examples of Major Assets for Biosecurity and Food Safety within North Central Region 1862 Land-Grant Institutions



F. Industrial Bioeconomy Assets (Biofuels, Biobased Chemicals and Materials)

The use of biomass as feedstocks for the production of a broad range of industrial products including fuels, chemicals, polymers and materials represents a win-win scenario for the intensive agricultural states of the North Central region. The rapidly emerging bioeconomy provides a path to adding significant value to farm output and an opportunity for local processing of biomass and the development of home-grown industries

for the conversion of biomass into value-added fuels, chemicals and materials. Furthermore, the development of this bioeconomy also has import substitution effects, benefiting the regional and national economy through the use of domestic biomass for the manufacturing of industrial products (rather than the use of imported feedstocks such as foreign oil). As Battelle notes in a recent report to the State of Iowa, "helping the farmer, helping industry and displacing imports is a rare alignment of economic development benefits—an alignment unique to the bioeconomy."[20]

As shown on page 14 (Figure 6), the North Central region has emerged as the leading producer of biofuels and the region's land-grant universities have made significant investments in developing the faculty and specialized infrastructure assets required to assure a leading position in the bioeconomy. Figure 16 highlights some of the core assets already deployed by regional land-grant institutions and their experiment stations:

Bioeconomy Example

Biobased Products in Ohio

In support of Ohio's leading polymer and plastics industry, faculty at Ohio State University's Ohio Agricultural Research and Development Center (OARDC) are partnering with Natural Fiber Composites Corporation (NFCC) to create a new generation of composite materials from plant-derived fibers for use in transportation, construction, consumer, and industrial products. OARDC research engineers are working to optimize fiber processing for application into composites. OARDC and USDA scientists are looking at agricultural materials to determine potential use as fibers or fillers for composites. The initiative includes support from the Ohio Corn Growers Association, the Ohio Soybean Council, and the Ohio Wheat Growers Association, as well as collaboration with Fypon, Ltd., a leading manufacturer of polyurethane millwork. In collaboration with the City of Wooster and Wayne Economic Development Council, OARDC has built a pilot plant in Wooster that will produce six million pounds of fiber materials a year and employing eight people. The plant is expected to generate $12 million in revenue and 37 jobs in Ohio by 2012.

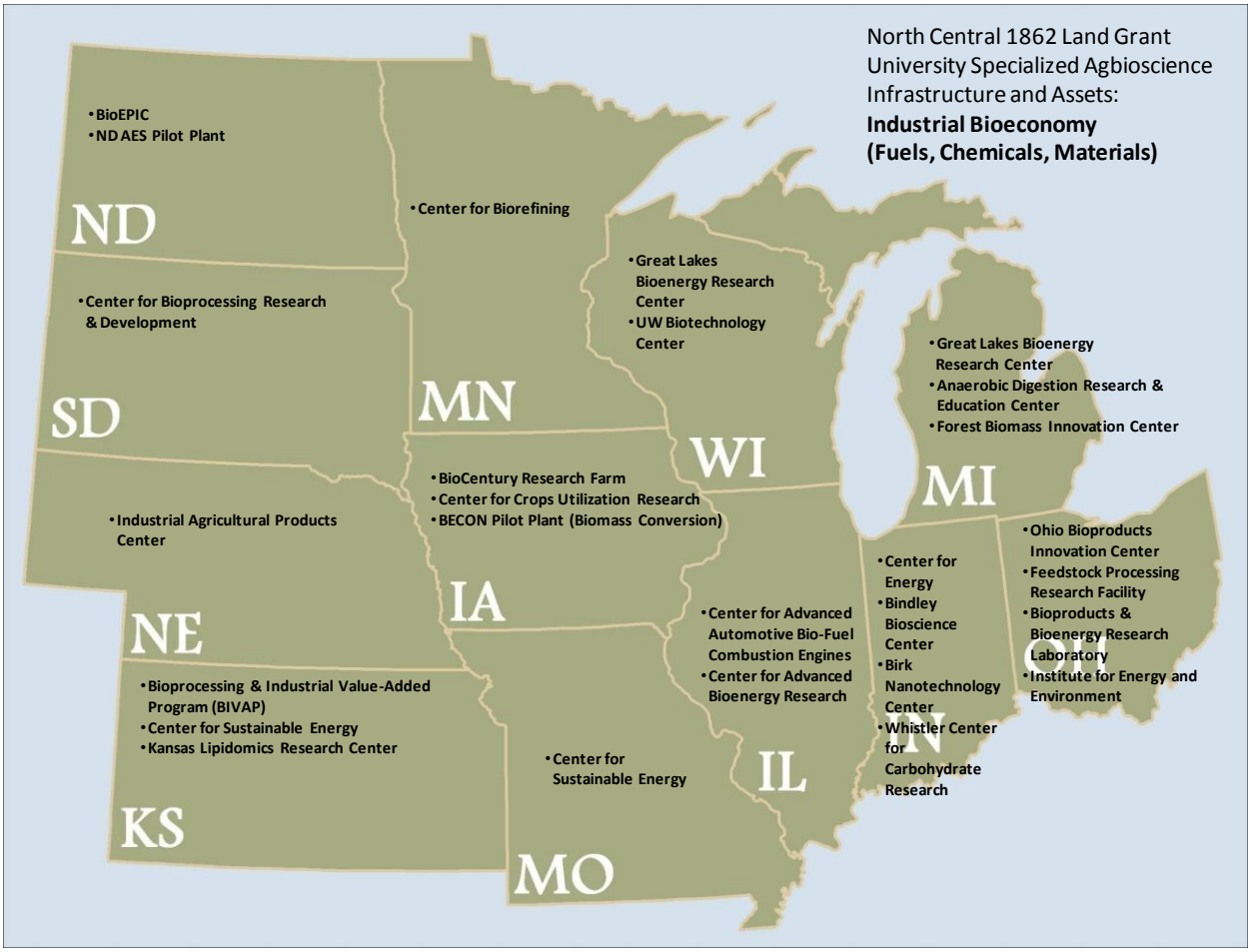
The bioeconomy opportunity is of considerable size and economic importance. Indeed, as Battelle notes in its recent report to Iowa:

"The bioeconomy already represents a substantial size market, with significant growth predicted into the future. In 2008, the global biofuels market was valued at $60.6 billion and forecasted to grow to $77.1 billion by 2013 (Frost & Sullivan, 2010). U.S. ethanol production increased more than four times between 2002 and 2009, increasing

[20] Battelle Memorial Institute, Technology Partnership Practice. 2010. *"Iowa Biosciences Core Competency Assessment and Platform Identification."* Performed for the Iowa Department of Development.

from 2 billion gallons per year to 9 billion gallons, while continued growth is mandated under the Energy Independence and Security Act of 2007 (EISA) which calls for corn ethanol production to reach 15 billion gallons by 2011. While first-generation biofuels (ethanol) will continue to dominate the market through 2013 second generation (cellulosic ethanol) and third-generation technologies (algae-based oils/fuels) will also emerge as key drivers of market growth. Beyond liquid biofuels, biobased chemicals and materials also address a large-scale market opportunity. In 2009, biobased chemicals had a market value of $45 billion and were forecasted to grow to $60 billion by 2014. Industry insiders project that the global biopolymers market will grow 27.3% between 2009 and 2015, and reach 2.7 million tons (GBI Research, 2010). "

Figure 16: Examples of Major Assets for Industrial Bioeconomy Development within North Central Region 1862 Land-Grant Institutions



While biofuels are certainly a key element in regional bioeconomy R&D they are not the only area of opportunity and development being pursued. Biomass presents opportunities for the production of chemical intermediates and specialty chemicals from plant oils, from sugars and starches, and (anticipated for the future) ligno-cellulosic (woody) biomass. These biomass resources will also be feedstocks for second and third generation advanced liquid biofuels also. Plant fibers, in combination with biobased resins, polymers and other chemicals form the basis for an advanced materials and composite materials industry also. Figure 17 illustrates the general structure of the emerging bioeconomy and the products being generated:

A Bioeconomy Example

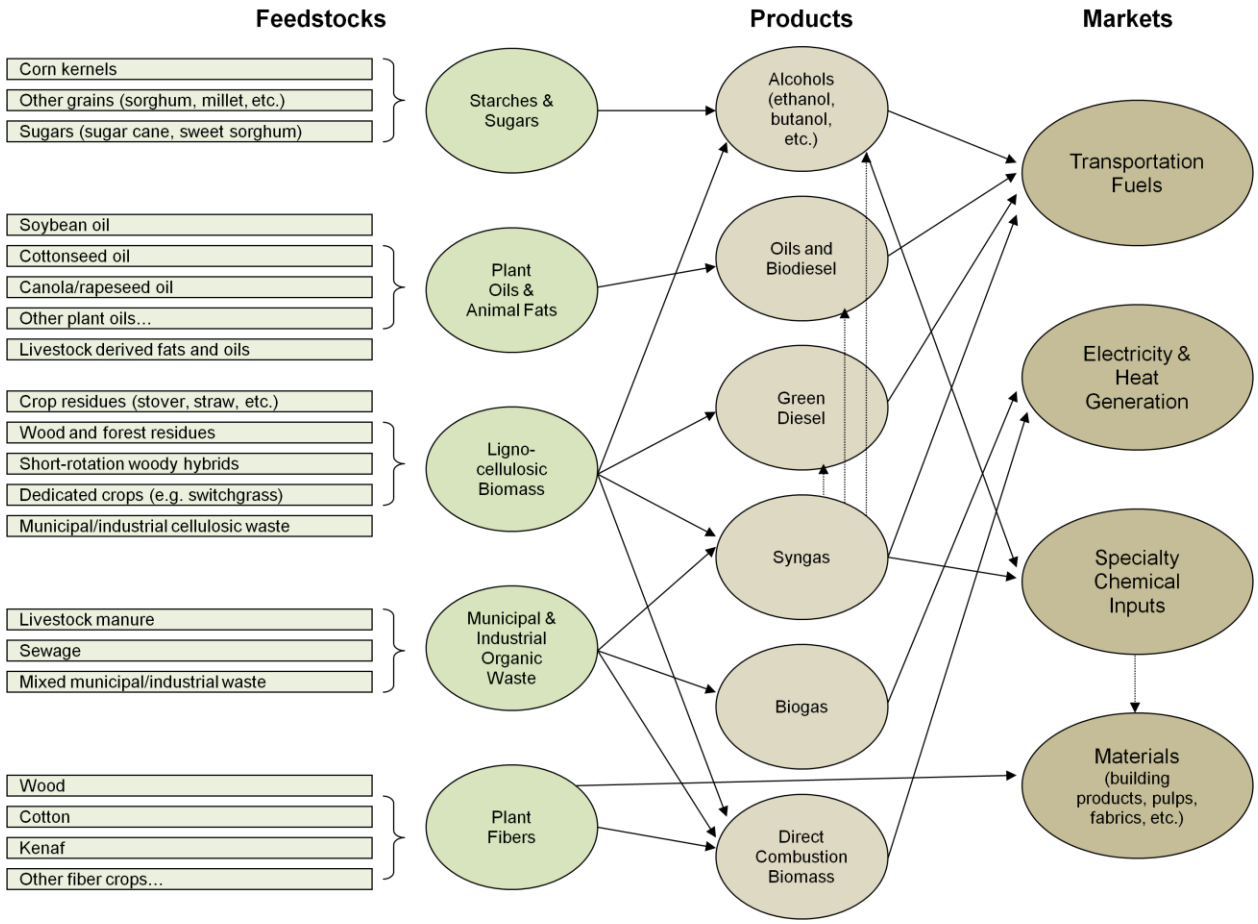
Great Lakes Bioenergy Research Center

The Great Lakes Bioenergy Research Center (GLBRC) is led by the University of Wisconsin-Madison, with Michigan State University as the major partner. The goal of GLBRC is to perform the basic research needed to generate technology to convert cellulosic biomass into ethanol and other advanced biofuels. The expertise of GLBRC researchers spans a wide array of disciplines, from microbiology to economics to engineering. The only academically-based DOE Center, the GLBRC is guided by an educational philosophy that emphasizes understanding the complex relationships among energy production, technology, economics, society and the environment. GLBRC research is focused on:

- **Improved plants** – Developing and optimizing improved biofuel feedstocks or energy crops for conversion into sustainable fuel.
- **Improved processing** – Developing integrated approaches to biomass pretreatment and enzymatic hydrolysis that will generate easily fermentable sugar streams.
- **Improved catalysts** – Improving microbial and chemical methods for conversion of cellulosic biomass into ethanol, advanced biofuels, or other chemical feedstocks that can replace fossil fuels.
- **Sustainability** – Understanding and mitigating bottlenecks in environmental and socioeconomic sustainability of biofuels, and optimizing tradeoffs and profitability for policy development.

Additional scientific partners are the Department of Energy National Laboratories, the Wisconsin Paper Council, Wisconsin Electrical Utilities, Biomass Thermal Energy Council, Wisconsin BioIndustry Alliance, Upper Midwest Municipal Power Association, and Midwest Food Processors Association. GLBRC is also connected to the Wisconsin Bioenergy Initiative (WBI), a multi-disciplinary effort focused on a range of bioenergy research and development issues. The WBI is also partnering with University of Wisconsin-Extension to increase relationships and curricula relevant to bioenergy business development, feedstock production and logistics, and sustainable biomass production practices.

Figure 17: Simplified Categorization of the Bioeconomy Opportunity - Biomass Feedstocks, Biobased Products and Market Applications



G. Environmental Sciences and Sustainability Assets

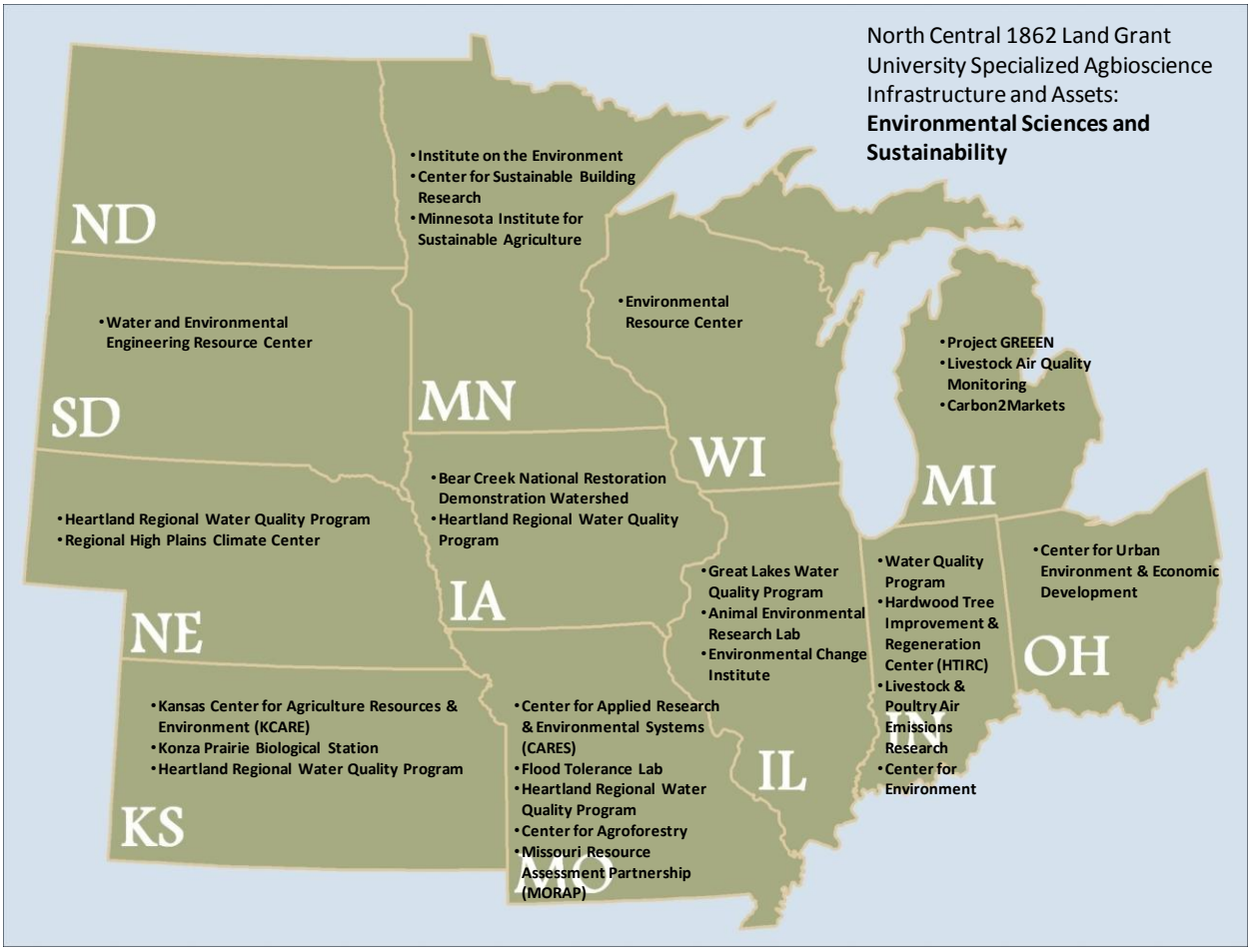
As noted earlier in this report, experiment stations, extension services and land-grant universities in general, have an important role to play in the development and implementation of solutions to environmental challenges. These institutions within the North Central region are making contributions across a broad range of environmental and sustainability fronts in areas as diverse as:

- Carbon sequestration via no-till agronomy
- Water resource preservation
- Organic waste stream utilization for bioenergy and other value-added applications
- Development of crops with reduced water consumption needs, reduced fertilization needs or the ability to grow in harsh environments.

Land-grant contributions to environmental preservation and sustainability are occurring at all spatial scales—from major initiatives focused at the global scale (such as The Ohio State University's "Targeted Investment in Excellence program" in climate, soil and water)

to the micro-scale, working with individual land-owners via extension on projects such as soil and water conservation, livestock waste management and confined animal air quality assurance measures. Extension also plays a major role in education at the K-12 level and beyond focused on environmental sustainability and conservation practices. Figure 18 highlights some major environment related initiatives across the region:

Figure 18: Examples of Major Assets for Environmental Sciences and Sustainability within North Central Region 1862 Land-Grant Institutions



An Environmental Example

Adapting to Climate Variability – The University of Nebraska High Plains Regional Climate Center

The mission of the High Plains Regional Climate Center (HPRCC) is to increase the use and availability of climate data in the High Plains region of the United States (includes parts of Nebraska, South Dakota, Kansas, Wyoming, Colorado, Oklahoma and Texas). HPRCC research projects include the study of drought, the development of drought monitoring strategies, and the development of more effective tools to monitor and predict the impact of climate variability on crop production in the region. HPRCC extension personnel have organized workshops for members of the High Plains community whose work is connected to soil and water conservation, sustainable agriculture systems, agricultural competitiveness and profitability, and natural resources and environmental management. In addition to weather observations, the online system for HPRCC includes crop water use and crop performance for major crops, pest development, livestock conditions, and soil water and heat indices.

An Environmental Example

Environmental Sustainability – Heartland Regional Water Quality Program

The Heartland Regional Water Quality Program is a partnership of land-grant universities in Iowa, Kansas, Missouri, and Nebraska, US EPA Region 7, USDA NRCS and state environmental agencies in the four previously mentioned states. Some key results include 1) influence over direction of federal CAFO regulations as related to manure nutrient management planning, 2) development and successful commercial implementation of the concept of vegetative treatment systems technology for application to animal feeding operations through efforts to assemble national experts, development of consensus guidance documents in cooperation with NRCS, and education of regulatory and private sector communities on applied research and field results of technology application, 3) improvement in quality and consistency of Phosphorus Index tools used by states in region for public policy implementation, 4) development of regional guidance documents for environmental protection and agronomic application of inorganic and organic fertilizers and pesticides.

H. Land-Grants, Experiment Stations and Extension Services as Agents of Innovation and Technology-Based Economic Development

In each of the theme areas highlighted above the universities are making innovation contributions—innovations in techniques, innovations in technologies and innovations in practical applications. It is also the case that this university-based innovation is generating valuable intellectual property for commercialization. As university researchers conduct R&D, discoveries lead to internal university invention disclosures. Professionals in technology transfer, licensing and technology commercialization at the universities then step-in to evaluate these invention disclosures and determine their potential application to commercial needs and opportunities. In many cases discoveries are quickly disseminated into practice in the field, usually through extension translational activities, without the university seeking

intellectual property protection. Indeed, one of the foundational principals of land-grant universities was this diffusion of new university-generated knowledge into practice. In today's knowledge-driven, technology-based economy, however, it is often the case that the innovations generated have significant intellectual property value and the universities then seek to patent these innovations and place them into use via the start-up of new commercial enterprises or via licensing of the technology to existing enterprises.

In conducting this research project, Battelle asked each of the 12 universities to provide statistics on their intellectual property activity for the five year period 2006 through 2010. The results, shown on Table 3, indicate that during this time period the combined universities, in agbioscience fields, generated 1,851 invention disclosures (an average of 370 per year). These resulted in 1,396 patents applied for with a total of 551 patents awarded within the five-year time period. As indication of the applied usefulness of university generated IP to industry, 978 licenses for university agbioscience discoveries were executed in this time period (an average of 196 per year).

Table 3: Intellectual Property Statistics for Agbioscience at the 12 North Central Land-grant Institutions

	2006	2007	2008	2009	2010	5-Yr. Total
Invention disclosures	238	264	182	206	192	1851
Patents applied for	239	231	221	200	140	1396
Patents awarded	77	107	96	105	98	551
Licenses executed	112	157	147	147	128	978

Commercializable innovations and advanced technology development at the 12 institutions demonstrate a spectrum of application in a broad range of areas, including for example:

- Infectious disease control and vaccines
- New crop development and plant variety improvement
- Crop protection
- Invasive species control
- Pest control
- Livestock nutrition
- Biofuels production
- New biobased products
- Novel biomaterials
- Bioactive compounds
- Novel antibiotics
- Herbicide tolerant crops
- Rapid detection of food-borne pathogens
- Pathogen decontamination and sterilization technologies.

It is important to note that the Land-grants are being proactive in encouraging entrepreneurship and the development of new companies based on agbioscience innovations. The Ohio State University, for example, has established ATECH as the innovation commercialization arm of the Ohio Agricultural Research and Development Center (OARDC) and is developing the BioHio Research Park as a dedicated home for company business incubation and for the attraction of bioscience and agribusiness R&D enterprises to co-locate with the university. Many other examples of agbio research parks, or research parks with significant agbioscience industry tenants, exist across the region with additional examples including: the University of Wisconsin Madison University Research Park; Purdue Research Park; University of Illinois Research Park; South Dakota State University Innovation Campus; University of Nebraska Technology Park; Nebraska Innovation Campus; North Dakota State University Research and Technology Park; Michigan State University Corporate Research Park, and the Kansas Bioscience Park (incorporating the new Kansas State University Innovation Campus).

Also of note is a new development being pursued by the University of Minnesota. "UMore Park," or the "University of Minnesota Outreach, Research and Education Park", will be a 5,000 acre development comprising a comprehensive sustainable residential community with research and education components focused on renewable energy, sustainable living, health and wellness and regional economic development. The park represents an example of the way in which the comprehensive science and technology attributes of land-grants can be applied to innovations at a formerly unprecedented scale.

The 12 Land-grant institutions are, in effect, operating a comprehensive innovation-to-commercialization continuum.

The 12 land-grant institutions are, in effect, operating a comprehensive innovation-to-commercialization continuum. Undertaking basic research and applied research the universities are generating new technologies and innovations that then move into commercial incubation (either as new business entities, or transferred via licensing to existing businesses for commercialization). Increasingly, the investments of these institutions in incubator facilities, business accelerators and research parks are paying off in the growth of regional agbioscience enterprises with associated job growth and positive economic impacts.

H. Land-Grants, Experiment Stations and Extension Services as Social and Community Support Agents

Extension services and faculty within land-grant institutions are also active in research and extension activities focused on regional, state and local issues beyond agricultural production and value-added manufacturing. There also exists a long-standing focus on building stronger, healthier, more economically sustainable communities—with work taking place at the community level (on issues such as leadership and economic development) and the family and individual level (with

programs in family and consumer sciences and the extensive youth development programs provided through 4-H). Key categories of social and community support programs operated by the land-grants/extension services in the North Central region include:

- **4-H Youth Development** – Developing life skills in youth to build character and help them make appropriate life and career choices. Via 4-H, at-risk youth participate in activities that enhance their education and are proven to increase school retention.
- **Leadership Development** – Trains community leaders in the skills needed for sound community stewardship and decision making.
- **Family and Consumer Sciences** – Helps build stronger families via a focus on family communication, financial management, child care, health care strategies, nutrition and food preparation skills.
- **Community and Economic Development** – Works with local governments to develop action plans and strategies for economic and community development. Activities performed include work on business development, retention, attraction and expansion together with community management issues such as waste disposal, tourism development, and land use planning.

These social and community support activities have significant economic impacts, as illustrated in focused analysis performed by Battelle in Nebraska, Ohio and Oklahoma. In Nebraska, for example, Battelle calculated that a 5% in-school retention gain attributable to 4-H positive impacts on youth results in $51.3 million in annual personal income gains in Nebraska.[21]

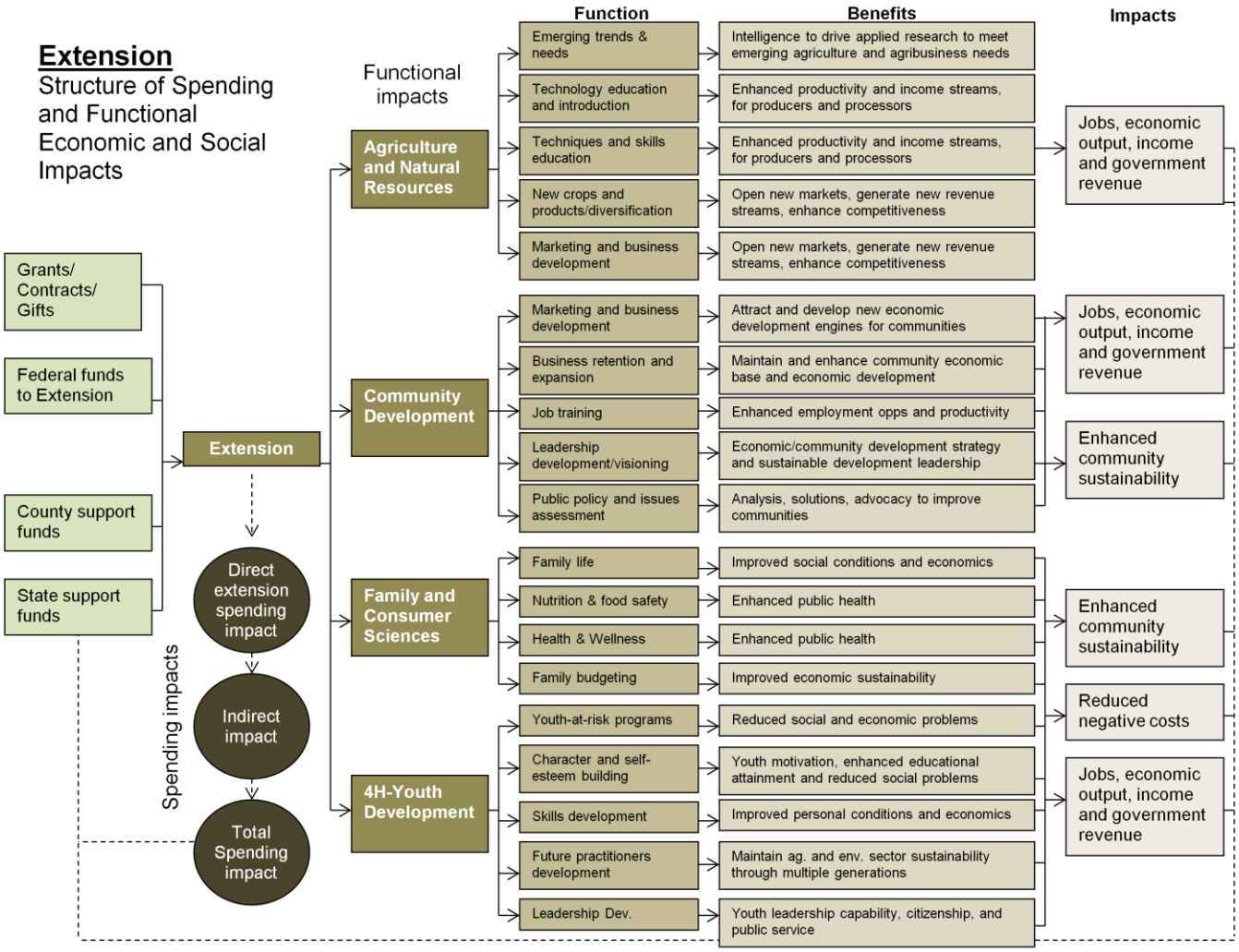
In Nebraska, Battelle calculated that a 5% in-school retention gain attributable to 4-H positive impacts on youth results in $51.3 million in annual personal income gains in Nebraska.

The overall structure of the impacts generated by extension operations across their broad suite of activities is illustrated on Figure 19.

It should also be noted that extension services play an important role in coordinating volunteer activities to benefit communities. In an analysis performed for The Ohio State University extension system, Battelle found that extension played a critically important role in recruiting and engaging youth and adult volunteers to meet a range of social and community needs across the state. In just 2004, it was found that extension leveraged the volunteer services of over 37,000 Ohioans with a combined voluntary time contribution of **over 5 million hours** with an equivalent monetary benefit of $77.4 million (an amount that exceeded the total annual budget of Ohio State Extension for that year).[22]

[21] Battelle Memorial Institute. *"The University of Nebraska Institute for Agriculture and Natural Resources: A Generator of Positive Economic Impacts for Nebraska".* February 2007.
[22] Battelle Memorial Institute. *"The Ohio State University Extension: A Generator of Positive Economic Impacts for Ohio."* January, 2005.

Figure 19: The Structure and Scope of Extension Service Impacts



It is evident that the North Central region is home to an intensive cluster of land-grant university-based assets addressing key agricultural, economic and social needs and opportunities. The region has distinctive resources directed at the most pressing global and national challenges addressed by agbioscience and the system of land-grant universities, experiment stations and extension services represents a powerful national asset for further development and advancement in the modern BioCentury.

VI. Into The Future – North Central Agbioscience as a Driver of Promise and Progress

The Future of Land-Grant Experiment Station and Extension Services

As has been discussed, modern agriculture is at the forefront of addressing critical global issues via advanced scientific methods and technology development. While the system of extension and experiment stations was originally developed to translate innovation in agronomic practice onto the farm, today's land-grant experiment stations and extension specialists are a far cry from the early days when scientists like George Washington Carver (an alumni and former professor at Iowa State University) transported important findings from the research station to the farm via horse-drawn wagon. Today's global challenges and opportunities have grown in number, placing even greater demands on modern agriculture to address worldwide food security, while at the same time advancing U.S. interests in renewable energy, food safety, human health, natural resource sustainability, and global economic competitiveness.

"In this new century, opportunities exist to help advance America's greatness in the midst of many challenges. Energy, water, food, environment, health, economic productivity, global competitiveness and the quality of living environments are all paramount to the future… Extension, at all levels, is positioned and prepared to engage in education to meet the challenges and opportunities of this new century."

2010 Strategic Opportunities for Cooperative Extension. Association of Public and Land-Grant Universities

Agricultural research and extension services have adapted to these challenges and responded to emerging opportunities with new technologies to increase farm yields, reduce input costs and protect crops and livestock against pests and disease; the development of improved pathogen detection and food decontamination processes; research into new feedstocks and pathways for renewable energy, biobased chemicals and materials, and advanced nutrition products; and new biomedical research and development using plants and animal.

A. Collaborating on Grand Challenges

Modern agbioscience work is, and increasingly will be, multi-disciplinary and collaborative. Indeed this model of university collaborations on "grand science challenges" is being followed in the North Central U.S., with initiatives such as the Great Lakes Bioenergy Research Center and the National Center for Food Protection and Defense.

Increasingly, new technologies and practices are shared among researchers and transferred to producers through digital communication tools, like the "eXtension" network that provides real-time data to extension specialists and farmers. These innovations in collaboration and technology-sharing speak not only to the size and complexity of the issues, but also to the capacity of experiment station and extension service staff to adapt in order to address pressing challenges.

B. New Industry for the United States

Over the next few decades, new discoveries in renewable energy will help to significantly reduce U.S. foreign oil imports that have added billions of dollars to the national trade deficit and funded anti-western regimes throughout the Middle East. Bioenergy research work is ongoing at labs across the North Central region—such as at North Dakota State's Bioenergy and Product Innovation Center (BioEPIC), Iowa State's BioCentury Research Farm, Wisconsin and Michigan State's Great Lakes Bioenergy Research Center, and Ohio State's Advanced Energy and Biobased Products Innovation Center. R&D at these institutions is exploring energy crops, biomass pre-treatment and techniques and technologies for advanced production. Extension specialists will increasingly work with farmers and businesses in both rural and urban areas to transfer biofuel and biobased product technologies from discovery to pilot-testing into sustainable, economically profitable feedstocks, advanced biofuels, and natural chemicals to replace billions of gallons of petroleum. Production of biomass alone has the potential of generating $90 billion for American farmers by the 2020. Commercialization of cellulosic biofuels is expected to create 800,000 new jobs (190,000 direct new cleantech jobs, and 610,000 indirect new jobs) in the U.S. by 2022.[23]

C. A Genetics-Empowered Revolution

Future discoveries will increase farm yields and farm income by improving plant resistance to disease, tolerance to environmental stresses (like drought, flooding and high salinity) and nitrogen use efficiency (input traits). Increasingly, however, desirable output traits are being introduced into crops and biomass that produce plants with targeted characteristics.

Advances in biology and plant genetics have enabled scientists to identify, isolate and introduce specific genes into plants. New genomics tools are providing agbioscientists at the 12 institutions with highly precise tools and techniques for customizing crops and biomass feedstocks for both input and output traits. The application of biotech crops with pest and disease-resistance traits has already helped drastically increase crop gains and reduce the cost of production for farmers around the world.[24] With the assistance of land-grant research, development and education, continued progress in agbioscience fields will yield breakthroughs that will expand the variety of beneficial traits to new and existing biotech crops. Future discoveries will increase farm

[23] World Economic Forum. 'The Future of Industrial Biorefineries.' (2010). http://www3.weforum.org/docs/WEF_FutureIndustrialBiorefineries_Report_2010.pdf.

[24] According to Graham Brooks and Peter Barfoot in their 2010 assessment of GM crops ('*GM Crops: global socio-economic and environmental impacts 1996-2008*'), the accumulated benefits to biotech crop farmers from 1996 to 2008 was valued at $51.9 billion, with half of that going to farmers in developing countries. In 2008 alone the economic benefits were $9.2 billion, again with roughly half of that going to farmers in developing countries and half going to farmers in industrial countries. The introduction of these crops and the associated reduction in insecticide and herbicide treatments has meant fewer passes of farm equipment in the field and thus less fossil-fuel used. Herbicide tolerant crops have also facilitated the adoption of conservation tillage practices (like no-till or limited till) which has aided in soil conservation and carbon sequestration. As a result of these practices, in 2008 biotech crops helped reduce carbon emissions by 31.75 billion pounds of CO2, the equivalent of removing about 7 million cars from the road.

yields and farm income by improving plant resistance to disease, tolerance to environmental stresses (like drought, flooding and high salinity), and nitrogen use efficiency (input traits). Increasingly, however, desirable output traits are being introduced into crops and biomass that produce plants with targeted characteristics—such as increased oil content and protein levels, and specific fatty acid profiles—that are desired for commercial food, feed, and industrial applications. Similar advancements are taking place in the application of biotechnology to livestock.

Advancements not only enhance agricultural productivity and farm incomes; they open up a world of opportunity in new markets for agrihealth products like plant-made pharmaceuticals, advanced health and nutrition products, biofuels and biobased industrial products.

These kinds of advancements will not only enhance agricultural productivity and farm incomes; they open up a world of opportunity in new markets for agrihealth products like plant-made pharmaceuticals, advanced health and nutrition products, biofuels and biobased industrial products. The biobased industry alone—which involves the conversion of sustainable plant-based resources into energy, chemicals and materials—has the potential to generate up to $230 billion for the global economy by 2020.[25] To support these opportunities research work into plant breeding and genetics is ongoing at land-grant experiment stations across the North Central region, often in collaboration with private sector partners. The proximity of the North Central land-grant universities to distinctive clusters of plant bioscience and animal bioscience companies (including worldwide leaders such as Monsanto) makes the North Central region a particularly vibrant center for realizing America's agbioscience industry opportunity. Indeed, major collaborative university-industry research centers have developed in the region and are proactively developing commercial agbioscience technologies that will drive national economic development.

The proximity of the North Central Land-grant universities to distinctive clusters of plant bioscience and animal bioscience companies makes the North Central region a particularly vibrant center for realizing America's agbioscience industry opportunity.

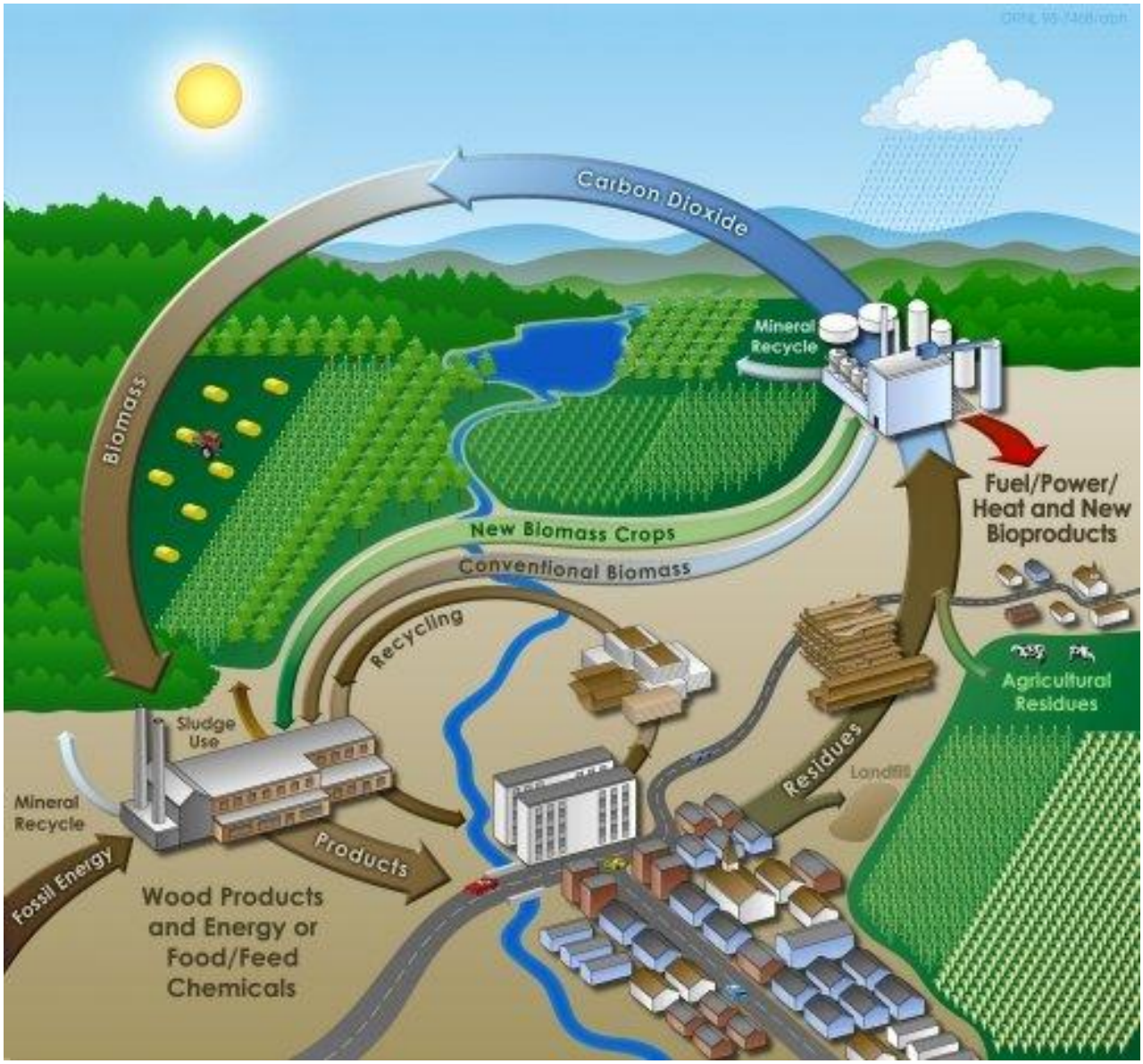
D. A Closed-Loop, Sustainable Economic System

Agbioscience-driven advances, in-part empowered by land-grant university-based research, are enabling a move towards a sustainable bio-based, closed-loop carbon system and economy. As Figure 20 illustrates, this closed-loop system (powered by solar-energy driven photosynthesis) recycles carbon dioxide. Crops absorb sunlight and carbon dioxide and form the biomass feedstocks for a broad range of food, fuel and biobased product industries. Carbon emissions in the production and use of these feedstocks are absorbed into the closed loop carbon system for further plant growth. As an inherently environmentally sustainable system, the modern biobased economy represents the only way forward for a long-term solution to the need for economic activity and environmental protection.

[25] World Economic Forum (2010).

Figure 20: Agbioscience Closed-Loop Sustainable Economic System

Graphic developed by, and reproduced with the permission of, Oak Ridge National Laboratory



E. Extension and the Biobased Future

Extension service programs across the North Central region will increasingly work with researchers, farmers and input providers to facilitate the commercial introduction of new technologies, crops and livestock. Unlike other industries which are often dominated by manufacturing at just a few companies, agricultural production is rooted across many thousands of producers who need to be introduced to the latest tools, techniques, and technologies and educated in their use. Extension is of central importance in assuring innovations are adopted

and applied appropriately – thereby assuring productive and state-of-the-art agricultural practice. Equally important, the intensive nature of biomass production required to fuel the bioeconomy will place stress upon land and water resources, and extension is on the frontline of new agronomic techniques to conserve soil and protect natural resources while at the same time boosting agricultural productivity. Extension specialists, and land-grant ag-economists, also provide a central coordinating role between industry and farmers—studying emerging markets and technologies and connecting farmers to opportunities for the production of high-value specialty crops, with companies across a broad range of sectors.

As the landscape continues to change and agriculture continues to play an ever-expanding role in addressing the most pressing issues of our time, the land-grant system of experiment stations and extension services will continue to adapt to new challenges and new opportunities. This robust network will deliver cutting edge research for commercialization, help prepare a skilled workforce for high-tech job opportunities in the agbioscience industries, and continue to provide timely and unbiased support for American farmers at a time of unprecedented growth and technological expansion. Indeed, agricultural research and extension education will provide the fundamental architecture for U.S. growth, prosperity and competitiveness in the 21st Century Bioeconomy. Realizing this promising future, however, depends on ongoing public and governmental support for the land-grant mission and the provision of required financial resources to enable the continued work of experiment stations and extension services.

Modern U.S. economic progress will increasingly be rooted in the commercial use of biological resources, and no institution is more relevant to research, education and knowledge diffusion in this environment of opportunity than the land-grant university.

From 1862 onwards the land-grant model has contributed to the U.S. economy. Today the relevance of this model is perhaps greater than it has ever been as modern bioscience discovery propels the U.S. into the BioCentury. Modern U.S. economic progress will increasingly be rooted in the commercial use of biological resources, and no institution is more relevant to research, education and knowledge diffusion in this environment of opportunity than the land-grant university. The North Central region, in particular, will be at the leading edge of agbioscience-driven innovation, education and commercial development. The clustering of intensive academic, institutional and commercial bioscience R&D, combined with an extremely high productivity farming environment and advanced processing industries makes the North Central region a good bet for BioCentury economic leadership.

VII. A System at Risk – Threats and Challenges to U.S. and North Central Agbioscience-Based Development

America's land-grant universities, colleges of agriculture, experiment stations and extension services face considerable challenges.

While agriculture and agbioscience have extreme relevance to human health, economic and social progress, and environmental sustainability in the 21st Century, the core institutions supporting advancements in these fields—land-grant universities, colleges of agriculture, experiment stations and extension services—face considerable challenges.

Table 4 highlights some of the diverse challenges and issues facing experiment stations, extension services and land-grant universities, and it is evident that the challenges come from multiple quarters. **Fundamentally, the importance of agbiosciences is expanding due to its relevance to global needs and challenges—BUT, this is occurring at a time of budget crises within federal, state and local funding agencies and within private industry.** There is, therefore, a fundamental tension between meeting expanding needs and opportunities while attempting to operate within a budget crisis environment. The challenge is compounded by a general lack of understanding in public circles regarding the extreme importance of agbiosciences, experiment stations and extension services to future global stability, national economic development and human and environmental health.

There is a fundamental tension between meeting expanding needs and opportunities while attempting to operate within a budget crisis environment.

Table 4: Challenges to Agbioscience Institutions in the Current Environment

	Challenges and Issues
Federal	• Decline of federal formula funding. • A need to increase funding for agbioscience related R&D, via NIFA, if land-grants are to fully address the major issues and opportunities.
State	• Rising tide of state fiscal crises limiting support to state universities, experiment stations and extension. • Fiscal problems for U.S. counties limiting traditional local support for extension.
General Public	• Lack of communications regarding the growing importance of agriculture and agbioscience to global issues and development opportunities. • Need for those benefiting from programs to voice their impact and appreciation with key decision makers. • Need to communicate the "public value" of programs • Need to better connect the message of *agriculture = food = nutrition = health*

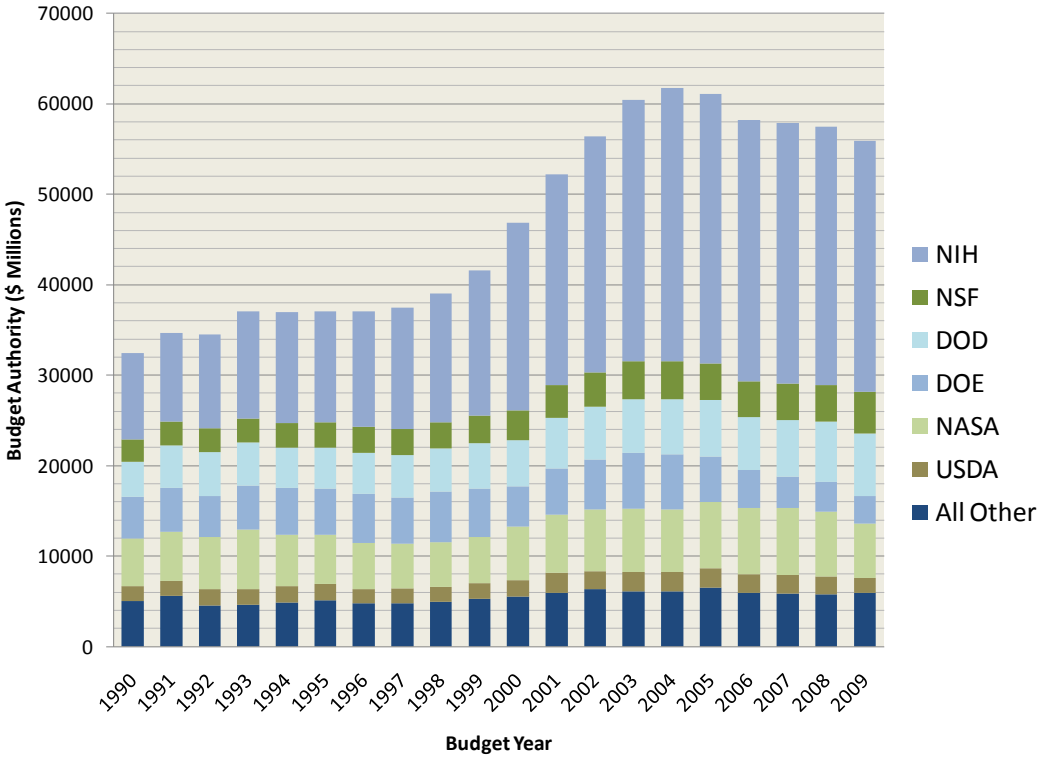
Internal	• Limited communication of mission, value and impacts internally within university systems. Agbioscience relevance often misunderstood within large universities. • Slow to revamp or remove ineffective or outmoded programs and delivery systems. • Lack of appropriate response to private research farms and consultancies. • Bridging the campus/field gap, especially for departments and faculty not having a traditional engagement with extension. • The diversification of land-grant universities away from their primary mission and a resulting diminution of agricultural college's internal political capital.
Industry	• With the agricultural production sector declining in percentage of national employment, and thus political power, how does the system extend and broaden its support base. • Increasing demands for services related to new and expanding areas of agbioscience, including biofuels, biobased products and advanced nutrition and health products.

The R&D Funding Environment

Agbiosciences are critically important to tackling many of the most pressing issues facing the nation and the globe—yet agbiosciences receive the least amount of funding attention in the national R&D funding scheme.

Perhaps chief among the challenges faced is an uncertain funding environment for agbioscience R&D and associated extension activities. **As shown in this report, agbiosciences are critically important to tackling many of the most pressing issues facing the nation and globe—yet, as a collective suite of disciplines, agbiosciences receive the comparatively low levels of funding in the national R&D funding scheme.** Figure 21 graphically illustrates funding, showing the smaller amount of funding provided via USDA versus other agencies.

Figure 21: Federal Funding by Major Agency – 1990 through 2009 (in 2008 constant dollars)
(Source: American Association for the Advancement of Science - http://www.aaas.org/spp/rd/guihist.htm)



Food Security and Nutrition is the Leading Global Health Issue

"On average, 62 million people die each year, of whom probably 36 million (58 per cent) directly or indirectly as a result of nutritional deficiencies, infections, epidemics or diseases which attack the body when its resistance and immunity have been weakened by undernourishment and hunger."

Jean Ziegler "The Right to Food: Report by the Special Rapporteur on the Right to Food, Mr. Jean Ziegler, Submitted in Accordance with Commission on Human Rights Resolution 2000/10". United Nations, February 7, 2001, p. 5.

Experts and global NGO's note the substantial impact of agriculture, food and the environment on sustaining human health and promoting wellness (see sidebar). However, federal funding priorities indicate that our nation places a much higher emphasis on funding research to diagnose and treat disease (via the NIH) versus the preventive health attributes embodied in agbioscience. This is illustrated by the fact that the National Institutes of Health (NIH) budget for 2010 stands at over $31 billion, more than 20 times larger than the USDA National Institute of Food and Agriculture (NIFA) budget of $1.5 billion. Furthermore, the funding difference has been widening as the NIH saw funding increase by 74% between 2000 and 2010, whereas the NIFA budget increased by 36.5%.

This does not imply that NIH is getting too much. Actually the contrary is the case and R&D across the board should receive more investment for the U.S. to sustain its innovation position versus growing international competition. Rather, it raises the

point that NIFA funding should be considered a priority for expanded government support, because the issues and strategic opportunities presenting themselves through agbiosciences for the U.S. are so great.

Not Just a Federal Issue

NIFA research funding constraints represent a challenge, but it is not the only financial challenge facing experiment stations and extension services. Extension is funded by the USDA, at the federal level, with federal funding matched and highly leveraged by state and local (county) partners. Current budgetary challenges are impacting each of these three legs of the funding stool. Representatives of North

Thus, at risk is far more than the federal funding alone. Declining federal funding for extension services and experiment stations has a cascading effect—negatively impacting the leveraging of federal funds with state and local matches. In addition, general budget crises in many states are leading state governors and legislatures to consider drastic cuts to funding of what they see as "discretionary programs" such as agricultural research and extension.

An Awareness Gap

As the lackluster economy puts a stranglehold on state budgets and officials search for places to make cuts, one target of the ax is agriculture programs, including Extension.

Some were potentially draconian. Michigan was threatened with a 44% cut in funding for Extension and research stations after narrowly escaping elimination through line item vetoes. In October, however, the governor approved a budget that included the programs.

Hembree Brandon
Delta Farm Press
February 4, 2010

In part it may be that agbioscience has been failing to communicate its collective relevance and importance. The public, media and political leaders inherently understand the importance of biomedical research to discovering new cures and treatments for disease and the impact this has on human lives, but may have less knowledge of the more complex relationship between the economy, environment and human health encompassed by agbioscience.

Table 5 illustrates national public opinion on the most important issues facing the U.S. and on the surface it may be thought that agriculture or agbiosciences are conspicuous by their absence. However, think more deeply and it is easy to see the relevance of agbioscience solutions and development opportunities to each issue.

Enhanced communications by America's land-grant universities may help to build further understanding among the general public and key constituencies, such as political leaders, regarding the central role of agbioscience in addressing the most pressing issues and challenges facing our nation and the planet.

The risk of not raising awareness, and making agbioscience a priority for the nation and states, is an erosion of financial support for experiment stations and extension. The federal government and individual states are clearly in an era of belt-tightening and almost all programs appear

to be at risk for funding cut-backs. Work performed by land-grant institutions in agbioscience can provide a substantial return on investment for funders—but that has to be consistently explained to key stakeholders and decision makers in order to sustain and grow agbiosciences funding. Independent research performed by Battelle in Nebraska and in Oklahoma found that the land-grant agbioscience complex in these states generated between a 15 to 1 and 25 to 1 return for state resources[26]. This high return is a message that must be communicated in order to sustain support.

Table 5: CNN/Opinion Research Corporation Poll for October 27-30, 2010 of U.S. Adults
(1,006 adults nationwide. Margin of error ± 3 points)

"Which of the following is the most important issue facing the country today: [see below]?"

Most Important Issue	Percent	Agbioscience Relevance ***(Not asked or cited in poll)***
The economy	52	Direct impact. Agriculture and the value-added food chain is an important part of the economy and national exports. Furthermore, emerging areas of agbioscience technology in biobased products, biofuels, advanced foods and nutrition etc. present significant economic development and job creation opportunities.
The federal budget deficit	8	Direct Impact. Agbioscience based economic development boosts business taxes and income taxes, while the U.S. throughout 2010 has enjoyed a positive balance of trade in the agriculture sector.
Education	8	Direct Impact. Extension programs, such as 4-H have a proven impact on youth educational attainment and school attendance. Extension is an important contributor to education programs in both urban and rural communities, while Land-grant universities provide direct higher education services.
Health care	8	Direct Impact. A well rounded diet with appropriate nutrition balance is critical to health. Agbiosciences directly address food safety, zoonotic disease monitoring and control, and a broad range of family and community health issues.
The wars in Iraq and Afghanistan	8	Indirect Impact. Agricultural productivity enhancement is considered by most development economists to be the fundamental building block of progress in developing economies. Achieving food security and enhanced rural community economics is fundamental to building prosperity and economic and social security in Iraq and Afghanistan.
Illegal immigration	8	Direct Impact. Much of the migration into the U.S. comes from the rural poor of Latin American nations. Work being undertaken in North Central Land-grant institutions in crops and agronomy improvements and value-added product development from agriculture is fundamental to improving living conditions in Central and South America and reducing the impetus for migration.

[26] Battelle Technology Partnership Practice research reports:
"*The Oklahoma State University Division of Agricultural Sciences and Natural Resources Agbiosciences Activities Deliver Positive Economic Benefits for Oklahoma*". March 2007
"*The University of Nebraska Institute if Agriculture and Natural Resources: A Generator of Positive Economic Impacts for Nebraska*". February 2007.

Terrorism	**4**	**Indirect Impact. Economic opportunity, jobs and rising incomes in developing countries are a deterrent to individuals becoming desperate and open to the influence of terrorist recruiters. US AID programs in rural and agricultural development, mostly coordinated via American land-grant universities through the CRSP program are enhancing rural economies and agriculture across the globe.**
Energy and environmental policies	4	Direct Impact. Biofuels are a renewable energy resource and part of the solution to the U.S. and World's energy challenge. Agbiosciences and associated disciplines are on the frontier of fighting environmental degradation and improved agricultural productivity is the only solution to pressures to clear marginal land for food production.
Other	1	

Standing Still is Not an Option

The United States is not alone in the pursuit of frontier science as a driver of economic and societal development. Traditional competitors in Europe are being joined by fast developing economies such as India, China and Korea that see the benefits of investing in scientific research and applied development projects—including agbioscience projects.

At stake is leadership in the areas of science and technology development, and technical education, most relevant to key global challenges—and, therefore, most likely to generate high demand and economic opportunities.

The National Academies[27] has sounded warning bells regarding U.S. funding for science and the preparedness of our education system to sustain a leadership position. With funding challenges coming across multiple fronts we have a system at risk—a system in which the U.S. currently has a leading position and tremendous potential opportunities, but one that can be rapidly eroded by foreign competitors if the U.S. fails to support the system and its key institutions.

In Conclusion

Agbiosciences represent an opportunity for the United States—an opportunity to expand on U.S. leadership in a biobased, sustainable resource-driven economy with wide ranging innovation and technology-based development opportunities. Within the U.S. the North Central region is a clear leader in agbiosciences and production within the agricultural value-chain, a position that is supported by the R&D and education activities of agricultural experiment stations, extension systems and their twelve land-grant universities. These

[27] National Academies. July 2008. *"Rising Above the Gathering Storm, Revisited: Rapidly Approaching a Category Five."* National Academies Press.

institutions should be considered priorities for further strategic investment and development given their importance in realizing the intrinsic growth potential of agbiosciences for the U.S. and regional economies.

Appendices

Appendix A.

Agbioscience Industry Employment in the North Central U.S.

Table A1. Agbioscience Industry Employment Metrics, North Central Region and U.S., 2009

Major Agbioscience Sector	2009 Establishments	2009 Employment	2009 Location Quotient	Percent Change Empl, 2001-07	Percent Change Empl, 2007-09	2009 Avg. Annual Wages
North Central Region						
Total Private Sector	**2,590,744**	**25,348,437**	**1.00**	**-0.8%**	**-6.6%**	**$ 40,516**
Total Agbioscience Sector	**890,504**	**2,345,205**	**1.25**	**-8.6%**	**-5.3%**	**$ 43,100**
Ag, Biological, & Medical Research, Testing, & Services	8,980	114,424	0.77	34.7%	0.4%	$ 53,871
Agricultural Processing	1,223	37,578	1.16	-5.1%	-7.9%	$ 52,434
Commodity Wholesaling & Storage Operations	4,583	63,275	2.08	0.8%	2.7%	$ 46,896
Food, Nutrition, & Health	8,344	486,009	1.28	-5.5%	-0.1%	$ 42,011
Industrial Products & Fuels	13,865	485,441	1.40	-13.9%	-18.2%	$ 45,814
Inputs to Production	9,858	160,566	2.10	-7.8%	0.8%	$ 53,370
Landscaping	23,123	133,476	0.87	16.2%	-7.4%	$ 28,661
Primary Production - Incorporated	17,728	161,791	0.61	8.0%	2.6%	$ 28,674
Primary Production - Unincorporated	802,800	702,643	1.59	-17.7%	-2.1%	n/a
United States						
Total Private Sector	**10,926,132**	**108,849,400**	**n/a**	**3.9%**	**-6.1%**	**$ 44,357**
Total Agbioscience Sector	**2,557,188**	**8,052,447**	**n/a**	**-5.6%**	**-6.4%**	**$ 42,028**
Ag, Biological, & Medical Research, Testing, & Services	40,664	638,572	n/a	41.0%	2.5%	$ 68,120
Agricultural Processing	4,587	138,585	n/a	-10.9%	-15.6%	$ 45,778
Commodity Wholesaling & Storage Operations	8,354	130,472	n/a	1.0%	0.7%	$ 43,052
Food, Nutrition, & Health	33,359	1,624,982	n/a	-4.0%	-2.1%	$ 41,628
Industrial Products & Fuels	50,296	1,493,942	n/a	-15.7%	-20.3%	$ 46,746
Inputs to Production	23,007	328,701	n/a	-6.7%	-4.1%	$ 51,237
Landscaping	104,239	660,132	n/a	25.6%	-10.3%	$ 29,343
Primary Production - Incorporated	92,672	1,134,061	n/a	-0.1%	-2.1%	$ 25,830
Primary Production - Unincorporated	2,200,010	1,903,000	n/a	-16.6%	-0.6%	n/a

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN; unincorporated farm employment from BEA.

- The agbioscience industry employed 2.35 million across nearly 88,000 individual private sector establishments and more than 800,000 unincorporated farms in the North Central Region in 2009. This represents a highly concentrated and specialized regional industry cluster in the region relative to the nation with a location quotient of 1.25 or 25 percent greater employment concentration compared with the national average. Location Quotients (LQs) measure the degree of job concentration within the region relative to the nation.[28]
- The 12-state region has varied specializations across its major agbioscience industry subsectors in what is truly a broad cluster of industries. Five of the nine major component subsectors are considered specialized and leading in this region, including: inputs to production (LQ is 2.10);

[28] Location quotients (LQs) are a standard measure of the concentration of a particular industry in a region relative to the nation. The LQ is the share of total state or regional employment in the particular industry divided by the share of total industry employment in the nation. An LQ greater than 1.0 for a particular industry indicates that the region has a greater relative concentration, whereas an LQ less than 1.0 signifies a relative underrepresentation. An LQ greater than 1.20 denotes employment concentration significantly above the national average. In this analysis, regional specializations are defined by LQs of 1.20 or greater.

commodity wholesaling and storage (LQ is 2.08); primary agricultural production, unincorporated (LQ is 1.59); industrial products and fuels (LQ is 1.40); and food, nutrition, and health (LQ is 1.28). A sixth subsector, agricultural processing, is highly concentrated and nearly specialized with a LQ of 1.16 in 2009.

- Workers in the North Central agbioscience sector are paid about $2,600 more per year or 6 percent compared with their counterparts in the overall private sector. This wage premium for regional agbioscience workers is unlike the national sector where workers earn less, on average, compared with the private sector. This different wage relationship in the region likely represents a greater degree of value-added activities in the region and/or a more intensive concentration of high-skilled occupations within the regional sector.

Figure A1. Employment Composition of the North Central Agbioscience Sector, 2009

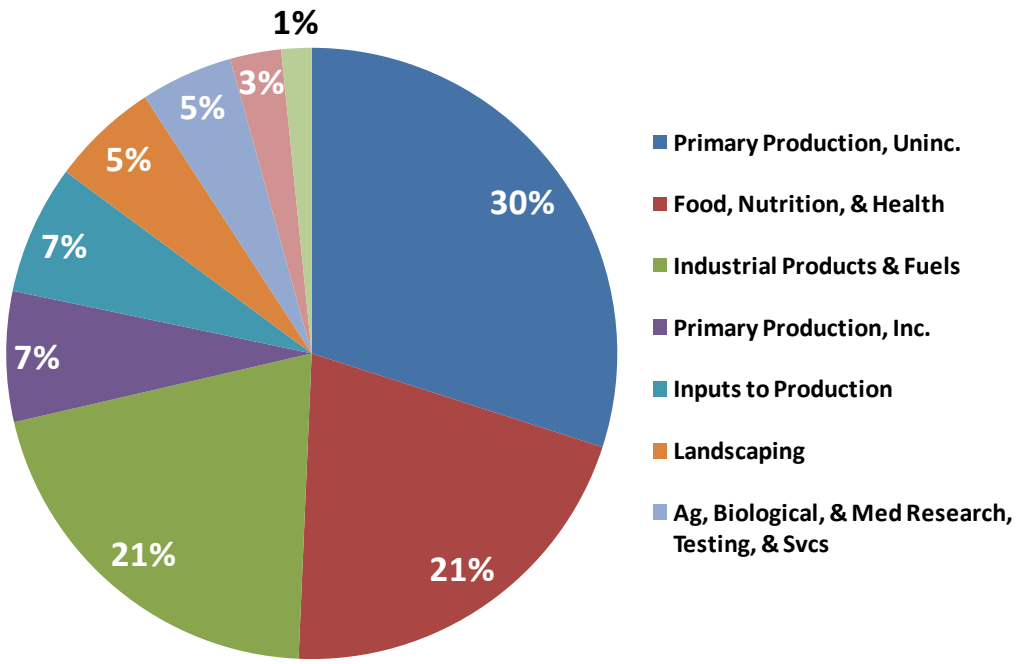
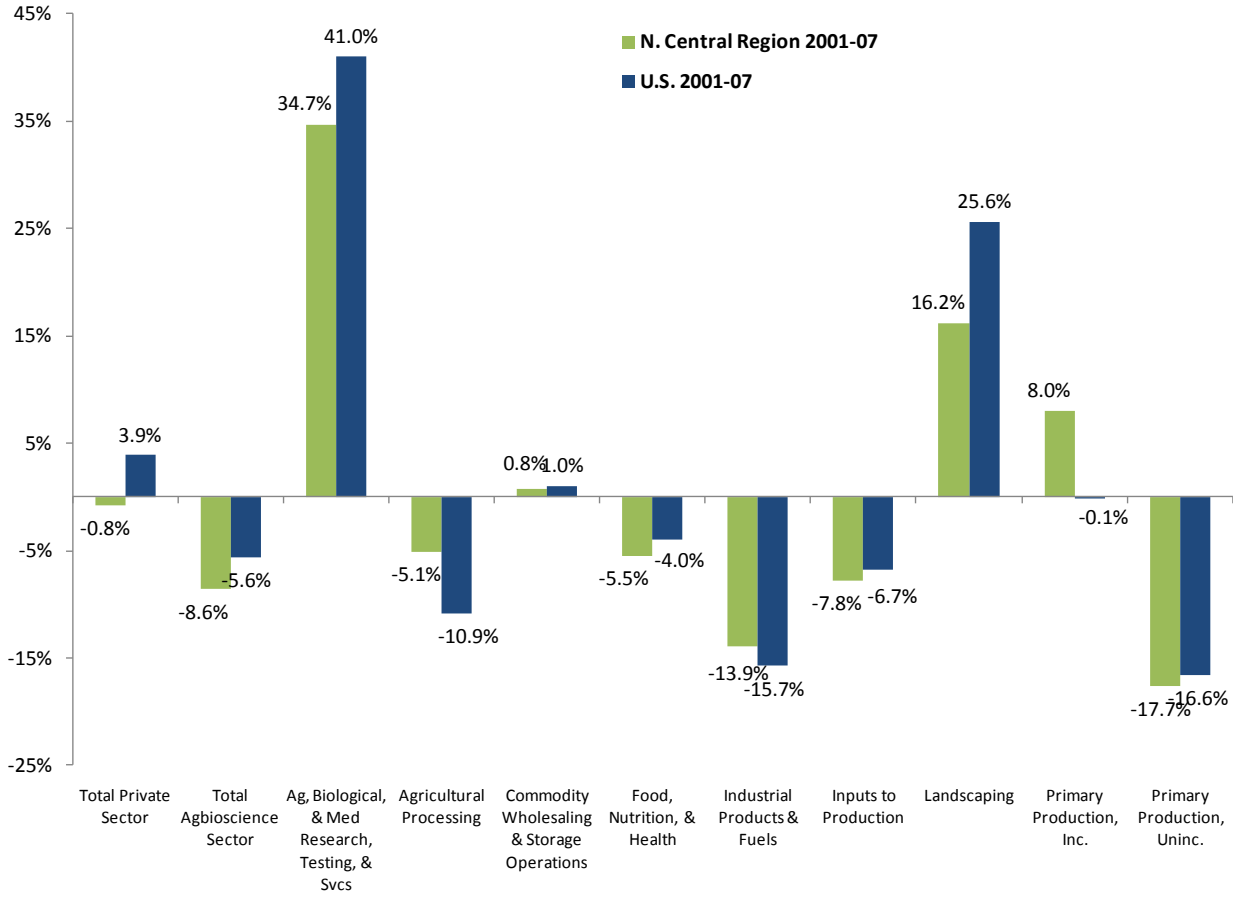
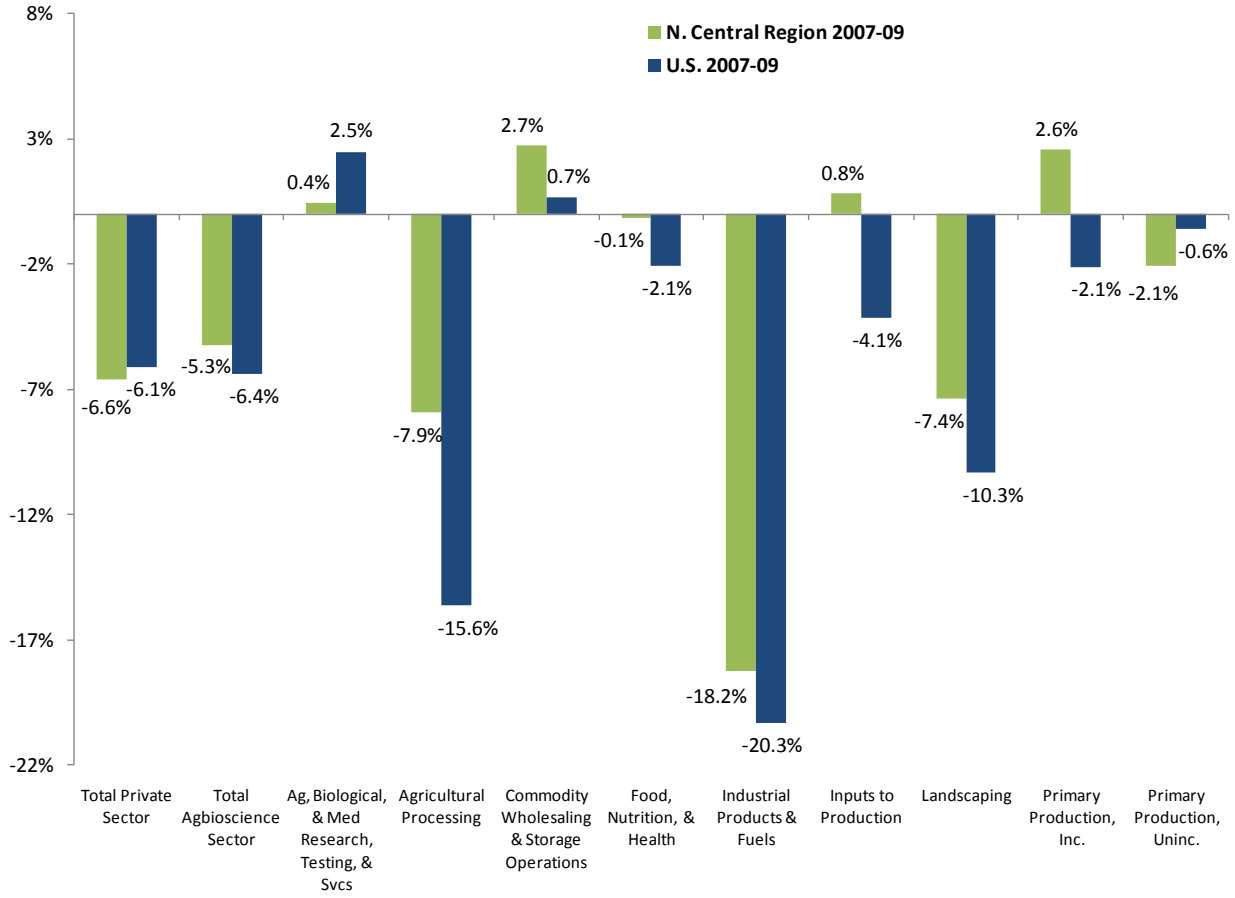


Figure A2. Employment Trends over the Previous Full Business Cycle, 2001-07



- During the previous business cycle, overall private sector growth in the North Central region contracted while the national private sector grew (-0.8% vs. 3.9%, respectively). Regional employment in the agbiosciences also contracted and at a rate faster than the nation (-8.6% vs. -5.6%).
- The North Central region, as a national leader in the agbiosciences and in agricultural production, has largely driven national trends which can be seen in the chart on employment changes. One exception is within incorporated primary agricultural production, where during the 2001 through 2007 period it grew in the 12-state region by a rapid 8.0% while the national sector remained essentially unchanged.
- Key job growth drivers in the agbiosciences include the major research and testing subsector, landscaping, and incorporated agricultural production.

Figure A3. Employment Trends over the Recent Recession, 2007–09



- The recent recession, which began in late 2007, had a major negative impact on the U.S. labor market overall, the affects of which continue to be felt.
- Over the 2-year recessionary period, the North Central private sector and the U.S. had similar employment declines in both the overall private sector and the agbiosciences.
- Despite the recession, however, the 12-state region experienced job gains in four of the nine major agbioscience subsectors—commodity wholesaling and storage (up 2.7%); incorporated ag production (up 2.6%); inputs to production (up 0.8%); and ag, biological and medical research, testing, and services (up 0.4%).

Appendix B.

Agbioscience Academic R&D in the North Central Region

Figure B1: Agbioscience Academic R&D Expenditures, FY 2009

Academic R&D Expenditures in the North Central Region & U.S., FY 2009 ($ in Thousands)								
State	Bio/Biomedical Engineering	Chemical Engineering	Chemistry	Agricultural Sciences	Biological Sciences	Agbio Total	Agbio Share of Total R&D	Total Academic R&D
IA	$563	$5,951	$11,625	$54,606	$117,364	$190,109	33.8%	$562,569
IL	$24,841	$21,198	$88,815	$97,251	$441,168	$673,273	31.9%	$2,113,124
IN	$15,614	$10,224	$52,691	$111,610	$151,483	$341,622	34.0%	$1,005,216
KS	$828	$9,957	$15,899	$59,190	$130,076	$215,950	48.9%	$441,321
MI	$20,746	$31,014	$43,756	$98,574	$287,180	$481,270	27.6%	$1,742,051
MN	$13,797	$9,204	$14,045	$76,010	$108,110	$221,166	29.2%	$757,745
MO	$9,966	$2,898	$20,426	$69,864	$252,107	$355,261	35.2%	$1,008,901
ND	$0	$1,966	$6,684	$54,162	$3,470	$66,282	35.7%	$185,708
NE	$3,682	$7,580	$6,129	$59,455	$123,543	$200,389	50.9%	$393,611
OH	$21,978	$54,973	$51,872	$64,321	$291,764	$484,908	25.6%	$1,895,074
SD	$418	$2,111	$5,817	$28,166	$19,195	$55,707	54.5%	$102,299
WI	$6,125	$9,677	$26,884	$47,370	$276,996	$367,052	30.5%	$1,203,919
North Central Region	**$118,558**	**$166,753**	**$344,643**	**$820,579**	**$2,202,456**	**$3,652,989**	**32.0%**	**$11,411,538**
U.S. Total	**$650,108**	**$695,404**	**$1,589,329**	**$3,057,451**	**$10,152,632**	**$16,144,924**	**29.4%**	**$54,935,457**

Source: National Science Foundation Survey of R&D Expenditures at Universities and Colleges, 2009

- Agbioscience R&D at North Central Region academic institutions is highly concentrated. In 2009, agbioscience-related R&D in the North Central Region comprised 32.0 percent of all academic R&D compared to 29.4 percent nationally.

- Among the states in this region, Illinois was a clear leader in agbioscience academic R&D expenditures with over $670 million; Ohio and Michigan also had substantial agbioscience-related R&D activity, each having spent more than $480 million in 2009.

- In Kansas, Nebraska, and South Dakota agbioscience-related academic R&D accounts for around half of all academic R&D expenditures.

- Of the agbioscience academic R&D categories, Agricultural Sciences had the second largest expenditures nationally with over $3 billion (Biological Sciences was the leader with $10 billion); the pattern is the same in the North Central Region.

Figure B2: Trends in Agbioscience Academic R&D Expenditures, FY 2000–09

Nominal Change in Agbioscience-related Academic R&D in the North Central Region & U.S.						
State	FY 2000 AgBio Total	FY 2004 AgBio Total	FY 2009 AgBio Total	Change 2000-04	Change 2004-09	Change 2000-09
IA	$133,345	$170,744	$190,109	28.0%	11.3%	42.6%
IL	$349,362	$497,964	$673,273	42.5%	35.2%	92.7%
IN	$183,819	$306,258	$341,622	66.6%	11.5%	85.8%
KS	$122,113	$169,042	$215,950	38.4%	27.7%	76.8%
MI	$270,235	$382,145	$481,270	41.4%	25.9%	78.1%
MN	$134,331	$151,799	$221,166	13.0%	45.7%	64.6%
MO	$275,400	$346,300	$355,261	25.7%	2.6%	29.0%
ND	$39,709	$61,415	$66,282	54.7%	7.9%	66.9%
NE	$113,249	$170,636	$200,389	50.7%	17.4%	76.9%
OH	$287,888	$417,642	$484,908	45.1%	16.1%	68.4%
SD	$14,205	$23,615	$55,707	66.2%	135.9%	292.2%
WI	$218,932	$282,438	$367,052	29.0%	30.0%	67.7%
North Central Region	**$2,142,588**	**$2,979,998**	**$3,652,989**	**39.1%**	**22.6%**	**70.5%**
U.S. Total	**$9,293,118**	**$12,715,352**	**$16,144,924**	**36.8%**	**27.0%**	**73.7%**

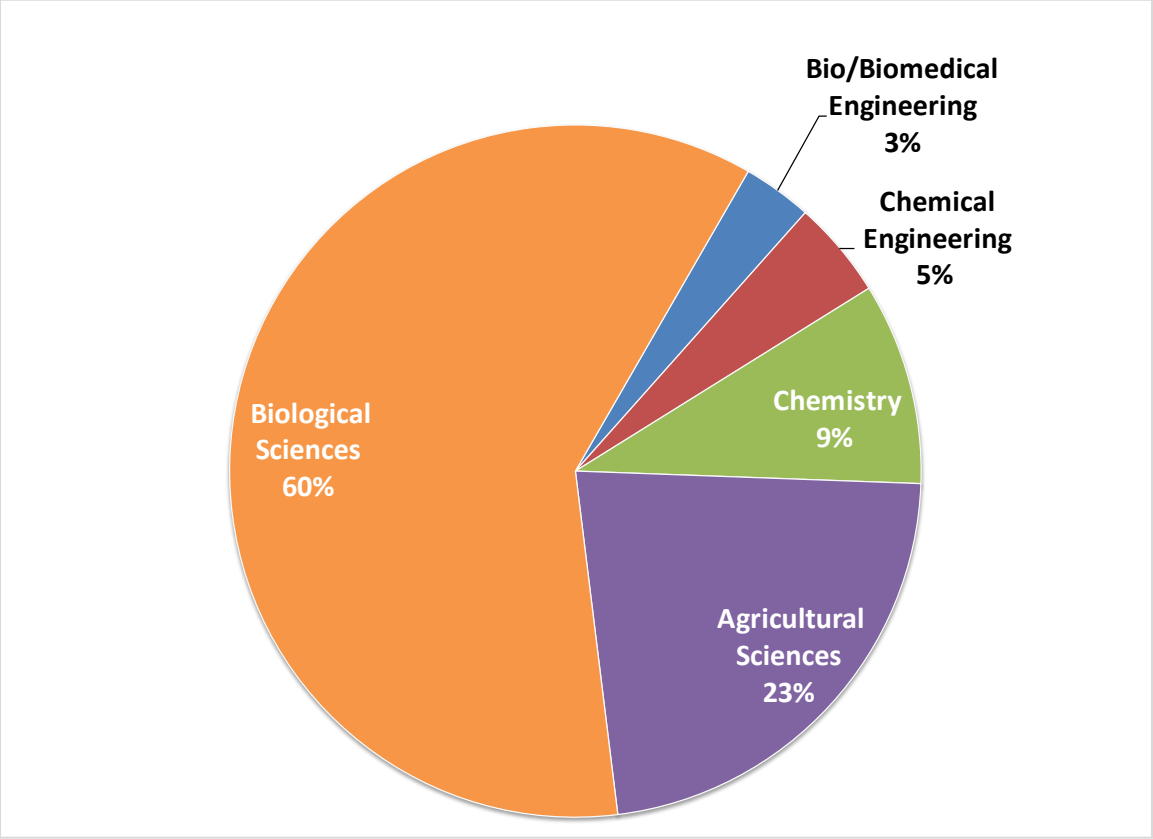
Source: National Science Foundation Survey of R&D Expenditures at Universities and Colleges, 2009

- Despite the high concentration of agbioscience-related R&D in the region, overall growth in agbioscience academic R&D between 2000 and 2009 in the North Central Region remained just below that for the nation (NC Region=70.5 percent; US=73.7 percent).

- All 12 states in the North Central Region have grown their agbioscience-related academic R&D between 2000 and 2009; though some more significantly than others. Among those with at least $100 million in R&D in 2000, 6 states outpaced U.S. growth.

- Between 2000 and 2004, growth in agbioscience R&D in the North Central Region exceeded the nation by more than 2 percentage points. However, the period from 2004–2009 saw rapid deceleration in growth with agbioscience R&D expenditures in the North Central Region dipping below the U.S. average.

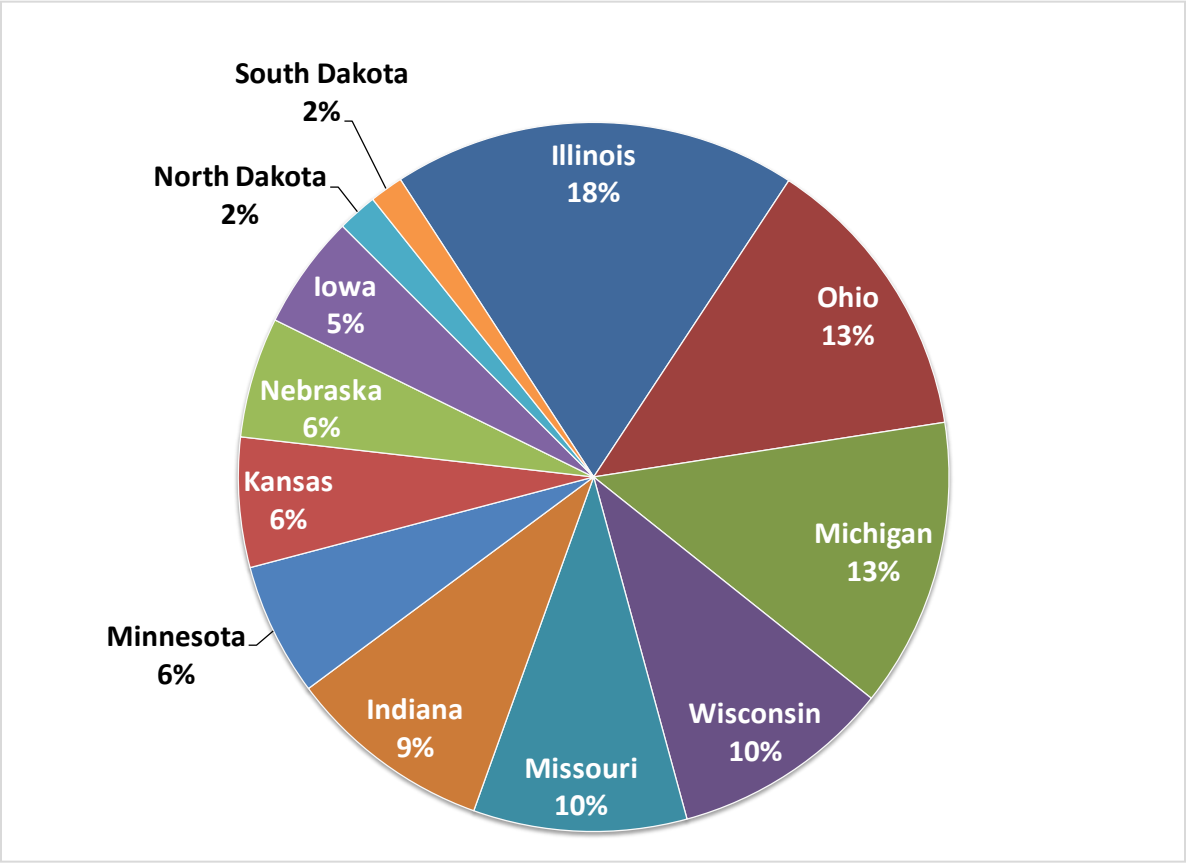
Figure B3: North Central Region Agbioscience Academic R&D Expenditures by Field, FY 2009



Source: National Science Foundation Survey of R&D Expenditures at Universities and Colleges, 2009

- The majority of agbioscience-related academic R&D in the North Central Region is in Biological Sciences (60%; $2.2 billion). This is similar to the national composition/share (63%).
- Agricultural Sciences accounts for 23 percent of agbioscience-related academic R&D in 2009 at $820 million, again similar to the U.S. share (19%).
- Chemistry, Chemical Engineering and Bio/Biomedical Engineering each account for less than 10% of academic R&D expenditures in agbioscience-related categories.

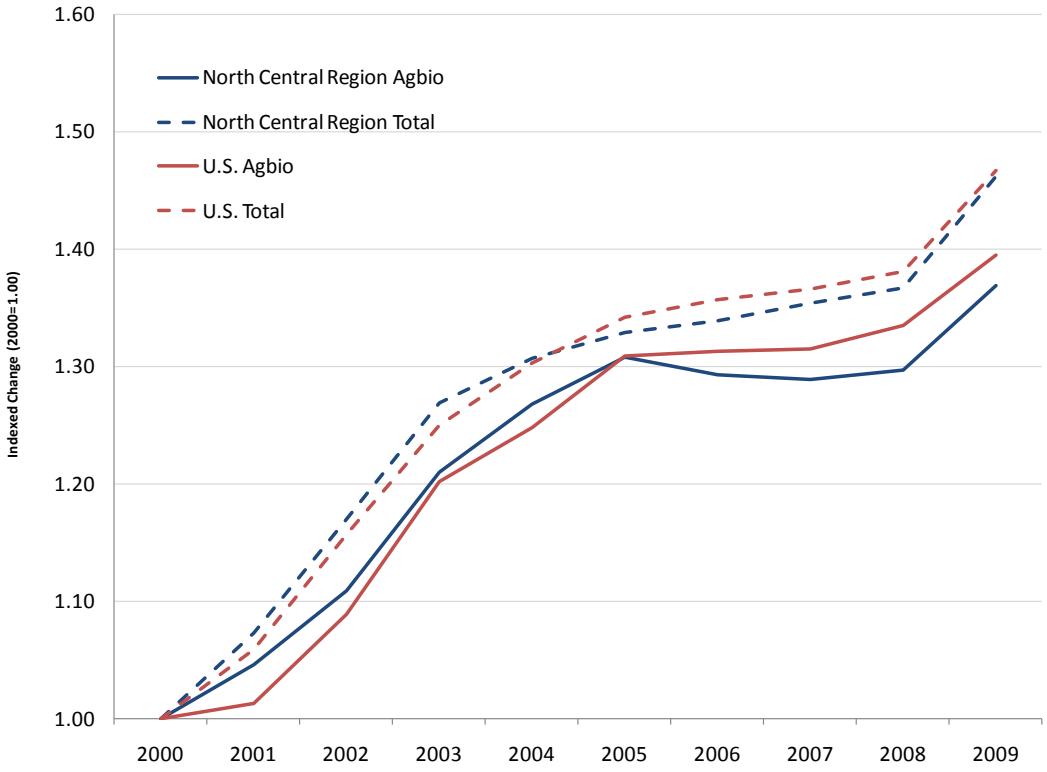
Figure B4: North Central Region Agbioscience-related Academic R&D by State, FY 2009



Source: National Science Source: Foundation Survey of R&D Expenditures at Universities and Colleges, 2009

- Illinois has the largest proportion (18%) of agbioscience-related academic R&D Expenditures among the 12 North Central Region states.
- Ohio (13%), Michigan (13%), Wisconsin (10%) and Missouri (10 %) also represent a significant share of regional academic R&D expenditures in the agbiosciences.
- North Dakota and South Dakota have the fewest agbioscience academic R&D expenditures, each with 2% of the North Central Region's total expenditures.

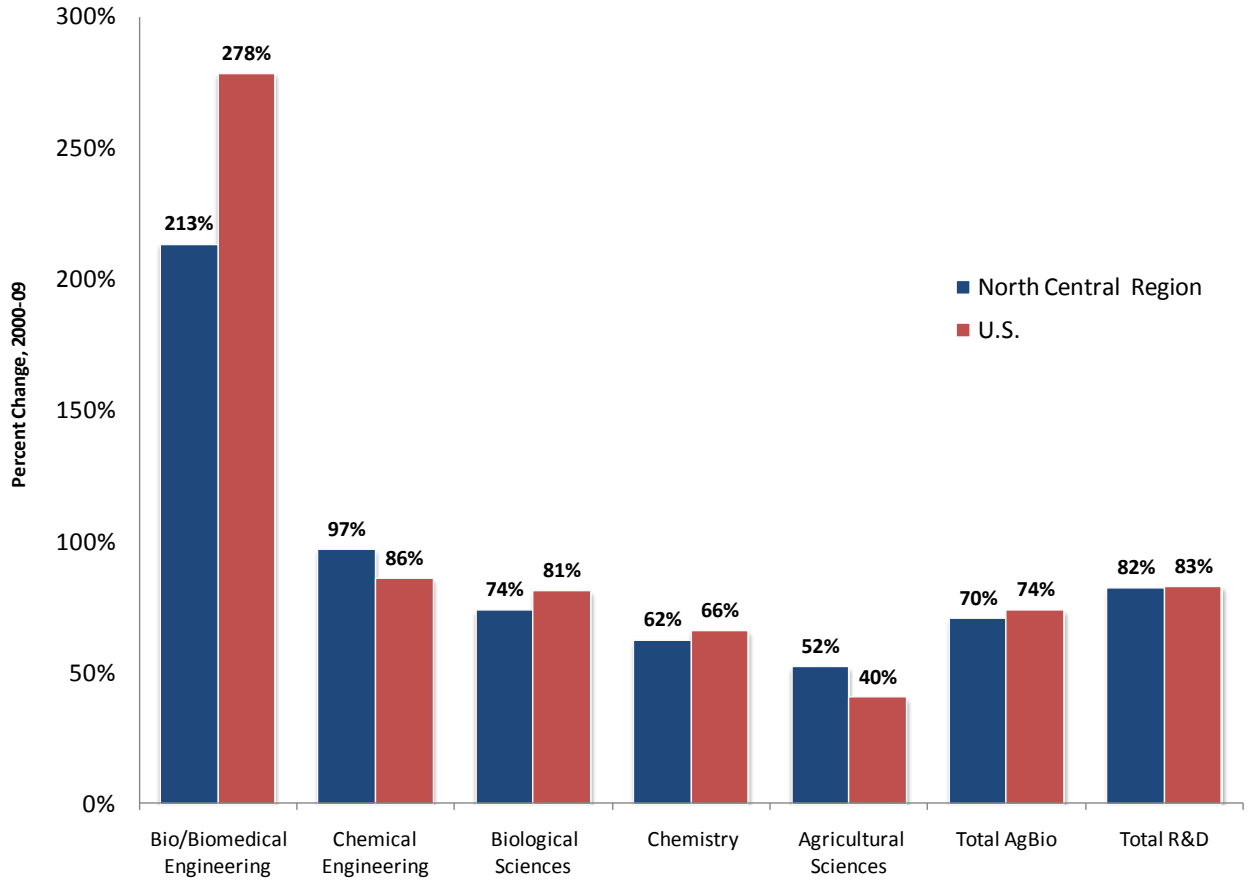
Figure B5: Change in Real Academic R&D Expenditures in the North Central Region & U.S., 2000–09



Note: R&D expenditures adjusted for inflation using the CPI-U from the U.S. Bureau of Labor Statistics
Source: National Science Source: Foundation Survey of R&D Expenditures at Universities and Colleges, 2009

- In both the North Central Region and the U.S., growth in total academic R&D expenditures has exceeded that of agbioscience-related R&D expenditures over the last decade.
- In general, the regional growth trend has largely tracked that of the U.S., although in recent years it has flipped. From 2000–2005, growth in Total R&D expenditures in the North Central Region exceeded the national average; since 2005 the North Central Region's growth has been below the U.S.
- Growth patterns for agbioscience-related R&D closely follow Total R&D pattern; however, the difference in North Central Region and U.S. agbioscience growth rates were more pronounced than for total academic R&D expenditures from 2005–2009.

Figure B6: Nominal Change in Academic R&D in the North Central Region and U.S. by Category, 2000–09



Source: National Science Source: Foundation Survey of R&D Expenditures at Universities and Colleges, 2009

- While growth in total academic R&D expenditures in the North Central Region over the last decade was on par with the nation, growth in total agbioscience-related R&D expenditures has lagged slightly (4% below the national average by 2009).
- The North Central Region experienced substantial growth in Chemical Engineering and Agricultural Sciences compared to the U.S. with growth rates in Chemical Engineering and Agricultural Sciences more than 10% greater than those for the U.S.
- Despite significant growth in Bio/Biomedical Engineering R&D (though expenditures in this field represent the smallest base), the North Central Region did not achieve the same level of growth as the nation (213% vs. 278%**).**

Appendix C.

Background on Land-grant Universities, Extension Services and Experiment Stations

1890 and 1994 Land-grant Universities

In addition to the 1862 Land-grant Universities, the land-grant system also includes 1890 and 1994 Land-grant Universities and Institutions, which were established to serve the African American and Native American communities. Close collaboration between Land-grants—like that between Lincoln University of Missouri and the University of Missouri—has helped link underserved populations with important agricultural research, discoveries, technologies and educational resources.

The 1890 Land-grant Universities are a robust network of 18 colleges and universities, primarily in the Southern United States, started as a result of the Second Morrill Act in 1890 which allowed African Americans to attend Land-grant Universities. Lincoln University of Missouri (in Jefferson City) was founded in 1866 for the benefit of freed African Americans. The school continues its tradition of inclusion and diversity today, through numerous programs reaching underserved audiences, assisting limited resource and small scale farmers, and increasing technology transfer to small farmers around the world. In 1972 the University of Missouri and Lincoln University established a unified extension program —the first such partnership between two state land-grant universities. The relationship has enabled greater technical assistance for families on small farms and leadership education for African-American youths.

The 1994 Land-grant Institutions are Native American tribally-controlled colleges and universities that were given land-grant status by Congress in 1994. These institutions primarily serve Native American populations that are typically located in remote, underserved communities. These institutions use a variety of tools including distance education and culturally relevant curriculum to reach a population that is geographically isolated and has no other means of higher education beyond high school. Over half of the thirty-three 1994 land-grants are located in the North Central region—in North and South Dakota, Minnesota, Wisconsin, Kansas and Nebraska.

Agricultural Experiment Stations

The Agricultural Experiment Station is a research center that conducts scientific investigations to address agronomic, biological, economic and social challenges in the U.S. food and agriculture system. Each state has at least one main experiment station, but often several other branch stations, which are administered by the state land-grant universities. Most experiment station scientists are also faculty members of their state's Land-grant university.

Research at these experiment stations covers a number of areas, including: agricultural systems, plants, animals, biotechnology and genomics, food, nutrition and health, natural resources, and international trade, markets and policy. Research may be basic or applied. Basic research discovers the underlying

processes and systems that make a plant, animal, ecosystem, food system, community or marketplace work. For example, basic research might discover the genetic map of the soybean.

Applied research expands on basic research findings to uncover practical ways that new knowledge can be advanced to the benefit of farmers, ranchers, suppliers, processors, consumers and communities. For example, researchers can use the genetic map of the soybean to develop new traits for making the soybean more drought resistant.

Experiment station scientists often collaborate with farmers, ranchers, seed producers, suppliers, processors and other stakeholders in the agriculture community. They also work closely with Agricultural Extension Services—specialists who help inform and educate members of rural and urban communities about new developments in food and agriculture. Research at the Experiment Stations may be conducted individually or in collaboration with researchers at other universities across several states or regions that share climate, soil, market outlets, and other conditions.

Federal and state governments provide funding for the research conducted at these stations, with the federal money administered through the USDA National Institute of Food and Agriculture (NIFA). Additional income is received from grants, contracts and the sale of products.

National Institute of Food and Agriculture (NIFA) supports the base programs of state Agricultural Experiment Stations and Extension Services at land-grant universities. NIFA administers federal appropriations through three funding mechanisms: Competitive Grants, Formula Grants and Non-competitive Grant Programs.

Agricultural Extension Services

Agricultural Extension Services help address community needs through informational and educational programs based on the basic and applied research discoveries made by Experiment Station scientists. Extension Service providers collaborate with farmers, seed companies, processors, manufacturers, small businesses and others in rural and urban areas.

Extension work on agriculture includes the development of research and educational programs to help individuals learn new ways to produce income through alternative enterprises, improved marketing strategies, and management skills. Programs are also designed to help farmers and ranchers improve productivity through resource management, pest management, soil testing, livestock production practices and marketing. In addition to the focus on agriculture, Extension Services also focuses on 4-H Youth Development, Leadership Development, Natural Resources, Family and Consumer Sciences, and Community and Economic Development.

The National eXtension Initiative has created a website (referred to as “eXtension”) to help researchers and extension service personnel exchange knowledge and reach a much broader audience in the community. The eXtension website provides credible expertise, field-tested data, unbiased research,

and dependable solutions to myriad and complex challenges for farmers, families, small businesses and others.

Extension Service Programs are administered through county and regional offices connected to the state Land-grant university. In fact local extension service offices are open in practically every county in the United States. Extension service offices are supported by the USDA National Institute of Food and Agriculture (NIFA), which distributes annual Congressional appropriated formula grants to supplement state and county funds.

Appendix D.

Compilation of Information Supplied by Individual Institutions[29]

Full-Time Equivalent Figures

	Extension	Experiment Station
2006	7921	6909
2007	8052	6836
2008	7991	6860
2009	7890	6730
2010	7601	6724
5-yr Change	-320	-185
% Change from '06-10	-4.04%	-2.68%

Budget Total – Extension Service Programs

	TOTAL ($ in millions)				
	Federal	State	County	Other (e.g. grants)	Total
2006	105.47	237.13	176.88	126.14	644.63
2007	109.52	244.83	180.21	137.19	671.71
2008	108.37	253.03	183.82	151.89	697.11
2009	110.09	254.67	182.94	155.77	703.47
2010	114.26	245.70	177.63	161.60	699.19
Annual Growth (Inflation-adjusted	-0.94%	-1.99%	-2.69%	3.46%	-0.91%

Budget Total – Experiment Station Programs

	TOTAL ($ in millions)			
	Federal	State	Other (e.g. grants)	Total
2006	151.49	321.93	382.79	856.2
2007	155.47	327.67	380.84	863.98
2008	151.93	342.92	406.53	901.38
2009	168.96	346.99	423.08	939.03
2010	167.46	339.57	448.65	955.67
Annual Growth (Inflation-adjusted @ 3%)	-0.45%	-1.57%	1.03%	-0.21%

[29] Data for Appendix D were provided directly by the 12 participating universities. Universities varied in the degree of detail provided and this variation is reflected in the amount of information listed under each university. Battelle did not independently verify these data.

Intellectual Property

		2006	2007	2008	2009	2010	5-Yr TOTAL
TOTALS	Invention disclosures	238	264	182	206	192	**1851**
	Patents applied for	239	231	221	200	140	**1396**
	Patents awarded	77	107	96	105	98	**551**
	Licenses executed	112	157	147	147	128	**978**

Experiment Stations

School	# Experiment Station	Acres	Counties
Ohio State University	11	6,351	Ashtabula, Clark, Coshocton, Franklin, Huron, Jackson, Noble, Pike, Sandusky, Wayne, Wood
North Dakota State University	9	22,380	Fargo (main station on campus), Casselton, Carrington, Streeter, Dickinson, Hettinger, Langdon, Minot, Williston
Michigan State University	15	18,980	Ionia, Chippewa, Ingham, Delta, Barry (2 stations), Missaukee, Montcalm, Clinton, Leelanau, Van Buren, Tuscola, Berrien, Allegan, Alger
Iowa State Unviersity	20	15,698	Boone (multiple stations), Buena Vista, Pottawattamie, Delaware, Story (multile stations), Lucas, Muscatine, Adair, Floyd, Hancock, O'Brien, Washington, Monona
University of Nebraska	21	40,000	Scottsbluff, Lincoln, Madison, Saunders (multiple stations), Cheyenne, Grant, Hooker (2 stations), Cherry, Keith
University of Wisconsin	11	7,613	Columbia, Dane, Door, Grant, Oneida, Sauk, Washburn, Waushura, Wood, Marathon
University of Illinois	7	2,378	Fayette, Champaign, Pope, Dekalb, Warren, Pike, Kane
Kansas State University	6	21,991	Riley, Johnson, Haskell, Sedgwick, Butler, Ellis, Trego, Finney, Greeley, Thomas, Labette and Cherokee
University of Missouri	20	14,500	Gentry, Atchison, Holt, Grundy, Linn, Knox, Howard, Crawford, Lawrence, Butler, Pemiscot, Boone (2 stations)
University of Minnesota	9	16,724	Polk, Itasca, Carlton, Ramsey, Dakota, Carver, Waseca, Redwood, Stevens
Purdue University	11	9,512	Lawrence, Tippecanoe, La Porte, Whiley, Randolph, Jennings, Knox, and Dubois
South Dakota State University	9		South Shore, Beresford, Brookings, Highmore, Miller, Pierre, Cottonwood, Wall, and Antelope
TOTAL	**149**	**176,127**	

Number of People Reached by Extension Services

Incomplete table (not every school provided information useful for this table)

School	Number of People Reached
Ohio State University	
North Dakota State University	
Michigan State University	300,000 to 500,000
Iowa State University	1,168,988
University of Nebraska	1,105,903 including duplicates (400,000 non-duplicated)
University of Wisconsin	
University of Illinois	
Kansas State University	1,116,617
University of Missouri	Direct contact = 575,259; Indirect = 507,411; Total = 1,082,670
University of Minnesota	
Purdue University	1,300,000
South Dakota State University	

Key Centers, Institutes, Programs or Initiatives

Ohio State University

1. ***Food and Agricultural Technology Commercialization and Economic Development Program (ATECH)*** – links College of Food, Ag and Enviro Science (CFAES) research, outreach, and engagement with private sector firms to develop commercialization opportunities through sponsored research and business development activities
2. ***Extension Advanced Energy Network*** – provides linkages with Extension research and outreach for renewable energy; assist local governments to assess the potential energy based economic development within their community through evaluation of different activities
3. ***Collaboration with Ohio BioProducts Innovation Center*** – Extension outreach and project development for biodigester facilities for public and private sector
4. ***Educational and applied research assistance to SE Ohio Solid Biofuel Working Group*** – potential development of forest and crop production as biomass feedstock for coal-fired plant conversion to biomass
5. ***Increasing Profitable Yields above Trend Line (signature program of Ag and Natural Resources)*** – Multi-system approach to incorporate technology, genetics and information into plant production systems to increase productivity to meet food, feed, fiber and industrial demand for Ohio crops
6. ***Food Security, Production and Human Health***
7. ***Advance Bioenergy and Biobased Products***
8. ***Environmental Quality and Sustainability***
9. ***ATECH, Commercialization and economic development***

North Dakota State University

1. ***BioEnergy and Product Innovation Center (BioEPIC)*** – identify and enhance opportunities for expanding North Dakota's role in producing renewable energy and bioproducts, efficiently using energy, and maintaining a sustainable healthy environment; includes biomass production, harvesting, transportation

and development of technologies, products and processing to utilize biomass and other biological feedstocks; helps communities become sustainable through the production of renewable energy and biobased products; provide economic, marketing and feasibility studies to help individuals and industry adopt energy-efficient strategies

2. ***Center for Agricultural Policy and Trade Studies (CAPTS)*** – to enhance net farm income through in-depth trade and agricultural policy research for crop producers, ranchers and decision makers; includes examination of economics of bio-energy
3. ***Northern Crops Institute (NCI)*** – international meeting/learning center and collaborative effort among North Dakota, Minnesota, Montana and South Dakota to support promotion and market development of crops grown in this region
4. ***Oilseed Development Center of Excellence (ODCE)*** – facilitate the long-term development of oilseed agriculture in North Dakota, and establish ongoing multi-disciplinary research and outreach to facilitate commercialization of agricultural technology in North Dakota; focuses on commercial issues and facilitating the final stages of commercialization of traits in grains and oilseeds for food and non-food uses; goal of encouraging private sector investment to increase farm incomes; focus on - trait development and commercialization, outreach for producers and consumers, economic modeling and policy analysis
5. ***Quentin N Burdick Center for Cooperatives*** – strengthen cooperatives in order to expand employment and economic opportunities

Michigan State University

1. ***Project GREEEN*** – collaborative effort by plant-based commodities and businesses in cooperation with the Michigan Agricultural Experiment Station (MAES), MSU Extension, and the Michigan Department of Agriculture (MDA) to advance Michigan's economy through its plant-based agriculture. Its mission is to develop research and educational programs, ensure and improve food safety, and protect and preserve the quality of the environment
2. ***MSU Product Center*** - help develop and commercialize high value, consumer-responsive products and businesses in the agriculture and natural resource sectors
3. ***Great Lakes Bioenergy Research Center*** - to perform the basic research that generates technology to convert cellulosic biomass to ethanol and other advanced biofuels (funded by Dept of Energy as one of the DOE Bioenergy Research Centers)
4. ***Long-Term Ecological Research Project***
5. ***Land Policy Institute***

Iowa State University

1. ***Center for Plant Responses to Environmental Stresses*** – seeks fundamental information on the ways plants respond to environmental stresses and how they can be modified to tolerate those stresses
2. ***Center for Agricultural and Rural Development (CARD)*** – the go to economic and policy analysis research entity with ISU; clients include US Congress, USDA, Federal Administration, ag groups, and int'l entities
3. ***Center for Integrated Animal Genomics (CIAG)*** – uses integrated systems-wide genomics approaches to address current and future challenges and opportunities in animal agriculture and health
4. ***Ag Marketing Resource Center*** – partnership with UC-Davis and Kansas State; internet site provides relevant info to farmers and agribiz involved in value-added agriculture

University of Missouri

1. **Missouri 4-H Center for Youth Development Center:** The Centers mission is to create environments in which young people acquire knowledge, develop life skills and form attitudes that will enable them to become self-directed, productive members of society. The Center accomplishes this mission by providing formal and non-formal research-based, community-focused experiential learning; youth and adult leadership development experiences; and partnerships for programming and funding.
2. **Interdisciplinary Plant Group:** The IPG is a community of MU faculty, students, and professionals who are pursuing novel, creative, and transformative ideas in the field of plant biology from a range of scientific disciplines. Established in 1981, the IPG provides a supportive, open, and flexible research

environment that transcends traditional departmental boundaries, facilitates the sharing of ideas and resources, and creates opportunities for interdisciplinary collaborations. The IPG is comprised of 51 faculty-led research teams, representing the divisions of Biochemistry, Biological Sciences, and Plant Sciences and the departments of Forestry and Computer Science.

3. **Food and Agricultural Policy Research Institute (FAPRI)**: Since its inception in 1984, FAPRI has encouraged effective agricultural policy through the development and operation of comprehensive analytical systems. These systems focus on the food and agricultural industries and impact on the economy and environment. FAPRI-Missouri works closely with its affiliate unit, located at Iowa State University. Other research partners in the FAPRI consortium are at Texas A&M University, the University of Arkansas, Arizona State University and Texas Tech University.
4. **Office of Social and Economic Data Analysis (OSEDA):** OSEDA is a policy analysis program of the Division of Applied Social Sciences and MU Extension. OSEDA collaborates closely with Missouri state agencies to conduct research and demonstration projects in public education, health, economic development and demographic analysis. OSEDA uses an extensive electronic data archive to produce reports and applications that foster program planning and improvement. OSEDA draws from U.S. Census Bureau data, and many other sources, to provide comprehensive, impartial analyses on an enormous range of demographic-related issues.
5. **Center for Agroforestry:** The University of Missouri Center for Agroforestry (UMCA), established in 1998, is one of the world's leading centers contributing to the science underlying agroforestry. Interdisciplinary collaboration is one of the outstanding hallmarks of the Center. Research on the benefits of agroforestry is supported from a broad spectrum of disciplines: forestry, fisheries and wildlife, entomology, plant pathology, agronomy, animal science, horticulture, soils, atmospheric science, agricultural economics and rural sociology. Linked with the Center's solid science and research programs are several key collaborations and partnerships with landowners, natural resource professionals, federal and state agencies and non-profit organizations. Through these critical relationships, UMCA and its partners are producing an expanding list of positive outcomes for landowners, the natural environment and society as a whole.
6. **Food and Agricultural Policy Research Institute**
7. **Rural Policy Research Institute**
8. **Institute for Continental Climate Viticulture and Enology**
9. **Center for Applied research and Environmental Systems**
10. **National Center for Soybean Biotechnology**
11. **National Swine Resource and Research Center**
12. **Missouri Maize Center**
13. **Community Policy Analysis Center**
14. **Economics and Management of Agrobiotechnology Center**
15. **Missouri Value Added Center**

University of Nebraska

1. Sustainable animal production systems
2. Resource stewardship for a secure future
3. Crops for the future
4. Functional foods and healthier humans
5. Leaders for the next generation

University of Wisconsin

1. ***Great Lakes Bioenergy Research Center (GLBRC)*** is a consortium of universities, government laboratories and businesses led by the University of Wisconsin-Madison to explore the vast potential of bioenergy, with funding provided by the Department of Energy. GLBRC also connects to the Wisconsin Bioenergy Initiative (WBI), a multi-disciplinary effort focused on a range of bioenenergy research and development issues. The WBI is also partner to efforts with UW-Extension and increasingly relationships and curricula are being discussed and developed around bioenergy business development, feedstock production and logistics, and sustainable biomass production practices (crop and woody biomass).

2. ***The WI Center for Dairy Research*** is one of the premier dairy research centers in the US, more than 30 scientists and staff research dairy protein processing/separation procedures, use of dairy ingredients in foods, and technologies for dairy product safety and quality. On the agricultural production side of dairy, the Center for Dairy Profitability (CDP) is a multi-disciplinary, multi-university Center that focuses on issues of farm business management, labor, markets/marketing, and production practices.
3. ***The UW Biotechnology Center*** is a comprehensive, multidisciplinary center that supports, coordinates, disseminates and advances biotechnology research tools, education, training and analysis for basic and applied research.
4. ***The UW Food Research Institute (FRI) and the Applied Food Safety Laboratory*** conducts basic and applied research on food-borne bacteria, molds, protozoa and viruses, with emphasis on microbial and toxin detection systems, pre-harvest and post-harvest intervention strategies, and mitigating diet-related diseases.
5. ***The Environmental Resources Center (ERC)*** focuses on applied research, communication, and education focused on the "human dimensions" of environmental issues. ERC's mission is to empower individuals and communities to make well-informed decisions about their environments and the social processes involved in caring for those environments. ERC leads environmental research and outreach on topics such as best environmental education practices, bioenergy generation and environmental sustainability, farm and home environmental management, training for conservation professionals, volunteer water quality monitoring, water program planning and evaluation, watershed education, and youth environmental stewardship education.

Special Asset or Infrastructure Investments supporting Agbio

Ohio State University

1. Research work on miscanthus production in Ohio
2. Feedstock demonstration project located at Farm Science Review Center researching various feedstock potential for biomass crops, and educating growers on potential of these crops
3. OARDC Wooster campus
4. Molecular and Cellular Imaging Center
5. Plant and Animal Agrosecurity Research Facility
6. Food Industries Center with pilot plant, sensory evaluation and process evaluation
7. Feedstock Processing research facility
8. BioHio, a university-private industry research park currently under development at OARDC – incubator facility with offices, labs, biodigester, other infrastructure.

North Dakota State University

1. ***ND Agricultural Experiment Station Greenhouse*** – provide scientists with high quality conventional, L-2 and BL-3 research programs.
2. ***ND AES Pilot Plant*** – end-product utilization facility that houses research programs from School of Food Systems and the department of Ag & Biosystems Engineering; wet and dry lab space dedicated to biobased ag products and/or food processing research; houses food chemistry analytical lab, quality control, bioprocessing lab, and pilot scale bio-products facility.
3. ***NDSU High Throughput Genotyping Center*** – instrumental to carry out molecular genetic research on biotic and abiotic stresses that effect crop production; has allowed scientists to screen large genetic collections for mutations, developing high-resolution maps of chromosomes and chromosomal regions for physical mapping and gene cloning, conducting genetic testing.
4. ***NDEAS Beef Research Complex*** – carry out research in genetics, nutrition, fetal development and management of beef cattle; to enhance the ability of livestock scientists to answer critical questions of beef cattle production in northern plains.
5. ***NDAES Vet Diagnostic Lab with BL-3 facility*** – to carry out research and diagnostics on livestock diseases and zoonotic diseases.

Michigan State University

1. Meats Laboratory/Dairy Plant
2. Large animal containment facilities and livestock/air quality monitoring chambers (BSL-3 Ag micro labs)
3. Plant transformation center
4. Air Care I and II, mobile air quality labs
5. Anaerobic digestion research and education center.

Iowa State University

1. ***BioCentury Research Farm (BCRF)*** – combined farm and processing facility dedicated to advancing the discovery, development and deployment of technologies for sustainable production of biomass feedstocks, biofuels, and biobased products, and to understand the effects of production of biomass and biofuels on rural landscape and communities.
2. ***Center for Crops Utilization Research*** – pilot plant that conducts basic and applied research, development and technology transfer and commercialization activities in developing new food, feed, biofuels and biobased products to add value and increase utilization of Midwestern crops.
3. ***Seed Science Center/BioSafety Institute for Genetically Modified Agricultural Products (BIGMAP)*** – provides science-based analysis of the risks and benefits of genetically modified plant and animal products along with guidance and education to help safeguard consumers and environment; improves the production, quality assurance, marketing, utilization, and regulatory environment for seed through research, testing, teaching and outreach.
4. ***Iowa State Dairy Farm*** – conducts research on dairy cow nutrition, genetics, physiology and calf management; teaches next generation dairy producers and vets; provides extension to current producers
5. ***Bear Creek National Restoration Demonstration Watershed*** – 27-mile drainage basin restored with university R&D and landowner cooperation to develop a stream management approach applicable to agricultural watersheds in the Midwest.

University of Missouri

1. **Flood Tolerance Lab:** This facility at the Horticulture and Agroforestry Research Center provides a unique field laboratory for studying the response of plant species to the periodic flooding common to mid-western floodplains. The laboratory has 12 channels, each approximately 20-ft wide by 600-ft long. Each channel can be independently adjusted for water depth, standing or flowing water, and duration of flooding. Selected grasses, legumes, and tree species are being evaluated for flood tolerance. The flood tolerance of hardwood planting stock and genetic variation in ecotypes from seed collected from bottomland and upland stands is also being evaluated.
2. **Missouri Plant Sciences Center:** A facility that will combine cutting-edge plant science research with manufacturing capabilities. The state of Missouri provided approximately $7.5 million in funding and incentives for the center, which will capitalize on the state's leadership position in plant science to create high-paying, high-tech jobs and serve as a catalyst for capital investment in northeast Missouri. The Missouri Plant Science Center is a joint venture of the state's **Missouri Technology Corporation**, the **University of Missouri system** and the city of Mexico. The 25,000-square foot facility will house traditional office space, wet and dry laboratories, and manufacturing equipment to process soybeans and other plant-based material into value-added products.
3. **Center for Applied Research and Environmental Systems (CARES):** CARES is an interdisciplinary center to assist public sectors through the use of the latest technologies in geographic information systems, satellite imagery, environmental modeling and the Internet to compile, analyze and distribute information to better understand and manage human, community, natural resource, and environmental issues and problems. **CARES hosts Community Issues Management (CIM)** -- an integrated data system with 13 national collaborators, including University of Missouri Extension and United Way in several states. CIM integrates over 500 national, state and local data layers in additional to multimedia data, which community organizations and others use as a tool to foster participation in transparent, data-informed and collaborative decision making.
4. **Pasture-based Dairy:** The University of Missouri's Pasture-based Dairy, located at the Southwest Research Center, provides producers with applied research, extension education, and objective

information on pasture-based dairy systems. In 1999, the MU Southwest Center established a seasonal, pasture-based research and demonstration dairy to address the above issues and to evaluate this alternative to conventional confinement dairies. It is internationally recognized as a leader in development of pasture-based dairy technologies. Working closely with a diverse set of dairy producers, the Center's outreach and research efforts have addressed questions related to management-intensive grazing, forage evaluation, comparison of dairy breeds under grazing conditions, seasonal breeding and estrous detection methods, efficiencies of milking in a high-throughput milking parlor, summer heat stress in dairy cows on pasture and economic evaluations of pasture-based dairying.

5. **National Swine Resource and Research Center :** The NSRRC) was established in 2003 to develop the infrastructure to ensure that biomedical investigators across a variety of disciplines have access to critically needed swine models of human health and disease. The NSRRC will also serve as a central resource for reagents, creation of new genetically modified swine, and information and training related to use of swine models in biomedical research. Swine are the optimal model species for investigation of a large number of human diseases and have made valuable contributions to almost every field of human medicine. Swine share anatomic and physiologic characteristics with humans that make them ideal models for research. In addition, the anatomy and physiology make pig organs likely candidates for xenotransplantation.
6. **Food for the 21st Century Program**
7. **Plant Transformation Center**
8. **Brody Environmental Chambers**
9. **Flood Tolerance Lab**
10. **Field Crop Drought Simulators**
11. **Wilbur Enns Entomology Museum**
12. **AES Centers, Farms and Forests**

University of Nebraska

1. ***Core for Applied Genomics and Ecology (CAGE)*** – CAGE provides genome researchers with high-capacity sequencing applications such as whole genome sequencing, large-scale sequencing of BACS, fosmids and metagenome libraries as well as deep sequencing applications which allow investigators to survey highly complex populations of microorganisms or to look for variants within uniform populations.
2. ***Food Processing Center (FPC) and Food Allergy Research and Resource Program (FARRP)*** – The FPC provides Pilot Plant, Food Safety, Product Development, and Business Development services to large and small food processors throughout Nebraska and the world. The facilities and services are used on a contract basis; the Center is staffed with full time employees dedicated to meeting the needs of business. The FARRP's mission is to develop and provide the food industry with credible information, expert opinions, tools, and services relating to allergenic foods.
3. ***Research and Extension Centers/Research Land Sites*** – IANR owns or leases from the University of Nebraska Foundation 40,000 acres to support research and extension education activities throughout the state. These land holdings support dryland and irrigated crops, several animal agriculture systems (from pasture to feedlot feeding), and the ecological study of unique prairie, grassland, and forest systems.
4. ***Plant Transformation Core Research Facility*** – provides the resources for the evaluation of transgenes in plant systems. The Facility is a state of the art laboratory with the expertise to deliver genetic constructs into model plant systems and two target crops, wheat and soybean. Researchers are provided with either R0 plants or R1 seed derived from the primary transformants.
5. ***Two animal health facilities*** offer bio-containment conditions and housing for laboratory and large food animals allowing study of infectious agents, microorganisms and clinical medicine impacting animal and human health. Within these facilities is a germ-free mouse facility, ideally suited to modeling important human immune responses and gastrointestinal health.

University of Wisconsin

- ***The National Magnetic Resonance Facility*** at Madison is a state of the art NMR spectrometer facility located in at UW-Madison and available for the analysis of biomacromolecules, especially proteins and RNA molecules, metabolomics and natural products.
- ***The UW–Discovery Farms Program*** is a cooperative effort between Wisconsin farmers involved in a wide variety of enterprises located in many diverse physical settings and UW-Extension and UW-Madison. The goal of the program is to conduct environmental and economic research on working Wisconsin farms and using this research to educate and improve communications between the agricultural community, consumers, researchers, and policy-makers. Under the direction of a producer-led steering committee, the program takes a real-world approach to finding the most practical solutions to agriculture's environmental challenges.
- ***The Insect Research Collection (IRC)*** contains more than 2.5 million specimens and is the only collection in the state of Wisconsin with the mission of representing the insect fauna of Wisconsin and Great Lakes region.
- ***The OJ Noer Turfgrass Research and Education Facility***, one of 12 WI Agricultural Research Stations, is dedicated to the testing, development, and promotion of turfgrasses and turfgrass management technologies. The nearby West Madison Ag Research Station compliments the work done at OJ Noer by focusing resources on several "urban" horticulture and plant production issues.
- ***Emmons Blaine Dairy Cattle Research Center*** located on the Arlington Research Station is a state-of-the-art free stall dairy facility built in 2008 for research such as pen based nutrition work, mammary and reproductive physiology research, calf growth studies, transition cow management projects, and individual animal intakes (via an Insentec research pen). The close presence of the Arlington facility helps with collaborative research between the research and Extension faculty (and the university's stakeholders). These facilities have led to faculty receiving several large integrated USDA grants on dairy production issues.

University of Illinois

- Expanded Food and Nutrition Education Program
- IPM – includes website, newsletter and meetings
- Farm Doc – an interactive web-page on farm management
- University of Illinois MarketMaker – software program that matches producers and buyers of specialty commodities (http://www.marketmaker.uiuc.edu/)
- 4-H.

Company Spin-offs

Ohio State University

- BioHio Research Park (in the process)
- Wooster Biotech
- Spray Redux

Michigan State University

- ***Neogen*** – markets diagnostic test kits for food safety; Produces superior dehydrated culture media with wide and varied uses, including: animal vaccines, biotech, diagnostics, foodborne pathogen detection, human vaccines and pharmaceuticals; markets a complete line of stuff for animal safety; markets life science diagnostic equipment
- ***AFID Therapeutics*** – defines and delivers advanced chemical and biochemical technologies and strategies and employs them in the design, discovery, delivery, and development of new drugs. Behind the company is an extensive web of synthetic chemistry patents and expertise covering processes and compositions that allow the preparation of very advanced small molecule drugs and new advanced materials for use in their delivery.
- Natural Products Technologies –

- ***Working Bugs*** – green chemical manufacturer using fermentation processes to produce products for the chemical, agricultural, food, and pharmaceutical industries. We have the equipment and capacity to manufacture our own products and perform contract manufacturing for other companies.
- ***Diversified Natural Products*** – renewable chemistry company. We use agricultural crops and transform them into green chemicals that directly substitute petrochemicals (chemicals derived from fossil fuels).

Iowa State University

- ***Harrisvaccines (dba Sirrah Bios)*** – veterinary service company; advancing toward solutions in swine diseases like Porcine Reproductive Respiratory Syndrome Virus (PRRSV) and Swine Influenza Virus (SIV).
- ***Metabolic Technologies, Inc.*** – develops safe and effective nutritional products; provides clinical and laboratory research for products.
- ***FarmRisk, Inc.*** – consultancy specializing in innovative crop insurance products for US crop and livestock producers.
- ***Advanced Genome Technologies*** – biotech company utilizing proprietary genome modification technologies to develop products for commercial license and sale; primarily in plant and fungal genomes.
- ***Molecular Express*** – retailer for lab supplies; research laboratory that develops aptamers for medical application.

University of Missouri

- **AndroLogika LLC:** reproductive testing and technology development company developing novel approaches to fertility testing in humans, farm animals and pets, in addition to non-hormonal immuno-contraception. Initial customers are producers and breeders of cattle, hogs, horses and pets. Expansion to human male infertility diagnostics and contraceptive development is planned in the second phase of Company development. Peter Sutovsky, Professor, Division of Animal Sciences
- **ValueAg, LLC :** an economic, market and financial consulting company built around years of experience of the principal partners. We take pride in our unbiased assessment of potential business opportunities. We assess a variety of business opportunities within the agricultural sector and draw upon some of the leading experts within fields related to agriculture. Joe Parcell, Associate Professor, Division of Applied Social Sciences.

University of Nebraska

- ***Goldfinch Solutions, LLC*** – established to commercialize beef tenderness classification technology; moving toward development of a commercial instrument capable of certifying tender beef carcasses. Research suggests consumers are willing to pay a premium for steaks that can be guaranteed tender. The U.S. harvests over 26 million market cattle each year. This technology has the potential to significantly improve customer satisfaction with beef and add value through the supply chain.

University of Wisconsin

- ***Quintessence Biosciences*** is working to improve the lives of cancer patients by developing new drugs based on EVade Ribonuclease technologies.
- ***Aova Technologies*** produces animal feed additives that support superior growth and increase natural resistance to disease. The feed additives are produced from egg yolk powder derived from hens that have been immunized with a proprietary vaccine.
- ***ThirdWave Technologies*** develops molecular diagnostic tools becoming widely used in women's health screening, esp. human papilloma virus that has been linked to cervical cancer.
- ***Nimblegen Roche*** provides sensitive ChIP-chip (chromatin immunoprecipitation on chip) microarrays and services that enable precise identification of DNA binding sites or chromatin structure across whole genomes or within biologically focused regions including promoters.
- ***Deltanoid Pharmaceuticals*** is a drug development company involved in breakthrough treatments for osteoporosis, renal osteodystrophy, psoriasis and other disease targets. The company specializes in designing advanced vitamin D analog drugs.

Ohio State University

- ***Average Crop Revenue (ACRE) Farm Program –*** new farm support program in 2008 Farm Bill; its support levels adjust with market revenue and are not fixed at levels set by Congress.
- ***Web-based tools for Management of Fusarium Head Blight on Wheat –*** used by growers, crop consultants, and processors to make management and marketing decisions in 24 states, including Ohio. Extension personnel in wheat-growing area use the tool to deliver state customized advice to users; together with other aids, this tool helps growers make cost-efficient and environmentally-sound disease management decisions, applying fungicides only when needed to minimize yield and quality losses; this reduces the entry of harmful toxins into the food chain and minimizes contamination of the environment with fungicides.
- ***Beneficial use of foundry sand as a soil substitute leads to USEPA Guidelines –*** millions of pounds of spent foundry sand (SFS) discarded as industrial waste in US; disposed in landfills at a cost to the foundry industry; marketing SFS as a soil substitute will promote green technology thru the re-use of SFS, provide a badly needed soil substitute, increase global competitiveness of US foundry industry, and create startup businesses and jobs focused on production and marketing SFS as a soil substitute or in soil blends; diverting 10% of the 10 million tons of SFS generated annually from landfills (cost $30/ton) would save the industry $30 million annually.
- ***New Promoter Improves Gene Expression in Soybeans –*** Scientists at OARDC have isolated and extensively characterized a promoter for soybean (Glycine max) polyubiquitin (Gmubi) gene. This Gmubi promoter leads to higher levels of gene expression than any other native soybean promoter that has been isolated to date.
- ***Development of technology for the production of polyurethane (PU) foam from crude glycerin –*** innovative low-cost process was developed to produce polyurethane foam from crude glycerin and lignocellulosic biomass; crude glycerin is a very low value waste stream in the biodiesel plant; with this technology crude glycerin can produce PU foam for half the price of petroleum based PU foam. Arlington Products LLC in Mansfield, OH has formed a new company (a biodiesel plant with 5 mgy capacity) to commercialize the PU technology; this is expected to have a major impact on biodiesel industry thru increased value of their by-products.
- ***Development of Product peeling technology for fruits and vegetables –*** current peeling processes use large quantities of caustic soda and steam, and pose an environmental hazard, large energy usage and high cost; new environmentally friendly process Ohmic Peeling uses less caustic soda and water instead of steam; technology has been licensed to Morning Star in California.
- ***Community Based Water Quality Trading –***
- ***Improving the Safety of Shell Eggs –*** novel process for pasteurization of raw shell eggs to reduce the incidence of Salmonella, the most reported food-transmitted disease in US (human illness due to Salmonella estimated at 1.4 million annually in US); fresh shell egg is one of the most common means of transmitting this disease; production of pathogen-free shell eggs is mandated by govt., but presently no technology to meet the requirement; new process relies on ozone to decontaminate the eggs; eggs pasteurized with this process have excellent fresh qualities and assured safety; research funding for commercialization provided by Egg Tech, NIFA, and Brazer professorship fund.
- ***Coronavirus (CoVs) –*** identification and molecular characterization of CoVs from wild animals provides critical information on the diversity and evolution of CoVs; the accumulated genetic diversity of CoVs increases the possibility of transmission to other species as demonstrated by the emergence of SARS-CoV from civet cats; findings that minks have CoVs with high genetic variability shows need for continuous monitoring of animal species for emergence of new strains of CoVs.
- ***Genome Sequencing of Beneficial Nematode will generate breakthroughs in biological control of pests –*** the first complete genome of an entomopathogenic nematode (EPN) sequenced by OARDC scientists; EPNs have emerged as excellent biological control agents of insect pests, used in citrus groves, strawberry plantations, cranberry bogs, ornamentals and turf; collaboration between scientists at OARDC, Washington Univ. in St Louis, California Technology Institute, Michigan State, BYU and Rutgers; the genome sequence data revolutionizes research in over 100 academic and industrial laboratories

developing EPN and their symbiotic bacteria as biological control agents worldwide; facilitates functional genomic research toward enhancement of infective juvenile longevity, stress tolerance, and virulence that will improve efficacy and use of EPN as a biocontrol, leading to reduced reliance on chemical insecticides.

North Dakota State University

- ***Plant Breeding Programs*** - Developing improved crop cultivars for the northern plains; more than 12 plant breeding programs to support diverse crop agricultural system in North Dakota; recent releases of improved crop cultivars, like Glenn wheat, have provided direct economic benefits of more than $75million annually to the state; ND AES-developed cultivars are well received by growers; cultivars of all commodities released by ND AES are known worldwide for high cereal or food quality traits, keeping them in high demand in domestic and export markets.

Michigan State University

- Aphid resistant germplasm in soybeans
- Dry bean varieties with significant market penetration
- Technology to enhance plant's seed oil content for food and animal feed
- Technology to prevent Salmonella contamination in almonds
- Ammonia expansion technology to convert cellulose to biofuels
- Enzyme technology to convert plant fibers to biofuel
- New technique to test the DNA of E. Coli bacteria
- Livestock air emissions model for facility testing.

Iowa State University

- Researchers developed soybeans with low levels of linoleic acid resulting in an oil with longer shelf life, without hydrogenation.
- Sequencing of corn genome; sequencing strain B73, developed in 1970s at Iowa State, now grown by more than half the cornbelt; map of genome could help scientists modify and improve corn plants that can withstand global climate change, add nutritional value to grain, sequester carbon in agricultural soils, or boost yields to help crops meet the growing demands for food, feed, fiber and fuel.
- Thomas Bobik, professor of biochemistry, biophysics and molecular biology, invented a process for manufacturing isobutene by identifying a new, natural enzyme that produces the fuel organically.
- Doubled haploid facility helps corn breeders more quickly produce inbred lines for research and private use.
- Researchers developed a new, environmentally friendly way to extract soybean oil for food and biodiesel using water and enzymes to replace the petroleum derived hexane.
- ISU Plant Transformation facility provides expertise and service in the genetic transformation of crop plants of corn, rice and soybeans; improves transformation technologies; trains scientists and students.
- A team of ISU researchers used a microscopic fungus to produce biodiesel from plant processing wastes; commercialized as Mycofuel, made from lignocellulosic biomass, such as switchgrass, corn stover and forestry wastes.
- BioInformatics to Implement Gene Selection developed for the statistical analysis of beef cattle genome technology.
- Scientists are finding new ways to identify animals harboring Salmonella; findings have identified gene expression signature, or classifier, that can predict the level to which the animal will carry or transmit Salmonella; results can help weed out pigs that are Salmonella "shedders" from swine herds through traditional animal breeding methods and manipulation of guilty genes.

University of Missouri

- Soybean Genome: a team of scientists including members of The National Center for Soybean Biotechnology at the University of Missouri College of Agriculture, Food and Natural Resources, announced that they have identified the location of approximately 1.1 billion base pairs in the soybean. Soybeans are one of the most important crop plants for their protein and oil, representing an almost $30

billion industry in the U.S. The plant is a significant foodstuff in most of the world and the leading animal feed in the U.S. It also is used in the manufacture of plastics, hydraulic oil and cleaning products.

- Show Me Select Replacement Heifer Program: Producers from 103 (90%) of 114 counties have participated in the Show-Me-Select Replacement Heifer Program. The *Missouri Show-Me-Select* Replacement Heifer Program was developed and designed to improve reproductive efficiency of beef herds in Missouri and increase individual farm income. The program objectives include: 1) a total quality management approach for health and management of heifers from weaning to late gestation; 2) increased marketing opportunities for, and added value to, Missouri-raised heifers; and 3) the creation of reliable sources of quality commercial and purebred replacement females.

- Stochastic Models of agricultural policy – Researchers at the Food and Agriculture Policy Research Institute (FAPRI) developed and maintain stochastic models used to evaluate the impact of policy decisions on agricultural productivity and profitability.
- Soybean Breeding Program: The college's two breeding programs have develop several new soybean lines annually that meet the needs of growers in the bootheel region and the remainder of the state. This partnership with the MO Soybean Association allows the association to license and market the new lines.
- Wheat Breeding Program: the wheat breeding program develops new lines of wheat suitable of Missouri and surrounding states with a focus on *Fusarium* head blight (scab) resistance and high yield. Recent successful releases include, Bess, Truman and Jake.

University of Nebraska

- IANR developed wheat varieties add $30–35 million dollars of value each year to Nebraska's agricultural economy.
- IANR scientists discovered a gene that has been used to create broadleaf crops that tolerate spraying with the popular herbicide dicamba.
- IANR scientists have discovered clear evidence for the importance of host genetic control in shaping individual microbiome diversity in mammals, a key step toward understanding the factors that govern the assemblages of gut microbiota associated with complex diseases.
- IANR researchers have conducted long-term research on crop water use and management efficiency techniques that have allowed NE farmers to increase crop production yields while using less water (See Extension impact section).

University of Wisconsin

- Aova Technologies produces animal feed additives that support superior growth and increase natural resistance to disease. The feed additives are produced from egg yolk powder derived from hens that have been immunized with a proprietary vaccine.
- Work is progressing collaborations with UW-Madison, UW-Green Bay, and UW-Platteville in evaluating farm-based, community and industrial digester systems; business development programming with technology venders, engineering firms, developers, both Wisconsin and elsewhere for gasification projects.

Industry Partnerships

Ohio State University

- ***Mendel Biotechnology*** – biomass research and outreach for miscanthus
- ***The Andersons, Inc (publicly traded agribusiness company)*** – OARDC faculty accelerating the commercialization of Advanced Granular Technology (AGT), a novel way to contain, transport and deliver agricultural chemicals more effectively to specific areas by eliminating spray drift common in liquid chemical applications, reduces spills and is more environmentally safe.
- ***Natural Fibers Composites Corporate (NFCC)*** – OARDC faculty working with NFCC to create a new generation of composite materials from plant-derived fibers for use in transportation, construction, consumer and industrial products; work supported by Ohio Corn Growers Assoc, Ohio Soybean Council, and Ohio Wheat Growers Association; currently a pilot plant in Wooster producing 6 million pounds of fiber materials a year and is expected to generate $12 M in revenue and 37 jobs in 2012.
- ***Quasar Energy Group*** – major OARDC initiative to convert municipal and agricultural waste into energy; quasar has set up a lab and engineering office at OARDC Wooster campus; quasar interested in commercializing an OARDC-patented process for converting solid wastes, such as yard trimmings and crop residue into methane; this innovation can double the biogas as conventional liquid biodigesters and recycle the effluent, thus reducing costs and benefitting the enviro; quasar has built a biomass energy facility on OARDC campus – 500,000 gallon digester can process 40–50 wet tons of waste/day and produce 600kW of electricity, and can supply half of the OARDC campus energy needs.
- ***Developing a domestic source of rubber*** – creation of natural rubber from Russian dandelions; OARDC collaboration with U of Akron, Oregon State, Cooper Tire, Bridgeston Americas, and Veyance Technologies; OARDC scientists developing germplasm lines to lead to new advanced varieties of Russian dandelion to form the basis of new agricultural industry domestically producing natural rubber; pilot-scale facility on OARDC Wooster campus.
- ***Arisdyne*** – working with OARDC to enhance the efficiency of biofuel production; goal is to optimize Arisdyne's controlled flow cavitation (CFC) technology for the ethanol industry; improvements in corn conversion efficiency can have high impact ton industry; assuming a 3% increase in ethanol yield from this technology, if it were installed in just 50% of US corn ethanol plants, it would create an additional 225 million gallons of ethanol annually.
- ***Ohio Department of Development, Energy Resource Division*** – '*Energy Outreach and Research Plan'* was designed to reach residents and businesses to increase the number of energy efficiency and renewable energy projects, including biomass, and application of state, federal and utility incentives. Includes major electric utilities in OH, energy advocacy organizations, non-profits, and state/local government agencies
- ***Liquid Health*** – labs developing long shelf life additives for the specialty bottled, nutrition, water and juice markets.
- ***MTD/Nature's Touch*** – develop a new line of all natural fertilizer (Nature's Touch makes organic fertilizers, pesticides and herbicides; MTD makes outdoor power equipment and is based in Cleveland, OH).
- ***Ohio Soybean Council*** – to maximize yield and profit on soybeans.
- ***AgBioscience Centers of Innovation*** – partnership between OSU Extension and Ohio Agricultural Research and Development Center (OARDC) to enhance and accelerate the process of knowledge generation and implementation in Ohio; transform discovery and knowledge into innovations that have positive social, economic and environmental impacts; commercialize discoveries/create start-up companies/expand

existing companies; cross-discipline research – agriculture, biology, social sciences, engineering, business; identify discoveries with commercial potential; link fundamental and translational research; leverage resources; overcome barriers to commercialize agbioscience.

- ***Center for Diagnostic Assays*** – developing diagnostic tests for infectious pathogens, an essential for the health of food-producing animals and plants and the safety and security of our food supply; currently developing diagnostic assays for infectious bursal disease virus (IBDV) of poultry, crop-damaging phytoplasma bacteria and E. coli,
- ***Center for Food and Agrosecurity*** – brings advances in food safety to commercial applications, including novel processing techniques that eliminate dangerous bacteria (e.g., using ozone and UV radiation for Salmonella in eggs), tamper-proof caps for food packages, and rapid tests to diagnose foodborne pathogens such as noroviruses.
- ***Center for Advanced Functional Food Research and Entrepreneurship*** – Developing functional foods to combat chronic illnesses like obesity, diabetes, heart disease, vascular disease and cancer threatening the aging American population; includes berry compounds that fight cancer, heart-healthy soy bread, and a soy-tomato drink to combat cholesterol and cancer.
- ***Center for Urban Environment and Economic Development*** – development and commercialization of new organic and biological products to meet the fertility, pest control and pollution mitigation needs of a rapidly expanding urban landscape; includes pest-killing nematodes, biocontrol-amended soils, and techniques for reclamation of urban brownfields,
- ***Center for Innovation Based Enterprise*** – help address barriers to commercialization by providing research with access to contract design, finance, marketing and risk-management support.
- ***Ohio BioProducts Innovation Center (OBIC)*** – develop specialty chemicals, polymers and industrial products from renewable plant resources; example, OARDC plant breeders are creating high-yield, disease resistant varieties of soybeans, wheat and corn.

North Dakota State University

- Collaboration with Bayer Crop Science and Ducks Unlimited, as well as South Dakota State University and University of Minnesota to increase winter cereal production along major duck migration routes
- Cooperative agreement with Monsanto to improve canola production; effort is focused on improving the genetic potential of canola to increase oil yields per acre; developed hybrids that produce significantly higher oil per acre
- Agreement between NDSU Foundation Seedstock program and Busch Ag Resources to produce foundation-grade seed for barley producers in northern plains; increase seedstock and distribution using the state's seed allocation and distribution system
- Negotiating with a number of companies for transgenic crop development.

Michigan State University

- Integrator positions in sugar beets, potato, soybean and fruit IPM
- Potato storage research facility
- Enviroweather
- Frontier Renewable Resources
- Artisan distilling program.

Iowa State University

- ***Wine Quality Lab*** – with the Midwest Grape and Wine Industry, provides grape-growing and wine-making information to emerging agribusinesses; institute partners with community colleges to develop job training programs specific to the wine industry, including wine diagnostic services for improving wine quality.
- ***Seed Science Center*** – houses the largest public seed testing laboratory in the world; for over a hundred years the lab has provided professional seed-testing services for the seed industry; performs tests on about 40,000 seed samples annually.
- ***Iowa Soybean Association*** – support research for plant breeding and production.

- ***Iowa Pork Producers Association*** –
- ***Pioneer (a DuPont Company)*** – Pioneer Hi-Bred has pledged $1 million over five years to the BioCentury Research Farm for research and development of new technologies involved in harvesting, storage and transportation of crops and crop residues.
- ***DuPont Danisco Cellulosic Ethanol, ConocoPhillips, Archer Daniels Midland, Alliant Energy, Hawkeye Renewables, Idaho National Labs and AGCO*** are providing financial and technical support for a Sun Grant project on corn stover harvesting, storage and transportation.
- ***Avello Bioenergy*** is based in the BioCentury Research Farm and using the facility's pyrolysis and thermochemical equipment to develop products from crops and crop residues. Mixing bio-oil with asphalt the firm created a new material that is being tested as a substitute for petroleum based asphalt.
- ***Deere and Co.*** providing tractor for ISU.

University of Missouri

- ***Pasture Based Dairy Program*** – MU Extension, College of Agriculture, Food & Natural Resources and Dairy Farmers of America - Expansion and growth in Missouri's Dairy industry resulting from this partnership were $100 million in new investment, generated $40 million in annual milk sales, added $124 million in total farm output, and added 1,100 additional jobs in the state of Missouri.
- ***Master Gardeners of Missouri*** – MU Extension & Missouri Botanical Garden: This partnership involves the joint training of 200 Master Gardeners each year, answering of 31,116 gardening question, building and maintaining community gardens in St Louis, conducting 75 educational programs by the Master Gardeners, and staffing Kemper Gardening Center.
- ***Soybean Biotechnology:*** we receive about $2M annually in support from the Missouri Soybean Association to support work in trait analysis, variety development and basic research on the improvement of soybean for Missouri producers.
- ***Institute for Continental Climate Viticulture and Enology:*** our grape and wine program receives about $700K annual to support personnel, research and outreach top improve viticulture and enology in Missouri and regionally. The funding comes from the State Grape and Wine Board to support the development of the wine industry in the state.

University of Nebraska

- ***The Crop Management and Diagnostic program*** is a collaborative effort between the multiple UNL departments and private sector consulting and agribusinesses for the purpose of implementing the latest research technology and practices relative to crop production (genetics, nutrient management, pest management), improved profitability, and environmental protection (water management, water quality protection from nutrients and pesticides). Key collaborators over the past 5 years have included major agribusinesses such as Monsanto, BASF, and Pioneer as well as a host of smaller Coops and independent crop consultants. In-depth educational experiences are delivered through a mix of in-field hands-on diagnostic opportunities, and classroom experiences. Since 1996 over 12,000 agribusiness representatives, crop consultants and producers have attended. Educational programs annually reach participants that manage or directly influence decisions on 57% of the row crop production acres in Nebraska plus additional participants from 12 other states. Significant behavioral changes have been documented relative to crop management, nutrient management, pest management, and soil and water management. One example of impact is that 58% of producers report an increase in yield the year after attendance directly as a result of information from the program.
- ***Food Allergy Research and Resource Program (FARRP)*** partners with and is funded by approximately 50 multinational and US food manufacturers in order to provide research-based information on Food Allergens. FARRP takes a comprehensive approach working with and collaborating with research institutions, governmental authorities, consumer groups, and scientific societies around the globe so as to share their experience and knowledge to improve the safety of food products for consumers with food allergies and sensitivities. They focus on two missions: 1) To develop and provide the food industry with credible information, expert opinions, tools, and services relating to allergenic foods. 2) To develop and

provide the agricultural biotechnology industry with credible information, expert opinions, tools, and services relating to novel foods and food ingredients including genetically modified products.

- A related industry sponsored program, ***"AllergenOnline"*** is funded by major multinational seed companies and provides public access to peer reviewed allergen lists and a sequence searchable database intended for identifying proteins that may present a potential risk of allergenic cross-reactivity. This website/database was designed to help in assessing the safety of proteins that may be introduced into foods through genetic engineering or food processing methods.
- ***The Food Processing Center*** provides proprietary business development, analytical and pilot plant facilities to companies throughout the world. (See http://fpc.unl.edu)
- ***Time Warner Cable & 4-H*** – Through a partnership with Time Warner Cable (TWC), five new 4-H clubs focused on the science of robotics were formed. Each of these clubs were led by a TWC employee and met weekly at the TWC facility to learn more about robotics. These teams then competed at the state First Lego League Competition which was co-sponsored by TWC. As a result if these efforts, one of these 4-H'ers was selected from across the country to accompany the CEO of TWC to White House to be recognized for their efforts in developing young scientists. TWC also developed a documentary of the project which is now being shared with their counterparts as a model for partnering with the Land-grant to grow the science skills of youth.

University of Wisconsin

- UW vegetable breeders developed unique beet germplasm with high levels of pigment, while UW food scientists developed methods for pigment extraction, stabilization, and concentration. The resulting high pigment germplasm is licensed to Phyto Colorants, a startup company designed to provide technical expertise and germplasm for natural colorants. This work, in many cases occurs in close collaboration with the state's potato and vegetable growing association leaders. This close working relationship and trust has led to other efforts to deal with complex issues such as water "availability" in the Central Sands potato and vegetable production region of the state. This applied investigative work has involved integrated leadership from both the research and Extension communities, faculty of UW-Stevens Point and the industry.
- Food Research Institute (FRI) research supported by the International Dairy Foods Association and their members (e.g. Dean Foods, HP Hood, Safeway, Kroger, Kraft, General Mills) led to changes in cooling regulations for cultured dairy products; FRI also has identified novel use of antimicrobial ingredients to enhance the microbiological safety of traditional and reduced-sodium processed meat products that benefit the dairy and meat industry and protects public health.
- The Wisconsin Center for Dairy Research partners with the Wisconsin Milk Marketing Board (farmer funded check-off program) to provide product development and technical support for the dairy industry. This includes working with companies such as Kellogg's to reformulate the cheese powder used in Cheez Its to enhance cheese flavor leading to increased sales, and with Seymour Dairy to provide technical support which led to re-opening a previously closed dairy plant which now employees 30+ people and is one of the largest blue cheese manufacturers in the U.S. The work of the Center for Dairy Profitability similarly supports the economic, management, and production practices of Wisconsin's $25 billion+ dairy industry.
- John Deere and the Dept. of Biological Systems Engineering have extensive research activities in biomass feedstock harvest and logistics, precision farming and improved hay and forage production systems. These projects have advanced knowledge while supporting the education of many graduate and undergraduate engineers. The Biological Systems Engineering also strongly supports (through personnel and collaboration) the annual Farm Technology Days 3-day event that showcases a range of new field-based machinery technologies, crop processing systems, etc.
- Agrium, Inc. and Agrotain International collaborate with the Dept. of Soil Science to evaluate agronomic and environmental benefits of ESN® and SuperU® in irrigated vegetable production on sandy soil. These products reduce nitrate leaching by one-half compared to conventional fertilizers thereby reducing water pollution due to fertilizer leaching.

- On issues of Bioenergy, strong partnerships exist with Wisconsin Paper Council (bio-energy opportunities for both craft/integrated and paper conversion facilities); Wisconsin Electrical (regulated) Utilities (biomass supply chain development, biomass energy policy); BiomassThermal Energy Council (biomass supply chain, contracting and co-development of projects—forestry a ag, and CHP); Wisconsin Bioindustry Alliance (bioenergy and biofuel incentives and policy); Upper Midwest Municipal Power Association (biomass fueled electrical generation, project development and supply chain); Midwest Food Processors Association (resource recovery, nutrient management and biogas).

University of Illinois

- Extension on board of directors of IL Soybean Association, IL Farm Bureau, Land Improvement Contractors, IL Corn Growers, IL Fertilizer and Chemical Assoc; IL Pork Producers, IL Beef Association; allows Extension to learn about problems and opportunities face by organizations and develop programs to address these.

Cross-Institutional Partnerships

Ohio State University

- AFRI applications with North Central universities for research/outreach funding for advanced biofuels.
- Tri-state dairy nutrition conference with OSU, Purdue and Michigan State, resulted in major impacts to the feed and dairy industries.
- IPM collaborative with Virginia Tech, Clemson, Florida A&M, North Carolina A&T, Purdue, Consortium for International Crop Protection (CICP), Michigan State, NC State, Pennsylvania State, UC-Davis.
- Porcine Reproductive and Respiratory Syndrome, with U of Illinois, Purdue, Iowa State, Kansas State, U of Minnesota, and U of Missouri.
- Midwest Poultry Consortium – with entire North Central network plus Florida.
- SolCAP – Solanaceae Coordinated Agricultural Project with Michigan State, Cornell and Oregon State.
- Potato breeding and genetics with Iowa State, Michigan State, Minnesota, Nebraska, N Dakota, and Wisconsin.

North Dakota State University

- Collaboration with Bayer Crop Science and Ducks Unlimited, as well as South Dakota State University and University of Minnesota to increase winter cereal production along major duck migration routes.
- Genome research
    - NDAES scientists working closely with scientists at the University of Minnesota on the Barley Genome Project
    - NDAES scientists working closely with scientists at Minnesota, Michigan, Wisconsin, Nebraska and other states to understand genome of dry bean.
- Four-State Ruminant Consortium with South Dakota, Wyoming and Montana to enhance rural and economic development through sheep and beef cattle enterprises.

Michigan State University

- North Central Center for Rural Development
- Extension positions funded jointly with Purdue and Ohio State
- IR-4 regional laboratory
- PROSPER with Iowa State – a youth risk prevention program
- Bovine TB research with University of Minnesota.

Iowa State University

- ***Community Vitality Center***
- ***Sustainable Bioenergy CAP*** – an AFRI proposal for multi-institutional research of sustainable approach to creating energy from crops and crop residues.

- ***Regional Approach to Climate Change CAP*** – another AFRI proposal for multi-institutional research into sustainable corn-based production and processing systems in the north central region with a focus on climate mitigation and adaptation.
- ***North Central Bioeconomy Consortium*** – consists of reps from the twelve north central state Land-grants – ag directors, experiment station directors and extension directors.

University of Nebraska

- ***The Heartland Regional Water Quality Program*** is a partnership of Land-grant universities in Iowa, Kansas, Missouri, and Nebraska, US EPA Region 7, USDA NRCS and state environmental agencies in the 4 previously mentioned states. Some key results include 1) influence over direction of federal CAFO regulations as related to manure nutrient management planning , 2) development and successful commercial implementation of the concept of vegetative treatment systems technology for application to animal feeding operations through efforts to assemble national experts, development of consensus guidance documents in cooperation with NRCS, and education of regulatory and private sector communities on applied research and field results of technology application, 3) improvement in quality and consistency of Phosphorus Index tools used by states in region for public policy implementation, 4) development of regional guidance documents for environmental protection and agronomic application of inorganic and organic fertilizers and pesticides.
- ***eXtension*** is an interactive web learning environment delivering researched knowledge from the land-grant university system. It is a collaborative effort of most Land-grant universities and USDA NIFA connecting knowledge consumers with knowledge providers – Land-grant university faculty. eXtension provides collaborative space and multiple web educational products for faculty use in developing new educational and information resources on wide-ranging topics. Currently, 50 Communities of Practice (CoP) or multi-state faculty teams focused around a subject matter focus are currently engaged in assembling national content of which 32 have launched their public web site presence.
- ***The Regional High Plains Climate Center's*** mission is to increase the use and availability of climate data in the High Plains region. HPRCC personnel work closely with scientists from other regional and federal climate centers on climate services and programs and provide a regional structure for climate applications. The long-term objectives of the HPRCC are to carry out applied climate studies, develop improved climate information products, and provide climate services in the High Plains region. Primary roles of the Center include: Data Collection. The HPRCC is well recognized as one of the centers of expertise in the use of automated weather stations to obtain near-real time climate data. Scientists from around the nation and from other countries have visited the HPRCC to receive training in the collection, management, and summarization of near real-time data. Applied Research. Research projects are aimed at producing new climate information for use in expanding the climate service activities. The HPRCC staff has developed soil water monitoring capabilities that, together with the regional weather network, allow more quantitative monitoring of weather impacts in the region. Research objectives include the study of drought, development of drought monitoring strategies, and predicting the impact of weather and climate change on crop production in the region. Education. HPRCC has helped organize and cosponsor workshops in regard to the climate change issue and possible impacts in the region. Cooperation with federal climate centers has included sponsoring (together with the National Climate Data Center) data base management systems and corresponding training in the region and participation in the Centennial Program to recognize community contributions to weather data collection. In addition, the HPRCC worked with the Climate Prediction Center to develop a joint program to identify climate impacts in the High Plains region in a timely fashion. Services. Climate information is necessary to address many requests from users whose work touches soil and water conservation, sustainable agriculture systems, agricultural competitiveness and profitability, and natural resources and environmental management. In addition to the weather observations the Online System includes crop water use and crop performance for major crops, pest development, livestock conditions, soil water, and heat indices.

University of Missouri

- Integrated Crop Management Systems (IPM Center), (Extension funding - $104,000)
- Food & Agriculture Policy Research Institute: USDA-NIFA Special Grant with Texas A&M and Iowa State ($1,139,000)
- eXtension (Extension funding - $67,000 plus faculty serving on CoP)
- Endophyte Research: USDA-ARS Special grant with Arkansas and Oregon ($994,000)
- Rural Policy Research Institute (RUPRI): USDA-NIFA Special Grant with Iowa State and University of Nebraska ($835,000)
- MU Extension partnership with Lincoln University
- Pecan Management with Kansas State University
- Viticulture with Kansas State University
- Heartland Regional Water Quality Program
- Agroforestry Center
- Food and Agricultural Research Institute
- Rural Policy Research Institute

University of Wisconsin

- Great Lakes Bioenergy Research Center is a consortium of universities, government laboratories and businesses led by the University of Wisconsin-Madison to explore the vast potential of bioenergy, with funding provided by the Department of Energy.
- The Institute for Environmentally Integrated Dairy Management (IEIDM) at Marshfield is a consortium between the UW, the NRCS, the USDA and the National Farm Medicine Center to improve nutrient management systems (crop and cropping patterns; livestock feeding and management systems; manure treatment, handling, storage, and application strategies) and to reduce degradation of air, water, and soil from livestock waste.
- Wisconsin Bioenergy Initiative has partnered with Wood Residual Solutions to examine the economic and environmental returns from pelletizing wood solid fuel for large-scale commercial applications, and with EFRIM to assess the viability of cow manure as a combustion source for use in power plants.
- On other projects and development activities associated with bioenergy and biomass production and use, collaborations with Auburn University., University of Missouri, North Dakota State University, University of Wisconsin-Platteville, University of Wisconsin-Stevens Point, University of Wisconsin-Green Bay; University of Wisconsin-River Falls; four technical colleges in the Wisconsin Technical College System.
- A large, multi-state, interdisciplinary AFRI project proposal was recently funded on “local food” research and integrated programming with Wisconsin leading (UW-Madison and UW-Extension) but involving Michigan State and interests in several large cities in the region (Milwaukee, Chicago, Detroit and others). Similar proposals have been prepared around issues of Climate Change, Food Security, Biofuels, and Childhood Obesity with other universities in the North Central Region.
- The University of Wisconsin Extension network connects not only to the main 1862 land-grant in Madison but also to four-year universities and researchers in Platteville, River Falls, Superior, and Stevens Point. Within UW-Extension, there also are efforts conducted in cooperation with the 1994 Tribal Colleges (two in the state) to move forward tribally-led and initiated education and applied research around issues such as water protection, health, and leadership around key environmental issues.

University of Illinois

- University of Illinois MarketMaker
- Agrability – program for disabled farmers, started in IL but has spread across many states
- Soybean Research Technology
- Great Lakes Water Quality Program.

Unique Assets of North Central region for Agbio

- Population density
- Agricultural Production
- Number of urban centers
- Non-biased agronomic information from Extension services
- Land-grant universities and their existing networks provide breadth and depth of content and program development
- Ongoing and timely research at all stages —basic, translational and applied
- Integration with Ag media services
- Respect, engagement and loyalty in small communities
- Interconnection with ag services and products providers
- Public-private research and extension partnerships
- Multi-disciplinary research/extension/educational models like the BioCentury Research Farm at ISU
- The North Central Region is America's "bio-basket" for sustainable food and fuel production systems. Some of the unique assets that Nebraska contributes to the north central region include:
    - Soils, natural resources, and infrastructure critical to support national and international growing demands for production of food, fiber, protein, and energy.
    - Internationally recognized expertise and leadership addressing water for food production.
    - National leadership for Cooperative Extension systems designed to survive and thrive in the 21st Century with specific national expertise in areas such as web delivery of educational experiences and research-based science, measurement of impact, STEM education for youth, competitive integrated proposal development.
    - A growing and dynamic research portfolio that is increasingly impact based and designed to represent the continuum of research from basic to applied…all focused on Food, Fuel, Water and People.
- Much of the region remains "water rich" and this will prove to be an increasingly valuable asset. The region is also endowed with excellent soil resources, expanding forests, and a well-educated work force, all of which will improve our economic position in a new biocentric economy.
- There exists in the state a strong sense of collaboration and positive partnerships between the University (including Extension and the Experiment Station) and our public sector partners in agencies such as the USDA- NRCS, Rural Development, FSA, etc. These interactive partnerships also include the Office of Energy Independence, the Department of Ag, Trade and Consumer Protection, Department of Natural Resources, and others. This relationship helps on regulatory issues that require education and applied research related to best management practices for issues like water protection and others.
- The state of Wisconsin has a very strong history of leadership in leading applied research that connects university research to real working farms in ways that engage both the ag community and researchers. The Discovery Farms system is an example of this type of collaborative, participatory research.
- Extremely strong intellectual resources in public and private universities.
- Expertise in logistics and infrastructure.
- Unsurpassed natural resources e.g., fresh water and biomass.
- Diverse and well-connected manufacturing sector.
- Willingness to explore regional solutions to research and outreach challenges

Experiment Station Program

School	Number of Experiment Station Locations	Acres
Iowa State University	20	15,698
Kansas State University		
Michigan State University	15	18,980
North Dakota State University	9	22,380
Purdue University		
South Dakota State University		
The Ohio State University	11	6,351
University of Illinois		
University of Minnesota		
University of Missouri	12	9,929
University of Nebraska	21	40,000
University of Wisconsin	11	7,613

Extension Service Program

Ohio State University

- Pesticide Applicator training
- Conservation tillage conference
- Pest monitoring
- Renewable energy programs
- 4-H – workforce preparation
- ***See Info Request form for details***

North Dakota State University

- Wheat Fusarium Head Blight Management
- Soybean Production
- Industrial and Manufacturing Engineering – in May 2009 NDSU College of Engineering and Architecture partnered with NDSU Extension Service to create an industrial and manufacturing engineering program to provide outreach, education and research capacity to North Dakota's inventors and manufacturers
- 4-H, Teaching Science through Technology – provide hands-on learning experiences that encourage young minds and develop young leaders proficient in science, engineering and technology workforce skills; identify and deliver a curriculum and other educational materials to enhance interest and skill development in a variety of science, engineering and technology areas
- Flood preparation and recovery
- ***See Info Request form for details***

Iowa State University

- In FY '09 1,168,988 clients had contact with ISU extension programs
- ***See Info Request form for details***

University of Nebraska

- ***See Info Request form for details***

University of Missouri

- **Agriculture Programs/ Impacts -- Missouri Show-Me-Select Replacement Heifer Program:** The Missouri Show-Me-Select Replacement Heifer Program improves the reproductive efficiency and genetic quality of beef herds in Missouri and increases individual farm income. Program objectives include (1) a total quality management approach for health and management of heifers from weaning to late gestation; (2) increased marketing opportunities for, and added value to, Missouri-raised heifers; and (3) creation of reliable sources of quality commercial and purebred replacement females. The total net impact on Missouri's economy resulting from Show-Me-Select Replacement Heifer Program has exceeded $45,000,000 over 12 years.
- **Business Development Programs/ Impacts -- Extension's Missouri Small Business and Technology Development Centers (SBTDC):**- The program's threefold purpose includes: 1) stimulating technological innovation and transfer, 2) increasing opportunities for Missouri businesses and researchers through programs such as federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (SBTT) grants and 3) effectively growing early-stage businesses through quality business technical assistance and services. Achievements since April 2008 include program clients garnering 32 Phase I SBIR/STTR research awards totaling more than $4.6 million. Missouri's success rate at winning these research awards is 28 percent or nearly double the national average of 15 percent.
- **Community Development Programs/ Impacts --** MU Extension has partnered with the **Old North St. Louis Restoration Group,** UM-St. Louis, the Missouri Department of Agriculture, Gateway Greening and the Missouri Foundation for Health to create a healthy, dynamic and sustainable community in the neighborhood called Old North St. Louis. The partnership's joint efforts have resulted in $35 million of Crown Square redevelopment, including 27 buildings undergoing historic rehabilitation, 32 high-quality affordable apartments in nine historic buildings and 20 new homes built, and new 3-block main street in final development. To address the neighborhood's "urban food desert" issues, the partnership has established a viable farmers' market, community garden, Old North Community Supported Agriculture (CSA) and opened a neighborhood grocery co-op.
- **Family and Consumer Science Programs/ Impacts -- Volunteer Income Tax Assistance (VITA)**: In the 2009 tax season, sites supported by MU Extension faculty prepared 3,645 federal and state returns, saving clients more than $729,000 in preparation fees and providing $4.2 million in refunds for an economic impact of $10.5 million.
- **4-H and Other Youth Development Programs/ Impacts -- 4-H —Engaging Missouri's youth in science, engineering and technology (SET):** A recent nationwide study of more than 2,000 Missouri adolescents, both 4-H members and nonparticipants, found that 4-H'ers are more likely to:
    - take part in science, engineering and computer technology programs;
    - perform better in subjects related to science compared to their classmates;
    - plan to pursue careers in those fields; and
    - have higher levels of involvement among young women in programs related to the technology and science industries.
        - In Missouri, one of every 10 young people ages 5-18 participates in 4-H.
- **Pasture-based Dairy Team**
- **Show Me Select Replacement Heifer Program**
- **Commercial Agriculture Program**
- **Other high impact/notable Extension programs --** Missouri's multidisciplinary Pasture-based Dairy program focuses on 1) improving the existing "true" pasture-based dairies, 2) developing new opportunities for start-ups and 3) creating opportunities for traditional dairies to transition into "hybrid operations" that efficiently utilize their forage base. Expansion and growth resulting from these programmatic efforts have resulted in $100 million in new investment, generated $40 million in annual milk sales, added $124 million in total farm output, and added 1,100 additional jobs in the state of Missouri.

University of Wisconsin

- In FY '09, 1,100,290 people were served by the programs of University of Wisconsin Extension

- ***See Info Request form for details***

University of Illinois

- Pumpkin production and processing; IL leads nation in pumpkin production
- Corn and Soybean Classics – provides latest info on crops to producers
- Biofuels
- Wine growers.

Into the Future – Challenges

Ohio State University

- ***Experiment Station*** – Sustainable support from federal and state govt. for infrastructure; Rapidly expanding stakeholder base; support to commercialize IP; research park development.
- ***Extension*** – The need to create and support specialist and educator positions in advanced energy subject matter; Entrepreneurship, creativity; Local Funding, State Funding; Establishment of MOUs with 4-H Affiliated Organizations; Crop profitability controlling input and increasing yields.

North Dakota State University

- ***Experiment Stations*** – need for renovation, repair or replacement of certain facilities; operating funds to carry out preliminary research are minimal, as are equipment funds; NDAES has obtained some funding from state but more is necessary.
- ***Extension*** – housing and labor shortages; record water levels in Devils Lake Basin; water diversion to provide flood protection to Red River Valley; Diminishing federal funding.

Michigan State University

- Funding issues/challenges making it difficult to meet expectations for research and extension productivity.

Iowa State University

- ***Experiment Station*** – Maintaining quality research in the face of dwindling funding support from traditional sources, particularly federal and state government; Budget has declined from $90.7 million in FY ’05 to $89.6 million in FY ’09, while at the same time new initiatives such as research into bioenergy and bioproducts required additional funds. As a result the experiment station has gone to other sources for funding, including commercial entities and commodity groups. Funding from these groups has increased from 18 percent of the total budget in FY ’05 to almost 23 percent in FY ’09. Funds from these companies frequently include non-disclosure agreements that limit the free flow of information gained from research, thus limiting its overall impact; With reduced resources comes reduced ability to respond to emergency issues of interest to the agricultural community; Attracting and keeping talent is more challenge in the face of reduced resources.
- ***Extension*** – Harder to maintain the daily interaction with members of community on limited budget and reduced personnel; Limited budgets make it harder for Extension to continue to be a set of competitive service providers; More difficult to provide public value when required to pursue private resources.

University of Nebraska

- ***Experiment Station*** – The need to create impactful research for Nebraskans now, while ensuring a balanced research portfolio so that we are positioned to impact Nebraska’s future; Fiscal challenges related to laboratory infrastructure and infrastructure maintenance at field research sites; Developing broad-based multidisciplinary research teams (that cross unit, campus and institutional boundaries and cultures) that will have the critical expertise necessary to solve major societal problems; The need to streamline accountability and business practices to ensure maximum faculty and staff productivity.
- ***Extension*** – Declining state support and static federal and local support is leading to severe financial challenges for meeting the expectations of clientele in Extension program delivery; A traditional clientele that expects delivery of educational programs through traditional media and face to face formats as well as a growing on-line clientele that is looking for educational experiences in the web environment

challenges our ability to deliver competitive educational experiences; Those who pay the bills require increasing accountability for how resources are being spent, the behavioral and conditional changes that are resulting, and an understanding of the public value of these education programs in addition to the benefits to individual clientele groups; Competitive grant programs are becoming an increasingly critical means of financing educational programs but do not provide the long-term sustainable support necessary to produce and measure behavioral and conditional changes by participating clientele; Critical emerging issues requiring new skills and investment of resources in areas of animal systems (e.g., animal welfare), crops of the future (e.g., bioenergy production), water quantity, food safety, obesity, and youth development (e.g., STEM); Identification of resources for meeting emerging issues and access to services for rural residents.

University of Missouri

- ***Experiment Station:***
    - Meeting the research needs of the bioeconomy
    - Meeting the challenges of climate change: mitigation and adaptation
    - State and Federal budget pressures
    - Continued operation and maintenance of our Centers, Farms and Forests
    - Continued education of the public and elected officials about the importance of ag research
- ***Extension:*** State, Federal and County Budget Pressures

University of Wisconsin

- ***Experiment Station*** – Shifting National Priorities and the need to adjust current research and extension activities to address current national priorities; Increased biosecurity concerns for agricultural research programs; Reduced state resources and competition with other state needs, esp. secondary education corrections facilities and transportation; Maintenance and replacement of aging facilities; Meeting compliance for environmental regulations, especially water quality and manure management; Increased administrative and financial reporting requirements.
- ***Extension*** – University of Wisconsin Extension has a primary strength in having a very strong, locally-based presence. This is a cultural expectation of communities and is considered part of the "Wisconsin Idea." With increasingly challenged public sector budgets, maintaining this presence in creative ways while retaining the strong support of communities (that also helps to feed the larger university system) will be a challenge; UWEX enjoys the support of a diverse cross-section of agricultural and other business leaders. The state is incredibly diverse agriculturally and from a business perspective (diverse agriculture, food manufacturing, other "heavy" manufacturing, tourism, and natural resource industries. Serving all well in a difficult budget environment is a challenge; UWEX faculty specialists in many areas represent the top talent in the country (or Region). An example is the dairy team which includes campus faculty and agents. Recognition of the source and value of knowledge delivered through "third parties" is often a challenge. This includes consultants, veterinarians, partner agencies, and the Internet). A survey is being conducted to document the use of UWEX information by "multiplier" groups so that the full value of the work can be understood more fully. This will inform and answer questions and challenges such as "we do not need _____ because we get all our information from our crop consultant" (or from the Internet). We hope to better inform stakeholders of the value of the "root" source of this new research-based information.

University of Illinois

- ***Extension*** – Ability to retain adequate funding; Ability to retain recognition for materials developed.

Into the Future Opportunities

Ohio State University

- ***Experiment Station*** – Rapidly expanding stakeholder base; Research park development; Public-Private partnerships.

- ***Extension*** – Research, outreach and engagement activities in agbiosciences to address topics related to biomass, solar, wind, energy efficiency including building materials and biodigesters; More emphasis on the science and technology aspects of traditional 4-H projects; Youth Leadership Development; providing education to non-Extension youth groups/ organizations; Engaging volunteers in planning committees and in-service updates through technology rather than face-to-face; The growth of world population has once again exceeded the capacity to produce food, therefore, shortening the distance between discovery of basic agricultural research and its application, to include applied research, is as critical as ever; Animal protein products will be increasing in demand as the economies of China and India continue to grow. Yet, the threat of "animal rights activists" to US agriculture's research based livestock production systems is real. The public will need science based information to form rational decisions in what is becoming a hotly contested political issue, that may have tremendous economic and public health ramifications; Water resources maybe the most limiting factor in future food production systems. It is an area of research and education that cannot be ignored; as the "baby boomers" retire, there will be a significant "brain drain" of agriculture science knowledge. Succession planning of Extension and Research faculty is of critical importance; Farmers are requesting more on farm, applied research. Extension should position itself to serve this growing demand.

North Dakota State University

- ***Experiment Stations*** – long-term collaborative relationships with trait providers; plant breeding programs with excellent germplasm with unique traits; developing useful markers for MAS is critical to enhance seed yield; Good supply of phenotyping data which are needed for genotyping; Inter-disciplinary collaboration among departments in university allows research programs to overcome constraints.
- ***Extension*** – NDSU Extension is a valued and reliable source of unbiased, research-based information.

Michigan State University

- Bioeconomy
- Cross-disciplinary programs.

Iowa State University

- ***Experiment Station*** – Funding for sustainable agricultural systems, sustainable bioenergy, and health, food and nutrition to provide plentiful, safe and nutritious food, sustainable biofuels and biobased products, and advance environmental services like maintaining/improving soil and water quality and carbon sequestration; Bioeconomy—bio-renewables, biofuels, biobased products, biochemical and thermochemical processing, co-product development, utilization of waste streams, socio-economic environmental analysis, life-cycle analysis, energy efficiency; and policy analysis; Bioinformatics - data mining, predictive system biology, linking translational and applied animal and plant genomics; Research into wildlife and domestic animal disease to develop science-based disease control strategies for the benefit of wildlife, ag systems, biodiversity and biosecurity; Climate science—climate change modeling, policy analysis, mitigation and adaptation, impacts on crops and livestock.

University of Nebraska

- ***Experiment Station*** – Broad-based recognition among State and University leaders of the importance of agricultural and life sciences research to the current and future economic well being of Nebraska; Station - Increasing strength of our basic-research portfolio, now even better positioned to support our translational/applied research efforts designed to improve Food and Fuel production, sustainability use our Water resources and improve the overall wellbeing of Nebraska Citizens (people); Strong programmatic linkages with UNL Extension, helping to ensure our research benefits Nebraskans; Resources (people and land) uniquely suited to address the big societal challenges in food production, fuel production, water and the environment; Exciting campus-wide research initiatives that will bring increasing resources and focus on the life-sciences and Water, two critical areas of importance to Experiment Station programs and research.

- ***Extension*** – Opportunity for delivery of educational experiences to both new and existing clientele through the web environment in a manner that encourages learning at the convenience of the learner; Opportunity enhancing peer to peer learning experiences and interactions by using web social media resources; New partnership opportunities for Cooperative Extension with public and private sector organizations (e.g., Time Warner Cable and STEM education, Department of Defense and military family needs, Monsanto and new crop production and water conservation technologies.); Opportunity to use on-farm and other clientele driven research for both enhancing educational experiences of clientele and enhancing applied research capacity.

University of Missouri

- ***Experiment Station:***
  - Enhanced grant opportunities for research funding through AFRI
  - Increased partnerships with the private sector
  - Regional approaches for building research capacity and marketing ag intellectual property
  - Mizzou Advantage
- ***Extension Service:***
  - Food for the Future
  - Media of the Future
  - One Health, One Medicine: The Convergence of Human and Animal Health
  - Sustainable Energy
  - Understanding and Managing Disruptive and Transformational Technologies

University of Wisconsin

- ***Experiment Station*** – Strengthened partnerships with stakeholders, esp. in private sector; Increased joint (multistate, interdisciplinary) activities; Opportunities to better connect with environmental research in pursuit of more 'sustainable' management.
- ***Extension*** – Urban and metropolitan food systems including issues of production, logistics, creation of reliable and safe supply chains, human nutrition, energy, youth involvement, impacts on local community and economic development; Climate change and associated decision making points that can be understood and acted upon by decision makers; Creation of sustainable biofuels and biomass feedstocks and impacts on communities, food production systems, and related human impacts.

University of Illinois

- ***Extension*** – Social media; Digital divide, poor connectivity in rural areas; Shifting demands, e.g., move to fruit and vegetable production; Biomass production.