IMPACT & INNOVATION:

Agbioscience in the Southern United States

The Importance of the Southern Region's Land-grant Extension Service and Experiment Station System

Performed For:

Southern Association of Agricultural Experiment Station Directors and the Association of Southern Regional Extension Directors

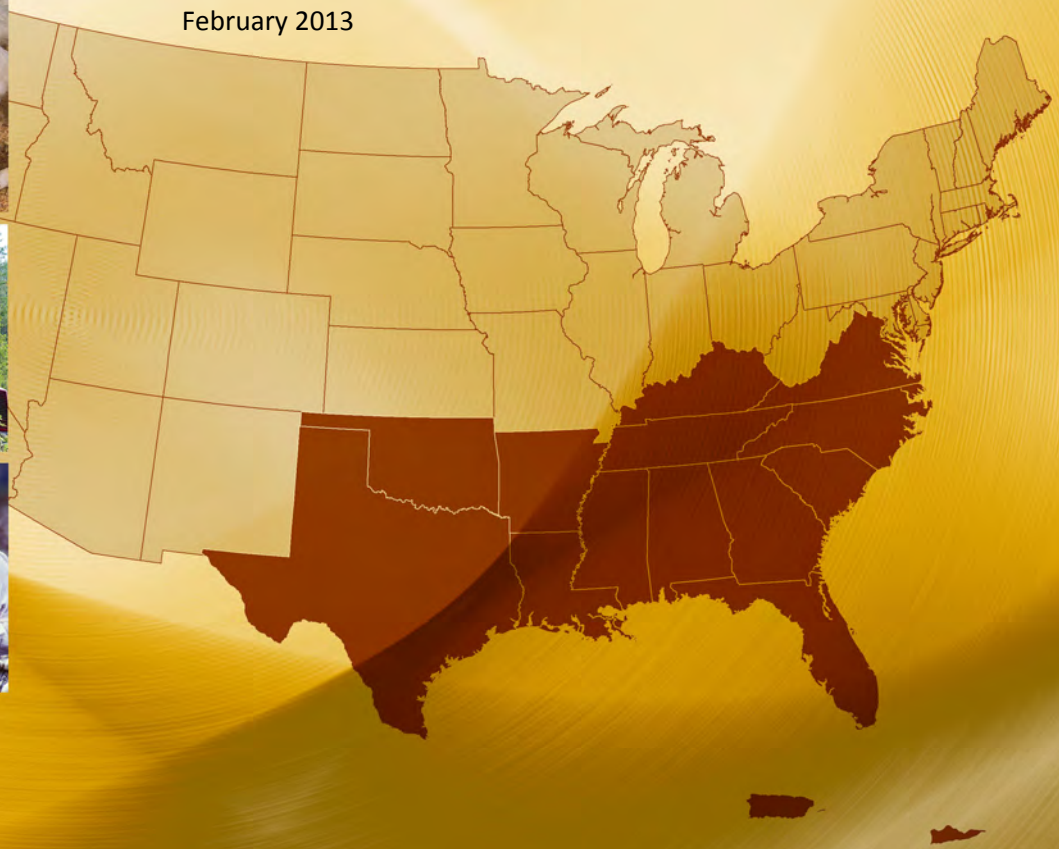
With Sponsorship By:

Auburn University • Clemson University • Louisiana State University • Mississippi State University • North Carolina State University • Oklahoma State University • Texas A&M University • University of Arkansas • University of Florida • University of Georgia • University of Kentucky • University of Puerto Rico • University of Tennessee • University of the Virgin Islands • Virginia Polytechnic Institute & State University

Performed By:

Battelle Technology Partnership Practice and BioDimensions

February 2013



Battelle
The Business of Innovation

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Sponsoring Universities in the
Southern Region of the United States:

ABSTRACT

The current and future importance of the agbiosciences is hard to overstate. Agbioscience, and its value-chain in production agriculture, forestry and downstream value-added industrial activity, is critically important for national and global economic growth and sustainability. For instance, this science and industry sector is fundamental to the survival of the world's expanding population, the food security of our nation, and the health of our population. Equally important, the agbiosciences provide a path to economic growth for our nation built upon domestic renewable resources as feedstocks for fuels, chemicals, fibers, and industrial materials. This powerful asset, present in every state, cannot be ignored; however, the agbioscience sector cannot be expected to provide for our nation's expanding needs without significant and continued investment of public funds for research, development, knowledge dissemination and adoption. The vast majority of everything we eat, drink, and wear is generated by independent producers. Those farmers, ranchers, foresters, food processors, and manufacturers rely on the researchers, specialists and agents of the Southern Region's Land-grant Extension Service and Experiment Station System to provide the scientific and technological advancements that increase their efficiency in production, marketing, processing, and new product development. Agbioscience R&D and an effective Extension delivery system are essential for the United States and the Southern Region to remain competitive and secure.

The agbiosciences provide a pathway to a secure and sustainable global and domestic economic future. The sector produces outputs with assured and growing demand, and those nations and regions that have the specialized skills, assets, knowledge, and scientific infrastructure required to produce agbioscience innovations will be particularly well positioned to realize economic growth and development from a wide range of industries.

The Southern United States stands out as a region that is particularly well positioned to advance economically via agbioscience development. A set of positive characteristics in terms of agronomic production environments, climate and growing season, water resource availability, and other land and natural assets create a resilient and flexible production base. These natural and agronomic assets are further supported by a robust infrastructure, with port facilities, railroad and river barge capacity, pipelines, and other assets able to support agriculture, forest and fisheries-oriented economic growth. In addition to being a global leader in traditional agricultural economic activity, the Southern Region can count itself as one of a select few regions in the world that is also leading the charge in emerging areas of the modern bioeconomy.

Within the Southern Region, the agbioscience sector and its associated impacts already account for a major part of the overall regional economy. Agriculture, forestry, and fisheries generate $240 billion in regional economic activity and support over 2.2 million jobs with labor income totaling $62 billion. In addition, the downstream processing of agriculture, forestry, and fisheries output into

value-added food and industrial products adds an additional $1 trillion in output across the Southern Region's economy, and almost 4.6 million jobs with labor income totaling over $200 billion.

This economic performance does not occur through serendipity. It results from the hard work of producers and processors, and is uniquely supported, developed, and enhanced by the publically supported Land-grant Universities that conduct agbioscience research, develop new technologies and practice innovations, and work proactively to disseminate knowledge and adopt innovations and best practices into applications across the agbioscience value-chain. Through the delivery of specific mission-based activities, the Southern Region's Land-grant Extension Service and Experiment Station System assures the growth and success of the regional agbiosciences, associated industry sectors, and supporting communities by:

- Providing R&D based innovations and practice recommendations that enhance productivity across the agbioscience value-chain
- Working to solve specific problems and challenges identified by producers, industry, and key stakeholders
- Assuring a safe and secure domestically produced food supply
- Catalyzing the development of the modern industrial bioeconomy (biobased fuels, chemicals, and materials) to foster economic diversification, value-added product development, and energy independence
- Fostering ecological and environmental stewardship and natural resource management
- Building stronger, healthier, economically-resilient rural, suburban, and urban communities
- Developing the specialized human capital required to sustain economic growth.

As shown by Battelle in this detailed report, the Southern Region's Extension Service and Experiment Station System represents a uniquely powerful resource for sustaining and securing the region's competitiveness and leadership in what is, and will be, a sector of core economic, social, and strategic importance. In recognition of this importance, the System is traditionally supported by federal, state, and local governments, and by industry, producers, commodity organizations, and other key stakeholders. This support must not only be sustained, but ideally (given the size and scope of grand domestic and global challenges addressed by the agbiosciences) should be significantly expanded so that the Southern Region can take advantage of the large-scale opportunities presented.

Contents

INTRODUCTION

Agbiosciences: Past, Present and Future

Agriculture is an activity that is inherently woven throughout the fabric of human history. At the dawn of civilization, humankind's planting of crops and herding of livestock made possible the creation of the first sustainable settlements. As agricultural knowledge and capabilities increased, successful farmers began to generate a surplus of food beyond their immediate family needs and paved the way for others in their communities to adopt other trades and crafts that could be bartered for food. Thus, in generating stable communities and initial trade in goods, agriculture formed the foundation of human civilization and allowed the formation of the first commercial economies.

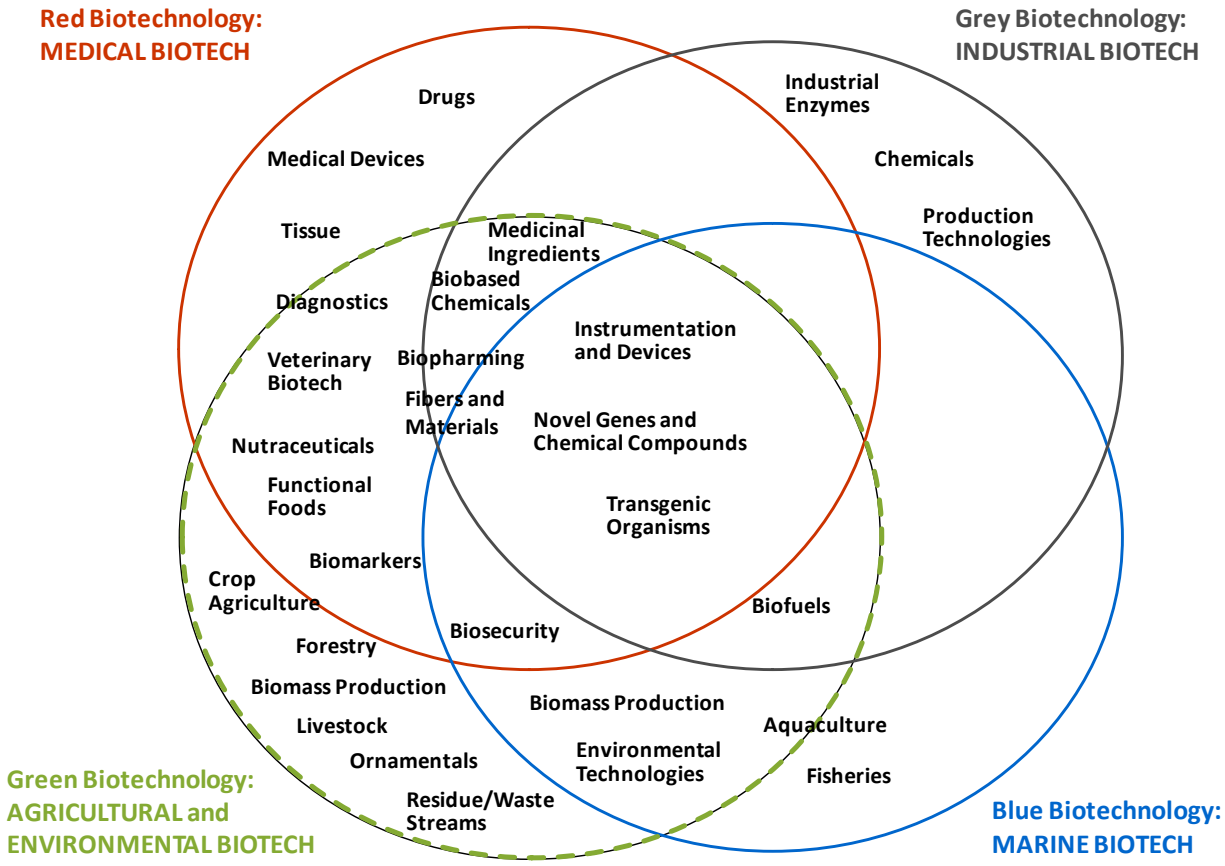
From the time of its first emergence, through to the present period, and into the foreseeable future, agriculture represents an industry of central importance to humanity. Through the cultivation of land and the use of renewable biological resources, agriculture provides the foundational energy humans need in order to pursue every other aspect of their lives. In the developing world it is well recognized that the ability of farmers to move beyond subsistence farming and into a position of trading surplus crops in the marketplace represents the first step on the development ladder. Thus, within the developing world, agricultural productivity represents the keystone of economic progress and development, just as it did thousands of years ago. In the developed world agriculture today is no less important, but in a different way. The high productivity of modern farms and forests, made possible by agbioscience advancements, means that developed nations have the opportunity to move beyond the production of basic food and fiber, into the application of biomass to a broad-range of exciting new industries in renewable biofuels, bio-based chemicals and biomaterials.

Modern agbiosciences are opening pathways to new categories of products, and to novel applications of food and biomass. While traditional methods of plant and livestock breeding have boosted farm yields, new tools and technologies rooted in advancements in molecular biology, genomics and other modern arenas of bioscience have opened the door to a new green revolution—a revolution in which plants, animals and biological resources can be engineered to meet a broad range of challenges facing humankind.

Many of the most pressing challenges facing our civilization today and into the future have direct or indirect ties to agriculture and agbioscience solutions. We need to find solutions to the nutritional needs of an expanding global population (that today stands at over 7 billion people) and do so without degrading our

finite agronomic land or causing further deforestation. We need to provide a diet that sustains strength and health, allowing the world's population to be productive. We need to expand the use of renewable and sustainable resources and move away from economies dependent on non-renewable resources and waste. We need to address the challenges of global climate effects, water resource depletion, pollution and the proliferation of toxins and contaminants from human activity. Agriculture and agbioscience have a central role to play in each of these grand challenges as illustrated in Figure 1.

Figure 1: Agbiosciences within the 21st Century Bioeconomy



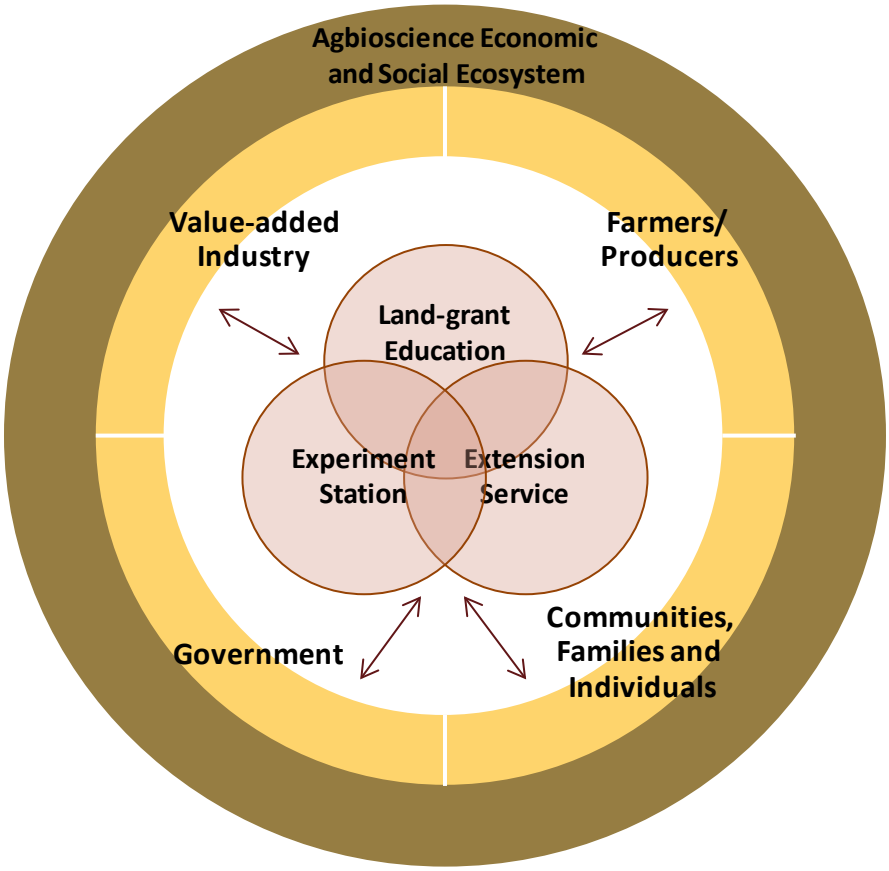
Land-grant Extension Service and Experiment Station System: A Critically Important Support System

Against this background of agbioscience importance, relevance and future promise, it must be recognized that agriculture is also a unique industry structured around more than 2 million individual U.S. farms (effectively small and midsize businesses for the most part). The complexity of the industry, the annual "make-or-break" decisions that producers face, the great geographic

variability of the production environment, and dynamic nature of threats and challenges that face the industry, might be overwhelming if not for the special system of agbioscience research, education and extension support that extends across the nation through U.S. Land-grant Universities. As illustrated in Figure 2, this tripartite mission of research, education and extension works as an integrated system to support:

- Farmers, foresters, fisheries professionals and other biomass producers and harvesters
- Value-added industries, in the production of inputs to agriculture and the conversion of agricultural, forest and fisheries biomass into value-added industrial and consumer products
- Rural and urban communities, families and individuals who directly or indirectly depend on the agbioscience-driven economy
- Government (as it works to provide a sustainable economic and policy framework suited to the ongoing needs and growth of the industry).

Figure2: Land-grant Universities and their Extension Service and Experiment Station System – An Integrated Research, Education and Extension System in Support of the Agbioscience Economic and Social Ecosystem



Notably, the Land-grant Cooperative Extension Service (CES) and Agricultural Experiment Station (AES) System, herein referred to as the Extension Service and Experiment Station System, provides a mechanism that supports a two-way exchange of knowledge and information. The challenges of producers, businesses in the agbioscience value-chain, communities and social groups are understood and anticipated by a uniquely diverse and distributed network of Extension professionals and Experiment Station research scientists—a network able to sustain regular contact with the needs of those in the field, in industry, in government and in community leadership positions. In turn, the Extension Service and Experiment Station System provides the specialized assets, infrastructure, and human capital (supported by federal, state and local resources) required to bring science to bear on the challenges and issues presented, and to disseminate and assist in the adoption of knowledge in regards to innovations, advancements, practice recommendations and technologies back into the field. There is thus a robust feedback loop that benefits the agbioscience sector through the presence and operations of the Land-grant Extension Service and Experiment Station System. It is a quite unique and inherently American system that has served the nation well, and positions the country and its individual states for success in an increasingly bioscience-driven century.

Recognizing the critically important role that their institutions have played, and will continue to play in regional, national and global agbioscience development, the directors of the Extension Service and Experiment Station System across the 13 states and two U.S. territories comprising the Southern Region (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Puerto Rico, and the U.S. Virgin Islands) came together to commission a study that would highlight their assets and capabilities.

Battelle's Technology Partnership Practice (TPP) and BioDimensions was engaged to produce an independent analysis regarding the importance and relevance of agbiosciences, the current size and scope of the agbioscience ecosystem in the Southern Region, and the special assets, capabilities and infrastructure contained within the 1862 Southern Land-grant Universities that work to sustain and grow this ecosystem. Battelle TPP, and their partners at BioDimensions, were selected for the work based on a long-standing track record of expertise in agbiosciences and agbioscience development economics, and the recent work of Battelle and BioDimensions in producing a similar assessment for 12 Land-grant Universities in the North Central U.S.[1]

[1] Battelle Memorial Institute and BioDimensions. 2011. "Power and 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."

About This Report

Within this report, Battelle/BioDimensions takes a structured approach to discussion of the relevance of agbiosciences, the U.S. and Southern Region positions in the global agbioscience economy, the important role played by Land-grant Universities in supporting the agbioscience ecosystem, and the specific assets and impacts of the Extension Service and Experiment Station System. The report also measures the current expenditure impacts of these institutions and the multiplier effects of these expenditures in each state economy, but more importantly, discusses many of the key functional impacts being generated by these institutions through their actual research, extension and education activities. The report also highlights the special promise that agbiosciences holds for advancing the U.S. and Southern Region economies, but it also outlines some of the very real threats facing the Land-grant system that constrain its ability to optimize benefits for society and the economy.

IMPORTANCE OF THE AGBIOSCIENCE INDUSTRY TO THE SOUTHERN REGION

A Strategic Industry in a Highly Dynamic Operating Environment

The agricultural bioscience (agbioscience) sector is a knowledge-based industry that is constantly advancing as scientists, engineers, researchers, and Extension educators gain new insights in plant and animal genetics, nutrition, health and a broad range of other life science applications. Innovations in the agbioscience sector have shifted agriculture's focus to not only include high-productivity food and fiber production but also specific goals of improving public health, increasing social and economic well-being, and enhancing environmental sustainability.

Agriculture today is playing an important role in leveraging basic and applied sciences to deliver innovative new technological products. Increasingly, agbioscience is being seen by states as a technology-based economic development engine, leveraging America's leadership in life sciences and associated technologies to evolve new business clusters in such diverse areas as: advanced nutrition products and functionally enhanced foods; natural health products and production of biopharmaceuticals and vaccines through agricultural pathways; bio-based industrial products (such as biofuels, green chemicals, and biomaterials); and tools and technologies to facilitate sound stewardship of the environment and natural resources. The technological breakthroughs from agbiosciences Research & Development (R&D) take shape in new and innovative products used in everyday life, across the Southern Region, the nation and the world.

Notably, agriculture and agbiosciences represents a "home-grown" industry, leveraging the natural resource assets of the United States to form a modern economic driver that is an important component of the economic and social fabric of every state in the nation. Indeed, one of the most notable characteristics of agbiosciences, compared to most other technology-focused economic sectors, is the highly diffused nature of its primary production and value-added economic activity. While sectors such as information technology and software development, aerospace manufacturing, medical device manufacturing, etc. are highly concentrated in certain major metropolitan areas, agbioscience and its value-chain is unique in being a science and technology-driven sector that is present in every county in the nation.

While agriculture and agbiosciences represent a key innovation sector for the entire nation, it is an industry that operates in a highly dynamic and competitive market. Globalization, trade liberalization, changing consumer preferences,

public concern about food safety and the environment, and changes in the relationship between agriculture and rural communities have altered the context in which agbioscience development is being pursued and conducted. Thus, not only is agbioscience adapting to advanced bioscience and other technological developments, it is also having to adapt to substantial shifts in the economic and social frameworks within which it operates.

As with all industries that sell a significant percentage of their output into worldwide commodities markets, the agbioscience industry is an exceptionally competitive field of business. For the Southern Region's large and significant agbioscience industrial sector to remain competitive, the region's producers must be equipped with the knowledge, skills, tools, and inputs required to produce quality products at competitive prices and that anticipate changing market preferences. It may come as a surprise to those outside of agriculture that this industry, perhaps more than any other industry, requires specialized local industry research and development (R&D) to remain competitive. Unlike producers of the typical manufactured product, agricultural producers have to work within a dynamic production environment that contains great geographic variety and year-to-year variability, uncertainties, and risks. It is also unique in being a production industry driven by the output of over 2 million individual producers (there being 2,181,000 farms in the U.S.)[2], so unlike other production sectors (such as automobile manufacturing, aerospace, information technology, chemicals, etc.) the industry does not comprise a few large entities with substantial R&D budgets, but rather comprises millions of smaller entities that have to rely on R&D, information and advice produced by external parties. It is a very unique industry.

To be successful in this dynamic production environment, a producer needs to make informed decisions across a broad range of variables, including for example:

- Climatic conditions, such as amount of rainfall, amount of sunlight, temperature ranges, etc.
- The emergence of bacterial, fungal, and viral diseases and pathogens that impact the production of crops and livestock
- The control of insects and other pests impacting pre- and post-harvest output
- Land management, including the retention of soil, the maintenance of optimal soil fertility, and drainage management.

[2] Farms, Land in Farms, and Livestock Operations 2011 Summary: Released February 2012, by the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture.

The producer also has to consider what impact these variables may have on farmers in other regions, countries, and continents whose production will affect commodity prices and thus return on investment for the farmer. Those involved in the U.S. agbioscience industry face an almost overwhelming series of decisions each year that may make or break their bottom line (such as those illustrated in Figure 3):

Figure 3: Agricultural Production – A Unique Industry with Annual Make-or-Break Decisions

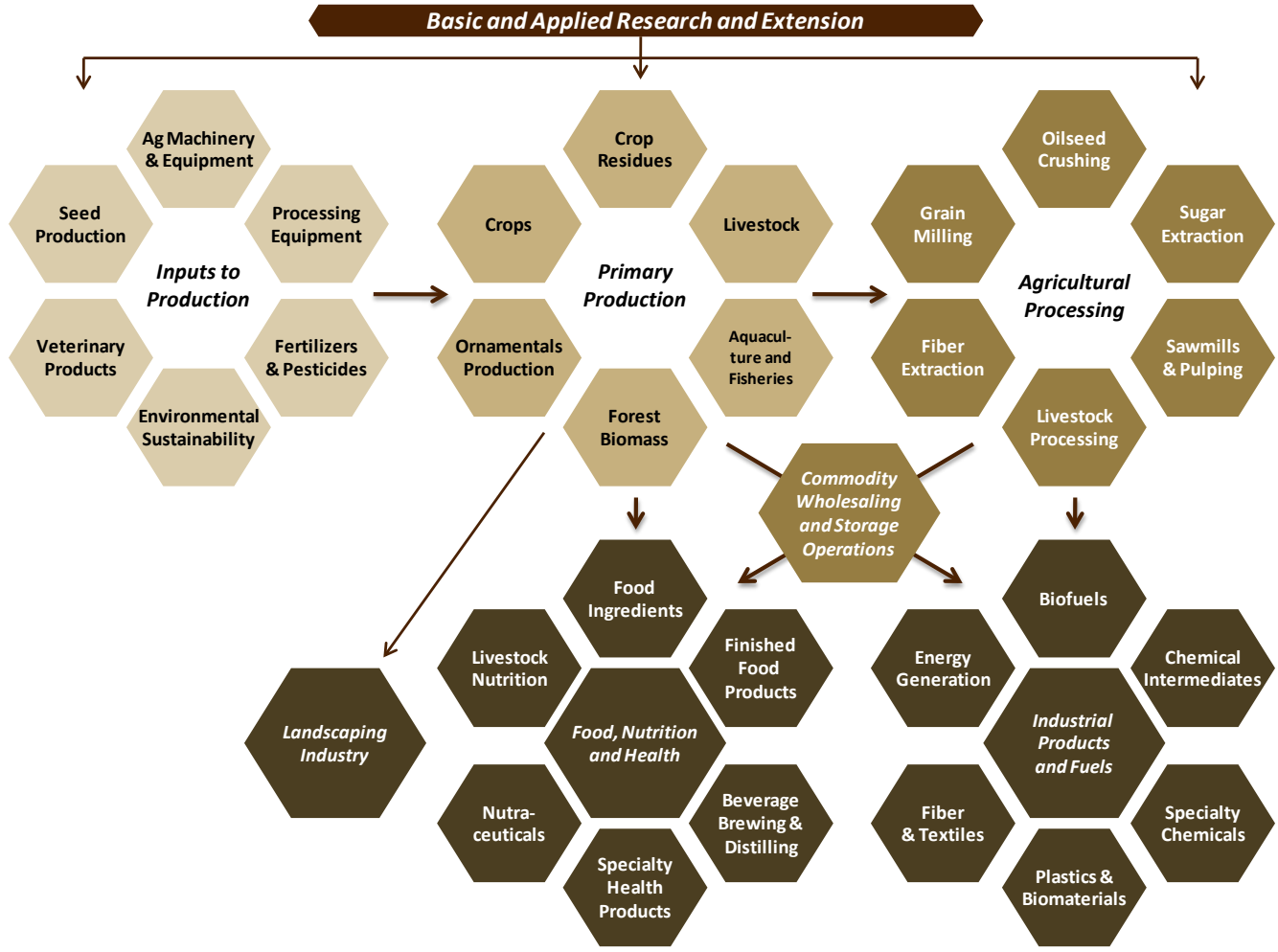
No other category of business faces such a variable and risky series of decisions that must be made and repeated year after year. Yet, as will be evidenced in the narrative and data outlined in this chapter it represents a strategic, domestic, export oriented industry that is supported by a robust network of government, industry and university-based assets that help to inform and support producer decisions and ongoing productivity enhancement across the agbioscience value-chain. In the U.S. overall, and within the specific states of the Southern Region, agbioscience economic sustainability and progress is underpinned by:

- The specialized work of Land-grant Universities in performing basic and applied agbioscience R&D, education services, knowledge dissemination and adoption, and proactive industry support
- USDA R&D, extension, outreach and production supports
- Advanced research and product development performed by major agbioscience corporations in the private sector.

Agbiosciences Defined

What do we mean when we use the term "agbiosciences?" Battelle considers agbiosciences to encompass a broad continuum of activity in the development, production and value-added use of plant and animal 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 technologies and inputs used in production, primary agricultural, aquacultural, and forestry production itself, and the downstream processing of agriculture, aquaculture, and forest outputs into useful technologies and products. Furthermore, the agbioscience industry is supported and driven by strong communities and resilient youth and families that help to sustain this complex system. 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



Land Use (1000s of acres)[1]	United States
Total Land Area	2,260,994
Farmland	916,990
% Used as Farmland	41%
Farms in 2011[1]	
Number of Farms	**2,181,000**
Value Added to the U.S. Economy by Agricultural Prodution and Services ($1,000s) in 2011[2]	
Total Ag Output	418,050,919
Agriculture Receipts by Commodity ($1000s) in 2011[2]	
Corn	63,874,136
Cattle and Calves	62,925,466
Dairy products	39,532,545
Soybeans	37,574,197
Broilers	23,172,674
Total Ag Commodities	**338,520,560**
Top 5 Agriculture Exports ($ millions)[3]	
Soybeans	18,564.1
Corn	9,808.4
Wheat and products	7,060.1
Cotton	5,895.9
Feeds and fodder	5,139.6
Total Ag Exports	**115,815.1**

[1]Farms, Land in Farms, and Livestock Operations 2011 Summary: Released February 2012, by the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture. http://www.nass.usda.gov/

[2] USDA US Farm and Wealth Statistics at http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx#13953

[3] USDA Economic Research Service; USDA Foreign Agricultural Service (Global Agricultural Trade System)

The Agbioscience Industry in the United States

In the context of global agricultural production, it is generally acknowledged that the U.S. is the worldwide leader. Comprising just 6.1 percent of global land area, the United States in 2011/12 produced, for example, 21.1 percent of global oilseeds, 16.6 percent of the world's grains, and 12.6 percent of worldwide cotton[3]. In livestock, the U.S. is the worldwide leader in poultry and beef production (with 21.8 percent and 21.0 percent of global production respectively), and produces 9.9 percent of the world's pork. [4]

As a result of this large-scale output, agriculture is a critically important part of the U.S. economy. In 2011, there were over 2.1 million farms in the United States using nearly 917 million acres (about 40 percent) of the country's total land area for crops, forests and pastureland. These farms directly contributed over $418 billion to the U.S. economy, including $115 billion in exports. Fisheries add an additional $5.4 billion in direct output to the U.S. economy.[5]

Agriculture's contribution to the national economy, and society, however, does not end at the farm gate. Highly productive American farmers provide the feedstocks and base products that drive a complex agribusiness value-chain. Innovation in ag-based products results in expanded product lines and new business generation that increase U.S. economic output and generate critically important employment opportunities in many of our most hard hit economic regions. Battelle analysis indicates that the U.S. agbioscience industry sector employed nearly 8 million individuals across more than 2.5 million establishments in 2010.[6] This dynamic industry and the incomes it generates contributes to improved social conditions and quality of life for residents throughout the United States and, in particular, greatly impacts rural regions that, as noted previously, are often less impacted by growth in other technology sectors. A healthy and productive agbioscience industry is thus foundational for the nation's rural economy and small towns, but it also extends its

[3] USDA Office of Global Analysis. Foreign Agricultural Service at http://www.fas.usda.gov/psdonline/psdreport.aspx?hidReportRetrievalName=BVS&hidReportRetrievalID=425&hidReportRetrievalTemplateID=2

[4] U.S. Census Bureau. Online at http://www.census.gov/compendia/statab/2012/tables/12s1376.pdf

[5] It should be noted that while the U.S. is a clear global leader in many agricultural commodities it is far less so in quaculture. U.S. freshwater and marine aquaculture, according to NOAA statistics (http://www.nmfs.noaa.gov/aquaculture/aquaculture_in_us.html), is a $1 billion industry (just 1 percent of a global $100 billion industry sector). Including fisheries, as well as aquaculture, the U.S. imports 86 percent of total consumption.

[6] Battelle analysis of Bureau of Labor Statistics, QCEW data, enhanced file from IMPLAN; unincorporated farm employment from BEA.

positive impacts into major urban areas (where much value-added production occurs).

While the traditional application of agriculture to food production remains a key component of the economic mix, modern research developments and innovations in agbioscience are creating new markets for crops and crop residues as renewable, bio-based feedstocks for a number of key industries, including renewable energy, chemicals, plastics and health products. New technologies, applied to applications in biofuels production and bio-processing, can use renewable domestic resources to prevent pollution, reduce costs, and conserve water and energy, while delivering valuable, innovative products to improve the quality of life not only for Americans but for people around the world.

While the U.S. is currently the global leader in agbioscience and agricultural production, 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 what many have termed the BioCentury. The U.S. is, for example, at the forefront of developing and applying the tools and technologies of biotechnology and genomics in producing new and improved crops for global markets and is applying its technological expertise in the development of new feedstocks and 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.

U.S. leadership cannot be taken for granted, however. Agbiosciences have been increasingly recognized as a strategic opportunity for science and technology-based economic growth in a number of developed and developing nations. To sustain its global leadership position, the U.S. will need to continue to invest in the basic and applied research and extension required to maintain the nation's position as a global leader in agbioscience innovation and the application of innovations to high productivity agricultural production and value-added product development.

Agbiosciences in the Southern Region

Agricultural Production Analysis

As noted above, the United States stands as the global leader in agricultural production, and within the U.S., the Southern Region is a significant contributor to that position. The Southern Region includes 13 states and two U.S. territories, including: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Puerto Rico, and the U.S. Virgin Islands.

Land Use (1000s of acres)[1]	Southern Region	Percent of U.S.
Total Land Area	534,356	24%
Farmland	271,950	30%
% Used as Farmland	51%	NA
Farms in 2011[1]		
Number of Farms	**878,100**	**40%**
Value Added to the U.S. Economy by Agricultural Prodution and Services ($1,000s) in 2011[3]		
Total Ag Output	**107,112,694**	**26%**
Agriculture Receipts by Commodity ($1000s) in 2011[2]		
Cattle and Calves	19,286,179	31%
Broilers	18,732,036	81%
Cotton	6,542,339	78%
Greenhouse/Nursery	5,300,413	34%
Corn	4,940,496	8%
Soybeans	4,765,364	13%
Dairy Products	4,279,129	11%
Hogs	4,159,967	19%
Chicken Eggs	2,910,017	40%
Wheat	2,386,334	16%
Total Ag Commodities	**82,095,182**	**24%**
Top 5 Agriculture Exports ($ millions)[3]		
Cotton	4,866.2	83%
Chicken meat	2,768.5	89%
Soybeans	2,633.3	14%
Rice	1,519.5	65%
Beef and veal	1,160.6	28%
Total Ag Exports	**28,062.8**	**24%**

[1]Farms, Land in Farms, and Livestock Operations 2011 Summary: Released February 2012, by the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture. http://www.nass.usda.gov/

[2]USDA US Farm and Wealth Statistics at http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx#13953

[3] USDA Economic Research Service; USDA Foreign Agricultural Service (Global Agricultural Trade System)

Agricultural production is a major industry across the South, contributing over $107 billion to the Southern Region's economy. In a number of commodities the region holds a preeminent position—for example, the region accounts for approximately 80 percent of the nation's broilers and cotton (statistics that are particularly telling given that the U.S. is considered a global leader in the production of both broilers and cotton). In addition, the region accounts for 40 percent of the nation's egg production, 34 percent of the greenhouse/ nursery stock, and 31 percent of the cattle and calves (another area of agricultural production for which the U.S. leads the world).

What is particularly unique about the Southern Region when compared to the nation overall is the percentage of land utilized for agricultural production as well as the number of farms involved. In 2011, there were nearly 880,000 farms in the Southern Region—representing 40 percent of the nation's total number of farms in a land area that represents 24 percent of the United States. These farms cover nearly 272 million acres (over 50 percent) of the region's total land area. These numbers indicate that within the Southern Region, the role of small farms is quite important since more land is dedicated to farming across smaller farms than one would expect when compared to national statistics.

Agricultural production in the Southern Region also contributed 24 percent of U.S. agricultural exports, or $28.1 billion, a significant economic benefit to the region and the nation. In multiple major commodity categories, the region is highly important and productive—responsible for

89 percent of U.S. chicken meat exports, 80 percent of cotton exports, 65 percent of rice exports, and 97 percent of the nation's unmanufactured tobacco production.[7]

The Southern Region is a particularly important contributor to the forestry and forest industry sectors of the U.S. economy. Fifty percent of the total land area of the Southern Region is forested, versus just 33 percent in the nation overall. The region contains 267 million acres of forest, of which 210 million acres is categorized by the USDA Forest Service as timber land.[8] In terms of forest inventory, the south is a particularly productive growing environment, accounting for 49.7 percent of the nation's annual timber growth (from just 24 percent of the nation's land area), according to the most complete production assessment undertaken.[9] In terms of harvesting, the Region accounted for an even higher percentage of national forest output, accounting for 62.3 percent of the nation's production. Also important to note, that in the Southern Region forest growth exceeds removals, with 15.0 billion cubic feet of growth in 2006, 9.8 billion cubic feet in removals, and just 3.8 billion in mortality.[10] In terms of direct economic output, Battelle's analysis of IMPLAN data show that commercial logging, forest products and timber tract production in the Southern Region totaling $8.5 billion per year.

With all except four of the regions states and territories having a coastline, commercial fisheries are also an important component of the economic mix. National Oceanic and Atmospheric Administration (NOAA) Fisheries data indicate that the Southern Region had a landed catch of almost 2.4 billion in 2011, worth $1.2 billion.[11]

Agbioscience Industry Analysis

The Southern Region's significant level of agricultural output and productivity, together with the discovery and application of new technologies in agbioscience, has fueled the development of 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.

[7] USDA Economic Research Service; USDA Foreign Agricultural Service (Global Agricultural Trade System)

[8] USDA Forest Service. Forest Inventory and Analysis FIDO database, accessed February 13, 2013.

[9] USDA Forest Service. Forest Inventory and Analysis. "U.S. Forest Resource Facts and Historical Trends." 2007 data.

[10] USDA Forest Service. Forest Inventory and Analysis FIDO database, accessed February 13, 2013.

[11] NOAA Fisheries: Office of Science and Technology. Fisheries Statistics Division. Online data service, accessed at: http://www.st.nmfs.noaa.gov/st1/commercial/index.html

In 2011, in addition to the nearly 880,000 farms in the region, the Southern Region contained more than 82,000 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, aquaculture, and forestry processing services such as grain milling, oilseed crushing, and lumber milling.
- 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 value-added industries employed nearly 2.7 million people (approximately 7.5 percent of private sector employment in the region) (see Appendix A for additional details).[12] This represents a three percent higher level of employment concentration for the regional industry cluster than the nation—a location quotient (LQ) of 1.03.[13] The agbioscience industry in the Southern Region is also relatively diverse with significant employment across all Battelle measured agbioscience subsectors, and has two regionally specialized industry subsectors: Agricultural Processing (LQ is 1.28); and Primary Production—Unincorporated (LQ is 1.23).

It is clear that the industries involved in the value-added agriculture and agribusiness chain represents a core strength for the region to build upon. The region is also a hub for major agbioscience-based companies, for example:

- Eight of the top 25 U.S. and Canada food processing manufacturers have their HQ operations in the Southern Region (PepsiCo, Tyson Foods, Dean Foods, Smithfield Foods, Pilgrim's Pride, Coca-Cola, Mars, and Dr Pepper Snapple Group).[14]
- Two of the world's preeminent agricultural equipment manufacturers are based in the region (AGCO and Alamo Group).[15]
- Several of the world's largest agbioscience companies, such as Syngenta, Monsanto, Bayer Crop Science and Dow Agrosciences have major subsidiaries or R&D operations in the Southern Region.

[12] 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

[13] 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. In this analysis, regional specializations are defined by LQs of 1.20 or greater.

[14] See http://www.foodprocessing.com/top100/index.html

[15] See http://www.firstresearch.com/Industry-Research/Agricultural-Machinery-Manufacturing.html

- Four of the top 10 animal health product suppliers have primary operations in the Southern Region (Pfizer Poultry Health Division, Merial, Novartis, and Virbac).[16]

Using the IMPLAN input-output model developed for the Southern Region, Battelle measured the economic impacts of the agricultural, forestry and fisheries production sector in the Southern Region and the production contained in the downstream value-added production activities in food, fiber and biofuel products production sectors.[17]

The Battelle analysis finds that the Southern Region's agbioscience industry and its associated impacts accounts for a major part of the overall regional economy. As shown in Table 1, agriculture, forestry and fisheries underpin $240 billion in economic activity in the Southern Region and support 2.22 million jobs with labor income totaling $62 billion. In addition, the value-added downstream processing of agriculture, forestry and fisheries output adds an additional $1 trillion in economic output across the Southern Region's economy, and almost 4.6 million jobs with labor income totaling over $200 billion.

Table 1: Agbioscience Economic Activity in the Southern Region

	Agriculture, Forestry and Fisheries Production (Direct, Indirect and Induced Impacts Total)	**Downstream Value-Added Agbio Manufacturing** (Direct, Indirect and Induced Impacts Total)
Total Economic Output	$240 billion	$1,000 billion
Total Employment	2.22 million	4.57 million
Total Labor Income	$62 billion	$205 billion

Taken together, this active system of agricultural production and advanced value-added manufacturing places the Southern Region among the global leaders in both traditional agricultural economic activity and a leader in emerging areas of the modern bioeconomy.

In the future, the Southern Region is particularly well positioned to advance economically via agbioscience. A set of positive characteristics in terms of agronomic production environments, climate, water resource availability and other land and natural assets create a resilient and flexible production base. These natural and agronomic assets are further supported by a robust infrastructure, with port facilities, railroad and river barge capacity, pipelines and other assets able to support agriculture, forest and fisheries oriented economic growth.

[16] See http://www.vpgcorp.com/webfiles/brochures1/animalhealth.pdf

[17] It should be noted that the downstream value-added sectors used in this analysis are limited to food and feed products manufacturing, wood products and paper manufacturing, textiles, and biofuels. Not included are biobased products such as chemicals and polymers that may be biobased but are contained within overall economic sectors largely based on pertrochemical usage.

A POWERFUL SUPPORT SYSTEM—THE SOUTHERN LAND-GRANT EXTENSION SERVICE AND EXPERIMENT STATION SYSTEM

The Relevance of the Land-grant Extension Service and Experiment Station System in the 21st Century Economy

It has become clear that the primary production of agricultural commodities and the manufacturing and distribution of value-added agricultural products compete in a challenging global marketplace. In real terms, the movement of commodity prices in worldwide markets has trended consistently downward for the past 40 years (on average declining by 2 percent annually).[18] The United Nations Food and Agriculture Organization (FAO) notes as follows:

> *Several factors have contributed to this long-term decline. Prices of agricultural commodities can be expected to decline relative to industrial products as technological advances reduce costs and make it possible, at given prices, to expand production at a rate that outstrips both population growth and increases in demand spurred by rising incomes. Prices of some commodities have also been driven lower by oversupply, fueled by intense global competition in production, reduced transportation costs and new technologies that have increased productivity and introduced synthetic alternatives to some commodities. In some cases, the emergence of major new producers has also affected market balance.*[19]

Against this trend of increased global competition, price, and production cost pressures, Southern producers and agri-businesses, including the vertically integrated ag-production, ag-processing, food-processing, and products' distribution chain, have had to strive to increase production efficiency and sustain consistent increases in output and quality.

Against such a background of rapid and dramatic change, can the Extension Service and Experiment Station System, established in the late 1800s, be relevant? The surprising answer is that agricultural research institutions and agricultural extension may well be *more* necessary and relevant than ever before. ***Much of what is required for 21st century success (innovation, technology transfer, human capital enhancement, productivity improvement, networking, and quality of environment and place) is directly addressed through the mission and operations of the Land-grant Extension Service and Experiment Station System.***

[18] "Recent Developments and Long-Term Trends: Long-Terms Trends Reveal Structural Changes." *The State of Agricultural Commodity Markets 2004,* United Nations Food and Agriculture Organization (FAO), FAO Economic and Social Development Department, 2004.

[19] Ibid.

The 1862 Land-Grant Universities in the Southern Region include:

- *Auburn University*
- *Clemson University*
- *Louisiana State University*
- *Mississippi State University*
- *North Carolina State University*
- *Oklahoma State University*
- *Texas A&M University*
- *University of Arkansas*
- *University of Florida*
- *University of Georgia*
- *University of Kentucky*
- *University of Puerto Rico*
- *University of Tennessee*
- *University of the Virgin Islands*
- *Virginia Polytechnic Institute & State University*

Being able to compete in the world agricultural economy requires constant innovation, practice improvement, new technology introduction, skills enhancement, and global intelligence—exactly the competitive factors that the Land-grant Extension Service and Experiment Station System was created to enhance, develop, and support. Since the enactment of the Morrill Land-grant Act of 1862, that was enhanced by the Hatch Act of 1887 and the Smith-Lever Act of 1914, the Southern Land-grant Universities have maintained the continuous operations of the Extension Service and Experiment Station System dedicated to supporting the agricultural community with research, analysis, information, and advice.

Research conducted by Extension Service and Experiment Station System 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 ranges from basic to applied. Basic research focuses on the underlying processes and systems that make a plant, animal, ecosystem, food system, community or marketplace work. For example, basic research might investigate molecular mechanisms of disease activity within a crop plant, or seek to identify the whole genome sequence of a crop plant or livestock species. Applied research expands on basic research findings to produce knowledge and innovations that can be advanced to the benefit of farmers, ranchers, suppliers, processors, consumers and communities. For example, applied researchers can use the genetic map of a crop, together with an understanding of the genes associated with disease resistance to develop a crop variety expressing traits that combat disease causing pathogens.

Experiment Station scientists often collaborate with farmers, ranchers, seed producers, suppliers, processors and other stakeholders in the agriculture community. They also work closely with Extension Service, which is comprised of specialists and county agents who, through transformational education, help lead members of both rural and urban communities to adopt new developments in food, agriculture and socioeconomic systems relevant to their progress. Research and extension 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.

Congress created the Extension Service and Experiment Station System over a century ago to address rural and agricultural issues. At that time, more than 50 percent of the U.S. population lived in rural areas, and 30 percent of the workforce was engaged in farming. The system's engagement with rural America helped make possible the American agricultural revolution, which dramatically increased farm productivity, for example:

- In 1945, it took up to 14 labor-hours to produce 100 bushels of corn on 2 acres of land.
- In 2011, that same 100 bushels of corn were produced on less than an acre with less than three labor-hours.

Despite the sharp decline in the population and workforce of rural America over the last century, the Extension Service and Experiment Station System remains an important contributor to the nation's economic development and social well-being. By adapting to changing times and landscapes, the system has continued to sustain its relevancy and importance by addressing a wide range of social, agricultural and environmental needs in both urban and rural areas.

Today, the Extension Service and Experiment Station System focuses on a wide array of critical issues affecting people's daily lives and each the region's future. Specifically, the system works to improve the quality of life for all citizens by helping to

- Improve agricultural profitability and productivity
- Create new products
- Protect animal and plant health
- Enhance environmental sustainability
- Promote sound human nutrition and health
- Strengthen children, youth, and families
- Revitalize the region's communities.

The Southern Region's Land-grant Extension Service and Experiment Station System provides a sophisticated suite of research, development, education, and advisory services dedicated to improving the competitiveness and sustainability of the region's agbioscience industry sectors. Together, the Southern Region's Land-grant Extension Service and Experiment Station System is a pragmatic, applied asset dedicated to finding workable solutions to the challenges facing the region's agriculture, related industries, families, and communities. Via basic scientific research, and translational and applied R&D, the System is a consistent source of new products, processes, and techniques that help make the region's agricultural producers among the most productive in the world.

At a national level, the Extension Service and Experiment Station System has sought to advance recognition and understanding of the extreme relevance and importance of their work. The Experiment Station Committee on Organization

and Policy and the Extension Committee on Organization and Policy, both of the Association of Public and Land-grant Universities, published long range strategic plans in 2010; titled respectively, “A Science Roadmap for Food and Agriculture” and "Strategic Opportunities for Cooperative Extension". From these national strategies, the Southern Region has adopted the following integrated goals as shown in Table 2:

Table 2: Southern Region Extension Service and Experiment Station System Integrated Challenges

Integrated Challenges[20]
• Ensure a safe, secure, and abundant food supply for the United States and the world • Improve human health, nutrition, and wellness of the U.S. population • Strengthen individual, family, and community development and resilience and prepare youth, families and individuals for success in the global workforce • Increase effective decision-making regarding environmental stewardship • Enhance the sustainability, competitiveness, and profitability of U.S. food and agricultural systems, including adapting to and mitigating the impacts of climate changes on food, feed, fiber, and fuel systems • Create pathways to energy independence, including the development of the bioeconomy from renewable natural resources

The System is dedicated to fulfilling multiple functions of critical importance to economic and social progress in the Southern Region—and these functions directly relate to the economic and social needs and challenges of states by serving as:

- **An innovation engine** using science to develop and test new technologies and bioscience innovations to sustain the current agriculture economy and power a new economy based on agbioscience discoveries by improving and expanding product lines and new business generation to increase the Southern Region’s economic output.
- **A transformational educator** working to improve the adoption of technology to enhance productivity, improve quality of life, and expand the economic base of the region.
- **A teacher** seeking to significantly enhance human capital, generate new scientists and well-educated practitioners, and promote lifelong learning across the region.

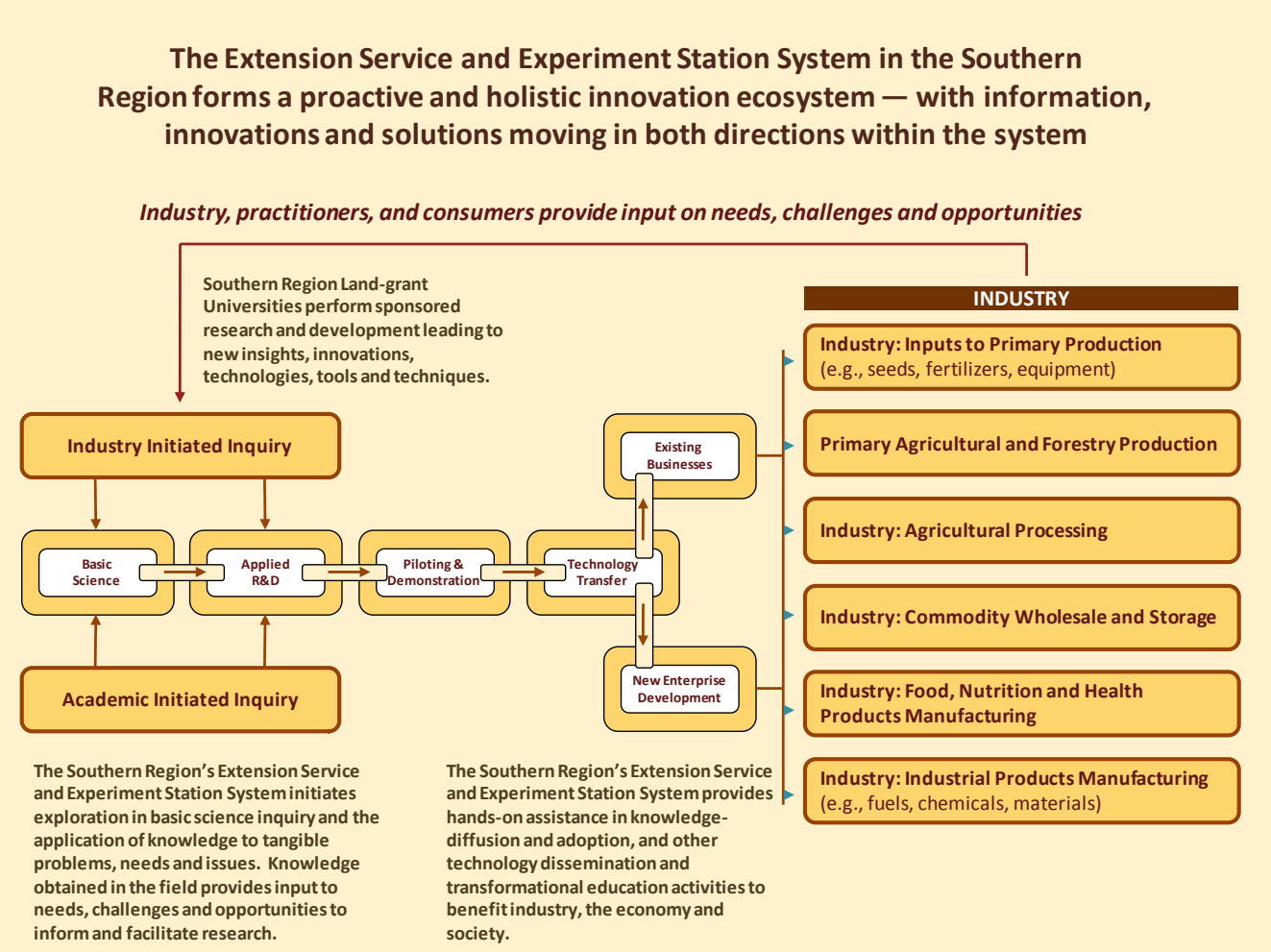
[20] Derived from the Association of Public and Land-grant Universities, Experiment Station Committee on Organization and Policy – Science and Technology Committee “A Science Roadmap for Food and Agriculture” published November 2010 and Association of Public and Land-grant Universities, Extension Committee on Organization and Policy – Science and Technology Committee “Strategic Opportunities for Cooperative Extension” published 2010.

- **A regional network**—with a presence in every county—linking communities, businesses, and the general population to the intensive R&D and technical resources of the System.
- **A cross-disciplinary entity** that is flexible, using integrated approaches to tackle complex problems in scientific, economic, and social areas.
- **A catalyst** for the improvement of natural resource management practices, enhancing the environment, and sustaining the quality of place in the Southern Region, ensuring the attractiveness of the region for human capital and new ventures.
- **A deliverer** of research, teaching, and extension efforts to bolster food safety, a safe food supply, and the protection and promotion of the health of the region's citizens.
- **A strengthener** of the quality of life of individuals and families, thereby contributing to community sustainability and vitality.
- **A provider** of 4-H Youth Development and leadership services, helping to provide the next generation of workers, leaders, and responsible citizens.

The Southern Region's Land Grant Extension Service and Experiment Station System works to sustain the economic viability of the region's industries and communities and to expand the economy via the development and adoption of new products and technologies for Southern producers.

Through a systematic pipeline of research and extension (see Figure 5), comprising Experiment Station and Extension Service programs, these institutions are leading the way in agbioscience R&D, transformational education, new knowledge dissemination and adoption, and commercialization of technologies for the agricultural production and processing sectors. The Extension Service and Experiment Station System conducts basic and applied research and extension in 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, 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 5: Land-grant Universities and their Experiment Stations and Extension Service – A Unique System for Agbioscience Research, Development and Education



As Figure 5 illustrates, 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 best practices that are tested and piloted through the unique infrastructure contained in the Extension Service and Experiment Station System. Via licensing, new business formation, knowledge-diffusion and adoption, and other technology dissemination activities, the Land-grants 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 and

adopted into commercial sectors—keeping them competitive and helping to drive regional economic growth.

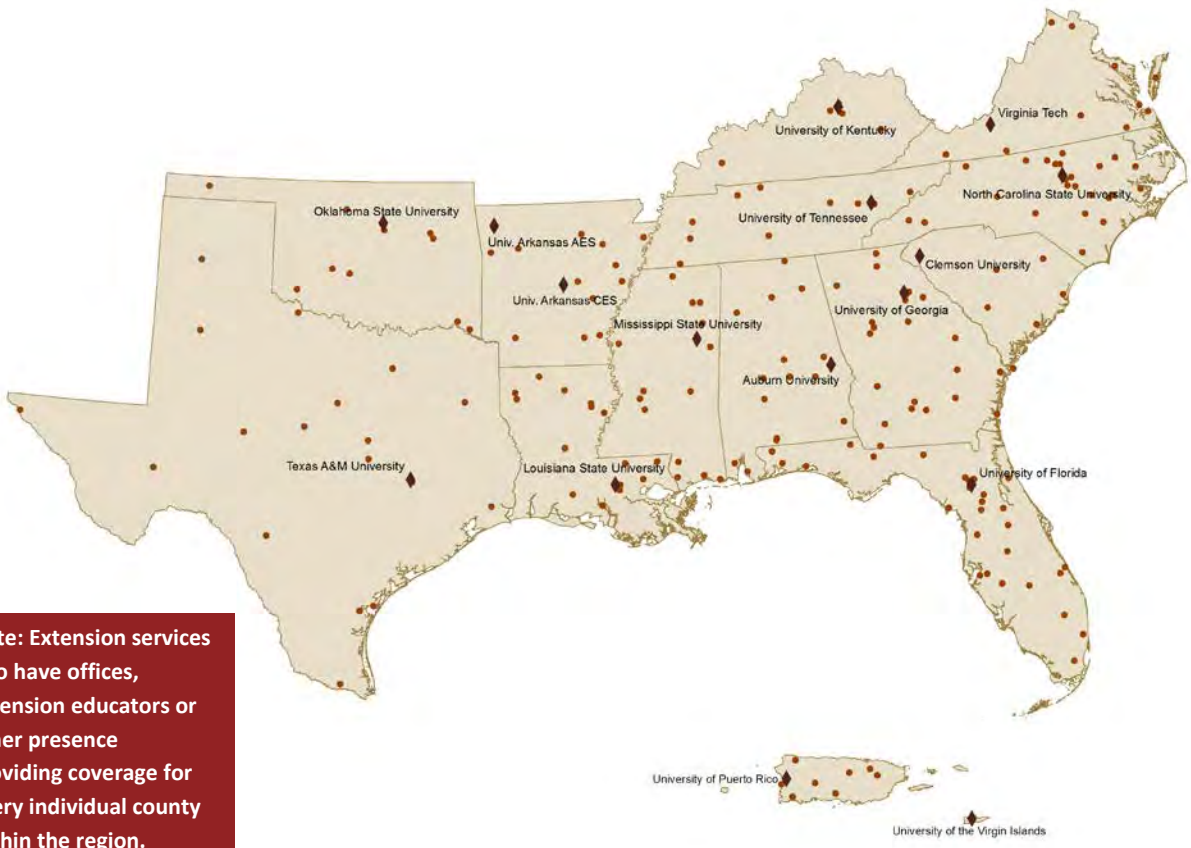
It is important to note that in addition to the significant support received from state and local governments, the Extension Service and Experiment Station System delivers its wide array of programs and activities in partnership with the United States Department of Agriculture (USDA), specifically the National Institute of Food and Agriculture, in addition to other federal programs, such as NOAA's National Sea Grant College Program, which has significant relevance to the Southern Region's coastal areas. A more detailed discussion of federal funding for the Extension Service and Experiment Station System can be found in Appendix B.

Size and Scope of the Southern Region's Land-grant Extension Service and Experiment Station System

The fifteen Southern Land-grant Universities constitute large-scale assets for agbioscience R&D and research translation**.** In terms of the Extension Service and Experiment Station System's operations, the fifteen combined institutions have 14,076 Extension personnel and 21,222 Experiment Station personnel. Combined Extension Service budgets in 2011 totaled almost $992 million while the Experiment Stations stood at a combined $1,183 million.

The thirteen states and two territories 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 Research and Extension Center (REC) locations providing environments suited to testing and developing agricultural inputs, crop varieties, agricultural equipment and livestock operations. Within the Southern Region, there are 251 REC locations covering a combined area of 257,936 acres. Figure 6 illustrates the significant geographic coverage provided by these REC assets. To these assets must, of course, be added the specialized local knowledge provided by Extension specialists and county agents who cover each county across the region—providing support and education for land-owners, agricultural producers, processors, communities, families, and youth.

Figure 6: Research and Extension Centers of the Southern Region



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

The Southern Region's Land-grant Extension Service and Experiment Station System strives to be a holistic network—working to integrate research and extension activities to provide pragmatic programs that sustain, expand, and develop the agriculture-based economy and social fabric of the region. The System works to solve an array of critical issues affecting Southerners' daily lives and the region's economic and social future. The advanced research, educational offerings, and programmatic activities of the System empower people and communities to solve problems, stimulate economic development, and improve lives.

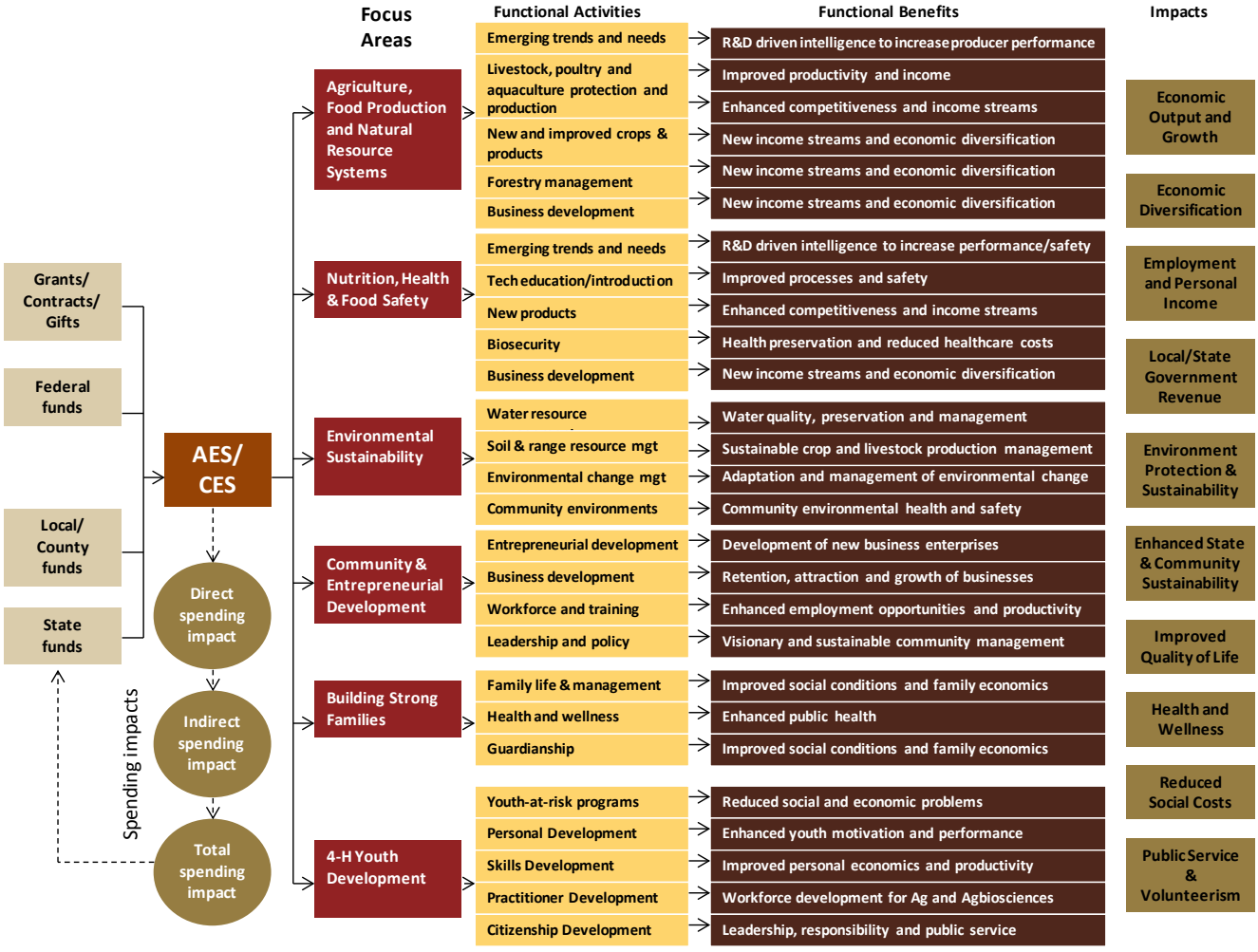
The Southern Region's Land-grant Extension Service and Experiment Station System's past and present contributions to economic and social progress in the region are the subject of the rest of this report. In evaluating The Southern Region's Land-grant Extension Service and Experiment Station System's broad range of impacts, Battelle analyzed measurable impacts in two general areas:

- **Economic Impacts (Backward Linkages).** As an operating entity, irrespective of the diverse benefits that result from the dissemination of scientific knowledge and functional expertise, the Southern Region's Land-grant Extension Service and Experiment Station System generates a significant economic impact for the region via its direct and indirect spending. The System receives funds from federal, state, and local governments, extramural sources, and industrial contracts, it invests these funds in human capital, resources, and infrastructure to benefit the region. In turn, the expenditures of the System's faculty and staff within the region generate significant economic impact as well. These types of impacts, involving expenditures by the Extension Service and Experiment Station System and its employed populations, are termed "backward linkage impacts" or "spending impacts"—and the structure of these impacts is represented by the brown ovals in Figure 7.

- **Functional Impacts (Forward Linkages).** The dissemination of R&D discoveries and know-how from the Southern Region's Land-grant Extension Service and Experiment Station System into the communities it serves produces impacts that accrue from the actual scientific, education, and extension activities undertaken. For example, technologies, expertise, and services that may increase the efficiency and productive capacity of clients and client industries have impact on the economy of the region. These impacts are categorized as "forward linkage impacts" which, rather than being related to institutional spending, are more importantly related to institutional mission and function.

Figure 7 graphically illustrates the multiple dimensions of the Southern Region's Land-grant Extension Service and Experiment Station System's widespread impacts on the region.

Figure7: The Scope of the Southern Region's Land-grant Extension Service and Experiment Station System's Impacts



SOUTHERN REGION EXTENSION SERVICE AND EXPERIMENT STATION SYSTEM INSTITUTIONAL EXPENDITURE IMPACTS (BACKWARD LINKAGE IMPACTS)

Introduction

The following analysis examines the backward-linkage or expenditure impacts of the Southern Region's Extension Service and Experiment Station System operations. The impacts measured through this analysis are those that are typically measured using quantitative economic models, and are most often described as the "economic impacts" for a program or industry.

In measuring these impacts the focus is on an assessment of the role these specific expenditures and associated employment play in generating overall regional economic activity from an operational perspective. The analysis treats these Extension Service and Experiment Station System operations as if they represent an "industry", but with specific allowances for their public sector nature.

The impacts developed and modeled in this analysis consist of three types: ***direct impacts*** (the specific impact of the operations and expenditures in the first round of spending), ***indirect impacts*** (the impact of expenditures made to suppliers), and ***induced impacts*** (the additional economic impact of the spending of employees and suppliers' employees in the overall economy that can be attributed to the direct expenditures). The three types—*direct, indirect, and induced*—taken together, are considered the ***total impacts***. In other words, I/O analysis models the flow of funds that originate from direct Extension Service and Experiment Station System expenditures in the economy and the ongoing "ripple effect" of these expenditures"—i.e., every dollar spent in the economy may be partially re-spent (or recirculated) in the local economy, thereby generating additional economic activity and impact. The size of this ripple effect is characterized by the ratio of total impacts to direct impacts and is referred to as the ***impact multiplier***.

Methodology

Data Collection

The core operational data for this analysis was obtained from the Southern Region Land-grant Extension Service and Experiment Station financial offices using data collection forms provided by Battelle. Each financial office is unique

and the availability or non-availability of certain data led to the development of a standard core set of impact model inputs as detailed in Table 3.

Table 3. Summary of Combined Extension Service and Experiment Station System Impact Input Data for FY2011 ($ in Millions)

Impact Input Type	Data
Salaries & Benefits	$1,416.4
Headcount	*36,166*
Expenditures on External Contractors	$43.3
Other Operational Expenditures	$346.7
Capital Equipment Expenditures	$38.6
Construction/Repair Expenditures	$82.1

Source: Southern Region Land-grant Extension Service and Experiment Station Financial Offices

Economic Impact Models

Estimates of the Southern Region Extension Service and Experiment Station System's economic impacts were calculated using 2010 IMPLAN U.S. specific I/O models generated by MIG, Inc. The IMPLAN model system consists of specialized software for impact analysis and highly detailed data tables, available at the national and individual state levels. I/O analysis represents the generally accepted standard methodology for measurement of economic impacts. IMPLAN models are widely used to analyze the economic impacts of companies, projects, or entire industries.

Battelle acquired the necessary data files for use with the IMPLAN system and developed a customized model to quantify the direct, indirect and induced impacts of the Southern Region's Extension Service and Experiment Station System operations. It should be noted that the IMPLAN system does not currently develop models for either Puerto Rico or the U.S. Virgin Islands. Therefore, while the operational data from these two areas were included in the Southern Region inputs, the actual model developed for the analysis combined the remaining 13 state files into a single, Southern Region impact model.

Based upon input data and the overall operations of the Extension Service and Experiment Station System, Battelle developed a functional modeling approach for the input data sectors. This approach is used to provide a more realistic estimation of the impacts versus treating the employment and financial data as simply "university" data. For example, the spending of Experiment Station operations is more similar to other R&D operations than it is to general broad university spending. Similarly, Extension Service operations are treated as a multifunctional service provider with services stemming from a variety of sectors that can be more readily modeled through sector aggregation approach. This

structure and the mapping and aggregation scheme used in the IMPLAN modeling is shown in Table 4.

This functional modeling approach, while more robust, provides additional challenges to estimating its overall economic impact. The inputs for the staff and consultant functions were kept separate to allow the results to maintain only the Land-grant University employment and expenditures as "direct" impacts. The local, state, and federal tax contexts were also modified to the public sector nature of the Land-grant Extension Service and Experiment Station System.

Table 4. Mapping & Aggregation of Input Data to IMPLAN Sectors for Southern Region Extension Service and Experiment Station System Impact Analysis

Model Sector Aggregation	IMPLAN Sector		NAICS Code(s)
Experiment Station Personnel & Consultant Functions	376	Scientific research & development services	5417
Extension Service Personnel & Consultant Functions	19	Support activities for agriculture/forestry	115
	375	Environmental & other technical consulting services	54162, 54169
	379	Veterinary services	54194
	392	Colleges, universities, & professional schools	6112-3
Capital Equipment Purchases	203	Farm machinery & equipment manufacturing	333111
	204	Lawn/garden equipment manufacturing	333112
	234	Electronic computer manufacturing	334111
	254	Analytical laboratory instrument manufacturing	334516
	299	Institutional furniture manufacturing	337127
New Construction	34	Construction of new commercial & health care structures	23*
Maint./Repair Construction	39	Maint./repair construction of commercial structures	23*

Source: Land-grant Extension Service and Experiment Station System's input data; Battelle calculations and analysis; IMPLAN 2010 multi-state model

Economic Impact of the Southern Region's Extension Service and Experiment Station System

This section details the results of economic impact analysis for the combined data inputs from the Region's Extension Service and Experiment Station System operations. Battelle provides the direct effect values driving the model; additional I/O model-estimated indirect and induced impacts; and a summation of the total impacts (direct, indirect, and induced). An impact multiplier is also provided for each of the core economic measures—for every one job or dollar of direct effect, the multiplier number will equal the total (including the direct effect) number of jobs or dollars created in the regional economy (e.g., a 1.7 employment multiplier equates to one direct job plus 0.7 indirect and induced jobs).

The following data are provided from each model: ***employment*** (combined number of full and part-time workers), ***labor income*** (measures cash, benefits and non-cash payments received by individuals in the economy, including sole proprietors), ***value-added*** (the difference between an industry's or an establishment's total output and the cost of its intermediate inputs), ***economic output*** (the dollar value of sales, goods, and services produced in an economy, is sometimes referred to as business volume, and represents the typical measure expressed as ***economic impact*** in a standard economic impact study), ***state and local tax revenue*** (including sales, income, and property taxes), and ***federal tax revenue*** (including sales and income taxes, and both institutional and employee contributions to Social Security). [21]

Southern Region's Land-grant Extension Service and Experiment Station System's Impacts

The overall *economic impact* of the combined Extension Service and Experiment Station System's operations within the Southern Region is calculated to be $5.4 billion in 2011, amounting to an output multiplier of 2.5 (Table 5). **The Extension Service and Experiment Station System is ultimately responsible for nearly 63,000 jobs in the region** (36,166 direct jobs and an additional 26,817 indirect and induced jobs). Together, this Southern Region Extension Service and Experiment Station System impacted workforce receives $2.55 billion in wages and benefits. (The individual economic impact for Extension Service and Experiment Station operations can be found in Appendix C.)

Table 5. Combined Extension Service and Experiment Station System Southern Region Impacts ($ in Millions)

Impact Type	Employment	Labor Income	Value-Added	Output	State & Local Tax Revenue	Federal Tax Revenue
Direct Effect	36,166	$1,416.4	$1,435.9	$2,135.7	$24.7	$241.4
Indirect Effect	8,906	$412.8	$677.2	$1,050.9	$44.2	$93.6
Induced Effect	17,911	$720.8	$1,320.7	$2,223.5	$121.0	$170.8
Total Effect	62,983	$2,550.1	$3,433.8	$5,410.2	$190.0	$505.9
Impact Multiplier	1.7	1.8	2.4	2.5		

Source: Land-grant Extension Service and Experiment Station System's input data; Battelle calculations and analysis; IMPLAN 2010 multi-state model

[21] Note: multipliers are not meaningful in the context of tax revenue data, i.e., a dollar of tax revenue does not generate additional tax revenue. Furthermore, the estimation of tax revenue is subject to significant variability due to ever-changing rate structures, the use of available exemptions, and the accounting of potential income, if any, subject to taxation. These figures should be viewed with some measure of caution in this analysis.

The direct expenditures of Extension Service and Experiment Station System operations, indirect impacts of contractors and suppliers, and the induced impact of Extension Service and Experiment Station System staff and suppliers staff's personal spending combine to generate $190 million in state and local tax revenue and nearly $506 million in federal tax revenues. The tax revenues are significant in that the Land-grant University homes for these programs are tax-exempt organizations, and hence these revenues are driven almost completely from personal income and supplier income and purchases.

Return on Investment Generated by Southern Region Land-grant Extension Service and Experiment Station System's Expenditures

The Southern Region's Land-grant Extension Service and Experiment Station System's operations are supported by federal, state, and local (primarily county) resources. In FY 2011, total income received by the Extension Service and Experiment Station System totaled $2.175 billion (see Table 6).

Table 6. Extension Service and Experiment Station System Sources of Income

Source of Income	Extension Service	Experiment Station	Total
Federal	$220,007,099	$328,150,135	$548,157,234
State	$492,333,386	$570,020,362	$1,062,353,748
Local	$175,117,807	$4,510,865	$179,628,672
Industrial	$59,134,636	$191,475,917	$250,610,553
Other Income	$45,022,880	$89,125,727	$134,148,606
Total Revenue	$991,615,808	$1,183,283,006	$2,174,898,813

For the federal government's legislative appropriation of $548 million and the states and local's collective appropriation of $1.24 billion, all three levels of government received an economic return. The return on their investment in terms of overall economic development associated with institutional expenditures included $5.4 billion in economic output, $2.55 billion in earned income from the 26,817 citizens whose jobs resulted from the Extension Service and Experiment Station System. In terms of returns to government through tax receipts, the federal government received $506 million in federal tax revenues. Tax revenue returns from Extension Service and Experiment Station System expenditures are lower at the state and local level (generating $190 million in state and local tax revenue), but it must be remembered that this is only counting tax revenues resulting from institutional expenditures in the economy —*not* the impacts and associated government revenues that occur through the functional research and extension impacts which are discussed in the next section of this report.

FUNCTIONAL IMPACTS OF THE SOUTHERN REGION EXTENSION SERVICE AND EXPERIMENT STATION SYSTEM'S ACTIVITIES (FORWARD LINKAGE IMPACTS)

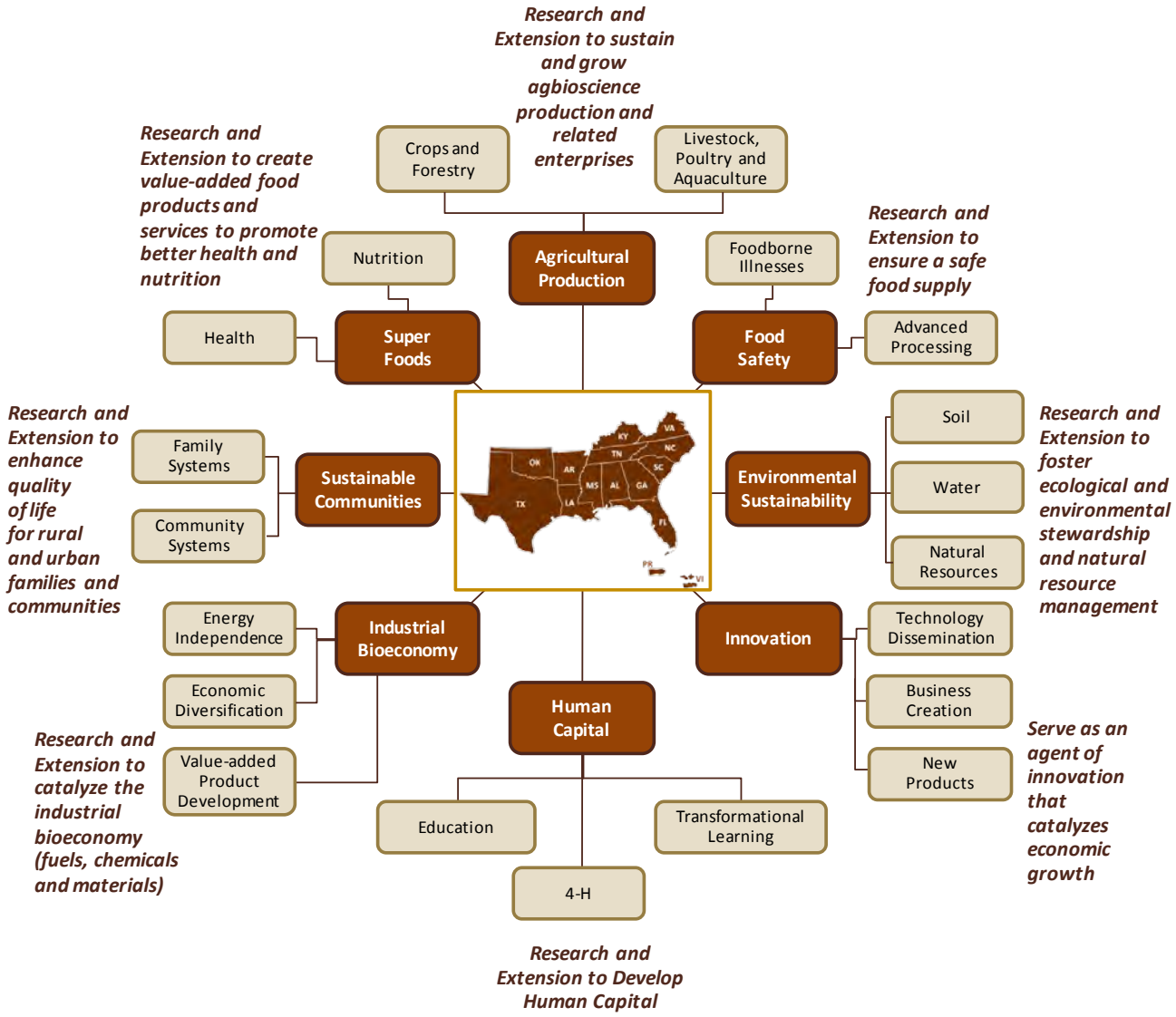
As the previous chapter showed, the Southern Region's Extension Service and Experiment Station System generates economic impacts through their direct expenditures within their respective local, state and regional economies. While it is correct to acknowledge those impacts, they represent the least important aspects of overall impacts generated by these institutions. The Southern Region's Extension Service and Experiment Station System does not exist simply to recirculate state, local and federal funds through expenditures—their primary purpose, their mission, is to conduct research, develop new technologies and practice innovations, and to disseminate knowledge and recommendations into their served communities to enhance economic and social wellbeing. It is the delivery of these mission-based activities that generate the most important and widespread impacts of these institutions—their functional impacts.

As previously highlighted, the Southern Region's Extension Service and Experiment Station System provides an integrated approach to research, develop, pilot, demonstrate, disseminate, and assist in the adoption of new innovations to benefit practitioners, industry, and regional communities. 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, helping to improve the health of the region's citizens, and ensuring the sustainability of the environment for the next generation and beyond. With combined budgets totaling $2.175 billion, it would be an almost impossible task to illustrate all of the research and extension programs and educational initiatives of the Southern Region Extension Service and Experiment Station System and its impacts on individual communities, home states, the region, the nation, and the world. Rather than attempt this, the Battelle/BioDimensions project team provides an assessment herein of:

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

Figure 8 classifies the many core categories of impacts generated by this unique system—illustrating the broad suite of impact categories addressed by the Land-grant Extension Service and Experiment Station System.

Figure 8: Core Categories of Functional Research and Extension Impact Areas in Agbiosciences at Southern Land-grant Universities



Within the Southern Region, thousands of projects are undertaken annually by the 15 Land-grant Universities, and it would be impossible to illustrate the impacts of each and every one. Rather than provide a complete listing, Battelle reviewed major assets and placed them into eight functional mission categories:

1. **Sustain and grow agbioscience production and related business enterprises**
2. **Create value-added food products and services to promote better health and nutrition**
3. **Ensure a safe food supply**

4. **Foster ecological and environmental stewardship and natural resource management**
5. **Serve as an agent of innovation that catalyzes economic growth**
6. **Catalyze the industrial bioeconomy (fuels, chemicals, materials) to foster economic diversification, value-added product development, and energy independence**
7. **Build stronger, healthier, economically sustainable communities**
8. **Develop human capital.**

The functional impacts related to each of these eight categories are discussed in detail below. In addition, Battelle selected multiple case studies that serve to illustrate, or "bring to life" many examples of the economic and social functional impacts being generated by specific Extension Service and Experiment Station programs across the Southern Region.

Sustain and Grow Agbioscience Production and Related Business Enterprises

Develop, improve, and protect plants

At their core, the Southern Region's Extension Service and Experiment Station System is focused on conducting, disseminating, and assisting in the adoption of research and extension that achieves improved outcomes, profitability, and sustainability for the region's agriculture production, forestry, and related industries. While the system certainly offers a broad suite of research, teaching, and extension programs in a range of fields, it is, at its heart, using scientific research to reinforce agricultural sustainability and growth in the region. Key functions under this mission involve conducting R&D designed to improve and sustain current crops, forest, and agriculture-based products in the state and the dissemination and adoption of information and technologies through extension to farmers, producers, and processors.

Research in this area includes the development and breeding of improved and new crop varieties displaying enhanced characteristics suited to the region's diverse growing and production environment. These characteristics may be enhanced yields; improved disease, pathogen, or pest resistance; and special traits designed to add market value (such as enhanced texture, processability, color, and flavor). Such improvements in plants are developed through traditional plant breeding and hybridization techniques or the latest techniques in molecular biology, genomics and genetic engineering for improved input and output traits.

It is important to always keep in mind that agricultural and forest production takes place in a dynamic, changing environment. New diseases emerge, diseases and pests evolve resistance to cultural practices or agricultural chemicals, climatic conditions change and cycle, and market demands and preferences change. Within this changing environment, the Southern Region's Extension Service and Experiment Station System predicts issues and needs and proactively work to develop new crop varieties (corn, soybeans, cotton, rice, tobacco, wheat, peanuts, stone fruits, berries, turf grass and ornamentals, etc.), forage varieties, diagnostic tools, treatment chemistries, livestock therapeutics, and specific strategies to keep the Southern Region at the leading edge of agricultural productivity, despite its many challenges.

Without this support system, the region's producers would have to rely on commercial research and the research of out-of-region universities—research that would not be specific and customized to specialized regional characteristics (and, therefore, likely not as effective), and would have limited, unbiased assistance in translating research findings, disseminating, or assisting in adopting these findings to their benefits. This need for a localized support system is all the more important in the Southern Region due to the number of farms and their relatively smaller size versus the rest of the nation. Unlike other regions that have much larger, incorporated farms that have additional resources available to them, the Southern Region is comprised of nearly 880,000 farms—representing 40 percent of the nation's total number of farms in a land area that represents 24 percent of the United States. These numbers indicate that within the Southern Region, the role of small farms is very important since more land is dedicated to farming across smaller farms than one would expect when compared to national statistics. These smaller farms rely extensively on the knowledge and information dissemination provided by the Extension Service and Experiment Station System, as illustrated in the following textbox.

The Southern Region Extension Service and Experiment Station System's Strength in Plant Breeding

U.S. agriculture enjoys extremely high levels of productivity, and the output of crop plants in the U.S. per acre of land has experienced steady expansion due to the work of plant breeders at Land-grant Universities. Using traditional breeding, advanced molecular and genomics techniques, faculty at the Southern Region's Extension Service and Experiment Station System leverage their specific knowledge of their state and regional agronomic conditions (soils, climate, pests, etc.) to develop crop cultivars and varieties best suited to high levels of quality and yield for regional producers. The work of Southern Region Experiment Station and Extension Specialists and educators addresses the improvement of crops in terms of both input characteristics (nutrient use efficiency, fertilizer application reduction, water use efficiency, weed and pest resistance, etc.) and output characteristics (including yield, quality and functional characteristics). Progress in the field relies on a diverse suite of academic disciplines, uniquely covered by Land-grant University departments, including molecular, cellular and developmental biology, genetics and genomics, plant breeding, plant pathology, entomology, soil science, agronomy and multiple associated disciplines. Furthermore, the considerable volume of production and test environments deployed by the Extension Service and Experiment Station System across the broad variety of agronomic production environments in the Southern Region, gives the Land-grants a unique set of assets for the long-term field trials required to bring new cultivars to market and prove their value to producers.

The Southern Region contains highly diverse agronomic production conditions. Soils vary from rich flood plain deposits along the Mississippi, to dry prairie environments and a great range of types in between. Variations in soils, rainfall and pest profiles impact which crops are developed and grown, and the tremendously varied conditions of the Southern Region means there is also great diversity in crops and crop varieties. Such a high degree of variation means that Land-grant plant breeding programs are especially important in the Southern Region, because there is less of the large-scale homogeneous mono-cropping that appeals to the private crop breeding programs of agribiotech companies. In the Southern Region, the Extension Service and Experiment Station System is involved in plant breeding and improvement programs in a very wide range of crops, ranging from major commodities like wheat (where in Oklahoma, for example, 47 percent of crop acreage comprises Oklahoma State University developed varieties), cotton, peanuts, soybeans and rice through to specialized crops such as sorghum, dedicated energy crops, fruits and vegetables. Plant breeders within the region also sustain active programs in forage crop development, turf grass and in specialized ornamentals and landscaping plants.

Figure 9 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure focused on developing, improving, and protecting plants in the region. This is not, of course, an exhaustive inventory, but does serve to illustrate the intensity of specialized resources and assets dedicated to this field.

Figure 9: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities to Develop, Improve, and Protect Plants

Some examples of the many specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to develop, improve, protect and cultivate plants include the following case studies. As noted previously, these represent only a sampling of the large number of projects and programs undertaken by the regional Land-grant system.

CASE STUDY 1: UNIVERSITY OF ARKANSAS – Supporting the Rice Basket of the United States

Arkansas is the leading producer and processor of rice in the United States. In 2011 Arkansas farmers grew nearly half of all the rice produced in the U.S.—1.2 million acres of production, resulting in 7.8 billion pounds of the crop, valued at over $1 billion.[22] *The University of Arkansas is supporting the rice industry in the United States through comprehensive research and extension programs in rice breeding, best practices for production, rice processing, and marketing information.*[23]

- ***Rice Breeding*** *– Scientists at the University of Arkansas Rice Research and Extension Center are developing a hybrid rice breeding program in cooperation with Louisiana, Mississippi, Missouri and Texas. Collectively, these five states produce nearly 80 percent of the rice eaten in the U.S. Currently, one company is the source of rice hybrids, which often outperform conventional, inbred varieties developed at public institutions. A successful public hybrid breeding program will provide an alternative source for producers.*
- ***Rice Production Management*** *– Soil scientists at the University of Arkansas have developed an innovative soil nitrogen test to improve nitrogen fertilizer recommendations for rice. This test will reduce incidence of over- and under- application of nitrogen fertilizer thus helping to maximize yields and control fertilizer costs, a major expense in crop production budgets.*
- ***Rice Processing*** *– Scientists with the Rice Processing Program conduct research to improve the efficiency and effectiveness of rice processing and enhance the quality and value of rice and rice products. Their research includes the characterization of rice produced using sustainable practices, drying, storage, and quality assessment of rice and rice products.*
- ***Rice Marketing*** *– The Arkansas Global Rice Model provides research and insight on regulatory policies, consumer demand, and trends in local and global market conditions to help rice farmers make informed decisions on the production and sale of their crop.*

CASE STUDY 2: OKLAHOMA STATE UNIVERSITY – Timing Cattle Removal from Wheat Pastures Saves Farmers $275 Million Annually

Oklahoma farmers plant about 5.7 million acres of wheat annually. Of this about 2.5 million acres are "dual-purpose" wheat acres that are also used for livestock grazing during the fall and winter. While dual-purpose wheat fields can offer an economic benefit to farmers, grazing also removes wheat leaves and can thus affect the productive yield of the wheat crop. According to Oklahoma State research grazing two weeks past First Hollow Stem (FHS) stage of growth in wheat can reduce yield by as much as 58 percent. (Cattle weight gains from grazing past FHS are generally not sufficient to offset these yield losses).[24]

About ten years ago Oklahoma State Research and Extension Service identified the FHS stage of growth as the optimal time to remove cattle from the wheat pasture. This gives the plant adequate time to replace damaged or eaten green leaf prior to the reproductive growth stage of the plant. Assessing FHS is relatively simple: farmers begin by checking the stem of wheat samples from ungrazed fields in mid-February to measure the size of the hollow stem beneath the developing wheat head. When this hollow area is about half an inch (the diameter of a dime) it is time to remove the cattle from the field.[25]

[22] USDA. National Agricultural Statistics Service. www.nass.usda.gov.

[23] University of Arkansas. Division of Agriculture – Rice Research and Extension Center. http://aaes.uark.edu/rice.html.

[24] Oklahoma State University - Division of Agricultural Sciences and Natural Resources. Oklahoma Agricultural Experiment Station and Oklahoma Cooperative Extension Service. '2010 Oklahoma State University Combined Research and Extension Annual Report.' http://intranet.okstate.edu/OCES/OCES_OAES_2010_POW_CSREES.pdf.

[25] 'First Hollow Stem: A Critical Wheat Growth Period for Dual-Purpose Producers.' Edwards, Jeff and Horn, Gerald. Oklahoma State University. Division of Agricultural Sciences and Natural Resources. Oklahoma Cooperative Extension Service. http://osufacts.okstate.edu/docushare/dsweb/Get/Document-6693/PSS_2147web.pdf.

Through extensive educational efforts conducted by Oklahoma Cooperative Extension Service over the last decade, it is estimated that at least 75 percent of dual-purpose wheat producers in Oklahoma use FHS as a criterion for removal of cattle from wheat pasture. In 2010 the FHS research and extension program is estimated to have saved Oklahoma producers about $110 per acre, or approximately $275 million over the whole state.[26]

CASE STUDY 3: UNIVERSITY OF GEORGIA – Pigweed Infestation Threatens Survival of Cotton Production

The first case of pigweed resistant to glyphosate (Roundup) was confirmed in Georgia—the first confirmed case in the world. If not killed early pigweed, also known as Palmar amaranth, can grow as tall as a small shade tree in the fields, steal nutrients from cotton plants, reduce yields, and in severe cases make harvest difficult or impossible. Glyphosate-resistant pigweed has now been confirmed in cotton and soybean fields in many Southern states (GA, TN, MS, AL, AR, FL, SC and NC). In Georgia the weed has spread across the state and infested one million acres of cotton. Similarly high infestation rates exist across the region, where 4.9 million acres of cotton were planted in 2011 and 8.7 million acres of soybeans.[27] *The problem is now starting to spread outside the Southern Region, too.*

In 1997 farmers in Georgia started planting cotton developed to stay healthy when sprayed with Roundup, a glyphosate herbicide. Farmers could spray the herbicide over the top of their cotton crop and kill the weeds without killing the crop. Almost all cotton farmers in Georgia use Roundup Ready cotton because it saves them time and money. But depending on this one tool for weed management has created the conditions for glyphosate-resistant pigweed to grow and spread.[28]

Extension agents in Georgia are recommending a strategy of diversity beyond just herbicide use for an integrated weed management program. That strategy includes hand weeding, deep tilling the soil to reduce pigweed germination, and cover crop planting. But the expanded weed management approach has come with added expenses. In 2011 half of Georgia's one million acres of cotton was weeded by hand for pigweed—something rarely done in the past—with a direct cost to the farmer of $11 million. Farmers have gone from spending $25 per acre a few years ago on weed control in cotton to spending $60–100 per acre. While this program has yielded positive results, the increased costs, coupled with declining cotton prices, has challenged the sustainability of dryland cotton farming in the state.[29]

The cotton and soybean industries, chemical companies and agricultural researchers and Extension agents across the Southern Region are responding to the problem and helping farmers understand the challenges and impacts of the weed and adapt effective management programs to combat it. Research and Extension agents in the South—who have several years of experience dealing with the problem—are also sharing their findings with Extension agents in the Midwest, where they have only more recently confirmed a pigweed infestation.

[26] Oklahoma State University - Division of Agricultural Sciences and Natural Resources. Oklahoma Agricultural Experiment Station and Oklahoma Cooperative Extension Service. '2010 Oklahoma State University Combined Research and Extension Annual Report.' http://intranet.okstate.edu/OCES/OCES_OAES_2010_POW_CSREES.pdf.

[27] USDA. National Agricultural Statistics Service. http://www.nass.usda.gov/.

[28] 'Pigweed still threatens to root out Georgia cotton.' Haire, Brad. University of Georgia. College of Agricultural and Environmental Services. July 1, 2010. www.caes.uga.edu/applications/gafaces/?public=viewStory&pk_id=3856.

[29] Interview with Dr. Stan Culpepper, Associate Professor and Extension Agronomist. University of Georgia - College of Agricultural and Environmental Services. (September 26, 2012).

CASE STUDY 4: NORTH CAROLINA STATE – Southern Region Small Fruit Consortium

The Southern Region Small Fruit Consortium (SRSFC) was established in 1999 and provides a regional collaborative approach to supporting small fruit growers in the South. SRSFC includes North Carolina State, Clemson University, University of Georgia, University of Tennessee, Virginia Tech, and Arkansas. A collaborative regional approach lends itself to the individual strengths of each of the participating Land-grant Universities. Small fruits included in the consortium's research are: blueberries, brambles, bunch grapes, muscadines, and strawberries.

One of the goals of SRSFC is to enhance county agent expertise in small fruit production so they can be more effective in providing advice to growers. Since 1999 SRSFC has sponsored 22 agent training programs covering 548 agents in the six member states on a broad range of subject matter important to small fruits producers: e.g., pesticides, insecticides, harvest equipment, breeding programs, new technologies and protective cultures to help increase yield, quality and market value.[30]

Demonstrated by the significant growth of the small fruits industry in the region of the last decade, this collaborative approach to research and extension is working. Over the last decade income generated from small fruits production in the Southern Region has increased over 300 percent, from $62 million in 2001 to $207 million in 2011. North Carolina, one of the largest small fruit producers in the region, generated $99 million from small fruit production in 2011.[31]

Livestock, poultry and aquatic species protection and production

Livestock, poultry, and aquatic species represent a very important component of agbioscience economic activity within the Southern Region. Direct production of livestock, poultry, and aquatic species comprises a significant portion of the region's production activities. However, basic production is but one component of the vertically integrated value chain, which also includes such diverse components as suppliers of inputs and services to farms; on-farm production of feed crops; feed processing and blending operations; input transportation; livestock transportation; livestock harvest and processing; and value-added food product manufacturing, distribution, wholesaling, and retail. Directly and indirectly, livestock, poultry, and aquatic species are a keystone of a healthy agricultural sector and related industry for the region.

Livestock, poultry, and aquatic species also represent an important opportunity for further agbioscience development in the future. The presence of ruminant livestock is an important contributor to the economic feasibility of ethanol production, adding value to distillation byproducts that may be used as animal feed. Animal waste products from livestock and poultry operations also present opportunities for biofuel production through digestion and biogas production technologies. Furthermore, a strong livestock, poultry, and aquaculture sector presents opportunities for animal-based production of a range of

[30] Interview with Dr. Gina Fernandez. Associate Professor and Small Fruits Specialist. North Carolina State University – College of Agriculture and Life Sciences. (Sept., 27 2012).

[31] USDA - National Agricultural Statistics Service. 'Non Citrus Fruits: 2011 Summary.' http://usda01.library.cornell.edu/usda/current/NoncFruiNu/NoncFruiNu-07-06-2012.pdf.

biopharmaceuticals, functional foods, and other new technological innovations for the region's future.

In the livestock, poultry, and aquatic species arena, animal improvements come via traditional breeding techniques, and the application of modern molecular assisted breeding whereby biomarkers and genes are identified that are associated with desirable enhancements and breeding stock selected to encourage the proliferation of these positive characteristics. Land-grant Universities are active participants in the identification of biomarkers and genes and the breeding of advanced livestock, poultry, and aquatic varieties, as illustrated in the following textbox.

The Southern Region Extension Service and Experiment Station System's Research and Extension Focus on Supporting the Poultry Industry

The United States poultry industry is the largest in the world, and an important export engine for the U.S. economy. Poultry meat is now the most popular meat with U.S. consumers, with the average American consuming almost 84 pounds of chicken per year (more than twice the per capita consumption level of 1970). The Southern Region is the clear leader in the nation's poultry sector, accounting for over $23 billion in production value in 2011 – fully two-thirds (66 percent) of the entire industry's sales nationally[32]. The region is particularly noteworthy in broiler production, having a total 2011 production value of $18.7 billion (80.9 percent of total U.S. production value). The Southern Region also produces almost 40 percent of the nation's eggs.

The poultry industry receives considerable attention in the Southern Region from the Land-grant Extension Service and Experiment Station System in terms of research and extension activities, and this system has invested in multiple specialized R&D facilities to support basic and applied poultry research. The work of the Land- grant Universities in support of poultry covers a broad suite of activities in areas as diverse as enhanced feed development, production environment design, poultry health, meat and egg quality, and food safety. Able to address the full-range of industry needs, from basic molecular biology and genetics of poultry, through to highly pragmatic production and market development issues, the Land-grant Universities of the Southern Region provide a uniquely focused resource for meeting the specialized needs of poultry producers, the value-added poultry-based food production sector, and the needs of consumers.

Figure 10 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure focused on livestock, poultry, and aquatic species production and protection in the region. This is not, of course, an exhaustive inventory, but does serve to illustrate the intensity of specialized resources and assets dedicated to this field.

[32] Source: USDA, National Agricultural Statistics Service. "Poultry – Production and Value 2011 Summary" (April 2012). Comprises sales of broilers, turkeys, chickens and eggs.

Figure 10: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities to Enhance the Production and Protection of the Livestock, Poultry, and Aquatic Species Industry in the Region.

Examples of the many specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to enhance the production of livestock, poultry, and aquatic species and protect the resulting products include the following case studies.

CASE STUDY 5: Louisiana State University – Anaplasmosis Vaccine Saves Cattle and Dairy Farmers $300 Million Annually

Protecting the health of beef and dairy cattle is important to the profitability of farmers and the growth of these industries. In 2011 the U.S. cattle industry represented a $63 billion industry in terms of farm receipts; dairy products added another $39.5 billion.[33] *One major health threat to the industry's livestock is Anaplasmosis bacteria, which cause a disease that destroys red blood cells in cattle, causing anemia, weight loss and even death. This pathogen is spread by ticks and horseflies, as well as infected cows. In the United States it is estimated to cost cattle and dairy producers $300 million per year.*

Anaplasmosis occurs primarily in warm tropical and sub-tropical climates and is a threat to cattle around the world, particularly in North America, South America and Africa. In the United States, where it was once only found in the Gulf and West coasts, it has now spread to other parts of the country with the movement and distribution of cattle. It is likely present in every state in the country.

Research at the Louisiana State University (LSU) Agriculture Center's Veterinary Science Department in the 1980s and 1990s led to the discovery of a vaccine for anaplasmosis. The vaccine is currently produced in an LSU AgCenter laboratory in Baton Rouge by University Products, LLC (www.anaplasmosisvaccine.com), a company managed by Dr. Donald Gene Luther, one of the original vaccine researchers. The University Products vaccine causes the treated cattle's immune system to create antibodies and immunity to protect the animal from the diseases of anaplasmosis.

Since 2000 University Products has marketed hundreds of thousands of doses of the vaccine as an experimental vaccine to cattle and dairy farmers in Arkansas, California, Florida, Indiana, Illinois, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Nevada, Oklahoma, Oregon, Texas, Tennessee, Wisconsin, and Puerto Rico. By the end of 2012 the company expects to have license and laboratory approved by the USDA, which will expand availability of the vaccine globally.[34]

CASE STUDY 6: AUBURN UNIVERSITY – Catfish Genome Project: Improving the Competitiveness of Aquaculture

Natural fisheries around the world are currently harvested at or above their maximum sustainable levels. Since the 1980s many of these fisheries have been in decline because of over-harvesting and habitat degradation. Aquaculture needs to grow in order to provide a viable alternative seafood source for these fisheries. Rapid growth in aquaculture production is also needed to help address the food demands of a growing world population and provide a rich source of protein and other vitamins and minerals for the human diet.

The Catfish Genome Project at Auburn University is conducting research to develop superior catfish breeds that will improve the competitiveness and profitability of American catfish farmers. Catfish production in the United States is the largest sector of the U.S. aquaculture industry, accounting for over $350 M in sales in 2010. Catfish production is concentrated in four states—Alabama, Mississippi, Arkansas and Louisiana.[35, 36]

The U.S. catfish industry is well positioned to help address major global issues, like declining natural fisheries and rising global population. But for American catfish farmers to capture value from this opportunity they must be able to compete with overseas producers, particularly in Asia. Over the past decade American catfish producers have seen their share of this market fluctuate as a result of this global competition.

Researchers with the Catfish Genome Project at Auburn University are working to identify specific gene associations with performance traits in the catfish—such as growth rate, feed conversion efficiency, disease resistance, body conformation and fillet yield. This research involves mapping the catfish genome (defined as the complete set of genetic material in the catfish) with DNA markers (akin to genetic landmarks), gene discovery, physical mapping of how the gene sequences fit

[33] USDA. Economic Research Services. 'State Fact Sheets.' http://www.ers.usda.gov/data-products/state-fact-sheets/state-data.aspx?StateFIPS=00#P465ddc4eb9ff457fb8b229b400f24306_2_657iT24R0x0.

[34] *Anaplasmosis vaccine gains additional approvals.* Bogren, Rick. Louisiana State University. LSU AgCenter. July 27, 2012. http://www.lsuagcenter.com/news_archive/2012/july/headline_news/Anaplasmosis-vaccine-gains-additional-approvals.htm.

[35] USDA. Economic Research Services. 'Aquaculture.' www.ers.usda.gov.

[36] USDA. National Agricultural Statistics Service. 'Catfish Production.' www.nass.usda.gov.

together in the genome, and QTL (quantitative trait loci) mapping to understand specifically which genes contribute to a single trait like growth rate.

Once the catfish genome has been mapped and the genes controlling performance traits are understood, technologies can be developed based on this information to combine all the desirable genes together, reduce or eliminate the undesirable genes, and ultimately develop superior breeds of catfish.[37]

CASE STUDY 7: CLEMSON UNIVERSITY – Improved Grazing Management Strategies for South Carolina Cattle

Tall fescue is grown on 36 million acres in the U.S. It is the predominant forage crop in the South. Its popularity is related to ease establishment, drought tolerance, excellent grazing persistence, and long grazing season. A number of these desirable attributes are due to the presence of a fungus which lives inside the plant—referred to as an 'endophyte'. The particular endophyte in tall fescue produces a toxin that can negatively affect animal reproductive performance, as well as the ability of the animal to gain weight. The impact of these effects is estimated to cost the U.S. beef industry $1 billion annually.[38]

While varieties of non-toxic fescue have been developed and are becoming more widely used in other parts of the U.S., most forage systems in the South still depend on toxic varieties. There are an estimated one million acres of tall fescue grown in South Carolina, and the state has approximately 91,900 cattle grazing on toxic fescue each year. Scientists at Clemson University have identified ways to improve reproductive rates in cattle by 20 percent just by grazing cows on alternative forages during breeding season. The findings are useful not only for the improvements to reproductive performance. A grazing management strategy that recommends removing the cows from toxic fescue just during breeding season is a less onerous suggestion for farmers than having to replace all their stands of toxic fescue. Assuming current market prices for calves (600 pounds) of $720, the annual impact to the beef cattle industry in South Carolina if cattle producers adopted this approach would be an added $13.2 million in revenue.[39]

Clemson University Extension agents are supporting these findings through 'Fescue Toxicosis and Management Workshops' to improve farmer understanding of the impact of toxic tall fescue consumption, increase integration of non-toxic fescue in the field, and recommend adoption of new grazing management strategies to limit economic losses.

CASE STUDY 8: UNIVERSITY OF KENTUCKY – Gluck Equine Research Center

There are 9.2 million domestic horses in the US; 115 million worldwide. The equine industry contributes $102 billion annually to the U.S. economy, and creates or supports 1.4 million full-time jobs.[40]

Lexington, Kentucky is the horse capital of the world. In Lexington, the Gluck Equine Research Center at the University of Kentucky's College of Agriculture provides a world-class institute for research into the health and wellbeing of horses. Internationally recognized scientists at this facility are leading the way in research of equine genetics and genomics, infectious diseases and immunology, musculoskeletal sciences, pharmacology and reproductive health. Their work has contributed to the development of vaccines and diagnostic tests to prevent and diagnose diseases, the sequencing of the equine genome, the detection of performance enhancing drugs, and identification of the causes of costly pregnancy losses.[41]

[37] Auburn University. College of Agriculture – Fisheries and Allied Aquaculture. http://www.ag.auburn.edu/fish/research/research-programs-in/aquaculture/the-catfish-genome-project/.

[38] 'Novel Endophyte-Infected Tall Fescue.' Hancock, Dennis; and Andrae, John. University of Georgia. College of Agricultural and Environmental Sciences. http://www.caes.uga.edu/publications/pubDetail.cfm?pk_id=7045.

[39] Interview with Dr. John Andrea, Assistant Professor, Clemson University - Department of Animal and Veterinary Sciences, and Department of Entomology, Soils, and Plant Sciences. (October 9, 2012).

[40] American Horse Council. 'National Economic Impact of the U.S. Horse Industry.' http://www.horsecouncil.org/national-economic-impact-us-horse-industry.

[41] University of Kentucky. Maxwell H. Gluck Equine Research Center. 'Research Report 2011.' http://www.ca.uky.edu/gluck/images/Research%20Report%202011.pdf.

Research into equine genomics offers transformative opportunities for scientific research in biology and medicine, and a better understanding of complex diseases that have confounded horse owners, breeders and veterinarians since the first horse was domesticated. In 2007 the horse genome was sequenced at Harvard/MIT labs in close collaboration with scientists at the Gluck Equine Research Center. The genome sequence data has opened the door to a wide range of important research possibilities, including the identification and characterization of genes for disease traits of the musculoskeletal, neuromuscular, cardiovascular and respiratory systems. At the Gluck Equine Research Center the Immunogenetics and Genomics team is researching hereditary diseases, developmental defects of the musculoskeletal system, infectious diseases, reproductive dysfunction, and even coat color patterns.[42, 43]

Since the genetic basis for diseases in horses is very similar to those found in people discoveries of how specific genes affect specific traits and medical issues in horses could have direct application to human health. For instance, determining the genes responsible for certain musculoskeletal diseases in horses—like limb malformation, osteoarthritis, and susceptibility to tendon and ligament injury—could shed new light on similar human conditions and thus lead to advancements in human biology and medicine.[44, 45]

CASE STUDY 9: UNIVERSITY OF PUERTO RICO – New Cattle Breed Could Strengthen Dairy Industry in Puerto Rico

Dairy cows suffer from heat stress caused by the subtropical climate in the Caribbean. This stress reduces both milk production and fertility in dairy cows.

There are 77,000 head of dairy cows in Puerto Rico. Dairy cows in Puerto Rico produced 645 million pounds of milk in 2011, generating revenue of $217 million for the dairy industry.[46] *Increasing the population of a breed of dairy cattle that can maintain higher levels of milk yields during the hotter months will benefit dairy farmers in Puerto Rico and help strengthen the profitability and sustainability of the dairy cow industry.*

USDA scientists have identified a single gene found in some cattle—referred to as the Slick Hair gene—that gives these cattle shorter, slick hair and keeps them cooler in the subtropical heat than cattle that do not possess the gene. Cows with the slick hair gene are capable of maintaining a body temperature half a degree Celsius lower than non-slick hair cows. While this may not sound like a huge difference it is expected to be enough to allow Slick Hair cows to maintain a higher feed intake and milk yield. It is also expected to help these cows maintain a body temperature below 40 degrees Celsius, which in turn should increase embryo survival and fertility.[47]

Scientists at the University of Puerto Rico College of Agricultural Sciences are researching the milk production potential (i.e., milk yields, lactation length, milk fat percentages) and feed efficiency of Slick Hair cows to evaluate their performance, better understand the benefits of this breed in Puerto Rico, and assess the benefits of increasing the population of Slick Hair cows in the country. Since a subtropical climate persists across the Caribbean, information and strategies for Slick Hair dairy cows in Puerto Rico could benefit dairy farmers and economies across the region.

[42] 'Taking a Broader Perspective on Chondrocyte Gene Expression.' MacLeod, James. Equine Disease Quarterly. November 15, 2004.

[43] 'Proposal to sequence the genome of the domestic horse.' Bailey, Ernest; Antczak, Doug; et al. Science. 2009.

[44] White Paper on Veterinary Medical Genetics. Bailey, Ernest.

[45] Interview with Dr. James MacLeod, Professor, University of Kentucky – College of Agriculture, Department of Veterinary Sciences, Gluck Equine Research Center. (October 2, 2012).

[46] USDA. National Agricultural Statistics Service. 'Puerto Rico.' http://usda01.library.cornell.edu/usda/current/puertorico/puertorico-04-26-2012.txt.

[47] '"Slick" Gene Helps Cattle Beat the Heat.' Flores, Alfredo. USDA – Agricultural Research Services. August 14, 2008. http://www.ars.usda.gov/is/pr/2008/080814.htm?pf=1.

CASE STUDY 10: UNIVERSITY OF THE VIRGIN ISLANDS – Aquaculture

University of Virgin Islands Agricultural Experiment Station has been researching tilapia production systems since 1979. In 1999 aquaculture experts with the Experiment Station designed the 'International Tilapia and Aquaponics Course' which was started to disseminate knowledge and best practices in aquaponics to people around the world. Aquaponics is the combined production of fish and plants in recirculating water flow systems. In an aquaponics system water flows from the fish tank to the plants and back again in a mutually beneficial, self-cleaning cycle that: (1) enables the plants to absorb the nutrients in the organic waste from the water in the fish tank, and (2) recirculates filtered clean water back to the fish in their tank.

Aquaponics is great for areas that have a temperate climate, issues with water quality and availability, and expensive land. The Virgin Islands fits all three of these categories, as do many urban areas of the United States. To date the program has taught 700 students from 45 states and 52 countries in the 'International Tilapia and Aquaponics Course'.

As the cited examples illustrate, the Southern Region's Extension Service and Experiment Station System is dedicated to sustaining and growing agbioscience production and related economic activity in the region. Many of the examples provided demonstrate a significant direct economic impact. In an attempt to illustrate the overall potential economic impact by the wide array of functional activities undertaken throughout the system, Battelle chose to analyze and illustrate the effect that a one percent increase in total agricultural production as well as a one percent increase in each of the agbioscience value-chain industry sectors would have on the Southern Region. While it is highly likely that the Southern Region's Extension Service and Experiment Station programmatic activities and research and extension endeavors generate considerably more than a one percent gain in the region on an annual basis, a conservative one percent estimate serves as a baseline for considering the significant effects of agbioscience productivity on the economy. Therefore, the impact of a 1 percent increase in the Southern Region is shown in the following text box.

The Economic Impact of Increased Agbioscience Activity on the Southern Region

Using the IMPLAN input-output model developed for the Southern Region, Battelle estimated two different scenarios for production increases.

The first scenario constitutes a one percent increase in each of the agricultural production sectors (including crops, dairy, poultry and eggs, cattle, fisheries, and forestry) in the Southern Region. ***A one percent increase in production would yield:***

- ***More than $1.0 billion annually in increased production across the Southern Region.***
- ***Nearly $2.4 billion in economic output annually across the region.***
- ***Total value-added would equate to $1.044 billion annually.***
- ***$622.1 million in personal income in the production year for the citizens of the Southern Region.***
- ***More than 22,130 jobs would be created within the Region.***

The second scenario constitutes a one percent increase in each of the agbioscience value-chain industry sectors in the Southern Region. These sectors include industries that place significant demands on agricultural production (including various food processing, lumber, and paper sectors, among others) as inputs to their operations. ***A one percent increase in production from these agbioscience value-chain industry sectors would yield:***

- ***More than $4.5 billion annually in increased production across the Southern Region.***
- ***More than $10.0 billion in economic output annually across the region.***
- ***Total value-added would equate to just under $4.0 billion annually.***
- ***$2.0 billion in personal income in the production year for the citizens of the Southern Region.***
- ***More than 45,650 jobs would be created within the Region.***
- ***Included as indirect and induced effects within this agbioscience value-chain industry demand would be an increase in agricultural production of $682.3 million.***

Create Value-Added Food Products and Services to Promote Better Health and Nutrition

Research increasingly confirms that what humans eat has a significant impact on health, quality of life, and longevity. In the U.S., a common diet consists of high intakes of fat and saturated fat, and low intakes of calcium and fiber-containing foods, such as whole grains, vegetables, and fruits. This poor nutritional intake is associated with chronic health conditions that can impair the quality of life and hasten mortality.

For instance, diet is a significant factor in the risk of heart disease, cancer, stroke, and diabetes, four of the leading causes of death in the United States, and responsible for over half of all deaths annually.[48] These health conditions incur considerable medical expenses, lost work, disability, and premature

[48] Centers for Disease Control and Prevention, *National Vital Statistic Report*, October 26, 2012. See http://www.cdc.gov/nchs/data/nvsr/nvsr61/nvsr61_07.pdf

deaths, much of it unnecessary since a significant proportion of these conditions are believed to be preventable through improved diets and nutritional practices.

A growing body of research shows that common, modifiable health risks (such as tobacco use, obesity, poor nutrition, stress and lack of exercise) significantly impact direct and indirect health costs to employers, including medical claims, pharmaceutical expenditures, time away from work, workers' compensation costs and productivity at work:

- Obesity-related medical claims account for 2.8 percent of all medical costs for adults ages 19 to 64 years old.[49]
- Among overweight and obese adults, each one-unit increase in body mass index (BMI) yields an additional $119.70 in medical costs and $82.60 in drug costs.[50]
- Medical care charges for employees with no days of physical activity are approximately 4.7 percent higher than are charges for those who were active one day a week.[51]

Additionally, there is a direct relationship between the number of individual health risks and health costs. High-risk employees (5+ health risks), on average, incur an extra $3,321 in annual medical costs above baseline. High-risk employees are also 12.2 percent less productive than are low-risk employees (0-2 health risks).[52]

This national problem has spurred the Southern Land-grant Agricultural Extension and Experiment Station System to build active programs specializing in health and nutrition. While each individual institution tailors its programs to meet the needs of its constituents, there are a number of programs that are common across the System, including:

- Expanded Food and Nutrition Education Program (EFNEP) - through an experiential learning process, program participants learn how to make food choices which can improve the nutritional quality of the meals they serve their families.
- Supplemental Nutrition Assistance Program – Education (SNAP-Ed) - a program that supports nutrition education for persons eligible for the

[49] Long DA, Reed R, Lehman G. "The Cost of Lifestyle Health Risks: Obesity," *Journal of Occupational and Environmental Medicine*, March 2006, 244-51.

[50] Wang F. "Association of Healthcare Costs With per Unit Body Mass Index Increase," *Journal of Occupational and Environmental Medicine*, July 2006, 668-74.

[51] Pronk NP. "Relationship Between Modifiable Health Risks and Short-Term Health Care Charges," *JAMA*, Dec. 15, 1999, 2235-9.

[52] Mayo Clinic Health Solutions. The True Cost of Poor Health. See http://www.hreonline.com/pdfs/05022008Extra_MayoCostOfHealth.pdf

Supplemental Nutrition Assistance Program (SNAP). The program provides education and conducts social marketing campaigns to increase the likelihood that people eligible for SNAP will make healthy food choices within a limited budget and choose physically active lifestyles.

- Programming related to healthy lifestyles to prevent obesity. Typical educational programs provide information on healthy eating, discuss serving sizes, the number of servings needed per day, healthy food versus junk food, and issues regarding obesity-related diseases.

- Programming related to diabetes. Typical education programs provide individuals with type 2 diabetes, and their family and friends, with tools for the self management of diabetes. Education focuses on nutrition and self-management strategies that can help individuals avoid diabetes and its associated complications. According to the American Diabetes Association, the national cost of diabetes in the U.S. exceeds $174 billion.[53] Diabetes is a growing epidemic in the South, where the prevalence of diagnosed diabetes has risen sharply since 1995 (more than 100 percent).[54]

In addition to its work to promote better health and nutrition, as awareness of advances in biotechnology increases, a growing area of interest is in the use of foods for medical purposes. There is a long-standing tradition in many cultures of using natural herbs and foods to treat ailments. In recent years, so-called "superfoods" have started to receive increased attention. Probiotics, prebiotics, functional foods, clinical foods and nutraceuticals are all talked about and promoted as being good for consumers either in general or by specifically targeting a bodily function, such as improving digestion, bone density, etc. As technology evolves and more is understood about how to tailor food and drug combinations to better fit individual needs, the opportunities for tailored foods that use improved genetic profiling are burgeoning. By 2020, many in the pharmaceuticals and food industries predict biotechnical advances to combine foods grown in the field and drugs developed in the lab.

This growing area of market demand is catalyzing the Southern 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

[53] See http://www.diabetes.org/advocate/resources/cost-of-diabetes.html

[54] Centers for Disease Control November 16, 2012 Morbidity and Mortality Weekly Report. See http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6145a4.htm?s_cid=mm6145a4_w#tab

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."

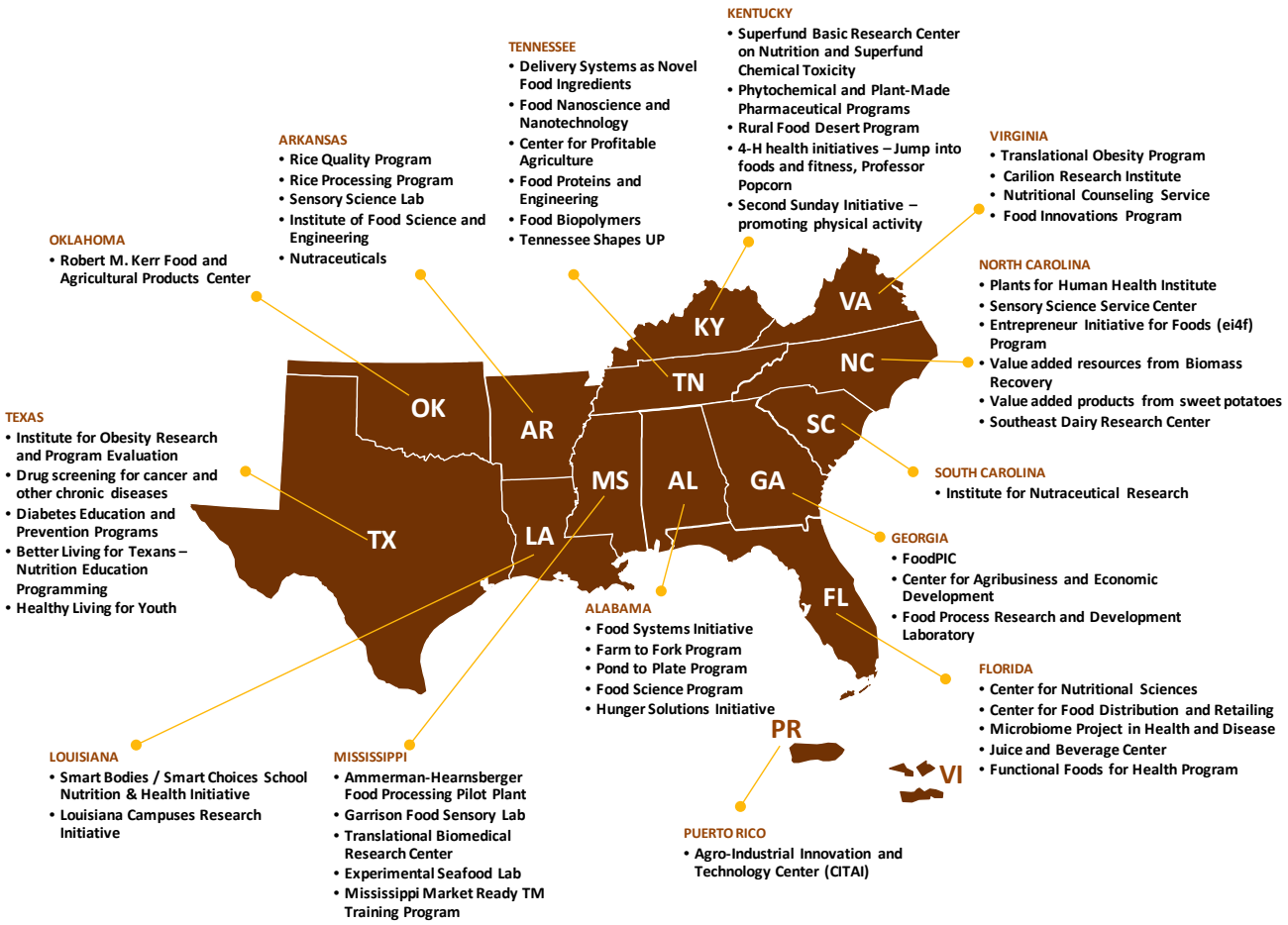
- **Phytochemicals** – Nutritionists use the term phytochemical when referring to naturally occurring components of plants that have physiological effects on humans. Such physiological effects might include, for example, enhanced immune system activity, chemoprevention, and reduced cholesterol.

- **Pharmaceuticals** – Modern transgenic 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".

One person's functional food can be another person's nutraceutical. Given that they are cheaper than pharmaceutical products and can sometimes provide similar benefits, nutraceuticals are a growth sector attracting pharmaceutical and biotech companies, including the likes of Monsanto, DuPont, Abbott, Johnson & Johnson, Novartis and Genzyme Transgenics. BCC Research reports that in 2011 the global nutraceutical market was already valued at $151 billion and was forecasted to reach $207 billion by 2016, a projected compound annual growth rate (CAGR) of 6.5 percent (BCC Research, 2011). Just-foods.com research indicates that the global functional foods market will reach a market size of $90.5 billion in 2013. Industry experts anticipate the U.S. market for functional foods to grow between 8.5 percent and 20 percent annually in the near term (Pricewaterhouse Coopers, 2009).

Figure 11 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure focused on creating value-added food products and services to promote better health and nutrition in the region. This is not, of course, an exhaustive inventory, but does serve to illustrate the intensity of specialized resources and assets dedicated to this field.

Figure 11: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities to Create Value-Added Food Products and Services to Promote Better Health and Nutrition in the Region



Examples of the many specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to create value-added food products and services to promote better health and nutrition include the following case studies.

CASE STUDY 11: LOUISIANA STATE UNIVERSITY – Producing Human Drugs in Chicken Eggs Could Reduce Drugs Costs and Increase Availability

Protein-based drugs are the fastest growing class of drugs for the treatment of infectious, inflammatory, and cardiovascular diseases in humans. The numbers of people with these types of diseases, including diabetes are growing. With more than 100 protein-based pharmaceuticals in various stages of clinical trials, the drug industry needs production methods more economical than the current ones involving facilities costing from $250 million to $500 million each.

In 2003, an LSU AgCenter researcher announced that he had developed a revolutionary process to produce proinsulin—which can be processed into human insulin—as well as other proteins and peptides in poultry eggs. Transgenic chickens can produce pharmaceutical-grade protein drugs such as insulin and growth hormone for a fraction of the cost of processes currently used. The process allows the production of human protein drugs in the eggs of chickens.

The technology starts by injecting a rooster with a specific DNA and mating it with a hen. Scientists screen the offspring for the desired protein-producing trait and cross the offspring to produce subsequent generations that carry the trait in both males and females. After that, basically, all that is required is to feed the chickens and collect their eggs. The transgenic production of human protein drugs using a chicken as a bio-reactor in no way harms the chicken.[55]

The LSU AgCenter and the scientist who developed the approach have the patents and have licensed them to TransGenRx LLC, a biological manufacturing company in Louisiana. In 2012 TransGenRx announced that it had entered into an agreement with Novocyt, LLC to use this technology to produce several growth factor proteins intended for use in new human biopharmaceuticals.[56]

CASE STUDY 12: NORTH CAROLINA STATE UNIVERSITY – Plants for Human Health Institute

The Plants for Human Health Institute (PHHI) at North Carolina State conducts fruit and vegetable research to develop and market mainstream fruits, vegetables and natural products that contain powerful properties to improve human health. PHHI is a partnership between the university's agricultural research and extension programs and Dole, General Mills and Monsanto.

One of the main goals of PHHI research is to identify compounds in fruits and vegetables that benefit human health. Blueberries are a big part of the research done at PHHI. North Carolina ranks sixth in the nation for blueberry production, with a market value of $58 million; the U.S. blueberry market is $501 million.[57] *According to research at North Carolina State, blueberries have a bioactive compound that can assist treatment of individuals with diabetes as well as reduce inflammation in athletes.*[58]

Researchers at PHHI are currently sequencing the blueberry genome. The results of this work will benefit medical and agricultural development. Genetic information from this sequence will help scientists better understand which genes are responsible for making the natural components in blueberries that positively affect human health. It will also help with breeding and variety improvement to increase yield and revenue for farmers.

[55] 'LSU AgCenter Announces Biotechnology Breakthrough.' Gould, Frankie. Louisiana State University. LSU AgCenter. June 6, 2003. http://70.169.69.243/news_files/7360760621f4b5d5ae3d0934785f2b56-0.html.

[56] 'TransGenRx signs agreement with Novocyt.' Bogren, Rick. Louisiana State University. LSU AgCenter. February 9, 2012. http://www.lsuagcenter.com/news_archive/2012/february/headline_news/TransGenRx-signs-agreement-with-Novocyt.htm.

[57] USDA – National Agricultural Statistics Service. 'Non Citrus Fruits: 2011 Summary.' http://usda01.library.cornell.edu/usda/current/NoncFruiNu/NoncFruiNu-07-06-2012.pdf.

[58] Interview with Dr. Mary Ann Lila, Director of Plants for Human Health Institute. (October 3, 2012).

CASE STUDY 13: UNIVERSITY OF GEORGIA – Innovative Stem Cell Research in Pigs at UGA Regenerative Bioscience Center

At the University of Georgia Regenerative Bioscience Center (RBC) multidisciplinary teams of scientists are leading projects at the forefront of stem cell research in animals that could have promising future applications for animal and human health and food security.

Mice are presently the most commonly used animal models for stem cell research, but this approach has major limitations since mice are physiologically different from humans. For instance, mice heart rates are four times faster than humans, and mice do not get clogged arteries like humans do.

Pigs, on the other hand, are more like humans than mice. A team of scientists at RBC has overcome an important technological barrier to conducting stem cell research in pigs, and, as a result, they were able to grow and harvest induced pluripotent stem cells (IPS cells) in pigs. These cells were then injected into another pig embryo. The first piglets carrying these new stem cells were born in 2009.

These scientists are now considering a wide range of applications for these new pig stem cells and the pigs they can produce. They are currently collaborating with scientists at Emory University to develop insulin-producing pancreatic islet cells that could someday be used to help treat people with diabetes, a disease that affects nearly 26 million American children and adults.[59] *Scientists also believe that this new technology for harvesting IPS cells in pigs may also be used to genetically engineer healthier livestock. They are also working with the Bill & Melinda Gates Foundation to breed chickens resistant to Newcastle Virus, a disease that kills up to one-quarter of the chickens in sub-Saharan Africa every year.*[60]

CASE STUDY 14: TEXAS A&M – The Power of Natural Antioxidants to Fight Colon Cancer

Research on antioxidants in red wine has demonstrated that they may help inhibit the development of colon cancer (also referred to as colorectal cancer), the third most prevalent type of cancer in the United States after prostate and breast cancer.

In 2008 over 150,000 Americans were diagnosed with colon cancer; and over 50,000 deaths were linked to this disease. Globally the situation is even greater, with over 1.2 million new incidents of the disease identified, and 600,000 deaths recorded.[61] *That the disease is linked to obesity is even more worrying for the U.S. and an American population that is facing an obesity epidemic, with one-third of the population obese and another third overweight.*[62]

Researchers at the Texas A&M Institute for Obesity Research and Program Evaluation are conducting studies to better understand the anti-cancer effects of polyphenolics in red wine and fruit and the underlying mechanisms and interactions with cancer-causing molecules and cancer cells. Polyphenols are the most abundant antioxidant compounds in the human diet. They are found in fruits and vegetables, cereals, tea, coffee, chocolate and red wine. Recent studies with rats at the Institute demonstrated that polyphenolic extracts from pomegranate, mango and plums were successful in preventing colon cancer and colon inflammation. Based on these findings and findings from other research groups, polyphenolics could be reasonably expected to have some kind of efficacy in the prevention of colon cancer in humans. To help determine this efficacy the Institute has begun a study on humans with a high risk of colon cancer; results are expected in 2013.[63]

[59] 'Scientists use pig embryo to create stem cells.' Falco, Miriam. CNN.com. May 4, 2010. http://thechart.blogs.cnn.com/2010/05/04/scientists-use-pig-embryo-to-create-stem-cells/.

[60] 'Researchers work to develop disease-resistant livestock.' Peppers, Faith. University of Georgia – College of Agricultural and Environmental Sciences. May 25, 2011. http://www.caes.uga.edu/applications/gafaces/?public=viewStory&pk_id=4123.

[61] World Health Organization – International Agency for Research on Cancer. GLOBOCAN 2008. http://globocan.iarc.fr/

[62] 'Pounding Away at America's Obesity Epidemic.' National Public Radio. May 14, 2012. http://www.npr.org/2012/05/14/152667325/pounding-away-at-americas-obesity-epidemic

[63] Interview with Dr. Susanne Talcott, Director of Research, Institute for Obesity Research Program at Texas A&M. (October 29, 2012).

CASE STUDY 15: VIRGINIA TECH – Translational Obesity Program, Turning Research into Best Practices

The combination of physical inactivity and unhealthy eating is contributing to an obesity epidemic in the United States and increasing the number of people with diabetes and cardiovascular disease in this country. Obesity has been estimated to contribute to over nine percent of all total healthcare expenditures in America.[64] *Alternatively, healthy eating habits and regular physical activity can improve quality of life, prevent chronic diseases such as diabetes, hypertension and cancer, and reduce healthcare costs. In Virginia almost 30 percent of adults are obese.*[65] *According to Virginia Tech research nearly 75 percent of adults do not meet current recommendations for physical activity, and nearly as many are also not meeting current dietary recommendations for fruit and vegetable consumption.*[66]

In response to this problem, the Translational Obesity Research Program at Virginia Tech's College of Agriculture and Life Sciences partnered with Virginia Cooperative Extension to develop and promote fruit and vegetable consumption and regular physical activity through a 'Fit Extension' program. The Translational Obesity research staff's evidence-based, collaborative approach to program development, implementation and review helps ensure that the interventions are practical, reach the intended target audience and are scalable over time.

From 2009–11 the 'Fit Extension' program was delivered by Cooperative Extension agents and evaluated by research staff with the Translational Obesity Research Program. Over 3,000 participants took part in the program each year. The results were significant and positive. In each of the years the number of participants eating the recommended number of servings of fruits and vegetables increased by over 15 percent. The program also significantly increased the number of participants engaging in physical activity. Based on improvements in participants meeting recommendations for physical activity, researchers have estimated that the healthcare and job productivity costs savings to be as high as $750,000.[67]

Ensure a Safe Food Supply

Any food can carry risks of foodborne illness to the consumer. Micro-organisms present a substantial detection and eradication challenge, and their extremely rapid reproductive rate means that a few organisms missed today can multiply into millions within 24 hours. Fruits and vegetables, even when washed, may still harbor dangerous micro-organisms. Animal products can likewise harbor organisms that can pose a risk to human health if appropriate tools and techniques are not used to offset the risk.

The Centers for Disease Control and Prevention (CDC)[68] notes:

> *An estimated 76 million cases of foodborne disease occur each year in the United States. The great majority of these cases are mild and cause symptoms for only a day or two. Some cases are more serious, and CDC estimates that there are 325,000 hospitalizations and 5,000 deaths related to foodborne diseases each year.*

[64] Virginia Tech. College of Agriculture and Life Sciences. Obesity Initiative. http://www.crc.hnfe.vt.edu/obesinit_misson.html.

[65] Center for Disease Control and Prevention. Overweight and Obesity. http://www.cdc.gov/obesity/data/adult.html.

[66] Virginia Tech. Translational Obesity Research Program. 'Fit Extension' impact statement.

[67] Virginia Tech. Translational Obesity Research Program. 'Fit Extension' impact statement.

[68] *Foodborne Illness.* U.S. Department of Health and Human Services, CDC Division of Bacterial and Mycotic Diseases, January 2005. Online at http://www.cdc.gov/ncidod/dbmd/diseaseinfo/foodborneinfections_g.htm#mostcommon.

The most common forms of foodborne infections are bacterial (*Campylobacter, Salmonella,* and *E. coli* O157:H7) or viral via the calicivirus (also known as Norwalk and Norwalk-like viruses). *Campylobacter* resides in poultry, *Salmonella* is widespread in the intestines of birds and mammal species, and *E. coli* 0157 is endemic to cattle.

Foodborne illnesses result in considerable economic costs. In an agriculture- and food-based economy, preserving product safety is crucially important—not only for human and animal health, but also for economic sustainability. Food product recalls can run to tens of millions of dollars and have negative effects that ripple through many sectors of the economy. Accidental contaminations can occur at multiple stages in the agriculture and food chain, from contaminations on the farm to poor food handling by food preparers at a restaurant or home. In addition to these challenges, emerging diseases also threaten the food supply, most notably potential outbreaks of diseases such as scrapie, bovine spongiform encephalopathy, chronic wasting disease, and foot-and-mouth disease.

The Food and Drug Administration (FDA) released estimates of the incidence of foodborne disease concluding that between 3.3 million and 12.3 million illnesses occur in the United States in any given year and up to 3,900 deaths (a lower estimate than the CDC's). If these numbers are extrapolated on a normative national level for the Southern Region (which has 35 percent of the U.S. population), then the FDA data suggest that between 1.2 million and 4.3 million foodborne illnesses will occur annually in the South and nearly 1,400 deaths. USDA researchers have estimated monetary losses from the seven leading foodborne pathogens to be between $6.5 billion and $13.3 billion nationwide. This would equate to losses of between $2.3 billion and $4.7 billion for the South.[69]

The Southern Region's Land-grant Extension Service and Experiment Station System not only expands the agbioscience economy of the region, it also has many initiatives that work to protect agriculture, agribusiness, and consumers from threats to food security and consumer health—thereby working to reduce the health and economic costs resulting from foodborne illness and other threats. Maintaining a safe and secure supply chain, from production to consumption, is a prime objective of the System's efforts. As has been evidenced above, food safety problems, such as pathogen outbreaks, can cause significant health problems and severely damage major components of the Southern economy—so the Extension Service and Experiment Station System is on the frontlines of prevention, with research, teaching, and extension related

[69] J. Buzby and T. Roberts. "ERS Updates U.S. Foodborne Disease Costs for Seven Pathogens." *Food Review*, September–December 1996, pp. 20–25. Online at http://www.ers.usda.gov/publications/foodreview/sep1996/Sept96e.pdf.

programs focused on food safety, biosecurity, and advanced processing technologies. One specific area of emphasis in which the System is heavily engaged across the network is in helping to develop safety standards and subsequently providing the required education and certification programs to ensure that the standards are adhered to, such as the Hazard Analysis and Critical Control Point (HACCP), Good Agricultural Practices (GAP) and Good Handling Practices (GHP) Certification programs.

Figure 12 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure focused on ensuring a safe food supply. This is not, of course, an exhaustive list, but does serve to illustrate the intensity of specialized resources and assets dedicated to this field.

Figure 12: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities Helping to Ensure a Safe Food Supply within the Region

Examples of the specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to ensure a safe food supply include the following case studies.

CASE STUDY 16: AUBURN – Poultry Product Safety and Quality Program

Alabama is one of the leading producers of poultry in the United States. The state's poultry industry, along with allied sectors, provides 80,000 jobs. It is an important part of many local economies. Over one billion broiler chickens are produced in the state annually, generating $2.4 billion in revenue for local farmers. In fact, the South is the leading broiler producing region in the country.[70]

The sustainability of the U.S. poultry industry is vital to maintaining a safe and secure food supply and preserving hundreds of rural economies in many states. The Auburn University Poultry Products Safety and Quality (PPSQ) Program is a uniquely designed, farm-to-fork poultry products program that focuses on poultry processing, value-added products and food safety. The PPSQ goal is to develop the knowledge and technology needed for the production of wholesome, high quality poultry products through comprehensive research, teaching, and extension-outreach efforts.[71]

Food safety is a major priority for the industry. A significant portion (10–20 percent) of reported foodborne illnesses in the United States are attributed to poultry products. Food safety risks associated with poultry include pathogenic bacteria such as Salmonella, Campylobacter and Listeria, all of which are recognized causes of foodborne illness. In addition to these pathogens, which are typically carried from live production into processing, other chemical (i.e., drug and pesticide residues) and physical (i.e., bone fragments, foreign objects) hazards may persist in final product.[72]

PPSQ is working to gain a full understanding of the nature of these pathogens from poultry production through processing. The Program is investigating and developing methods to reduce or eliminate the threat of these pathogens in poultry products.

CASE STUDY 17: CLEMSON UNIVERSITY – Nanotechnology Applications for Food Safety

Foodborne illnesses are a major public health issue in the United States. From Salmonella in peanut butter and E. coli in ground beef sold at the grocery store, to Listeria in apple slices in children's meals at McDonald's and Burger King.[73]

Foodborne agents cause an estimated 48 million illnesses annually in the United States. The Center for Disease Control and Prevention reported that during 2008, the most recent year for which data are finalized, 1,034 foodborne disease outbreaks were reported, which resulted in 23,152 cases of illness, 1,276 hospitalizations, and 22 deaths. Norovirus (acquired by ingesting food or water contaminated with feces or fluids) was the leading cause of these outbreaks. Salmonella was the leading cause of hospitalizations and deaths and the cause of more than half of the multistate outbreaks.[74]

[70] National Poultry Technology Council. 'Industry Fact Sheet.' http://www.aces.edu/poultryventilation/documents/NPTCIndustryFactSheet.pdf.

[71] Auburn University. College of Agriculture – Department of Poultry Sciences. Poultry Products Safety and Quality Peak of Excellence Program. http://www.ag.auburn.edu/poul/peakwelcome.html.

[72] Interview with Dr. Don Conner, Department Head and Professor, Department of Poultry Science. (October 9, 2012).

[73] 'Peanut Butter Recall Expands Dramatically as Sunland Plant Tests Positive for Salmonella.' Huffington Post. October 5, 2012. http://www.huffingtonpost.com/2012/10/05/peanut-butter-recall_n_1944031.html#slide=1555520.

[74] Center for Disease Control and Prevention – Surveillance for Foodborne Disease Outbreaks in the United States. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6035a3.htm?s_cid=mm6035a3_w.

Prior to consumption detection of bacteria and pathogens, and pathogen-inducing conditions, is a critical means of reducing incidence of these illnesses and outbreaks. In the field of nanotechnology scientists at Clemson University are testing ways to use biological molecules known as PDA (polydiacetylene) liposomes to act as sensors to detect infectious agents in food. The sensory ability of these liposomes has already been well documented in laboratory experiments. Clemson scientists are now modeling PDA sensors for real world applications. For instance, these PDA sensors could be used to detect pathogens in food by announcing the presence of a particular pathogen through irreversible color change. PDA sensors could be incorporated or attached into fibers, printed on surfaces or dispersed in aerosol sprays. This technology could be used in bacteria detecting cotton swabs or tissues to quickly and cheaply determine the presence of contamination on food preparation surfaces, cutlery and appliances. It could also be used in packaging materials for food—like absorbent pads under meats—to indicate spoilage, or E. coli or Salmonella contamination.[75, 76]

Foster Ecological and Environmental Stewardship and Natural Resource Management

Agriculture and forestry's long-term vitality and prosperity depend on the ability to coexist sustainably with the natural environment. Clearly, agriculture and forestry is not environmentally neutral—agriculture and timber production changes the structure and use of the landscape; uses water and soil resources; and often requires fertilizers, pesticides, and other chemicals to sustain productivity. Natural ecosystems are affected by agriculture and timber practices, and backward and forward linkages exist between agroecosystems (crops, pastures, timber tracts, ponds, and ranchland) and the environment (including energy, air, water, and land). This interface is a knife that cuts both ways: agriculture and forestry influences the environment, and the environment influences agriculture and forestry.

In a region that depends on its environment, not only for quality of life but also as the underpinning of its agriculture, forestry and fisheries-based economy, the work of the Land-grant Universities in ecological and environmental stewardship and natural resource management is of critical importance. The Extension Service and Experiment Station System in general, has an important role to play in the development and implementation of solutions to environmental challenges. These institutions within the Southern Region are making contributions across a broad range of environmental and sustainability fronts in areas as diverse as:

- the ecology of agricultural systems;
- response of agroecosystems to environmental stress (climate change, soil degradation, pollutants, waste materials, air and water quality, and changing land and water use);

[75] Polydiacetylene Liposome Sensing Systems (white paper). Dawson, Paul.

[76] Interview with Dr. Paul Dawson, Professor, Clemson University - Department of Food, Nutrition and Packaging Sciences. (October 30, 2012).

- crops and livestock, including wildlife, ecology and processes; and
- characteristics of agroecosystems from a biological, physical, and environmental standpoint.

It is important to note that this work is not only focused on the broad rural environment, but also on the urban environment and associated community sustainability issues.

Given the significance of agbiosciences to the Southern Region's economy, and the fact that agricultural and livestock production accounts for 272 million acres and forestry accounts for 215 million acres (accounting for a combined total of more than 90 percent of the region's total land mass), it is imperative that an effective balance of agbiosciences and the environment be reached to ensure economic and ecological sustainability, enhanced public health, reduced environmental degradation and associated costs, a more appealing environment for attracting human capital, and new environmental technologies and discoveries that present commercialization opportunities.

Figure 13 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure focused on fostering ecological and environmental stewardship and natural resource management. This is not, of course, an exhaustive list, but does serve to illustrate the intensity of specialized resources and assets dedicated to ensuring environmental sustainability.

Figure 13: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities Helping to Foster Ecological and Environmental Stewardship and Natural Resource Management within the Region

Examples of the specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to foster ecological and environmental stewardship and natural resource management include the following case studies.

CASE STUDY 18: MISSISSIPPI STATE – Mississippi-Alabama Sea Grant Consortium

The Mississippi-Alabama Sea Grant Consortium (MSAGC) provides leadership to coastal communities in the region through research, education, extension and outreach on a wide range of issues related to aquaculture, wetland conservation and habitat restoration. The Consortium includes nine universities in Mississippi and Alabama, with Extension Service programs in each state directed by Mississippi State and Auburn respectively.[77]

For over 30 years program specialists with MSAGC have worked with local governments, federal agencies, schools and other organizations to assist communities in developing strategies for sustainable coastal resource management. Balancing coastal development and ecosystem health is a big challenge for these communities—like Gulfport and Biloxi—whose economies benefit extensively from tourism, a $1.7 billion industry in the Mississippi Gulf Coast.[78] *MSAGC conducts research and outreach to address critical needs for properly managing and restoring vital coastal ecosystems and the benefits they provide local communities. The beaches of Mississippi and Alabama are part of this ecosystem and a major point of attraction for tourists.*

MSAGC supported preliminary work led by the Mississippi State University Coastal Research and Extension Center to restore a three acre section of the Mississippi coast using new techniques to develop a "living" and sustainable shoreline. Whereas the old approach was to rebuild dunes with more sand and fence off the area, the new approach relied on planting more native dune vegetation, like sea oats and panic grass to prevent erosion.[79] *As a result of the success of this project, the Army Corps of Engineers sponsored an expanded restoration project using similar techniques to a 26 mile stretch of a beach severely damaged by Hurricane Katrina. Over 300 community volunteers joined in the effort, helping plant over 10,000 native plants on lower and upper portions of the beach to improve the natural landscape and reduce wind erosion. The project ultimately helped reduce maintenance cost by keeping sand on the beach and off the roads. It enhanced the habitat diversity for birds and other wildlife, and it made a more attractive beach destination for tourists.*[80]

CASE STUDY 19: TEXAS A&M – Texas Water Resource Institute

2011 was the driest year on record for Texas and arguably the worst drought in the state's history. Losses on crops and livestock were $7.6 billion; add damages caused by fires and that figure climbs to nearly $8.5 billion. Water resource management is clearly a major issue for the state and its residents.[81]

The 'Efficient Irrigation for Water Conservation in the Rio Grande Basin' initiative, led by Texas A&M AgriLife Research and Extension Service and managed by the Texas Water Resource Institute, focuses on increasing available water, meeting present and future water demands, and creating new sources of water for the region. This work includes expanding efficient use of available water resources by improving canals and implementing more efficient irrigation systems. Rio Grande Basin agriculture is highly productive with irrigation claiming more than 85 percent of its water. The basin's agricultural crop industry, comprised principally of cotton, grain sorghum, grapefruit, chilies, pecans, citrus, sugarcane and vegetables, has an economic impact of more than $1 billion annually. Persistent drought in the region limits the amount of water available for agriculture and urban uses.

[77] Mississippi-Alabama Sea Grant Consortium. http://d276864.h39.zee-hosting.com/page.asp?id=3.

[78] 'Mississippi Gulf Coast Regional Brief.' Gulf Coast Business Council Research Foundation. March 28, 2012. http://www.msgcbc.org/docmsgcbc/Regional%20Brief%20-%20Q1_2012.pdf.

[79] Interview with Dr. Dave Burrage, Mississippi State Extension Professor and Program Leader for Mississippi-Alabama Sea Grant Consortium. (October 31, 2012).

[80] 'Program Review Panel Report.' Mississippi-Alabama Sea Grant Consortium. 2012.

[81] 'The Texas Drought Seen Firsthand from the Eyes of Ranchers.' Jones, Malcolm. The Daily Beast. August 9, 2012. http://www.thedailybeast.com/articles/2012/08/09/the-texas-drought-seen-firsthand-from-the-eyes-of-ranchers.html.

Texas A&M AgriLife Research and Extension Service has conducted irrigation studies and worked with local producers to implement new irrigation technologies, like micro-irrigation and border flooding (i.e., flooding the area just around the tree instead of the entire grove). As a result of this work over half of Texas's 27,500 acres of citrus groves are now utilizing improved irrigation technologies and water conservation methods.[82] *By investing in precision irrigation, improved canal infrastructure and rural and urban water conservation, both urban and agricultural interests have benefited tremendously from increased water availability.*[83] *Over the past ten years these efforts have saved the Rio Grande Basin 1.6 trillion gallons of water, equivalent to the annual water usage of 60 million people.*[84]

CASE STUDY 20: UNIVERSITY OF THE VIRGIN ISLANDS – Agroforestry

Forests cover 60 percent of the Virgin Islands and play a vital role in local ecosystems.[85] *The Agroforestry Program at the University of the Virgin Islands (UVI) Agricultural Experiment Station is researching native trees to develop best practices for new growth to support forest restoration and maintain a rich and diverse forest system that benefits the environment and the community. Before the agroforestry research began at UVI in 1999 there was very little documented information about native tree species and how to grow them from seed.*

Forests support soil and water conservation. Water is a precious resource on the islands—there are no lakes or rivers and few springs. The forest system helps maintain surface and groundwater supplies by reducing surface runoff and increasing infiltration of ground water to the aquifers. Healthy forests also support a healthy marine system in the Caribbean. A healthy forest reduces soil erosion and protects coral reefs from the negative impact of sedimentation.

Increased production of native tree species could also increase the use of locally grown forest products used in arts and crafts, medicines, and charcoal-making. Wooden arts and crafts, sold primarily to tourists from cruise ships, bring $600,400 in revenue annually to local artisans on the islands.[86] *Due to the lack of a consistent wood supply from local forests most of that wood comes from the Dominican Republic, Haiti, Indonesia and South America.*[87]

CASE STUDY 21: UNIVERSITY OF ARKANSAS – The Center for Agricultural and Rural Sustainability

Over the last decade there has been an increased emphasis on sustainability in agriculture as demand from consumers and retailers has increased for products from sustainable sources. However, the definition of 'sustainability' was subjected to a great degree of variability in the marketplace. This variability made it more difficult for producers to meet standards that differed across product markets.

To help shape the sustainability conversation the Center for Agricultural and Rural Sustainability partnered with Field to Market—The Keystone Alliance for Sustainable Agriculture. This initiative is made up of leading commodity crop producers, processers, and retailers, including Coca Cola, General Mills, Walmart, and Kellogg Company. Together these stakeholders first came up with a mutually agreed upon definition of sustainable agriculture:

[82] 'Agricultural Water Conservation Demonstration Initiative.' McLemore, Tom. Harlingen Irrigation District. 2010. https://www.twdb.texas.gov/conservation/agriculture/demonstration/doc/ADI_2010.pdf.

[83] Texas Water Resource Institute

[84] Interview with Dr. Roel Lopez, Director of Texas Water Resource Institute, and Dr. Danielle Kalisek, Project Manager for Rio Grande Basin Initiative. (October 29, 2012).

[85] 'The Status of U.S. Virgin Islands' Forests.' USDA - Forest Service, Southern Research Station. Resource Bulletin SRS122. 2007.

[86] Ibid

[87] Ibid

- *Meeting the needs of the present while improving the ability of future generations to meet their own needs by focusing on specifically defined outcomes*
- *Increasing agricultural productivity to meet future nutritional needs while decreasing impacts on the environment, including water, soil, habitat, air quality and climate emissions, and land use*
- *Improving human health through access to safe, nutritious food*
- *Improving the social and economic well-being of agricultural communities*[88]

The Initiative then developed indicators for agricultural sustainability that covered environmental and socioeconomic issues.[89] *A tool was developed to assist farmers in understanding how their farm is meeting these indicators. The tool will also help farmers determine how environmental outcomes affect their management costs. The Field to Market Initiative originally focused on six commodity crops—corn, cotton, potatoes, rice, soybeans, and wheat. As the program continues work is being done to expand to other crops, as well as to areas outside of the U.S.*

CASE STUDY 22: UNIVERSITY OF FLORIDA – Irrigation Equipment Testing Helps Conserve Water in Florida

Florida's water supplies are challenged by a large and growing population, an extensive agricultural sector, and seasonal droughts. According to the U.S. Geological Service, Floridians use almost 7 billion gallons of water per day.[90] *Nearly half of that is used in farming, and a significant portion of the rest is used for urban irrigation.*

A key area of research for irrigation experts at the University of Florida is the efficient use of irrigation water for agriculture and urban landscaping. Agriculture and urban irrigation equipment makers have been developing new irrigation technologies for a long time. Yet only in the last decade, as these technologies have become more affordable and water supply issues more urgent, has demand for these technologies really increased.

University of Florida researchers are conducting independent research to apply and evaluate new irrigation technologies with smart controllers that monitor certain aspects of the environment—like soil moisture, evaporation and plant transpiration—to determine when water is actually needed. They are far more efficient than past irrigation systems that ran on timers, which could turn the system on regardless of whether water was actually needed.

In one study of soil moisture controllers the research showed that irrigation for green bell peppers (produced on about 20,000 acres in the state) can be cut by up to 50 percent without negatively affecting production. Research has also shown that the use of these smart controllers can reduce water use for landscape irrigation by 30–50 percent. These independent studies help inform the makers of the technology, as well as the users, and thus improve product quality as well as adoption.[91]

[88] Field to Market – The Keystone Alliance for Sustainable Agriculture. 'Environmental and Socioeconomic Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States.' July 2012. http://www.usarice.com/doclib/188/6132.pdf.

[89] Interview with Dr. Marty Matlock. Director of the Center for Agricultural and Rural Sustainability at the University of Arkansas (October 4, 2012).

[90] US Geological Service - Water Use in the United States. http://water.usgs.gov/watuse/.

[91] Interview with Dr. Michael Dukes, Professor of Environmental Horticulture. University of Florida - Department of Agricultural and Biological Engineering. (October 9, 2012).

Serving as an Agent of Innovation that Catalyzes Economic Growth

Technology Dissemination/Commercialization

In a knowledge-driven economy, intellectual property has become the most valuable property of all. While software and information technology dominated U.S. technology growth in the 1980s and 1990s, bioscience disciplines have been making the headlines more recently. The post-genomic era, with its quantum leap forward in the understanding of fundamental and functional life mechanisms, is spawning new avenues of discovery and innovation. Against this backdrop of bioscience prominence, the importance of the Land-grant Universities as a generator of intellectual property and scientific discoveries comes clearly into focus.

In an effort to spur technology dissemination/commercialization, the Bayh-Dole Act, enacted by the federal government in 1980, enabled the creation of a uniform patent policy among the many federal agencies that fund research, enabling universities to retain title to inventions made under federally-funded research programs. As a result, this legislation has been instrumental in encouraging universities to participate in technology dissemination activities.

The Land-grant Extension Service and Experiment Station System has an established track record in developing new crop cultivars, animal disease diagnostics, vaccines, and related discoveries, initiatives that catalyze economic growth via innovations in techniques, innovations in technologies, and innovations in practical applications. As a result, 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 dissemination of new university-generated knowledge and its adoption 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 thereby creating licensing revenue streams.

In conducting this project, Battelle asked each of the 15 universities to provide statistics on their intellectual property activity for the three year period 2009

through 2011. As illustrated in Table 7, of the institutions that reported data, the results indicate that during this time period the combined universities, in agbioscience fields, generated 1,247 invention disclosures (an average of 416 per year). These resulted in 1,009 patents applied for with a total of 453 patents awarded, as well as 54 plant variety protection certificates applied for with a total of 33 certificates awarded within the three-year time period. As an indication of the applied usefulness of university generated IP to industry, 1,473 licenses for university agbioscience discoveries were executed in this time period (an average of 491 per year). In addition, for the plant variety certificates and licenses held, the universities received $124 million in revenue, monies which are returned to the university and help to continue to advance future agbioscience development.

Table 7: Reported Intellectual Property Statistics for Agbioscience-related Activities at the Southern Land-grant Universities

	2009	2010	2011	3-Yr. Total
# of Invention Disclosures	415	438	394	1247
# of [US] Patents Applied For	298	414	297	1009
# of Patents Awarded	152	183	118	453
# of Licenses Executed	569	388	516	1473
# of Plant Variety Protection Certificates Applied For	17	22	15	54
# of Plant Variety Protection Certificates Awarded	11	15	7	33
$ Value of Income received from Plant Variety/Germplasm Development	$12,342,934	$12,194,076	$12,891,933	$37,428,943
$ Value of Income received from all other Intellectual Property	$24,582,680	$29,838,405	$31,863,402	$86,284,487

Business Creation

In addition to licensing technology, the Land-grant Universities have also been involved in the direct generation of new business enterprises founded on agbioscience and related research and extension discoveries. In the past three years, the combined universities, in agbioscience fields, created 52 business start-ups as a result of licensing, as well as numerous other businesses through other means.

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 15 Land-grant Universities are, in effect, operating a comprehensive innovation-to-commercialization continuum. By undertaking basic and applied research, the universities are generating new technologies and innovations that then move into commercial incubation. 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.

Figure 14 highlights some of the companies that have been created in the Southern Region as a result of the research discoveries, innovation, and technologies developed within the Southern Land-grant Extension Service and Experiment Station System. This is not an exhaustive list, but does serve to illustrate the intensity of specialized resources and assets dedicated to serving as an agent of innovation.

Figure 14: Start-Up Companies Located in the Southern Region that Spun-off from Research Discoveries, Innovation, and Technologies Developed within the Land-grant Extension Service and Experiment Station System

Examples of the specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to serve as an agent of innovation that catalyze economic growth include the following case studies.

CASE STUDY 23: OKLAHOMA STATE UNIVERSITY – Food and Agricultural Products Center Supporting New Food Product Enterprises

The Robert M. Kerr Food and Agricultural Products Center (FAPC) has served the food and fiber industries of Oklahoma for over a decade. This state-funded center works with food and agribusiness operations of all sizes, supporting projects related to food safety, new product development, engineering, analytical chemistry, and economic and market analysis. A study in 2006 revealed that firms working with FAPC attributed $93 million of their 2006 sales and 157 jobs directly to the assistance provided by FAPC. Direct, indirect and induced economic impacts attributable to FAPC were estimated at 800 jobs and $308 million in economic activity for the state of Oklahoma that year.[92]

FAPC has assisted in the development of value-added enterprises by offering a combination of in-house technical and laboratory services for entrepreneurs and existing businesses, on-site technical assistance, and various business and marketing assistance programs and workshops. One beneficiary of these services is Suan Grant, founder of Suan's Foods, which produces jellies, jams and other condiments. Today Suan's Foods complete line of products is available in 17 states and 175 stores nationwide. She makes and markets a variety of products, including tomato jam, pepper relish, mango lemon fruit butter, and pineapple cinnamon jam. It all began with a home recipe just a couple years earlier and a test kitchen at FAPC. Suan first started working with FAPC in 2009 to market a Scotch Bonnet pepper jelly she had developed while living in Jamaica. Through a host of services provided by FAPC Suan learned about business planning, marketing, trademarking, health regulations, branding, product evaluation, legal issues, product co-packing, and labeling regulations. FAPC specialists also worked with Suan to prepare her product for large-scale production, first with small batches in a test kitchen, testing and improving the recipe for commercialization. Then, when she was ready to market larger batches of the jelly, FAPC helped her identify a local co-packer (i.e., a processor under contract to manufacture the product to her specifications). Through trade shows like the Dallas Gourmet Market and other networking support FAPC helped introduce Suan to numerous large-scale buyers from around the world.[93, 94, 95]

CASE STUDY 24: UNIVERSITY OF PUERTO RICO – Supporting New Business Development in Puerto Rico

The effects of the global economic crisis have hit Puerto Rico hard. Since 2005 Puerto Rico's GDP growth rate has gone from positive 2.5 percent to minus 6 percent in 2010.[96] *This economic recession has also contributed to a rising unemployment rate that grew to 16 percent in 2010.*[97]

To address this challenge and empower local communities during hard times the Government of Puerto Rico and the University of Puerto Rico Agricultural Extension Service collaborated to design and implement a Community Entrepreneurship Toolbox. The goal of this toolbox is to deliver training workshops to community members and stimulate local business development in the tourism, service and manufacturing sectors.

[92] '10-Year Economic Impact.' McConaghy, Justin and Holcomb, Rodney. Robert M. Kerr Food & Agricultural Products Center.

[93] Interview with Dr. Roy Escoubas, Director of Robert Kerr Food and Agricultural Products Center. (October 1, 2012).

[94] Interviews with Chuck Willoughby and Andrea Graves of the Robert Kerr Food and Agricultural Products Center. (October 16, 2012).

[95] Interview with Suan Grant. (October 17, 2012).

[96] Index Mundi. 'Puerto Rico GDP – real growth rate.' http://www.indexmundi.com/puerto_rico/gdp_real_growth_rate.html.

[97] U.S. Department of Labor. Bureau of Labor Statistics. 'Puerto Rico.' http://data.bls.gov/timeseries/LASST43000003.

The result has been positive. From 2008–2010 over 350 community members received training in entrepreneurial skills, combined with skills training in agriculture, artisanship, craftsmanship, tailoring, and child and elderly services. Since then fifteen new small businesses have been formed, including artisan groups, bakers, tailors and farmers markets. One of the most notable of these is the Verdes de Corazon, a ceramic college artisanship group. In 2010 the Bacardi Corporation commissioned the group for a mural to welcome international visitors to the company's headquarters in San Juan.[98]

New products

The Land-grant Extension Service and Experiment Station System provides an integrated service to research, develop, test, and introduce new and enhanced crops and products for the agricultural sector in the region. Services range from development of enhanced strains of existing crops (having enhanced disease resistance, increased yield and quality characteristics, for example) to the introduction of completely new crops, livestock, and value-added products. Currently, Southern farmers are seeing income increased through enhanced strains of rice, wheat, cotton, soybeans, and vegetable and fruit crops. In addition, research at the Southern Land-grants is producing new opportunities in biorenewables and biopharming.

The introduction of new crops and products for Southern agriculture is no simple task. It has to be facilitated through the System's network of practitioners, scientists, and field staff who can advise producers on the best path to take, help them analyze the suitability of their land to new production requirements, evaluate the marketability and revenue potential from new or enhanced products, and plan their introduction.

An example of specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to serve as an agent of innovation that catalyzes economic growth can be seen in the following case study.

[98] University of Puerto Rico. '2010 University of Puerto Rico Extension Annual Report of Accomplishments and Results.' http://www.reeis.usda.gov/web/areera/reports/2010/2010-University-of-Puerto-Rico-Extension-Annual-Report-of-Accomplishments-and-Results.pdf.

CASE STUDY 25: UNIVERSITY OF KENTUCKY – Kentucky Tobacco Research and Development Center

The Kentucky Tobacco Research and Development Center is leading the way for discovery of new crop opportunities for Kentucky farmers. Through the use of agricultural biotechnology tools and applications, like crop genetics, research conducted at the Center has identified high-value opportunities for transgenic tobacco varieties used to produce plant-made pharmaceuticals, as well as natural products and novel compounds derived from plants.

KTRDC acts as an incubator for commercialization of discoveries by providing a range of services:

- *Field testing, disease testing and containment of transgenic crops*
- *Plant breeding to enhance gene expression in new varieties of tobacco intended for production systems for plant-based pharmaceuticals*
- *Collecting novel species of plants from the wild for seed and utilization as a source of natural products*
- *Providing equipment, laboratory and office space, and small grants for researchers*

The production of plants to make modern medicine offers an exciting opportunity to drastically reduce the cost of drugs, as well as increase their availability. Transgenic ("genetically engineered") tobacco is a favorite choice for research in the field of plant-based pharmaceuticals due to its high biomass yield and rapid scalability. And since tobacco is not used for food or feed it greatly reduces the risk of transgenic material contaminating food or feed supplies.

The Center is also developing new technologies to expand the discovery and use of substances made naturally by tobacco and other plants for use as flavors, fragrances and natural insecticides. One of the companies formed from KTRDC research is Naprogenix. Naprogenix is using genetic screening technologies developed by faculty at the University of Kentucky to mine plants for novel biological activity and the potential to produce natural products for the pharmaceutical, agrochemical and health and nutrition industries.[99, 100]

Catalyze the industrial bioeconomy (fuels, chemicals, materials) to foster economic diversification, value-added product development, and energy independence

The dependence of industrialized nations on fossil fuels and associated synthetic products has become an increasing problem because of the volatility of pricing for finite fossil resources and the significant geo-political and environmental challenges associated with them. As such, a concerted national and international push is being made to develop alternatives to fossil fuels and fossil resource chemicals, an effort that has been coined "the biorenewable economy". The biorenewable economy is focused on the commercial application of bioresources to produce energy, industrial commodities, and specialty products**.** Opportunities for biorenewables are substantial and can only increase as fossil resources dwindle and prices rise as demand outstrips supply. Examples of opportunities in biorenewables include the following:

[99] University of Kentucky. College of Agriculture - Kentucky Tobacco Research and Development Center. http://www.ca.uky.edu/KTRDC/.

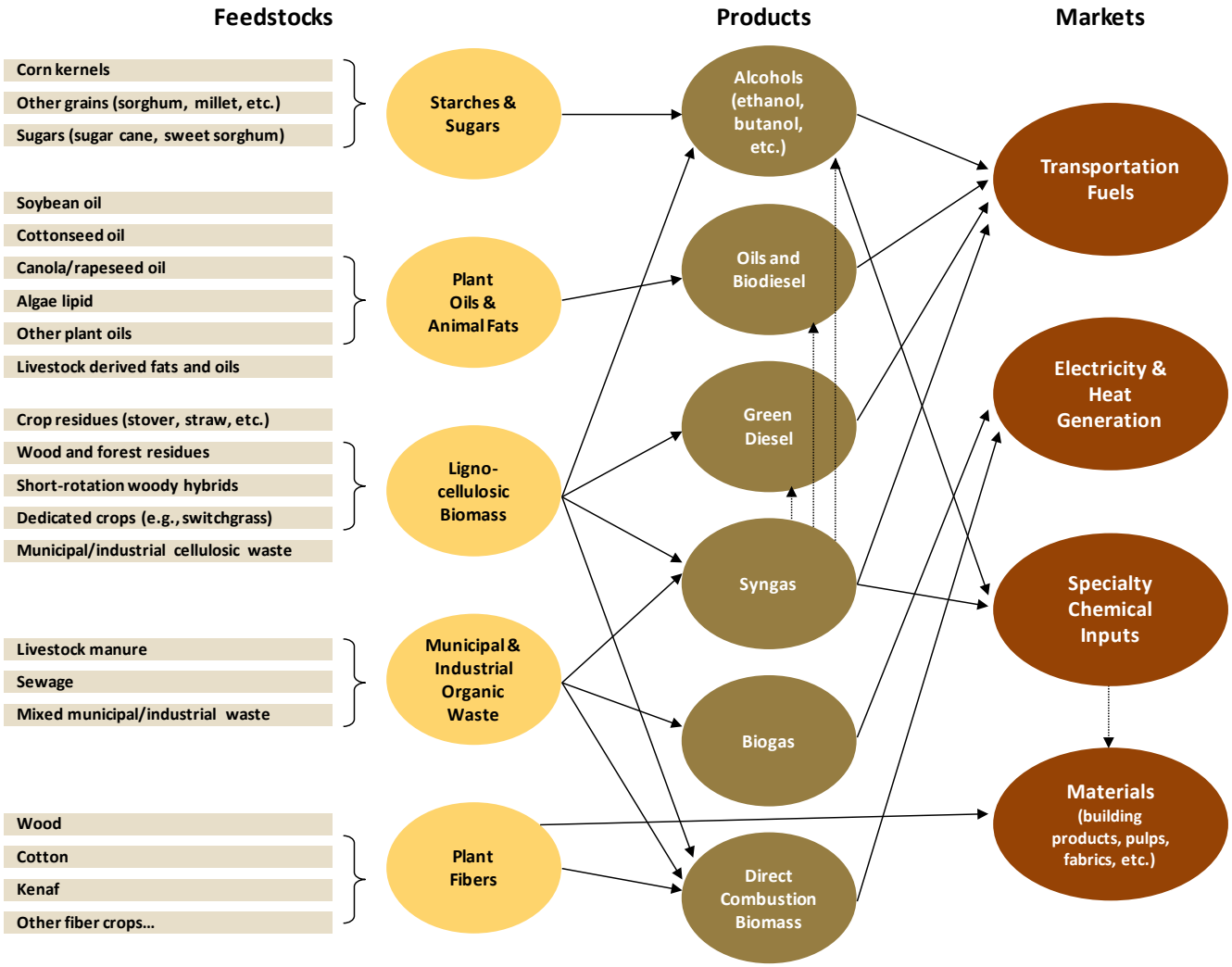
[100] Interview with Dr. Ling Yuan, Associate Professor, University of Kentucky – Department of Plant Sciences; and Dr. Orlando Chambers, Managing Director of Kentucky Tobacco Research and Development Center. (October 9, 2012).

- Biofuels (such as ethanol, biodiesel, methane gas)
- Biocomposite materials (such as construction materials, insulation, sound-deadening panels)
- Specialty chemicals (such as plastics/polymers, adhesives, lubricants, catalysts)
- Fibers (for carpeting, textiles, and other applications)
- Environmental remediation and protection systems (such as microbes for toxic waste disposal).

These economic opportunities also add significant value to farm output. 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 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."[101] Figure 15 illustrates the general structure of the emerging bioeconomy and the products being generated:

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

Figure 15: Simplified Categorization of the Bioeconomy Opportunity – Biomass Feedstocks, Biobased Products and Market Applications



Much of the future for these products depends on the ongoing research and extension activities that the Southern Region's Extension Service and Experiment Station System is working on, specifically the development of processing technologies that will generate price-competitive products, as illustrated in the following textbox.

The Southern Region Extension Service and Experiment Station System's Research and Extension Focus on Supporting the Forest Product Sector through Advancements in Industrial Biomass

America's forests produce the raw materials that feed a variety of industries, from dimensional lumber and composite construction materials, to pulp and paper products and, increasingly, biomass for conversion into value-added energy, fuels and chemicals. The United States contains 514 million acres of timberland, of which over 204 million acres (almost 40 percent) are located in the Southern Region[102]. The importance of the Southern Region as a hub for the forest products industry is made even clearer by the fact that in terms of annual growth of timber, the region produces 13,272 million cubic feet of growth – almost half of national timber growth (26,744 million cubic feet). Forestland in the Southern Region supports a range of social and economic goods for the region – from ecosystem services and wildlife habitat, through to the resources that supply a value-chain of lumber companies, sawmills, pulp and paper mills, construction product manufacturers and furniture manufacturers. Into the future, sustainable forest biomass presents a unique resource for supporting not only traditional forest products industries, but also new industries in advanced biofuels, biobased products, chemicals and polymers.

The network of Land-grant Universities in the Southern Region of the United States is helping to lead the way in the development of America's 21st Century Bioeconomy built on renewable resources. This Bioeconomy is based on the use of crops, trees, grasses and crop and forest residues to heat and power our homes and businesses, fuel our cars, and manufacture innovative materials, i.e. 'biobased products', like specialty chemicals and plastics. 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.[103]

The Southern Region has a combination of assets that provide significant strategic advantages in the development of a strong bioeconomy, including diverse crop and biomass production (corn, cotton, soybeans, wheat, rice, grain sorghum, hardwoods and softwoods); existing industrial infrastructure adaptable to biobased manufacturing; and superior logistics (rail, road, river and sea) for transporting feedstock from farm to factory to market.

Developing successful, new agricultural value chains for this bioeconomy will require a critical understanding of the complex relationship among the components of these value chains, from feedstock production and transportation, to mechanical, chemical and biological processing and conversion technologies required to turn raw materials into the next generation of biofuels or renewable chemicals. Researchers and practitioners within the Southern Region's Land-grant Extension Service and Experiment Station System is providing just the kinds of skills and expertise to help lead important new developments in this bioeconomy.

Strong research and extension capacity supports crop research to identify the best feedstock for the geography, improve yields and optimize production, harvest and post-harvest logistics systems. Fundamental scientific research and translational support mechanisms are also helping to advance cutting edge bioprocesses, like the use of bacterial fermentation (studied by researchers at University of Georgia) to increase the yields of valuable bio-chemical compounds that can be converted into pharmaceuticals, plastics, personal care products, clothing fibers, and hundreds of other products.

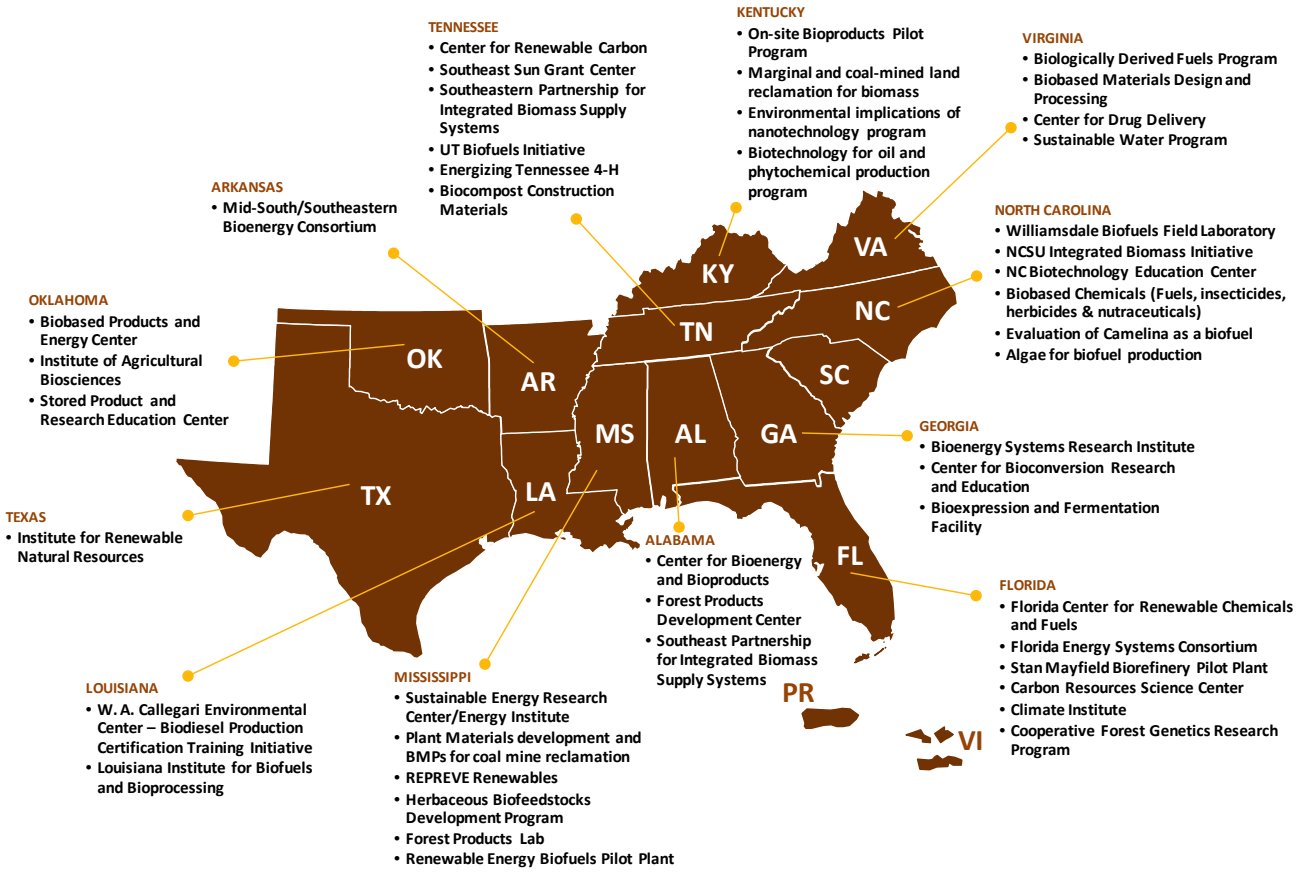
Figure 16 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure that serve to catalyze the industrial bioeconomy (fuels, chemicals, materials) to foster economic diversification, value-added product development, and energy independence. This is not, of course, an exhaustive list, but does

[102] U.S. Census Bureau. "Statistical Abstract of the United States, 2012"

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

serve to illustrate the intensity of specialized resources and assets dedicated to growing the industrial bioeconomy in the Southern Region.

Figure 16: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities that Catalyze the Growth of the Industrial Bioeconomy within the Region



Examples of the specific projects undertaken by the Southern Region's Extension Service and Experiment Station System to catalyze the growth of the industrial bioeconomy within the region include the following case studies.

CASE STUDY 26: UNIVERSITY OF FLORIDA – Florida Center for Renewable Chemicals and Fuels

The Florida Center for Renewable Chemicals and Fuels at the University of Florida promotes research to support the commercial development of biorefineries that use agricultural feedstocks—like energy grasses, sugarcane bagasse (pulpy residue left after juice is extracted) and trees—to make renewable fuels and chemicals.[104]

In 2008, the global biofuels market was valued at $60.6 billion and forecasted to grow to $77.1 billion by 2013. U.S. ethanol production increased more than four times between 2002 and 2009, from 2 billion gallons per year to 9 billion gallons. Beyond liquid biofuels, biobased chemicals and materials also present an enormous market opportunity. In 2009, biobased chemicals had a market value of $45 billion and were forecasted to grow to $60 billion by 2014.[105]

In order to help the state of Florida develop commercial opportunities in these renewable industries, research at the Center is focused on solving issues critical to improving the efficiency of producing biomass crops and converting them into renewable chemicals and biofuels. This research includes:

- ***Feedstock Development and Improvement:** to identify, improve and optimize production of specific biomass energy crops and trees (e.g., Sugarcane, Sweet Sorghum, Sugar Beets, Napier Grass, Ryegrass, Elephant Grass, Pine, Poplar, Jatropha, and Eucalyptus).*
- ***Biocatalysts and Process Improvement:** to develop, improve and test enzymes that degrade biomass feedstocks and convert them into sugars that can serve as an inexpensive renewable source for conversion into biofuels and renewable chemicals.*
- ***Biofuels Pilot Plant:** to optimize the main components of the biorefinery process, from feedstock pre-treatment to fermentation of sugars into ethanol and organic acids, and otherwise serve as a laboratory for the conversion of biomass into biofuels and renewable chemicals.*[106]

CASE STUDY 27: UNIVERSITY OF TENNESSEE – Southeastern Partnership for Integrated Biomass Supply Systems

The Southeastern Partnership for Integrated Biomass Supply Systems (SPIBSS) was formed to demonstrate real world solutions to barriers limiting development of advanced biofuel production in the Southeast United States. SPIBSS is also creating new metrics for improved decision-making about biorefinery development, and delivering outreach programs to share its findings.

As part of SPIBSS, scientists at the University of Tennessee are focusing their research and extension work on the crop production side of the biomass-to-biofuel supply chain. Research on production, harvest and logistics of perennial grasses, like switchgrass, are important to the success of this supply chain. Under the direction of University of Tennessee SPIBSS has 5,000 acres of switchgrass being grown on private farms. Perennial grasses were decided as the best feedstock because they can be harvested in the fall and lend themselves to longer term land use. Switchgrass has good yields on marginal land and is ideal for small farmers and landowners. The switchgrass will be processed into biofuels at Genera's biorefinery in Vonore, Tennessee. SPIBSS is also addressing sustainability issues by developing analysis to reduce the environmental footprint of the biomass supply chain.[107]

[104] University of Florida. Florida Center for Renewable Chemicals and Fuels. http://fcrc.ifas.ufl.edu/

[105] Battelle Memorial Institute, Technology Partnership Practice. 'Power & Promise: Agbioscience in the North Central United States.' 2011.

[106] Florida Center for Renewable Chemicals and Fuels. 'Accountability Measures. July 2010 – June 2011.'

[107] Interview with Dr. Timothy Rials, Director of the Center for Renewable Carbon, University of Tennessee (October 3, 2012).

Through these activities, the partnership is helping to meet the U.S. goal of producing at least 16 billion gallons of the mandated advanced biofuels from cellulosic biomass feedstocks by 2022. The benefits of a successful cellulosic biofuels industry will be tremendous, not only for biofuel manufacturers, but also for American national security and economic development. A multi-billion gallon cellulosic biofuels industry will offer new jobs to support rural communities and farm households and provide economic development for many agriculturally dependent areas. According to University experts, the manufacturing of cellulosic biofuels to meet the 16 billion gallon target would directly employ 24,000 workers as well as support thousands of additional jobs in feedstock production, harvest and transportation.[108]

Build stronger, healthier, more economically sustainable communities

A community's quality of place is the sum of those cultural, social, recreational, environmental, educational, and personal development assets that serve the needs of the population. Within this context, strong evidence suggests that the Southern Land-grant Extension Service and Experiment Station System is of substantial importance to sustaining and improving quality of life and quality of place in the South.

For instance, much of the work of the Extension Service focuses on addressing critical issues related to community and family sustainability for the citizens of the Southern Region. In fact, Cooperative Extension Service was formed under a mandate to diffuse knowledge and to develop a more informed and educated population of agricultural practitioners and community residents to help improve the overall quality of life and economic sustainability across the region.

Figure 17 highlights some of the Southern Region Extension Service and Experiment Station System's key initiatives, specialized programs, and infrastructure that serve to build stronger, healthier, more economically sustainable communities and families in the region. This is not, of course, an exhaustive list, but does serve to illustrate the intensity of specialized resources and assets dedicated to building stronger communities and families in the Southern Region.

[108] Agricultural Marketing Resource Center. 'Renewable Energy Newsletter.' February 2009.

Figure 17: Examples of Key Initiatives, Institutes, and Programs within the Southern Region's Land-grant Universities that Build Stronger, Healthier, More Economically Sustainable Communities and Families in the Region

Supporting Community Development

While the American economy is firmly rooted in free enterprise, this competitive system, by its very nature, produces extremes of success and failure. Just as the 19th and 20th centuries saw a powerhouse industrial nation emerge from an agrarian societal base, so too is the 21st century bringing dramatic change as the economy shifts to an information- or knowledge-based, technologically driven platform. As economic adjustments take place, some communities immediately prosper; but, many others face great challenges in altering their economic base and structure to fit into the New Economy.

Community development programs and initiatives help local business communities, current and emerging community leaders, and elected and appointed government officials investigate and create viable options for economic and community development by:

- Helping create an inclusive decision-making environment;
- Increasing the knowledge base for individual and community decisions; and,
- Developing clientele skills necessary to help achieve their individual and community goals.

The Extension Service and Experiment Station System plays an important role in helping communities adjust to changing economic conditions. Through multiple initiatives (in new business development, business retention and expansion, product development strategy, marketing and community promotion, workforce development, public policy assessment, and leadership development), the Extension Service and Experiment Station System provides development assistance to communities in every Southern county.

While each individual institution tailors its programs to meet the specific needs of its communities, there are a number of programs that are common across the System, including:

- Extension Disaster Education Network (EDEN) – provides communities and individuals with the tools they need to prepare for, respond to, and recover from natural and man-made disasters.
- Market Maker - connects local buyers and sellers to make marketing and business easier, more efficient, and sustainable.
- Leadership and Civic Engagement Training **-** helps communities and community groups come together, solve problems, make decisions, and strengthen local leadership.
- Southern Rural Development Center - seeks to strengthen the capacity of the Southern Region's Land-grant Universities to address critical contemporary rural development issues impacting the well-being of people and communities in the rural South.

An example of a specific project undertaken to support community development is shown in the following case study.

CASE STUDY 28: MISSISSIPPI STATE UNIVERSITY – Mississippi Institute for Forest Inventory, Enabling Biofuel Development

The Mississippi Institute for Forest Inventory (MIFI) and the Forest and Wildlife Research Center (FWRC) at Mississippi State University developed and implemented a web-based forest inventory analysis system that has been used in monitoring, planning, extension outreach and biofuel industry recruitment. The MIFI system serves as the database for many important energy and environmental applications, including assessing woody biomass availability for biofuel, determining forest harvest patterns, and modeling the effects of land-use on water quality.

MIFI has a proven track record for developing relationships and bringing companies in the biofuel industry to the State of Mississippi, including BHT Hickory, Bluefire Ethanol, Interchem, and KiOR. KiOR is a next-generation renewable fuels company that has developed a proprietary Biomass Fluid Catalytic Cracking process to convert biomass into renewable crude oil. In 2011, KiOR began construction on its first commercial-scale plant in Columbus, Mississippi, and has plans to open four larger plants in Mississippi and throughout the Southern Region over the next several years, operating at a scale that will compete with other biofuels producers and traditional petroleum production. The southern yellow pine is an important biomass product, and will be used as the primary feedstock in the facility in Columbus, Mississippi. KiOR utilized the MIFI/FWRC forest inventory analysis tool to better understand the regional woody biomass supply and site the Columbus plant.

Building and Sustaining Stronger Families

A core element of Extension Service activities envisioned in the original Smith-Lever Act was the "development of practical applications of research knowledge and giving of instruction and practical demonstrations of existing or improved practices or technologies in … home economics … and subjects relating thereto."[109] Extension Service was conceived not only as a technological and educational institution for agricultural practitioners, but also as a provider of resources that would strengthen American family life and communities. Today, that original vision of Extension Service as a supporter of families is very much alive.

The Southern Land-grant Extension Service and Experiment Station System operates a wide range of programs aimed at building and sustaining stronger families by

- Teaching families to access, use, and manage resources wisely;
- Teaching families to strengthen and improve relationship skills; and,
- Helping communities identify family needs and design and implement plans to meet those needs.

As the economics of global agbioscience production continues to place financial stresses on individual farms, the Southern Land-grant Extension Service and

[109] http://www.higher-ed.org/resources/smith.htm.

Experiment Station System has develop and disseminated a variety of programs and initiatives to educate families on how to manage under new business models. For instance, there has been a significant rise in the number of families now involved in agritourism, ecotourism, locally grown initiatives, and hunting leases across the Southern Region, all in an effort to diversify and increase income streams to build and sustain stronger families. This is in addition to a number of farm financial management programs that have been developed to help families deal with increasingly complex agricultural systems. An example of such a program is shown in the following case study.

CASE STUDY 29: UNIVERSITY OF TENNESSEE – MANAGE Program

Since the 1980s, there has been a shift in American agriculture that has led to an increase in costs—for inputs, machinery and land, as well as an increase in farm debt to cover some of these costs. This has resulted in greater pressure on family farm operations and the decline and consolidation of farm operations. The number of farms in Tennessee has declined by 12.5 percent since the 1980s, from 90,565 in 1982 to 79,280 in 2007 (last available census data).[110]

As a result of the farm crisis of the 1980s, Tennessee legislative leaders worked with state agricultural leaders and UT Extension Service to establish the MANAGE program. Through the MANAGE Program University of Tennessee Extension Service works with Tennessee farm families to assess their total farming business through farm and financial management. MANAGE is offered at no cost to farm families in all Tennessee counties.

Since its inception in 1986 19,000 families in Tennessee have benefited from the MANAGE program. Today MANAGE works with farm families on long-term farm management, marketing and financial management. Within the past year, financial planning software has been used by 600 Tennessee farm families. Area specialists have also worked with more than 6,000 additional farmers on record keeping, partial budgeting and marketing decisions.

[110] USDA – National Agricultural Statistics Service. 'Census of Agriculture.' http://www.agcensus.usda.gov/index.php.

Develop Human Capital

The innovation economy has reshaped previously held beliefs regarding productivity. Knowledge has supplanted labor-intensive careers as the preferred path to economic growth and stability. Human capital has become the primary determinant of a region's economic vitality. Today's challenging workplace demands academic skills (i.e., a college degree) as well as "intangible" assets such as flexibility, problem-solving abilities, and interpersonal skills. Old hierarchical, boundary-laden, and static organizational structures are giving way to new kinds of "learning organizations" with flattened hierarchies. More decision-making and problem-solving authority rests in the hands of front-line employees, and self-managed, cross-functional teams are replacing bureaucratic assembly lines. Furthermore, extensive cross-training, teamwork, and flexible work assignments are taking the place of elaborate work rules.

"Human Capital's Role in the New Economy." Issue Brief, Economic & Technology Policy Studies, NGA Center for Best Practices, May 2002

The importance of a well-educated, skillful, and creative workforce is hard to overstate. Economists have long realized that "the most important elements in the quest for a competitive advantage in commerce, be it at the micro, or firm, level or at the macro, or national, level, are the skills and initiative of its workforce."[111] In a world economy, where natural resources, machines, and technology are made highly mobile and, thus, relatively less important, the importance of workers expands. As Lester Thurow notes, "People will move, but more slowly. Skilled people become the only sustainable source of competitive advantage."[112]

The critical importance of workforce education to the sustainability of America's competitive edge and high standard of living must be understood. The nation and its regions can maintain competitiveness and support high wages only if it is more productive per unit of labor than its competitors. The United States must maintain higher levels of productivity through two main routes—the application of technology and the skills and know-how of the workforce. Without sustained leadership in these two areas, the U.S. economic position and standing in the world will decline. Indeed, these two factors are really only one—workforce skills—because "technology is only as good as the ingenuity of those who can both maintain and use it to its fullest potential."[113]

The route to economic success cannot be solely based on inventing more products than the next country or region. It must also be built on the ability to produce that invented product more inexpensively and at a higher quality level than can be achieved elsewhere, so that the product can be exported and the income earned. In this environment, there is very little room for the unskilled worker—the successful labor force will need to be equipped with higher-order thinking skills, including problem solving, learning skills and strategies, creative and innovative thinking, and decision making.

In many regards, recognition of the importance of a skilled and adaptable populace, versed in the application of modern tools and technologies, was a root cause for the original development of Land-grant Universities. The Morrill Act of 1862 established Land-grant Universities in each state to educate citizens in agriculture, home economics, mechanical arts, and other practical professions. Further support for disseminating

[111] K. C. Gray and E. L. Herr. *Workforce Education: The Basics,* Needham Heights, MA: Allyn & Bacon, 1998.

[112] L. Thurow. *Head to Head: The Coming Economic Battle Among Japan, Europe, and America,* New York: Morrow & Company, 1992.

[113] K. C. Gray and E. L. Herr. *Workforce Education.*

technological knowledge and skills across the American population was provided by 1914's Smith-Lever Act, which established the partnership between agricultural colleges and USDA to provide Cooperative Extension Service.

Today, these central activities of Land-grant Universities—research, education, and extension—are just as relevant as they have ever been. The Southern Land-grant Universities are directly impacting the regional economy by producing graduates with the specific agbioscience-related skills and knowledge to help sustain the important industry sector. Table 8 provides the number of students that graduated in the most recent year with a degree in an agriculture-related field of study.

Table 8: Agriculture-Related Degrees at the 15 Southern Land-grant Universities

	Regional Total
Bachelor's Degree	8,526
Master's Degree	1,417
Doctorate Degree	589

In addition, the Land-grant Extension Service and Experiment Station System provides valuable workforce education through a variety of certification programs relevant to the agbioscience industry, including: ServSafe - National Restaurant Association Food Safety Certification; Hazard Analysis and Critical Control Points (HACCP) Certification; Master Farmer Certification; Master Gardener Certification; and, Pesticide Applicator Certification.

Through undergraduate education programs, graduate programs, support of statewide K-12 education initiatives, adult education workforce development, and 4-H Youth Development activities, the Extension Service and Experiment Station System is impacting human capital development across exceptionally broad population groups. The following narrative further examines the impact of one particular segment—youth.

4-H Youth Development

Through 4-H Youth Development activities, adolescents acquire the cognitive, social, and emotional skills and abilities required to navigate life. The experiences of adolescence vary for every youth; and his or her development is influenced by culture, gender, and socioeconomic class, as well as by formal and informal settings, such as home, church, and school, and extracurricular activities and similar relationships, such as with peer friends, work colleagues, parents, teachers, and mentors. Young people develop their personalities and life skills based on these early adolescence experiences.

As a time of rapid change in young people, early adolescence offers an excellent opportunity for positively influencing their development. The Southern Land-grant Extension Service focuses its research, teaching, and extension activities, such as 4-H, school enhancement, and other related programs, on helping Southern youth become productive, contributing members of society. Furthermore, these efforts influence youth from all ethnic, racial, and socioeconomic backgrounds who live in rural, suburban, and urban communities.

For the past decade, the national 4-H Council has engaged the Institute for Applied Research in Youth Development at Tufts University to analyze the impact of 4-H programming. The *4-H Study of Positive Youth Development*[114] is a longitudinal study that began in 2002, and continues today, surveying more than 7,000 adolescents from diverse backgrounds across 48 U.S. states.

The research conducted for the study shows that 4-H youth are competent, confident, caring, and connected, and that they exhibit strong character. Overall, the Tufts study shows that 4-H'ers contribute more to their families and communities, achieve higher grades in school, and are more likely to go to college than youth who are not in 4-H, or even youth who participate in other out-of-school programs. In addition, youth involved in 4-H lead healthier, more productive lives, are less likely to suffer from depression and are less likely to participate in risky behaviors like drinking and smoking.

Specifically, the study has found that **4-H youth excel in school and the sciences.** The research indicates that 4-H participants obtain higher educational achievement and higher motivation for future education. Young people in 4-H:

- Report better grades, higher levels of academic competence and an elevated level of engagement at school.
- Are nearly two times more likely to plan to go to college.
- Are more likely to pursue future courses or careers in science, engineering and computer technology.
- Girls in 4-H are two times more likely to pursue scientific careers than their peers.

The study also found that **4-H youth make healthier choices.** According to the most recent report, 4-H'ers—regardless of their background, socio-economic status, race, and gender—make healthier life style choices as a result of the

[114] See http://ase.tufts.edu/iaryd/researchPositive4HPublications.htm

health and safety education and experiences they receive through 4-H programming. The research indicates that young people in 4-H are

- 3.4 times more likely to delay sexual intercourse by 12th grade.
- Found to have significantly lower drug, alcohol and cigarette use than their peers.
- 2.3 times more likely to exercise and be physically active.[115]

When one considers that more than 2.7 billion Southern youth have participated in 4-H programming in the last year, the impact of this initiative on the region is sizeable.

An example of the impact of a 4-H project undertaken within the Southern Region is shown in the following case study:

CASE STUDY 30: VIRGINIA TECH – 4-H Program Developing Math and Science Skills in Local Youth

A recent Harvard University study revealed that American students were lagging many of their counterparts around the world in math and science achievement scores—ranking 25th in math and 17th in science. A solid foundation in math and science skills at an early age is considered vital to creating a future generation that supports America's global competitiveness in science, technology, engineering, and other high-tech, high-wage fields.[116]

The Virginia 4-H Program supports math and science skill development for youth through its STEM (Science, Technology, Math and Engineering) Program, which to date has reached approximately 33,000 youth. 4-H STEM projects help students learn high-tech skills and give them hands-on application of science skills through biotechnology, robotics, computer technology, space and flight, and engineering sciences. Youth learn to think like a scientist—to observe, ask thoughtful questions, predict outcomes, and conduct experiments.

The Virginia 4-H Program, managed by Virginia Cooperative Extension Service, provides development education for youth on a wide range of topics—animal science; food, nutrition and health; plants, soils and entomology; science, technology, engineering and math; leadership and personal development; communication and expressive arts. Through 4-H, young people are encouraged to participate in a variety of activities that emphasize 4-H's "learning by doing" philosophy of youth development. With a direct connection to research at Virginia's Land-grant Universities, Virginia Tech and Virginia State University, 4-H is the first experience many young people have with higher education.[117]

[115] See http://www.4-h.org/about/youth-development-research/positive-youth-development-study/

[116] 'Achievement Growth: International and U.S. State Trends in Student Performance.' Hanushek, Eric, et al. Harvard Kennedy School – Program on Education Policy and Governance and Education Next. July 2012. http://www.hks.harvard.edu/pepg/PDF/Papers/PEPG12-03_CatchingUp.pdf.

[117] Virginia Tech. Virginia Cooperative Extension. 4-H Youth Development. http://www.4-h.ext.vt.edu/index.html.

A SYSTEM FACING SIGNIFICANT GLOBAL CHALLENGES—THE SOUTHERN LAND-GRANT EXTENSION SERVICE AND EXPERIMENT STATION SYSTEM

The agbioscience industry in this nation is often overlooked or taken for granted. Much attention has been paid to medical advancements stemming from modern biological sciences, but the tools and technologies of the life scientist are no less powerful in advancing plant science, animal science, and agricultural sciences. Indeed, modern agbiosciences represent perhaps the most promising arena of applied science for addressing many of the most pressing challenges facing humanity—*food security, human health, economic growth, and environmental sustainability.*

Agbiosciences provide a pathway to a sustainable global and domestic economic future. The sector produces products with assured demand, and those nations and regions that have the specialized skills, assets, knowledge and scientific infrastructure required to produce agbioscience innovations will be particularly well positioned to realize economic growth and development from the agbioscience industry.

While it is clear that 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—the nation's Land-grant Extension Service and Experiment Station System—face considerable challenges.

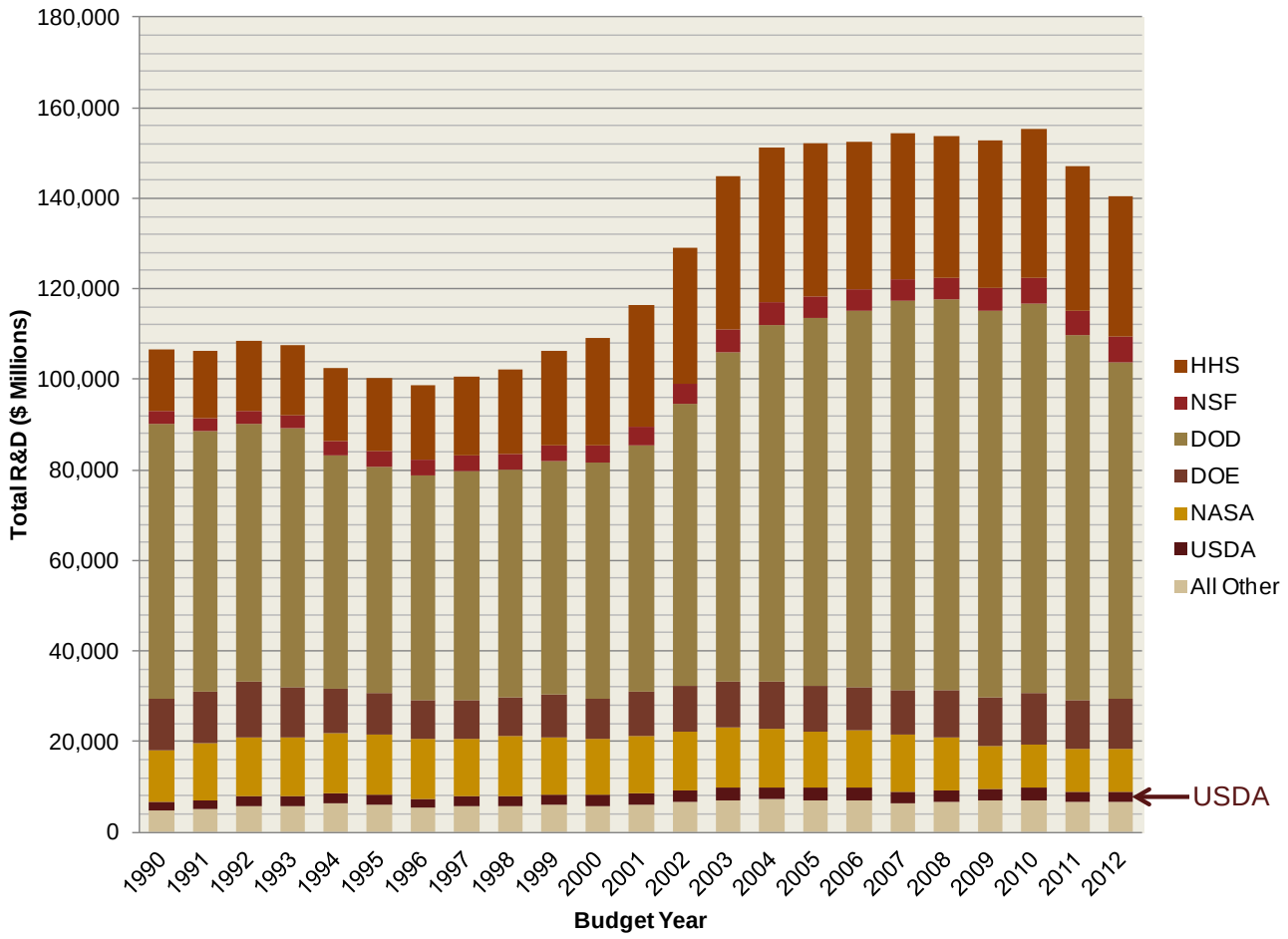
Table 9 highlights some of the diverse challenges and issues facing the Land-grant Extension Service and Experiment Station System, and it is evident that the challenges come from multiple quarters. Fundamentally, the importance of agbiosciences is expanding due to its relevance to global needs and challenges—BUT, 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.

Table 9: Challenges to Extension Service and Experiment Station System in the Current Environment

	Challenges and Issues
Federal	• Decline of federal funding, reducing capacity of Extension Service and Experiment Station System • Potentially significant cuts to research and extension funding due to federal fiscal conditions • A need to increase funding for agbioscience related research and extension, via NIFA, if Land-grants are to fully address the major issues and opportunities
State/Local	• Rising tide of state fiscal crises limiting support to state universities, including Extension Service and Experiment Station System • Fiscal problems for local counties limiting traditional local support for Extension Service
General Public	• Lack of understanding regarding the growing importance of agbioscience global issues and development opportunities • Need for those benefiting from programs to voice the System's impact and value with key decision makers • Need to communicate the "public value" of programs • Need to better connect the message of *agriculture = food and economic security= nutrition=health*
Operational	• Increased institutional operating costs • Increased federal/state regulations • Increased competetition for funding from social programs

Perhaps chief among the challenges faced is an uncertain funding environment for agbioscience research and extension activities. Pressure on the federal government to reduce spending, in combination with economic challenges at the state and local levels, generates an uncertain environment. This problem is further exacerbated when it is understood that the agbiosciences receive comparatively low levels of funding attention at the national level. Figure 18 illustrates this funding situation, showing the level of R&D funding provided via USDA versus other agencies.

Figure 18: Federal Funding by Major Agency – 1990 through 2012 (in 2012 constant dollars)



(Source: American Association for the Advancement of Science - Accessed online at http://www.aaas.org/spp/rd/guihist.shtml)

Ideally, recognition of the large-scale market opportunities in the agbioscience space should spur increased investment in USDA funding for the Extension Service and Experiment Station System and related R&D funding. Without such expanded investment it will be difficult to sustain U.S. 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.

While the current level of federal research and extension funding represents an issue, it is not the only financial challenge facing the Extension Service and Experiment Station System. Historically, federal funding has been highly leveraged by state and local (county) partners. Current budgetary challenges are impacting these additional sources of funds. With each of these three legs of the funding stool facing significant constraints, the Extension Service and

Experiment Station System is being faced by what some term the "perfect storm".

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 the Land-grant Extension Service and Experiment Station System and, therefore, a reduction in the nation's ability to compete effectively in global agriculture and agbioscience that in the long-term can impede the nation's ability to feed itself, which in turn damages national food security. 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 Universities in agbioscience though can provide a high return for funders—giving back to the government more than is received. 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[118].

The United States is not alone in the pursuit of agbioscience as a driver of economic and societal development. Traditional competitors in Europe are being joined by fast developing economies such as India, China and Singapore that see the benefits of investing in scientific research and applied development projects—including agbioscience projects. Other developed nations, are making major investments in their agbioscience infrastructure and attracting investment from US industry because of their expanding agbioscience R&D capabilities.

The National Academies[119] 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.

[118] 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.

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

In conclusion, the Southern Land-grant Extension Service and Experiment Station System has been, is, and will continue to be a primary engine for economic and social sustainability and growth. Ultimately, the System is focused on improving and sustaining the Southern Region of the United States—improving its economy, preserving its environment, growing a skilled workforce, and contributing to continued social sustainability and responsibility. As clearly indicated throughout this report, the 15 Land-grant Universities are positively impacting not only the region as a whole, but their individual states and localities in significant ways through both their diverse array of activities, as well as their close partnerships with agbioscience producers and community stakeholders.

Taken together, it is evident that the Southern Land-grant Extension Service and Experiment Station System is having powerful impacts on the region's economic growth and on economic and social sustainability. The impact of the System's programs and expenditures represent a significant return on investment for federal, state, and local funding sources. As a result, **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.**

APPENDIX A: AGBIOSCIENCE INDUSTRY EMPLOYMENT IN THE SOUTHERN REGION

The agbioscience industry in the Southern Region is significant in size, but has declined in employment over the last decade. Despite this challenge, the sector has opportunities with a niche specialization in agricultural processing and related strengths to leverage. The agbioscience industry employed nearly 2.7 million across nearly 1 million individual private sector establishments in the Southern Region in 2010 (see Table A-1). This represents a three percent higher level of employment concentration for the regional industry cluster than the nation—a location quotient of 1.03. Location Quotients (LQs) measure the degree of job concentration within the region relative to the nation.[120] Overall, the industry has shed jobs since 2001, mimicking the national trend, but unfortunately at an even greater rate of decline—15.4 percent for the region compared to 12.4 percent for the nation.

The agbioscience industry in the Southern Region is relatively diverse with six of its nine major subsectors employing more than 100,000 and the remaining three with more than 35,000 jobs in 2010. Primary Production - Unincorporated, with nearly 770,000 jobs in 2010, represents the largest of the nine major subsectors with approximately a quarter of the region's agbioscience jobs (28 percent). Food, Nutrition, and Health as well as Industrial Products and Fuels both employed more than 500,000. Though not considered specialized, Industrial Products and Fuels employment is highly concentrated in the region with a LQ of 1.12. The Southern Region has two specialized industry subsectors, which include: Agricultural Processing (LQ is 1.28); and Primary Production - Unincorporated (LQ is 1.23).

Workers in the Southern agbioscience sector are paid about $1,550 less (3.8 percent) per year when compared with their counterparts in the overall private sector. This wage for regional agbioscience workers is similar to the national sector where workers also earn less, on average, compared with the private sector. However, the differential for the nation is even greater, about $2,800 less (6.2 percent) per year.

[120] 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.

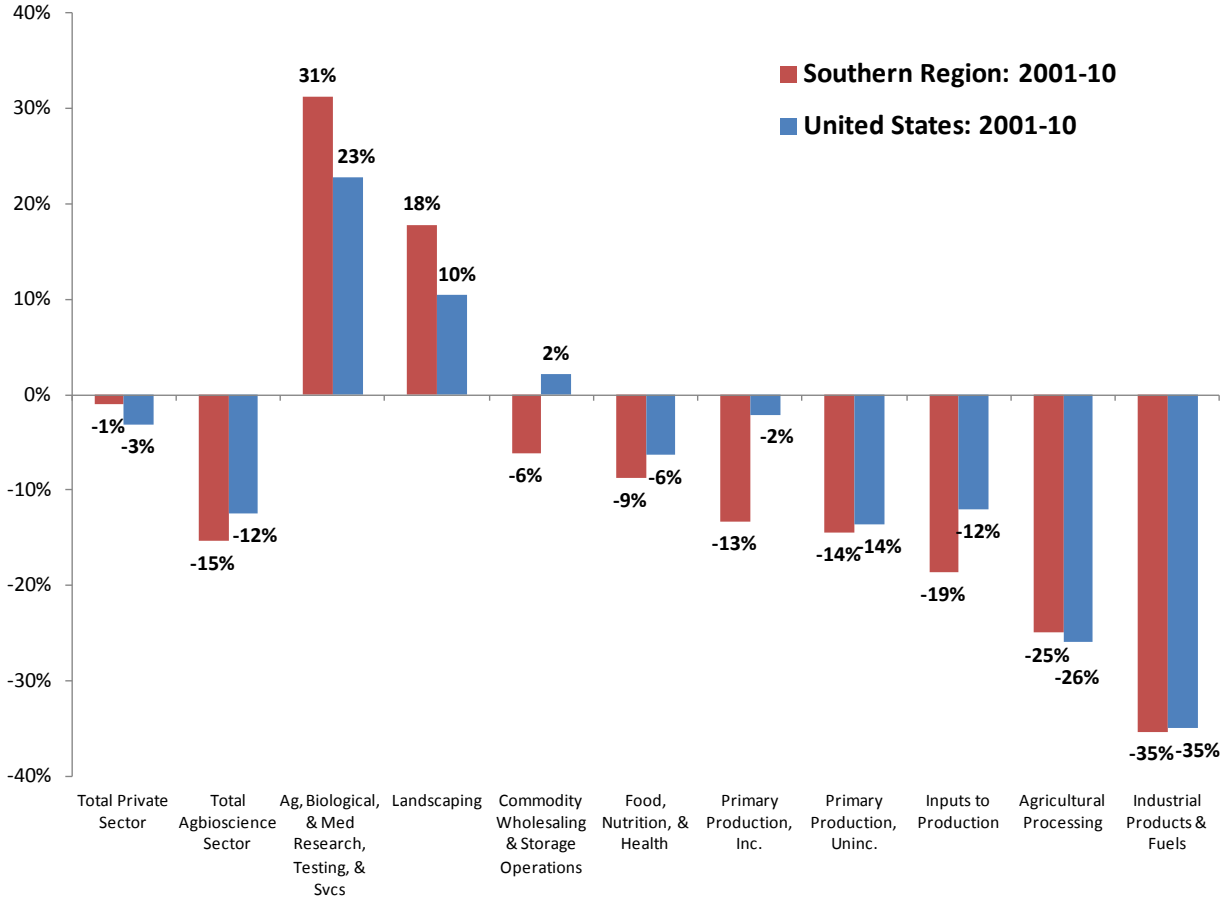
Table A-1. Agbioscience Industry Employment Metrics, Southern Region and U.S., 2001-2010

Major Agbioscience Sector	2010 Establishments	2010 Employment	2010 Location Quotient	Percent Change Empl, 2001-07	Percent Change Empl, 2007-10	Percent Change Empl, 2001-10	2010 Avg. Annual Wages
Southern Region							
Total Private Sector	**3,623,285**	**35,719,367**	**1.00**	**6.3%**	**-6.9%**	**-1.0%**	**$ 41,523**
Total Agbioscience Sector	**999,834**	**2,692,515**	**1.03**	**-7.0%**	**-9.0%**	**-15.4%**	**$ 39,971**
Ag, Biological, & Medical Research, Testing, & Services	13,599	156,072	0.79	26.9%	3.4%	31.3%	$ 48,114
Agricultural Processing	1,761	57,497	1.28	-9.7%	-16.9%	-25.0%	$ 45,132
Commodity Wholesaling & Storage Operations	2,138	35,521	0.82	0.0%	-6.2%	-6.2%	$ 37,217
Food, Nutrition, & Health	8,941	522,852	0.98	-4.3%	-4.7%	-8.8%	$ 38,640
Industrial Products & Fuels	16,227	537,154	1.12	-15.5%	-23.4%	-35.3%	$ 49,536
Inputs to Production	6,906	87,357	0.82	-5.3%	-14.0%	-18.6%	$ 50,533
Landscaping	32,531	227,175	1.06	29.5%	-9.0%	17.8%	$ 27,520
Primary Production - Incorporated	33,331	299,622	0.79	-8.1%	-5.6%	-13.3%	$ 26,602
Primary Production - Unincorporated	884,400	769,265	1.23	-13.1%	-1.5%	-14.5%	n/a
United States							
Total Private Sector	**10,897,141**	**108,090,200**	**n/a**	**4.0%**	**-6.8%**	**-3.1%**	**$ 45,638**
Total Agbioscience Sector	**2,549,038**	**7,935,671**	**n/a**	**-5.5%**	**-7.4%**	**-12.4%**	**$ 42,827**
Ag, Biological, & Medical Research, Testing, & Services	40,584	594,649	n/a	19.5%	2.7%	22.8%	$ 66,261
Agricultural Processing	4,439	136,458	n/a	-10.9%	-16.9%	-25.9%	$ 48,140
Commodity Wholesaling & Storage Operations	8,313	131,052	n/a	1.0%	1.1%	2.2%	$ 43,720
Food, Nutrition, & Health	33,784	1,618,355	n/a	-4.0%	-2.5%	-6.4%	$ 42,956
Industrial Products & Fuels	48,196	1,446,748	n/a	-15.7%	-22.8%	-35.0%	$ 48,928
Inputs to Production	22,658	323,382	n/a	-6.7%	-5.7%	-12.1%	$ 52,776
Landscaping	103,932	646,916	n/a	25.6%	-12.1%	10.4%	$ 29,744
Primary Production - Incorporated	95,132	1,146,111	n/a	-0.3%	-1.8%	-2.1%	$ 26,626
Primary Production - Unincorporated	2,192,000	1,892,000	n/a	-12.6%	-1.1%	-13.6%	n/a

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data, enhanced file from IMPLAN; unincorporated farm employment from BEA. Unincorporated farm data do not include Puerto Rico and U.S. Virgin Islands.

The past decade, which includes the recent global recession, which began in late 2007, has had a major negative impact on the U.S. labor market overall, the affects of which continue to be felt. As Figure A-1 illustrates, during this ten year period, overall private sector growth in the Southern Region contracted, although not to the same extent that the national private sector contracted (-1 percent vs. -3 percent, respectively). However, regional employment in the agbiosciences contracted at a rate faster than the nation (-15 percent vs. -12 percent). Despite this decline, two subsectors have been growing faster than the nation over the past decade—Agricultural, Biological, & Medical Research, Testing, & Services at a rate of 31 percent, and Landscaping at a rate of 18 percent. In all other subsectors, the Southern Region declined at a faster rate than the nation or mirrored the decline of the nation.

Figure A-1. Employment Trends in the Agbiosciences and Major Subsectors, 2001-2010



APPENDIX B: THE SOUTHERN REGION'S AGBIOSCIENCE INNOVATION ECOSYSTEM

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 disciplines 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 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 the Extension Service. The integrated Land-grant Extension Service and Experiment Station 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.

The region's Land-grant Universities work across the research continuum from basic research to application-oriented development and knowledge adoption creating new knowledge and commercializing existing knowledge thereby spurring economic diversification and development within the region. In examining the region's research and extension capacity, it is important to look at the institutional factors that allow research and extension to take place: R&D expenditures (see Table B-1). In analyzing the amount of academic R&D expenditures in agbioscience-related fields in the Southern Region, it is evident that:

- Agbioscience R&D in the Southern Region is significantly more concentrated than nationally. In FY 2010, agbioscience-related fields accounted for 33.7 percent of the Southern states' total academic science and engineering (S&E) research and development (R&D) compared to 29.5 percent nationally.

- Among the states, the share of agbioscience R&D to total science and engineering (S&E) R&D ranges from a high of 52.8 percent in Arkansas to a low of 23.9 percent in Puerto Rico.

- When the smaller Agricultural Sciences subset is analyzed, the Southern Region continued to be significantly concentrated, accounting for 36.2 percent of all U.S. Agricultural Sciences academic R&D.

Table B-1: Academic R&D Expenditures in Agbioscience-Related Fields, FY2010

Academic R&D Expenditures in AgBio-Related Fields in Southern Region and U.S., FY2010 (Dollars in $1000's)								
State	Bio/Biomedical Engineering	Chemical Engineering	Chemistry	Agricultural Sciences	Biological Sciences	AgBio Total	2010 Agbio Share of All S&E R&D	Total, Academic R&D
AL	$18,770	$9,223	$7,869	$72,543	$131,221	$239,626	28.8%	$832,363
AR	$1,392	$1,985	$10,038	$68,649	$52,993	$135,057	52.8%	$255,736
FL	$25,919	$6,830	$46,308	$154,283	$267,820	$501,160	28.0%	$1,788,835
GA	$39,204	$28,202	$58,619	$68,397	$341,982	$536,404	34.3%	$1,562,189
KY	$6,823	$6,265	$12,306	$60,729	$114,193	$200,316	37.2%	$538,189
LA	$3,816	$10,105	$26,457	$73,502	$189,949	$303,829	46.2%	$657,569
MS	$1,113	$5,870	$23,021	$104,516	$34,114	$168,634	40.3%	$418,235
NC	$29,437	$21,160	$51,373	$98,236	$548,853	$749,059	30.9%	$2,422,885
OK	$719	$36,016	$12,907	$40,548	$77,304	$167,494	43.7%	$383,110
PR	$222	$2,752	$14,701	$931	$8,910	$27,516	23.9%	$115,163
SC	$13,531	$27,451	$35,647	$19,188	$133,215	$229,032	37.1%	$616,776
TN	$10,082	$11,243	$25,581	$44,440	$246,078	$337,424	38.3%	$879,994
TX	$53,160	$62,588	$109,508	$178,952	$968,477	$1,372,685	32.5%	$4,223,400
VA	$21,856	$9,202	$40,226	$94,152	$208,979	$374,415	33.0%	$1,134,543
VI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$31,272
Southern Region	**$226,044**	**$238,892**	**$474,561**	**$1,079,066**	**$3,324,088**	**$5,342,651**	**33.7%**	**$15,860,259**
U.S. Totals	$741,317	$797,416	$1,751,352	$2,984,189	$10,947,345	$17,221,619	**29.5%**	$58,338,100

Source: National Science Foundation Higher Education R&D Survey, 2010

Note: Starting in 2005, most Virgin Island-based academic R&D was reported consistently in the various "Other" categories maintained by NSF, hence field-breakouts and a summary of agbioscience-related R&D is not possible.

In addition, the role of the Land-grant System is dominant in this field (see Table B-2). Specifically,

- The Land-grant Universities account for a wide ranging share of state-level agbioscience-related R&D. Ranging from 69 percent in Kentucky (University of Kentucky) and Mississippi (Mississippi State University) to 15 percent in Texas (Texas A&M University)

- However, when focused just on the Agricultural Sciences category alone, almost every Land-grant University accounts for 80 percent or more.

Table B-2. Land-grant University Role in State-level Agbioscience-Related R&D, FY 2010

Land-grant University Share of State Academic R&D in AgBio-Related Fields in the Southern Region, FY 2010							
State/Land-grant University	Bio/ Biomedical Engineering	Chemical Engineering	Chemistry	Agricultural Sciences	Biological Sciences	AgBio Total	Total, Academic R&D
AL							
Auburn University - All Campuses	0%	58%	23%	82%	4%	30%	17%
AR							
University of Arkansas - Main Campus	96%	100%	58%	86%	4%	52%	41%
FL							
University of Florida	46%	62%	32%	90%	49%	60%	36%
GA							
University of Georgia	3%	0%	7%	94%	26%	29%	14%
KY							
University of Kentucky - All Campuses	29%	53%	46%	91%	63%	69%	65%
LA							
Louisiana State University - All Campuses	0%	59%	41%	98%	61%	67%	57%
MS							
Mississippi State University	100%	99%	21%	96%	15%	69%	53%
NC							
North Carolina State University - Raleigh	34%	97%	16%	84%	15%	27%	15%
OK							
Oklahoma State University - All Campuses	0%	40%	24%	89%	40%	50%	40%
PR							
University of Puerto Rico - Mayaguez	100%	100%	14%	100%	27%	30%	22%
SC							
Clemson University	83%	16%	20%	87%	17%	27%	23%
TN							
University of Tennessee - All Campuses	31%	53%	26%	88%	21%	32%	32%
TX							
Texas A&M University - College Station	33%	28%	21%	68%	2%	15%	16%
VA							
Virginia Polytechnic Institute	50%	58%	42%	94%	26%	47%	35%

Source: National Science Foundation Higher Education R&D Survey, 2010

A strong research and development base is critical to supporting modern economies and increasing the economic vitality of a region. Regions with a robust base of research and development activities can capitalize on the resulting innovations and technologies through the creation of new products, companies and industries and high-wage jobs. As shown in Table B-3, when the level of the Southern Region's agbioscience academic R&D expenditures is examined over time, it is discovered that:

- Overall, growth in agbioscience-related R&D within the Southern Region outpaced the U.S. by just under 10 percent (Southern Region 94.5 percent compared to U.S. 85.3 percent) for the period of 2000–2010

- Every state grew their agbioscience-related R&D over the 11 year period, with growth rates ranging from a high of 134.6 percent in Florida to a low of just 10.6 percent in Puerto Rico.[121]

    - Six states more than doubled their agbioscience-related R&D in the FY 2000–FY 2010 period: Florida, Kentucky, North Carolina, Tennessee, South Carolina, and Louisiana.

- Much of the higher growth rate in agbioscience-related R&D stems from a growth rate from 2005–2010 that exceed overall U.S. agbioscience-related growth by 5.6 percent.

Table B-3. Trends in Agbioscience Academic R&D Expenditures, FY 2000–10

Nominal Change is Agbioscience-related Academic R&D in the Southern Region & U.S.						
State	FY 2000 AgBio Total	FY 2005 AgBio Total	FY 2010 AgBio Total	Change 2000–2005	Change 2005–2010	Change 2000–2010
AL	$150,847	$188,968	$239,626	25.3%	26.8%	58.9%
AR	$68,164	$108,422	$135,057	59.1%	24.6%	98.1%
FL	$213,580	$384,284	$501,160	79.9%	30.4%	134.6%
GA	$303,930	$418,384	$536,404	37.7%	28.2%	76.5%
KY	$88,735	$154,472	$200,316	74.1%	29.7%	125.7%
LA	$148,908	$246,075	$303,829	65.3%	23.5%	104.0%
MS	$102,054	$141,864	$168,634	39.0%	18.9%	65.2%
NC	$350,522	$487,532	$749,059	39.1%	53.6%	113.7%
OK	$103,653	$121,188	$167,494	16.9%	38.2%	61.6%
PR	$24,877	$17,704	$27,516	-28.8%	55.4%	10.6%
SC	$108,402	$153,443	$229,032	41.5%	49.3%	111.3%
TN	$155,389	$284,979	$337,424	83.4%	18.4%	117.1%
TX	$723,174	$1,096,679	$1,372,685	51.6%	25.2%	89.8%
VA	$202,323	$290,066	$374,415	43.4%	29.1%	85.1%
VI	$1,798	$-	$-	0	0	0
Southern Region	**$2,746,356**	**$4,094,060**	**$5,342,651**	**49.1%**	**30.5%**	**94.5%**
U.S. Totals	$9,293,118	$13,789,782	$17,221,619	48.4%	24.9%	85.3%

Source: National Science Foundation Higher Education R&D Survey (and predecessor surveys), FY 2000–2010

[121] Note, Puerto Rico's growth rate reflects a reported change in the Agricultural Sciences R&D expenditures at the University of Puerto Rico – Mayaguez from $18.493 million in 2000 to $931 thousand in 2010.

APPENDIX C: ECONOMIC IMPACTS BY TYPE OF ENTITY

Southern Region's Agricultural Experiment Station Impact Details

Table C-1. Summary of Southern Region Agricultural Experiment Station Impact Input Data ($ in Millions)

Impact Input Type	Data
Salaries & Benefits	$743.2
Headcount	*21,222*
Expenditures on External Contractors	$30.5
Other Operational Expenditures	$30.4
Capital Equipment Expenditures	$29.6
Construction/Repair Expenditures	$70.1

Source: Southern Region Agricultural Experiment Stations

Table C-2. Southern Region Agricultural Experiment Station Impacts ($ in Millions)

Impact Type	Employment	Labor Income	Value-Added	Output	State & Local Tax Revenue	Federal Tax Revenue
Direct Effect	21,222	$743.2	$754.5	$1,220.1	$13.2	$128.9
Indirect Effect	5,855	$276.3	$417.6	$630.1	$23.3	$56.8
Induced Effect	9,982	$401.7	$736.0	$1,239.1	$67.4	$95.2
Total Effect	37,059	$1,421.2	$1,908.1	$3,089.3	$104.0	$280.9
Impact Multiplier	1.7	1.9	2.5	2.5		

Source: Southern Region Agricultural Experiment Stations input data; Battelle calculations and analysis; IMPLAN 2010 multi-state model

Southern Region's Cooperative Extension Service Impact Details

Table C-3. Summary of Southern Region Cooperative Extension Service Impact Input Data ($ in Millions)

Impact Input Type	Data
Salaries & Benefits	$673.2
Headcount	*14,076*
Expenditures on External Contractors	$12.8
Other Operational Expenditures	$0.8
Capital Equipment Expenditures	$9.0
Construction/Repair Expenditures	$12.0

Source: Southern Region Cooperative Extension Service

Table C-4. Southern Region Cooperative Extension Service Impacts ($ in Millions)

Impact Type	Employment	Labor Income	Value-Added	Output	State & Local Tax Revenue	Federal Tax Revenue
Direct Effect	14,944	$673.2	$681.4	$915.6	$11.5	$112.5
Indirect Effect	3,051	$136.5	$259.6	$420.8	$20.9	$36.8
Induced Effect	7,929	$319.1	$584.7	$984.5	$53.6	$75.6
Total Effect	25,954	$1,128.9	$1,525.7	$2,320.9	$85.9	$225.0
Impact Multiplier	1.7	1.7	2.2	2.5		

Source: Southern Region Cooperative Extension Service input data; Battelle calculations and analysis; IMPLAN 2010 multi-state model